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Burn-up Credit Criticality Safety Benchmark Phase III-C

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NUCLEAR ENERGY AGENCY

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OECD Nuclear Energy Agency
Steering Committee for Nuclear Energy

Nuclear Science Committee

Burn-up Credit Criticality Safety Benchmark Phase III-C

Nuclide Composition and Neutron Multiplication Factor of a Boiling Water Reactor Spent Fuel Assembly for Burn-up Credit and Criticality Control of Damaged Nuclear Fuel

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Nuclear Science

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Nuclear Science Committee

Working Party on Nuclear Criticality Safety

Expert Group on Burn-up Credit Criticality

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
– to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

Foreword

The NEA Expert Group on Burn-up Credit Criticality (EGBUC) has organised several international benchmarks to assess the accuracy and validity of burn-up credit methodologies.

For BWR fuel, the Phase III-B benchmark was a remarkable landmark that provided general information on the burn-up properties of BWR spent fuel. It was based on the 8x8 type fuel assembly, although now 9x9 type fuel assemblies are widely used. The Phase III-B benchmark was first carried out in 2002, since then, nuclear data libraries have been revised, and the methodologies used in carrying out the burn-up calculation have also evolved.

Considering the importance of 9x9 "STEP-3 BWR fuel" assemblies in Japan from the viewpoint of criticality control of damaged fuel generated by the accident of the Fukushima Daiichi Nuclear Power Station accident, a new international burn-up calculation benchmark for this type of BWR fuel assembly was organised to carry out the inter-comparison of the averaged isotopic compositions and to obtain related values of interest for the burn-up credit criticality safety community.

This report presents the results of the Phase III-C benchmark. This benchmark was proposed and approved at the meeting of the NEA/NSC/WPNCS Expert Group on Burn-up Credit Criticality in September 2012. The basic model for the benchmark problem is an infinite two-dimensional array of BWR 9x9 type fuel assemblies. In total, 35 calculation results from 16 institutes in 9 countries were received.

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Executive summary

Criticality control of damaged nuclear fuel is one of the key issues in the decommissioning operation of the Fukushima Daiichi Nuclear Power Station accident. The average isotopic composition of spent nuclear fuel as a function of burn-up is required in order to evaluate criticality parameters of the mixture of damaged nuclear fuel with other materials.

The NEA Expert Group on Burn-up Credit Criticality (EGBUC) has organised several international benchmarks to assess the accuracy of burn-up calculation methodologies. For BWR fuel, the Phase III-B benchmark, published in 2002, was a remarkable landmark that provided general information on the burn-up properties of BWR spent fuel based on the 8x8 type fuel assembly.

Since the publication of the Phase III-B benchmark, all major nuclear data libraries have been revised; in Japan from JENDL-3.2[2] to JENDL-4[3], in Europe from JEF-2.2[4] to JEFF-3.1 [5] and in the US from ENDF/B-VI [6] to ENDF/B-VII.1 [7]. Burn-up calculation methodologies have been improved by adopting continuous-energy Monte Carlo codes and modern neutronics calculation methods.

Considering the importance of the criticality control of damaged fuel in the Fukushima Daiichi Nuclear Power Station accident, a new international burn-up calculation benchmark for the 9x9 STEP-3 BWR fuel assemblies was organised to carry out the inter-comparison of the averaged isotopic composition in the interest of the burn-up credit criticality safety community.

Benchmark specifications were proposed and approved at the EGBUC meeting in September 2012 and distributed in October 2012. The deadline for submitting results was set at the end of February 2013.

The basic model for the benchmark problem is an infinite two-dimensional array of BWR fuel assemblies consisting of a 9x9 fuel rod array with a water channel in the centre. The initial uranium enrichment of fuel rods without gadolinium is 4.9, 4.4, 3.9, 3.4 and 2.1 wt% and 3.4 wt% for the rods using gadolinium.

The burn-up conditions are similar to those in the previous Phase III-B benchmark. A constant specific power of 25.3 MW/tHM is assumed for a final burn-up value of 50 GWd/tHM. Three cases of cooling time are requested after the burn-up; 0, 5 and 15 years. A constant void fraction of 0, 40 or 70% during the burn-up is assumed.

The present benchmark is a compilation of 35 calculation results from 16 institutes in 9 countries covering different cross-section libraries. The total number of the calculation results is twice that of the previous Phase III-B benchmark.

Concerning nuclide density, the 2-sigma$^{(r)}$ of ^{235}U is less than 6% and $^{239, 240, 241}$Pu are less than 7%. For minor actinides, 2-sigma$^{(r)}$ becomes larger than 10% because of a difference in the cross-section data adopted by each calculation code. For fission product isotopes, 2-sigma$^{(r)}$ is less than 7%, except for some nuclides. Generally, the mutual-agreement of nuclide density has improved from the previous benchmark.

For the neutron multiplication factors, 2-sigma$^{(r)}$ is less than 1.1% for lower burn-up and it becomes about 1.6% at 10 GWd/t and gets smaller at 30 and 50 GWd/t. This might be a sufficient agreement considering that the adopted nuclides for the criticality calculation differ in the diverse methodologies used. Comparison of peak k_{inf} shows that it has approximately 2-sigma[r] of 1% and it becomes larger for higher void fraction cases.

Comparison of the burn-up distribution results is not the main purpose of this benchmark, but was requested to confirm the credibility of the calculation. A general good agreement of the burn-up distribution is shown. However, how gadolinium depletion is handled may still pose an issue to solve and some uncertainty depending on the analysis code used still remains.

Using this benchmark, progress of the burn-up calculation capability is confirmed. Introduction of continuous-energy Monte Carlo codes has a clear advantage in treating multi-dimensional burn-up calculation problems, even though longer process time (CPU) is required. Treatment of the gadolinium rod is still a key issue.

The difference of the neutron multiplication factor generated by the burn-up calculation results was confirmed by the analysis using the same criticality calculation code, MVP. It was less than 3% when the latest code system was used, including continuous-energy Monte Carlo codes and deterministic codes. This is the first time this kind of value has been shown by an extensive international benchmark problem. These results show that even if calculation codes are benchmarked using the well-qualified experimental data before being adopted in the safety review process, it should be understood that some uncertainty in the evaluation of the neutron multiplication factor arising from the uncertainty of the burn-up calculation methodology used still remains.

Chapter 1. Overview of benchmark specifications

The basic model for the benchmark problem is an infinite two-dimensional array of BWR fuel assemblies consisting of a 9x9 fuel rod array with a water channel in the centre (Figure 1.1).

The initial uranium enrichment of fuel rods without gadolinium is 4.9, 4.4, 3.9, 3.4 and 2.1 wt% and that with gadolinium is 3.4 wt%. The channel box is surrounded by 0.67cm-thick water and reflective boundary conditions should be adopted.

The burn-up condition is similar to that of the previous Phase III-B benchmark. The constant specific power of 25.3 MW/tHM is assumed to be the final burn-up value of 50 GWd/tHM. Three cases of cooling time are requested after the burn-up, i.e. 0, 5 and 15 years. A constant void fraction of 0, 40 or 70% during the burn-up is assumed. The case name and irradiation conditions are summarised in Table 1.1. Participants in this benchmark were requested to send the following information:

- number densities of all nuclides including gadolinium isotopes specified in Table 1.2, which are averaged over all fuel rods for selected case numbers 1b, 2a, 2b, 2c, 3b, 5b, 5c, 6b, 8b, 8c, 9b, 11b, 11c and 12b, respectively;
- neutron multiplication factors for the burn-up of 0, 0.2, 10, 12, 20, 30 and 50 GWd/t;
- maximum neutron multiplication factor and the corresponding burn-up;
- considering symmetrical fuel rod array, burn-up of each fuel pin shown in Figure 1.2 in the unit of GWd/t at assembly averaged burn-up of 12, 30 and 50 GWd/t;
- analysis environment that includes information on the computer code, nuclear data libraries, and modelling used for the analyses.

Precise problem specifications are given in the Appendices.

Table 1.1. Case name

Assembly Averaged Burn-up	12 GWd/t			20 GWd/t			30 GWd/t			50 GWd/t		
Cooling [Year]	0	5	15	0	5	15	0	5	15	0	5	15
0% V.F.*	1a	**1b**	1c	4a	4b	4c	7a	7b	7c	10a	10b	10c
40% V.F.	**2a**	**2b**	**2c**	5a	**5b**	**5c**	8a	**8b**	**8c**	11a	**11b**	**11c**
70% V.F.	3a	**3b**	3c	6a	**6b**	6c	9a	**9b**	9c	12a	**12b**	12c

* V.F. means Void Fraction

Table 1.2. Benchmarked nuclides

Actinides (13 nuclides)	^{234,235,236,238}U, ^{237}Np, ^{238,239,240,241,242}Pu, ^{241,243}Am, ^{244}Cm
FP (26 nuclides)	^{90}Sr, ^{95}Mo, ^{99}Tc, ^{101}Ru, ^{103}Rh, ^{109}Ag, ^{129}I, ^{131}Xe, ^{133,134,137}Cs, ^{144}Ce, ^{143,145,148}Nd ^{147,149,150,151,152}Sm, ^{153,154,155}Eu, ^{155,156,157,158}Gd

Figure 1.1. Modelled BWR assembly for Phase III-C benchmark

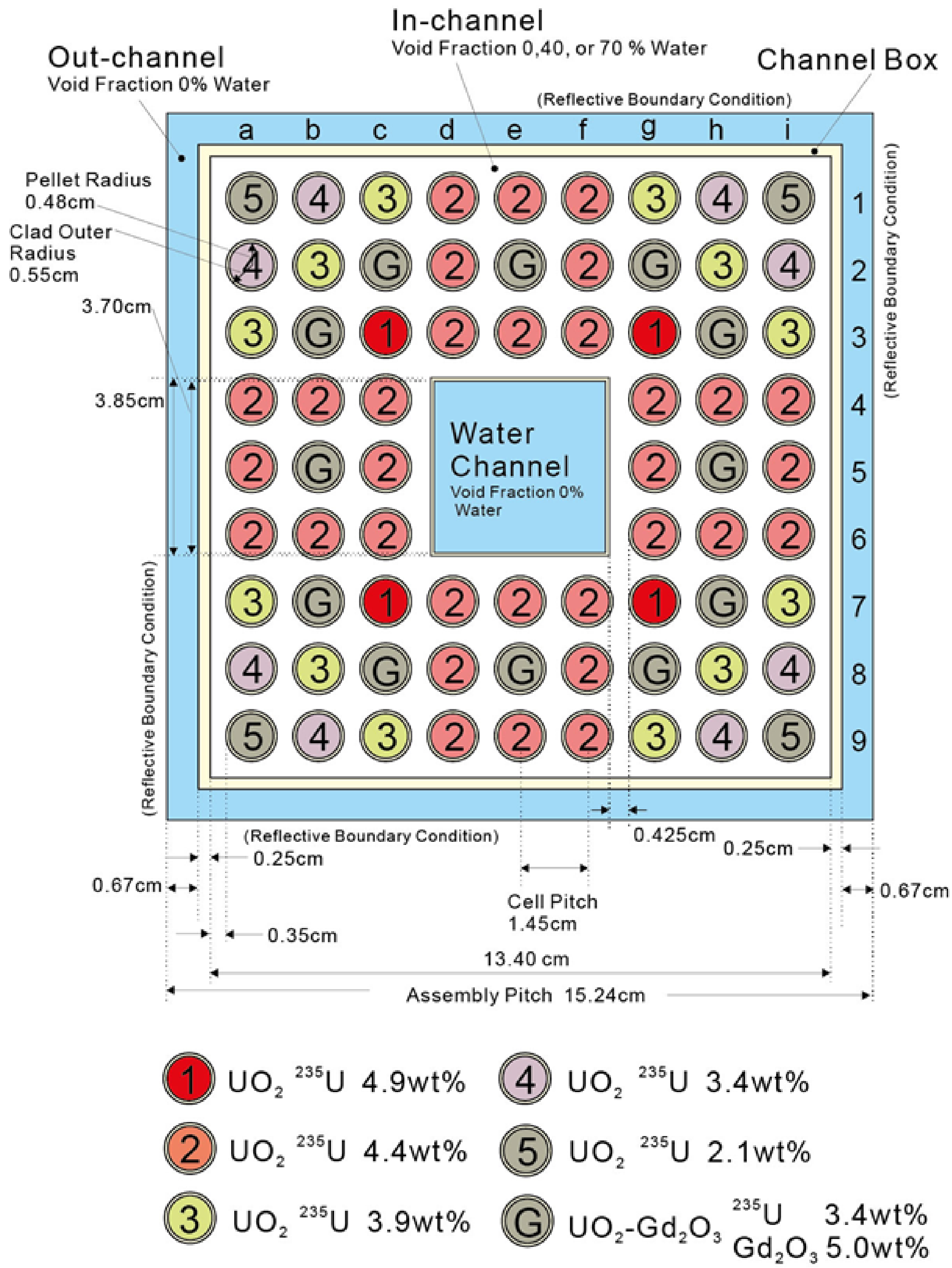
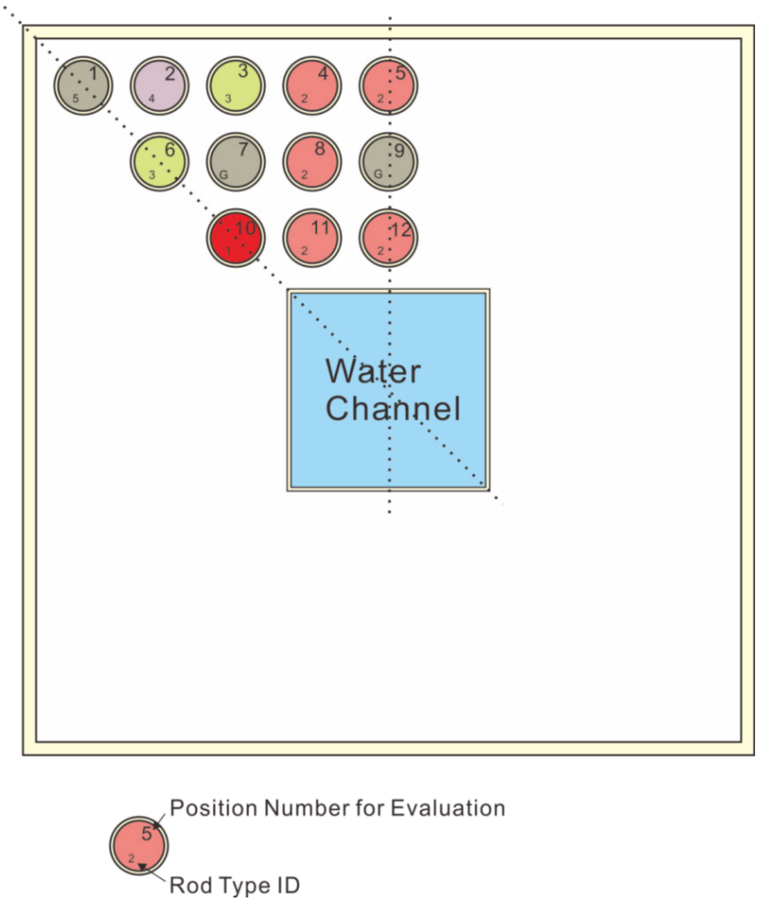


Figure 1.2. Position number of fuel rod for evaluation



Rod Type ID is shown in Figure 1.1.

Chapter 2. Participants and analysis method

2.1 Participants

Table 2.1 lists the final participants in the Phase III-C benchmark. A few participants sent several results using different cross-section libraries. In this report, each set of calculation results will be referred to using an alphabetical identifier by result receiving order, A, B, … Z, a, b,… h, and i, respectively. The total number of the set of calculation results is twice that of the previous Phase III-B benchmark and implies the high-level interests in the criticality issue of damaged fuel and the general burn-up problem for updated fuel design parameters.

2.2 Calculation code

Table 2.2 summarises the adopted calculation code system in this benchmark. SCALE6 is the code system most widely used by the participants. All SCALE6 users (nine results) adopted TRITON or TRITON-6 control module. Eight results (D, F, G, H, I, M, P and c) adopted SCALE TRITON, T-DEPL sequence with NEWT. Only one result (d) used SCALE6 TRITON-6 sequence with KENO-VI. In the last Phase III-B benchmark, the users of the SCALE system ran into the difficulty of not being able to treat the two-dimensional burn-up calculation problem. The current version of the SCALE system overcomes that problem. CASMO code (versions 4 and 5) was also used by several participants.

This benchmark differs greatly from the Phase III-B benchmark in that burn-up calculation code systems based on continuous-energy Monte Carlo codes are now widely used (more than 40% of results).

Table 2.3 summarises information on the burn-up step and UO_2-Gd_2O_3 fuel rod treatment of each participant. For the UO_2-Gd_2O_3 fuel rod, many participants used more than eight region divisions. Few participants adopted five divisions. Division in the azimuthal direction is not widely adopted. Many participants set a large number of burn-up steps before 15 GWd/t, i.e. before gadolinium depletion. BWR fuel vendors used more than 50 burn-up steps before 15 GWd/t even with a predictor-corrector method.

2.3 Nuclear data library

Table 2.4 summarises the adopted neutron cross-section libraries. Sixteen results used ENDF/B-VII.0 (SCALE is widely used and ENDF/B-VII.0 is the basis for the standard library provided in the SCALE system). Many participants used data libraries based on ENDF/B-VII.0 as the “second choice”, even if they used other libraries, i.e. JENDL or JEFF. In this sense, ENDF is the most commonly used library in this field. However, since the evaluation of neutron cross-section data is often conducted under the umbrella of international cooperation, all major nuclear data libraries today include some evaluation data adopted from other libraries. Comparison between calculations adopting different cross-section data libraries is therefore sometimes a difficult task.

All Japanese participants used JENDL. Seven results from Japan used JENDL-4. Only results ID **i** used JENDL-3.2. JENDL-4 is widely used in Japan but not used in any other country. JEFF-3.1.1 and 3.1.2 libraries, on the other hand, were used only by European participants. Interestingly, some results based on old cross-section libraries such as

JENDL-3.2, JEF-2.2 and ENDF/B-VI were provided. Especially, we have four results using JEF-2.2, which reflect the continued usage of already superseded libraries (such as JEF-2.2) that have nevertheless a long history of qualification in some code systems.

Table 2.1(1/2). A list of participants in the Phase III-C benchmark

Country	Institute	Code	Neutron data library	Contact Person*	Results ID
Japan	JAEA	SWAT4(MVP)	JENDL-4	Yuriko Uchida, Kenya Suyama	**A**
		SWAT4(SRAC2006)	JENDL-4		**B**
		MVP-BURN	JENDL-4		**C**
		MOSRA-SRAC ver.2013	JENDL-4	Kensuke Kojima	**h**
	NFI	MVP-BURN	JENDL-3.2	Ryota Watanabe	**i**
	JNES	CASMO5 ver.2.02.00	JENDL-4	Sakai Tomohiro	**E**
	TOSHIBA	MCNP-BURN2	JENDL-4	Kenichi Yoshioka	**L**
	GNF-J	LANCR01	ENDF/B-VII.0	Tadashi Ikehara	**V**
		MONTEBURNS2	ENDF/B-VII.0		**W**
		MONTEBURNS2	JENDL-4		**X****
United States	U.S. NRC	SCALE 6.1.1 (TRITON, T-DEPL)	ENDF/B-VII.0	Amrit Patel	**D**
	ORNL	SCALE 6.1.2 (TRITON, T-DEPL)	ENDF/B-VII.0	James Banfield	**P**
Germany	BfS	SCALE 6.1 (TRITON, T-DEPL)	ENDF/B-VII.0	Benjamin Ruprecht	**F**
	GRS	SCALE 6.1.1 (TRITON, T-DEPL)	ENDF/B-VII.0	Matthias Behler	**M**
		SERPENT 1.1.18	ENDF/B-VII	Volker Hannstein	**N**
		HELIOS 1.10	ENDF/B-VI.8	Matías Zilly	**O**
		KENOREST	JEF-2.2	Maik Stuke	**U**
Spain	UPM&CSN	SCALE 6.1.1 (TRITON, T-DEPL)	ENDF/B-VII.0	Nuria Garcia-Herranz	**G**
		SERPENT 1.1.18	ENDF/B-VII.0		**Q**
		SERPENT 1.1.18	JEFF-3.1.1		**R**

* "Contact person" is as of February 2013.

*Results ID **X** has an additional data set (ID **X-A**) for complementary analyses adopting new cross-section data library of ORIGEN2 burn-up module. Please see Section 3.7.1 for more detail.

Table 2.1(2/2). A list of participants in the Phase III-C benchmark

Country	Institute	Code	Neutron data library	Contact Person*	Results ID
France	IRSN	SCALE 6.1(TRITON, T-DEPL)	ENDF/B-V	Ludyvine Jutier	**H**
		SCALE 6.1(TRITON, T-DEPL)	ENDF/B-VII.0		**I**
		VESTA 2.1.5	ENDF/B-VII.0	Wim Haeck	**J**
		VESTA 2.1.5	JEFF-3.1		**K**
Finland	TVO	CASMO-4E, v2.10.22	JEF-2.2(j20200)	Anssu Ranta-aho	**S**
		CASMO-4E, v2.10.22	ENDF/B-VI(e60201)		**T**
	VTT	CASMO-4E, v2.10.22	ENDF/B-VI(e60200)	Karin Rantamäki	**Y**
		CASMO-4E, v2.10.22	JEF-2.2(j20200)		**Z**
		SERPENT 2.1.11	ENDF/B-VII.0		**a**
		SERPENT 2.1.11	JEF-2.2		**b**
Sweden	EMS	SCALE 6.1.1 (TRITON, T-DEPL)	ENDF/B-VII.0	Dennis Mennerdahl	**c**
		SCALE 6.1.1 (TRITON, , T6-DEPL)	ENDF/B-VII.0		**d**
Belgium	SCK/CEN	ALEPH 2.5	JEFF-3.1.2	Nadia Messaoudi	**e**
Switzerland	PSI	CASMO-5M v1.07.01	ENDF-B/VII.0	Olivier Leray	**f**
		MCNPX 2.7.0	ENDF/B-VII.0	Marco Pecchia	**g**

* "Contact person" is as of February 2013.

Table 2.2. Adopted calculation code system in the Phase III-C benchmark

Codes	Number of results	Continuous-energy Monte Carlo
SCALE 6.1	9	No
CASMO-4 and CASMO-5	6	No
SERPENT	5	Yes
MVP-BURN	2	Yes
MONTEBURNS2	2	Yes
VESTA	2	Yes
SWAT4(MVP)	1	Yes
MCNP-BURN2	1	Yes
KENOREST	1	No
HELIOS	1	No
MOSRA-SRAC ver.2013	1	No
SWAT4(SRAC2006)	1	No
LANCR 01	1	No
MCNPX	1	Yes
ALEPH	1	Yes

Table 2.3(1/3). A list of parameters for UO_2-Gd_2O_3 burn-up problem

Country	Institute	Results ID	Code	Number of burn-up regions in UO_2-Gd_2O_3 rods	Burn-up steps
Japan	JAEA	**A**	SWAT4(MVP)	radial:8, azimuthal:1 (of equal volume)	0～1G : 4step ～15G:28step,～50G : 15step
		B	SWAT4(SRAC2006)	radial:8, azimuthal:1 (of equal volume)	0～1G : 4step ～15G:28step,～50G : 15step
		C	MVP-BURN	radial:8, azimuthal:4 (of equal volume)	0～1G : 4step ～15G:28step,～50G : 15step
		h	MOSRA-SRAC ver.2013	radial:9, azimuthal:1	0～1G : 7step ～15G:56step,～50G : 26step
	NFI	**i**	MVP-BURN	radial:10, azimuthal:1 (concentric regions)	0～1G : 4step ～15G:56step,～50G : 21step
	JNES	**E**	CASMO5 ver.2.02.00	radial:8	0～1G : 4step ～15G:29step,～50G : 14step
	TOSHIBA	**L**	MCNP-BURN2	radial:10, azimuthal:4 (of equal volume)	0～1G : 3step ～15G:14step,～50G : 16step
	GNF-J	**V**	LANCR01	radial:10, azimuthal:1 (of equal volume)	0～1G : 4step ～15G:14step,～50G : 8step
		W	MONTEBURNS2	radial:10, azimuthal:1 (of equal volume)	0～1G : 4step ～15G:50step,～50G : 20step
		X*	MONTEBURNS2	radial:10, azimuthal:1 (of equal volume)	0～1G : 4step ～15G:50step,～50G : 20step
United States	U.S. NRC	**D**	SCALE 6.1.1	radial:5	0～1G : 13step ～15G:31step,～50G : 12step
	ORNL	**P**	SCALE 6.1.2	radial:5 (of equal volume)	0～0.1G : 1step ～0.5G:2step,～12G:23step, ～50G : 19step

Table 2.3(2/3). A list of parameters for UO_2-Gd_2O_3 burn-up problem

Country	Institute	Results ID	Code	Number of burn-up regions in UO_2-Gd_2O_3 rods	Burn-up steps
Germany	BfS	**F**	SCALE 6.1	radial:5, azimuthal:1	0～1G : 6step ～15G:34step,～50G : 50step
	GRS	**M**	SCALE 6.1.1	-	-
		N	SERPENT 1.1.18	radial:10	0～1G : 2step ～15G:11step,～50G : 4step
		O	HELIOS 1.10	radial:6, azimuthal:1 (of equal volume)	0～1G : 3step ～15G:12step,～50G : 13step
		U	KENOREST	radial:5	0～1G : 2step ～15G:15step,～50G : 12step
Spain	UPM&CSN	**G**	SCALE 6.1.1	radial:5, azimuthal:1 (of equal volume)	0～1G : 3step ～15G:17step,～50G : 38step
		Q	SERPENT 1.1.18	radial:10 (of equal volume)	0～1G : 3step ～15G:14step,～50G : 7step
		R	SERPENT 1.1.18	radial:10 (of equal volume)	0～1G : 3step ～15G:14step,～50G : 7step
France	IRSN	**H**	SCALE 6.1	radial:8, azimuthal:1	0～1G : 1step ～15G:14step,～50G : 35step
		I	SCALE 6.1	radial:8, azimuthal:1	0～1G : 1step ～15G:14step,～50G : 35step
		J	VESTA 2.1.5	radial:5 (r/2, 3r/4, 7r/8, 15r/16,r)	0～1G : 2step ～15G:28step,～50G : 70step
		K	VESTA 2.1.5	radial:5 (r/2, 3r/4, 7r/8, 15r/16,r)	0～1G : 2step ～15G:28step,～50G : 70step

Table 2.3(3/3). A list of parameters for UO_2-Gd_2O_3 burn-up problem

Country	Institute	Results ID	Code	Number of burn-up regions in UO_2-Gd_2O_3 rods	Burn-up steps
Finland	TVO	**S**	CASMO-4E, v2.10.22	radial:10 (of equal volume)	0～1G : 4step ～15G:28step,～50G : 14step
		T	CASMO-4E, v2.10.22	radial:10 (of equal volume)	0～1G : 4step ～15G:28step,～50G : 14step
	VTT	**Y**	CASMO-4E, v2.10.22	radial:10	0～1G : 0step ～15G:1step,～50G : 3step
		Z	CASMO-4E, v2.10.22	radial:10	0～1G : 0step ～15G:1step,～50G : 3step
		a	SERPENT 2.1.11	radial:10 (of equal volume)	0～1G : 4step ～15G:10step,～50G : 8step
		b	SERPENT 2.1.11	radial:10 (of equal volume)	0～1G : 4step ～15G:10step,～50G : 8step
Sweden	EMS	**c**	SCALE 6.1.1(TRITON)	radial:5 (concentric regions)	0～1G : 5step ～15G:15step,～50G : 19step
		d	SCALE 6.1.1(TRITON6)	radial:5 (concentric regions)	0～1G : 5step ～15G:15step,～50G : 19step
Belgium	SCK•CEN	**e**	ALEPH 2.5	-	-
Switzer-land	PSI	**f**	CASMO-5M v1.07.01	radial:10	0～0.5G: 3step ～15G:29step ～50G:14step
		g	MCNPX 2.7.0	radial:5	0～14G: 70step ～50G:48step

Table 2.4. Adopted neutron cross-section libraries in the Phase III-C benchmark

Cross-section library	Number of results	(%)
ENDF/B-VII.0	16	45.7%
JENDL-4	7	20.0%
JEFF-3.1.2	1	2.9%
JEFF-3.1.1	1	2.9%
JEFF-3.1	1	2.9%
JEF-2.2	4	11.4%
ENDF/B-VI.8	1	2.9%
ENDF/B-VI	2	5.7%
ENDF/B-V	1	2.9%
JENDL-3.2	1	2.9%

Chapter 3. Results from participants

3.1 Comparison of nuclide density

The results from all participants are summarised in Tables 3.1 to 3.14. In order to evaluate the dispersion of all results, 2-sigma$^{(r)}$ (%) values are summarised in Table 3.15 and shown in Figure 3.1. 2-sigma$^{(r)}$ (%) is defined as:

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \ ,$$

$$2 - sigma = 2 \times \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2} \text{ and}$$

$$2 - sigma^{(r)}(\%) = \left({2 - sigma}\middle/{\overline{x}} \right) \times 100$$

Where

X_1: number density of nuclides submitted from results **i**, and

n: total number of results.

Table 3.15 and Figure 3.1 reveal that the 2-sigma$^{(r)}$ of ^{235}U is less than 6% and $^{239, 240, 241}$Pu are less than 7%. For minor actinides, i.e. ^{237}Np, $^{241, 243}$Am and ^{244}Cm, 2-sigma$^{(r)}$ becomes larger than 10%, which is the result of the difference of the evaluated nuclear data adopted by each calculation code. For fission product isotopes which are important for reactivity evaluation, i.e. ^{95}Mo, ^{99}Tc, ^{101}Ru, ^{103}Rh, ^{109}Ag, ^{133}Cs, $^{147, 149, 150, 151, 152}$Sm, $^{143, 145}$Nd, ^{153}Eu and ^{155}Gd, in general, 2-sigma$^{(r)}$ is less than 7%, except for ^{109}Ag(<30%), ^{147}Sm(<10%), $^{149, 151, 152}$Sm(<20%) and ^{155}Gd(<50%).

Concerning ^{155}Gd, the results seem to belong to one of two groups. For example, one is approximately 2.6×10^{-7} 10^{24}/cm^3 (results based on JENDL-4, JENDL-3.2, ENDF/B-VII and JEFF-3.1) and the other is 1.9×10^{-7} 10^{24}/cm^3 (results based on ENDF/B-V, ENDF/B-VI excluding results ID **O,** and JEF-2.2 with the exception of *Results ID **U** and **b***) for case12 b. For ^{109}Ag, the results seem to belong to one of two groups. For example, one is approximately 7.0×10^{-7} 10^{24}/cm^3 (results based on JENDL-4 with the exception of results ID **E**, ENDF/B-VII and ID **J**, **N**, **Q**, **a** and **f**, ENDF/B-V, ENDF/B-VI, JEF-2.2 and JEFF-3.1) and the other is 5.0×10^{-7} 10^{24}/cm^3 (based on *Results ID **E**, **J**, **N**, **Q**, **a** and **f***) for case 2 c. Considering the generation chain of ^{109}Ag, this characteristic comes from the difference of the adopted fission yield data.

For other fission products which are important for severe accident analysis such as ^{90}Sr, ^{129}I and ^{137}Cs have 2-sigma$^{(r)}$ of approximately 20%. ^{134}Cs also has a relatively large 2-sigma$^{(r)}$ (%) value. Based on the experience of the analyses of the post-irradiation examination, ^{134}Cs should have a 2-sigma$^{(r)}$ value of less than 10% [3] if the latest nuclear data are adopted. As JENDL-4 adopted a new evaluation of ^{133}Cs neutron capture cross-section based on the integral experiment, i.e. post-irradiation examination, the results based on JENDL-4 might show a large difference from the results using old libraries.

Figure 3.2 shows the dependency of 2-sigma$^{(r)}$ (%) on the burn-up value at 40% void fraction with 15-year cooling. Figure 3.3 reveals the dependency of 2-sigma$^{(r)}$ (%) on the void fraction at 12 GWd/t with 5-year cooling while Figure 3.4 shows the dependency of 2-sigma(r) (%) on the cooling time at 12 GWd/t with 40% void fraction. As shown in these figures, 2-sigma(r) (%) of nuclide density depends strongly on burn-up, not on void fraction or cooling time.

3.2 Neutron multiplication factor

Tables 3.16, 3.17 and 3.18 summarise the neutron multiplication factors, whereas Figures 3.5, 3.6 and 3.7 show the neutron multiplication factors against the burn-up value. The 2-sigma(r) of the neutron multiplication factor is approximately 1.1% for lower burn-up, and it is about 1.6% at 10 GWd/t and gets smaller at 30 and 50 GWd/t, which might be a sufficient agreement considering the difference of the adopted nuclide for the criticality calculation. Table 3.19 shows the peak k_{inf} and the corresponding burn-up. Many participants submitted corresponding burn-up with three significant digits. Comparison of peak k_{inf} shows that it has approximately 2-sigma(r) of 1% and it becomes larger as the void fraction increases. Again, it should be noted that each k_{inf} was evaluated by different codes, and the isotopes adopted in each criticality calculation are also different. To study the effect of the difference of burn-up calculation results on the criticality calculation, an independent criticality calculation should be carried out, using the same code and the same library and adopting the submitted nuclide density.

3.3 Burn-up distribution

Tables 3.20, 3.21 and 3.22 summarise the burn-up values of each burn-up region shown in Figure 1.2 of the benchmark specification at 0, 40 and 70% void fractions, respectively. As the main purpose of this benchmark is to evaluate the criticality property, the burn-up distribution data were requested to check the reliability of the calculation. Many participants submitted burn-up distributions which give us correct assembly averaged burn-up values, i.e. 12, 30 and 50 GWd/t. Some of them give us slightly different averaged burn-up values from the assembly averaged burn-up (*Results ID D, F, G, M, P, a, b, c, d*). This could be a consequence of the difference in the treatment of numerical data when submitting data to the authors. A similar difference from the average value was also shown in the Phase III-B benchmark. Some participants used the specific power of 25.3 MW/tHM including also a small fraction of power generated in the cladding, the water and the channel box (by the ratio of about 0.1/25.3) by gamma heating.

Tables 3.23, 3.24 and 3.25 show the summary of burn-up distribution at each burn-up region, standard deviation (sigma) and 2-sigma(r) (%). These tables reveal a larger than expected sigma of UO_2-Gd_2O_3 rods (Regions 7 and 9), especially at low assembly averaged burn-up (12 GWd/t) due to many results of SCALE6.1 (*Results ID D, F, G, H, I, M, P, c and d)* and KENOREST (*Result ID U*) and MCNPX2.7 (*Result ID g*) having different burn-up distribution from other codes. The difference of KENOREST (*Result ID U*) may have been caused by users not applying the predictor-corrector method.

Tables 3.26, 3.27 and 3.28 summarise the burn-up distribution for void fractions 0, 40 and 70%, with the exception of all results of SCALE6.1 (*Results ID D, F, G, H, I, M, P, c and d*), KENORST (*Result ID U*) and MCNPX2.7 (*Result ID g*). These tables imply that generally many SCALE6.1, KENOREST and MCNPX2.7 users have a different burn-up value of UO_2-Gd_2O_3 fuel pin from other codes. By excluding SCALE6.1, KENOREST and MCNPX2.7, 2-sigma(r) of the Gd fuel pin is less than approximately 3% even in the low burn-up case (12 GWd/t). The burn-up of the gadolinium isotope is still a difficult problem for deterministic codes and some uncertainty depending on the analyses code and participants still remains. For the case of MCNPX2.7, considering the difference from other systems based on the continuous-energy Monte Carlo code, the possibility of a neutron source convergence problem may arise.

Table 3.1(1). All results for Case 1b (No void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.98E-06	6.03E-06	5.98E-06	5.94E-06	5.98E-06	5.90E-06	5.94E-06	5.89E-06	5.94E-06	5.94E-06	5.94E-06	5.97E-06	5.94E-06	5.93E-06
^{235}U	6.12E-04	6.10E-04	6.13E-04	6.09E-04	6.14E-04	6.07E-04	6.11E-04	6.11E-04	6.10E-04	6.13E-04	6.13E-04	6.12E-04	6.10E-04	6.12E-04
^{236}U	4.88E-05	4.96E-05	4.87E-05	4.95E-05	4.86E-05	4.90E-05	4.94E-05	4.95E-05	4.94E-05	4.90E-05	4.90E-05	4.88E-05	4.93E-05	4.90E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	1.72E-06	1.68E-06	1.71E-06	1.77E-06	1.69E-06	1.73E-06	1.80E-06	1.79E-06	1.79E-06	1.77E-06	1.75E-06	1.75E-06	1.78E-06	1.79E-06
^{238}Pu	1.64E-07	1.58E-07	1.64E-07	1.55E-07	1.51E-07	1.54E-07	1.58E-07	1.65E-07	1.58E-07	1.56E-07	1.57E-07	1.68E-07	1.56E-07	1.56E-07
^{239}Pu	6.78E-05	6.61E-05	6.78E-05	6.76E-05	6.82E-05	6.79E-05	7.02E-05	7.31E-05	7.04E-05	6.66E-05	6.57E-05	6.71E-05	6.99E-05	6.89E-05
^{240}Pu	1.26E-05	1.23E-05	1.26E-05	1.26E-05	1.26E-05	1.28E-05	1.30E-05	1.35E-05	1.29E-05	1.31E-05	1.34E-05	1.29E-05	1.29E-05	1.26E-05
^{241}Pu	3.41E-06	3.25E-06	3.39E-06	3.34E-06	3.38E-06	3.36E-06	3.45E-06	3.49E-06	3.44E-06	3.45E-06	3.49E-06	3.50E-06	3.43E-06	3.39E-06
^{242}Pu	4.59E-07	4.36E-07	4.54E-07	4.46E-07	4.47E-07	4.56E-07	4.57E-07	4.70E-07	4.51E-07	4.71E-07	4.89E-07	4.78E-07	4.54E-07	4.45E-07
^{241}Am	1.00E-06	9.58E-07	9.98E-07	9.84E-07	9.94E-07	9.91E-07	1.02E-06	1.03E-06	1.01E-06	1.02E-06	1.03E-06	1.04E-06	1.01E-06	9.98E-07
^{243}Am	2.00E-08	1.77E-08	1.98E-08	2.12E-08	1.91E-08	2.23E-08	2.22E-08	2.34E-08	2.22E-08	2.27E-08	2.12E-08	2.08E-08	2.21E-08	2.16E-08
^{244}Cm	1.19E-09	1.02E-09	1.18E-09	1.11E-09	1.12E-09	1.17E-09	1.16E-09	1.21E-09	1.16E-09	1.19E-09	1.10E-09	1.23E-09	1.16E-09	1.13E-09
^{90}Sr	1.28E-05	1.28E-05	1.27E-05	1.29E-05	1.27E-05	1.27E-05	1.28E-05	1.28E-05	1.29E-05	1.27E-05	1.25E-05	1.29E-05	1.28E-05	1.30E-05
^{95}Mo	1.74E-05	1.74E-05	1.73E-05	1.75E-05	1.73E-05	1.74E-05	1.75E-05	1.75E-05	1.75E-05	1.73E-05	1.74E-05	1.74E-05	1.75E-05	1.75E-05
^{99}Tc	1.74E-05	1.74E-05	1.68E-05	1.73E-05	1.68E-05	1.72E-05	1.73E-05	1.73E-05	1.73E-05	1.70E-05	1.71E-05	1.72E-05	1.72E-05	1.68E-05
^{101}Ru	1.49E-05	1.49E-05	1.48E-05	1.50E-05	1.48E-05	1.49E-05	1.50E-05	1.51E-05	1.50E-05	1.49E-05	1.49E-05	1.49E-05	1.50E-05	1.49E-05
^{103}Rh	9.51E-06	9.50E-06	9.44E-06	9.51E-06	9.30E-06	9.47E-06	9.54E-06	9.59E-06	9.58E-06	9.49E-06	9.51E-06	9.53E-06	9.53E-06	9.50E-06
^{109}Ag	6.06E-07	5.94E-07	5.99E-07	6.13E-07	3.07E-07	6.15E-07	6.27E-07	6.36E-07	6.25E-07	4.32E-07	6.64E-07	6.23E-07	6.23E-07	4.25E-07
^{129}I	1.84E-06	1.83E-06	1.84E-06	1.91E-06	1.77E-06	1.90E-06	1.91E-06	1.92E-06	1.92E-06	1.87E-06	2.20E-06	1.84E-06	1.91E-06	1.91E-06
^{131}Xe	7.81E-06	7.83E-06	7.76E-06	7.90E-06	7.68E-06	7.85E-06	7.89E-06	7.86E-06	7.92E-06	7.83E-06	7.80E-06	7.82E-06	7.89E-06	7.86E-06
^{133}Cs	1.88E-05	1.88E-05	1.82E-05	1.84E-05	1.82E-05	1.83E-05	1.84E-05	1.85E-05	1.85E-05	1.85E-05	1.83E-05	1.83E-05	1.84E-05	1.83E-05
^{134}Cs	1.08E-07	1.05E-07	1.05E-07	1.04E-07	1.04E-07	1.03E-07	1.04E-07	9.84E-08	1.05E-07	1.04E-07	1.03E-07	1.03E-07	1.04E-07	1.04E-07
^{137}Cs	1.55E-05	1.54E-05	1.53E-05	1.55E-05	1.53E-05	1.54E-05	1.55E-05	1.55E-05	1.56E-05	1.54E-05	1.52E-05	1.55E-05	1.55E-05	1.58E-05
^{144}Ce	1.02E-07	1.02E-07	1.02E-07	1.03E-07	1.01E-07	1.02E-07	1.03E-07	1.03E-07	1.03E-07	1.02E-07	1.02E-07	9.53E-08	1.03E-07	1.02E-07
^{143}Nd	1.46E-05	1.46E-05	1.45E-05	1.47E-05	1.45E-05	1.46E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.46E-05	1.47E-05	1.45E-05
^{145}Nd	1.04E-05	1.04E-05	1.04E-05	1.05E-05	1.03E-05	1.04E-05	1.04E-05	1.05E-05	1.05E-05	1.04E-05	1.05E-05	1.04E-05	1.04E-05	1.04E-05
^{148}Nd	4.77E-06	4.79E-06	4.77E-06	4.85E-06	4.76E-06	4.82E-06	4.85E-06	4.83E-06	4.87E-06	4.82E-06	4.86E-06	4.79E-06	4.85E-06	4.83E-06
^{147}Sm	4.16E-06	4.15E-06	4.13E-06	4.15E-06	4.07E-06	4.12E-06	4.14E-06	4.15E-06	4.16E-06	4.12E-06	4.12E-06	4.18E-06	4.14E-06	4.11E-06

Table 3.1(1). All results for Case 1b (No void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{149}Sm	9.16E-08	9.09E-08	9.42E-08	9.51E-08	9.55E-08	9.47E-08	9.65E-08	1.00E-07	9.70E-08	9.20E-08	8.93E-08	9.19E-08	9.63E-08	9.68E-08
^{150}Sm	3.19E-06	3.16E-06	3.24E-06	3.26E-06	3.19E-06	3.24E-06	3.27E-06	3.34E-06	3.28E-06	3.18E-06	3.19E-06	3.20E-06	3.26E-06	3.26E-06
^{151}Sm	2.81E-07	2.87E-07	2.81E-07	2.81E-07	2.93E-07	2.80E-07	2.85E-07	3.36E-07	2.86E-07	2.89E-07	2.97E-07	2.86E-07	2.85E-07	2.84E-07
^{152}Sm	1.64E-06	1.75E-06	1.63E-06	1.71E-06	1.65E-06	1.67E-06	1.66E-06	1.66E-06	1.69E-06	1.64E-06	1.64E-06	1.64E-06	1.68E-06	1.64E-06
^{153}Eu	8.50E-07	7.76E-07	8.44E-07	8.15E-07	8.46E-07	8.33E-07	8.58E-07	8.38E-07	8.46E-07	8.49E-07	8.29E-07	8.52E-07	8.41E-07	8.53E-07
^{154}Eu	5.52E-08	5.03E-08	5.55E-08	5.37E-08	5.48E-08	5.46E-08	5.62E-08	5.27E-08	5.59E-08	5.50E-08	4.87E-08	5.44E-08	5.53E-08	5.61E-08
^{155}Eu	2.51E-08	2.45E-08	2.49E-08	2.52E-08	2.50E-08	2.52E-08	2.57E-08	1.88E-08	2.56E-08	2.53E-08	2.56E-08	2.57E-08	2.54E-08	2.56E-08
^{155}Gd	7.80E-07	6.62E-07	8.07E-07	4.98E-07	7.27E-07	4.49E-07	6.66E-07	9.25E-07	7.90E-07	4.95E-07	5.11E-07	5.96E-07	1.01E-06	8.36E-07
^{156}Gd	9.59E-05	9.62E-05	9.59E-05	9.62E-05	9.60E-05	9.63E-05	9.61E-05	9.58E-05	9.59E-05	9.62E-05	9.63E-05	9.61E-05	9.57E-05	9.59E-05
^{157}Gd	2.24E-08	1.83E-08	2.24E-08	1.84E-08	2.21E-08	1.75E-08	1.99E-08	2.30E-08	2.14E-08	2.04E-08	1.93E-08	2.25E-08	2.29E-08	2.44E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.1(2). All results for Case 1b (No void, 12 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.89E-06	5.93E-06	5.94E-06	5.94E-06	5.94E-06	5.94E-06	5.97E-06	5.95E-06	5.94E-06	5.98E-06	5.94E-06	5.94E-06	5.93E-06	5.90E-06
^{235}U	6.14E-04	6.11E-04	6.13E-04	6.12E-04	6.15E-04	6.13E-04	6.11E-04	6.12E-04	6.13E-04	6.14E-04	6.14E-04	6.15E-04	6.12E-04	6.14E-04
^{236}U	4.87E-05	4.94E-05	4.90E-05	4.90E-05	4.79E-05	4.94E-05	4.77E-05	4.93E-05	4.88E-05	4.85E-05	4.93E-05	4.79E-05	4.91E-05	4.76E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	1.70E-06	1.81E-06	1.79E-06	1.76E-06	1.58E-06	1.67E-06	1.80E-06	1.77E-06	1.75E-06	1.72E-06	1.66E-06	1.58E-06	1.78E-06	1.66E-06
^{238}Pu	1.54E-07	1.59E-07	1.57E-07	1.55E-07	1.43E-07	1.53E-07	1.61E-07	1.53E-07	1.52E-07	1.62E-07	1.53E-07	1.43E-07	1.55E-07	1.51E-07
^{239}Pu	6.92E-05	7.06E-05	6.78E-05	6.77E-05	6.96E-05	6.84E-05	7.00E-05	6.85E-05	6.78E-05	6.78E-05	6.96E-05	6.96E-05	6.84E-05	6.80E-05
^{240}Pu	1.26E-05	1.30E-05	1.29E-05	1.29E-05	1.27E-05	1.25E-05	1.31E-05	1.27E-05	1.25E-05	1.25E-05	1.27E-05	1.27E-05	1.26E-05	1.29E-05
^{241}Pu	3.37E-06	3.45E-06	3.43E-06	3.41E-06	3.45E-06	3.48E-06	3.34E-06	3.41E-06	3.35E-06	3.39E-06	3.51E-06	3.45E-06	3.39E-06	3.46E-06
^{242}Pu	4.16E-07	4.55E-07	4.61E-07	4.61E-07	4.30E-07	4.35E-07	4.12E-07	4.51E-07	4.42E-07	4.52E-07	4.39E-07	4.30E-07	4.52E-07	4.48E-07
^{241}Am	9.89E-07	1.02E-06	1.01E-06	1.00E-06	1.01E-06	1.02E-06	9.77E-07	1.01E-06	9.80E-07	9.91E-07	1.03E-06	1.01E-06	9.99E-07	1.01E-06
^{243}Am	2.03E-08	2.23E-08	2.23E-08	2.00E-08	1.80E-08	2.07E-08	1.65E-08	2.01E-08	2.12E-08	1.99E-08	2.10E-08	1.81E-08	2.18E-08	1.94E-08
^{244}Cm	1.07E-09	1.18E-09	1.16E-09	1.03E-09	9.54E-10	1.11E-09	7.97E-10	1.02E-09	1.07E-09	1.02E-09	1.12E-09	9.54E-10	1.14E-09	1.01E-09
^{90}Sr	1.26E-05	1.28E-05	1.30E-05	1.27E-05	1.28E-05	1.27E-05	1.28E-05	-	1.26E-05	1.26E-05	1.26E-05	1.28E-05	1.28E-05	1.29E-05
^{95}Mo	1.73E-05	1.75E-05	1.74E-05	1.75E-05	1.75E-05	1.73E-05	1.75E-05	1.71E-05	1.71E-05	1.71E-05	1.73E-05	1.75E-05	1.74E-05	1.75E-05
^{99}Tc	1.67E-05	1.73E-05	1.68E-05	1.68E-05	1.69E-05	1.67E-05	1.73E-05	1.65E-05	1.63E-05	1.64E-05	1.67E-05	1.69E-05	1.67E-05	1.70E-05
^{101}Ru	1.48E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.48E-05	1.49E-05	1.48E-05	1.46E-05	1.46E-05	1.48E-05	1.49E-05	1.49E-05	1.49E-05
^{103}Rh	9.38E-06	9.55E-06	9.51E-06	9.50E-06	9.30E-06	9.46E-06	9.48E-06	9.38E-06	9.53E-06	9.55E-06	9.48E-06	9.30E-06	9.43E-06	9.28E-06
^{109}Ag	6.27E-07	6.27E-07	4.28E-07	6.45E-07	5.80E-07	6.04E-07	5.91E-07	5.89E-07	6.73E-07	6.77E-07	6.10E-07	5.80E-07	4.47E-07	6.23E-07
^{129}I	1.90E-06	1.91E-06	1.91E-06	2.24E-06	1.97E-06	1.55E-06	1.86E-06	1.86E-06	2.37E-06	2.37E-06	1.56E-06	1.98E-06	1.91E-06	2.42E-06
^{131}Xe	7.75E-06	7.89E-06	7.86E-06	7.83E-06	7.80E-06	7.67E-06	7.84E-06	7.76E-06	7.80E-06	7.77E-06	7.67E-06	7.80E-06	7.83E-06	7.88E-06
^{133}Cs	1.83E-05	1.84E-05	1.82E-05	1.80E-05	1.80E-05	1.83E-05	1.86E-05	1.82E-05	1.83E-05	1.83E-05	1.83E-05	1.80E-05	1.83E-05	1.80E-05
^{134}Cs	8.96E-08	1.05E-07	1.03E-07	1.02E-07	1.07E-07	9.88E-08	1.17E-07	9.59E-08	1.02E-07	1.05E-07	9.85E-08	1.07E-07	1.03E-07	1.04E-07
^{137}Cs	1.53E-05	1.55E-05	1.58E-05	1.55E-05	1.54E-05	1.54E-05	1.55E-05	1.54E-05	1.51E-05	1.51E-05	1.54E-05	1.54E-05	1.54E-05	1.55E-05
^{144}Ce	1.01E-07	1.03E-07	1.02E-07	1.02E-07	1.00E-07	1.01E-07	1.03E-07	1.02E-07	9.93E-08	9.92E-08	1.02E-07	1.01E-07	1.02E-07	1.01E-07
^{143}Nd	1.46E-05	1.47E-05	1.45E-05	1.46E-05	1.45E-05	1.45E-05	1.47E-05	1.44E-05	1.45E-05	1.45E-05	1.46E-05	1.46E-05	1.45E-05	1.46E-05

Table 3.1(2). All results for Case 1b (No void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.04E-05	1.04E-05	1.04E-05	1.05E-05	1.04E-05	1.04E-05	1.05E-05	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05
^{148}Nd	4.79E-06	4.85E-06	4.82E-06	4.87E-06	4.86E-06	4.81E-06	4.83E-06	4.81E-06	4.85E-06	4.82E-06	4.81E-06	4.86E-06	4.82E-06	4.85E-06
^{147}Sm	4.12E-06	4.14E-06	4.11E-06	4.11E-06	4.11E-06	4.07E-06	4.05E-06	3.95E-06	4.15E-06	4.17E-06	4.08E-06	4.11E-06	4.11E-06	4.16E-06
^{149}Sm	9.88E-08	9.74E-08	9.56E-08	9.20E-08	9.79E-08	9.98E-08	9.84E-08	9.51E-08	9.34E-08	9.29E-08	1.00E-07	9.79E-08	9.57E-08	9.48E-08
^{150}Sm	3.24E-06	3.28E-06	3.26E-06	3.26E-06	3.21E-06	3.26E-06	3.29E-06	3.23E-06	3.20E-06	3.20E-06	3.26E-06	3.21E-06	3.25E-06	3.24E-06
^{151}Sm	2.95E-07	2.87E-07	2.89E-07	2.92E-07	3.03E-07	3.01E-07	2.85E-07	2.84E-07	2.90E-07	2.89E-07	3.03E-07	3.03E-07	2.82E-07	2.90E-07
^{152}Sm	1.67E-06	1.65E-06	1.64E-06	1.65E-06	1.69E-06	1.70E-06	1.73E-06	1.63E-06	1.68E-06	1.68E-06	1.70E-06	1.69E-06	1.64E-06	1.64E-06
^{153}Eu	8.28E-07	8.62E-07	8.52E-07	8.30E-07	8.11E-07	8.23E-07	8.19E-07	8.18E-07	8.70E-07	8.71E-07	8.23E-07	8.11E-07	8.50E-07	8.43E-07
^{154}Eu	5.45E-08	5.68E-08	5.54E-08	4.93E-08	4.99E-08	5.39E-08	4.99E-08	5.31E-08	5.66E-08	5.69E-08	5.39E-08	4.99E-08	5.58E-08	6.62E-08
^{155}Eu	1.87E-08	2.58E-08	2.56E-08	2.58E-08	2.05E-08	1.94E-08	2.67E-08	2.46E-08	2.76E-08	2.75E-08	1.87E-08	2.05E-08	2.54E-08	2.41E-08
^{155}Gd	1.11E-06	7.43E-07	7.55E-07	7.47E-07	6.75E-07	6.13E-07	4.30E-07	4.97E-07	6.17E-07	7.99E-07	6.36E-07	6.75E-07	7.09E-07	7.86E-07
^{156}Gd	9.53E-05	9.60E-05	9.59E-05	9.61E-05	9.62E-05	9.62E-05	9.63E-05	9.64E-05	9.60E-05	9.59E-05	9.62E-05	9.62E-05	9.60E-05	9.60E-05
^{157}Gd	2.50E-08	1.99E-08	2.21E-08	2.02E-08	1.95E-08	2.02E-08	1.94E-08	1.81E-08	2.02E-08	2.20E-08	2.04E-08	1.95E-08	2.04E-08	1.98E-08
^{158}Gd	1.06E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.1(3). All results for Case 1b (No void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ$^{(r)}$
^{234}U	5.94E-06	5.94E-06	5.91E-06	5.94E-06	5.76E-06	5.99E-06	5.95E-06	5.94E-06	8.26E-08	1.39E-02
^{235}U	6.10E-04	6.11E-04	6.07E-04	6.11E-04	6.11E-04	6.13E-04	6.14E-04	6.12E-04	3.91E-06	6.38E-03
^{236}U	4.95E-05	4.94E-05	4.99E-05	4.92E-05	4.92E-05	4.86E-05	4.73E-05	4.89E-05	1.22E-06	2.49E-02
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	8.13E-06	3.81E-04
^{237}Np	1.80E-06	1.79E-06	1.84E-06	1.74E-06	1.79E-06	1.70E-06	1.55E-06	1.74E-06	1.38E-07	7.98E-02
^{238}Pu	1.58E-07	1.58E-07	1.74E-07	1.45E-07	1.57E-07	1.62E-07	1.36E-07	1.56E-07	1.44E-08	9.27E-02
^{239}Pu	7.06E-05	7.04E-05	7.00E-05	6.91E-05	6.84E-05	6.74E-05	6.79E-05	6.87E-05	2.98E-06	4.34E-02
^{240}Pu	1.31E-05	1.31E-05	1.30E-05	1.28E-05	1.26E-05	1.25E-05	1.27E-05	1.28E-05	5.21E-07	4.07E-02
^{241}Pu	3.48E-06	3.47E-06	3.56E-06	3.38E-06	3.35E-06	3.33E-06	3.37E-06	3.42E-06	1.27E-07	3.71E-02
^{242}Pu	4.63E-07	4.64E-07	4.85E-07	4.46E-07	4.47E-07	4.44E-07	4.31E-07	4.51E-07	3.39E-08	7.51E-02
^{241}Am	1.03E-06	1.02E-06	1.04E-06	9.97E-07	9.83E-07	9.82E-07	9.91E-07	1.00E-06	3.77E-08	3.75E-02
^{243}Am	2.22E-08	2.27E-08	2.19E-08	2.12E-08	2.05E-08	1.88E-08	1.84E-08	2.07E-08	3.30E-09	1.60E-01
^{244}Cm	1.17E-09	1.20E-09	1.18E-09	1.11E-09	1.08E-09	1.10E-09	1.01E-09	1.10E-09	1.80E-10	1.63E-01
^{90}Sr	1.28E-05	1.28E-05	1.28E-05	1.28E-05	1.28E-05	1.27E-05	1.30E-05	1.28E-05	2.07E-07	1.62E-02
^{95}Mo	1.75E-05	1.75E-05	1.77E-05	1.74E-05	1.74E-05	1.73E-05	1.73E-05	1.74E-05	2.50E-07	1.44E-02
^{99}Tc	1.73E-05	1.73E-05	1.71E-05	1.69E-05	1.68E-05	1.68E-05	1.68E-05	1.70E-05	5.88E-07	3.46E-02
^{101}Ru	1.50E-05	1.50E-05	1.52E-05	1.49E-05	1.49E-05	1.48E-05	1.46E-05	1.49E-05	2.60E-07	1.75E-02
^{103}Rh	9.58E-06	9.58E-06	9.77E-06	9.03E-06	9.35E-06	9.44E-06	9.37E-06	9.46E-06	2.51E-07	2.65E-02
^{109}Ag	6.32E-07	6.31E-07	6.73E-07	3.76E-07	5.91E-07	5.95E-07	7.26E-07	5.86E-07	1.84E-07	3.15E-01
^{129}I	1.92E-06	1.92E-06	2.25E-06	1.74E-06	1.85E-06	1.82E-06	2.26E-06	1.95E-06	4.09E-07	2.10E-01
^{131}Xe	7.91E-06	7.91E-06	7.91E-06	7.77E-06	7.82E-06	7.77E-06	7.78E-06	7.82E-06	1.35E-07	1.72E-02
^{133}Cs	1.85E-05	1.85E-05	1.84E-05	1.84E-05	1.82E-05	1.82E-05	1.83E-05	1.83E-05	3.79E-07	2.07E-02
^{134}Cs	1.05E-07	1.04E-07	1.08E-07	1.02E-07	1.03E-07	1.03E-07	9.70E-08	1.03E-07	8.69E-09	8.42E-02
^{137}Cs	1.55E-05	1.56E-05	1.58E-05	1.55E-05	1.55E-05	1.53E-05	1.56E-05	1.54E-05	3.11E-07	2.01E-02
^{144}Ce	1.03E-07	1.03E-07	1.04E-07	1.02E-07	1.02E-07	1.02E-07	1.01E-07	1.02E-07	3.01E-09	2.96E-02
^{143}Nd	1.47E-05	1.47E-05	1.48E-05	1.47E-05	1.46E-05	1.46E-05	1.46E-05	1.46E-05	1.83E-07	1.25E-02

Table 3.1(3). All results for Case 1b (No void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.05E-05	1.05E-05	1.07E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.30E-07	1.25E-02
^{148}Nd	4.86E-06	4.87E-06	4.96E-06	4.84E-06	4.84E-06	4.77E-06	4.80E-06	4.83E-06	7.63E-08	1.58E-02
^{147}Sm	4.15E-06	4.15E-06	4.18E-06	4.08E-06	3.85E-06	4.14E-06	4.14E-06	4.11E-06	1.27E-07	3.08E-02
^{149}Sm	9.65E-08	9.64E-08	8.79E-08	9.67E-08	9.45E-08	9.37E-08	9.47E-08	9.52E-08	5.84E-09	6.13E-02
^{150}Sm	3.27E-06	3.28E-06	3.20E-06	3.26E-06	3.23E-06	3.24E-06	3.22E-06	3.24E-06	7.34E-08	2.26E-02
^{151}Sm	2.85E-07	2.85E-07	2.87E-07	2.84E-07	2.80E-07	2.80E-07	2.89E-07	2.89E-07	2.09E-08	7.22E-02
^{152}Sm	1.72E-06	1.69E-06	1.67E-06	1.65E-06	1.64E-06	1.64E-06	1.67E-06	1.67E-06	5.96E-08	3.57E-02
^{153}Eu	8.19E-07	8.45E-07	8.55E-07	8.49E-07	8.36E-07	8.40E-07	8.34E-07	8.38E-07	3.81E-08	4.55E-02
^{154}Eu	5.41E-08	5.55E-08	5.64E-08	5.56E-08	5.51E-08	5.41E-08	5.07E-08	5.43E-08	6.26E-09	1.15E-01
^{155}Eu	2.55E-08	2.56E-08	2.53E-08	2.54E-08	2.49E-08	2.49E-08	2.54E-08	2.44E-08	4.86E-09	1.99E-01
^{155}Gd	5.92E-07	6.11E-07	1.12E-06	5.24E-07	6.51E-07	6.62E-07	7.17E-07	6.98E-07	3.34E-07	4.78E-01
^{156}Gd	9.61E-05	9.55E-05	9.57E-05	9.59E-05	9.60E-05	9.61E-05	9.58E-05	9.60E-05	4.64E-07	4.84E-03
^{157}Gd	1.99E-08	2.03E-08	2.37E-08	1.99E-08	2.04E-08	2.04E-08	2.34E-08	2.08E-08	3.62E-09	1.74E-01
^{158}Gd	1.12E-04	1.11E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	2.09E-06	1.87E-02

Table 3.2(1). All results for Case 2a (40% void, 12 GWd/tHM, No cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.88E-06	5.94E-06	5.88E-06	5.84E-06	5.89E-06	5.81E-06	5.84E-06	5.79E-06	5.84E-06	5.84E-06	5.84E-06	5.87E-06	5.84E-06	5.83E-06
^{235}U	6.19E-04	6.16E-04	6.19E-04	6.16E-04	6.20E-04	6.14E-04	6.18E-04	6.18E-04	6.17E-04	6.19E-04	6.19E-04	6.19E-04	6.17E-04	6.18E-04
^{236}U	4.96E-05	5.06E-05	4.95E-05	5.03E-05	4.94E-05	4.98E-05	5.02E-05	5.01E-05	5.02E-05	4.99E-05	4.99E-05	4.96E-05	5.01E-05	4.99E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	1.97E-06	1.94E-06	1.97E-06	2.03E-06	1.92E-06	2.00E-06	2.06E-06	2.04E-06	2.05E-06	2.03E-06	2.02E-06	2.01E-06	2.03E-06	2.06E-06
^{238}Pu	2.10E-07	2.02E-07	2.14E-07	2.00E-07	2.02E-07	1.98E-07	2.03E-07	2.09E-07	2.02E-07	2.02E-07	2.01E-07	2.15E-07	2.00E-07	2.02E-07
^{239}Pu	7.74E-05	7.54E-05	7.73E-05	7.70E-05	7.78E-05	7.80E-05	8.02E-05	8.23E-05	7.97E-05	7.63E-05	7.54E-05	7.68E-05	7.93E-05	7.86E-05
^{240}Pu	1.37E-05	1.34E-05	1.37E-05	1.37E-05	1.37E-05	1.39E-05	1.41E-05	1.45E-05	1.39E-05	1.42E-05	1.45E-05	1.40E-05	1.39E-05	1.37E-05
^{241}Pu	5.41E-06	5.17E-06	5.38E-06	5.29E-06	5.33E-06	5.36E-06	5.46E-06	5.40E-06	5.39E-06	5.47E-06	5.52E-06	5.53E-06	5.41E-06	5.38E-06
^{242}Pu	5.50E-07	5.25E-07	5.44E-07	5.33E-07	5.32E-07	5.47E-07	5.43E-07	5.44E-07	5.33E-07	5.61E-07	5.82E-07	5.68E-07	5.38E-07	5.33E-07
^{241}Am	9.18E-08	8.76E-08	9.14E-08	9.18E-08	9.01E-08	9.33E-08	9.48E-08	9.33E-08	9.34E-08	9.56E-08	9.33E-08	9.32E-08	9.37E-08	9.32E-08
^{243}Am	2.93E-08	2.61E-08	2.90E-08	3.09E-08	2.78E-08	3.28E-08	3.24E-08	3.31E-08	3.20E-08	3.32E-08	3.09E-08	3.05E-08	3.20E-08	3.17E-08
^{244}Cm	2.54E-09	2.19E-09	2.51E-09	2.37E-09	2.37E-09	2.52E-09	2.46E-09	2.44E-09	2.43E-09	2.54E-09	2.34E-09	2.64E-09	2.44E-09	2.41E-09
^{90}Sr	1.41E-05	1.42E-05	1.41E-05	1.42E-05	1.40E-05	1.41E-05	1.42E-05	1.42E-05	1.42E-05	1.41E-05	1.39E-05	1.43E-05	1.42E-05	1.44E-05
^{95}Mo	1.21E-05	1.22E-05	1.21E-05	1.22E-05	1.21E-05	1.21E-05	1.22E-05	1.22E-05	1.22E-05	1.21E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05
^{99}Tc	1.71E-05	1.71E-05	1.66E-05	1.71E-05	1.66E-05	1.69E-05	1.70E-05	1.71E-05	1.70E-05	1.68E-05	1.69E-05	1.70E-05	1.70E-05	1.66E-05
^{101}Ru	1.49E-05	1.49E-05	1.49E-05	1.50E-05	1.48E-05	1.49E-05	1.50E-05	1.50E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05
^{103}Rh	8.27E-06	8.28E-06	8.21E-06	8.25E-06	8.09E-06	8.22E-06	8.28E-06	8.31E-06	8.30E-06	8.27E-06	8.28E-06	8.29E-06	8.27E-06	8.28E-06
^{109}Ag	6.67E-07	6.54E-07	6.61E-07	6.73E-07	3.37E-07	6.79E-07	6.88E-07	6.90E-07	6.82E-07	4.74E-07	7.29E-07	6.84E-07	6.81E-07	4.66E-07
^{129}I	1.86E-06	1.85E-06	1.88E-06	1.95E-06	1.80E-06	1.94E-06	1.96E-06	1.97E-06	1.96E-06	1.92E-06	2.13E-06	1.86E-06	1.95E-06	1.96E-06
^{131}Xe	7.53E-06	7.55E-06	7.49E-06	7.61E-06	7.40E-06	7.56E-06	7.60E-06	7.55E-06	7.63E-06	7.56E-06	7.52E-06	7.54E-06	7.60E-06	7.60E-06
^{133}Cs	1.83E-05	1.84E-05	1.78E-05	1.79E-05	1.77E-05	1.78E-05	1.79E-05	1.80E-05	1.80E-05	1.81E-05	1.79E-05	1.79E-05	1.79E-05	1.79E-05
^{134}Cs	6.61E-07	6.42E-07	6.43E-07	6.39E-07	6.35E-07	6.31E-07	6.39E-07	5.96E-07	6.40E-07	6.40E-07	6.33E-07	6.45E-07	6.39E-07	6.36E-07
^{137}Cs	1.73E-05	1.73E-05	1.72E-05	1.74E-05	1.72E-05	1.73E-05	1.74E-05	1.74E-05	1.74E-05	1.73E-05	1.70E-05	1.74E-05	1.74E-05	1.77E-05
^{144}Ce	8.61E-06	8.62E-06	8.56E-06	8.65E-06	8.54E-06	8.59E-06	8.63E-06	8.65E-06	8.66E-06	8.59E-06	8.57E-06	8.60E-06	8.64E-06	8.59E-06
^{143}Nd	1.39E-05	1.39E-05	1.39E-05	1.39E-05	1.38E-05	1.38E-05	1.39E-05	1.40E-05	1.40E-05	1.40E-05	1.40E-05	1.39E-05	1.39E-05	1.38E-05

Table 3.2(1). All results for Case 2a (40% void, 12 GWd/tHM, No cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.04E-05	1.03E-05	1.04E-05	1.03E-05	1.03E-05	1.03E-05
^{148}Nd	4.78E-06	4.80E-06	4.78E-06	4.85E-06	4.77E-06	4.82E-06	4.85E-06	4.83E-06	4.86E-06	4.83E-06	4.88E-06	4.80E-06	4.85E-06	4.84E-06
^{147}Sm	7.55E-07	7.55E-07	7.50E-07	7.50E-07	7.49E-07	7.45E-07	7.49E-07	7.52E-07	7.53E-07	7.49E-07	7.48E-07	7.53E-07	7.50E-07	7.47E-07
^{149}Sm	7.61E-08	7.52E-08	7.89E-08	7.86E-08	7.96E-08	7.88E-08	8.07E-08	8.40E-08	8.08E-08	7.67E-08	7.38E-08	7.65E-08	8.01E-08	8.14E-08
^{150}Sm	3.23E-06	3.18E-06	3.28E-06	3.29E-06	3.21E-06	3.27E-06	3.31E-06	3.38E-06	3.31E-06	3.22E-06	3.25E-06	3.24E-06	3.29E-06	3.30E-06
^{151}Sm	3.20E-07	3.29E-07	3.20E-07	3.20E-07	3.38E-07	3.20E-07	3.25E-07	3.81E-07	3.26E-07	3.29E-07	3.39E-07	3.26E-07	3.24E-07	3.24E-07
^{152}Sm	1.59E-06	1.73E-06	1.59E-06	1.67E-06	1.61E-06	1.63E-06	1.60E-06	1.61E-06	1.64E-06	1.60E-06	1.60E-06	1.60E-06	1.63E-06	1.60E-06
^{153}Eu	8.94E-07	8.06E-07	8.98E-07	8.52E-07	8.92E-07	8.73E-07	9.00E-07	8.72E-07	8.83E-07	8.94E-07	8.76E-07	8.96E-07	8.78E-07	8.98E-07
^{154}Eu	9.80E-08	8.81E-08	9.86E-08	9.47E-08	9.73E-08	9.67E-08	9.95E-08	9.35E-08	9.82E-08	9.80E-08	8.77E-08	9.73E-08	9.74E-08	9.96E-08
^{155}Eu	5.37E-08	5.21E-08	5.33E-08	5.39E-08	5.35E-08	5.40E-08	5.48E-08	3.96E-08	5.45E-08	5.43E-08	5.51E-08	5.39E-08	5.41E-08	5.47E-08
^{155}Gd	1.25E-06	1.18E-06	1.29E-06	8.83E-07	1.23E-06	8.50E-07	1.13E-06	1.50E-06	1.29E-06	8.57E-07	8.77E-07	1.04E-06	1.49E-06	1.27E-06
^{156}Gd	9.52E-05	9.55E-05	9.52E-05	9.57E-05	9.53E-05	9.57E-05	9.54E-05	9.51E-05	9.52E-05	9.56E-05	9.57E-05	9.54E-05	9.50E-05	9.52E-05
^{157}Gd	3.49E-08	2.84E-08	3.53E-08	2.66E-08	3.45E-08	2.58E-08	2.97E-08	3.86E-08	3.42E-08	3.07E-08	2.89E-08	3.43E-08	3.86E-08	3.91E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.2(2). All results for Case 2a (40% void, 12 GWd/tHM, No cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.80E-06	5.84E-06	5.84E-06	5.83E-06	5.85E-06	5.84E-06	5.86E-06	5.87E-06	5.85E-06	5.88E-06	5.84E-06	5.85E-06	5.84E-06	5.80E-06
^{235}U	6.20E-04	6.18E-04	6.19E-04	6.19E-04	6.22E-04	6.20E-04	6.18E-04	6.19E-04	6.20E-04	6.21E-04	6.21E-04	6.22E-04	6.18E-04	6.20E-04
^{236}U	4.96E-05	5.01E-05	4.99E-05	4.99E-05	4.86E-05	5.04E-05	4.86E-05	5.02E-05	4.97E-05	4.92E-05	5.03E-05	4.86E-05	4.99E-05	4.82E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	1.95E-06	2.02E-06	2.05E-06	2.03E-06	1.83E-06	1.92E-06	2.13E-06	2.04E-06	2.02E-06	1.98E-06	1.92E-06	1.83E-06	2.04E-06	1.92E-06
^{238}Pu	1.96E-07	1.99E-07	2.02E-07	1.99E-07	1.82E-07	1.95E-07	2.13E-07	1.97E-07	1.96E-07	2.07E-07	1.95E-07	1.82E-07	2.00E-07	1.94E-07
^{239}Pu	7.84E-05	7.96E-05	7.75E-05	7.74E-05	7.92E-05	7.77E-05	8.10E-05	7.76E-05	7.74E-05	7.73E-05	7.92E-05	7.92E-05	7.80E-05	7.77E-05
^{240}Pu	1.35E-05	1.41E-05	1.40E-05	1.40E-05	1.37E-05	1.35E-05	1.44E-05	1.37E-05	1.36E-05	1.36E-05	1.37E-05	1.37E-05	1.37E-05	1.40E-05
^{241}Pu	5.28E-06	5.40E-06	5.43E-06	5.40E-06	5.43E-06	5.45E-06	5.45E-06	5.39E-06	5.30E-06	5.37E-06	5.52E-06	5.43E-06	5.37E-06	5.46E-06
^{242}Pu	4.91E-07	5.40E-07	5.49E-07	5.51E-07	5.09E-07	5.15E-07	5.02E-07	5.38E-07	5.29E-07	5.42E-07	5.19E-07	5.09E-07	5.41E-07	5.33E-07
^{241}Am	9.06E-08	9.41E-08	9.44E-08	9.10E-08	9.25E-08	9.31E-08	9.09E-08	9.24E-08	9.16E-08	9.06E-08	9.44E-08	9.25E-08	9.34E-08	9.35E-08
^{243}Am	2.92E-08	3.21E-08	3.25E-08	2.92E-08	2.61E-08	3.01E-08	2.45E-08	2.93E-08	3.11E-08	2.91E-08	3.03E-08	2.61E-08	3.20E-08	2.81E-08
^{244}Cm	2.22E-09	2.43E-09	2.47E-09	2.20E-09	2.00E-09	2.33E-09	1.71E-09	2.17E-09	2.35E-09	2.23E-09	2.34E-09	2.00E-09	2.44E-09	2.13E-09
^{90}Sr	1.41E-05	1.42E-05	1.44E-05	1.41E-05	1.42E-05	1.41E-05	1.42E-05	-	1.39E-05	1.39E-05	1.40E-05	1.42E-05	1.41E-05	1.42E-05
^{95}Mo	1.21E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.21E-05	1.21E-05	1.18E-05	1.19E-05	1.20E-05	1.21E-05	1.22E-05	1.21E-05	1.22E-05
^{99}Tc	1.65E-05	1.71E-05	1.66E-05	1.66E-05	1.67E-05	1.65E-05	1.70E-05	1.63E-05	1.61E-05	1.61E-05	1.65E-05	1.67E-05	1.65E-05	1.68E-05
^{101}Ru	1.48E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.49E-05	1.49E-05	1.48E-05	1.46E-05	1.46E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05
^{103}Rh	8.15E-06	8.28E-06	8.28E-06	8.26E-06	8.07E-06	8.23E-06	8.23E-06	8.12E-06	8.27E-06	8.28E-06	8.25E-06	8.07E-06	8.20E-06	8.05E-06
^{109}Ag	6.89E-07	6.84E-07	4.70E-07	7.09E-07	6.34E-07	6.61E-07	6.53E-07	6.44E-07	7.41E-07	7.46E-07	6.69E-07	6.34E-07	4.92E-07	6.87E-07
^{129}I	1.91E-06	1.90E-06	1.96E-06	2.19E-06	1.99E-06	1.59E-06	1.87E-06	1.90E-06	2.39E-06	2.39E-06	1.59E-06	1.99E-06	1.97E-06	2.41E-06
^{131}Xe	7.47E-06	7.59E-06	7.60E-06	7.57E-06	7.52E-06	7.38E-06	7.53E-06	7.47E-06	7.53E-06	7.50E-06	7.38E-06	7.52E-06	7.56E-06	7.60E-06
^{133}Cs	1.79E-05	1.80E-05	1.79E-05	1.76E-05	1.76E-05	1.79E-05	1.80E-05	1.77E-05	1.78E-05	1.78E-05	1.79E-05	1.76E-05	1.78E-05	1.76E-05
^{134}Cs	5.41E-07	6.31E-07	6.33E-07	6.24E-07	6.59E-07	6.08E-07	7.20E-07	5.83E-07	6.23E-07	6.43E-07	6.06E-07	6.59E-07	6.33E-07	6.38E-07
^{137}Cs	1.72E-05	1.72E-05	1.77E-05	1.74E-05	1.73E-05	1.72E-05	1.74E-05	1.72E-05	1.69E-05	1.69E-05	1.72E-05	1.73E-05	1.73E-05	1.74E-05
^{144}Ce	8.54E-06	8.64E-06	8.58E-06	8.53E-06	8.50E-06	8.57E-06	8.65E-06	8.55E-06	8.43E-06	8.42E-06	8.56E-06	8.50E-06	8.59E-06	8.52E-06
^{143}Nd	1.38E-05	1.39E-05	1.38E-05	1.38E-05	1.39E-05	1.38E-05	1.39E-05	1.37E-05	1.37E-05	1.37E-05	1.38E-05	1.39E-05	1.38E-05	1.39E-05

Table 3.2(2). All results for Case 2a (40% void, 12 GWd/tHM, No cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.03E-05	1.03E-05	1.03E-05	1.02E-05	1.02E-05	1.02E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05
^{148}Nd	4.79E-06	4.85E-06	4.83E-06	4.88E-06	4.87E-06	4.82E-06	4.83E-06	4.81E-06	4.85E-06	4.82E-06	4.82E-06	4.87E-06	4.82E-06	4.87E-06
^{147}Sm	7.49E-07	7.51E-07	7.47E-07	7.45E-07	7.49E-07	7.42E-07	7.33E-07	7.34E-07	7.53E-07	7.55E-07	7.42E-07	7.49E-07	7.46E-07	7.56E-07
^{149}Sm	8.40E-08	7.97E-08	8.06E-08	7.66E-08	8.25E-08	8.41E-08	8.37E-08	7.97E-08	7.76E-08	7.70E-08	8.46E-08	8.25E-08	7.96E-08	7.89E-08
^{150}Sm	3.28E-06	3.30E-06	3.30E-06	3.31E-06	3.26E-06	3.31E-06	3.32E-06	3.26E-06	3.24E-06	3.24E-06	3.31E-06	3.26E-06	3.29E-06	3.29E-06
^{151}Sm	3.38E-07	3.23E-07	3.29E-07	3.33E-07	3.49E-07	3.47E-07	3.31E-07	3.22E-07	3.31E-07	3.29E-07	3.49E-07	3.49E-07	3.21E-07	3.31E-07
^{152}Sm	1.63E-06	1.61E-06	1.60E-06	1.61E-06	1.66E-06	1.67E-06	1.70E-06	1.58E-06	1.63E-06	1.63E-06	1.67E-06	1.66E-06	1.60E-06	1.60E-06
^{153}Eu	8.67E-07	8.96E-07	8.97E-07	8.76E-07	8.46E-07	8.57E-07	8.47E-07	8.56E-07	9.15E-07	9.16E-07	8.58E-07	8.46E-07	8.93E-07	8.88E-07
^{154}Eu	9.66E-08	9.87E-08	9.84E-08	8.83E-08	8.88E-08	9.55E-08	8.77E-08	9.39E-08	9.99E-08	1.00E-07	9.55E-08	8.88E-08	9.89E-08	1.16E-07
^{155}Eu	3.99E-08	5.48E-08	5.48E-08	5.54E-08	4.18E-08	3.96E-08	5.80E-08	5.24E-08	5.69E-08	5.69E-08	3.98E-08	4.18E-08	5.43E-08	5.62E-08
^{155}Gd	1.71E-06	9.35E-07	1.19E-06	1.17E-06	1.18E-06	1.08E-06	8.85E-07	8.57E-07	1.02E-06	1.26E-06	1.12E-06	1.18E-06	1.10E-06	1.21E-06
^{156}Gd	9.45E-05	9.56E-05	9.52E-05	9.54E-05	9.55E-05	9.55E-05	9.56E-05	9.58E-05	9.54E-05	9.52E-05	9.55E-05	9.55E-05	9.53E-05	9.54E-05
^{157}Gd	4.47E-08	2.75E-08	3.48E-08	3.18E-08	3.06E-08	3.10E-08	3.17E-08	2.67E-08	3.12E-08	3.47E-08	3.16E-08	3.06E-08	3.20E-08	3.15E-08
^{158}Gd	1.06E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.2(3). All results for Case 2a (40% void, 12 GWd/tHM, No cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ(r)
^{234}U	5.84E-06	5.85E-06	5.80E-06	5.85E-06	5.65E-06	5.89E-06	5.85E-06	5.84E-06	8.95E-08	1.53E-02
^{235}U	6.17E-04	6.18E-04	6.14E-04	6.18E-04	6.17E-04	6.19E-04	6.21E-04	6.19E-04	3.72E-06	6.01E-03
^{236}U	5.03E-05	5.02E-05	5.07E-05	5.00E-05	5.00E-05	4.94E-05	4.79E-05	4.97E-05	1.33E-06	2.67E-02
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	1.06E-05	4.98E-04
^{237}Np	2.07E-06	2.05E-06	2.11E-06	1.98E-06	2.05E-06	1.96E-06	1.78E-06	1.99E-06	1.56E-07	7.81E-02
^{238}Pu	2.03E-07	2.02E-07	2.21E-07	1.93E-07	2.02E-07	2.11E-07	1.77E-07	2.01E-07	1.79E-08	8.91E-02
^{239}Pu	8.06E-05	8.03E-05	7.97E-05	7.88E-05	7.80E-05	7.69E-05	7.74E-05	7.83E-05	3.07E-06	3.93E-02
^{240}Pu	1.42E-05	1.42E-05	1.41E-05	1.39E-05	1.37E-05	1.36E-05	1.38E-05	1.39E-05	5.57E-07	4.02E-02
^{241}Pu	5.50E-06	5.47E-06	5.61E-06	5.30E-06	5.30E-06	5.30E-06	5.34E-06	5.40E-06	1.74E-07	3.22E-02
^{242}Pu	5.50E-07	5.50E-07	5.78E-07	5.25E-07	5.36E-07	5.35E-07	5.13E-07	5.37E-07	3.91E-08	7.29E-02
^{241}Am	9.57E-08	9.51E-08	9.48E-08	9.18E-08	9.03E-08	9.02E-08	9.26E-08	9.26E-08	3.58E-09	3.86E-02
^{243}Am	3.22E-08	3.29E-08	3.18E-08	3.06E-08	3.01E-08	2.79E-08	2.68E-08	3.01E-08	4.61E-09	1.53E-01
^{244}Cm	2.47E-09	2.52E-09	2.48E-09	2.33E-09	2.30E-09	2.38E-09	2.09E-09	2.34E-09	3.79E-10	1.62E-01
^{90}Sr	1.42E-05	1.42E-05	1.42E-05	1.41E-05	1.42E-05	1.41E-05	1.44E-05	1.42E-05	2.22E-07	1.57E-02
^{95}Mo	1.22E-05	1.22E-05	1.24E-05	1.21E-05	1.22E-05	1.21E-05	1.21E-05	1.21E-05	1.84E-07	1.52E-02
^{99}Tc	1.70E-05	1.70E-05	1.69E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.67E-05	5.61E-07	3.35E-02
^{101}Ru	1.50E-05	1.50E-05	1.53E-05	1.49E-05	1.49E-05	1.49E-05	1.46E-05	1.49E-05	2.50E-07	1.68E-02
^{103}Rh	8.31E-06	8.31E-06	8.48E-06	7.85E-06	8.11E-06	8.22E-06	8.14E-06	8.22E-06	2.17E-07	2.63E-02
^{109}Ag	6.94E-07	6.91E-07	7.39E-07	4.11E-07	6.49E-07	6.57E-07	8.00E-07	6.43E-07	2.03E-07	3.15E-01
^{129}I	1.97E-06	1.96E-06	2.20E-06	1.76E-06	1.86E-06	1.85E-06	2.30E-06	1.97E-06	3.80E-07	1.93E-01
^{131}Xe	7.62E-06	7.62E-06	7.62E-06	7.48E-06	7.54E-06	7.50E-06	7.51E-06	7.54E-06	1.32E-07	1.76E-02
^{133}Cs	1.80E-05	1.80E-05	1.79E-05	1.79E-05	1.78E-05	1.78E-05	1.79E-05	1.79E-05	3.49E-07	1.96E-02
^{134}Cs	6.43E-07	6.36E-07	6.60E-07	6.23E-07	6.31E-07	6.33E-07	5.94E-07	6.33E-07	5.60E-08	8.85E-02
^{137}Cs	1.74E-05	1.74E-05	1.77E-05	1.73E-05	1.74E-05	1.72E-05	1.75E-05	1.73E-05	3.42E-07	1.98E-02
^{144}Ce	8.65E-06	8.65E-06	8.72E-06	8.62E-06	8.63E-06	8.56E-06	8.55E-06	8.58E-06	1.28E-07	1.49E-02
^{143}Nd	1.39E-05	1.39E-05	1.41E-05	1.39E-05	1.39E-05	1.38E-05	1.39E-05	1.39E-05	1.61E-07	1.16E-02

Table 3.2(3). All results for Case 2a (40% void, 12 GWd/tHM, No cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.04E-05	1.04E-05	1.05E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.25E-07	1.21E-02
^{148}Nd	4.86E-06	4.86E-06	4.97E-06	4.83E-06	4.84E-06	4.78E-06	4.81E-06	4.83E-06	7.49E-08	1.55E-02
^{147}Sm	7.50E-07	7.52E-07	7.57E-07	7.49E-07	7.06E-07	7.52E-07	7.52E-07	7.48E-07	1.82E-08	2.43E-02
^{149}Sm	8.05E-08	8.03E-08	7.17E-08	8.03E-08	7.85E-08	7.84E-08	7.96E-08	7.95E-08	5.92E-09	7.45E-02
^{150}Sm	3.30E-06	3.31E-06	3.24E-06	3.29E-06	3.27E-06	3.27E-06	3.26E-06	3.28E-06	7.54E-08	2.30E-02
^{151}Sm	3.26E-07	3.25E-07	3.27E-07	3.25E-07	3.19E-07	3.19E-07	3.30E-07	3.31E-07	2.49E-08	7.52E-02
^{152}Sm	1.68E-06	1.64E-06	1.62E-06	1.59E-06	1.60E-06	1.59E-06	1.62E-06	1.63E-06	7.12E-08	4.38E-02
^{153}Eu	8.55E-07	8.83E-07	9.00E-07	8.90E-07	8.78E-07	8.84E-07	8.85E-07	8.79E-07	4.57E-08	5.20E-02
^{154}Eu	9.51E-08	9.77E-08	1.00E-07	9.83E-08	9.77E-08	9.59E-08	9.04E-08	9.62E-08	1.04E-08	1.09E-01
^{155}Eu	5.45E-08	5.46E-08	5.41E-08	5.41E-08	5.38E-08	5.33E-08	5.42E-08	5.21E-08	1.10E-08	2.12E-01
^{155}Gd	1.00E-06	9.95E-07	1.60E-06	9.53E-07	1.13E-06	1.19E-06	1.17E-06	1.14E-06	4.19E-07	3.66E-01
^{156}Gd	9.55E-05	9.49E-05	9.50E-05	9.53E-05	9.53E-05	9.53E-05	9.51E-05	9.53E-05	5.37E-07	5.63E-03
^{157}Gd	3.00E-08	3.08E-08	4.30E-08	3.00E-08	3.16E-08	3.26E-08	3.68E-08	3.27E-08	8.65E-09	2.64E-01
^{158}Gd	1.12E-04	1.11E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.96E-06	1.75E-02

Table 3.3(1). All results for Case 2b (40% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.89E-06	5.95E-06	5.89E-06	5.85E-06	5.90E-06	5.82E-06	5.85E-06	5.80E-06	5.85E-06	5.85E-06	5.84E-06	5.88E-06	5.85E-06	5.84E-06
^{235}U	6.19E-04	6.17E-04	6.19E-04	6.16E-04	6.20E-04	6.14E-04	6.18E-04	6.18E-04	6.17E-04	6.19E-04	6.19E-04	6.19E-04	6.17E-04	6.18E-04
^{236}U	4.96E-05	5.06E-05	4.95E-05	5.03E-05	4.94E-05	4.98E-05	5.02E-05	5.01E-05	5.02E-05	4.99E-05	4.99E-05	4.96E-05	5.01E-05	4.99E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	2.04E-06	2.01E-06	2.04E-06	2.10E-06	1.99E-06	2.07E-06	2.14E-06	2.11E-06	2.12E-06	2.11E-06	2.09E-06	2.08E-06	2.10E-06	2.13E-06
^{238}Pu	2.16E-07	2.08E-07	2.16E-07	2.05E-07	1.99E-07	2.04E-07	2.08E-07	2.14E-07	2.07E-07	2.07E-07	2.08E-07	2.22E-07	2.06E-07	2.07E-07
^{239}Pu	7.83E-05	7.63E-05	7.83E-05	7.79E-05	7.88E-05	7.90E-05	8.12E-05	8.33E-05	8.07E-05	7.73E-05	7.63E-05	7.77E-05	8.02E-05	7.95E-05
^{240}Pu	1.37E-05	1.34E-05	1.36E-05	1.37E-05	1.37E-05	1.39E-05	1.41E-05	1.45E-05	1.39E-05	1.42E-05	1.45E-05	1.40E-05	1.39E-05	1.37E-05
^{241}Pu	4.24E-06	4.06E-06	4.22E-06	4.15E-06	4.18E-06	4.21E-06	4.28E-06	4.24E-06	4.23E-06	4.29E-06	4.33E-06	4.34E-06	4.24E-06	4.22E-06
^{242}Pu	5.50E-07	5.25E-07	5.44E-07	5.33E-07	5.32E-07	5.47E-07	5.43E-07	5.44E-07	5.33E-07	5.61E-07	5.82E-07	5.68E-07	5.38E-07	5.33E-07
^{241}Am	1.25E-06	1.20E-06	1.24E-06	1.23E-06	1.23E-06	1.24E-06	1.27E-06	1.25E-06	1.25E-06	1.27E-06	1.27E-06	1.28E-06	1.25E-06	1.25E-06
^{243}Am	2.93E-08	2.61E-08	2.90E-08	3.10E-08	2.78E-08	3.29E-08	3.25E-08	3.31E-08	3.20E-08	3.33E-08	3.10E-08	3.06E-08	3.21E-08	3.17E-08
^{244}Cm	2.10E-09	1.81E-09	2.07E-09	1.96E-09	1.97E-09	2.09E-09	2.04E-09	2.02E-09	2.01E-09	2.09E-09	1.93E-09	2.18E-09	2.02E-09	1.99E-09
^{90}Sr	1.25E-05	1.26E-05	1.25E-05	1.26E-05	1.24E-05	1.25E-05	1.26E-05	1.26E-05	1.26E-05	1.25E-05	1.23E-05	1.27E-05	1.26E-05	1.28E-05
^{95}Mo	1.72E-05	1.73E-05	1.71E-05	1.73E-05	1.71E-05	1.72E-05	1.73E-05	1.73E-05	1.73E-05	1.72E-05	1.73E-05	1.73E-05	1.73E-05	1.73E-05
^{99}Tc	1.73E-05	1.73E-05	1.68E-05	1.72E-05	1.67E-05	1.71E-05	1.72E-05	1.72E-05	1.72E-05	1.69E-05	1.70E-05	1.72E-05	1.71E-05	1.68E-05
^{101}Ru	1.49E-05	1.49E-05	1.49E-05	1.50E-05	1.48E-05	1.49E-05	1.50E-05	1.50E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05
^{103}Rh	9.65E-06	9.65E-06	9.58E-06	9.63E-06	9.43E-06	9.60E-06	9.67E-06	9.70E-06	9.69E-06	9.64E-06	9.64E-06	9.67E-06	9.65E-06	9.65E-06
^{109}Ag	6.69E-07	6.56E-07	6.61E-07	6.75E-07	3.38E-07	6.81E-07	6.91E-07	6.93E-07	6.84E-07	4.75E-07	7.31E-07	6.87E-07	6.83E-07	4.67E-07
^{129}I	1.88E-06	1.87E-06	1.88E-06	1.95E-06	1.81E-06	1.95E-06	1.96E-06	1.97E-06	1.96E-06	1.92E-06	2.23E-06	1.89E-06	1.96E-06	1.96E-06
^{131}Xe	7.76E-06	7.77E-06	7.71E-06	7.84E-06	7.61E-06	7.79E-06	7.82E-06	7.78E-06	7.85E-06	7.78E-06	7.74E-06	7.76E-06	7.83E-06	7.82E-06
^{133}Cs	1.87E-05	1.87E-05	1.81E-05	1.83E-05	1.81E-05	1.82E-05	1.83E-05	1.84E-05	1.83E-05	1.85E-05	1.82E-05	1.82E-05	1.83E-05	1.82E-05
^{134}Cs	1.23E-07	1.20E-07	1.20E-07	1.19E-07	1.18E-07	1.18E-07	1.19E-07	1.12E-07	1.20E-07	1.19E-07	1.18E-07	1.18E-07	1.19E-07	1.19E-07
^{137}Cs	1.55E-05	1.55E-05	1.53E-05	1.55E-05	1.53E-05	1.54E-05	1.55E-05	1.55E-05	1.55E-05	1.54E-05	1.52E-05	1.55E-05	1.55E-05	1.58E-05
^{144}Ce	1.01E-07	1.01E-07	1.01E-07	1.02E-07	1.00E-07	1.01E-07	1.02E-07	1.02E-07	1.02E-07	1.01E-07	1.01E-07	9.45E-08	1.02E-07	1.01E-07
^{143}Nd	1.46E-05	1.46E-05	1.45E-05	1.46E-05	1.45E-05	1.45E-05	1.46E-05	1.47E-05	1.47E-05	1.46E-05	1.47E-05	1.46E-05	1.46E-05	1.45E-05

Table 3.3(1). All results for Case 2b (40% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.04E-05	1.03E-05	1.04E-05	1.04E-05	1.03E-05	1.03E-05
^{148}Nd	4.78E-06	4.80E-06	4.78E-06	4.85E-06	4.77E-06	4.82E-06	4.85E-06	4.83E-06	4.87E-06	4.83E-06	4.88E-06	4.80E-06	4.85E-06	4.84E-06
^{147}Sm	4.08E-06	4.06E-06	4.05E-06	4.05E-06	3.98E-06	4.03E-06	4.05E-06	4.06E-06	4.07E-06	4.04E-06	4.04E-06	4.09E-06	4.05E-06	4.03E-06
^{149}Sm	1.01E-07	1.00E-07	1.04E-07	1.05E-07	1.06E-07	1.05E-07	1.07E-07	1.11E-07	1.07E-07	1.02E-07	9.94E-08	1.01E-07	1.06E-07	1.07E-07
^{150}Sm	3.23E-06	3.18E-06	3.28E-06	3.29E-06	3.21E-06	3.27E-06	3.31E-06	3.38E-06	3.31E-06	3.22E-06	3.25E-06	3.24E-06	3.29E-06	3.30E-06
^{151}Sm	3.13E-07	3.21E-07	3.13E-07	3.13E-07	3.30E-07	3.13E-07	3.18E-07	3.72E-07	3.19E-07	3.22E-07	3.31E-07	3.18E-07	3.17E-07	3.17E-07
^{152}Sm	1.59E-06	1.73E-06	1.59E-06	1.67E-06	1.61E-06	1.63E-06	1.60E-06	1.61E-06	1.64E-06	1.60E-06	1.60E-06	1.60E-06	1.63E-06	1.60E-06
^{153}Eu	9.04E-07	8.15E-07	8.98E-07	8.61E-07	9.01E-07	8.82E-07	9.10E-07	8.82E-07	8.92E-07	9.04E-07	8.86E-07	9.06E-07	8.88E-07	9.07E-07
^{154}Eu	6.55E-08	5.89E-08	6.59E-08	6.32E-08	6.51E-08	6.46E-08	6.65E-08	6.25E-08	6.56E-08	6.55E-08	5.86E-08	6.47E-08	6.51E-08	6.65E-08
^{155}Eu	2.59E-08	2.51E-08	2.57E-08	2.60E-08	2.58E-08	2.60E-08	2.65E-08	1.91E-08	2.63E-08	2.62E-08	2.66E-08	2.66E-08	2.61E-08	2.64E-08
^{155}Gd	1.28E-06	1.20E-06	1.31E-06	9.11E-07	1.26E-06	8.78E-07	1.15E-06	1.52E-06	1.32E-06	8.85E-07	9.06E-07	1.07E-06	1.52E-06	1.30E-06
^{156}Gd	9.52E-05	9.55E-05	9.52E-05	9.57E-05	9.53E-05	9.58E-05	9.54E-05	9.51E-05	9.52E-05	9.56E-05	9.57E-05	9.54E-05	9.50E-05	9.52E-05
^{157}Gd	3.51E-08	2.87E-08	3.56E-08	2.68E-08	3.46E-08	2.60E-08	2.98E-08	3.88E-08	3.44E-08	3.08E-08	2.91E-08	3.45E-08	3.88E-08	3.92E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.3(2). All results for Case 2b (40% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.80E-06	5.85E-06	5.84E-06	5.84E-06	5.85E-06	5.85E-06	5.87E-06	5.87E-06	5.85E-06	5.89E-06	5.85E-06	5.85E-06	5.84E-06	5.80E-06
^{235}U	6.20E-04	6.18E-04	6.19E-04	6.19E-04	6.22E-04	6.20E-04	6.18E-04	6.19E-04	6.20E-04	6.21E-04	6.21E-04	6.22E-04	6.18E-04	6.20E-04
^{236}U	4.96E-05	5.01E-05	4.99E-05	4.99E-05	4.86E-05	5.04E-05	4.86E-05	5.02E-05	4.97E-05	4.92E-05	5.03E-05	4.86E-05	4.99E-05	4.82E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	2.01E-06	2.09E-06	2.12E-06	2.10E-06	1.90E-06	2.00E-06	2.21E-06	2.11E-06	2.09E-06	2.05E-06	2.00E-06	1.90E-06	2.11E-06	1.99E-06
^{238}Pu	2.01E-07	2.04E-07	2.08E-07	2.06E-07	1.88E-07	2.01E-07	2.17E-07	2.02E-07	2.01E-07	2.13E-07	2.00E-07	1.88E-07	2.05E-07	2.00E-07
^{239}Pu	7.94E-05	8.05E-05	7.84E-05	7.84E-05	8.02E-05	7.86E-05	8.20E-05	7.86E-05	7.83E-05	7.82E-05	8.01E-05	8.02E-05	7.89E-05	7.86E-05
^{240}Pu	1.35E-05	1.41E-05	1.40E-05	1.40E-05	1.37E-05	1.35E-05	1.44E-05	1.37E-05	1.36E-05	1.36E-05	1.37E-05	1.37E-05	1.37E-05	1.40E-05
^{241}Pu	4.15E-06	4.24E-06	4.26E-06	4.24E-06	4.27E-06	4.28E-06	4.28E-06	4.23E-06	4.17E-06	4.22E-06	4.33E-06	4.26E-06	4.22E-06	4.29E-06
^{242}Pu	4.91E-07	5.40E-07	5.49E-07	5.51E-07	5.09E-07	5.15E-07	5.02E-07	5.38E-07	5.29E-07	5.42E-07	5.19E-07	5.09E-07	5.41E-07	5.33E-07
^{241}Am	1.22E-06	1.25E-06	1.26E-06	1.24E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.22E-06	1.23E-06	1.27E-06	1.25E-06	1.24E-06	1.25E-06
^{243}Am	2.92E-08	3.22E-08	3.25E-08	2.92E-08	2.61E-08	3.01E-08	2.46E-08	2.94E-08	3.12E-08	2.92E-08	3.04E-08	2.62E-08	3.21E-08	2.82E-08
^{244}Cm	1.83E-09	2.00E-09	2.04E-09	1.81E-09	1.66E-09	1.93E-09	1.41E-09	1.80E-09	1.94E-09	1.84E-09	1.95E-09	1.66E-09	2.01E-09	1.76E-09
^{90}Sr	1.24E-05	1.26E-05	1.27E-05	1.25E-05	1.26E-05	1.25E-05	1.25E-05	-	1.24E-05	1.24E-05	1.24E-05	1.26E-05	1.25E-05	1.26E-05
^{95}Mo	1.71E-05	1.73E-05	1.73E-05	1.73E-05	1.73E-05	1.72E-05	1.73E-05	1.69E-05	1.70E-05	1.70E-05	1.71E-05	1.73E-05	1.72E-05	1.74E-05
^{99}Tc	1.66E-05	1.73E-05	1.67E-05	1.68E-05	1.68E-05	1.66E-05	1.72E-05	1.64E-05	1.62E-05	1.63E-05	1.66E-05	1.68E-05	1.66E-05	1.69E-05
^{101}Ru	1.48E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.49E-05	1.49E-05	1.48E-05	1.46E-05	1.46E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05
^{103}Rh	9.51E-06	9.67E-06	9.66E-06	9.62E-06	9.42E-06	9.60E-06	9.60E-06	9.49E-06	9.64E-06	9.65E-06	9.63E-06	9.42E-06	9.57E-06	9.40E-06
^{109}Ag	6.89E-07	6.86E-07	4.70E-07	7.09E-07	6.36E-07	6.63E-07	6.55E-07	6.46E-07	7.43E-07	7.48E-07	6.71E-07	6.36E-07	4.94E-07	6.89E-07
^{129}I	1.95E-06	1.93E-06	1.97E-06	2.27E-06	1.99E-06	1.59E-06	1.91E-06	1.90E-06	2.42E-06	2.43E-06	1.59E-06	1.99E-06	1.97E-06	2.45E-06
^{131}Xe	7.68E-06	7.81E-06	7.81E-06	7.79E-06	7.74E-06	7.59E-06	7.76E-06	7.68E-06	7.75E-06	7.72E-06	7.60E-06	7.74E-06	7.78E-06	7.83E-06
^{133}Cs	1.82E-05	1.83E-05	1.82E-05	1.79E-05	1.79E-05	1.82E-05	1.83E-05	1.81E-05	1.82E-05	1.81E-05	1.82E-05	1.79E-05	1.82E-05	1.79E-05
^{134}Cs	1.01E-07	1.18E-07	1.18E-07	1.17E-07	1.23E-07	1.13E-07	1.34E-07	1.09E-07	1.16E-07	1.20E-07	1.13E-07	1.23E-07	1.18E-07	1.19E-07
^{137}Cs	1.53E-05	1.54E-05	1.58E-05	1.55E-05	1.54E-05	1.54E-05	1.55E-05	1.54E-05	1.51E-05	1.51E-05	1.54E-05	1.54E-05	1.54E-05	1.55E-05
^{144}Ce	1.00E-07	1.02E-07	1.01E-07	1.01E-07	9.93E-08	1.00E-07	1.02E-07	1.01E-07	9.84E-08	9.83E-08	1.01E-07	1.00E-07	1.01E-07	1.01E-07
^{143}Nd	1.45E-05	1.46E-05	1.45E-05	1.45E-05	1.45E-05	1.45E-05	1.46E-05	1.44E-05	1.44E-05	1.44E-05	1.45E-05	1.46E-05	1.45E-05	1.46E-05

Table 3.3(2). All results for Case 2b (40% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.03E-05	1.03E-05	1.03E-05	1.02E-05	1.02E-05	1.02E-05	1.03E-05	1.03E-05	1.03E-05	1.04E-05
^{148}Nd	4.79E-06	4.85E-06	4.83E-06	4.88E-06	4.87E-06	4.82E-06	4.83E-06	4.81E-06	4.85E-06	4.82E-06	4.82E-06	4.87E-06	4.82E-06	4.87E-06
^{147}Sm	4.04E-06	4.06E-06	4.03E-06	4.03E-06	4.02E-06	3.98E-06	3.94E-06	3.86E-06	4.06E-06	4.08E-06	3.98E-06	4.02E-06	4.02E-06	4.08E-06
^{149}Sm	1.10E-07	1.06E-07	1.06E-07	1.02E-07	1.10E-07	1.11E-07	1.11E-07	1.05E-07	1.03E-07	1.02E-07	1.12E-07	1.09E-07	1.06E-07	1.05E-07
^{150}Sm	3.28E-06	3.30E-06	3.30E-06	3.31E-06	3.26E-06	3.31E-06	3.32E-06	3.26E-06	3.24E-06	3.24E-06	3.31E-06	3.26E-06	3.29E-06	3.29E-06
^{151}Sm	3.30E-07	3.16E-07	3.22E-07	3.26E-07	3.41E-07	3.39E-07	3.23E-07	3.15E-07	3.23E-07	3.21E-07	3.41E-07	3.41E-07	3.14E-07	3.24E-07
^{152}Sm	1.63E-06	1.61E-06	1.60E-06	1.61E-06	1.66E-06	1.67E-06	1.70E-06	1.58E-06	1.63E-06	1.63E-06	1.67E-06	1.66E-06	1.60E-06	1.60E-06
^{153}Eu	8.76E-07	9.05E-07	9.06E-07	8.86E-07	8.56E-07	8.67E-07	8.56E-07	8.65E-07	9.25E-07	9.26E-07	8.67E-07	8.56E-07	9.03E-07	8.97E-07
^{154}Eu	6.45E-08	6.59E-08	6.57E-08	5.90E-08	5.94E-08	6.39E-08	5.86E-08	6.27E-08	6.68E-08	6.71E-08	6.38E-08	5.93E-08	6.61E-08	7.73E-08
^{155}Eu	1.90E-08	2.64E-08	2.64E-08	2.67E-08	2.08E-08	1.97E-08	2.77E-08	2.53E-08	2.83E-08	2.83E-08	1.90E-08	2.08E-08	2.62E-08	2.80E-08
^{155}Gd	1.71E-06	9.63E-07	1.22E-06	1.20E-06	1.20E-06	1.10E-06	9.15E-07	8.84E-07	1.05E-06	1.29E-06	1.14E-06	1.20E-06	1.13E-06	1.24E-06
^{156}Gd	9.45E-05	9.56E-05	9.53E-05	9.54E-05	9.55E-05	9.55E-05	9.56E-05	9.58E-05	9.54E-05	9.52E-05	9.55E-05	9.56E-05	9.53E-05	9.54E-05
^{157}Gd	4.47E-08	2.77E-08	3.50E-08	3.20E-08	3.08E-08	3.12E-08	3.19E-08	2.69E-08	3.14E-08	3.49E-08	3.18E-08	3.08E-08	3.21E-08	3.16E-08
^{158}Gd	1.06E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.3(3). All results for Case 2b (40% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	$2*\sigma^{(r)}$
^{234}U	5.85E-06	5.86E-06	5.81E-06	5.86E-06	5.66E-06	5.90E-06	5.86E-06	5.85E-06	9.00E-08	1.54E-02
^{235}U	6.17E-04	6.18E-04	6.14E-04	6.18E-04	6.17E-04	6.19E-04	6.21E-04	6.19E-04	3.71E-06	6.00E-03
^{236}U	5.03E-05	5.02E-05	5.07E-05	5.00E-05	5.01E-05	4.94E-05	4.79E-05	4.97E-05	1.33E-06	2.67E-02
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	1.06E-05	4.98E-04
^{237}Np	2.14E-06	2.12E-06	2.19E-06	2.05E-06	2.12E-06	2.03E-06	1.85E-06	2.07E-06	1.58E-07	7.67E-02
^{238}Pu	2.09E-07	2.07E-07	2.27E-07	1.90E-07	2.07E-07	2.13E-07	1.80E-07	2.06E-07	1.89E-08	9.21E-02
^{239}Pu	8.16E-05	8.12E-05	8.07E-05	7.97E-05	7.89E-05	7.78E-05	7.84E-05	7.92E-05	3.11E-06	3.92E-02
^{240}Pu	1.42E-05	1.42E-05	1.41E-05	1.38E-05	1.37E-05	1.36E-05	1.38E-05	1.39E-05	5.57E-07	4.02E-02
^{241}Pu	4.32E-06	4.29E-06	4.41E-06	4.16E-06	4.16E-06	4.16E-06	4.19E-06	4.24E-06	1.37E-07	3.22E-02
^{242}Pu	5.50E-07	5.50E-07	5.78E-07	5.26E-07	5.36E-07	5.35E-07	5.13E-07	5.37E-07	3.91E-08	7.29E-02
^{241}Am	1.27E-06	1.27E-06	1.30E-06	1.23E-06	1.22E-06	1.23E-06	1.23E-06	1.25E-06	4.05E-08	3.25E-02
^{243}Am	3.22E-08	3.30E-08	3.19E-08	3.07E-08	3.01E-08	2.79E-08	2.67E-08	3.02E-08	4.65E-09	1.54E-01
^{244}Cm	2.04E-09	2.08E-09	2.05E-09	1.94E-09	1.91E-09	1.97E-09	1.73E-09	1.93E-09	3.11E-10	1.61E-01
^{90}Sr	1.26E-05	1.26E-05	1.26E-05	1.25E-05	1.25E-05	1.25E-05	1.28E-05	1.25E-05	1.98E-07	1.58E-02
^{95}Mo	1.73E-05	1.73E-05	1.76E-05	1.72E-05	1.73E-05	1.72E-05	1.72E-05	1.72E-05	2.38E-07	1.38E-02
^{99}Tc	1.72E-05	1.72E-05	1.70E-05	1.67E-05	1.67E-05	1.68E-05	1.67E-05	1.69E-05	5.82E-07	3.45E-02
^{101}Ru	1.50E-05	1.50E-05	1.53E-05	1.49E-05	1.49E-05	1.49E-05	1.46E-05	1.49E-05	2.50E-07	1.68E-02
^{103}Rh	9.70E-06	9.70E-06	9.89E-06	9.16E-06	9.48E-06	9.58E-06	9.50E-06	9.59E-06	2.50E-07	2.60E-02
^{109}Ag	6.96E-07	6.93E-07	7.41E-07	4.13E-07	6.51E-07	6.57E-07	8.00E-07	6.45E-07	2.03E-07	3.15E-01
^{129}I	1.97E-06	1.97E-06	2.28E-06	1.78E-06	1.89E-06	1.87E-06	2.30E-06	1.99E-06	4.07E-07	2.04E-01
^{131}Xe	7.85E-06	7.84E-06	7.84E-06	7.70E-06	7.77E-06	7.72E-06	7.72E-06	7.76E-06	1.40E-07	1.80E-02
^{133}Cs	1.83E-05	1.83E-05	1.83E-05	1.82E-05	1.81E-05	1.81E-05	1.82E-05	1.82E-05	3.63E-07	1.99E-02
^{134}Cs	1.20E-07	1.19E-07	1.23E-07	1.16E-07	1.18E-07	1.18E-07	1.11E-07	1.18E-07	1.04E-08	8.85E-02
^{137}Cs	1.55E-05	1.55E-05	1.57E-05	1.54E-05	1.55E-05	1.53E-05	1.56E-05	1.54E-05	3.07E-07	1.99E-02
^{144}Ce	1.02E-07	1.02E-07	1.03E-07	1.01E-07	1.02E-07	1.01E-07	1.01E-07	1.01E-07	2.91E-09	2.89E-02
^{143}Nd	1.47E-05	1.47E-05	1.48E-05	1.46E-05	1.46E-05	1.45E-05	1.45E-05	1.46E-05	1.79E-07	1.23E-02

Table 3.3(3). All results for Case 2b (40% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.04E-05	1.04E-05	1.06E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.26E-07	1.22E-02
^{148}Nd	4.86E-06	4.86E-06	4.97E-06	4.83E-06	4.84E-06	4.78E-06	4.81E-06	4.83E-06	7.49E-08	1.55E-02
^{147}Sm	4.05E-06	4.06E-06	4.09E-06	3.99E-06	3.74E-06	4.06E-06	4.05E-06	4.03E-06	1.35E-07	3.36E-02
^{149}Sm	1.07E-07	1.07E-07	9.71E-08	1.07E-07	1.05E-07	1.04E-07	1.05E-07	1.05E-07	7.05E-09	6.69E-02
^{150}Sm	3.30E-06	3.31E-06	3.24E-06	3.29E-06	3.27E-06	3.27E-06	3.26E-06	3.28E-06	7.54E-08	2.30E-02
^{151}Sm	3.19E-07	3.18E-07	3.20E-07	3.17E-07	3.12E-07	3.12E-07	3.23E-07	3.23E-07	2.39E-08	7.40E-02
^{152}Sm	1.68E-06	1.64E-06	1.62E-06	1.60E-06	1.60E-06	1.59E-06	1.62E-06	1.63E-06	7.12E-08	4.38E-02
^{153}Eu	8.64E-07	8.92E-07	9.10E-07	9.00E-07	8.88E-07	8.94E-07	8.85E-07	8.87E-07	4.58E-08	5.16E-02
^{154}Eu	6.36E-08	6.53E-08	6.68E-08	6.57E-08	6.52E-08	6.41E-08	6.04E-08	6.43E-08	6.99E-09	1.09E-01
^{155}Eu	2.63E-08	2.64E-08	2.61E-08	2.61E-08	2.57E-08	2.57E-08	2.61E-08	2.52E-08	5.32E-09	2.11E-01
^{155}Gd	1.03E-06	1.02E-06	1.63E-06	9.80E-07	1.15E-06	1.22E-06	1.20E-06	1.17E-06	4.14E-07	3.53E-01
^{156}Gd	9.56E-05	9.49E-05	9.50E-05	9.53E-05	9.53E-05	9.53E-05	9.51E-05	9.54E-05	5.39E-07	5.65E-03
^{157}Gd	3.02E-08	3.10E-08	4.31E-08	3.01E-08	3.18E-08	3.27E-08	3.70E-08	3.29E-08	8.63E-09	2.62E-01
^{158}Gd	1.12E-04	1.11E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.96E-06	1.75E-02

Table 3.4(1). All results for Case 2c (40% void, 12 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.91E-06	5.97E-06	5.91E-06	5.86E-06	5.91E-06	5.83E-06	5.86E-06	5.82E-06	5.86E-06	5.86E-06	5.86E-06	5.90E-06	5.86E-06	5.86E-06
^{235}U	6.19E-04	6.17E-04	6.20E-04	6.16E-04	6.20E-04	6.14E-04	6.18E-04	6.18E-04	6.17E-04	6.19E-04	6.20E-04	6.19E-04	6.17E-04	6.18E-04
^{236}U	4.97E-05	5.06E-05	4.95E-05	5.03E-05	4.94E-05	4.98E-05	5.02E-05	5.01E-05	5.02E-05	4.99E-05	4.99E-05	4.96E-05	5.02E-05	4.99E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	2.08E-06	2.04E-06	2.07E-06	2.13E-06	2.03E-06	2.10E-06	2.17E-06	2.15E-06	2.15E-06	2.14E-06	2.13E-06	2.11E-06	2.14E-06	2.17E-06
^{238}Pu	2.00E-07	1.93E-07	2.00E-07	1.90E-07	1.84E-07	1.88E-07	1.93E-07	1.97E-07	1.91E-07	1.92E-07	1.92E-07	2.05E-07	1.90E-07	1.92E-07
^{239}Pu	7.83E-05	7.63E-05	7.82E-05	7.79E-05	7.87E-05	7.90E-05	8.12E-05	8.33E-05	8.06E-05	7.72E-05	7.63E-05	7.77E-05	8.02E-05	7.95E-05
^{240}Pu	1.37E-05	1.34E-05	1.36E-05	1.37E-05	1.37E-05	1.39E-05	1.41E-05	1.45E-05	1.39E-05	1.41E-05	1.45E-05	1.40E-05	1.39E-05	1.37E-05
^{241}Pu	2.61E-06	2.50E-06	2.60E-06	2.55E-06	2.57E-06	2.59E-06	2.64E-06	2.61E-06	2.61E-06	2.64E-06	2.67E-06	2.68E-06	2.61E-06	2.60E-06
^{242}Pu	5.50E-07	5.25E-07	5.44E-07	5.33E-07	5.32E-07	5.47E-07	5.43E-07	5.44E-07	5.33E-07	5.61E-07	5.82E-07	5.68E-07	5.38E-07	5.33E-07
^{241}Am	2.85E-06	2.72E-06	2.83E-06	2.79E-06	2.80E-06	2.82E-06	2.88E-06	2.84E-06	2.84E-06	2.88E-06	2.90E-06	2.91E-06	2.85E-06	2.83E-06
^{243}Am	2.93E-08	2.61E-08	2.90E-08	3.10E-08	2.78E-08	3.29E-08	3.24E-08	3.31E-08	3.20E-08	3.33E-08	3.09E-08	3.06E-08	3.21E-08	3.17E-08
^{244}Cm	1.43E-09	1.24E-09	1.41E-09	1.33E-09	1.34E-09	1.42E-09	1.39E-09	1.38E-09	1.37E-09	1.43E-09	1.31E-09	1.49E-09	1.37E-09	1.36E-09
^{90}Sr	9.86E-06	9.89E-06	9.80E-06	9.92E-06	9.78E-06	9.82E-06	9.88E-06	9.89E-06	9.92E-06	9.84E-06	9.70E-06	9.97E-06	9.89E-06	1.00E-05
^{95}Mo	1.72E-05	1.73E-05	1.71E-05	1.73E-05	1.71E-05	1.72E-05	1.73E-05	1.73E-05	1.73E-05	1.72E-05	1.73E-05	1.73E-05	1.73E-05	1.73E-05
^{99}Tc	1.73E-05	1.73E-05	1.68E-05	1.72E-05	1.67E-05	1.71E-05	1.72E-05	1.72E-05	1.72E-05	1.69E-05	1.70E-05	1.72E-05	1.71E-05	1.68E-05
^{101}Ru	1.49E-05	1.49E-05	1.49E-05	1.50E-05	1.48E-05	1.49E-05	1.50E-05	1.50E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05
^{103}Rh	9.65E-06	9.65E-06	9.58E-06	9.63E-06	9.43E-06	9.60E-06	9.67E-06	9.70E-06	9.69E-06	9.64E-06	9.64E-06	9.67E-06	9.65E-06	9.65E-06
^{109}Ag	6.69E-07	6.56E-07	6.61E-07	6.75E-07	3.38E-07	6.81E-07	6.91E-07	6.93E-07	6.84E-07	4.75E-07	7.31E-07	6.87E-07	6.83E-07	4.67E-07
^{129}I	1.88E-06	1.87E-06	1.88E-06	1.95E-06	1.81E-06	1.95E-06	1.96E-06	1.97E-06	1.96E-06	1.92E-06	2.23E-06	1.89E-06	1.96E-06	1.96E-06
^{131}Xe	7.76E-06	7.77E-06	7.71E-06	7.84E-06	7.61E-06	7.79E-06	7.82E-06	7.78E-06	7.85E-06	7.78E-06	7.74E-06	7.76E-06	7.83E-06	7.82E-06
^{133}Cs	1.87E-05	1.87E-05	1.81E-05	1.83E-05	1.81E-05	1.82E-05	1.83E-05	1.84E-05	1.83E-05	1.85E-05	1.82E-05	1.82E-05	1.83E-05	1.82E-05
^{134}Cs	4.30E-09	4.18E-09	4.18E-09	4.16E-09	4.13E-09	4.11E-09	4.16E-09	3.90E-09	4.18E-09	4.17E-09	4.12E-09	4.09E-09	4.16E-09	4.15E-09
^{137}Cs	1.23E-05	1.23E-05	1.22E-05	1.23E-05	1.22E-05	1.22E-05	1.23E-05	1.23E-05	1.23E-05	1.22E-05	1.21E-05	1.23E-05	1.23E-05	1.26E-05
^{144}Ce	1.40E-11	1.40E-11	1.40E-11	1.41E-11	1.44E-11	1.40E-11	1.40E-11	1.42E-11	1.42E-11	1.40E-11	1.40E-11	1.29E-11	1.40E-11	1.41E-11
^{143}Nd	1.46E-05	1.46E-05	1.45E-05	1.46E-05	1.45E-05	1.45E-05	1.46E-05	1.47E-05	1.47E-05	1.46E-05	1.47E-05	1.46E-05	1.46E-05	1.45E-05

Table 3.4(1). All results for Case 2c (40% void, 12 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.04E-05	1.03E-05	1.04E-05	1.04E-05	1.03E-05	1.03E-05
^{148}Nd	4.78E-06	4.80E-06	4.78E-06	4.85E-06	4.77E-06	4.82E-06	4.85E-06	4.83E-06	4.87E-06	4.83E-06	4.88E-06	4.80E-06	4.85E-06	4.84E-06
^{147}Sm	5.21E-06	5.18E-06	5.17E-06	5.17E-06	5.15E-06	5.14E-06	5.16E-06	5.18E-06	5.19E-06	5.15E-06	5.16E-06	5.19E-06	5.17E-06	5.14E-06
^{149}Sm	1.01E-07	1.00E-07	1.04E-07	1.05E-07	1.06E-07	1.05E-07	1.07E-07	1.11E-07	1.07E-07	1.02E-07	9.94E-08	1.01E-07	1.06E-07	1.07E-07
^{150}Sm	3.23E-06	3.18E-06	3.28E-06	3.29E-06	3.21E-06	3.27E-06	3.31E-06	3.38E-06	3.31E-06	3.22E-06	3.25E-06	3.24E-06	3.29E-06	3.30E-06
^{151}Sm	2.90E-07	2.98E-07	2.90E-07	2.90E-07	3.05E-07	2.90E-07	2.95E-07	3.45E-07	2.95E-07	2.98E-07	3.07E-07	2.95E-07	2.94E-07	2.93E-07
^{152}Sm	1.59E-06	1.73E-06	1.59E-06	1.67E-06	1.61E-06	1.63E-06	1.60E-06	1.61E-06	1.64E-06	1.60E-06	1.60E-06	1.60E-06	1.63E-06	1.60E-06
^{153}Eu	9.04E-07	8.15E-07	8.98E-07	8.61E-07	9.01E-07	8.82E-07	9.10E-07	8.82E-07	8.92E-07	9.04E-07	8.86E-07	9.06E-07	8.88E-07	9.07E-07
^{154}Eu	2.92E-08	2.63E-08	2.94E-08	2.82E-08	2.91E-08	2.88E-08	2.97E-08	2.79E-08	2.93E-08	2.92E-08	2.62E-08	2.89E-08	2.91E-08	2.97E-08
^{155}Eu	6.03E-09	5.85E-09	5.98E-09	6.05E-09	6.00E-09	6.06E-09	6.15E-09	4.45E-09	6.13E-09	6.09E-09	6.18E-09	6.57E-09	6.07E-09	6.15E-09
^{155}Gd	1.30E-06	1.22E-06	1.33E-06	9.31E-07	1.28E-06	8.98E-07	1.17E-06	1.53E-06	1.34E-06	9.05E-07	9.26E-07	1.09E-06	1.54E-06	1.32E-06
^{156}Gd	9.52E-05	9.55E-05	9.52E-05	9.57E-05	9.53E-05	9.58E-05	9.54E-05	9.51E-05	9.52E-05	9.56E-05	9.57E-05	9.54E-05	9.50E-05	9.52E-05
^{157}Gd	3.51E-08	2.87E-08	3.56E-08	2.68E-08	3.46E-08	2.60E-08	2.98E-08	3.88E-08	3.44E-08	3.08E-08	2.91E-08	3.45E-08	3.88E-08	3.92E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.4(2). All results for Case 2c (40% void, 12 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.80E-06	5.87E-06	5.86E-06	5.86E-06	5.87E-06	5.86E-06	5.89E-06	5.87E-06	5.87E-06	5.90E-06	5.87E-06	5.87E-06	5.86E-06	5.82E-06
^{235}U	6.20E-04	6.18E-04	6.19E-04	6.19E-04	6.22E-04	6.20E-04	6.18E-04	6.19E-04	6.20E-04	6.21E-04	6.21E-04	6.22E-04	6.18E-04	6.20E-04
^{236}U	4.96E-05	5.01E-05	4.99E-05	4.99E-05	4.86E-05	5.04E-05	4.86E-05	5.02E-05	4.97E-05	4.92E-05	5.03E-05	4.86E-05	5.00E-05	4.82E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	2.01E-06	2.13E-06	2.16E-06	2.13E-06	1.93E-06	2.03E-06	2.25E-06	2.11E-06	2.12E-06	2.08E-06	2.03E-06	1.93E-06	2.15E-06	2.02E-06
^{238}Pu	1.85E-07	1.89E-07	1.92E-07	1.90E-07	1.74E-07	1.86E-07	2.01E-07	1.87E-07	1.86E-07	1.97E-07	1.85E-07	1.74E-07	1.90E-07	1.84E-07
^{239}Pu	7.93E-05	8.05E-05	7.84E-05	7.83E-05	8.01E-05	7.86E-05	8.20E-05	7.86E-05	7.83E-05	7.82E-05	8.01E-05	8.01E-05	7.89E-05	7.86E-05
^{240}Pu	1.35E-05	1.41E-05	1.39E-05	1.40E-05	1.37E-05	1.35E-05	1.43E-05	1.36E-05	1.36E-05	1.36E-05	1.37E-05	1.37E-05	1.36E-05	1.39E-05
^{241}Pu	2.56E-06	2.61E-06	2.62E-06	2.61E-06	2.64E-06	2.65E-06	2.64E-06	2.60E-06	2.58E-06	2.61E-06	2.67E-06	2.64E-06	2.60E-06	2.65E-06
^{242}Pu	4.91E-07	5.40E-07	5.49E-07	5.51E-07	5.09E-07	5.15E-07	5.02E-07	5.38E-07	5.29E-07	5.42E-07	5.19E-07	5.09E-07	5.41E-07	5.33E-07
^{241}Am	2.77E-06	2.85E-06	2.86E-06	2.84E-06	2.84E-06	2.85E-06	2.86E-06	2.84E-06	2.78E-06	2.81E-06	2.90E-06	2.84E-06	2.83E-06	2.86E-06
^{243}Am	2.91E-08	3.21E-08	3.25E-08	2.92E-08	2.61E-08	3.01E-08	2.46E-08	2.94E-08	3.11E-08	2.92E-08	3.04E-08	2.61E-08	3.20E-08	2.82E-08
^{244}Cm	1.25E-09	1.37E-09	1.39E-09	1.23E-09	1.13E-09	1.32E-09	9.63E-10	1.22E-09	1.32E-09	1.26E-09	1.33E-09	1.13E-09	1.37E-09	1.20E-09
^{90}Sr	9.72E-06	9.89E-06	1.00E-05	9.82E-06	9.92E-06	9.84E-06	9.79E-06	-	9.76E-06	9.75E-06	9.70E-06	9.92E-06	9.86E-06	9.96E-06
^{95}Mo	1.71E-05	1.73E-05	1.73E-05	1.73E-05	1.73E-05	1.72E-05	1.73E-05	1.69E-05	1.70E-05	1.70E-05	1.71E-05	1.73E-05	1.72E-05	1.74E-05
^{99}Tc	1.66E-05	1.73E-05	1.67E-05	1.68E-05	1.68E-05	1.66E-05	1.72E-05	1.64E-05	1.62E-05	1.63E-05	1.66E-05	1.68E-05	1.66E-05	1.69E-05
^{101}Ru	1.48E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.49E-05	1.49E-05	1.48E-05	1.46E-05	1.46E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05
^{103}Rh	9.51E-06	9.67E-06	9.66E-06	9.62E-06	9.42E-06	9.60E-06	9.60E-06	9.49E-06	9.64E-06	9.65E-06	9.63E-06	9.42E-06	9.57E-06	9.40E-06
^{109}Ag	6.89E-07	6.86E-07	4.70E-07	7.09E-07	6.36E-07	6.63E-07	6.55E-07	6.46E-07	7.43E-07	7.48E-07	6.71E-07	6.36E-07	4.94E-07	6.89E-07
^{129}I	1.95E-06	1.93E-06	1.97E-06	2.27E-06	1.99E-06	1.59E-06	1.91E-06	1.90E-06	2.42E-06	2.43E-06	1.59E-06	1.99E-06	1.97E-06	2.45E-06
^{131}Xe	7.68E-06	7.81E-06	7.81E-06	7.79E-06	7.74E-06	7.59E-06	7.76E-06	7.68E-06	7.75E-06	7.72E-06	7.60E-06	7.74E-06	7.78E-06	7.83E-06
^{133}Cs	1.82E-05	1.83E-05	1.82E-05	1.79E-05	1.79E-05	1.82E-05	1.83E-05	1.81E-05	1.82E-05	1.81E-05	1.82E-05	1.79E-05	1.82E-05	1.79E-05
^{134}Cs	3.49E-09	4.10E-09	4.13E-09	4.08E-09	4.27E-09	3.94E-09	4.66E-09	3.79E-09	4.04E-09	4.17E-09	3.92E-09	4.26E-09	4.14E-09	4.13E-09
^{137}Cs	1.22E-05	1.22E-05	1.25E-05	1.23E-05	1.22E-05	1.22E-05	1.23E-05	1.22E-05	1.20E-05	1.20E-05	1.22E-05	1.22E-05	1.22E-05	1.23E-05
^{144}Ce	1.39E-11	1.40E-11	1.41E-11	1.41E-11	1.35E-11	1.36E-11	1.42E-11	1.40E-11	1.34E-11	1.34E-11	1.44E-11	1.43E-11	1.41E-11	1.40E-11
^{143}Nd	1.45E-05	1.46E-05	1.45E-05	1.45E-05	1.45E-05	1.45E-05	1.46E-05	1.44E-05	1.44E-05	1.44E-05	1.45E-05	1.46E-05	1.45E-05	1.46E-05

Table 3.4(2). All results for Case 2c (40% void, 12 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.04E-05	1.03E-05	1.03E-05	1.03E-05	1.02E-05	1.02E-05	1.02E-05	1.03E-05	1.03E-05	1.03E-05	1.04E-05
^{148}Nd	4.79E-06	4.85E-06	4.83E-06	4.88E-06	4.87E-06	4.82E-06	4.83E-06	4.81E-06	4.85E-06	4.82E-06	4.82E-06	4.87E-06	4.82E-06	4.87E-06
^{147}Sm	5.15E-06	5.18E-06	5.14E-06	5.14E-06	5.13E-06	5.08E-06	5.02E-06	4.96E-06	5.18E-06	5.21E-06	5.08E-06	5.13E-06	5.13E-06	5.21E-06
^{149}Sm	1.10E-07	1.06E-07	1.06E-07	1.02E-07	1.09E-07	1.11E-07	1.11E-07	1.05E-07	1.03E-07	1.02E-07	1.12E-07	1.09E-07	1.06E-07	1.05E-07
^{150}Sm	3.28E-06	3.30E-06	3.30E-06	3.31E-06	3.26E-06	3.31E-06	3.32E-06	3.26E-06	3.24E-06	3.24E-06	3.31E-06	3.26E-06	3.29E-06	3.29E-06
^{151}Sm	3.05E-07	2.93E-07	2.98E-07	3.02E-07	3.16E-07	3.14E-07	2.99E-07	2.92E-07	2.99E-07	2.98E-07	3.15E-07	3.15E-07	2.91E-07	2.99E-07
^{152}Sm	1.63E-06	1.61E-06	1.60E-06	1.61E-06	1.66E-06	1.67E-06	1.70E-06	1.58E-06	1.63E-06	1.63E-06	1.67E-06	1.66E-06	1.60E-06	1.60E-06
^{153}Eu	8.76E-07	9.05E-07	9.06E-07	8.86E-07	8.56E-07	8.67E-07	8.56E-07	8.65E-07	9.25E-07	9.26E-07	8.67E-07	8.56E-07	9.03E-07	8.97E-07
^{154}Eu	2.88E-08	2.95E-08	2.94E-08	2.63E-08	2.65E-08	2.85E-08	2.62E-08	2.80E-08	2.98E-08	3.00E-08	2.85E-08	2.65E-08	2.95E-08	3.46E-08
^{155}Eu	4.32E-09	6.14E-09	6.15E-09	6.23E-09	5.15E-09	4.88E-09	6.30E-09	5.88E-09	7.00E-09	7.00E-09	4.31E-09	5.14E-09	6.11E-09	6.91E-09
^{155}Gd	1.71E-06	9.83E-07	1.24E-06	1.22E-06	1.22E-06	1.11E-06	9.37E-07	9.03E-07	1.07E-06	1.31E-06	1.16E-06	1.22E-06	1.15E-06	1.26E-06
^{156}Gd	9.45E-05	9.56E-05	9.53E-05	9.54E-05	9.55E-05	9.55E-05	9.56E-05	9.58E-05	9.54E-05	9.52E-05	9.55E-05	9.56E-05	9.53E-05	9.54E-05
^{157}Gd	4.47E-08	2.77E-08	3.50E-08	3.20E-08	3.08E-08	3.12E-08	3.19E-08	2.69E-08	3.14E-08	3.49E-08	3.18E-08	3.08E-08	3.21E-08	3.16E-08
^{158}Gd	1.06E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.4(3). All results for Case 2c (40% void, 12 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ^(r)
^{234}U	5.86E-06	5.87E-06	5.83E-06	5.87E-06	5.67E-06	5.92E-06	5.87E-06	5.86E-06	9.11E-08	1.55E-02
^{235}U	6.17E-04	6.18E-04	6.14E-04	6.18E-04	6.17E-04	6.20E-04	6.21E-04	6.19E-04	3.72E-06	6.02E-03
^{236}U	5.03E-05	5.02E-05	5.08E-05	5.01E-05	5.01E-05	4.94E-05	4.79E-05	4.98E-05	1.33E-06	2.67E-02
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	1.06E-05	4.98E-04
^{237}Np	2.18E-06	2.16E-06	2.22E-06	2.08E-06	2.16E-06	2.06E-06	1.88E-06	2.10E-06	1.60E-07	7.62E-02
^{238}Pu	1.93E-07	1.92E-07	2.10E-07	1.76E-07	1.92E-07	1.97E-07	1.66E-07	1.90E-07	1.75E-08	9.21E-02
^{239}Pu	8.16E-05	8.12E-05	8.07E-05	7.97E-05	7.89E-05	7.78E-05	7.83E-05	7.92E-05	3.11E-06	3.93E-02
^{240}Pu	1.42E-05	1.42E-05	1.40E-05	1.38E-05	1.37E-05	1.35E-05	1.37E-05	1.38E-05	5.57E-07	4.02E-02
^{241}Pu	2.66E-06	2.64E-06	2.72E-06	2.56E-06	2.56E-06	2.56E-06	2.58E-06	2.61E-06	8.66E-08	3.32E-02
^{242}Pu	5.50E-07	5.50E-07	5.78E-07	5.26E-07	5.36E-07	5.35E-07	5.13E-07	5.37E-07	3.91E-08	7.29E-02
^{241}Am	2.90E-06	2.88E-06	2.95E-06	2.79E-06	2.78E-06	2.79E-06	2.81E-06	2.84E-06	9.02E-08	3.18E-02
^{243}Am	3.22E-08	3.29E-08	3.18E-08	3.07E-08	3.01E-08	2.79E-08	2.67E-08	3.01E-08	4.64E-09	1.54E-01
^{244}Cm	1.39E-09	1.42E-09	1.39E-09	1.32E-09	1.30E-09	1.34E-09	1.18E-09	1.32E-09	2.12E-10	1.61E-01
^{90}Sr	9.90E-06	9.90E-06	9.87E-06	9.85E-06	9.80E-06	9.81E-06	1.00E-05	9.86E-06	1.68E-07	1.71E-02
^{95}Mo	1.73E-05	1.73E-05	1.76E-05	1.72E-05	1.55E-05	1.72E-05	1.72E-05	1.72E-05	6.49E-07	3.77E-02
^{99}Tc	1.72E-05	1.72E-05	1.70E-05	1.67E-05	1.67E-05	1.68E-05	1.67E-05	1.69E-05	5.80E-07	3.43E-02
^{101}Ru	1.50E-05	1.50E-05	1.53E-05	1.49E-05	1.49E-05	1.49E-05	1.46E-05	1.49E-05	2.50E-07	1.68E-02
^{103}Rh	9.70E-06	9.70E-06	9.89E-06	9.16E-06	9.48E-06	9.58E-06	9.50E-06	9.59E-06	2.50E-07	2.60E-02
^{109}Ag	6.96E-07	6.93E-07	7.41E-07	4.13E-07	6.51E-07	6.57E-07	8.00E-07	6.45E-07	2.03E-07	3.15E-01
^{129}I	1.97E-06	1.97E-06	2.28E-06	1.78E-06	1.89E-06	1.87E-06	2.30E-06	1.99E-06	4.07E-07	2.04E-01
^{131}Xe	7.85E-06	7.84E-06	7.84E-06	7.70E-06	7.77E-06	7.72E-06	7.72E-06	7.76E-06	1.40E-07	1.80E-02
^{133}Cs	1.83E-05	1.83E-05	1.83E-05	1.82E-05	1.81E-05	1.81E-05	1.82E-05	1.82E-05	3.63E-07	1.99E-02
^{134}Cs	4.20E-09	4.16E-09	4.30E-09	4.06E-09	4.08E-09	4.12E-09	3.85E-09	4.11E-09	3.66E-10	8.91E-02
^{137}Cs	1.23E-05	1.23E-05	1.25E-05	1.22E-05	1.23E-05	1.22E-05	1.24E-05	1.23E-05	2.46E-07	2.00E-02
^{144}Ce	1.42E-11	1.42E-11	1.42E-11	1.45E-11	1.38E-11	1.39E-11	1.39E-11	1.40E-11	6.25E-13	4.46E-02
^{143}Nd	1.47E-05	1.47E-05	1.48E-05	1.46E-05	1.46E-05	1.45E-05	1.45E-05	1.46E-05	1.79E-07	1.23E-02

Table 3.4(3). All results for Case 2c (40% void, 12 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	1.04E-05	1.04E-05	1.06E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.26E-07	1.22E-02
^{148}Nd	4.86E-06	4.86E-06	4.97E-06	4.83E-06	4.84E-06	4.78E-06	4.81E-06	4.83E-06	7.49E-08	1.55E-02
^{147}Sm	5.17E-06	5.18E-06	5.22E-06	5.16E-06	4.76E-06	5.18E-06	5.17E-06	5.14E-06	1.67E-07	3.24E-02
^{149}Sm	1.07E-07	1.07E-07	9.71E-08	1.07E-07	1.05E-07	1.04E-07	1.05E-07	1.05E-07	7.04E-09	6.68E-02
^{150}Sm	3.30E-06	3.31E-06	3.24E-06	3.29E-06	3.27E-06	3.27E-06	3.26E-06	3.28E-06	7.54E-08	2.30E-02
^{151}Sm	2.95E-07	2.94E-07	2.97E-07	2.94E-07	2.89E-07	2.89E-07	2.99E-07	2.99E-07	2.21E-08	7.39E-02
^{152}Sm	1.68E-06	1.64E-06	1.62E-06	1.60E-06	1.60E-06	1.59E-06	1.62E-06	1.63E-06	7.12E-08	4.38E-02
^{153}Eu	8.64E-07	8.92E-07	9.10E-07	9.00E-07	8.88E-07	8.94E-07	8.85E-07	8.87E-07	4.58E-08	5.16E-02
^{154}Eu	2.84E-08	2.92E-08	2.98E-08	2.93E-08	2.91E-08	2.86E-08	2.69E-08	2.87E-08	3.13E-09	1.09E-01
^{155}Eu	6.13E-09	6.14E-09	6.07E-09	6.08E-09	5.84E-09	5.98E-09	6.09E-09	5.93E-09	1.29E-09	2.18E-01
^{155}Gd	1.05E-06	1.04E-06	1.65E-06	1.00E-06	1.18E-06	1.24E-06	1.22E-06	1.19E-06	4.10E-07	3.45E-01
^{156}Gd	9.56E-05	9.49E-05	9.50E-05	9.53E-05	9.53E-05	9.53E-05	9.51E-05	9.54E-05	5.39E-07	5.65E-03
^{157}Gd	3.02E-08	3.10E-08	4.31E-08	3.01E-08	3.17E-08	3.27E-08	3.70E-08	3.29E-08	8.63E-09	2.63E-01
^{158}Gd	1.12E-04	1.11E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.96E-06	1.75E-02

Table 3.5(1). All results for Case 3b (70% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.80E-06	5.88E-06	5.80E-06	5.75E-06	5.84E-06	5.72E-06	5.76E-06	5.70E-06	5.76E-06	5.75E-06	5.74E-06	5.79E-06	5.75E-06	5.75E-06
^{235}U	6.25E-04	6.23E-04	6.26E-04	6.23E-04	6.25E-04	6.21E-04	6.24E-04	6.24E-04	6.23E-04	6.25E-04	6.26E-04	6.25E-04	6.23E-04	6.25E-04
^{236}U	5.07E-05	5.18E-05	5.05E-05	5.13E-05	5.04E-05	5.08E-05	5.12E-05	5.09E-05	5.13E-05	5.11E-05	5.11E-05	5.05E-05	5.12E-05	5.10E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	2.39E-06	2.35E-06	2.38E-06	2.45E-06	2.08E-06	2.43E-06	2.50E-06	2.43E-06	2.44E-06	2.47E-06	2.46E-06	2.43E-06	2.43E-06	2.49E-06
^{238}Pu	2.81E-07	2.71E-07	2.82E-07	2.67E-07	2.23E-07	2.66E-07	2.71E-07	2.72E-07	2.67E-07	2.71E-07	2.73E-07	2.89E-07	2.66E-07	2.71E-07
^{239}Pu	9.03E-05	8.82E-05	9.03E-05	9.01E-05	9.22E-05	9.24E-05	9.37E-05	9.35E-05	9.16E-05	8.95E-05	8.86E-05	8.99E-05	9.13E-05	9.17E-05
^{240}Pu	1.47E-05	1.44E-05	1.46E-05	1.47E-05	1.50E-05	1.50E-05	1.51E-05	1.54E-05	1.47E-05	1.52E-05	1.55E-05	1.50E-05	1.47E-05	1.47E-05
^{241}Pu	5.09E-06	4.89E-06	5.07E-06	4.99E-06	5.08E-06	5.08E-06	5.13E-06	4.84E-06	5.00E-06	5.14E-06	5.18E-06	5.18E-06	5.03E-06	5.05E-06
^{242}Pu	6.27E-07	6.02E-07	6.22E-07	6.06E-07	6.24E-07	6.23E-07	6.14E-07	5.91E-07	5.99E-07	6.37E-07	6.59E-07	6.46E-07	6.05E-07	6.05E-07
^{241}Am	1.50E-06	1.44E-06	1.50E-06	1.47E-06	1.50E-06	1.50E-06	1.52E-06	1.43E-06	1.48E-06	1.52E-06	1.52E-06	1.54E-06	1.49E-06	1.49E-06
^{243}Am	4.06E-08	3.64E-08	4.01E-08	4.28E-08	3.84E-08	4.58E-08	4.47E-08	4.37E-08	4.36E-08	4.62E-08	4.30E-08	4.24E-08	4.38E-08	4.39E-08
^{244}Cm	3.47E-09	3.03E-09	3.61E-09	3.23E-09	3.21E-09	3.47E-09	3.35E-09	3.15E-09	3.27E-09	3.48E-09	3.21E-09	3.65E-09	3.28E-09	3.29E-09
^{90}Sr	1.23E-05	1.24E-05	1.23E-05	1.24E-05	1.22E-05	1.22E-05	1.23E-05	1.24E-05	1.24E-05	1.23E-05	1.21E-05	1.24E-05	1.24E-05	1.25E-05
^{95}Mo	1.71E-05	1.71E-05	1.70E-05	1.71E-05	1.70E-05	1.70E-05	1.71E-05	1.71E-05	1.72E-05	1.71E-05	1.71E-05	1.71E-05	1.71E-05	1.71E-05
^{99}Tc	1.72E-05	1.72E-05	1.67E-05	1.71E-05	1.67E-05	1.70E-05	1.70E-05	1.71E-05	1.71E-05	1.69E-05	1.70E-05	1.71E-05	1.70E-05	1.67E-05
^{101}Ru	1.50E-05	1.49E-05	1.49E-05	1.50E-05	1.48E-05	1.49E-05	1.50E-05	1.50E-05	1.50E-05	1.49E-05	1.50E-05	1.50E-05	1.50E-05	1.49E-05
^{103}Rh	9.77E-06	9.78E-06	9.70E-06	9.74E-06	9.54E-06	9.74E-06	9.79E-06	9.79E-06	9.78E-06	9.78E-06	9.75E-06	9.79E-06	9.75E-06	9.79E-06
^{109}Ag	7.28E-07	7.15E-07	7.18E-07	7.34E-07	3.71E-07	7.45E-07	7.49E-07	7.37E-07	7.36E-07	5.17E-07	7.92E-07	7.45E-07	7.35E-07	5.06E-07
^{129}I	1.92E-06	1.92E-06	1.93E-06	2.00E-06	1.85E-06	2.00E-06	2.01E-06	2.01E-06	2.00E-06	1.97E-06	2.26E-06	1.93E-06	2.00E-06	2.02E-06
^{131}Xe	7.69E-06	7.71E-06	7.64E-06	7.77E-06	7.55E-06	7.71E-06	7.75E-06	7.70E-06	7.78E-06	7.72E-06	7.68E-06	7.69E-06	7.75E-06	7.76E-06
^{133}Cs	1.86E-05	1.86E-05	1.80E-05	1.82E-05	1.80E-05	1.81E-05	1.81E-05	1.82E-05	1.82E-05	1.84E-05	1.81E-05	1.81E-05	1.82E-05	1.81E-05
^{134}Cs	1.40E-07	1.35E-07	1.36E-07	1.35E-07	1.30E-07	1.33E-07	1.35E-07	1.25E-07	1.35E-07	1.36E-07	1.35E-07	1.33E-07	1.35E-07	1.35E-07
^{137}Cs	1.55E-05	1.55E-05	1.53E-05	1.54E-05	1.53E-05	1.54E-05	1.54E-05	1.55E-05	1.55E-05	1.54E-05	1.52E-05	1.55E-05	1.54E-05	1.58E-05
^{144}Ce	1.00E-07	1.01E-07	1.00E-07	1.01E-07	9.96E-08	1.00E-07	1.00E-07	1.01E-07	1.01E-07	1.00E-07	1.00E-07	9.37E-08	1.01E-07	1.00E-07
^{143}Nd	1.45E-05	1.46E-05	1.45E-05	1.46E-05	1.44E-05	1.45E-05	1.46E-05	1.46E-05	1.46E-05	1.46E-05	1.47E-05	1.45E-05	1.46E-05	1.44E-05

Table 3.5(1). All results for Case 3b (70% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	1.02E-05	1.03E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.03E-05	1.03E-05	1.02E-05	1.03E-05	1.03E-05	1.02E-05	1.02E-05
^{148}Nd	4.79E-06	4.81E-06	4.79E-06	4.85E-06	4.77E-06	4.82E-06	4.85E-06	4.83E-06	4.86E-06	4.84E-06	4.90E-06	4.81E-06	4.85E-06	4.84E-06
^{147}Sm	4.00E-06	3.98E-06	3.97E-06	3.96E-06	3.92E-06	3.94E-06	3.96E-06	3.98E-06	3.98E-06	3.96E-06	3.97E-06	4.01E-06	3.97E-06	3.94E-06
^{149}Sm	1.13E-07	1.12E-07	1.17E-07	1.18E-07	1.17E-07	1.18E-07	1.20E-07	1.25E-07	1.20E-07	1.14E-07	1.13E-07	1.14E-07	1.19E-07	1.21E-07
^{150}Sm	3.26E-06	3.20E-06	3.31E-06	3.32E-06	3.22E-06	3.30E-06	3.33E-06	3.42E-06	3.33E-06	3.25E-06	3.30E-06	3.27E-06	3.32E-06	3.33E-06
^{151}Sm	3.51E-07	3.64E-07	3.52E-07	3.52E-07	3.68E-07	3.55E-07	3.59E-07	4.11E-07	3.56E-07	3.61E-07	3.73E-07	3.57E-07	3.55E-07	3.57E-07
^{152}Sm	1.54E-06	1.70E-06	1.53E-06	1.62E-06	1.56E-06	1.58E-06	1.54E-06	1.56E-06	1.58E-06	1.54E-06	1.55E-06	1.54E-06	1.58E-06	1.54E-06
^{153}Eu	9.57E-07	8.50E-07	9.51E-07	9.06E-07	9.48E-07	9.30E-07	9.60E-07	9.23E-07	9.35E-07	9.58E-07	9.41E-07	9.59E-07	9.34E-07	9.60E-07
^{154}Eu	7.82E-08	6.93E-08	7.87E-08	7.49E-08	7.56E-08	7.70E-08	7.92E-08	7.45E-08	7.75E-08	7.87E-08	7.12E-08	7.77E-08	7.71E-08	7.95E-08
^{155}Eu	2.68E-08	2.58E-08	2.65E-08	2.68E-08	2.67E-08	2.68E-08	2.72E-08	1.94E-08	2.69E-08	2.71E-08	2.75E-08	2.74E-08	2.67E-08	2.73E-08
^{155}Gd	2.09E-06	2.10E-06	2.15E-06	1.69E-06	2.60E-06	1.72E-06	2.02E-06	2.37E-06	2.13E-06	1.62E-06	1.64E-06	1.87E-06	2.31E-06	2.09E-06
^{156}Gd	9.42E-05	9.44E-05	9.41E-05	9.48E-05	9.38E-05	9.48E-05	9.44E-05	9.41E-05	9.43E-05	9.46E-05	9.48E-05	9.44E-05	9.41E-05	9.42E-05
^{157}Gd	6.61E-08	5.75E-08	6.88E-08	4.44E-08	8.68E-08	4.59E-08	5.40E-08	8.36E-08	7.04E-08	5.05E-08	4.77E-08	6.21E-08	8.29E-08	7.85E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.5(2). All results for Case 3b (70% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.71E-06	5.76E-06	5.75E-06	5.74E-06	5.76E-06	5.75E-06	5.76E-06	5.78E-06	5.76E-06	5.79E-06	5.76E-06	5.76E-06	5.75E-06	5.70E-06
^{235}U	6.26E-04	6.25E-04	6.25E-04	6.25E-04	6.28E-04	6.26E-04	6.26E-04	6.25E-04	6.26E-04	6.27E-04	6.27E-04	6.28E-04	6.24E-04	6.27E-04
^{236}U	5.08E-05	5.12E-05	5.10E-05	5.10E-05	4.95E-05	5.16E-05	4.98E-05	5.14E-05	5.08E-05	5.02E-05	5.15E-05	4.95E-05	5.11E-05	4.90E-05
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02
^{237}Np	2.34E-06	2.45E-06	2.49E-06	2.46E-06	2.24E-06	2.35E-06	2.71E-06	2.47E-06	2.45E-06	2.40E-06	2.35E-06	2.24E-06	2.48E-06	2.34E-06
^{238}Pu	2.56E-07	2.66E-07	2.71E-07	2.69E-07	2.44E-07	2.60E-07	2.93E-07	2.64E-07	2.63E-07	2.77E-07	2.59E-07	2.44E-07	2.69E-07	2.59E-07
^{239}Pu	9.06E-05	9.31E-05	9.06E-05	9.05E-05	9.18E-05	8.98E-05	9.74E-05	8.99E-05	9.04E-05	9.03E-05	9.18E-05	9.18E-05	9.10E-05	9.08E-05
^{240}Pu	1.44E-05	1.51E-05	1.49E-05	1.50E-05	1.45E-05	1.43E-05	1.56E-05	1.45E-05	1.46E-05	1.46E-05	1.46E-05	1.45E-05	1.47E-05	1.50E-05
^{241}Pu	4.91E-06	5.09E-06	5.10E-06	5.07E-06	5.06E-06	5.08E-06	5.39E-06	5.04E-06	5.00E-06	5.07E-06	5.14E-06	5.06E-06	5.05E-06	5.13E-06
^{242}Pu	5.50E-07	6.12E-07	6.22E-07	6.26E-07	5.73E-07	5.79E-07	5.89E-07	6.11E-07	6.03E-07	6.19E-07	5.83E-07	5.73E-07	6.16E-07	6.04E-07
^{241}Am	1.44E-06	1.50E-06	1.51E-06	1.49E-06	1.48E-06	1.49E-06	1.58E-06	1.49E-06	1.47E-06	1.48E-06	1.51E-06	1.48E-06	1.49E-06	1.50E-06
^{243}Am	3.93E-08	4.45E-08	4.49E-08	4.04E-08	3.55E-08	4.10E-08	3.51E-08	4.06E-08	4.33E-08	4.05E-08	4.14E-08	3.56E-08	4.45E-08	3.88E-08
^{244}Cm	2.93E-09	3.32E-09	3.37E-09	2.99E-09	2.70E-09	3.15E-09	2.39E-09	2.96E-09	3.38E-09	3.19E-09	3.17E-09	2.70E-09	3.34E-09	2.90E-09
^{90}Sr	1.22E-05	1.23E-05	1.25E-05	1.23E-05	1.24E-05	1.23E-05	1.22E-05	-	1.22E-05	1.21E-05	1.22E-05	1.24E-05	1.23E-05	1.24E-05
^{95}Mo	1.70E-05	1.71E-05	1.71E-05	1.72E-05	1.72E-05	1.70E-05	1.70E-05	1.67E-05	1.68E-05	1.68E-05	1.70E-05	1.72E-05	1.71E-05	1.72E-05
^{99}Tc	1.66E-05	1.71E-05	1.67E-05	1.67E-05	1.67E-05	1.65E-05	1.71E-05	1.62E-05	1.62E-05	1.62E-05	1.65E-05	1.67E-05	1.66E-05	1.68E-05
^{101}Ru	1.48E-05	1.50E-05	1.49E-05	1.50E-05	1.49E-05	1.49E-05	1.49E-05	1.48E-05	1.46E-05	1.46E-05	1.49E-05	1.49E-05	1.49E-05	1.50E-05
^{103}Rh	9.62E-06	9.78E-06	9.80E-06	9.72E-06	9.52E-06	9.73E-06	9.73E-06	9.59E-06	9.73E-06	9.74E-06	9.76E-06	9.52E-06	9.70E-06	9.50E-06
^{109}Ag	7.46E-07	7.46E-07	5.09E-07	7.67E-07	6.86E-07	7.16E-07	7.21E-07	6.99E-07	8.12E-07	8.17E-07	7.25E-07	6.86E-07	5.39E-07	7.50E-07
^{129}I	2.00E-06	1.98E-06	2.02E-06	2.31E-06	2.00E-06	1.63E-06	1.96E-06	1.94E-06	2.48E-06	2.48E-06	1.63E-06	2.00E-06	2.03E-06	2.48E-06
^{131}Xe	7.60E-06	7.73E-06	7.75E-06	7.73E-06	7.66E-06	7.50E-06	7.65E-06	7.60E-06	7.69E-06	7.66E-06	7.51E-06	7.66E-06	7.72E-06	7.77E-06
^{133}Cs	1.81E-05	1.82E-05	1.81E-05	1.78E-05	1.78E-05	1.81E-05	1.83E-05	1.79E-05	1.81E-05	1.80E-05	1.81E-05	1.78E-05	1.81E-05	1.78E-05
^{134}Cs	1.12E-07	1.33E-07	1.34E-07	1.32E-07	1.40E-07	1.29E-07	1.55E-07	1.22E-07	1.32E-07	1.35E-07	1.28E-07	1.40E-07	1.34E-07	1.35E-07
^{137}Cs	1.53E-05	1.53E-05	1.58E-05	1.55E-05	1.54E-05	1.54E-05	1.54E-05	1.53E-05	1.51E-05	1.51E-05	1.54E-05	1.54E-05	1.54E-05	1.55E-05
^{144}Ce	9.95E-08	1.01E-07	1.00E-07	9.98E-08	9.84E-08	9.92E-08	1.01E-07	9.98E-08	9.75E-08	9.74E-08	9.98E-08	9.91E-08	1.00E-07	9.96E-08
^{143}Nd	1.45E-05	1.46E-05	1.44E-05	1.45E-05	1.45E-05	1.44E-05	1.46E-05	1.43E-05	1.44E-05	1.44E-05	1.45E-05	1.45E-05	1.44E-05	1.46E-05
^{145}Nd	1.02E-05	1.02E-05	1.02E-05	1.03E-05	1.03E-05	1.02E-05	1.02E-05	1.01E-05	1.01E-05	1.01E-05	1.02E-05	1.03E-05	1.02E-05	1.03E-05

Table 3.5(2). All results for Case 3b (70% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{148}Nd	4.80E-06	4.84E-06	4.84E-06	4.90E-06	4.89E-06	4.83E-06	4.82E-06	4.81E-06	4.86E-06	4.84E-06	4.83E-06	4.89E-06	4.83E-06	4.88E-06
^{147}Sm	3.96E-06	3.97E-06	3.94E-06	3.95E-06	3.93E-06	3.89E-06	3.82E-06	3.77E-06	3.97E-06	3.99E-06	3.89E-06	3.93E-06	3.94E-06	4.00E-06
^{149}Sm	1.24E-07	1.19E-07	1.20E-07	1.16E-07	1.24E-07	1.26E-07	1.31E-07	1.18E-07	1.15E-07	1.15E-07	1.27E-07	1.24E-07	1.19E-07	1.19E-07
^{150}Sm	3.32E-06	3.33E-06	3.33E-06	3.37E-06	3.31E-06	3.35E-06	3.35E-06	3.29E-06	3.27E-06	3.26E-06	3.35E-06	3.31E-06	3.33E-06	3.35E-06
^{151}Sm	3.71E-07	3.56E-07	3.62E-07	3.67E-07	3.87E-07	3.84E-07	3.76E-07	3.53E-07	3.64E-07	3.62E-07	3.86E-07	3.87E-07	3.54E-07	3.65E-07
^{152}Sm	1.58E-06	1.55E-06	1.54E-06	1.55E-06	1.63E-06	1.64E-06	1.67E-06	1.52E-06	1.58E-06	1.57E-06	1.64E-06	1.63E-06	1.54E-06	1.54E-06
^{153}Eu	9.21E-07	9.56E-07	9.59E-07	9.41E-07	8.95E-07	9.05E-07	8.90E-07	9.10E-07	9.79E-07	9.79E-07	9.06E-07	8.95E-07	9.55E-07	9.51E-07
^{154}Eu	7.67E-08	7.87E-08	7.87E-08	7.13E-08	7.07E-08	7.58E-08	6.98E-08	7.45E-08	7.95E-08	7.99E-08	7.57E-08	7.07E-08	7.89E-08	9.06E-08
^{155}Eu	1.93E-08	2.72E-08	2.73E-08	2.77E-08	2.10E-08	1.99E-08	2.86E-08	2.60E-08	2.91E-08	2.91E-08	1.92E-08	2.10E-08	2.71E-08	3.26E-08
^{155}Gd	2.53E-06	1.93E-06	2.01E-06	1.97E-06	2.06E-06	1.91E-06	2.31E-06	1.58E-06	1.81E-06	2.13E-06	1.98E-06	2.06E-06	1.86E-06	2.01E-06
^{156}Gd	9.35E-05	9.45E-05	9.42E-05	9.45E-05	9.46E-05	9.46E-05	9.40E-05	9.50E-05	9.44E-05	9.41E-05	9.45E-05	9.46E-05	9.44E-05	9.44E-05
^{157}Gd	9.49E-08	5.21E-08	6.77E-08	6.16E-08	5.85E-08	5.55E-08	6.79E-08	4.62E-08	5.85E-08	6.89E-08	5.83E-08	5.85E-08	6.07E-08	6.16E-08
^{158}Gd	1.07E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.5(3). All results for Case 3b (70% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	$2^*\sigma^{(r)}$
^{234}U	5.76E-06	5.76E-06	5.71E-06	5.77E-06	5.55E-06	5.81E-06	5.76E-06	5.76E-06	1.01E-07	1.75E-02
^{235}U	6.24E-04	6.25E-04	6.20E-04	6.25E-04	6.23E-04	6.26E-04	6.27E-04	6.25E-04	3.50E-06	5.60E-03
^{236}U	5.13E-05	5.12E-05	5.18E-05	5.11E-05	5.11E-05	5.03E-05	4.87E-05	5.08E-05	1.47E-06	2.90E-02
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	8.81E-06	4.14E-04
^{237}Np	2.51E-06	2.48E-06	2.56E-06	2.37E-06	2.48E-06	2.35E-06	2.17E-06	2.41E-06	2.24E-07	9.27E-02
^{238}Pu	2.72E-07	2.69E-07	2.93E-07	2.46E-07	2.69E-07	2.75E-07	2.35E-07	2.66E-07	2.94E-08	1.11E-01
^{239}Pu	9.45E-05	9.36E-05	9.29E-05	9.17E-05	9.07E-05	8.93E-05	9.04E-05	9.13E-05	3.61E-06	3.95E-02
^{240}Pu	1.52E-05	1.52E-05	1.50E-05	1.49E-05	1.47E-05	1.45E-05	1.47E-05	1.48E-05	6.45E-07	4.35E-02
^{241}Pu	5.18E-06	5.12E-06	5.26E-06	4.90E-06	4.97E-06	4.97E-06	5.03E-06	5.07E-06	2.10E-07	4.15E-02
^{242}Pu	6.23E-07	6.20E-07	6.55E-07	5.86E-07	6.11E-07	6.09E-07	5.85E-07	6.09E-07	4.63E-08	7.60E-02
^{241}Am	1.53E-06	1.51E-06	1.55E-06	1.45E-06	1.46E-06	1.47E-06	1.48E-06	1.49E-06	6.13E-08	4.11E-02
^{243}Am	4.42E-08	4.53E-08	4.38E-08	4.16E-08	4.16E-08	3.84E-08	3.70E-08	4.15E-08	6.25E-09	1.51E-01
^{244}Cm	3.34E-09	3.41E-09	3.36E-09	3.15E-09	3.15E-09	3.23E-09	2.83E-09	3.19E-09	5.32E-10	1.67E-01
^{90}Sr	1.23E-05	1.24E-05	1.23E-05	1.23E-05	1.23E-05	1.23E-05	1.25E-05	1.23E-05	1.96E-07	1.59E-02
^{95}Mo	1.71E-05	1.71E-05	1.74E-05	1.70E-05	1.71E-05	1.70E-05	1.70E-05	1.71E-05	2.33E-07	1.36E-02
^{99}Tc	1.71E-05	1.71E-05	1.70E-05	1.66E-05	1.66E-05	1.67E-05	1.66E-05	1.68E-05	5.63E-07	3.35E-02
^{101}Ru	1.50E-05	1.50E-05	1.53E-05	1.49E-05	1.49E-05	1.49E-05	1.46E-05	1.49E-05	2.47E-07	1.66E-02
^{103}Rh	9.82E-06	9.81E-06	1.00E-05	9.28E-06	9.61E-06	9.71E-06	9.62E-06	9.71E-06	2.53E-07	2.60E-02
^{109}Ag	7.56E-07	7.51E-07	8.02E-07	4.47E-07	7.06E-07	7.13E-07	8.68E-07	7.00E-07	2.20E-07	3.14E-01
^{129}I	2.02E-06	2.01E-06	2.31E-06	1.82E-06	1.94E-06	1.91E-06	2.33E-06	2.03E-06	4.06E-07	2.00E-01
^{131}Xe	7.77E-06	7.76E-06	7.77E-06	7.60E-06	7.71E-06	7.65E-06	7.65E-06	7.69E-06	1.48E-07	1.93E-02
^{133}Cs	1.82E-05	1.82E-05	1.82E-05	1.81E-05	1.80E-05	1.80E-05	1.81E-05	1.81E-05	3.63E-07	2.00E-02
^{134}Cs	1.36E-07	1.34E-07	1.39E-07	1.31E-07	1.33E-07	1.33E-07	1.25E-07	1.33E-07	1.31E-08	9.84E-02
^{137}Cs	1.55E-05	1.55E-05	1.57E-05	1.54E-05	1.55E-05	1.53E-05	1.56E-05	1.54E-05	3.04E-07	1.97E-02
^{144}Ce	1.01E-07	1.01E-07	1.02E-07	1.00E-07	1.01E-07	9.99E-08	9.97E-08	9.99E-08	2.80E-09	2.81E-02
^{143}Nd	1.46E-05	1.46E-05	1.47E-05	1.45E-05	1.45E-05	1.45E-05	1.45E-05	1.45E-05	1.76E-07	1.21E-02

Table 3.5(3). All results for Case 3b (70% void, 12 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.02E-05	1.02E-05	1.05E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.27E-07	1.24E-02
^{148}Nd	4.86E-06	4.86E-06	4.98E-06	4.83E-06	4.85E-06	4.79E-06	4.81E-06	4.84E-06	7.70E-08	1.59E-02
^{147}Sm	3.96E-06	3.97E-06	4.01E-06	3.90E-06	3.63E-06	3.98E-06	3.97E-06	3.94E-06	1.45E-07	3.68E-02
^{149}Sm	1.20E-07	1.20E-07	1.09E-07	1.19E-07	1.18E-07	1.16E-07	1.18E-07	1.19E-07	9.08E-09	7.65E-02
^{150}Sm	3.32E-06	3.33E-06	3.27E-06	3.32E-06	3.31E-06	3.31E-06	3.29E-06	3.31E-06	8.31E-08	2.51E-02
^{151}Sm	3.60E-07	3.58E-07	3.61E-07	3.57E-07	3.50E-07	3.49E-07	3.63E-07	3.64E-07	2.67E-08	7.33E-02
^{152}Sm	1.63E-06	1.59E-06	1.56E-06	1.54E-06	1.54E-06	1.54E-06	1.57E-06	1.57E-06	8.69E-08	5.52E-02
^{153}Eu	9.06E-07	9.37E-07	9.63E-07	9.48E-07	9.37E-07	9.44E-07	9.35E-07	9.35E-07	5.62E-08	6.01E-02
^{154}Eu	7.52E-08	7.74E-08	7.97E-08	7.81E-08	7.76E-08	7.61E-08	7.27E-08	7.65E-08	7.89E-09	1.03E-01
^{155}Eu	2.71E-08	2.71E-08	2.69E-08	2.68E-08	2.65E-08	2.65E-08	2.68E-08	2.60E-08	6.10E-09	2.34E-01
^{155}Gd	1.83E-06	1.74E-06	2.44E-06	1.79E-06	2.02E-06	2.06E-06	2.01E-06	2.01E-06	4.98E-07	2.48E-01
^{156}Gd	9.46E-05	9.40E-05	9.40E-05	9.43E-05	9.42E-05	9.43E-05	9.40E-05	9.43E-05	6.19E-07	6.57E-03
^{157}Gd	5.67E-08	5.64E-08	9.67E-08	5.43E-08	6.14E-08	6.34E-08	7.12E-08	6.37E-08	2.63E-08	4.12E-01
^{158}Gd	1.12E-04	1.11E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.82E-06	1.63E-02

Table 3.6(1). All results for Case 5b (40% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.37E-06	5.46E-06	5.37E-06	5.30E-06	5.37E-06	5.27E-06	5.30E-06	5.23E-06	5.30E-06	5.30E-06	5.30E-06	5.36E-06	5.30E-06	5.30E-06
^{235}U	4.71E-04	4.67E-04	4.72E-04	4.66E-04	4.73E-04	4.65E-04	4.69E-04	4.70E-04	4.68E-04	4.72E-04	4.73E-04	4.71E-04	4.68E-04	4.71E-04
^{236}U	7.43E-05	7.57E-05	7.40E-05	7.54E-05	7.39E-05	7.46E-05	7.50E-05	7.48E-05	7.51E-05	7.46E-05	7.45E-05	7.41E-05	7.51E-05	7.46E-05
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02
^{237}Np	4.03E-06	3.99E-06	4.01E-06	4.11E-06	3.95E-06	4.04E-06	4.19E-06	4.16E-06	4.14E-06	4.12E-06	4.14E-06	4.09E-06	4.09E-06	4.18E-06
^{238}Pu	7.52E-07	7.31E-07	7.52E-07	6.96E-07	6.78E-07	6.89E-07	7.05E-07	7.31E-07	7.01E-07	7.01E-07	7.17E-07	7.69E-07	6.94E-07	6.99E-07
^{239}Pu	9.35E-05	9.09E-05	9.37E-05	9.30E-05	9.44E-05	9.45E-05	9.73E-05	1.00E-04	9.71E-05	9.18E-05	9.02E-05	9.25E-05	9.58E-05	9.54E-05
^{240}Pu	2.62E-05	2.56E-05	2.60E-05	2.63E-05	2.61E-05	2.66E-05	2.71E-05	2.81E-05	2.69E-05	2.69E-05	2.75E-05	2.65E-05	2.68E-05	2.61E-05
^{241}Pu	9.40E-06	9.05E-06	9.35E-06	9.29E-06	9.44E-06	9.35E-06	9.55E-06	9.47E-06	9.43E-06	9.44E-06	9.48E-06	9.54E-06	9.41E-06	9.49E-06
^{242}Pu	2.28E-06	2.21E-06	2.25E-06	2.23E-06	2.22E-06	2.26E-06	2.26E-06	2.28E-06	2.22E-06	2.30E-06	2.38E-06	2.34E-06	2.24E-06	2.21E-06
^{241}Am	2.89E-06	2.78E-06	2.87E-06	2.87E-06	2.90E-06	2.89E-06	2.95E-06	2.93E-06	2.91E-06	2.92E-06	2.90E-06	2.94E-06	2.91E-06	2.93E-06
^{243}Am	2.03E-07	1.85E-07	2.01E-07	2.20E-07	1.94E-07	2.29E-07	2.27E-07	2.36E-07	2.24E-07	2.30E-07	2.14E-07	2.11E-07	2.25E-07	2.22E-07
^{244}Cm	2.47E-08	2.19E-08	2.44E-08	2.36E-08	2.35E-08	2.48E-08	2.42E-08	2.39E-08	2.40E-08	2.47E-08	2.28E-08	2.57E-08	2.40E-08	2.38E-08
^{90}Sr	1.97E-05	1.98E-05	1.96E-05	1.99E-05	1.96E-05	1.97E-05	1.98E-05	1.98E-05	1.99E-05	1.97E-05	1.94E-05	1.99E-05	1.98E-05	2.01E-05
^{95}Mo	2.79E-05	2.80E-05	2.78E-05	2.81E-05	2.77E-05	2.79E-05	2.80E-05	2.80E-05	2.81E-05	2.78E-05	2.79E-05	2.80E-05	2.80E-05	2.80E-05
^{99}Tc	2.81E-05	2.80E-05	2.74E-05	2.79E-05	2.73E-05	2.79E-05	2.80E-05	2.82E-05	2.81E-05	2.76E-05	2.77E-05	2.80E-05	2.80E-05	2.73E-05
^{101}Ru	2.49E-05	2.49E-05	2.48E-05	2.50E-05	2.47E-05	2.48E-05	2.50E-05	2.51E-05	2.50E-05	2.48E-05	2.50E-05	2.49E-05	2.50E-05	2.49E-05
^{103}Rh	1.58E-05	1.58E-05	1.56E-05	1.57E-05	1.54E-05	1.57E-05	1.58E-05	1.59E-05	1.59E-05	1.57E-05	1.57E-05	1.58E-05	1.58E-05	1.57E-05
^{109}Ag	1.46E-06	1.44E-06	1.44E-06	1.47E-06	7.58E-07	1.48E-06	1.50E-06	1.51E-06	1.49E-06	1.02E-06	1.59E-06	1.49E-06	1.49E-06	1.01E-06
^{129}I	3.29E-06	3.27E-06	3.29E-06	3.43E-06	3.17E-06	3.42E-06	3.44E-06	3.46E-06	3.44E-06	3.36E-06	3.86E-06	3.29E-06	3.43E-06	3.43E-06
^{131}Xe	1.23E-05	1.24E-05	1.22E-05	1.25E-05	1.20E-05	1.24E-05	1.24E-05	1.23E-05	1.25E-05	1.23E-05	1.23E-05	1.23E-05	1.25E-05	1.24E-05
^{133}Cs	3.02E-05	3.03E-05	2.94E-05	2.97E-05	2.93E-05	2.96E-05	2.97E-05	2.99E-05	2.98E-05	3.00E-05	2.96E-05	2.96E-05	2.97E-05	2.96E-05
^{134}Cs	3.00E-07	2.90E-07	2.91E-07	2.91E-07	2.89E-07	2.88E-07	2.91E-07	2.71E-07	2.91E-07	2.89E-07	2.87E-07	2.87E-07	2.89E-07	2.88E-07
^{137}Cs	2.55E-05	2.55E-05	2.53E-05	2.56E-05	2.53E-05	2.55E-05	2.56E-05	2.57E-05	2.57E-05	2.54E-05	2.51E-05	2.55E-05	2.56E-05	2.61E-05
^{144}Ce	1.23E-07	1.23E-07	1.22E-07	1.23E-07	1.21E-07	1.23E-07	1.23E-07	1.24E-07	1.24E-07	1.22E-07	1.22E-07	1.14E-07	1.23E-07	1.22E-07
^{143}Nd	2.23E-05	2.23E-05	2.22E-05	2.24E-05	2.22E-05	2.22E-05	2.24E-05	2.24E-05	2.24E-05	2.24E-05	2.24E-05	2.23E-05	2.24E-05	2.21E-05

Table 3.6(1). All results for Case 5b (40% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	1.66E-05	1.66E-05	1.65E-05	1.66E-05	1.64E-05	1.65E-05	1.66E-05	1.67E-05	1.66E-05	1.65E-05	1.67E-05	1.66E-05	1.66E-05	1.65E-05
^{148}Nd	7.94E-06	7.97E-06	7.94E-06	8.07E-06	7.92E-06	8.03E-06	8.06E-06	8.02E-06	8.09E-06	8.01E-06	8.09E-06	7.97E-06	8.06E-06	8.03E-06
^{147}Sm	6.31E-06	6.25E-06	6.26E-06	6.26E-06	6.19E-06	6.23E-06	6.25E-06	6.26E-06	6.28E-06	6.23E-06	6.24E-06	6.31E-06	6.26E-06	6.21E-06
^{149}Sm	9.34E-08	9.26E-08	1.02E-07	1.02E-07	1.04E-07	1.03E-07	1.05E-07	1.10E-07	1.04E-07	9.81E-08	9.76E-08	9.80E-08	1.03E-07	1.04E-07
^{150}Sm	5.64E-06	5.52E-06	5.67E-06	5.73E-06	5.51E-06	5.68E-06	5.73E-06	5.91E-06	5.73E-06	5.51E-06	5.60E-06	5.55E-06	5.71E-06	5.71E-06
^{151}Sm	3.25E-07	3.40E-07	3.27E-07	3.26E-07	3.57E-07	3.28E-07	3.34E-07	3.95E-07	3.34E-07	3.36E-07	3.49E-07	3.31E-07	3.31E-07	3.32E-07
^{152}Sm	2.63E-06	2.97E-06	2.62E-06	2.69E-06	2.69E-06	2.67E-06	2.65E-06	2.65E-06	2.69E-06	2.63E-06	2.66E-06	2.62E-06	2.68E-06	2.63E-06
^{153}Eu	1.85E-06	1.67E-06	1.84E-06	1.86E-06	1.87E-06	1.85E-06	1.87E-06	1.88E-06	1.86E-06	1.85E-06	1.83E-06	1.86E-06	1.85E-06	1.86E-06
^{154}Eu	1.72E-07	1.53E-07	1.72E-07	1.71E-07	1.73E-07	1.72E-07	1.76E-07	1.68E-07	1.75E-07	1.71E-07	1.51E-07	1.70E-07	1.72E-07	1.75E-07
^{155}Eu	5.07E-08	4.78E-08	5.01E-08	5.10E-08	5.04E-08	5.09E-08	5.17E-08	3.70E-08	5.15E-08	5.09E-08	5.21E-08	5.19E-08	5.11E-08	5.15E-08
^{155}Gd	8.71E-08	8.32E-08	8.64E-08	8.15E-08	8.80E-08	8.17E-08	8.29E-08	6.90E-08	8.27E-08	8.31E-08	8.81E-08	8.63E-08	8.20E-08	8.33E-08
^{156}Gd	9.61E-05	9.64E-05	9.61E-05	9.63E-05	9.62E-05	9.63E-05	9.63E-05	9.63E-05	9.62E-05	9.61E-05	9.63E-05	9.60E-05	9.62E-05	9.61E-05
^{157}Gd	2.71E-08	2.24E-08	2.69E-08	2.18E-08	2.54E-08	2.14E-08	2.27E-08	2.39E-08	2.32E-08	2.53E-08	2.41E-08	2.76E-08	2.29E-08	2.51E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.6(2). All results for Case 5b (40% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.23E-06	5.31E-06	5.30E-06	5.30E-06	5.30E-06	5.29E-06	5.27E-06	5.35E-06	5.31E-06	5.37E-06	5.30E-06	5.30E-06	5.30E-06	5.24E-06
^{235}U	4.73E-04	4.69E-04	4.71E-04	4.71E-04	4.76E-04	4.73E-04	4.70E-04	4.69E-04	4.72E-04	4.73E-04	4.75E-04	4.76E-04	4.70E-04	4.73E-04
^{236}U	7.42E-05	7.50E-05	7.46E-05	7.45E-05	7.25E-05	7.52E-05	7.24E-05	7.53E-05	7.43E-05	7.36E-05	7.50E-05	7.25E-05	7.47E-05	7.21E-05
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02
^{237}Np	3.97E-06	4.10E-06	4.16E-06	4.16E-06	3.88E-06	4.01E-06	4.56E-06	4.15E-06	4.10E-06	4.05E-06	4.00E-06	3.87E-06	4.15E-06	3.98E-06
^{238}Pu	6.86E-07	6.92E-07	7.01E-07	7.09E-07	6.69E-07	7.00E-07	7.79E-07	6.86E-07	6.81E-07	7.45E-07	6.96E-07	6.67E-07	6.96E-07	6.96E-07
^{239}Pu	9.56E-05	9.65E-05	9.35E-05	9.34E-05	9.66E-05	9.45E-05	9.97E-05	9.40E-05	9.39E-05	9.37E-05	9.64E-05	9.66E-05	9.46E-05	9.39E-05
^{240}Pu	2.60E-05	2.70E-05	2.65E-05	2.67E-05	2.60E-05	2.55E-05	2.69E-05	2.61E-05	2.61E-05	2.59E-05	2.61E-05	2.61E-05	2.61E-05	2.66E-05
^{241}Pu	9.31E-06	9.47E-06	9.54E-06	9.48E-06	9.68E-06	9.74E-06	1.02E-05	9.50E-06	9.29E-06	9.36E-06	9.73E-06	9.57E-06	9.37E-06	9.47E-06
^{242}Pu	2.06E-06	2.24E-06	2.27E-06	2.28E-06	2.13E-06	2.15E-06	2.23E-06	2.27E-06	2.19E-06	2.24E-06	2.16E-06	2.13E-06	2.25E-06	2.21E-06
^{241}Am	2.86E-06	2.93E-06	2.94E-06	2.90E-06	2.96E-06	2.97E-06	3.11E-06	2.93E-06	2.85E-06	2.85E-06	2.99E-06	2.93E-06	2.89E-06	2.89E-06
^{243}Am	2.05E-07	2.25E-07	2.26E-07	2.05E-07	1.85E-07	2.12E-07	1.86E-07	2.09E-07	2.17E-07	2.03E-07	2.13E-07	1.85E-07	2.24E-07	1.97E-07
^{244}Cm	2.19E-08	2.40E-08	2.42E-08	2.17E-08	2.01E-08	2.34E-08	1.84E-08	2.24E-08	2.35E-08	2.20E-08	2.34E-08	2.00E-08	2.41E-08	2.10E-08
^{90}Sr	1.95E-05	1.98E-05	2.00E-05	1.97E-05	1.97E-05	1.96E-05	1.97E-05	-	1.95E-05	1.95E-05	1.95E-05	1.97E-05	1.98E-05	1.99E-05
^{95}Mo	2.77E-05	2.80E-05	2.80E-05	2.81E-05	2.80E-05	2.78E-05	2.80E-05	2.76E-05	2.75E-05	2.76E-05	2.77E-05	2.80E-05	2.79E-05	2.82E-05
^{99}Tc	2.72E-05	2.81E-05	2.73E-05	2.74E-05	2.74E-05	2.71E-05	2.81E-05	2.69E-05	2.65E-05	2.66E-05	2.71E-05	2.74E-05	2.72E-05	2.76E-05
^{101}Ru	2.46E-05	2.50E-05	2.49E-05	2.50E-05	2.48E-05	2.47E-05	2.49E-05	2.48E-05	2.43E-05	2.44E-05	2.47E-05	2.48E-05	2.48E-05	2.49E-05
^{103}Rh	1.55E-05	1.58E-05	1.58E-05	1.57E-05	1.54E-05	1.57E-05	1.58E-05	1.56E-05	1.57E-05	1.57E-05	1.57E-05	1.54E-05	1.56E-05	1.53E-05
^{109}Ag	1.49E-06	1.49E-06	1.01E-06	1.55E-06	1.41E-06	1.45E-06	1.44E-06	1.42E-06	1.54E-06	1.55E-06	1.46E-06	1.41E-06	1.05E-06	1.49E-06
^{129}I	3.42E-06	3.39E-06	3.44E-06	3.93E-06	3.43E-06	2.79E-06	3.37E-06	3.35E-06	4.24E-06	4.25E-06	2.80E-06	3.43E-06	3.45E-06	4.21E-06
^{131}Xe	1.21E-05	1.24E-05	1.24E-05	1.23E-05	1.22E-05	1.19E-05	1.23E-05	1.23E-05	1.23E-05	1.22E-05	1.19E-05	1.22E-05	1.24E-05	1.24E-05
^{133}Cs	2.96E-05	2.98E-05	2.95E-05	2.91E-05	2.89E-05	2.95E-05	3.00E-05	2.96E-05	2.95E-05	2.94E-05	2.95E-05	2.89E-05	2.96E-05	2.91E-05
^{134}Cs	2.47E-07	2.88E-07	2.87E-07	2.84E-07	3.02E-07	2.80E-07	3.35E-07	2.70E-07	2.83E-07	2.92E-07	2.79E-07	3.01E-07	2.88E-07	2.89E-07
^{137}Cs	2.53E-05	2.55E-05	2.61E-05	2.56E-05	2.54E-05	2.54E-05	2.57E-05	2.55E-05	2.49E-05	2.49E-05	2.54E-05	2.54E-05	2.55E-05	2.56E-05
^{144}Ce	1.21E-07	1.23E-07	1.22E-07	1.22E-07	1.20E-07	1.21E-07	1.24E-07	1.23E-07	1.19E-07	1.19E-07	1.22E-07	1.21E-07	1.23E-07	1.22E-07
^{143}Nd	2.22E-05	2.24E-05	2.21E-05	2.22E-05	2.23E-05	2.22E-05	2.25E-05	2.21E-05	2.21E-05	2.21E-05	2.22E-05	2.23E-05	2.21E-05	2.23E-05
^{145}Nd	1.65E-05	1.66E-05	1.65E-05	1.67E-05	1.66E-05	1.66E-05	1.66E-05	1.64E-05	1.64E-05	1.64E-05	1.66E-05	1.66E-05	1.65E-05	1.66E-05

Table 3.6(2). All results for Case 5b (40% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{148}Nd	7.96E-06	8.06E-06	8.03E-06	8.10E-06	8.09E-06	8.00E-06	8.05E-06	8.02E-06	8.06E-06	8.02E-06	8.00E-06	8.09E-06	8.01E-06	8.09E-06
^{147}Sm	6.23E-06	6.27E-06	6.21E-06	6.22E-06	6.11E-06	6.06E-06	5.97E-06	6.01E-06	6.28E-06	6.31E-06	6.06E-06	6.12E-06	6.21E-06	6.30E-06
^{149}Sm	1.08E-07	1.04E-07	1.03E-07	1.01E-07	1.11E-07	1.12E-07	1.12E-07	1.03E-07	9.97E-08	9.90E-08	1.12E-07	1.10E-07	1.04E-07	1.05E-07
^{150}Sm	5.68E-06	5.72E-06	5.72E-06	5.78E-06	5.68E-06	5.73E-06	5.79E-06	5.66E-06	5.56E-06	5.56E-06	5.72E-06	5.68E-06	5.70E-06	5.75E-06
^{151}Sm	3.53E-07	3.30E-07	3.38E-07	3.44E-07	3.76E-07	3.72E-07	3.55E-07	3.31E-07	3.38E-07	3.35E-07	3.74E-07	3.75E-07	3.29E-07	3.41E-07
^{152}Sm	2.74E-06	2.66E-06	2.64E-06	2.67E-06	2.83E-06	2.83E-06	2.89E-06	2.64E-06	2.69E-06	2.68E-06	2.84E-06	2.83E-06	2.64E-06	2.65E-06
^{153}Eu	1.81E-06	1.86E-06	1.86E-06	1.84E-06	1.80E-06	1.79E-06	1.80E-06	1.77E-06	1.89E-06	1.89E-06	1.79E-06	1.80E-06	1.85E-06	1.87E-06
^{154}Eu	1.70E-07	1.75E-07	1.73E-07	1.53E-07	1.59E-07	1.69E-07	1.55E-07	1.65E-07	1.75E-07	1.75E-07	1.68E-07	1.59E-07	1.74E-07	2.29E-07
^{155}Eu	3.68E-08	5.17E-08	5.13E-08	5.24E-08	3.91E-08	3.77E-08	5.45E-08	4.87E-08	5.43E-08	5.44E-08	3.64E-08	3.92E-08	5.13E-08	4.76E-08
^{155}Gd	2.89E-08	7.89E-08	8.37E-08	8.77E-08	7.21E-08	6.80E-08	9.21E-08	8.02E-08	8.25E-08	8.76E-08	6.97E-08	7.20E-08	8.25E-08	7.93E-08
^{156}Gd	9.54E-05	9.62E-05	9.61E-05	9.63E-05	9.65E-05	9.63E-05	9.62E-05	9.64E-05	9.61E-05	9.61E-05	9.64E-05	9.66E-05	9.61E-05	9.63E-05
^{157}Gd	2.41E-08	2.24E-08	2.57E-08	2.37E-08	2.27E-08	2.37E-08	2.55E-08	2.21E-08	2.47E-08	2.70E-08	2.36E-08	2.24E-08	2.44E-08	2.36E-08
^{158}Gd	1.07E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.6(3). All results for Case 5b (40% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ^(r)
^{234}U	5.30E-06	5.31E-06	5.26E-06	5.31E-06	5.02E-06	5.38E-06	5.32E-06	5.30E-06	1.34E-07	2.52E-02
^{235}U	4.68E-04	4.69E-04	4.64E-04	4.69E-04	4.68E-04	4.72E-04	4.74E-04	4.71E-04	5.84E-06	1.24E-02
^{236}U	7.51E-05	7.50E-05	7.56E-05	7.50E-05	7.48E-05	7.39E-05	7.17E-05	7.44E-05	2.00E-06	2.70E-02
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	8.75E-06	4.12E-04
^{237}Np	4.21E-06	4.16E-06	4.29E-06	4.05E-06	4.16E-06	3.99E-06	3.74E-06	4.08E-06	2.76E-07	6.75E-02
^{238}Pu	7.09E-07	7.03E-07	7.75E-07	6.34E-07	7.00E-07	7.41E-07	6.33E-07	7.06E-07	6.80E-08	9.63E-02
^{239}Pu	9.77E-05	9.73E-05	9.60E-05	9.56E-05	9.47E-05	9.32E-05	9.39E-05	9.49E-05	4.41E-06	4.65E-02
^{240}Pu	2.72E-05	2.72E-05	2.69E-05	2.66E-05	2.62E-05	2.59E-05	2.62E-05	2.65E-05	1.11E-06	4.20E-02
^{241}Pu	9.62E-06	9.55E-06	9.61E-06	9.40E-06	9.26E-06	9.23E-06	9.42E-06	9.47E-06	3.70E-07	3.91E-02
^{242}Pu	2.29E-06	2.28E-06	2.37E-06	2.21E-06	2.22E-06	2.23E-06	2.15E-06	2.24E-06	1.31E-07	5.88E-02
^{241}Am	2.97E-06	2.95E-06	2.95E-06	2.90E-06	2.84E-06	2.84E-06	2.90E-06	2.91E-06	1.10E-07	3.79E-02
^{243}Am	2.26E-07	2.30E-07	2.18E-07	2.18E-07	2.10E-07	1.95E-07	1.89E-07	2.11E-07	3.01E-08	1.42E-01
^{244}Cm	2.44E-08	2.48E-08	2.38E-08	2.36E-08	2.23E-08	2.33E-08	2.06E-08	2.31E-08	3.21E-09	1.39E-01
^{90}Sr	1.98E-05	1.98E-05	1.97E-05	1.98E-05	1.97E-05	1.97E-05	2.01E-05	1.97E-05	3.25E-07	1.64E-02
^{95}Mo	2.81E-05	2.81E-05	2.84E-05	2.80E-05	2.79E-05	2.78E-05	2.78E-05	2.79E-05	3.55E-07	1.27E-02
^{99}Tc	2.80E-05	2.80E-05	2.78E-05	2.74E-05	2.71E-05	2.74E-05	2.73E-05	2.76E-05	9.12E-07	3.31E-02
^{101}Ru	2.50E-05	2.50E-05	2.54E-05	2.49E-05	2.48E-05	2.48E-05	2.43E-05	2.48E-05	4.32E-07	1.74E-02
^{103}Rh	1.59E-05	1.59E-05	1.61E-05	1.51E-05	1.53E-05	1.57E-05	1.54E-05	1.57E-05	4.08E-07	2.60E-02
^{109}Ag	1.51E-06	1.51E-06	1.63E-06	9.21E-07	1.39E-06	1.44E-06	1.72E-06	1.40E-06	4.32E-07	3.09E-01
^{129}I	3.45E-06	3.45E-06	3.94E-06	3.14E-06	3.30E-06	3.26E-06	3.94E-06	3.47E-06	6.81E-07	1.96E-01
^{131}Xe	1.25E-05	1.25E-05	1.24E-05	1.22E-05	1.23E-05	1.22E-05	1.23E-05	1.23E-05	3.03E-07	2.46E-02
^{133}Cs	2.98E-05	2.99E-05	2.96E-05	2.97E-05	2.94E-05	2.94E-05	2.96E-05	2.96E-05	6.13E-07	2.07E-02
^{134}Cs	2.92E-07	2.89E-07	2.97E-07	2.86E-07	2.85E-07	2.87E-07	2.70E-07	2.88E-07	2.59E-08	8.99E-02
^{137}Cs	2.57E-05	2.57E-05	2.60E-05	2.56E-05	2.55E-05	2.53E-05	2.58E-05	2.55E-05	5.07E-07	1.99E-02
^{144}Ce	1.24E-07	1.24E-07	1.24E-07	1.23E-07	1.22E-07	1.22E-07	1.22E-07	1.22E-07	3.62E-09	2.97E-02
^{143}Nd	2.24E-05	2.24E-05	2.25E-05	2.24E-05	2.22E-05	2.22E-05	2.22E-05	2.23E-05	2.41E-07	1.08E-02
^{145}Nd	1.66E-05	1.66E-05	1.69E-05	1.65E-05	1.65E-05	1.65E-05	1.66E-05	1.66E-05	2.03E-07	1.22E-02

Table 3.6(3). All results for Case 5b (40% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{148}Nd	8.08E-06	8.08E-06	8.24E-06	8.05E-06	8.03E-06	7.94E-06	7.98E-06	8.03E-06	1.24E-07	1.55E-02
^{147}Sm	6.25E-06	6.27E-06	6.31E-06	6.20E-06	5.55E-06	6.28E-06	6.27E-06	6.20E-06	2.84E-07	4.58E-02
^{149}Sm	1.05E-07	1.04E-07	9.34E-08	1.06E-07	9.79E-08	1.01E-07	1.03E-07	1.03E-07	1.02E-08	9.88E-02
^{150}Sm	5.73E-06	5.73E-06	5.55E-06	5.72E-06	5.60E-06	5.66E-06	5.65E-06	5.67E-06	1.75E-07	3.09E-02
^{151}Sm	3.33E-07	3.32E-07	3.32E-07	3.35E-07	3.24E-07	3.25E-07	3.39E-07	3.42E-07	3.53E-08	1.03E-01
^{152}Sm	2.74E-06	2.70E-06	2.68E-06	2.64E-06	2.63E-06	2.63E-06	2.71E-06	2.70E-06	1.72E-07	6.36E-02
^{153}Eu	1.84E-06	1.86E-06	1.88E-06	1.86E-06	1.79E-06	1.83E-06	1.81E-06	1.84E-06	8.53E-08	4.65E-02
^{154}Eu	1.70E-07	1.74E-07	1.76E-07	1.75E-07	1.69E-07	1.69E-07	1.54E-07	1.70E-07	2.55E-08	1.50E-01
^{155}Eu	5.12E-08	5.13E-08	5.15E-08	5.11E-08	4.96E-08	5.00E-08	5.11E-08	4.89E-08	1.07E-08	2.20E-01
^{155}Gd	8.21E-08	8.22E-08	8.53E-08	8.33E-08	8.20E-08	8.57E-08	8.33E-08	8.04E-08	2.12E-08	2.63E-01
^{156}Gd	9.63E-05	9.56E-05	9.63E-05	9.55E-05	9.61E-05	9.62E-05	9.58E-05	9.62E-05	5.16E-07	5.36E-03
^{157}Gd	2.27E-08	2.31E-08	2.23E-08	2.42E-08	2.44E-08	2.47E-08	2.82E-08	2.41E-08	3.47E-09	1.44E-01
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.94E-06	1.73E-02

Table 3.7(1). All results for Case 5c (40% void, 20 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.42E-06	5.51E-06	5.43E-06	5.35E-06	5.42E-06	5.32E-06	5.35E-06	5.29E-06	5.35E-06	5.36E-06	5.36E-06	5.42E-06	5.35E-06	5.35E-06
^{235}U	4.71E-04	4.67E-04	4.72E-04	4.66E-04	4.73E-04	4.65E-04	4.69E-04	4.70E-04	4.68E-04	4.72E-04	4.73E-04	4.71E-04	4.68E-04	4.71E-04
^{236}U	7.43E-05	7.57E-05	7.41E-05	7.54E-05	7.40E-05	7.47E-05	7.51E-05	7.49E-05	7.51E-05	7.46E-05	7.46E-05	7.41E-05	7.51E-05	7.47E-05
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02
^{237}Np	4.10E-06	4.06E-06	4.09E-06	4.18E-06	4.03E-06	4.12E-06	4.27E-06	4.24E-06	4.22E-06	4.20E-06	4.22E-06	4.17E-06	4.17E-06	4.26E-06
^{238}Pu	6.95E-07	6.76E-07	6.95E-07	6.43E-07	6.27E-07	6.37E-07	6.52E-07	6.76E-07	6.48E-07	6.48E-07	6.63E-07	7.11E-07	6.42E-07	6.46E-07
^{239}Pu	9.34E-05	9.08E-05	9.37E-05	9.29E-05	9.43E-05	9.45E-05	9.73E-05	1.00E-04	9.70E-05	9.18E-05	9.02E-05	9.25E-05	9.58E-05	9.53E-05
^{240}Pu	2.61E-05	2.56E-05	2.60E-05	2.63E-05	2.61E-05	2.66E-05	2.71E-05	2.81E-05	2.69E-05	2.69E-05	2.75E-05	2.65E-05	2.68E-05	2.60E-05
^{241}Pu	5.79E-06	5.57E-06	5.75E-06	5.72E-06	5.81E-06	5.76E-06	5.88E-06	5.83E-06	5.81E-06	5.81E-06	5.84E-06	5.89E-06	5.80E-06	5.85E-06
^{242}Pu	2.28E-06	2.21E-06	2.25E-06	2.23E-06	2.22E-06	2.26E-06	2.26E-06	2.28E-06	2.22E-06	2.30E-06	2.38E-06	2.34E-06	2.24E-06	2.21E-06
^{241}A	6.42E-06	6.19E-06	6.39E-06	6.36E-06	6.45E-06	6.41E-06	6.54E-06	6.48E-06	6.46E-06	6.47E-06	6.46E-06	6.51E-06	6.45E-06	6.50E-06
^{243}A	2.03E-07	1.85E-07	2.01E-07	2.20E-07	1.94E-07	2.29E-07	2.27E-07	2.36E-07	2.24E-07	2.30E-07	2.14E-07	2.11E-07	2.24E-07	2.22E-07
^{244}C	1.68E-08	1.49E-08	1.67E-08	1.61E-08	1.60E-08	1.69E-08	1.65E-08	1.63E-08	1.64E-08	1.68E-08	1.55E-08	1.76E-08	1.63E-08	1.62E-08
^{90}Sr	1.55E-05	1.56E-05	1.54E-05	1.56E-05	1.54E-05	1.55E-05	1.56E-05	1.56E-05	1.56E-05	1.55E-05	1.52E-05	1.57E-05	1.56E-05	1.58E-05
^{95}Mo	2.79E-05	2.80E-05	2.78E-05	2.81E-05	2.77E-05	2.79E-05	2.80E-05	2.80E-05	2.81E-05	2.78E-05	2.79E-05	2.80E-05	2.80E-05	2.80E-05
^{99}Tc	2.81E-05	2.80E-05	2.74E-05	2.79E-05	2.73E-05	2.79E-05	2.80E-05	2.82E-05	2.81E-05	2.76E-05	2.77E-05	2.80E-05	2.80E-05	2.73E-05
^{101}Ru	2.49E-05	2.49E-05	2.48E-05	2.50E-05	2.47E-05	2.48E-05	2.50E-05	2.51E-05	2.50E-05	2.48E-05	2.50E-05	2.49E-05	2.50E-05	2.49E-05
^{103}Rh	1.58E-05	1.58E-05	1.56E-05	1.57E-05	1.54E-05	1.57E-05	1.58E-05	1.59E-05	1.59E-05	1.57E-05	1.57E-05	1.58E-05	1.58E-05	1.57E-05
^{109}Ag	1.46E-06	1.44E-06	1.44E-06	1.47E-06	7.58E-07	1.48E-06	1.50E-06	1.51E-06	1.49E-06	1.02E-06	1.59E-06	1.49E-06	1.49E-06	1.01E-06
^{129}I	3.29E-06	3.27E-06	3.29E-06	3.43E-06	3.17E-06	3.42E-06	3.44E-06	3.46E-06	3.44E-06	3.36E-06	3.86E-06	3.29E-06	3.43E-06	3.43E-06
^{131}Xe	1.23E-05	1.24E-05	1.22E-05	1.25E-05	1.20E-05	1.24E-05	1.24E-05	1.23E-05	1.25E-05	1.23E-05	1.23E-05	1.23E-05	1.25E-05	1.24E-05
^{133}Cs	3.02E-05	3.03E-05	2.94E-05	2.97E-05	2.93E-05	2.96E-05	2.97E-05	2.99E-05	2.98E-05	3.00E-05	2.96E-05	2.96E-05	2.97E-05	2.96E-05
^{134}Cs	1.05E-08	1.01E-08	1.02E-08	1.02E-08	1.01E-08	1.01E-08	1.01E-08	9.48E-09	1.02E-08	1.01E-08	1.00E-08	9.98E-09	1.01E-08	1.01E-08
^{137}Cs	2.03E-05	2.03E-05	2.01E-05	2.04E-05	2.01E-05	2.02E-05	2.03E-05	2.04E-05	2.04E-05	2.02E-05	1.99E-05	2.03E-05	2.03E-05	2.07E-05
^{144}Ce	1.69E-11	1.70E-11	1.70E-11	1.71E-11	1.73E-11	1.70E-11	1.70E-11	1.72E-11	1.72E-11	1.69E-11	1.69E-11	1.56E-11	1.70E-11	1.70E-11
^{143}Nd	2.23E-05	2.23E-05	2.22E-05	2.24E-05	2.22E-05	2.22E-05	2.24E-05	2.24E-05	2.24E-05	2.24E-05	2.24E-05	2.23E-05	2.24E-05	2.21E-05

Table 3.7(1). All results for Case 5c (40% void, 20 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}N	1.66E-05	1.66E-05	1.65E-05	1.66E-05	1.64E-05	1.65E-05	1.66E-05	1.67E-05	1.66E-05	1.65E-05	1.67E-05	1.66E-	1.66E-05	1.65E-05
^{148}N	7.94E-06	7.97E-06	7.94E-06	8.07E-06	7.92E-06	8.03E-06	8.06E-06	8.02E-06	8.09E-06	8.01E-06	8.09E-06	7.97E-	8.06E-06	8.03E-06
^{147}S	7.83E-06	7.76E-06	7.77E-06	7.78E-06	7.75E-06	7.75E-06	7.77E-06	7.77E-06	7.80E-06	7.73E-06	7.75E-06	7.80E-	7.78E-06	7.71E-06
^{149}S	9.34E-08	9.26E-08	1.02E-07	1.02E-07	1.04E-07	1.03E-07	1.05E-07	1.10E-07	1.04E-07	9.81E-08	9.76E-08	9.80E-	1.03E-07	1.04E-07
^{150}S	5.64E-06	5.52E-06	5.67E-06	5.73E-06	5.51E-06	5.68E-06	5.73E-06	5.91E-06	5.73E-06	5.51E-06	5.60E-06	5.55E-	5.71E-06	5.71E-06
^{151}S	3.00E-07	3.15E-07	3.02E-07	3.02E-07	3.31E-07	3.04E-07	3.09E-07	3.66E-07	3.10E-07	3.11E-07	3.23E-07	3.06E-	3.06E-07	3.08E-07
^{152}S	2.63E-06	2.97E-06	2.62E-06	2.69E-06	2.69E-06	2.67E-06	2.65E-06	2.65E-06	2.69E-06	2.63E-06	2.66E-06	2.62E-	2.68E-06	2.63E-06
^{153}E	1.85E-06	1.67E-06	1.84E-06	1.86E-06	1.87E-06	1.85E-06	1.87E-06	1.88E-06	1.86E-06	1.85E-06	1.83E-06	1.86E-	1.85E-06	1.86E-06
^{154}E	7.70E-08	6.83E-08	7.69E-08	7.65E-08	7.71E-08	7.70E-08	7.84E-08	7.52E-08	7.81E-08	7.64E-08	6.73E-08	7.60E-	7.70E-08	7.81E-08
^{155}E	1.18E-08	1.11E-08	1.17E-08	1.19E-08	1.17E-08	1.18E-08	1.20E-08	8.60E-09	1.20E-08	1.19E-08	1.21E-08	1.28E-	1.19E-08	1.20E-08
^{155}	1.26E-07	1.20E-07	1.25E-07	1.21E-07	1.27E-07	1.21E-07	1.23E-07	9.73E-08	1.22E-07	1.22E-07	1.28E-07	1.25E-	1.21E-07	1.23E-07
^{156}	9.61E-05	9.64E-05	9.61E-05	9.63E-05	9.62E-05	9.63E-05	9.63E-05	9.63E-05	9.62E-05	9.61E-05	9.63E-05	9.60E-	9.62E-05	9.61E-05
^{157}	2.71E-08	2.24E-08	2.69E-08	2.18E-08	2.54E-08	2.14E-08	2.27E-08	2.39E-08	2.32E-08	2.53E-08	2.41E-08	2.76E-	2.29E-08	2.51E-08
^{158}	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-	1.12E-04	1.12E-04

Table 3.7(2). All results for Case 5c (40% void, 20 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.23E-06	5.36E-06	5.35E-06	5.35E-06	5.35E-06	5.35E-06	5.33E-06	5.40E-06	5.36E-06	5.42E-06	5.35E-06	5.35E-06	5.35E-06	5.29E-06
^{235}U	4.73E-04	4.69E-04	4.71E-04	4.71E-04	4.76E-04	4.73E-04	4.70E-04	4.69E-04	4.72E-04	4.73E-04	4.75E-04	4.76E-04	4.70E-04	4.73E-04
^{236}U	7.42E-05	7.50E-05	7.46E-05	7.46E-05	7.26E-05	7.52E-05	7.24E-05	7.53E-05	7.44E-05	7.37E-05	7.50E-05	7.26E-05	7.47E-05	7.21E-05
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02
^{237}Np	3.97E-06	4.18E-06	4.24E-06	4.24E-06	3.96E-06	4.09E-06	4.65E-06	4.15E-06	4.17E-06	4.12E-06	4.08E-06	3.95E-06	4.23E-06	4.05E-06
^{238}Pu	6.34E-07	6.39E-07	6.48E-07	6.56E-07	6.18E-07	6.47E-07	7.20E-07	6.34E-07	6.30E-07	6.88E-07	6.44E-07	6.17E-07	6.44E-07	6.43E-07
^{239}Pu	9.55E-05	9.65E-05	9.35E-05	9.34E-05	9.66E-05	9.45E-05	9.97E-05	9.39E-05	9.39E-05	9.37E-05	9.64E-05	9.65E-05	9.45E-05	9.39E-05
^{240}Pu	2.60E-05	2.70E-05	2.65E-05	2.67E-05	2.60E-05	2.55E-05	2.69E-05	2.60E-05	2.60E-05	2.59E-05	2.61E-05	2.61E-05	2.61E-05	2.66E-05
^{241}Pu	5.74E-06	5.83E-06	5.88E-06	5.84E-06	5.99E-06	6.02E-06	6.27E-06	5.85E-06	5.74E-06	5.78E-06	6.00E-06	5.91E-06	5.77E-06	5.85E-06
^{242}Pu	2.06E-06	2.24E-06	2.27E-06	2.28E-06	2.13E-06	2.15E-06	2.23E-06	2.27E-06	2.19E-06	2.24E-06	2.16E-06	2.13E-06	2.25E-06	2.21E-06
^{241}Am	6.35E-06	6.49E-06	6.53E-06	6.45E-06	6.57E-06	6.61E-06	6.91E-06	6.50E-06	6.32E-06	6.35E-06	6.63E-06	6.50E-06	6.42E-06	6.43E-06
^{243}Am	2.05E-07	2.25E-07	2.26E-07	2.04E-07	1.85E-07	2.12E-07	1.86E-07	2.09E-07	2.17E-07	2.03E-07	2.13E-07	1.84E-07	2.24E-07	1.97E-07
^{244}Cm	1.49E-08	1.64E-08	1.65E-08	1.47E-08	1.37E-08	1.60E-08	1.26E-08	1.53E-08	1.60E-08	1.50E-08	1.59E-08	1.37E-08	1.64E-08	1.44E-08
^{90}Sr	1.53E-05	1.56E-05	1.58E-05	1.55E-05	1.56E-05	1.55E-05	1.54E-05	-	1.54E-05	1.54E-05	1.52E-05	1.56E-05	1.55E-05	1.57E-05
^{95}Mo	2.77E-05	2.80E-05	2.80E-05	2.81E-05	2.80E-05	2.78E-05	2.80E-05	2.76E-05	2.75E-05	2.76E-05	2.77E-05	2.80E-05	2.79E-05	2.82E-05
^{99}Tc	2.72E-05	2.81E-05	2.73E-05	2.74E-05	2.74E-05	2.71E-05	2.81E-05	2.69E-05	2.65E-05	2.66E-05	2.71E-05	2.74E-05	2.72E-05	2.76E-05
^{101}Ru	2.46E-05	2.50E-05	2.49E-05	2.50E-05	2.48E-05	2.47E-05	2.49E-05	2.48E-05	2.43E-05	2.44E-05	2.47E-05	2.48E-05	2.48E-05	2.49E-05
^{103}Rh	1.55E-05	1.58E-05	1.58E-05	1.57E-05	1.54E-05	1.57E-05	1.58E-05	1.56E-05	1.57E-05	1.57E-05	1.57E-05	1.54E-05	1.56E-05	1.53E-05
^{109}Ag	1.49E-06	1.49E-06	1.01E-06	1.55E-06	1.41E-06	1.45E-06	1.44E-06	1.42E-06	1.54E-06	1.55E-06	1.46E-06	1.41E-06	1.05E-06	1.49E-06
^{129}I	3.42E-06	3.39E-06	3.44E-06	3.93E-06	3.43E-06	2.79E-06	3.37E-06	3.35E-06	4.24E-06	4.25E-06	2.80E-06	3.43E-06	3.45E-06	4.21E-06
^{131}Xe	1.21E-05	1.24E-05	1.24E-05	1.23E-05	1.22E-05	1.19E-05	1.23E-05	1.23E-05	1.23E-05	1.22E-05	1.19E-05	1.22E-05	1.24E-05	1.24E-05
^{133}Cs	2.96E-05	2.98E-05	2.95E-05	2.91E-05	2.89E-05	2.95E-05	3.00E-05	2.96E-05	2.95E-05	2.94E-05	2.95E-05	2.89E-05	2.96E-05	2.91E-05
^{134}Cs	8.58E-09	1.00E-08	1.00E-08	9.93E-09	1.05E-08	9.74E-09	1.16E-08	9.41E-09	9.82E-09	1.01E-08	9.66E-09	1.05E-08	1.01E-08	1.01E-08
^{137}Cs	2.01E-05	2.02E-05	2.07E-05	2.04E-05	2.02E-05	2.01E-05	2.04E-05	2.02E-05	1.98E-05	1.98E-05	2.01E-05	2.02E-05	2.02E-05	2.03E-05
^{144}Ce	1.68E-11	1.70E-11	1.70E-11	1.70E-11	1.64E-11	1.65E-11	1.73E-11	1.71E-11	1.62E-11	1.62E-11	1.73E-11	1.72E-11	1.71E-11	1.69E-11
^{143}Nd	2.22E-05	2.24E-05	2.21E-05	2.22E-05	2.23E-05	2.22E-05	2.25E-05	2.21E-05	2.21E-05	2.21E-05	2.22E-05	2.23E-05	2.21E-05	2.23E-05

Table 3.7(2). All results for Case 5c (40% void, 20 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.65E-05	1.66E-05	1.65E-05	1.67E-05	1.66E-05	1.66E-05	1.66E-05	1.64E-05	1.64E-05	1.64E-05	1.66E-05	1.66E-05	1.65E-05	1.66E-05
^{148}Nd	7.96E-06	8.06E-06	8.03E-06	8.10E-06	8.09E-06	8.00E-06	8.05E-06	8.02E-06	8.06E-06	8.02E-06	8.00E-06	8.09E-06	8.01E-06	8.09E-06
^{147}Sm	7.74E-06	7.79E-06	7.71E-06	7.72E-06	7.59E-06	7.52E-06	7.40E-06	7.50E-06	7.80E-06	7.84E-06	7.52E-06	7.59E-06	7.71E-06	7.83E-06
^{149}Sm	1.08E-07	1.04E-07	1.03E-07	1.01E-07	1.11E-07	1.12E-07	1.12E-07	1.03E-07	9.97E-08	9.90E-08	1.12E-07	1.10E-07	1.04E-07	1.05E-07
^{150}Sm	5.68E-06	5.72E-06	5.72E-06	5.78E-06	5.68E-06	5.73E-06	5.79E-06	5.66E-06	5.56E-06	5.56E-06	5.72E-06	5.68E-06	5.70E-06	5.75E-06
^{151}Sm	3.27E-07	3.06E-07	3.13E-07	3.18E-07	3.48E-07	3.45E-07	3.29E-07	3.07E-07	3.13E-07	3.10E-07	3.46E-07	3.46E-07	3.05E-07	3.16E-07
^{152}Sm	2.74E-06	2.66E-06	2.64E-06	2.67E-06	2.83E-06	2.83E-06	2.89E-06	2.64E-06	2.69E-06	2.68E-06	2.84E-06	2.83E-06	2.64E-06	2.65E-06
^{153}Eu	1.81E-06	1.86E-06	1.86E-06	1.84E-06	1.80E-06	1.79E-06	1.80E-06	1.77E-06	1.89E-06	1.89E-06	1.79E-06	1.80E-06	1.85E-06	1.87E-06
^{154}Eu	7.58E-08	7.82E-08	7.71E-08	6.83E-08	7.13E-08	7.54E-08	6.90E-08	7.37E-08	7.82E-08	7.84E-08	7.52E-08	7.11E-08	7.78E-08	1.03E-07
^{155}Eu	8.37E-09	1.20E-08	1.20E-08	1.22E-08	9.67E-09	9.33E-09	1.24E-08	1.13E-08	1.34E-08	1.35E-08	8.27E-09	9.69E-09	1.20E-08	1.18E-08
^{155}Gd	2.89E-08	1.19E-07	1.23E-07	1.28E-07	1.01E-07	9.64E-08	1.34E-07	1.18E-07	1.23E-07	1.29E-07	9.78E-08	1.01E-07	1.22E-07	1.15E-07
^{156}Gd	9.54E-05	9.62E-05	9.61E-05	9.63E-05	9.65E-05	9.63E-05	9.62E-05	9.64E-05	9.61E-05	9.61E-05	9.64E-05	9.66E-05	9.61E-05	9.63E-05
^{157}Gd	2.41E-08	2.24E-08	2.57E-08	2.37E-08	2.27E-08	2.37E-08	2.55E-08	2.21E-08	2.47E-08	2.70E-08	2.36E-08	2.24E-08	2.44E-08	2.36E-08
^{158}Gd	1.07E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.7(3). All results for Case 5c (40% void, 20 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	$2*\sigma^{(r)}$
^{234}U	5.36E-06	5.36E-06	5.32E-06	5.36E-06	5.07E-06	5.44E-06	5.36E-06	5.35E-06	1.39E-07	2.61E-02
^{235}U	4.68E-04	4.69E-04	4.64E-04	4.69E-04	4.68E-04	4.72E-04	4.74E-04	4.71E-04	5.85E-06	1.24E-02
^{236}U	7.52E-05	7.50E-05	7.56E-05	7.50E-05	7.48E-05	7.40E-05	7.17E-05	7.44E-05	2.00E-06	2.69E-02
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	8.75E-06	4.12E-04
^{237}Np	4.28E-06	4.24E-06	4.37E-06	4.13E-06	4.24E-06	4.06E-06	3.81E-06	4.16E-06	2.82E-07	6.77E-02
^{238}Pu	6.55E-07	6.49E-07	7.16E-07	5.86E-07	6.47E-07	6.85E-07	5.85E-07	6.53E-07	6.29E-08	9.64E-02
^{239}Pu	9.77E-05	9.73E-05	9.60E-05	9.56E-05	9.47E-05	9.32E-05	9.39E-05	9.49E-05	4.41E-06	4.65E-02
^{240}Pu	2.72E-05	2.72E-05	2.68E-05	2.66E-05	2.62E-05	2.59E-05	2.62E-05	2.64E-05	1.11E-06	4.20E-02
^{241}Pu	5.92E-06	5.88E-06	5.92E-06	5.78E-06	5.71E-06	5.68E-06	5.81E-06	5.84E-06	2.35E-07	4.02E-02
^{242}Pu	2.29E-06	2.28E-06	2.37E-06	2.21E-06	2.22E-06	2.23E-06	2.15E-06	2.24E-06	1.31E-07	5.88E-02
^{241}Am	6.58E-06	6.54E-06	6.55E-06	6.43E-06	6.31E-06	6.31E-06	6.43E-06	6.47E-06	2.44E-07	3.78E-02
^{243}Am	2.26E-07	2.30E-07	2.18E-07	2.18E-07	2.09E-07	1.94E-07	1.88E-07	2.11E-07	3.01E-08	1.42E-01
^{244}Cm	1.66E-08	1.69E-08	1.62E-08	1.61E-08	1.52E-08	1.59E-08	1.40E-08	1.58E-08	2.19E-09	1.39E-01
^{90}Sr	1.56E-05	1.56E-05	1.55E-05	1.56E-05	1.54E-05	1.54E-05	1.58E-05	1.55E-05	2.75E-07	1.77E-02
^{95}Mo	2.81E-05	2.81E-05	2.84E-05	2.80E-05	2.79E-05	2.78E-05	2.78E-05	2.79E-05	3.55E-07	1.27E-02
^{99}Tc	2.80E-05	2.80E-05	2.78E-05	2.74E-05	2.71E-05	2.74E-05	2.73E-05	2.76E-05	9.12E-07	3.31E-02
^{101}Ru	2.50E-05	2.50E-05	2.54E-05	2.49E-05	2.48E-05	2.48E-05	2.43E-05	2.48E-05	4.32E-07	1.74E-02
^{103}Rh	1.59E-05	1.59E-05	1.61E-05	1.51E-05	1.53E-05	1.57E-05	1.54E-05	1.57E-05	4.08E-07	2.60E-02
^{109}Ag	1.51E-06	1.51E-06	1.63E-06	9.21E-07	1.39E-06	1.44E-06	1.72E-06	1.40E-06	4.32E-07	3.09E-01
^{129}I	3.45E-06	3.45E-06	3.94E-06	3.14E-06	3.30E-06	3.26E-06	3.94E-06	3.47E-06	6.81E-07	1.96E-01
^{131}Xe	1.25E-05	1.25E-05	1.24E-05	1.22E-05	1.23E-05	1.22E-05	1.23E-05	1.23E-05	3.03E-07	2.46E-02
^{133}Cs	2.98E-05	2.99E-05	2.96E-05	2.97E-05	2.94E-05	2.94E-05	2.96E-05	2.96E-05	6.13E-07	2.07E-02
^{134}Cs	1.02E-08	1.01E-08	1.04E-08	9.97E-09	9.88E-09	1.00E-08	9.37E-09	1.00E-08	9.05E-10	9.02E-02
^{137}Cs	2.04E-05	2.04E-05	2.06E-05	2.03E-05	2.03E-05	2.01E-05	2.05E-05	2.03E-05	4.07E-07	2.01E-02
^{144}Ce	1.72E-11	1.72E-11	1.72E-11	1.75E-11	1.69E-11	1.69E-11	1.68E-11	1.69E-11	7.32E-13	4.32E-02
^{143}Nd	2.24E-05	2.24E-05	2.25E-05	2.24E-05	2.22E-05	2.22E-05	2.22E-05	2.23E-05	2.41E-07	1.08E-02

Table 3.7(3). All results for Case 5c (40% void, 20 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.66E-05	1.66E-05	1.69E-05	1.65E-05	1.65E-05	1.65E-05	1.66E-05	1.66E-05	2.03E-07	1.22E-02
^{148}Nd	8.08E-06	8.08E-06	8.24E-06	8.05E-06	8.03E-06	7.94E-06	7.98E-06	8.03E-06	1.24E-07	1.55E-02
^{147}Sm	7.77E-06	7.79E-06	7.84E-06	7.77E-06	6.87E-06	7.80E-06	7.78E-06	7.70E-06	3.58E-07	4.65E-02
^{149}Sm	1.05E-07	1.04E-07	9.34E-08	1.06E-07	9.79E-08	1.01E-07	1.03E-07	1.03E-07	1.02E-08	9.88E-02
^{150}Sm	5.73E-06	5.73E-06	5.55E-06	5.72E-06	5.60E-06	5.66E-06	5.65E-06	5.67E-06	1.75E-07	3.09E-02
^{151}Sm	3.08E-07	3.07E-07	3.07E-07	3.10E-07	3.00E-07	3.01E-07	3.14E-07	3.16E-07	3.26E-08	1.03E-01
^{152}Sm	2.74E-06	2.70E-06	2.68E-06	2.64E-06	2.63E-06	2.63E-06	2.71E-06	2.70E-06	1.72E-07	6.36E-02
^{153}Eu	1.84E-06	1.86E-06	1.88E-06	1.86E-06	1.79E-06	1.83E-06	1.81E-06	1.84E-06	8.53E-08	4.65E-02
^{154}Eu	7.61E-08	7.76E-08	7.87E-08	7.79E-08	7.56E-08	7.52E-08	6.85E-08	7.60E-08	1.14E-08	1.50E-01
^{155}Eu	1.19E-08	1.19E-08	1.20E-08	1.19E-08	1.13E-08	1.16E-08	1.19E-08	1.15E-08	2.53E-09	2.20E-01
^{155}Gd	1.21E-07	1.22E-07	1.25E-07	1.23E-07	1.20E-07	1.24E-07	1.22E-07	1.17E-07	3.58E-08	3.06E-01
^{156}Gd	9.63E-05	9.56E-05	9.63E-05	9.55E-05	9.61E-05	9.62E-05	9.58E-05	9.62E-05	5.16E-07	5.36E-03
^{157}Gd	2.27E-08	2.31E-08	2.23E-08	2.42E-08	2.44E-08	2.47E-08	2.82E-08	2.41E-08	3.47E-09	1.44E-01
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.94E-06	1.73E-02

Table 3.8(1). All results for Case 6b (70% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	5.25E-06	5.36E-06	5.25E-06	5.18E-06	5.31E-06	5.15E-06	5.18E-06	5.10E-06	5.18E-06	5.18E-06	5.17E-06	5.24E-06	5.18E-06	5.17E-06
^{235}U	4.84E-04	4.80E-04	4.85E-04	4.79E-04	4.85E-04	4.80E-04	4.83E-04	4.82E-04	4.80E-04	4.85E-04	4.85E-04	4.85E-04	4.80E-04	4.84E-04
^{236}U	7.51E-05	7.68E-05	7.49E-05	7.62E-05	7.47E-05	7.55E-05	7.59E-05	7.55E-05	7.61E-05	7.56E-05	7.55E-05	7.49E-05	7.61E-05	7.56E-05
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02
^{237}Np	4.64E-06	4.62E-06	4.62E-06	4.74E-06	4.16E-06	4.69E-06	4.83E-06	4.72E-06	4.71E-06	4.77E-06	4.80E-06	4.71E-06	4.66E-06	4.83E-06
^{238}Pu	9.56E-07	9.32E-07	9.56E-07	8.87E-07	7.71E-07	8.83E-07	8.98E-07	9.10E-07	8.82E-07	8.99E-07	9.18E-07	9.80E-07	8.77E-07	8.97E-07
^{239}Pu	1.10E-04	1.07E-04	1.10E-04	1.09E-04	1.12E-04	1.13E-04	1.14E-04	1.14E-04	1.12E-04	1.08E-04	1.07E-04	1.09E-04	1.11E-04	1.12E-04
^{240}Pu	2.80E-05	2.74E-05	2.78E-05	2.81E-05	2.83E-05	2.87E-05	2.88E-05	3.01E-05	2.84E-05	2.87E-05	2.94E-05	2.83E-05	2.83E-05	2.79E-05
^{241}Pu	1.10E-05	1.06E-05	1.09E-05	1.09E-05	1.12E-05	1.10E-05	1.12E-05	1.05E-05	1.09E-05	1.10E-05	1.11E-05	1.11E-05	1.09E-05	1.11E-05
^{242}Pu	2.46E-06	2.41E-06	2.44E-06	2.40E-06	2.48E-06	2.44E-06	2.43E-06	2.35E-06	2.37E-06	2.48E-06	2.56E-06	2.52E-06	2.40E-06	2.39E-06
^{241}Am	3.38E-06	3.27E-06	3.37E-06	3.37E-06	3.45E-06	3.41E-06	3.45E-06	3.26E-06	3.36E-06	3.42E-06	3.40E-06	3.43E-06	3.37E-06	3.43E-06
^{243}Am	2.65E-07	2.42E-07	2.63E-07	2.86E-07	2.52E-07	3.00E-07	2.94E-07	2.93E-07	2.88E-07	2.99E-07	2.79E-07	2.71E-07	2.90E-07	2.88E-07
^{244}Cm	3.85E-08	3.43E-08	3.83E-08	3.66E-08	3.59E-08	3.86E-08	3.73E-08	3.51E-08	3.67E-08	3.84E-08	3.55E-08	4.01E-08	3.69E-08	3.68E-08
^{90}Sr	1.93E-05	1.94E-05	1.92E-05	1.94E-05	1.92E-05	1.93E-05	1.93E-05	1.94E-05	1.95E-05	1.93E-05	1.90E-05	1.95E-05	1.94E-05	1.97E-05
^{95}Mo	2.76E-05	2.77E-05	2.74E-05	2.77E-05	2.74E-05	2.75E-05	2.76E-05	2.77E-05	2.77E-05	2.75E-05	2.76E-05	2.76E-05	2.77E-05	2.77E-05
^{99}Tc	2.79E-05	2.79E-05	2.72E-05	2.77E-05	2.71E-05	2.77E-05	2.78E-05	2.80E-05	2.78E-05	2.74E-05	2.76E-05	2.79E-05	2.78E-05	2.71E-05
^{101}Ru	2.49E-05	2.49E-05	2.48E-05	2.49E-05	2.47E-05	2.48E-05	2.49E-05	2.51E-05	2.50E-05	2.48E-05	2.50E-05	2.49E-05	2.49E-05	2.49E-05
^{103}Rh	1.59E-05	1.60E-05	1.58E-05	1.59E-05	1.56E-05	1.59E-05	1.60E-05	1.60E-05	1.60E-05	1.59E-05	1.58E-05	1.59E-05	1.59E-05	1.59E-05
^{109}Ag	1.58E-06	1.55E-06	1.55E-06	1.58E-06	8.35E-07	1.60E-06	1.61E-06	1.59E-06	1.59E-06	1.11E-06	1.70E-06	1.60E-06	1.58E-06	1.08E-06
^{129}I	3.37E-06	3.35E-06	3.37E-06	3.53E-06	3.25E-06	3.51E-06	3.53E-06	3.53E-06	3.53E-06	3.46E-06	3.92E-06	3.38E-06	3.51E-06	3.54E-06
^{131}Xe	1.21E-05	1.22E-05	1.20E-05	1.23E-05	1.18E-05	1.22E-05	1.23E-05	1.21E-05	1.23E-05	1.22E-05	1.21E-05	1.21E-05	1.23E-05	1.22E-05
^{133}Cs	3.00E-05	3.01E-05	2.92E-05	2.94E-05	2.92E-05	2.93E-05	2.94E-05	2.96E-05	2.95E-05	2.97E-05	2.93E-05	2.93E-05	2.94E-05	2.94E-05
^{134}Cs	3.35E-07	3.24E-07	3.26E-07	3.26E-07	3.14E-07	3.21E-07	3.26E-07	3.01E-07	3.26E-07	3.25E-07	3.23E-07	3.21E-07	3.24E-07	3.23E-07
^{137}Cs	2.55E-05	2.55E-05	2.53E-05	2.56E-05	2.53E-05	2.55E-05	2.56E-05	2.56E-05	2.56E-05	2.55E-05	2.51E-05	2.55E-05	2.56E-05	2.61E-05
^{144}Ce	1.21E-07	1.21E-07	1.21E-07	1.22E-07	1.20E-07	1.21E-07	1.21E-07	1.22E-07	1.22E-07	1.21E-07	1.21E-07	1.13E-07	1.22E-07	1.21E-07
^{143}Nd	2.24E-05	2.24E-05	2.22E-05	2.24E-05	2.22E-05	2.23E-05	2.24E-05	2.25E-05	2.25E-05	2.24E-05	2.25E-05	2.23E-05	2.24E-05	2.22E-05

Table 3.8(1). All results for Case 6b (70% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [1024/cm3] reported by participants (continued)

^{145}Nd	1.64E-05	1.64E-05	1.63E-05	1.64E-05	1.63E-05	1.63E-05	1.63E-05	1.65E-05	1.64E-05	1.63E-05	1.65E-05	1.64E-05	1.64E-05	1.64E-05
^{148}Nd	7.96E-06	7.99E-06	7.96E-06	8.06E-06	7.92E-06	8.02E-06	8.05E-06	8.02E-06	8.08E-06	8.03E-06	8.12E-06	7.99E-06	8.06E-06	8.04E-06
^{147}Sm	6.13E-06	6.06E-06	6.08E-06	6.07E-06	6.05E-06	6.04E-06	6.06E-06	6.08E-06	6.10E-06	6.05E-06	6.07E-06	6.13E-06	6.08E-06	6.03E-06
^{149}Sm	1.06E-07	1.05E-07	1.15E-07	1.15E-07	1.16E-07	1.17E-07	1.19E-07	1.23E-07	1.17E-07	1.11E-07	1.12E-07	1.11E-07	1.16E-07	1.18E-07
^{150}Sm	5.69E-06	5.55E-06	5.75E-06	5.79E-06	5.51E-06	5.75E-06	5.79E-06	5.99E-06	5.79E-06	5.58E-06	5.73E-06	5.62E-06	5.77E-06	5.79E-06
^{151}Sm	3.74E-07	3.97E-07	3.77E-07	3.77E-07	4.11E-07	3.82E-07	3.87E-07	4.48E-07	3.84E-07	3.88E-07	4.04E-07	3.81E-07	3.80E-07	3.85E-07
^{152}Sm	2.51E-06	2.93E-06	2.50E-06	2.57E-06	2.60E-06	2.56E-06	2.53E-06	2.51E-06	2.56E-06	2.51E-06	2.55E-06	2.51E-06	2.56E-06	2.52E-06
^{153}Eu	1.95E-06	1.73E-06	1.94E-06	1.95E-06	1.96E-06	1.94E-06	1.96E-06	1.97E-06	1.95E-06	1.95E-06	1.94E-06	1.95E-06	1.94E-06	1.96E-06
^{154}Eu	2.07E-07	1.81E-07	2.07E-07	2.05E-07	2.02E-07	2.07E-07	2.10E-07	2.03E-07	2.09E-07	2.07E-07	1.84E-07	2.05E-07	2.07E-07	2.10E-07
^{155}Eu	5.35E-08	4.99E-08	5.27E-08	5.39E-08	5.34E-08	5.35E-08	5.43E-08	3.86E-08	5.40E-08	5.38E-08	5.52E-08	5.46E-08	5.36E-08	5.42E-08
^{155}Gd	1.00E-07	9.54E-08	9.98E-08	9.16E-08	1.03E-07	9.20E-08	9.33E-08	7.89E-08	9.29E-08	9.44E-08	1.01E-07	9.96E-08	9.23E-08	9.47E-08
^{156}Gd	9.56E-05	9.60E-05	9.56E-05	9.60E-05	9.59E-05	9.60E-05	9.60E-05	9.60E-05	9.59E-05	9.56E-05	9.60E-05	9.56E-05	9.59E-05	9.56E-05
^{157}Gd	3.94E-08	3.26E-08	3.93E-08	3.02E-08	3.73E-08	3.08E-08	3.15E-08	3.25E-08	3.24E-08	3.72E-08	3.54E-08	3.93E-08	3.21E-08	3.71E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.8(2). All results for Case 6b (70% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	5.11E-06	5.19E-06	5.18E-06	5.17E-06	5.18E-06	5.17E-06	5.14E-06	5.24E-06	5.19E-06	5.24E-06	5.18E-06	5.18E-06	5.18E-06	5.11E-06
^{235}U	4.86E-04	4.83E-04	4.84E-04	4.84E-04	4.89E-04	4.86E-04	4.86E-04	4.82E-04	4.85E-04	4.87E-04	4.88E-04	4.89E-04	4.83E-04	4.87E-04
^{236}U	7.52E-05	7.59E-05	7.56E-05	7.55E-05	7.32E-05	7.63E-05	7.32E-05	7.63E-05	7.53E-05	7.44E-05	7.61E-05	7.32E-05	7.57E-05	7.26E-05
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02
^{237}Np	4.56E-06	4.73E-06	4.81E-06	4.82E-06	4.52E-06	4.67E-06	5.50E-06	4.79E-06	4.74E-06	4.66E-06	4.65E-06	4.51E-06	4.79E-06	4.62E-06
^{238}Pu	8.60E-07	8.82E-07	8.98E-07	9.08E-07	8.50E-07	8.88E-07	1.03E-06	8.78E-07	8.72E-07	9.46E-07	8.83E-07	8.49E-07	8.92E-07	8.87E-07
^{239}Pu	1.11E-04	1.13E-04	1.10E-04	1.10E-04	1.12E-04	1.10E-04	1.20E-04	1.09E-04	1.10E-04	1.10E-04	1.12E-04	1.12E-04	1.11E-04	1.10E-04
^{240}Pu	2.76E-05	2.89E-05	2.83E-05	2.85E-05	2.76E-05	2.70E-05	2.90E-05	2.76E-05	2.79E-05	2.78E-05	2.76E-05	2.77E-05	2.80E-05	2.85E-05
^{241}Pu	1.08E-05	1.10E-05	1.12E-05	1.11E-05	1.12E-05	1.12E-05	1.25E-05	1.10E-05	1.09E-05	1.09E-05	1.13E-05	1.11E-05	1.09E-05	1.10E-05
^{242}Pu	2.19E-06	2.41E-06	2.44E-06	2.46E-06	2.28E-06	2.29E-06	2.49E-06	2.44E-06	2.37E-06	2.43E-06	2.30E-06	2.28E-06	2.42E-06	2.37E-06
^{241}Am	3.31E-06	3.42E-06	3.44E-06	3.39E-06	3.42E-06	3.43E-06	3.82E-06	3.41E-06	3.33E-06	3.34E-06	3.46E-06	3.39E-06	3.39E-06	3.38E-06
^{243}Am	2.62E-07	2.93E-07	2.94E-07	2.67E-07	2.36E-07	2.71E-07	2.48E-07	2.72E-07	2.82E-07	2.63E-07	2.72E-07	2.36E-07	2.93E-07	2.56E-07
^{244}Cm	3.31E-08	3.71E-08	3.76E-08	3.37E-08	3.07E-08	3.56E-08	2.90E-08	3.47E-08	3.82E-08	3.58E-08	3.56E-08	3.06E-08	3.75E-08	3.25E-08
^{90}Sr	1.92E-05	1.94E-05	1.96E-05	1.92E-05	1.93E-05	1.92E-05	1.92E-05	-	1.91E-05	1.91E-05	1.91E-05	1.93E-05	1.93E-05	1.94E-05
^{95}Mo	2.74E-05	2.76E-05	2.77E-05	2.78E-05	2.77E-05	2.74E-05	2.75E-05	2.73E-05	2.72E-05	2.72E-05	2.74E-05	2.77E-05	2.75E-05	2.78E-05
^{99}Tc	2.70E-05	2.79E-05	2.71E-05	2.72E-05	2.72E-05	2.69E-05	2.78E-05	2.67E-05	2.63E-05	2.64E-05	2.69E-05	2.72E-05	2.70E-05	2.75E-05
^{101}Ru	2.46E-05	2.49E-05	2.49E-05	2.51E-05	2.49E-05	2.47E-05	2.49E-05	2.47E-05	2.43E-05	2.44E-05	2.47E-05	2.49E-05	2.48E-05	2.50E-05
^{103}Rh	1.57E-05	1.60E-05	1.59E-05	1.58E-05	1.55E-05	1.58E-05	1.60E-05	1.57E-05	1.58E-05	1.58E-05	1.59E-05	1.55E-05	1.58E-05	1.55E-05
^{109}Ag	1.59E-06	1.60E-06	1.09E-06	1.66E-06	1.50E-06	1.54E-06	1.56E-06	1.53E-06	1.67E-06	1.68E-06	1.56E-06	1.50E-06	1.14E-06	1.60E-06
^{129}I	3.52E-06	3.48E-06	3.54E-06	3.99E-06	3.46E-06	2.86E-06	3.47E-06	3.42E-06	4.36E-06	4.35E-06	2.87E-06	3.46E-06	3.55E-06	4.27E-06
^{131}Xe	1.19E-05	1.22E-05	1.22E-05	1.22E-05	1.20E-05	1.16E-05	1.20E-05	1.21E-05	1.21E-05	1.20E-05	1.17E-05	1.20E-05	1.22E-05	1.23E-05
^{133}Cs	2.94E-05	2.95E-05	2.93E-05	2.89E-05	2.86E-05	2.92E-05	2.96E-05	2.93E-05	2.92E-05	2.91E-05	2.92E-05	2.86E-05	2.93E-05	2.89E-05
^{134}Cs	2.73E-07	3.21E-07	3.22E-07	3.19E-07	3.41E-07	3.15E-07	3.79E-07	3.00E-07	3.17E-07	3.25E-07	3.13E-07	3.40E-07	3.23E-07	3.24E-07
^{137}Cs	2.53E-05	2.54E-05	2.61E-05	2.56E-05	2.54E-05	2.54E-05	2.56E-05	2.54E-05	2.49E-05	2.49E-05	2.54E-05	2.54E-05	2.55E-05	2.55E-05
^{144}Ce	1.20E-07	1.22E-07	1.21E-07	1.21E-07	1.19E-07	1.20E-07	1.22E-07	1.21E-07	1.18E-07	1.18E-07	1.20E-07	1.20E-07	1.21E-07	1.20E-07
^{143}Nd	2.22E-05	2.24E-05	2.22E-05	2.22E-05	2.23E-05	2.22E-05	2.25E-05	2.21E-05	2.21E-05	2.21E-05	2.23E-05	2.24E-05	2.22E-05	2.24E-05

Table 3.8(2). All results for Case 6b (70% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	1.63E-05	1.64E-05	1.63E-05	1.65E-05	1.65E-05	1.64E-05	1.64E-05	1.62E-05	1.62E-05	1.62E-05	1.64E-05	1.65E-05	1.63E-05	1.64E-05
^{148}Nd	7.96E-06	8.05E-06	8.04E-06	8.13E-06	8.11E-06	8.01E-06	8.03E-06	8.01E-06	8.07E-06	8.03E-06	8.01E-06	8.11E-06	8.02E-06	8.11E-06
^{147}Sm	6.06E-06	6.08E-06	6.03E-06	6.05E-06	5.90E-06	5.85E-06	5.72E-06	5.81E-06	6.09E-06	6.12E-06	5.85E-06	5.91E-06	6.02E-06	6.13E-06
^{149}Sm	1.22E-07	1.17E-07	1.18E-07	1.16E-07	1.27E-07	1.28E-07	1.32E-07	1.16E-07	1.13E-07	1.12E-07	1.28E-07	1.26E-07	1.17E-07	1.20E-07
^{150}Sm	5.76E-06	5.78E-06	5.80E-06	5.90E-06	5.77E-06	5.81E-06	5.84E-06	5.72E-06	5.63E-06	5.63E-06	5.81E-06	5.77E-06	5.78E-06	5.87E-06
^{151}Sm	4.09E-07	3.83E-07	3.91E-07	3.98E-07	4.40E-07	4.35E-07	4.28E-07	3.81E-07	3.91E-07	3.87E-07	4.39E-07	4.39E-07	3.80E-07	3.96E-07
^{152}Sm	2.64E-06	2.54E-06	2.52E-06	2.56E-06	2.77E-06	2.77E-06	2.83E-06	2.53E-06	2.58E-06	2.57E-06	2.78E-06	2.77E-06	2.52E-06	2.54E-06
^{153}Eu	1.89E-06	1.95E-06	1.95E-06	1.94E-06	1.87E-06	1.87E-06	1.87E-06	1.85E-06	1.99E-06	1.99E-06	1.87E-06	1.87E-06	1.95E-06	1.96E-06
^{154}Eu	2.03E-07	2.09E-07	2.08E-07	1.86E-07	1.91E-07	2.01E-07	1.85E-07	1.97E-07	2.10E-07	2.11E-07	2.01E-07	1.91E-07	2.09E-07	2.67E-07
^{155}Eu	3.82E-08	5.42E-08	5.42E-08	5.55E-08	4.02E-08	3.89E-08	5.74E-08	5.10E-08	5.70E-08	5.71E-08	3.75E-08	4.04E-08	5.41E-08	5.79E-08
^{155}Gd	3.78E-08	8.82E-08	9.54E-08	1.01E-07	8.31E-08	7.78E-08	1.09E-07	9.06E-08	9.32E-08	1.01E-07	7.97E-08	8.29E-08	9.32E-08	9.93E-08
^{156}Gd	9.50E-05	9.59E-05	9.56E-05	9.60E-05	9.63E-05	9.61E-05	9.58E-05	9.61E-05	9.56E-05	9.56E-05	9.61E-05	9.64E-05	9.56E-05	9.59E-05
^{157}Gd	3.52E-08	3.16E-08	3.79E-08	3.49E-08	3.12E-08	3.25E-08	4.01E-08	3.13E-08	3.65E-08	3.99E-08	3.26E-08	3.09E-08	3.57E-08	3.46E-08
^{158}Gd	1.07E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.13E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.12E-04	1.12E-04

Table 3.8(3). All results for Case 6b (70% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ(r)
^{234}U	5.19E-06	5.19E-06	5.13E-06	5.20E-06	4.89E-06	5.27E-06	5.19E-06	5.18E-06	1.49E-07	2.87E-02
^{235}U	4.83E-04	4.83E-04	4.78E-04	4.83E-04	4.81E-04	4.85E-04	4.87E-04	4.84E-04	5.49E-06	1.13E-02
^{236}U	7.59E-05	7.59E-05	7.65E-05	7.59E-05	7.57E-05	7.47E-05	7.23E-05	7.53E-05	2.24E-06	2.98E-02
^{238}U	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	7.87E-06	3.72E-04
^{237}Np	4.86E-06	4.78E-06	4.95E-06	4.61E-06	4.79E-06	4.57E-06	4.31E-06	4.71E-06	4.10E-07	8.71E-02
^{238}Pu	9.03E-07	8.93E-07	9.79E-07	8.04E-07	8.91E-07	9.33E-07	8.08E-07	8.96E-07	9.95E-08	1.11E-01
^{239}Pu	1.15E-04	1.14E-04	1.12E-04	1.12E-04	1.11E-04	1.09E-04	1.10E-04	1.11E-04	5.16E-06	4.64E-02
^{240}Pu	2.90E-05	2.90E-05	2.87E-05	2.86E-05	2.80E-05	2.76E-05	2.80E-05	2.82E-05	1.26E-06	4.46E-02
^{241}Pu	1.13E-05	1.11E-05	1.12E-05	1.08E-05	1.08E-05	1.08E-05	1.10E-05	1.10E-05	6.05E-07	5.48E-02
^{242}Pu	2.45E-06	2.43E-06	2.55E-06	2.34E-06	2.39E-06	2.41E-06	2.33E-06	2.41E-06	1.56E-07	6.50E-02
^{241}Am	3.48E-06	3.44E-06	3.44E-06	3.34E-06	3.30E-06	3.31E-06	3.40E-06	3.40E-06	1.81E-07	5.32E-02
^{243}Am	2.93E-07	2.97E-07	2.84E-07	2.77E-07	2.71E-07	2.52E-07	2.47E-07	2.74E-07	3.78E-08	1.38E-01
^{244}Cm	3.75E-08	3.81E-08	3.68E-08	3.58E-08	3.44E-08	3.61E-08	3.20E-08	3.58E-08	5.07E-09	1.42E-01
^{90}Sr	1.94E-05	1.94E-05	1.93E-05	1.93E-05	1.93E-05	1.92E-05	1.96E-05	1.93E-05	3.14E-07	1.63E-02
^{95}Mo	2.77E-05	2.77E-05	2.81E-05	2.76E-05	2.75E-05	2.75E-05	2.75E-05	2.76E-05	3.38E-07	1.22E-02
^{99}Tc	2.77E-05	2.78E-05	2.76E-05	2.72E-05	2.69E-05	2.72E-05	2.72E-05	2.74E-05	8.88E-07	3.25E-02
^{101}Ru	2.50E-05	2.50E-05	2.54E-05	2.48E-05	2.48E-05	2.48E-05	2.43E-05	2.48E-05	4.21E-07	1.70E-02
^{103}Rh	1.60E-05	1.60E-05	1.62E-05	1.52E-05	1.55E-05	1.58E-05	1.56E-05	1.58E-05	4.07E-07	2.58E-02
^{109}Ag	1.63E-06	1.61E-06	1.74E-06	9.90E-07	1.49E-06	1.54E-06	1.85E-06	1.50E-06	4.58E-07	3.05E-01
^{129}I	3.55E-06	3.54E-06	4.00E-06	3.21E-06	3.39E-06	3.35E-06	4.01E-06	3.55E-06	6.82E-07	1.92E-01
^{131}Xe	1.23E-05	1.23E-05	1.22E-05	1.19E-05	1.22E-05	1.21E-05	1.21E-05	1.21E-05	3.33E-07	2.75E-02
^{133}Cs	2.95E-05	2.96E-05	2.94E-05	2.94E-05	2.92E-05	2.92E-05	2.93E-05	2.93E-05	5.93E-07	2.02E-02
^{134}Cs	3.27E-07	3.22E-07	3.33E-07	3.17E-07	3.18E-07	3.20E-07	3.01E-07	3.22E-07	3.15E-08	9.78E-02
^{137}Cs	2.56E-05	2.56E-05	2.59E-05	2.55E-05	2.55E-05	2.53E-05	2.58E-05	2.55E-05	4.99E-07	1.96E-02
^{144}Ce	1.22E-07	1.22E-07	1.23E-07	1.22E-07	1.21E-07	1.21E-07	1.20E-07	1.21E-07	3.46E-09	2.87E-02
^{143}Nd	2.24E-05	2.24E-05	2.25E-05	2.24E-05	2.23E-05	2.22E-05	2.23E-05	2.23E-05	2.36E-07	1.06E-02

Table 3.8(3). All results for Case 6b (70% void, 20 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	1.64E-05	1.64E-05	1.67E-05	1.63E-05	1.63E-05	1.64E-05	1.64E-05	1.64E-05	2.04E-07	1.25E-02
^{148}Nd	8.07E-06	8.08E-06	8.25E-06	8.04E-06	8.04E-06	7.96E-06	7.99E-06	8.04E-06	1.24E-07	1.54E-02
^{147}Sm	6.06E-06	6.08E-06	6.13E-06	6.03E-06	5.33E-06	6.12E-06	6.09E-06	6.01E-06	3.09E-07	5.14E-02
^{149}Sm	1.19E-07	1.18E-07	1.06E-07	1.19E-07	1.11E-07	1.14E-07	1.17E-07	1.17E-07	1.26E-08	1.07E-01
^{150}Sm	5.79E-06	5.79E-06	5.62E-06	5.77E-06	5.69E-06	5.73E-06	5.73E-06	5.75E-06	1.95E-07	3.39E-02
^{151}Sm	3.87E-07	3.84E-07	3.85E-07	3.87E-07	3.74E-07	3.73E-07	3.92E-07	3.96E-07	4.33E-08	1.09E-01
^{152}Sm	2.63E-06	2.58E-06	2.56E-06	2.52E-06	2.51E-06	2.52E-06	2.60E-06	2.59E-06	2.16E-07	8.34E-02
^{153}Eu	1.93E-06	1.95E-06	1.97E-06	1.94E-06	1.88E-06	1.92E-06	1.90E-06	1.93E-06	1.01E-07	5.22E-02
^{154}Eu	2.03E-07	2.08E-07	2.11E-07	2.08E-07	2.02E-07	2.01E-07	1.86E-07	2.04E-07	2.79E-08	1.37E-01
^{155}Eu	5.40E-08	5.38E-08	5.42E-08	5.35E-08	5.22E-08	5.25E-08	5.35E-08	5.15E-08	1.20E-08	2.33E-01
^{155}Gd	9.26E-08	9.23E-08	9.73E-08	9.40E-08	9.27E-08	9.82E-08	9.44E-08	9.21E-08	2.34E-08	2.54E-01
^{156}Gd	9.60E-05	9.53E-05	9.59E-05	9.51E-05	9.57E-05	9.58E-05	9.53E-05	9.58E-05	6.22E-07	6.50E-03
^{157}Gd	3.15E-08	3.27E-08	3.28E-08	3.42E-08	3.55E-08	3.61E-08	4.15E-08	3.48E-08	6.38E-09	1.84E-01
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.12E-04	1.79E-06	1.60E-02

Table 3.9(1). All results for Case 8b (40% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	4.76E-06	4.87E-06	4.76E-06	4.65E-06	4.76E-06	4.63E-06	4.66E-06	4.58E-06	4.66E-06	4.67E-06	4.67E-06	4.75E-06	4.66E-06	4.66E-06
^{235}U	3.17E-04	3.12E-04	3.19E-04	3.11E-04	3.21E-04	3.12E-04	3.16E-04	3.19E-04	3.15E-04	3.19E-04	3.20E-04	3.18E-04	3.14E-04	3.18E-04
^{236}U	9.80E-05	9.99E-05	9.78E-05	9.94E-05	9.76E-05	9.85E-05	9.88E-05	9.84E-05	9.90E-05	9.85E-05	9.83E-05	9.78E-05	9.90E-05	9.83E-05
^{238}U	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	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02
^{237}Np	6.91E-06	6.92E-06	6.89E-06	7.03E-06	6.80E-06	6.89E-06	7.19E-06	7.11E-06	7.04E-06	7.06E-06	7.15E-06	7.03E-06	6.99E-06	7.17E-06
^{238}Pu	2.09E-06	2.06E-06	2.09E-06	1.89E-06	1.88E-06	1.86E-06	1.91E-06	1.98E-06	1.89E-06	1.90E-06	1.97E-06	2.14E-06	1.88E-06	1.89E-06
^{239}Pu	9.98E-05	9.67E-05	1.01E-04	9.92E-05	1.01E-04	1.01E-04	1.05E-04	1.08E-04	1.04E-04	9.79E-05	9.58E-05	9.88E-05	1.02E-04	1.03E-04
^{240}Pu	4.06E-05	3.99E-05	4.04E-05	4.09E-05	4.06E-05	4.14E-05	4.21E-05	4.40E-05	4.22E-05	4.17E-05	4.26E-05	4.10E-05	4.19E-05	4.00E-05
^{241}Pu	1.54E-05	1.49E-05	1.54E-05	1.52E-05	1.55E-05	1.53E-05	1.57E-05	1.56E-05	1.55E-05	1.54E-05	1.54E-05	1.55E-05	1.55E-05	1.60E-05
^{242}Pu	6.45E-06	6.36E-06	6.38E-06	6.34E-06	6.33E-06	6.38E-06	6.38E-06	6.44E-06	6.29E-06	6.46E-06	6.68E-06	6.59E-06	6.34E-06	6.26E-06
^{241}Am	4.90E-06	4.73E-06	4.88E-06	4.89E-06	4.93E-06	4.92E-06	5.05E-06	5.03E-06	4.97E-06	4.94E-06	4.86E-06	4.95E-06	4.97E-06	5.12E-06
^{243}Am	8.70E-07	8.09E-07	8.62E-07	9.61E-07	8.36E-07	9.80E-07	9.72E-07	1.02E-06	9.61E-07	9.79E-07	9.16E-07	9.00E-07	9.65E-07	9.58E-07
^{244}Cm	1.71E-07	1.56E-07	1.69E-07	1.68E-07	1.64E-07	1.72E-07	1.67E-07	1.65E-07	1.66E-07	1.70E-07	1.58E-07	1.78E-07	1.66E-07	1.65E-07
^{90}Sr	2.77E-05	2.78E-05	2.75E-05	2.79E-05	2.74E-05	2.76E-05	2.77E-05	2.77E-05	2.78E-05	2.76E-05	2.71E-05	2.79E-05	2.78E-05	2.81E-05
^{95}Mo	4.04E-05	4.05E-05	4.02E-05	4.05E-05	4.01E-05	4.03E-05	4.04E-05	4.05E-05	4.06E-05	4.02E-05	4.04E-05	4.05E-05	4.05E-05	4.04E-05
^{99}Tc	4.07E-05	4.06E-05	3.99E-05	4.04E-05	3.97E-05	4.06E-05	4.07E-05	4.12E-05	4.08E-05	4.01E-05	4.04E-05	4.08E-05	4.06E-05	3.97E-05
^{101}Ru	3.73E-05	3.72E-05	3.70E-05	3.73E-05	3.69E-05	3.72E-05	3.73E-05	3.76E-05	3.74E-05	3.70E-05	3.74E-05	3.73E-05	3.73E-05	3.71E-05
^{103}Rh	2.26E-05	2.27E-05	2.24E-05	2.25E-05	2.21E-05	2.25E-05	2.27E-05	2.28E-05	2.27E-05	2.25E-05	2.24E-05	2.26E-05	2.26E-05	2.25E-05
^{109}Ag	2.71E-06	2.68E-06	2.66E-06	2.71E-06	1.49E-06	2.72E-06	2.75E-06	2.78E-06	2.74E-06	1.90E-06	2.91E-06	2.75E-06	2.73E-06	1.86E-06
^{129}I	5.15E-06	5.11E-06	5.15E-06	5.37E-06	4.96E-06	5.36E-06	5.39E-06	5.42E-06	5.40E-06	5.27E-06	5.99E-06	5.14E-06	5.38E-06	5.37E-06
^{131}Xe	1.71E-05	1.73E-05	1.69E-05	1.74E-05	1.64E-05	1.73E-05	1.73E-05	1.71E-05	1.74E-05	1.72E-05	1.71E-05	1.71E-05	1.74E-05	1.72E-05
^{133}Cs	4.34E-05	4.36E-05	4.25E-05	4.29E-05	4.24E-05	4.27E-05	4.29E-05	4.33E-05	4.31E-05	4.33E-05	4.27E-05	4.32E-05	4.30E-05	4.27E-05
^{134}Cs	6.06E-07	5.87E-07	5.90E-07	5.92E-07	5.87E-07	5.85E-07	5.89E-07	5.47E-07	5.87E-07	5.86E-07	5.83E-07	5.84E-07	5.85E-07	5.82E-07
^{137}Cs	3.79E-05	3.79E-05	3.76E-05	3.80E-05	3.75E-05	3.78E-05	3.80E-05	3.81E-05	3.81E-05	3.77E-05	3.72E-05	3.79E-05	3.80E-05	3.86E-05
^{144}Ce	1.30E-07	1.31E-07	1.30E-07	1.31E-07	1.29E-07	1.30E-07	1.30E-07	1.31E-07	1.31E-07	1.30E-07	1.30E-07	1.22E-07	1.31E-07	1.29E-07
^{143}Nd	2.96E-05	2.96E-05	2.94E-05	2.96E-05	2.95E-05	2.94E-05	2.97E-05	2.98E-05	2.97E-05	2.97E-05	2.97E-05	2.96E-05	2.96E-05	2.93E-05

Table 3.9(1). All results for Case 8b (40% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [1024/cm3] reported by participants (continued)

^{145}Nd	2.37E-05	2.37E-05	2.36E-05	2.37E-05	2.35E-05	2.35E-05	2.36E-05	2.39E-05	2.37E-05	2.35E-05	2.38E-05	2.37E-05	2.36E-05	2.35E-05
^{148}Nd	1.19E-05	1.19E-05	1.19E-05	1.21E-05	1.18E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05	1.19E-05	1.21E-05	1.20E-05
^{147}Sm	8.51E-06	8.39E-06	8.45E-06	8.42E-06	8.37E-06	8.41E-06	8.42E-06	8.41E-06	8.47E-06	8.39E-06	8.41E-06	8.50E-06	8.44E-06	8.36E-06
^{149}Sm	9.06E-08	9.00E-08	9.79E-08	9.79E-08	1.00E-07	9.80E-08	1.00E-07	1.06E-07	9.91E-08	9.28E-08	9.38E-08	9.30E-08	9.36E-08	9.91E-08
^{150}Sm	8.68E-06	8.41E-06	8.73E-06	8.82E-06	8.35E-06	8.73E-06	8.80E-06	9.15E-06	8.80E-06	8.37E-06	8.60E-06	8.47E-06	8.83E-06	8.78E-06
^{151}Sm	3.36E-07	3.59E-07	3.39E-07	3.38E-07	3.84E-07	3.41E-07	3.49E-07	4.12E-07	3.47E-07	3.48E-07	3.63E-07	3.41E-07	3.44E-07	3.50E-07
^{152}Sm	3.67E-06	4.38E-06	3.65E-06	3.72E-06	3.82E-06	3.72E-06	3.70E-06	3.70E-06	3.75E-06	3.66E-06	3.73E-06	3.65E-06	3.74E-06	3.67E-06
^{153}Eu	3.25E-06	2.97E-06	3.23E-06	3.29E-06	3.32E-06	3.25E-06	3.28E-06	3.35E-06	3.28E-06	3.24E-06	3.24E-06	3.25E-06	3.27E-06	3.26E-06
^{154}Eu	3.59E-07	3.20E-07	3.58E-07	3.66E-07	3.65E-07	3.63E-07	3.67E-07	3.59E-07	3.67E-07	3.55E-07	3.08E-07	3.54E-07	3.65E-07	3.65E-07
^{155}Eu	9.58E-08	8.92E-08	9.44E-08	9.87E-08	9.59E-08	9.69E-08	9.76E-08	6.97E-08	9.78E-08	9.58E-08	9.77E-08	9.76E-08	9.72E-08	9.59E-08
^{155}Gd	1.32E-07	1.24E-07	1.30E-07	1.30E-07	1.33E-07	1.28E-07	1.30E-07	1.01E-07	1.29E-07	1.29E-07	1.33E-07	1.30E-07	1.29E-07	1.29E-07
^{156}Gd	9.59E-05	9.64E-05	9.59E-05	9.63E-05	9.63E-05	9.64E-05	9.63E-05	9.63E-05	9.62E-05	9.60E-05	9.64E-05	9.59E-05	9.62E-05	9.60E-05
^{157}Gd	2.62E-08	2.18E-08	2.63E-08	2.02E-08	2.36E-08	1.97E-08	2.11E-08	2.21E-08	2.10E-08	2.34E-08	2.24E-08	2.61E-08	2.13E-08	2.38E-08
^{158}Gd	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04

Table 3.9(2). All results for Case 8b (40% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	4.55E-06	4.67E-06	4.66E-06	4.66E-06	4.65E-06	4.64E-06	4.59E-06	4.73E-06	4.68E-06	4.76E-06	4.65E-06	4.65E-06	4.65E-06	4.58E-06
^{235}U	3.21E-04	3.16E-04	3.19E-04	3.18E-04	3.25E-04	3.22E-04	3.19E-04	3.15E-04	3.20E-04	3.21E-04	3.24E-04	3.25E-04	3.16E-04	3.21E-04
^{236}U	9.78E-05	9.88E-05	9.85E-05	9.82E-05	9.55E-05	9.90E-05	9.44E-05	9.93E-05	9.82E-05	9.73E-05	9.87E-05	9.55E-05	9.86E-05	9.51E-05
^{238}U	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	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02
^{237}Np	6.79E-06	7.03E-06	7.13E-06	7.21E-06	6.83E-06	6.97E-06	8.05E-06	7.13E-06	7.04E-06	6.94E-06	6.93E-06	6.81E-06	7.13E-06	6.92E-06
^{238}Pu	1.87E-06	1.87E-06	1.90E-06	1.95E-06	1.88E-06	1.93E-06	2.19E-06	1.84E-06	1.85E-06	2.07E-06	1.92E-06	1.87E-06	1.89E-06	1.93E-06
^{239}Pu	1.02E-04	1.04E-04	1.00E-04	1.00E-04	1.04E-04	1.01E-04	1.09E-04	1.01E-04	1.01E-04	1.01E-04	1.03E-04	1.03E-04	1.02E-04	1.01E-04
^{240}Pu	4.06E-05	4.21E-05	4.11E-05	4.14E-05	4.03E-05	3.95E-05	4.09E-05	4.01E-05	4.06E-05	4.03E-05	4.04E-05	4.06E-05	4.07E-05	4.14E-05
^{241}Pu	1.53E-05	1.56E-05	1.56E-05	1.55E-05	1.59E-05	1.60E-05	1.71E-05	1.57E-05	1.53E-05	1.53E-05	1.60E-05	1.57E-05	1.54E-05	1.55E-05
^{242}Pu	5.85E-06	6.34E-06	6.41E-06	6.49E-06	6.07E-06	6.10E-06	6.52E-06	6.43E-06	6.20E-06	6.34E-06	6.10E-06	6.06E-06	6.36E-06	6.25E-06
^{241}Am	4.91E-06	5.00E-06	5.01E-06	4.90E-06	5.04E-06	5.07E-06	5.45E-06	5.03E-06	4.87E-06	4.83E-06	5.11E-06	5.00E-06	4.94E-06	4.91E-06
^{243}Am	8.82E-07	9.66E-07	9.72E-07	8.87E-07	8.04E-07	9.16E-07	8.47E-07	8.79E-07	9.33E-07	8.64E-07	9.13E-07	8.01E-07	9.68E-07	8.55E-07
^{244}Cm	1.52E-07	1.66E-07	1.68E-07	1.52E-07	1.42E-07	1.64E-07	1.37E-07	1.54E-07	1.67E-07	1.59E-07	1.63E-07	1.41E-07	1.68E-07	1.47E-07
^{90}Sr	2.74E-05	2.77E-05	2.81E-05	2.75E-05	2.76E-05	2.75E-05	2.75E-05	-	2.74E-05	2.73E-05	2.73E-05	2.76E-05	2.77E-05	2.78E-05
^{95}Mo	4.01E-05	4.05E-05	4.05E-05	4.07E-05	4.05E-05	4.01E-05	4.04E-05	4.01E-05	3.99E-05	3.99E-05	4.00E-05	4.05E-05	4.03E-05	4.08E-05
^{99}Tc	3.96E-05	4.07E-05	3.97E-05	3.98E-05	3.98E-05	3.93E-05	4.09E-05	3.92E-05	3.88E-05	3.90E-05	3.93E-05	3.98E-05	3.95E-05	4.03E-05
^{101}Ru	3.68E-05	3.73E-05	3.72E-05	3.75E-05	3.72E-05	3.70E-05	3.73E-05	3.70E-05	3.63E-05	3.65E-05	3.70E-05	3.72E-05	3.71E-05	3.74E-05
^{103}Rh	2.23E-05	2.26E-05	2.25E-05	2.24E-05	2.20E-05	2.24E-05	2.28E-05	2.22E-05	2.23E-05	2.24E-05	2.25E-05	2.20E-05	2.24E-05	2.19E-05
^{109}Ag	2.73E-06	2.74E-06	1.87E-06	2.86E-06	2.60E-06	2.66E-06	2.64E-06	2.61E-06	2.77E-06	2.78E-06	2.69E-06	2.60E-06	1.94E-06	2.72E-06
^{129}I	5.37E-06	5.30E-06	5.39E-06	6.08E-06	5.28E-06	4.38E-06	5.30E-06	5.26E-06	6.57E-06	6.56E-06	4.40E-06	5.28E-06	5.41E-06	6.48E-06
^{131}Xe	1.68E-05	1.73E-05	1.73E-05	1.72E-05	1.69E-05	1.62E-05	1.70E-05	1.71E-05	1.71E-05	1.69E-05	1.63E-05	1.69E-05	1.72E-05	1.74E-05
^{133}Cs	4.30E-05	4.31E-05	4.27E-05	4.21E-05	4.16E-05	4.26E-05	4.32E-05	4.28E-05	4.25E-05	4.24E-05	4.26E-05	4.16E-05	4.28E-05	4.21E-05
^{134}Cs	5.07E-07	5.82E-07	5.83E-07	5.78E-07	6.18E-07	5.77E-07	6.82E-07	5.54E-07	5.73E-07	5.90E-07	5.73E-07	6.16E-07	5.85E-07	5.87E-07
^{137}Cs	3.75E-05	3.78E-05	3.87E-05	3.80E-05	3.76E-05	3.77E-05	3.81E-05	3.78E-05	3.70E-05	3.70E-05	3.77E-05	3.76E-05	3.78E-05	3.79E-05
^{144}Ce	1.29E-07	1.31E-07	1.30E-07	1.29E-07	1.28E-07	1.29E-07	1.31E-07	1.31E-07	1.27E-07	1.27E-07	1.29E-07	1.29E-07	1.31E-07	1.30E-07
^{143}Nd	2.95E-05	2.96E-05	2.94E-05	2.93E-05	2.97E-05	2.95E-05	2.99E-05	2.94E-05	2.93E-05	2.94E-05	2.96E-05	2.97E-05	2.93E-05	2.97E-05

Table 3.9(2). All results for Case 8b (40% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [1024/cm3] reported by participants (continued)

^{145}Nd	2.35E-05	2.36E-05	2.36E-05	2.39E-05	2.38E-05	2.37E-05	2.37E-05	2.34E-05	2.33E-05	2.34E-05	2.37E-05	2.38E-05	2.35E-05	2.38E-05
^{148}Nd	1.19E-05	1.21E-05	1.20E-05	1.21E-05	1.21E-05	1.20E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05
^{147}Sm	8.40E-06	8.46E-06	8.37E-06	8.38E-06	8.10E-06	8.02E-06	7.84E-06	8.08E-06	8.47E-06	8.51E-06	8.04E-06	8.11E-06	8.36E-06	8.49E-06
^{149}Sm	1.04E-07	9.93E-08	9.89E-08	9.81E-08	1.09E-07	1.09E-07	1.10E-07	9.90E-08	9.42E-08	9.36E-08	1.09E-07	1.08E-07	9.92E-08	1.02E-07
^{150}Sm	8.70E-06	8.78E-06	8.79E-06	8.95E-06	8.74E-06	8.77E-06	8.86E-06	8.69E-06	8.49E-06	8.50E-06	8.77E-06	8.74E-06	8.78E-06	8.93E-06
^{151}Sm	3.75E-07	3.44E-07	3.53E-07	3.60E-07	4.09E-07	4.04E-07	3.91E-07	3.46E-07	3.50E-07	3.46E-07	4.06E-07	4.06E-07	3.43E-07	3.58E-07
^{152}Sm	3.90E-06	3.72E-06	3.68E-06	3.75E-06	4.11E-06	4.10E-06	4.16E-06	3.70E-06	3.76E-06	3.74E-06	4.11E-06	4.12E-06	3.68E-06	3.73E-06
^{153}Eu	3.22E-06	3.27E-06	3.26E-06	3.26E-06	3.26E-06	3.22E-06	3.26E-06	3.06E-06	3.32E-06	3.31E-06	3.22E-06	3.26E-06	3.25E-06	3.33E-06
^{154}Eu	3.57E-07	3.66E-07	3.60E-07	3.14E-07	3.43E-07	3.57E-07	3.26E-07	3.38E-07	3.65E-07	3.64E-07	3.56E-07	3.41E-07	3.64E-07	5.44E-07
^{155}Eu	6.91E-08	9.76E-08	9.65E-08	9.87E-08	7.22E-08	7.10E-08	1.04E-07	8.84E-08	1.02E-07	1.01E-07	6.84E-08	7.26E-08	9.71E-08	8.51E-08
^{155}Gd	2.47E-08	1.26E-07	1.29E-07	1.34E-07	1.02E-07	9.82E-08	1.44E-07	1.20E-07	1.28E-07	1.31E-07	1.01E-07	1.02E-07	1.29E-07	1.14E-07
^{156}Gd	9.44E-05	9.62E-05	9.60E-05	9.64E-05	9.67E-05	9.64E-05	9.62E-05	9.64E-05	9.60E-05	9.59E-05	9.64E-05	9.68E-05	9.60E-05	9.62E-05
^{157}Gd	2.14E-08	2.08E-08	2.37E-08	2.20E-08	2.13E-08	2.19E-08	2.46E-08	2.09E-08	2.31E-08	2.68E-08	2.17E-08	2.08E-08	2.25E-08	2.20E-08
^{158}Gd	1.07E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04

Table 3.9(3). All results for Case 8b (40% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ^(r)^
^{234}U	4.67E-06	4.68E-06	4.61E-06	4.67E-06	4.29E-06	4.78E-06	4.68E-06	4.66E-06	1.82E-07	3.91E-02
^{235}U	3.16E-04	3.16E-04	3.10E-04	3.17E-04	3.15E-04	3.19E-04	3.21E-04	3.18E-04	7.47E-06	2.35E-02
^{236}U	9.89E-05	9.88E-05	9.93E-05	9.89E-05	9.87E-05	9.77E-05	9.47E-05	9.80E-05	2.72E-06	2.78E-02
^{238}U	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	1.22E-05	5.80E-04
^{237}Np	7.21E-06	7.11E-06	7.33E-06	6.97E-06	7.14E-06	6.86E-06	6.55E-06	7.04E-06	4.70E-07	6.67E-02
^{238}Pu	1.92E-06	1.90E-06	2.09E-06	1.71E-06	1.89E-06	2.06E-06	1.77E-06	1.93E-06	2.09E-07	1.08E-01
^{239}Pu	1.05E-04	1.04E-04	1.02E-04	1.03E-04	1.02E-04	1.00E-04	1.01E-04	1.02E-04	5.23E-06	5.15E-02
^{240}Pu	4.24E-05	4.25E-05	4.18E-05	4.14E-05	4.09E-05	4.01E-05	4.07E-05	4.11E-05	1.88E-06	4.58E-02
^{241}Pu	1.58E-05	1.57E-05	1.56E-05	1.55E-05	1.52E-05	1.53E-05	1.56E-05	1.56E-05	7.21E-07	4.63E-02
^{242}Pu	6.44E-06	6.41E-06	6.63E-06	6.29E-06	6.28E-06	6.33E-06	6.16E-06	6.33E-06	3.39E-07	5.35E-02
^{241}Am	5.09E-06	5.04E-06	4.94E-06	4.98E-06	4.84E-06	4.86E-06	4.98E-06	4.97E-06	2.39E-07	4.80E-02
^{243}Am	9.83E-07	9.82E-07	9.30E-07	9.39E-07	8.85E-07	8.40E-07	8.21E-07	9.10E-07	1.22E-07	1.34E-01
^{244}Cm	1.71E-07	1.71E-07	1.64E-07	1.65E-07	1.54E-07	1.62E-07	1.44E-07	1.61E-07	1.98E-08	1.23E-01
^{90}Sr	2.78E-05	2.78E-05	2.75E-05	2.77E-05	2.76E-05	2.76E-05	2.81E-05	2.76E-05	4.58E-07	1.66E-02
^{95}Mo	4.05E-05	4.05E-05	4.10E-05	4.04E-05	4.02E-05	4.02E-05	4.03E-05	4.04E-05	4.75E-07	1.18E-02
^{99}Tc	4.06E-05	4.06E-05	4.04E-05	4.00E-05	3.92E-05	4.00E-05	3.99E-05	4.01E-05	1.22E-06	3.04E-02
^{101}Ru	3.74E-05	3.74E-05	3.80E-05	3.72E-05	3.69E-05	3.70E-05	3.64E-05	3.72E-05	6.48E-07	1.74E-02
^{103}Rh	2.28E-05	2.27E-05	2.29E-05	2.17E-05	2.17E-05	2.25E-05	2.20E-05	2.24E-05	6.07E-07	2.71E-02
^{109}Ag	2.78E-06	2.77E-06	3.00E-06	1.78E-06	2.51E-06	2.65E-06	3.12E-06	2.58E-06	7.55E-07	2.93E-01
^{129}I	5.42E-06	5.41E-06	6.11E-06	4.92E-06	5.13E-06	5.11E-06	6.06E-06	5.42E-06	1.01E-06	1.86E-01
^{131}Xe	1.74E-05	1.74E-05	1.72E-05	1.68E-05	1.72E-05	1.70E-05	1.71E-05	1.71E-05	5.94E-07	3.48E-02
^{133}Cs	4.31E-05	4.31E-05	4.28E-05	4.30E-05	4.24E-05	4.25E-05	4.28E-05	4.28E-05	9.03E-07	2.11E-02
^{134}Cs	5.93E-07	5.86E-07	6.01E-07	5.82E-07	5.76E-07	5.84E-07	5.48E-07	5.85E-07	5.17E-08	8.85E-02
^{137}Cs	3.81E-05	3.81E-05	3.84E-05	3.80E-05	3.78E-05	3.76E-05	3.83E-05	3.79E-05	7.41E-07	1.96E-02
^{144}Ce	1.31E-07	1.31E-07	1.32E-07	1.31E-07	1.30E-07	1.30E-07	1.30E-07	1.30E-07	3.67E-09	2.83E-02
^{143}Nd	2.97E-05	2.97E-05	2.96E-05	2.96E-05	2.94E-05	2.95E-05	2.95E-05	2.96E-05	3.10E-07	1.05E-02

Table 3.9(3). All results for Case 8b (40% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	2.37E-05	2.37E-05	2.42E-05	2.35E-05	2.33E-05	2.36E-05	2.38E-05	2.36E-05	3.31E-07	1.40E-02
^{148}Nd	1.21E-05	1.21E-05	1.23E-05	1.20E-05	1.20E-05	1.19E-05	1.20E-05	1.20E-05	1.81E-07	1.50E-02
^{147}Sm	8.42E-06	8.44E-06	8.49E-06	8.38E-06	7.16E-06	8.49E-06	8.47E-06	8.33E-06	5.22E-07	6.26E-02
^{149}Sm	9.55E-08	9.49E-08	8.88E-08	1.01E-07	8.89E-08	9.79E-08	9.94E-08	9.86E-08	1.15E-08	1.17E-01
^{150}Sm	8.87E-06	8.88E-06	8.44E-06	8.79E-06	8.44E-06	8.72E-06	8.71E-06	8.71E-06	3.60E-07	4.14E-02
^{151}Sm	3.49E-07	3.48E-07	3.43E-07	3.51E-07	3.33E-07	3.38E-07	3.55E-07	3.59E-07	4.73E-08	1.32E-01
^{152}Sm	3.80E-06	3.76E-06	3.74E-06	3.68E-06	3.65E-06	3.67E-06	3.84E-06	3.80E-06	3.64E-07	9.58E-02
^{153}Eu	3.29E-06	3.29E-06	3.29E-06	3.27E-06	3.09E-06	3.21E-06	3.19E-06	3.24E-06	1.48E-07	4.56E-02
^{154}Eu	3.67E-07	3.68E-07	3.68E-07	3.65E-07	3.47E-07	3.52E-07	3.12E-07	3.58E-07	7.31E-08	2.04E-01
^{155}Eu	9.87E-08	9.78E-08	9.73E-08	9.68E-08	9.24E-08	9.40E-08	9.56E-08	9.19E-08	2.10E-08	2.28E-01
^{155}Gd	1.31E-07	1.30E-07	1.31E-07	1.30E-07	1.26E-07	1.29E-07	1.28E-07	1.22E-07	4.04E-08	3.31E-01
^{156}Gd	9.63E-05	9.56E-05	9.64E-05	9.45E-05	9.60E-05	9.61E-05	9.55E-05	9.61E-05	9.83E-07	1.02E-02
^{157}Gd	2.12E-08	2.15E-08	2.06E-08	2.25E-08	2.22E-08	2.33E-08	2.58E-08	2.26E-08	3.75E-09	1.66E-01
^{158}Gd	1.13E-04	1.12E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.95E-06	1.73E-02

Table 3.10(1). All results for Case 8c (40% void, 30 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	4.91E-06	5.03E-06	4.92E-06	4.79E-06	4.90E-06	4.81E-06	4.81E-06	4.73E-06	4.81E-06	4.81E-06	4.82E-06	4.91E-06	4.80E-06	4.80E-06
^{235}U	3.17E-04	3.12E-04	3.19E-04	3.11E-04	3.21E-04	3.15E-04	3.16E-04	3.19E-04	3.15E-04	3.19E-04	3.20E-04	3.18E-04	3.14E-04	3.18E-04
^{236}U	9.81E-05	9.99E-05	9.78E-05	9.95E-05	9.77E-05	9.93E-05	9.88E-05	9.85E-05	9.90E-05	9.85E-05	9.83E-05	9.79E-05	9.90E-05	9.84E-05
^{238}U	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	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02
^{237}Np	7.04E-06	7.04E-06	7.02E-06	7.16E-06	6.93E-06	7.06E-06	7.32E-06	7.24E-06	7.17E-06	7.19E-06	7.28E-06	7.16E-06	7.12E-06	7.31E-06
^{238}Pu	1.93E-06	1.90E-06	1.93E-06	1.74E-06	1.74E-06	1.73E-06	1.77E-06	1.83E-06	1.75E-06	1.76E-06	1.82E-06	1.98E-06	1.73E-06	1.75E-06
^{239}Pu	9.97E-05	9.66E-05	1.01E-04	9.92E-05	1.01E-04	1.01E-04	1.05E-04	1.08E-04	1.04E-04	9.79E-05	9.58E-05	9.88E-05	1.02E-04	1.03E-04
^{240}Pu	4.06E-05	3.99E-05	4.04E-05	4.09E-05	4.06E-05	4.15E-05	4.22E-05	4.40E-05	4.22E-05	4.17E-05	4.26E-05	4.10E-05	4.19E-05	4.00E-05
^{241}Pu	9.48E-06	9.16E-06	9.45E-06	9.39E-06	9.55E-06	9.44E-06	9.67E-06	9.63E-06	9.53E-06	9.48E-06	9.47E-06	9.58E-06	9.53E-06	9.84E-06
^{242}Pu	6.45E-06	6.36E-06	6.38E-06	6.34E-06	6.32E-06	6.38E-06	6.38E-06	6.44E-06	6.29E-06	6.46E-06	6.68E-06	6.59E-06	6.34E-06	6.26E-06
^{241}Am	1.07E-05	1.03E-05	1.07E-05	1.06E-05	1.08E-05	1.07E-05	1.10E-05	1.09E-05	1.08E-05	1.07E-05	1.06E-05	1.07E-05	1.08E-05	1.11E-05
^{243}Am	8.69E-07	8.08E-07	8.62E-07	9.60E-07	8.36E-07	9.80E-07	9.72E-07	1.02E-06	9.60E-07	9.78E-07	9.16E-07	8.99E-07	9.64E-07	9.57E-07
^{244}Cm	1.16E-07	1.06E-07	1.15E-07	1.14E-07	1.12E-07	1.17E-07	1.14E-07	1.13E-07	1.13E-07	1.16E-07	1.08E-07	1.22E-07	1.13E-07	1.12E-07
^{90}Sr	2.18E-05	2.19E-05	2.16E-05	2.19E-05	2.16E-05	2.19E-05	2.18E-05	2.18E-05	2.19E-05	2.17E-05	2.13E-05	2.20E-05	2.18E-05	2.21E-05
^{95}Mo	4.04E-05	4.05E-05	4.02E-05	4.05E-05	4.01E-05	4.05E-05	4.04E-05	4.05E-05	4.06E-05	4.02E-05	4.04E-05	4.05E-05	4.05E-05	4.04E-05
^{99}Tc	4.07E-05	4.06E-05	3.99E-05	4.04E-05	3.97E-05	4.08E-05	4.07E-05	4.12E-05	4.08E-05	4.01E-05	4.04E-05	4.08E-05	4.06E-05	3.97E-05
^{101}Ru	3.73E-05	3.72E-05	3.70E-05	3.73E-05	3.69E-05	3.73E-05	3.73E-05	3.76E-05	3.74E-05	3.70E-05	3.74E-05	3.73E-05	3.73E-05	3.71E-05
^{103}Rh	2.26E-05	2.27E-05	2.24E-05	2.25E-05	2.21E-05	2.26E-05	2.27E-05	2.28E-05	2.27E-05	2.25E-05	2.24E-05	2.26E-05	2.26E-05	2.25E-05
^{109}Ag	2.71E-06	2.68E-06	2.66E-06	2.71E-06	1.49E-06	2.73E-06	2.75E-06	2.78E-06	2.74E-06	1.90E-06	2.91E-06	2.75E-06	2.73E-06	1.86E-06
^{129}I	5.15E-06	5.11E-06	5.15E-06	5.37E-06	4.96E-06	5.38E-06	5.39E-06	5.42E-06	5.40E-06	5.27E-06	5.99E-06	5.14E-06	5.38E-06	5.37E-06
^{131}Xe	1.71E-05	1.73E-05	1.69E-05	1.74E-05	1.64E-05	1.74E-05	1.73E-05	1.71E-05	1.74E-05	1.72E-05	1.71E-05	1.71E-05	1.74E-05	1.72E-05
^{133}Cs	4.34E-05	4.36E-05	4.25E-05	4.29E-05	4.24E-05	4.30E-05	4.29E-05	4.33E-05	4.31E-05	4.33E-05	4.27E-05	4.32E-05	4.30E-05	4.27E-05
^{134}Cs	2.11E-08	2.05E-08	2.06E-08	2.06E-08	2.05E-08	2.05E-08	2.05E-08	1.91E-08	2.05E-08	2.04E-08	2.03E-08	2.03E-08	2.04E-08	2.03E-08
^{137}Cs	3.01E-05	3.01E-05	2.99E-05	3.02E-05	2.98E-05	3.02E-05	3.02E-05	3.03E-05	3.03E-05	3.00E-05	2.95E-05	3.01E-05	3.02E-05	3.07E-05
^{144}Ce	1.80E-11	1.81E-11	1.81E-11	1.81E-11	1.83E-11	1.81E-11	1.80E-11	1.82E-11	1.83E-11	1.80E-11	1.80E-11	1.66E-11	1.81E-11	1.79E-11
^{143}Nd	2.96E-05	2.96E-05	2.94E-05	2.96E-05	2.95E-05	2.96E-05	2.97E-05	2.98E-05	2.97E-05	2.97E-05	2.97E-05	2.96E-05	2.96E-05	2.93E-05
^{145}Nd	2.37E-05	2.37E-05	2.36E-05	2.37E-05	2.35E-05	2.36E-05	2.36E-05	2.39E-05	2.37E-05	2.35E-05	2.38E-05	2.37E-05	2.36E-05	2.35E-05

Table 3.10(1). All results for Case 8c (40% void, 30 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{148}Nd	1.19E-05	1.19E-05	1.19E-05	1.21E-05	1.18E-05	1.21E-05	1.21E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05	1.19E-05	1.21E-05	1.20E-05
^{147}Sm	1.03E-05	1.01E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.01E-05	1.02E-05	1.03E-05	1.02E-05	1.01E-05
^{149}Sm	9.06E-08	9.00E-08	9.79E-08	9.79E-08	1.00E-07	9.84E-08	1.00E-07	1.06E-07	9.91E-08	9.28E-08	9.38E-08	9.30E-08	9.36E-08	9.91E-08
^{150}Sm	8.68E-06	8.41E-06	8.73E-06	8.82E-06	8.35E-06	8.77E-06	8.80E-06	9.15E-06	8.80E-06	8.37E-06	8.60E-06	8.47E-06	8.83E-06	8.78E-06
^{151}Sm	3.11E-07	3.33E-07	3.14E-07	3.13E-07	3.55E-07	3.17E-07	3.23E-07	3.81E-07	3.21E-07	3.22E-07	3.36E-07	3.16E-07	3.18E-07	3.24E-07
^{152}Sm	3.67E-06	4.38E-06	3.65E-06	3.72E-06	3.82E-06	3.73E-06	3.70E-06	3.70E-06	3.75E-06	3.66E-06	3.73E-06	3.65E-06	3.74E-06	3.67E-06
^{153}Eu	3.25E-06	2.97E-06	3.23E-06	3.29E-06	3.32E-06	3.26E-06	3.28E-06	3.35E-06	3.28E-06	3.24E-06	3.24E-06	3.25E-06	3.27E-06	3.26E-06
^{154}Eu	1.60E-07	1.43E-07	1.60E-07	1.63E-07	1.63E-07	1.63E-07	1.64E-07	1.60E-07	1.64E-07	1.58E-07	1.37E-07	1.58E-07	1.63E-07	1.63E-07
^{155}Eu	2.23E-08	2.07E-08	2.20E-08	2.30E-08	2.23E-08	2.26E-08	2.27E-08	1.62E-08	2.28E-08	2.23E-08	2.27E-08	2.42E-08	2.26E-08	2.23E-08
^{155}Gd	2.05E-07	1.92E-07	2.03E-07	2.06E-07	2.07E-07	2.01E-07	2.04E-07	1.54E-07	2.04E-07	2.02E-07	2.08E-07	2.03E-07	2.04E-07	2.02E-07
^{156}Gd	9.59E-05	9.64E-05	9.59E-05	9.63E-05	9.63E-05	8.70E-05	9.63E-05	9.63E-05	9.62E-05	9.60E-05	9.64E-05	9.59E-05	9.62E-05	9.60E-05
^{157}Gd	2.62E-08	2.18E-08	2.63E-08	2.02E-08	2.36E-08	1.79E-08	2.11E-08	2.21E-08	2.10E-08	2.34E-08	2.24E-08	2.61E-08	2.13E-08	2.38E-08
^{158}Gd	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.01E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04

Table 3.10(2). All results for Case 8c (40% void, 30 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	4.55E-06	4.81E-06	4.80E-06	4.81E-06	4.80E-06	4.79E-06	4.76E-06	4.87E-06	4.82E-06	4.91E-06	4.80E-06	4.80E-06	4.80E-06	4.73E-06
^{235}U	3.21E-04	3.16E-04	3.19E-04	3.18E-04	3.25E-04	3.22E-04	3.19E-04	3.15E-04	3.20E-04	3.21E-04	3.24E-04	3.25E-04	3.16E-04	3.21E-04
^{236}U	9.78E-05	9.89E-05	9.85E-05	9.83E-05	9.56E-05	9.91E-05	9.45E-05	9.93E-05	9.82E-05	9.73E-05	9.88E-05	9.56E-05	9.87E-05	9.51E-05
^{238}U	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	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02
^{237}Np	6.79E-06	7.16E-06	7.27E-06	7.33E-06	6.96E-06	7.10E-06	8.19E-06	7.13E-06	7.16E-06	7.07E-06	7.07E-06	6.94E-06	7.26E-06	7.05E-06
^{238}Pu	1.72E-06	1.73E-06	1.76E-06	1.80E-06	1.73E-06	1.79E-06	2.02E-06	1.70E-06	1.71E-06	1.92E-06	1.78E-06	1.73E-06	1.75E-06	1.78E-06
^{239}Pu	1.02E-04	1.04E-04	1.00E-04	1.00E-04	1.04E-04	1.01E-04	1.09E-04	1.01E-04	1.01E-04	1.01E-04	1.03E-04	1.03E-04	1.01E-04	1.01E-04
^{240}Pu	4.05E-05	4.21E-05	4.11E-05	4.15E-05	4.03E-05	3.95E-05	4.09E-05	4.00E-05	4.06E-05	4.03E-05	4.04E-05	4.06E-05	4.07E-05	4.14E-05
^{241}Pu	9.46E-06	9.57E-06	9.61E-06	9.55E-06	9.82E-06	9.87E-06	1.06E-05	9.68E-06	9.45E-06	9.48E-06	9.87E-06	9.72E-06	9.48E-06	9.56E-06
^{242}Pu	5.85E-06	6.34E-06	6.41E-06	6.49E-06	6.07E-06	6.10E-06	6.52E-06	6.43E-06	6.20E-06	6.34E-06	6.10E-06	6.06E-06	6.36E-06	6.25E-06
^{241}Am	1.07E-05	1.08E-05	1.09E-05	1.07E-05	1.10E-05	1.10E-05	1.19E-05	1.09E-05	1.06E-05	1.06E-05	1.11E-05	1.09E-05	1.07E-05	1.07E-05
^{243}Am	8.81E-07	9.65E-07	9.71E-07	8.86E-07	8.04E-07	9.15E-07	8.46E-07	8.78E-07	9.32E-07	8.64E-07	9.12E-07	8.01E-07	9.67E-07	8.54E-07
^{244}Cm	1.04E-07	1.13E-07	1.15E-07	1.03E-07	9.67E-08	1.12E-07	9.35E-08	1.05E-07	1.14E-07	1.09E-07	1.11E-07	9.62E-08	1.15E-07	1.01E-07
^{90}Sr	2.14E-05	2.18E-05	2.21E-05	2.16E-05	2.18E-05	2.17E-05	2.15E-05	-	2.16E-05	2.15E-05	2.13E-05	2.17E-05	2.18E-05	2.19E-05
^{95}Mo	4.01E-05	4.05E-05	4.05E-05	4.07E-05	4.05E-05	4.01E-05	4.04E-05	4.01E-05	3.99E-05	3.99E-05	4.00E-05	4.05E-05	4.03E-05	4.08E-05
^{99}Tc	3.96E-05	4.07E-05	3.97E-05	3.98E-05	3.98E-05	3.93E-05	4.09E-05	3.92E-05	3.88E-05	3.90E-05	3.93E-05	3.98E-05	3.95E-05	4.03E-05
^{101}Ru	3.68E-05	3.73E-05	3.72E-05	3.75E-05	3.72E-05	3.70E-05	3.73E-05	3.70E-05	3.63E-05	3.65E-05	3.70E-05	3.72E-05	3.71E-05	3.74E-05
^{103}Rh	2.23E-05	2.26E-05	2.25E-05	2.24E-05	2.20E-05	2.24E-05	2.28E-05	2.22E-05	2.23E-05	2.24E-05	2.25E-05	2.20E-05	2.24E-05	2.19E-05
^{109}Ag	2.73E-06	2.74E-06	1.87E-06	2.86E-06	2.60E-06	2.66E-06	2.64E-06	2.61E-06	2.77E-06	2.78E-06	2.69E-06	2.60E-06	1.94E-06	2.72E-06
^{129}I	5.37E-06	5.30E-06	5.39E-06	6.08E-06	5.28E-06	4.38E-06	5.30E-06	5.26E-06	6.57E-06	6.56E-06	4.40E-06	5.28E-06	5.41E-06	6.48E-06
^{131}Xe	1.68E-05	1.73E-05	1.73E-05	1.72E-05	1.69E-05	1.62E-05	1.70E-05	1.71E-05	1.71E-05	1.69E-05	1.63E-05	1.69E-05	1.72E-05	1.74E-05
^{133}Cs	4.30E-05	4.31E-05	4.27E-05	4.21E-05	4.16E-05	4.26E-05	4.32E-05	4.28E-05	4.25E-05	4.24E-05	4.26E-05	4.16E-05	4.28E-05	4.21E-05
^{134}Cs	1.76E-08	2.03E-08	2.04E-08	2.02E-08	2.15E-08	2.00E-08	2.37E-08	1.93E-08	1.99E-08	2.05E-08	1.99E-08	2.14E-08	2.04E-08	2.04E-08
^{137}Cs	2.98E-05	3.00E-05	3.07E-05	3.02E-05	2.99E-05	2.99E-05	3.02E-05	3.00E-05	2.94E-05	2.94E-05	2.99E-05	2.99E-05	3.00E-05	3.01E-05
^{144}Ce	1.78E-11	1.80E-11	1.81E-11	1.81E-11	1.74E-11	1.75E-11	1.83E-11	1.82E-11	1.73E-11	1.73E-11	1.83E-11	1.82E-11	1.82E-11	1.80E-11
^{143}Nd	2.95E-05	2.96E-05	2.94E-05	2.93E-05	2.97E-05	2.95E-05	2.99E-05	2.94E-05	2.93E-05	2.94E-05	2.96E-05	2.97E-05	2.93E-05	2.97E-05
^{145}Nd	2.35E-05	2.36E-05	2.36E-05	2.39E-05	2.38E-05	2.37E-05	2.37E-05	2.34E-05	2.33E-05	2.34E-05	2.37E-05	2.38E-05	2.35E-05	2.38E-05

Table 3.10(2). All results for Case 8c (40% void, 30 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{148}Nd	1.19E-05	1.21E-05	1.20E-05	1.21E-05	1.21E-05	1.20E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05
^{147}Sm	1.02E-05	1.02E-05	1.01E-05	1.01E-05	9.79E-06	9.69E-06	9.47E-06	9.80E-06	1.02E-05	1.03E-05	9.71E-06	9.79E-06	1.01E-05	1.03E-05
^{149}Sm	1.04E-07	9.93E-08	9.89E-08	9.81E-08	1.09E-07	1.09E-07	1.10E-07	9.90E-08	9.42E-08	9.36E-08	1.09E-07	1.08E-07	9.92E-08	1.02E-07
^{150}Sm	8.70E-06	8.78E-06	8.79E-06	8.95E-06	8.74E-06	8.77E-06	8.86E-06	8.69E-06	8.49E-06	8.50E-06	8.77E-06	8.74E-06	8.78E-06	8.93E-06
^{151}Sm	3.47E-07	3.19E-07	3.27E-07	3.34E-07	3.79E-07	3.74E-07	3.62E-07	3.21E-07	3.24E-07	3.20E-07	3.76E-07	3.76E-07	3.17E-07	3.31E-07
^{152}Sm	3.90E-06	3.72E-06	3.68E-06	3.75E-06	4.11E-06	4.10E-06	4.16E-06	3.70E-06	3.76E-06	3.74E-06	4.11E-06	4.12E-06	3.68E-06	3.73E-06
^{153}Eu	3.22E-06	3.27E-06	3.26E-06	3.26E-06	3.26E-06	3.22E-06	3.26E-06	3.06E-06	3.32E-06	3.31E-06	3.22E-06	3.26E-06	3.25E-06	3.33E-06
^{154}Eu	1.59E-07	1.63E-07	1.61E-07	1.40E-07	1.53E-07	1.59E-07	1.46E-07	1.51E-07	1.63E-07	1.63E-07	1.59E-07	1.52E-07	1.62E-07	2.43E-07
^{155}Eu	1.57E-08	2.27E-08	2.25E-08	2.30E-08	1.79E-08	1.76E-08	2.37E-08	2.06E-08	2.51E-08	2.50E-08	1.55E-08	1.79E-08	2.26E-08	2.10E-08
^{155}Gd	2.47E-08	2.01E-07	2.03E-07	2.09E-07	1.56E-07	1.52E-07	2.24E-07	1.88E-07	2.04E-07	2.07E-07	1.54E-07	1.56E-07	2.03E-07	1.78E-07
^{156}Gd	9.44E-05	9.62E-05	9.60E-05	9.64E-05	9.67E-05	9.64E-05	9.62E-05	9.64E-05	9.60E-05	9.59E-05	9.64E-05	9.68E-05	9.60E-05	9.62E-05
^{157}Gd	2.14E-08	2.08E-08	2.37E-08	2.20E-08	2.13E-08	2.19E-08	2.46E-08	2.09E-08	2.31E-08	2.68E-08	2.17E-08	2.08E-08	2.25E-08	2.20E-08
^{158}Gd	1.07E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04

Table 3.10(3). All results for Case 8c (40% void, 30 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	$2^*\sigma^{(r)}$
^{234}U	4.82E-06	4.82E-06	4.77E-06	4.79E-06	4.43E-06	4.93E-06	4.82E-06	4.81E-06	2.02E-07	4.21E-02
^{235}U	3.16E-04	3.16E-04	3.10E-04	3.17E-04	3.15E-04	3.19E-04	3.21E-04	3.18E-04	7.27E-06	2.29E-02
^{236}U	9.89E-05	9.89E-05	9.93E-05	9.90E-05	9.87E-05	9.77E-05	9.48E-05	9.81E-05	2.74E-06	2.80E-02
^{238}U	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	1.78E-05	8.46E-04
^{237}Np	7.35E-06	7.25E-06	7.46E-06	7.10E-06	7.27E-06	6.99E-06	6.68E-06	7.16E-06	4.81E-07	6.72E-02
^{238}Pu	1.78E-06	1.76E-06	1.94E-06	1.58E-06	1.75E-06	1.91E-06	1.63E-06	1.79E-06	1.93E-07	1.08E-01
^{239}Pu	1.05E-04	1.04E-04	1.02E-04	1.03E-04	1.02E-04	1.00E-04	1.01E-04	1.02E-04	5.21E-06	5.13E-02
^{240}Pu	4.24E-05	4.25E-05	4.18E-05	4.14E-05	4.09E-05	4.01E-05	4.07E-05	4.11E-05	1.89E-06	4.60E-02
^{241}Pu	9.76E-06	9.67E-06	9.61E-06	9.55E-06	9.40E-06	9.42E-06	9.60E-06	9.60E-06	4.52E-07	4.71E-02
^{242}Pu	6.44E-06	6.41E-06	6.63E-06	6.29E-06	6.28E-06	6.33E-06	6.16E-06	6.33E-06	3.39E-07	5.35E-02
^{241}Am	1.10E-05	1.09E-05	1.08E-05	1.08E-05	1.06E-05	1.06E-05	1.08E-05	1.08E-05	4.99E-07	4.62E-02
^{243}Am	9.82E-07	9.81E-07	9.29E-07	9.38E-07	8.84E-07	8.39E-07	8.21E-07	9.09E-07	1.22E-07	1.34E-01
^{244}Cm	1.17E-07	1.17E-07	1.12E-07	1.13E-07	1.05E-07	1.11E-07	9.84E-08	1.10E-07	1.35E-08	1.23E-01
^{90}Sr	2.18E-05	2.18E-05	2.16E-05	2.18E-05	2.16E-05	2.17E-05	2.21E-05	2.17E-05	3.92E-07	1.80E-02
^{95}Mo	4.05E-05	4.05E-05	4.10E-05	4.04E-05	4.02E-05	4.02E-05	4.03E-05	4.04E-05	4.76E-07	1.18E-02
^{99}Tc	4.06E-05	4.06E-05	4.04E-05	4.00E-05	3.92E-05	4.00E-05	3.99E-05	4.01E-05	1.23E-06	3.07E-02
^{101}Ru	3.74E-05	3.74E-05	3.80E-05	3.72E-05	3.69E-05	3.70E-05	3.64E-05	3.72E-05	6.51E-07	1.75E-02
^{103}Rh	2.28E-05	2.27E-05	2.29E-05	2.17E-05	2.17E-05	2.25E-05	2.20E-05	2.24E-05	6.09E-07	2.72E-02
^{109}Ag	2.78E-06	2.77E-06	3.00E-06	1.78E-06	2.51E-06	2.65E-06	3.12E-06	2.58E-06	7.55E-07	2.93E-01
^{129}I	5.42E-06	5.41E-06	6.11E-06	4.92E-06	5.13E-06	5.11E-06	6.06E-06	5.42E-06	1.01E-06	1.86E-01
^{131}Xe	1.74E-05	1.74E-05	1.72E-05	1.68E-05	1.72E-05	1.70E-05	1.71E-05	1.71E-05	5.98E-07	3.50E-02
^{133}Cs	4.31E-05	4.31E-05	4.28E-05	4.30E-05	4.24E-05	4.25E-05	4.28E-05	4.28E-05	9.06E-07	2.12E-02
^{134}Cs	2.07E-08	2.05E-08	2.09E-08	2.03E-08	2.00E-08	2.04E-08	1.91E-08	2.04E-08	1.80E-09	8.85E-02
^{137}Cs	3.03E-05	3.03E-05	3.05E-05	3.02E-05	3.00E-05	2.99E-05	3.04E-05	3.01E-05	5.97E-07	1.99E-02
^{144}Ce	1.83E-11	1.83E-11	1.83E-11	1.85E-11	1.79E-11	1.80E-11	1.79E-11	1.80E-11	7.47E-13	4.15E-02
^{143}Nd	2.97E-05	2.97E-05	2.96E-05	2.96E-05	2.94E-05	2.95E-05	2.95E-05	2.96E-05	3.08E-07	1.04E-02
^{145}Nd	2.37E-05	2.37E-05	2.42E-05	2.35E-05	2.33E-05	2.36E-05	2.38E-05	2.36E-05	3.28E-07	1.39E-02

Table 3.10(3). All results for Case 8c (40% void, 30 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{148}Nd	1.21E-05	1.21E-05	1.23E-05	1.20E-05	1.20E-05	1.19E-05	1.20E-05	1.20E-05	1.82E-07	1.51E-02
^{147}Sm	1.02E-05	1.02E-05	1.03E-05	1.02E-05	8.62E-06	1.03E-05	1.02E-05	1.01E-05	6.45E-07	6.40E-02
^{149}Sm	9.55E-08	9.49E-08	8.88E-08	1.01E-07	8.89E-08	9.79E-08	9.94E-08	9.86E-08	1.15E-08	1.17E-01
^{150}Sm	8.87E-06	8.88E-06	8.44E-06	8.79E-06	8.44E-06	8.72E-06	8.71E-06	8.71E-06	3.61E-07	4.15E-02
^{151}Sm	3.24E-07	3.22E-07	3.17E-07	3.25E-07	3.09E-07	3.13E-07	3.28E-07	3.32E-07	4.37E-08	1.32E-01
^{152}Sm	3.80E-06	3.76E-06	3.74E-06	3.68E-06	3.65E-06	3.67E-06	3.84E-06	3.80E-06	3.63E-07	9.56E-02
^{153}Eu	3.29E-06	3.29E-06	3.29E-06	3.27E-06	3.09E-06	3.21E-06	3.19E-06	3.25E-06	1.48E-07	4.56E-02
^{154}Eu	1.64E-07	1.64E-07	1.64E-07	1.63E-07	1.55E-07	1.57E-07	1.39E-07	1.60E-07	3.27E-08	2.05E-01
^{155}Eu	2.30E-08	2.28E-08	2.26E-08	2.25E-08	2.10E-08	2.19E-08	2.23E-08	2.16E-08	4.87E-09	2.26E-01
^{155}Gd	2.06E-07	2.05E-07	2.06E-07	2.04E-07	1.98E-07	2.02E-07	2.01E-07	1.91E-07	6.86E-08	3.60E-01
^{156}Gd	9.63E-05	9.56E-05	9.64E-05	9.45E-05	9.60E-05	9.61E-05	9.55E-05	9.58E-05	3.23E-06	3.37E-02
^{157}Gd	2.12E-08	2.15E-08	2.06E-08	2.25E-08	2.22E-08	2.33E-08	2.58E-08	2.25E-08	3.96E-09	1.76E-01
^{158}Gd	1.13E-04	1.12E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.12E-04	4.27E-06	3.80E-02

Table 3.11(1). All results for Case 9b (70% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	4.64E-06	4.78E-06	4.64E-06	4.53E-06	4.70E-06	4.52E-06	4.55E-06	4.45E-06	4.54E-06	4.54E-06	4.54E-06	4.63E-06	4.54E-06	4.53E-06
^{235}U	3.39E-04	3.33E-04	3.41E-04	3.33E-04	3.42E-04	3.36E-04	3.39E-04	3.38E-04	3.35E-04	3.40E-04	3.41E-04	3.40E-04	3.34E-04	3.39E-04
^{236}U	9.85E-05	1.01E-04	9.82E-05	9.97E-05	9.79E-05	9.88E-05	9.92E-05	9.87E-05	9.97E-05	9.91E-05	9.88E-05	9.81E-05	9.97E-05	9.90E-05
^{238}U	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02
^{237}Np	7.80E-06	7.87E-06	7.79E-06	7.96E-06	7.13E-06	7.87E-06	8.14E-06	7.91E-06	7.85E-06	8.01E-06	8.13E-06	7.93E-06	7.81E-06	8.09E-06
^{238}Pu	2.58E-06	2.54E-06	2.57E-06	2.34E-06	2.12E-06	2.32E-06	2.37E-06	2.39E-06	2.31E-06	2.37E-06	2.45E-06	2.63E-06	2.30E-06	2.36E-06
^{239}Pu	1.20E-04	1.16E-04	1.21E-04	1.20E-04	1.24E-04	1.24E-04	1.26E-04	1.26E-04	1.22E-04	1.18E-04	1.16E-04	1.20E-04	1.21E-04	1.23E-04
^{240}Pu	4.35E-05	4.27E-05	4.33E-05	4.37E-05	4.40E-05	4.47E-05	4.49E-05	4.72E-05	4.45E-05	4.46E-05	4.56E-05	4.38E-05	4.42E-05	4.35E-05
^{241}Pu	1.79E-05	1.74E-05	1.79E-05	1.78E-05	1.83E-05	1.80E-05	1.83E-05	1.75E-05	1.78E-05	1.79E-05	1.79E-05	1.81E-05	1.78E-05	1.81E-05
^{242}Pu	6.62E-06	6.56E-06	6.54E-06	6.46E-06	6.70E-06	6.50E-06	6.48E-06	6.34E-06	6.38E-06	6.59E-06	6.83E-06	6.73E-06	6.43E-06	6.43E-06
^{241}Am	5.72E-06	5.54E-06	5.70E-06	5.73E-06	5.85E-06	5.80E-06	5.90E-06	5.63E-06	5.73E-06	5.78E-06	5.69E-06	5.79E-06	5.74E-06	5.83E-06
^{243}Am	1.05E-06	9.84E-07	1.04E-06	1.16E-06	1.01E-06	1.18E-06	1.17E-06	1.18E-06	1.15E-06	1.19E-06	1.11E-06	1.08E-06	1.16E-06	1.15E-06
^{244}Cm	2.44E-07	2.24E-07	2.42E-07	2.39E-07	2.30E-07	2.44E-07	2.37E-07	2.25E-07	2.34E-07	2.43E-07	2.26E-07	2.53E-07	2.35E-07	2.35E-07
^{90}Sr	2.70E-05	2.71E-05	2.69E-05	2.72E-05	2.68E-05	2.69E-05	2.70E-05	2.71E-05	2.72E-05	2.69E-05	2.65E-05	2.73E-05	2.71E-05	2.75E-05
^{95}Mo	3.99E-05	4.00E-05	3.96E-05	3.99E-05	3.95E-05	3.96E-05	3.98E-05	3.99E-05	3.99E-05	3.96E-05	3.99E-05	3.99E-05	3.99E-05	3.99E-05
^{99}Tc	4.04E-05	4.03E-05	3.96E-05	4.00E-05	3.95E-05	4.02E-05	4.03E-05	4.08E-05	4.04E-05	3.98E-05	4.01E-05	4.05E-05	4.02E-05	3.94E-05
^{101}Ru	3.73E-05	3.72E-05	3.70E-05	3.72E-05	3.69E-05	3.70E-05	3.72E-05	3.75E-05	3.73E-05	3.70E-05	3.74E-05	3.73E-05	3.72E-05	3.72E-05
^{103}Rh	2.28E-05	2.29E-05	2.26E-05	2.27E-05	2.23E-05	2.27E-05	2.29E-05	2.29E-05	2.28E-05	2.27E-05	2.26E-05	2.27E-05	2.27E-05	2.27E-05
^{109}Ag	2.88E-06	2.85E-06	2.82E-06	2.86E-06	1.63E-06	2.90E-06	2.91E-06	2.87E-06	2.88E-06	2.02E-06	3.06E-06	2.91E-06	2.87E-06	1.98E-06
^{129}I	5.28E-06	5.25E-06	5.28E-06	5.52E-06	5.09E-06	5.52E-06	5.54E-06	5.54E-06	5.53E-06	5.42E-06	6.08E-06	5.29E-06	5.51E-06	5.55E-06
^{131}Xe	1.68E-05	1.70E-05	1.66E-05	1.71E-05	1.61E-05	1.70E-05	1.70E-05	1.67E-05	1.71E-05	1.69E-05	1.68E-05	1.67E-05	1.70E-05	1.70E-05
^{133}Cs	4.30E-05	4.32E-05	4.20E-05	4.24E-05	4.21E-05	4.23E-05	4.24E-05	4.28E-05	4.25E-05	4.29E-05	4.23E-05	4.27E-05	4.24E-05	4.23E-05
^{134}Cs	6.67E-07	6.43E-07	6.49E-07	6.51E-07	6.29E-07	6.39E-07	6.48E-07	5.98E-07	6.46E-07	6.47E-07	6.44E-07	6.43E-07	6.45E-07	6.42E-07
^{137}Cs	3.79E-05	3.79E-05	3.76E-05	3.79E-05	3.75E-05	3.78E-05	3.79E-05	3.80E-05	3.80E-05	3.78E-05	3.73E-05	3.79E-05	3.79E-05	3.87E-05
^{144}Ce	1.29E-07	1.29E-07	1.28E-07	1.29E-07	1.27E-07	1.29E-07	1.29E-07	1.30E-07	1.30E-07	1.28E-07	1.28E-07	1.20E-07	1.29E-07	1.29E-07
^{143}Nd	3.01E-05	3.01E-05	2.99E-05	3.00E-05	2.98E-05	2.99E-05	3.01E-05	3.02E-05	3.01E-05	3.02E-05	3.02E-05	3.00E-05	3.00E-05	2.98E-05

Table 3.11(1). All results for Case 9b (70% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	2.34E-05	2.34E-05	2.33E-05	2.33E-05	2.32E-05	2.31E-05	2.32E-05	2.35E-05	2.33E-05	2.32E-05	2.35E-05	2.34E-05	2.33E-05	2.33E-05
^{148}Nd	1.19E-05	1.20E-05	1.19E-05	1.21E-05	1.18E-05	1.20E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05	1.19E-05	1.20E-05	1.20E-05
^{147}Sm	8.22E-06	8.07E-06	8.16E-06	8.11E-06	8.16E-06	8.10E-06	8.11E-06	8.13E-06	8.18E-06	8.10E-06	8.13E-06	8.20E-06	8.15E-06	8.07E-06
^{149}Sm	1.04E-07	1.02E-07	1.13E-07	1.13E-07	1.14E-07	1.14E-07	1.16E-07	1.21E-07	1.13E-07	1.08E-07	1.10E-07	1.08E-07	1.07E-07	1.16E-07
^{150}Sm	8.78E-06	8.45E-06	8.85E-06	8.93E-06	8.34E-06	8.84E-06	8.91E-06	9.29E-06	8.89E-06	8.51E-06	8.81E-06	8.59E-06	8.93E-06	8.92E-06
^{151}Sm	3.99E-07	4.35E-07	4.03E-07	4.04E-07	4.58E-07	4.09E-07	4.17E-07	4.80E-07	4.09E-07	4.15E-07	4.34E-07	4.06E-07	4.06E-07	4.13E-07
^{152}Sm	3.45E-06	4.29E-06	3.43E-06	3.49E-06	3.66E-06	3.49E-06	3.47E-06	3.44E-06	3.52E-06	3.45E-06	3.52E-06	3.43E-06	3.51E-06	3.47E-06
^{153}Eu	3.36E-06	3.05E-06	3.34E-06	3.40E-06	3.45E-06	3.36E-06	3.38E-06	3.45E-06	3.37E-06	3.35E-06	3.37E-06	3.36E-06	3.37E-06	3.37E-06
^{154}Eu	4.30E-07	3.79E-07	4.30E-07	4.37E-07	4.28E-07	4.36E-07	4.39E-07	4.31E-07	4.37E-07	4.28E-07	3.77E-07	4.26E-07	4.35E-07	4.37E-07
^{155}Eu	1.01E-07	9.31E-08	9.92E-08	1.04E-07	1.02E-07	1.02E-07	1.02E-07	7.29E-08	1.03E-07	1.01E-07	1.04E-07	1.03E-07	1.02E-07	1.02E-07
^{155}Gd	1.45E-07	1.36E-07	1.44E-07	1.43E-07	1.48E-07	1.40E-07	1.41E-07	1.11E-07	1.41E-07	1.41E-07	1.48E-07	1.43E-07	1.41E-07	1.42E-07
^{156}Gd	9.53E-05	9.59E-05	9.52E-05	9.60E-05	9.57E-05	9.60E-05	9.60E-05	9.60E-05	9.57E-05	9.54E-05	9.59E-05	9.52E-05	9.57E-05	9.53E-05
^{157}Gd	3.86E-08	3.19E-08	3.88E-08	2.89E-08	3.55E-08	2.94E-08	3.03E-08	3.09E-08	3.03E-08	3.54E-08	3.37E-08	3.90E-08	3.06E-08	3.48E-08
^{158}Gd	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04

Table 3.11(2). All results for Case 9b (70% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	4.41E-06	4.56E-06	4.54E-06	4.53E-06	4.53E-06	4.52E-06	4.46E-06	4.63E-06	4.55E-06	4.63E-06	4.53E-06	4.53E-06	4.53E-06	4.45E-06
^{235}U	3.41E-04	3.38E-04	3.40E-04	3.39E-04	3.46E-04	3.42E-04	3.46E-04	3.37E-04	3.41E-04	3.43E-04	3.45E-04	3.46E-04	3.37E-04	3.42E-04
^{236}U	9.86E-05	9.93E-05	9.90E-05	9.87E-05	9.56E-05	9.98E-05	9.45E-05	1.00E-04	9.87E-05	9.76E-05	9.94E-05	9.56E-05	9.92E-05	9.50E-05
^{238}U	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02
^{237}Np	7.66E-06	7.94E-06	8.08E-06	8.18E-06	7.80E-06	7.94E-06	9.51E-06	8.07E-06	7.98E-06	7.85E-06	7.90E-06	7.79E-06	8.07E-06	7.87E-06
^{238}Pu	2.28E-06	2.32E-06	2.37E-06	2.42E-06	2.32E-06	2.39E-06	2.80E-06	2.28E-06	2.30E-06	2.55E-06	2.37E-06	2.32E-06	2.36E-06	2.38E-06
^{239}Pu	1.21E-04	1.25E-04	1.21E-04	1.21E-04	1.24E-04	1.20E-04	1.35E-04	1.20E-04	1.21E-04	1.21E-04	1.23E-04	1.23E-04	1.22E-04	1.21E-04
^{240}Pu	4.31E-05	4.51E-05	4.40E-05	4.44E-05	4.28E-05	4.18E-05	4.36E-05	4.25E-05	4.36E-05	4.32E-05	4.28E-05	4.30E-05	4.37E-05	4.44E-05
^{241}Pu	1.77E-05	1.81E-05	1.82E-05	1.80E-05	1.83E-05	1.84E-05	2.09E-05	1.82E-05	1.78E-05	1.79E-05	1.85E-05	1.82E-05	1.79E-05	1.80E-05
^{242}Pu	5.93E-06	6.44E-06	6.54E-06	6.65E-06	6.16E-06	6.17E-06	6.86E-06	6.56E-06	6.35E-06	6.50E-06	6.17E-06	6.16E-06	6.49E-06	6.37E-06
^{241}Am	5.67E-06	5.83E-06	5.84E-06	5.73E-06	5.83E-06	5.84E-06	6.67E-06	5.83E-06	5.68E-06	5.65E-06	5.91E-06	5.79E-06	5.76E-06	5.72E-06
^{243}Am	1.05E-06	1.16E-06	1.17E-06	1.08E-06	9.59E-07	1.09E-06	1.05E-06	1.06E-06	1.12E-06	1.04E-06	1.09E-06	9.57E-07	1.17E-06	1.03E-06
^{244}Cm	2.12E-07	2.35E-07	2.39E-07	2.17E-07	2.00E-07	2.31E-07	1.97E-07	2.19E-07	2.39E-07	2.36E-07	2.29E-07	1.99E-07	2.40E-07	2.09E-07
^{90}Sr	2.67E-05	2.70E-05	2.74E-05	2.68E-05	2.69E-05	2.68E-05	2.67E-05	-	2.67E-05	2.66E-05	2.67E-05	2.69E-05	2.70E-05	2.71E-05
^{95}Mo	3.95E-05	3.98E-05	3.99E-05	4.01E-05	3.99E-05	3.95E-05	3.96E-05	3.95E-05	3.93E-05	3.94E-05	3.95E-05	3.99E-05	3.97E-05	4.02E-05
^{99}Tc	3.93E-05	4.04E-05	3.94E-05	3.95E-05	3.94E-05	3.88E-05	4.03E-05	3.88E-05	3.84E-05	3.87E-05	3.89E-05	3.94E-05	3.92E-05	4.00E-05
^{101}Ru	3.67E-05	3.72E-05	3.72E-05	3.75E-05	3.72E-05	3.69E-05	3.71E-05	3.69E-05	3.63E-05	3.64E-05	3.69E-05	3.72E-05	3.71E-05	3.74E-05
^{103}Rh	2.24E-05	2.28E-05	2.28E-05	2.26E-05	2.21E-05	2.26E-05	2.31E-05	2.23E-05	2.24E-05	2.25E-05	2.27E-05	2.22E-05	2.26E-05	2.21E-05
^{109}Ag	2.89E-06	2.90E-06	1.99E-06	3.00E-06	2.72E-06	2.79E-06	2.81E-06	2.76E-06	2.94E-06	2.97E-06	2.82E-06	2.72E-06	2.07E-06	2.86E-06
^{129}I	5.52E-06	5.46E-06	5.56E-06	6.19E-06	5.34E-06	4.49E-06	5.46E-06	5.38E-06	6.74E-06	6.74E-06	4.51E-06	5.34E-06	5.58E-06	6.58E-06
^{131}Xe	1.64E-05	1.70E-05	1.70E-05	1.69E-05	1.65E-05	1.58E-05	1.65E-05	1.68E-05	1.68E-05	1.66E-05	1.58E-05	1.65E-05	1.69E-05	1.71E-05
^{133}Cs	4.26E-05	4.26E-05	4.23E-05	4.17E-05	4.11E-05	4.21E-05	4.25E-05	4.23E-05	4.20E-05	4.19E-05	4.21E-05	4.11E-05	4.23E-05	4.16E-05
^{134}Cs	5.50E-07	6.38E-07	6.42E-07	6.37E-07	6.87E-07	6.39E-07	7.57E-07	6.04E-07	6.30E-07	6.49E-07	6.35E-07	6.85E-07	6.44E-07	6.47E-07
^{137}Cs	3.75E-05	3.77E-05	3.87E-05	3.81E-05	3.76E-05	3.76E-05	3.80E-05	3.78E-05	3.70E-05	3.69E-05	3.76E-05	3.76E-05	3.78E-05	3.78E-05
^{144}Ce	1.28E-07	1.29E-07	1.29E-07	1.28E-07	1.26E-07	1.27E-07	1.29E-07	1.29E-07	1.25E-07	1.25E-07	1.28E-07	1.27E-07	1.29E-07	1.28E-07
^{143}Nd	2.99E-05	3.01E-05	2.98E-05	2.98E-05	3.01E-05	2.99E-05	3.04E-05	2.98E-05	2.98E-05	2.98E-05	3.00E-05	3.02E-05	2.98E-05	3.02E-05

Table 3.11(2). All results for Case 9b (70% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	2.32E-05	2.33E-05	2.32E-05	2.36E-05	2.35E-05	2.34E-05	2.33E-05	2.31E-05	2.30E-05	2.31E-05	2.34E-05	2.35E-05	2.32E-05	2.35E-05
^{148}Nd	1.19E-05	1.20E-05	1.20E-05	1.21E-05	1.21E-05	1.20E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.20E-05	1.21E-05	1.20E-05	1.21E-05
^{147}Sm	8.11E-06	8.15E-06	8.08E-06	8.10E-06	7.74E-06	7.66E-06	7.45E-06	7.76E-06	8.15E-06	8.20E-06	7.68E-06	7.74E-06	8.06E-06	8.20E-06
^{149}Sm	1.20E-07	1.15E-07	1.15E-07	1.14E-07	1.27E-07	1.27E-07	1.33E-07	1.14E-07	1.09E-07	1.08E-07	1.27E-07	1.26E-07	1.15E-07	1.19E-07
^{150}Sm	8.83E-06	8.89E-06	8.93E-06	9.15E-06	8.87E-06	8.90E-06	8.94E-06	8.79E-06	8.61E-06	8.62E-06	8.89E-06	8.87E-06	8.91E-06	9.12E-06
^{151}Sm	4.49E-07	4.11E-07	4.21E-07	4.30E-07	4.97E-07	4.90E-07	4.93E-07	4.09E-07	4.18E-07	4.12E-07	4.94E-07	4.95E-07	4.08E-07	4.29E-07
^{152}Sm	3.71E-06	3.49E-06	3.47E-06	3.55E-06	4.01E-06	3.98E-06	4.06E-06	3.49E-06	3.54E-06	3.52E-06	4.00E-06	4.01E-06	3.47E-06	3.53E-06
^{153}Eu	3.33E-06	3.37E-06	3.37E-06	3.38E-06	3.36E-06	3.31E-06	3.36E-06	3.15E-06	3.43E-06	3.43E-06	3.31E-06	3.36E-06	3.36E-06	3.44E-06
^{154}Eu	4.28E-07	4.37E-07	4.33E-07	3.83E-07	4.11E-07	4.26E-07	3.95E-07	4.02E-07	4.38E-07	4.37E-07	4.26E-07	4.11E-07	4.36E-07	6.19E-07
^{155}Eu	7.18E-08	1.02E-07	1.02E-07	1.04E-07	7.45E-08	7.31E-08	1.09E-07	9.27E-08	1.06E-07	1.06E-07	7.04E-08	7.48E-08	1.02E-07	1.05E-07
^{155}Gd	3.12E-08	1.37E-07	1.42E-07	1.48E-07	1.12E-07	1.08E-07	1.60E-07	1.32E-07	1.40E-07	1.45E-07	1.11E-07	1.12E-07	1.41E-07	1.42E-07
^{156}Gd	9.37E-05	9.57E-05	9.54E-05	9.59E-05	9.64E-05	9.60E-05	9.55E-05	9.60E-05	9.54E-05	9.53E-05	9.61E-05	9.65E-05	9.53E-05	9.56E-05
^{157}Gd	3.21E-08	3.03E-08	3.57E-08	3.31E-08	3.01E-08	3.10E-08	4.01E-08	3.03E-08	3.44E-08	3.94E-08	3.10E-08	2.96E-08	3.42E-08	3.32E-08
^{158}Gd	1.08E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04

Table 3.11(3). All results for Case 9b (70% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ(r)
^{234}U	4.56E-06	4.56E-06	4.49E-06	4.56E-06	4.16E-06	4.67E-06	4.55E-06	4.54E-06	1.99E-07	4.37E-02
^{235}U	3.39E-04	3.38E-04	3.32E-04	3.38E-04	3.36E-04	3.40E-04	3.43E-04	3.39E-04	7.32E-06	2.16E-02
^{236}U	9.92E-05	9.92E-05	9.97E-05	9.95E-05	9.91E-05	9.80E-05	9.47E-05	9.85E-05	3.09E-06	3.14E-02
^{238}U	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	1.18E-05	5.61E-04
^{237}Np	8.18E-06	8.03E-06	8.31E-06	7.78E-06	8.05E-06	7.70E-06	7.40E-06	7.95E-06	6.97E-07	8.76E-02
^{238}Pu	2.38E-06	2.35E-06	2.57E-06	2.11E-06	2.34E-06	2.52E-06	2.19E-06	2.39E-06	2.80E-07	1.17E-01
^{239}Pu	1.27E-04	1.26E-04	1.23E-04	1.23E-04	1.22E-04	1.19E-04	1.21E-04	1.22E-04	6.54E-06	5.35E-02
^{240}Pu	4.53E-05	4.53E-05	4.47E-05	4.46E-05	4.38E-05	4.28E-05	4.34E-05	4.39E-05	2.12E-06	4.81E-02
^{241}Pu	1.85E-05	1.82E-05	1.81E-05	1.78E-05	1.76E-05	1.77E-05	1.81E-05	1.81E-05	1.11E-06	6.14E-02
^{242}Pu	6.53E-06	6.49E-06	6.77E-06	6.32E-06	6.41E-06	6.49E-06	6.32E-06	6.47E-06	4.00E-07	6.19E-02
^{241}Am	5.96E-06	5.87E-06	5.76E-06	5.74E-06	5.61E-06	5.65E-06	5.82E-06	5.79E-06	3.57E-07	6.17E-02
^{243}Am	1.18E-06	1.18E-06	1.12E-06	1.11E-06	1.06E-06	1.01E-06	9.97E-07	1.09E-06	1.42E-07	1.30E-01
^{244}Cm	2.42E-07	2.42E-07	2.33E-07	2.30E-07	2.17E-07	2.30E-07	2.06E-07	2.29E-07	2.83E-08	1.24E-01
^{90}Sr	2.70E-05	2.71E-05	2.68E-05	2.70E-05	2.70E-05	2.69E-05	2.74E-05	2.70E-05	4.62E-07	1.71E-02
^{95}Mo	3.98E-05	3.99E-05	4.04E-05	3.98E-05	3.96E-05	3.97E-05	3.97E-05	3.98E-05	4.63E-07	1.16E-02
^{99}Tc	4.02E-05	4.02E-05	4.01E-05	3.96E-05	3.89E-05	3.97E-05	3.97E-05	3.97E-05	1.19E-06	3.00E-02
^{101}Ru	3.73E-05	3.73E-05	3.79E-05	3.70E-05	3.68E-05	3.70E-05	3.63E-05	3.71E-05	6.40E-07	1.72E-02
^{103}Rh	2.30E-05	2.29E-05	2.30E-05	2.19E-05	2.19E-05	2.26E-05	2.22E-05	2.26E-05	6.18E-07	2.74E-02
^{109}Ag	2.95E-06	2.92E-06	3.16E-06	1.88E-06	2.65E-06	2.81E-06	3.30E-06	2.72E-06	7.80E-07	2.86E-01
^{129}I	5.57E-06	5.55E-06	6.20E-06	5.05E-06	5.27E-06	5.24E-06	6.16E-06	5.55E-06	1.01E-06	1.82E-01
^{131}Xe	1.71E-05	1.70E-05	1.69E-05	1.63E-05	1.69E-05	1.67E-05	1.67E-05	1.67E-05	6.79E-07	4.06E-02
^{133}Cs	4.25E-05	4.26E-05	4.23E-05	4.24E-05	4.19E-05	4.21E-05	4.24E-05	4.23E-05	9.00E-07	2.13E-02
^{134}Cs	6.51E-07	6.40E-07	6.61E-07	6.34E-07	6.31E-07	6.39E-07	6.02E-07	6.43E-07	6.18E-08	9.62E-02
^{137}Cs	3.80E-05	3.80E-05	3.84E-05	3.79E-05	3.78E-05	3.76E-05	3.83E-05	3.78E-05	7.40E-07	1.96E-02
^{144}Ce	1.29E-07	1.30E-07	1.30E-07	1.29E-07	1.28E-07	1.28E-07	1.28E-07	1.28E-07	3.54E-09	2.76E-02
^{143}Nd	3.02E-05	3.01E-05	3.01E-05	3.01E-05	2.98E-05	2.99E-05	3.00E-05	3.00E-05	3.17E-07	1.05E-02

Table 3.11(3). All results for Case 9b (70% void, 30 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	2.33E-05	2.33E-05	2.38E-05	2.32E-05	2.30E-05	2.33E-05	2.35E-05	2.33E-05	3.44E-07	1.48E-02
^{148}Nd	1.21E-05	1.21E-05	1.23E-05	1.20E-05	1.20E-05	1.19E-05	1.20E-05	1.20E-05	1.80E-07	1.49E-02
^{147}Sm	8.11E-06	8.14E-06	8.20E-06	8.10E-06	6.83E-06	8.22E-06	8.18E-06	8.02E-06	5.60E-07	6.98E-02
^{149}Sm	1.11E-07	1.10E-07	1.03E-07	1.16E-07	1.04E-07	1.12E-07	1.15E-07	1.14E-07	1.46E-08	1.28E-01
^{150}Sm	8.97E-06	8.98E-06	8.57E-06	8.88E-06	8.60E-06	8.83E-06	8.85E-06	8.83E-06	3.90E-07	4.42E-02
^{151}Sm	4.16E-07	4.13E-07	4.10E-07	4.18E-07	3.97E-07	3.99E-07	4.22E-07	4.29E-07	6.33E-08	1.48E-01
^{152}Sm	3.58E-06	3.53E-06	3.52E-06	3.46E-06	3.45E-06	3.47E-06	3.62E-06	3.60E-06	4.46E-07	1.24E-01
^{153}Eu	3.39E-06	3.39E-06	3.41E-06	3.36E-06	3.18E-06	3.32E-06	3.30E-06	3.35E-06	1.61E-07	4.81E-02
^{154}Eu	4.39E-07	4.40E-07	4.40E-07	4.35E-07	4.13E-07	4.19E-07	3.80E-07	4.28E-07	7.64E-08	1.78E-01
^{155}Eu	1.04E-07	1.03E-07	1.02E-07	1.01E-07	9.70E-08	9.85E-08	1.00E-07	9.69E-08	2.31E-08	2.38E-01
^{155}Gd	1.43E-07	1.41E-07	1.44E-07	1.41E-07	1.38E-07	1.43E-07	1.40E-07	1.35E-07	4.35E-08	3.23E-01
^{156}Gd	9.59E-05	9.51E-05	9.58E-05	9.40E-05	9.54E-05	9.55E-05	9.48E-05	9.56E-05	1.15E-06	1.20E-02
^{157}Gd	3.05E-08	3.15E-08	3.11E-08	3.27E-08	3.35E-08	3.48E-08	3.90E-08	3.33E-08	6.58E-09	1.98E-01
^{158}Gd	1.13E-04	1.12E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	1.14E-04	1.13E-04	1.80E-06	1.60E-02

Table 3.12(1). All results for Case 11b (40% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	3.70E-06	3.82E-06	3.71E-06	3.52E-06	3.69E-06	3.52E-06	3.57E-06	3.48E-06	3.55E-06	3.55E-06	3.57E-06	3.69E-06	3.55E-06	3.55E-06
^{235}U	1.13E-04	1.06E-04	1.15E-04	1.08E-04	1.18E-04	1.11E-04	1.15E-04	1.17E-04	1.11E-04	1.15E-04	1.16E-04	1.14E-04	1.12E-04	1.16E-04
^{236}U	1.24E-04	1.26E-04	1.23E-04	1.25E-04	1.23E-04	1.24E-04	1.24E-04	1.24E-04	1.25E-04	1.24E-04	1.24E-04	1.23E-04	1.25E-04	1.24E-04
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02
^{237}Np	1.26E-05	1.28E-05	1.26E-05	1.29E-05	1.25E-05	1.26E-05	1.32E-05	1.28E-05	1.27E-05	1.30E-05	1.32E-05	1.28E-05	1.28E-05	1.31E-05
^{238}Pu	7.04E-06	7.01E-06	7.06E-06	5.98E-06	6.45E-06	5.88E-06	6.07E-06	6.25E-06	5.94E-06	6.10E-06	6.34E-06	7.18E-06	5.95E-06	6.05E-06
^{239}Pu	9.54E-05	9.18E-05	9.72E-05	9.50E-05	9.82E-05	9.75E-05	1.02E-04	1.02E-04	9.71E-05	9.41E-05	9.17E-05	9.51E-05	9.82E-05	1.00E-04
^{240}Pu	6.16E-05	6.04E-05	6.13E-05	6.20E-05	6.18E-05	6.31E-05	6.41E-05	6.66E-05	6.41E-05	6.32E-05	6.45E-05	6.20E-05	6.37E-05	6.10E-05
^{241}Pu	2.21E-05	2.12E-05	2.22E-05	2.18E-05	2.24E-05	2.20E-05	2.29E-05	2.27E-05	2.21E-05	2.21E-05	2.19E-05	2.22E-05	2.23E-05	2.28E-05
^{242}Pu	2.08E-05	2.10E-05	2.06E-05	2.04E-05	2.05E-05	2.03E-05	2.03E-05	2.07E-05	2.03E-05	2.06E-05	2.14E-05	2.11E-05	2.03E-05	2.00E-05
^{241}Am	7.13E-06	6.83E-06	7.19E-06	7.18E-06	7.26E-06	7.28E-06	7.56E-06	7.54E-06	7.30E-06	7.26E-06	7.03E-06	7.10E-06	7.36E-06	7.53E-06
^{243}Am	4.46E-06	4.23E-06	4.41E-06	4.89E-06	4.28E-06	4.92E-06	4.92E-06	5.09E-06	4.87E-06	4.95E-06	4.71E-06	4.54E-06	4.90E-06	4.88E-06
^{244}Cm	1.73E-06	1.66E-06	1.71E-06	1.70E-06	1.65E-06	1.69E-06	1.65E-06	1.73E-06	1.65E-06	1.70E-06	1.61E-06	1.78E-06	1.66E-06	1.65E-06
^{90}Sr	4.01E-05	4.03E-05	3.99E-05	4.02E-05	3.98E-05	3.99E-05	3.99E-05	4.00E-05	4.01E-05	3.99E-05	3.92E-05	4.06E-05	4.01E-05	4.06E-05
^{95}Mo	6.23E-05	6.24E-05	6.19E-05	6.19E-05	6.16E-05	6.17E-05	6.18E-05	6.19E-05	6.21E-05	6.17E-05	6.22E-05	6.23E-05	6.19E-05	6.19E-05
^{99}Tc	6.31E-05	6.25E-05	6.21E-05	6.19E-05	6.16E-05	6.28E-05	6.28E-05	6.41E-05	6.30E-05	6.20E-05	6.25E-05	6.33E-05	6.24E-05	6.12E-05
^{101}Ru	6.16E-05	6.14E-05	6.11E-05	6.12E-05	6.09E-05	6.10E-05	6.12E-05	6.19E-05	6.13E-05	6.09E-05	6.16E-05	6.16E-05	6.12E-05	6.10E-05
^{103}Rh	3.28E-05	3.30E-05	3.26E-05	3.24E-05	3.22E-05	3.24E-05	3.28E-05	3.30E-05	3.27E-05	3.24E-05	3.22E-05	3.27E-05	3.26E-05	3.24E-05
^{109}Ag	5.77E-06	5.77E-06	5.63E-06	5.67E-06	3.57E-06	5.69E-06	5.75E-06	5.81E-06	5.75E-06	4.10E-06	6.01E-06	5.78E-06	5.73E-06	4.00E-06
^{129}I	9.07E-06	9.01E-06	9.08E-06	9.46E-06	8.73E-06	9.45E-06	9.50E-06	9.55E-06	9.50E-06	9.32E-06	1.04E-05	9.04E-06	9.48E-06	9.47E-06
^{131}Xe	2.34E-05	2.40E-05	2.32E-05	2.40E-05	2.18E-05	2.39E-05	2.40E-05	2.33E-05	2.41E-05	2.38E-05	2.36E-05	2.33E-05	2.40E-05	2.38E-05
^{133}Cs	6.58E-05	6.61E-05	6.45E-05	6.49E-05	6.44E-05	6.48E-05	6.51E-05	6.60E-05	6.53E-05	6.59E-05	6.50E-05	6.60E-05	6.51E-05	6.48E-05
^{134}Cs	1.43E-06	1.40E-06	1.40E-06	1.40E-06	1.39E-06	1.37E-06	1.38E-06	1.27E-06	1.37E-06	1.39E-06	1.39E-06	1.44E-06	1.37E-06	1.37E-06
^{137}Cs	6.19E-05	6.19E-05	6.14E-05	6.17E-05	6.12E-05	6.15E-05	6.17E-05	6.19E-05	6.19E-05	6.15E-05	6.06E-05	6.19E-05	6.17E-05	6.27E-05
^{144}Ce	1.26E-07	1.26E-07	1.26E-07	1.25E-07	1.25E-07	1.24E-07	1.25E-07	1.26E-07	1.26E-07	1.25E-07	1.25E-07	1.25E-07	1.25E-07	1.24E-07
^{143}Nd	3.59E-05	3.54E-05	3.57E-05	3.54E-05	3.60E-05	3.55E-05	3.61E-05	3.64E-05	3.58E-05	3.61E-05	3.58E-05	3.59E-05	3.58E-05	3.57E-05
^{145}Nd	3.52E-05	3.52E-05	3.51E-05	3.49E-05	3.49E-05	3.48E-05	3.49E-05	3.56E-05	3.50E-05	3.48E-05	3.56E-05	3.53E-05	3.49E-05	3.48E-05

Table 3.12(1). All results for Case 11b (40% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{148}Nd	1.97E-05	1.98E-05	1.97E-05	2.00E-05	1.96E-05	1.99E-05	1.99E-05	1.97E-05	2.00E-05	1.99E-05	2.00E-05	1.98E-05	1.99E-05	1.98E-05
^{147}Sm	1.10E-05	1.07E-05	1.09E-05	1.08E-05	1.09E-05	1.08E-05	1.09E-05	1.08E-05	1.09E-05	1.08E-05	1.08E-05	1.09E-05	1.09E-05	1.08E-05
^{149}Sm	8.18E-08	8.04E-08	8.81E-08	8.39E-08	9.01E-08	8.72E-08	8.98E-08	9.46E-08	8.68E-08	8.22E-08	8.53E-08	8.23E-08	8.37E-08	8.84E-08
^{150}Sm	1.44E-05	1.36E-05	1.46E-05	1.48E-05	1.35E-05	1.45E-05	1.46E-05	1.54E-05	1.46E-05	1.38E-05	1.43E-05	1.40E-05	1.47E-05	1.46E-05
^{151}Sm	3.48E-07	3.75E-07	3.56E-07	3.52E-07	4.12E-07	3.56E-07	3.68E-07	4.29E-07	3.56E-07	3.60E-07	3.80E-07	3.52E-07	3.62E-07	3.69E-07
^{152}Sm	5.14E-06	6.69E-06	5.11E-06	5.17E-06	5.53E-06	5.21E-06	5.18E-06	5.23E-06	5.28E-06	5.11E-06	5.28E-06	5.05E-06	5.27E-06	5.15E-06
^{153}Eu	6.01E-06	5.81E-06	5.97E-06	6.08E-06	6.32E-06	5.99E-06	6.05E-06	6.28E-06	6.04E-06	5.96E-06	6.06E-06	5.99E-06	6.06E-06	6.01E-06
^{154}Eu	7.51E-07	6.99E-07	7.53E-07	7.65E-07	7.91E-07	7.59E-07	7.70E-07	7.57E-07	7.57E-07	7.36E-07	6.26E-07	7.39E-07	7.67E-07	7.69E-07
^{155}Eu	2.04E-07	1.96E-07	2.01E-07	2.12E-07	2.11E-07	2.06E-07	2.08E-07	1.49E-07	2.08E-07	2.03E-07	2.05E-07	2.09E-07	2.08E-07	2.05E-07
^{155}Gd	2.41E-07	2.32E-07	2.38E-07	2.47E-07	2.50E-07	2.41E-07	2.43E-07	1.80E-07	2.42E-07	2.39E-07	2.42E-07	2.33E-07	2.43E-07	2.40E-07
^{156}Gd	9.72E-05	9.80E-05	9.71E-05	9.87E-05	9.85E-05	9.89E-05	9.86E-05	9.84E-05	9.85E-05	9.80E-05	9.89E-05	9.72E-05	9.85E-05	9.80E-05
^{157}Gd	2.70E-08	2.31E-08	2.69E-08	1.77E-08	2.06E-08	1.71E-08	1.86E-08	1.90E-08	1.74E-08	2.02E-08	1.97E-08	2.71E-08	1.84E-08	2.07E-08
^{158}Gd	1.15E-04	1.15E-04	1.15E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	1.14E-04

Table 3.12(2). All results for Case 11b (40% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	3.25E-06	3.57E-06	3.54E-06	3.55E-06	3.53E-06	3.51E-06	3.48E-06	3.65E-06	3.56E-06	3.71E-06	3.53E-06	3.53E-06	3.52E-06	3.45E-06
^{235}U	1.16E-04	1.15E-04	1.15E-04	1.14E-04	1.21E-04	1.17E-04	1.22E-04	1.13E-04	1.16E-04	1.17E-04	1.20E-04	1.21E-04	1.12E-04	1.16E-04
^{236}U	1.24E-04	1.24E-04	1.24E-04	1.23E-04	1.20E-04	1.25E-04	1.16E-04	1.25E-04	1.24E-04	1.23E-04	1.25E-04	1.20E-04	1.24E-04	1.20E-04
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.08E-02	2.08E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02
^{237}Np	1.23E-05	1.29E-05	1.31E-05	1.34E-05	1.27E-05	1.28E-05	1.49E-05	1.31E-05	1.29E-05	1.27E-05	1.27E-05	1.27E-05	1.31E-05	1.28E-05
^{238}Pu	5.98E-06	5.96E-06	6.10E-06	6.30E-06	6.20E-06	6.27E-06	7.19E-06	5.95E-06	5.94E-06	6.98E-06	6.23E-06	6.18E-06	6.05E-06	6.29E-06
^{239}Pu	9.64E-05	1.00E-04	9.69E-05	9.67E-05	9.80E-05	9.52E-05	1.08E-04	9.72E-05	9.78E-05	9.74E-05	9.75E-05	9.76E-05	9.83E-05	9.72E-05
^{240}Pu	6.11E-05	6.43E-05	6.27E-05	6.34E-05	6.08E-05	5.92E-05	6.00E-05	6.02E-05	6.22E-05	6.14E-05	6.07E-05	6.11E-05	6.22E-05	6.32E-05
^{241}Pu	2.21E-05	2.26E-05	2.24E-05	2.22E-05	2.27E-05	2.26E-05	2.50E-05	2.25E-05	2.22E-05	2.22E-05	2.29E-05	2.25E-05	2.22E-05	2.22E-05
^{242}Pu	1.90E-05	2.02E-05	2.05E-05	2.09E-05	1.97E-05	1.97E-05	2.09E-05	2.05E-05	1.99E-05	2.04E-05	1.97E-05	1.97E-05	2.04E-05	2.00E-05
^{241}Am	7.26E-06	7.46E-06	7.37E-06	7.16E-06	7.38E-06	7.36E-06	8.22E-06	7.40E-06	7.26E-06	7.12E-06	7.50E-06	7.34E-06	7.31E-06	7.21E-06
^{243}Am	4.54E-06	4.88E-06	4.95E-06	4.62E-06	4.10E-06	4.55E-06	4.53E-06	4.57E-06	4.81E-06	4.37E-06	4.52E-06	4.08E-06	4.95E-06	4.44E-06
^{244}Cm	1.56E-06	1.64E-06	1.69E-06	1.57E-06	1.45E-06	1.66E-06	1.47E-06	1.57E-06	1.63E-06	1.67E-06	1.64E-06	1.45E-06	1.71E-06	1.51E-06
^{90}Sr	3.96E-05	4.00E-05	4.08E-05	3.97E-05	3.99E-05	3.98E-05	3.96E-05	-	3.96E-05	3.96E-05	3.95E-05	3.99E-05	4.01E-05	4.01E-05
^{95}Mo	6.15E-05	6.19E-05	6.21E-05	6.26E-05	6.22E-05	6.14E-05	6.17E-05	6.16E-05	6.14E-05	6.17E-05	6.14E-05	6.22E-05	6.19E-05	6.27E-05
^{99}Tc	6.17E-05	6.27E-05	6.15E-05	6.17E-05	6.14E-05	6.03E-05	6.29E-05	6.05E-05	6.08E-05	6.13E-05	6.04E-05	6.14E-05	6.12E-05	6.28E-05
^{101}Ru	6.05E-05	6.12E-05	6.13E-05	6.19E-05	6.14E-05	6.09E-05	6.11E-05	6.07E-05	5.98E-05	6.02E-05	6.09E-05	6.14E-05	6.12E-05	6.19E-05
^{103}Rh	3.22E-05	3.27E-05	3.25E-05	3.22E-05	3.18E-05	3.22E-05	3.34E-05	3.19E-05	3.19E-05	3.22E-05	3.25E-05	3.18E-05	3.23E-05	3.17E-05
^{109}Ag	5.75E-06	5.73E-06	4.03E-06	5.91E-06	5.40E-06	5.56E-06	5.43E-06	5.54E-06	5.67E-06	5.71E-06	5.60E-06	5.40E-06	4.18E-06	5.61E-06
^{129}I	9.49E-06	9.32E-06	9.52E-06	1.06E-05	9.11E-06	7.75E-06	9.35E-06	9.27E-06	1.13E-05	1.12E-05	7.78E-06	9.11E-06	9.58E-06	1.12E-05
^{131}Xe	2.28E-05	2.39E-05	2.38E-05	2.38E-05	2.28E-05	2.14E-05	2.33E-05	2.37E-05	2.37E-05	2.32E-05	2.15E-05	2.29E-05	2.37E-05	2.41E-05
^{133}Cs	6.60E-05	6.54E-05	6.50E-05	6.41E-05	6.26E-05	6.46E-05	6.48E-05	6.51E-05	6.45E-05	6.41E-05	6.47E-05	6.26E-05	6.51E-05	6.38E-05
^{134}Cs	1.23E-06	1.36E-06	1.38E-06	1.37E-06	1.47E-06	1.40E-06	1.59E-06	1.32E-06	1.35E-06	1.39E-06	1.38E-06	1.47E-06	1.39E-06	1.39E-06
^{137}Cs	6.12E-05	6.14E-05	6.31E-05	6.20E-05	6.11E-05	6.14E-05	6.18E-05	6.14E-05	6.02E-05	6.02E-05	6.14E-05	6.11E-05	6.18E-05	6.15E-05
^{144}Ce	1.25E-07	1.25E-07	1.26E-07	1.25E-07	1.23E-07	1.25E-07	1.25E-07	1.25E-07	1.23E-07	1.22E-07	1.25E-07	1.24E-07	1.26E-07	1.25E-07
^{143}Nd	3.60E-05	3.60E-05	3.57E-05	3.53E-05	3.64E-05	3.60E-05	3.70E-05	3.57E-05	3.57E-05	3.58E-05	3.63E-05	3.65E-05	3.54E-05	3.62E-05

Table 3.12(2). All results for Case 11b (40% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.52E-05	3.49E-05	3.49E-05	3.57E-05	3.57E-05	3.55E-05	3.52E-05	3.46E-05	3.46E-05	3.50E-05	3.55E-05	3.57E-05	3.48E-05	3.57E-05
^{148}Nd	1.97E-05	1.99E-05	1.99E-05	2.01E-05	2.01E-05	1.98E-05	1.99E-05	1.99E-05	2.00E-05	1.99E-05	1.98E-05	2.01E-05	1.99E-05	2.01E-05
^{147}Sm	1.08E-05	1.09E-05	1.08E-05	1.08E-05	1.02E-05	1.00E-05	9.75E-06	1.04E-05	1.09E-05	1.10E-05	1.01E-05	1.02E-05	1.07E-05	1.09E-05
^{149}Sm	9.31E-08	8.88E-08	8.84E-08	8.97E-08	9.81E-08	9.73E-08	9.97E-08	8.78E-08	8.35E-08	8.31E-08	9.73E-08	9.71E-08	8.92E-08	9.37E-08
^{150}Sm	1.44E-05	1.46E-05	1.47E-05	1.51E-05	1.44E-05	1.43E-05	1.44E-05	1.44E-05	1.40E-05	1.41E-05	1.43E-05	1.44E-05	1.47E-05	1.51E-05
^{151}Sm	3.98E-07	3.62E-07	3.72E-07	3.83E-07	4.42E-07	4.34E-07	4.38E-07	3.64E-07	3.63E-07	3.58E-07	4.37E-07	4.38E-07	3.60E-07	3.82E-07
^{152}Sm	5.63E-06	5.22E-06	5.19E-06	5.35E-06	6.17E-06	6.11E-06	6.11E-06	5.26E-06	5.25E-06	5.19E-06	6.13E-06	6.18E-06	5.19E-06	5.35E-06
^{153}Eu	6.20E-06	6.04E-06	6.03E-06	6.11E-06	6.51E-06	6.30E-06	6.43E-06	5.66E-06	6.11E-06	6.09E-06	6.30E-06	6.51E-06	6.02E-06	6.33E-06
^{154}Eu	7.65E-07	7.66E-07	7.56E-07	6.47E-07	7.65E-07	7.78E-07	7.15E-07	7.11E-07	7.66E-07	7.61E-07	7.79E-07	7.62E-07	7.63E-07	1.41E-06
^{155}Eu	1.50E-07	2.08E-07	2.06E-07	2.09E-07	1.58E-07	1.57E-07	2.31E-07	1.90E-07	2.16E-07	2.14E-07	1.51E-07	1.59E-07	2.08E-07	1.84E-07
^{155}Gd	1.78E-08	2.41E-07	2.42E-07	2.46E-07	1.82E-07	1.79E-07	2.76E-07	2.24E-07	2.38E-07	2.39E-07	1.86E-07	1.82E-07	2.43E-07	2.08E-07
^{156}Gd	9.19E-05	9.84E-05	9.81E-05	9.89E-05	9.93E-05	9.87E-05	9.83E-05	9.84E-05	9.81E-05	9.73E-05	9.88E-05	9.95E-05	9.81E-05	9.80E-05
^{157}Gd	1.64E-08	1.82E-08	2.05E-08	1.95E-08	1.89E-08	1.90E-08	2.22E-08	1.83E-08	1.97E-08	2.72E-08	1.89E-08	1.85E-08	1.95E-08	1.96E-08
^{158}Gd	1.08E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04

Table 3.12(3). All results for Case 11b (40% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ$^{(r)}$
^{234}U	3.58E-06	3.58E-06	3.50E-06	3.54E-06	3.05E-06	3.73E-06	3.57E-06	3.55E-06	2.66E-07	7.48E-02
^{235}U	1.15E-04	1.15E-04	1.08E-04	1.15E-04	1.11E-04	1.14E-04	1.17E-04	1.15E-04	7.21E-06	6.28E-02
^{236}U	1.24E-04	1.24E-04	1.24E-04	1.24E-04	1.24E-04	1.23E-04	1.19E-04	1.23E-04	3.78E-06	3.07E-02
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	1.83E-05	8.81E-04
^{237}Np	1.32E-05	1.30E-05	1.33E-05	1.28E-05	1.31E-05	1.26E-05	1.23E-05	1.29E-05	8.75E-07	6.77E-02
^{238}Pu	6.12E-06	6.04E-06	6.60E-06	5.50E-06	6.00E-06	6.98E-06	5.87E-06	6.29E-06	8.77E-07	1.39E-01
^{239}Pu	1.02E-04	1.01E-04	9.87E-05	9.94E-05	9.79E-05	9.66E-05	9.79E-05	9.78E-05	5.94E-06	6.07E-02
^{240}Pu	6.44E-05	6.47E-05	6.36E-05	6.28E-05	6.25E-05	6.12E-05	6.16E-05	6.24E-05	3.20E-06	5.14E-02
^{241}Pu	2.30E-05	2.28E-05	2.23E-05	2.24E-05	2.21E-05	2.20E-05	2.26E-05	2.24E-05	1.16E-06	5.17E-02
^{242}Pu	2.04E-05	2.04E-05	2.12E-05	2.01E-05	2.03E-05	2.05E-05	2.01E-05	2.04E-05	9.59E-07	4.71E-02
^{241}Am	7.61E-06	7.54E-06	7.18E-06	7.42E-06	7.15E-06	7.12E-06	7.46E-06	7.33E-06	4.62E-07	6.31E-02
^{243}Am	4.99E-06	4.95E-06	4.74E-06	4.73E-06	4.31E-06	4.35E-06	4.32E-06	4.64E-06	5.61E-07	1.21E-01
^{244}Cm	1.71E-06	1.69E-06	1.65E-06	1.65E-06	1.50E-06	1.66E-06	1.49E-06	1.63E-06	1.69E-07	1.04E-01
^{90}Sr	4.00E-05	4.01E-05	3.96E-05	4.00E-05	3.99E-05	4.00E-05	4.07E-05	4.00E-05	6.86E-07	1.72E-02
^{95}Mo	6.20E-05	6.20E-05	6.29E-05	6.17E-05	6.15E-05	6.20E-05	6.19E-05	6.19E-05	7.21E-07	1.16E-02
^{99}Tc	6.22E-05	6.23E-05	6.25E-05	6.21E-05	6.03E-05	6.22E-05	6.25E-05	6.20E-05	1.84E-06	2.96E-02
^{101}Ru	6.14E-05	6.14E-05	6.25E-05	6.09E-05	6.04E-05	6.11E-05	6.01E-05	6.11E-05	1.09E-06	1.78E-02
^{103}Rh	3.30E-05	3.29E-05	3.27E-05	3.16E-05	3.06E-05	3.27E-05	3.15E-05	3.23E-05	1.07E-06	3.32E-02
^{109}Ag	5.81E-06	5.78E-06	6.29E-06	4.05E-06	5.19E-06	5.62E-06	6.38E-06	5.42E-06	1.40E-06	2.58E-01
^{129}I	9.55E-06	9.54E-06	1.06E-05	8.67E-06	8.89E-06	8.99E-06	1.04E-05	9.49E-06	1.61E-06	1.70E-01
^{131}Xe	2.40E-05	2.40E-05	2.37E-05	2.24E-05	2.37E-05	2.33E-05	2.36E-05	2.34E-05	1.41E-06	6.03E-02
^{133}Cs	6.54E-05	6.55E-05	6.48E-05	6.51E-05	6.40E-05	6.47E-05	6.54E-05	6.49E-05	1.64E-06	2.52E-02
^{134}Cs	1.39E-06	1.37E-06	1.42E-06	1.37E-06	1.36E-06	1.39E-06	1.31E-06	1.38E-06	1.15E-07	8.34E-02
^{137}Cs	6.19E-05	6.19E-05	6.23E-05	6.17E-05	6.16E-05	6.14E-05	6.25E-05	6.16E-05	1.17E-06	1.89E-02
^{144}Ce	1.26E-07	1.26E-07	1.26E-07	1.25E-07	1.24E-07	1.25E-07	1.26E-07	1.25E-07	1.88E-09	1.51E-02
^{143}Nd	3.62E-05	3.61E-05	3.52E-05	3.60E-05	3.52E-05	3.58E-05	3.60E-05	3.59E-05	7.77E-07	2.17E-02

Table 3.12(3). All results for Case 11b (40% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.50E-05	3.50E-05	3.59E-05	3.47E-05	3.43E-05	3.52E-05	3.58E-05	3.51E-05	8.04E-07	2.29E-02
^{148}Nd	2.00E-05	2.00E-05	2.03E-05	1.99E-05	1.99E-05	1.97E-05	1.99E-05	1.99E-05	2.82E-07	1.42E-02
^{147}Sm	1.08E-05	1.09E-05	1.09E-05	1.08E-05	8.61E-06	1.10E-05	1.10E-05	1.07E-05	9.43E-07	8.84E-02
^{149}Sm	8.74E-08	8.68E-08	7.97E-08	9.03E-08	7.67E-08	8.76E-08	8.98E-08	8.83E-08	1.12E-08	1.27E-01
^{150}Sm	1.49E-05	1.49E-05	1.38E-05	1.46E-05	1.35E-05	1.46E-05	1.46E-05	1.44E-05	8.80E-07	6.10E-02
^{151}Sm	3.69E-07	3.68E-07	3.55E-07	3.71E-07	3.40E-07	3.53E-07	3.75E-07	3.78E-07	6.04E-08	1.60E-01
^{152}Sm	5.30E-06	5.26E-06	5.23E-06	5.15E-06	5.07E-06	5.17E-06	5.52E-06	5.41E-06	8.13E-07	1.50E-01
^{153}Eu	6.10E-06	6.09E-06	6.06E-06	6.04E-06	5.51E-06	5.97E-06	6.01E-06	6.09E-06	4.09E-07	6.72E-02
^{154}Eu	7.80E-07	7.78E-07	7.65E-07	7.66E-07	6.99E-07	7.43E-07	6.44E-07	7.64E-07	2.37E-07	3.10E-01
^{155}Eu	2.13E-07	2.09E-07	2.07E-07	2.06E-07	1.91E-07	2.01E-07	2.03E-07	1.97E-07	4.27E-08	2.17E-01
^{155}Gd	2.48E-07	2.44E-07	2.43E-07	2.42E-07	2.29E-07	2.38E-07	2.38E-07	2.26E-07	8.56E-08	3.80E-01
^{156}Gd	9.86E-05	9.78E-05	9.89E-05	9.22E-05	9.79E-05	9.82E-05	9.71E-05	9.79E-05	3.15E-06	3.22E-02
^{157}Gd	1.89E-08	1.90E-08	1.77E-08	1.98E-08	1.90E-08	1.99E-08	2.19E-08	2.02E-08	5.70E-09	2.82E-01
^{158}Gd	1.14E-04	1.13E-04	1.14E-04	1.13E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	2.18E-06	1.91E-02

Table 3.13(1). All results for Case 11c (40% void, 50 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	4.23E-06	4.36E-06	4.25E-06	3.98E-06	4.16E-06	3.96E-06	4.03E-06	3.95E-06	4.00E-06	4.02E-06	4.05E-06	4.24E-06	4.00E-06	4.00E-06
^{235}U	1.13E-04	1.06E-04	1.15E-04	1.08E-04	1.18E-04	1.11E-04	1.15E-04	1.17E-04	1.11E-04	1.15E-04	1.16E-04	1.14E-04	1.12E-04	1.16E-04
^{236}U	1.24E-04	1.26E-04	1.23E-04	1.25E-04	1.23E-04	1.24E-04	1.24E-04	1.24E-04	1.25E-04	1.24E-04	1.24E-04	1.23E-04	1.25E-04	1.24E-04
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02
^{237}Np	1.28E-05	1.30E-05	1.28E-05	1.31E-05	1.27E-05	1.28E-05	1.34E-05	1.30E-05	1.29E-05	1.32E-05	1.34E-05	1.30E-05	1.30E-05	1.33E-05
^{238}Pu	6.50E-06	6.48E-06	6.52E-06	5.53E-06	5.96E-06	5.44E-06	5.61E-06	5.78E-06	5.49E-06	5.64E-06	5.86E-06	6.64E-06	5.50E-06	5.59E-06
^{239}Pu	9.54E-05	9.17E-05	9.72E-05	9.49E-05	9.81E-05	9.74E-05	1.02E-04	1.02E-04	9.71E-05	9.41E-05	9.16E-05	9.51E-05	9.82E-05	1.00E-04
^{240}Pu	6.21E-05	6.09E-05	6.18E-05	6.25E-05	6.21E-05	6.35E-05	6.46E-05	6.70E-05	6.46E-05	6.37E-05	6.49E-05	6.25E-05	6.42E-05	6.15E-05
^{241}Pu	1.36E-05	1.30E-05	1.37E-05	1.34E-05	1.38E-05	1.36E-05	1.41E-05	1.40E-05	1.36E-05	1.36E-05	1.35E-05	1.37E-05	1.37E-05	1.40E-05
^{242}Pu	2.08E-05	2.10E-05	2.06E-05	2.04E-05	2.05E-05	2.03E-05	2.03E-05	2.07E-05	2.03E-05	2.06E-05	2.14E-05	2.11E-05	2.03E-05	2.00E-05
^{241}Am	1.54E-05	1.48E-05	1.55E-05	1.54E-05	1.57E-05	1.56E-05	1.62E-05	1.61E-05	1.56E-05	1.56E-05	1.53E-05	1.54E-05	1.57E-05	1.61E-05
^{243}Am	4.45E-06	4.23E-06	4.41E-06	4.88E-06	4.28E-06	4.91E-06	4.91E-06	5.09E-06	4.87E-06	4.95E-06	4.70E-06	4.53E-06	4.89E-06	4.88E-06
^{244}Cm	1.18E-06	1.13E-06	1.16E-06	1.16E-06	1.13E-06	1.16E-06	1.12E-06	1.18E-06	1.13E-06	1.16E-06	1.10E-06	1.21E-06	1.13E-06	1.13E-06
^{90}Sr	3.15E-05	3.16E-05	3.14E-05	3.16E-05	3.13E-05	3.14E-05	3.14E-05	3.14E-05	3.16E-05	3.14E-05	3.08E-05	3.20E-05	3.15E-05	3.19E-05
^{95}Mo	6.23E-05	6.24E-05	6.19E-05	6.19E-05	6.16E-05	6.17E-05	6.18E-05	6.19E-05	6.21E-05	6.17E-05	6.22E-05	6.23E-05	6.19E-05	6.19E-05
^{99}Tc	6.31E-05	6.25E-05	6.21E-05	6.19E-05	6.16E-05	6.28E-05	6.28E-05	6.41E-05	6.30E-05	6.20E-05	6.25E-05	6.33E-05	6.24E-05	6.12E-05
^{101}Ru	6.16E-05	6.14E-05	6.11E-05	6.12E-05	6.09E-05	6.10E-05	6.12E-05	6.19E-05	6.13E-05	6.09E-05	6.16E-05	6.16E-05	6.12E-05	6.10E-05
^{103}Rh	3.28E-05	3.30E-05	3.26E-05	3.24E-05	3.22E-05	3.24E-05	3.28E-05	3.30E-05	3.27E-05	3.24E-05	3.22E-05	3.27E-05	3.26E-05	3.24E-05
^{109}Ag	5.77E-06	5.77E-06	5.63E-06	5.67E-06	3.57E-06	5.69E-06	5.75E-06	5.81E-06	5.75E-06	4.10E-06	6.01E-06	5.78E-06	5.73E-06	4.00E-06
^{129}I	9.07E-06	9.01E-06	9.08E-06	9.46E-06	8.73E-06	9.45E-06	9.50E-06	9.55E-06	9.50E-06	9.32E-06	1.04E-05	9.04E-06	9.48E-06	9.47E-06
^{131}Xe	2.34E-05	2.40E-05	2.32E-05	2.40E-05	2.18E-05	2.39E-05	2.40E-05	2.33E-05	2.41E-05	2.38E-05	2.36E-05	2.33E-05	2.40E-05	2.38E-05
^{133}Cs	6.58E-05	6.61E-05	6.45E-05	6.49E-05	6.44E-05	6.48E-05	6.51E-05	6.60E-05	6.53E-05	6.59E-05	6.50E-05	6.60E-05	6.51E-05	6.48E-05
^{134}Cs	5.00E-08	4.87E-08	4.88E-08	4.86E-08	4.85E-08	4.80E-08	4.81E-08	4.45E-08	4.78E-08	4.84E-08	4.83E-08	4.99E-08	4.78E-08	4.77E-08
^{137}Cs	4.91E-05	4.91E-05	4.87E-05	4.90E-05	4.86E-05	4.89E-05	4.90E-05	4.91E-05	4.91E-05	4.88E-05	4.81E-05	4.91E-05	4.90E-05	4.98E-05
^{144}Ce	1.74E-11	1.74E-11	1.75E-11	1.73E-11	1.77E-11	1.73E-11	1.72E-11	1.75E-11	1.75E-11	1.74E-11	1.74E-11	1.70E-11	1.73E-11	1.72E-11
^{143}Nd	3.59E-05	3.54E-05	3.57E-05	3.54E-05	3.60E-05	3.55E-05	3.61E-05	3.64E-05	3.58E-05	3.61E-05	3.58E-05	3.59E-05	3.58E-05	3.57E-05

Table 3.13(1). All results for Case 11c (40% void, 50 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants (continued)

^{145}Nd	3.52E-05	3.52E-05	3.51E-05	3.49E-05	3.49E-05	3.48E-05	3.49E-05	3.56E-05	3.50E-05	3.48E-05	3.56E-05	3.53E-05	3.49E-05	3.48E-05
^{148}Nd	1.97E-05	1.98E-05	1.97E-05	2.00E-05	1.96E-05	1.99E-05	1.99E-05	1.97E-05	2.00E-05	1.99E-05	2.00E-05	1.98E-05	1.99E-05	1.98E-05
^{147}Sm	1.28E-05	1.24E-05	1.28E-05	1.26E-05	1.27E-05	1.26E-05	1.27E-05	1.26E-05	1.27E-05	1.26E-05	1.26E-05	1.27E-05	1.27E-05	1.26E-05
^{149}Sm	8.18E-08	8.04E-08	8.81E-08	8.39E-08	9.01E-08	8.72E-08	8.98E-08	9.46E-08	8.68E-08	8.22E-08	8.53E-08	8.23E-08	8.37E-08	8.84E-08
^{150}Sm	1.44E-05	1.36E-05	1.46E-05	1.48E-05	1.35E-05	1.45E-05	1.46E-05	1.54E-05	1.46E-05	1.38E-05	1.43E-05	1.40E-05	1.47E-05	1.46E-05
^{151}Sm	3.22E-07	3.47E-07	3.30E-07	3.26E-07	3.82E-07	3.30E-07	3.41E-07	3.97E-07	3.30E-07	3.33E-07	3.52E-07	3.26E-07	3.35E-07	3.42E-07
^{152}Sm	5.14E-06	6.69E-06	5.11E-06	5.17E-06	5.53E-06	5.21E-06	5.18E-06	5.23E-06	5.28E-06	5.11E-06	5.28E-06	5.05E-06	5.27E-06	5.15E-06
^{153}Eu	6.01E-06	5.81E-06	5.97E-06	6.08E-06	6.32E-06	5.99E-06	6.05E-06	6.28E-06	6.04E-06	5.96E-06	6.06E-06	5.99E-06	6.06E-06	6.01E-06
^{154}Eu	3.35E-07	3.12E-07	3.36E-07	3.42E-07	3.53E-07	3.39E-07	3.44E-07	3.38E-07	3.38E-07	3.29E-07	2.79E-07	3.30E-07	3.42E-07	3.43E-07
^{155}Eu	4.75E-08	4.56E-08	4.68E-08	4.92E-08	4.91E-08	4.80E-08	4.83E-08	3.46E-08	4.84E-08	4.72E-08	4.77E-08	5.16E-08	4.85E-08	4.77E-08
^{155}Gd	3.98E-07	3.82E-07	3.93E-07	4.09E-07	4.12E-07	4.00E-07	4.03E-07	2.94E-07	4.01E-07	3.94E-07	3.99E-07	3.90E-07	4.03E-07	3.98E-07
^{156}Gd	9.72E-05	9.80E-05	9.71E-05	9.87E-05	9.85E-05	9.89E-05	9.86E-05	9.84E-05	9.85E-05	9.80E-05	9.89E-05	9.72E-05	9.85E-05	9.80E-05
^{157}Gd	2.70E-08	2.31E-08	2.69E-08	1.77E-08	2.06E-08	1.71E-08	1.86E-08	1.90E-08	1.74E-08	2.02E-08	1.97E-08	2.71E-08	1.84E-08	2.07E-08
^{158}Gd	1.15E-04	1.15E-04	1.15E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	1.14E-04

Table 3.13(2). All results for Case 11c (40% void, 50 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	3.25E-06	4.02E-06	4.00E-06	4.02E-06	4.00E-06	3.98E-06	4.03E-06	4.10E-06	4.01E-06	4.24E-06	4.00E-06	4.00E-06	3.98E-06	3.93E-06
^{235}U	1.16E-04	1.15E-04	1.15E-04	1.14E-04	1.21E-04	1.17E-04	1.22E-04	1.13E-04	1.16E-04	1.17E-04	1.20E-04	1.21E-04	1.12E-04	1.16E-04
^{236}U	1.24E-04	1.24E-04	1.24E-04	1.24E-04	1.20E-04	1.25E-04	1.16E-04	1.25E-04	1.24E-04	1.23E-04	1.25E-04	1.20E-04	1.24E-04	1.20E-04
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.08E-02	2.08E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02
^{237}Np	1.23E-05	1.31E-05	1.33E-05	1.36E-05	1.29E-05	1.29E-05	1.51E-05	1.31E-05	1.31E-05	1.29E-05	1.29E-05	1.29E-05	1.33E-05	1.30E-05
^{238}Pu	5.53E-06	5.51E-06	5.64E-06	5.82E-06	5.73E-06	5.79E-06	6.64E-06	5.49E-06	5.49E-06	6.45E-06	5.76E-06	5.71E-06	5.59E-06	5.82E-06
^{239}Pu	9.64E-05	1.00E-04	9.69E-05	9.67E-05	9.80E-05	9.52E-05	1.08E-04	9.72E-05	9.78E-05	9.74E-05	9.75E-05	9.76E-05	9.82E-05	9.72E-05
^{240}Pu	6.10E-05	6.48E-05	6.31E-05	6.38E-05	6.12E-05	5.97E-05	6.04E-05	6.06E-05	6.27E-05	6.19E-05	6.11E-05	6.15E-05	6.27E-05	6.36E-05
^{241}Pu	1.36E-05	1.39E-05	1.38E-05	1.37E-05	1.40E-05	1.40E-05	1.54E-05	1.38E-05	1.37E-05	1.37E-05	1.41E-05	1.39E-05	1.37E-05	1.37E-05
^{242}Pu	1.90E-05	2.02E-05	2.05E-05	2.09E-05	1.97E-05	1.97E-05	2.09E-05	2.05E-05	1.99E-05	2.04E-05	1.97E-05	1.97E-05	2.04E-05	2.00E-05
^{241}Am	1.55E-05	1.59E-05	1.58E-05	1.55E-05	1.58E-05	1.58E-05	1.76E-05	1.58E-05	1.55E-05	1.54E-05	1.61E-05	1.58E-05	1.56E-05	1.55E-05
^{243}Am	4.54E-06	4.88E-06	4.95E-06	4.62E-06	4.10E-06	4.55E-06	4.52E-06	4.57E-06	4.80E-06	4.37E-06	4.51E-06	4.08E-06	4.95E-06	4.43E-06
^{244}Cm	1.06E-06	1.12E-06	1.15E-06	1.07E-06	9.91E-07	1.14E-06	1.00E-06	1.07E-06	1.11E-06	1.14E-06	1.12E-06	9.86E-07	1.16E-06	1.03E-06
^{90}Sr	3.10E-05	3.15E-05	3.20E-05	3.12E-05	3.14E-05	3.14E-05	3.09E-05	-	3.13E-05	3.12E-05	3.09E-05	3.14E-05	3.15E-05	3.16E-05
^{95}Mo	6.15E-05	6.19E-05	6.21E-05	6.26E-05	6.22E-05	6.14E-05	6.17E-05	6.16E-05	6.14E-05	6.17E-05	6.14E-05	6.22E-05	6.19E-05	6.27E-05
^{99}Tc	6.17E-05	6.27E-05	6.15E-05	6.17E-05	6.14E-05	6.03E-05	6.29E-05	6.05E-05	6.08E-05	6.13E-05	6.04E-05	6.14E-05	6.12E-05	6.28E-05
^{101}Ru	6.05E-05	6.12E-05	6.13E-05	6.19E-05	6.14E-05	6.09E-05	6.11E-05	6.07E-05	5.98E-05	6.02E-05	6.09E-05	6.14E-05	6.12E-05	6.19E-05
^{103}Rh	3.22E-05	3.27E-05	3.25E-05	3.22E-05	3.18E-05	3.22E-05	3.34E-05	3.19E-05	3.19E-05	3.22E-05	3.25E-05	3.18E-05	3.23E-05	3.17E-05
^{109}Ag	5.75E-06	5.73E-06	4.03E-06	5.91E-06	5.40E-06	5.56E-06	5.43E-06	5.54E-06	5.67E-06	5.71E-06	5.60E-06	5.40E-06	4.18E-06	5.61E-06
^{129}I	9.49E-06	9.32E-06	9.52E-06	1.06E-05	9.11E-06	7.75E-06	9.35E-06	9.27E-06	1.13E-05	1.12E-05	7.78E-06	9.11E-06	9.58E-06	1.12E-05
^{131}Xe	2.28E-05	2.39E-05	2.38E-05	2.38E-05	2.28E-05	2.14E-05	2.33E-05	2.37E-05	2.37E-05	2.32E-05	2.15E-05	2.29E-05	2.37E-05	2.41E-05
^{133}Cs	6.60E-05	6.54E-05	6.50E-05	6.41E-05	6.26E-05	6.46E-05	6.48E-05	6.51E-05	6.45E-05	6.41E-05	6.47E-05	6.26E-05	6.51E-05	6.38E-05
^{134}Cs	4.26E-08	4.76E-08	4.82E-08	4.80E-08	5.12E-08	4.85E-08	5.51E-08	4.61E-08	4.70E-08	4.83E-08	4.79E-08	5.10E-08	4.87E-08	4.83E-08
^{137}Cs	4.86E-05	4.87E-05	5.01E-05	4.92E-05	4.85E-05	4.87E-05	4.91E-05	4.88E-05	4.78E-05	4.78E-05	4.87E-05	4.85E-05	4.91E-05	4.88E-05
^{144}Ce	1.73E-11	1.72E-11	1.75E-11	1.74E-11	1.68E-11	1.70E-11	1.75E-11	1.74E-11	1.67E-11	1.67E-11	1.77E-11	1.76E-11	1.76E-11	1.74E-11
^{143}Nd	3.60E-05	3.60E-05	3.57E-05	3.53E-05	3.64E-05	3.60E-05	3.70E-05	3.57E-05	3.57E-05	3.58E-05	3.63E-05	3.65E-05	3.54E-05	3.62E-05

Table 3.13(2). All results for Case 11c (40% void, 50 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.52E-05	3.49E-05	3.49E-05	3.57E-05	3.57E-05	3.55E-05	3.52E-05	3.46E-05	3.46E-05	3.50E-05	3.55E-05	3.57E-05	3.48E-05	3.57E-05
^{148}Nd	1.97E-05	1.99E-05	1.99E-05	2.01E-05	2.01E-05	1.98E-05	1.99E-05	1.99E-05	2.00E-05	1.99E-05	1.98E-05	2.01E-05	1.99E-05	2.01E-05
^{147}Sm	1.27E-05	1.27E-05	1.26E-05	1.26E-05	1.18E-05	1.17E-05	1.14E-05	1.21E-05	1.28E-05	1.28E-05	1.18E-05	1.18E-05	1.25E-05	1.28E-05
^{149}Sm	9.31E-08	8.88E-08	8.84E-08	8.97E-08	9.81E-08	9.72E-08	9.97E-08	8.78E-08	8.35E-08	8.31E-08	9.73E-08	9.71E-08	8.92E-08	9.37E-08
^{150}Sm	1.44E-05	1.46E-05	1.47E-05	1.51E-05	1.44E-05	1.43E-05	1.44E-05	1.44E-05	1.40E-05	1.41E-05	1.43E-05	1.44E-05	1.47E-05	1.51E-05
^{151}Sm	3.68E-07	3.35E-07	3.44E-07	3.55E-07	4.10E-07	4.02E-07	4.06E-07	3.37E-07	3.36E-07	3.31E-07	4.05E-07	4.05E-07	3.34E-07	3.53E-07
^{152}Sm	5.63E-06	5.22E-06	5.19E-06	5.35E-06	6.17E-06	6.11E-06	6.11E-06	5.26E-06	5.25E-06	5.19E-06	6.13E-06	6.18E-06	5.19E-06	5.35E-06
^{153}Eu	6.20E-06	6.04E-06	6.03E-06	6.11E-06	6.51E-06	6.30E-06	6.43E-06	5.66E-06	6.11E-06	6.09E-06	6.30E-06	6.51E-06	6.02E-06	6.33E-06
^{154}Eu	3.41E-07	3.42E-07	3.37E-07	2.89E-07	3.42E-07	3.48E-07	3.19E-07	3.17E-07	3.42E-07	3.40E-07	3.48E-07	3.40E-07	3.41E-07	6.29E-07
^{155}Eu	3.41E-08	4.83E-08	4.79E-08	4.86E-08	3.92E-08	3.88E-08	5.25E-08	4.42E-08	5.34E-08	5.30E-08	3.43E-08	3.93E-08	4.84E-08	4.55E-08
^{155}Gd	1.78E-08	4.00E-07	4.00E-07	4.06E-07	3.01E-07	2.97E-07	4.54E-07	3.70E-07	4.01E-07	4.00E-07	3.03E-07	3.02E-07	4.02E-07	3.46E-07
^{156}Gd	9.19E-05	9.84E-05	9.81E-05	9.89E-05	9.93E-05	9.87E-05	9.83E-05	9.84E-05	9.81E-05	9.73E-05	9.88E-05	9.95E-05	9.81E-05	9.80E-05
^{157}Gd	1.64E-08	1.82E-08	2.05E-08	1.95E-08	1.89E-08	1.90E-08	2.22E-08	1.83E-08	1.97E-08	2.72E-08	1.89E-08	1.85E-08	1.95E-08	1.96E-08
^{158}Gd	1.08E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	1.14E-04	1.14E-04	1.14E-04

Table 3.13(3). All results for Case 11c (40% void, 50 GWd/tHM, 15-year cooling) actinides and fission products [10^{24}/cm^3] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	2*σ$^{(r)}$
^{234}U	4.04E-06	4.04E-06	4.00E-06	3.95E-06	3.51E-06	4.26E-06	4.02E-06	4.02E-06	3.88E-07	9.66E-02
^{235}U	1.15E-04	1.15E-04	1.08E-04	1.15E-04	1.11E-04	1.14E-04	1.17E-04	1.15E-04	7.20E-06	6.27E-02
^{236}U	1.24E-04	1.24E-04	1.24E-04	1.24E-04	1.24E-04	1.23E-04	1.20E-04	1.23E-04	3.78E-06	3.06E-02
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	1.83E-05	8.81E-04
^{237}Np	1.34E-05	1.32E-05	1.35E-05	1.30E-05	1.33E-05	1.28E-05	1.25E-05	1.31E-05	8.97E-07	6.85E-02
^{238}Pu	5.65E-06	5.58E-06	6.10E-06	5.08E-06	5.54E-06	6.45E-06	5.43E-06	5.81E-06	8.11E-07	1.40E-01
^{239}Pu	1.02E-04	1.01E-04	9.87E-05	9.94E-05	9.79E-05	9.66E-05	9.78E-05	9.78E-05	5.94E-06	6.07E-02
^{240}Pu	6.49E-05	6.51E-05	6.40E-05	6.31E-05	6.29E-05	6.17E-05	6.21E-05	6.28E-05	3.25E-06	5.17E-02
^{241}Pu	1.42E-05	1.41E-05	1.37E-05	1.38E-05	1.36E-05	1.36E-05	1.40E-05	1.38E-05	7.22E-07	5.23E-02
^{242}Pu	2.04E-05	2.04E-05	2.12E-05	2.01E-05	2.03E-05	2.05E-05	2.01E-05	2.04E-05	9.59E-07	4.71E-02
^{241}Am	1.63E-05	1.61E-05	1.55E-05	1.59E-05	1.54E-05	1.54E-05	1.59E-05	1.57E-05	8.81E-07	5.60E-02
^{243}Am	4.98E-06	4.95E-06	4.74E-06	4.73E-06	4.31E-06	4.34E-06	4.31E-06	4.63E-06	5.60E-07	1.21E-01
^{244}Cm	1.17E-06	1.15E-06	1.12E-06	1.12E-06	1.02E-06	1.13E-06	1.02E-06	1.11E-06	1.15E-07	1.04E-01
^{90}Sr	3.15E-05	3.15E-05	3.11E-05	3.14E-05	3.11E-05	3.14E-05	3.20E-05	3.14E-05	5.91E-07	1.88E-02
^{95}Mo	6.20E-05	6.20E-05	6.29E-05	6.17E-05	6.15E-05	6.20E-05	6.19E-05	6.19E-05	7.24E-07	1.17E-02
^{99}Tc	6.22E-05	6.23E-05	6.25E-05	6.21E-05	5.99E-05	6.22E-05	6.25E-05	6.20E-05	1.88E-06	3.03E-02
^{101}Ru	6.14E-05	6.14E-05	6.25E-05	6.09E-05	6.04E-05	6.11E-05	6.01E-05	6.11E-05	1.09E-06	1.79E-02
^{103}Rh	3.30E-05	3.29E-05	3.27E-05	3.16E-05	3.06E-05	3.27E-05	3.15E-05	3.23E-05	1.08E-06	3.33E-02
^{109}Ag	5.81E-06	5.78E-06	6.29E-06	4.05E-06	5.18E-06	5.62E-06	6.38E-06	5.42E-06	1.40E-06	2.58E-01
^{129}I	9.55E-06	9.54E-06	1.06E-05	8.67E-06	8.87E-06	8.99E-06	1.04E-05	9.49E-06	1.61E-06	1.70E-01
^{131}Xe	2.40E-05	2.40E-05	2.37E-05	2.24E-05	2.38E-05	2.33E-05	2.36E-05	2.34E-05	1.41E-06	6.03E-02
^{133}Cs	6.54E-05	6.55E-05	6.48E-05	6.51E-05	6.40E-05	6.47E-05	6.54E-05	6.49E-05	1.63E-06	2.52E-02
^{134}Cs	4.86E-08	4.79E-08	4.94E-08	4.76E-08	4.70E-08	4.84E-08	4.54E-08	4.82E-08	3.99E-09	8.28E-02
^{137}Cs	4.92E-05	4.92E-05	4.94E-05	4.90E-05	4.88E-05	4.88E-05	4.96E-05	4.89E-05	9.40E-07	1.92E-02
^{144}Ce	1.75E-11	1.75E-11	1.75E-11	1.77E-11	1.71E-11	1.74E-11	1.74E-11	1.73E-11	5.06E-13	2.92E-02
^{143}Nd	3.62E-05	3.61E-05	3.52E-05	3.60E-05	3.52E-05	3.58E-05	3.60E-05	3.59E-05	7.79E-07	2.17E-02

Table 3.13(3). All results for Case 11c (40% void, 50 GWd/tHM, 15-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.50E-05	3.50E-05	3.59E-05	3.47E-05	3.41E-05	3.52E-05	3.58E-05	3.51E-05	8.31E-07	2.37E-02
^{148}Nd	2.00E-05	2.00E-05	2.03E-05	1.99E-05	1.99E-05	1.97E-05	1.99E-05	1.99E-05	2.82E-07	1.42E-02
^{147}Sm	1.26E-05	1.27E-05	1.27E-05	1.27E-05	1.00E-05	1.28E-05	1.28E-05	1.24E-05	1.13E-06	9.07E-02
^{149}Sm	8.74E-08	8.68E-08	7.97E-08	9.03E-08	7.32E-08	8.76E-08	8.98E-08	8.82E-08	1.17E-08	1.32E-01
^{150}Sm	1.49E-05	1.49E-05	1.38E-05	1.46E-05	1.35E-05	1.46E-05	1.46E-05	1.44E-05	8.85E-07	6.13E-02
^{151}Sm	3.42E-07	3.41E-07	3.28E-07	3.44E-07	3.13E-07	3.27E-07	3.47E-07	3.50E-07	5.60E-08	1.60E-01
^{152}Sm	5.30E-06	5.26E-06	5.23E-06	5.15E-06	5.06E-06	5.17E-06	5.52E-06	5.41E-06	8.13E-07	1.50E-01
^{153}Eu	6.10E-06	6.09E-06	6.06E-06	6.04E-06	5.50E-06	5.97E-06	6.01E-06	6.09E-06	4.11E-07	6.74E-02
^{154}Eu	3.48E-07	3.47E-07	3.42E-07	3.42E-07	3.12E-07	3.31E-07	2.87E-07	3.41E-07	1.06E-07	3.11E-01
^{155}Eu	4.95E-08	4.87E-08	4.81E-08	4.80E-08	4.32E-08	4.68E-08	4.72E-08	4.63E-08	9.94E-09	2.15E-01
^{155}Gd	4.11E-07	4.05E-07	4.01E-07	4.00E-07	3.75E-07	3.93E-07	3.93E-07	3.73E-07	1.45E-07	3.90E-01
^{156}Gd	9.86E-05	9.78E-05	9.89E-05	9.22E-05	9.78E-05	9.82E-05	9.71E-05	9.79E-05	3.15E-06	3.22E-02
^{157}Gd	1.89E-08	1.90E-08	1.77E-08	1.98E-08	1.90E-08	1.99E-08	2.19E-08	2.02E-08	5.70E-09	2.82E-01
^{158}Gd	1.14E-04	1.13E-04	1.14E-04	1.13E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	2.18E-06	1.91E-02

Table 3.14(1). All results for Case 12b (70% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
^{234}U	3.68E-06	3.84E-06	3.69E-06	3.51E-06	3.73E-06	3.52E-06	3.55E-06	3.42E-06	3.52E-06	3.53E-06	3.53E-06	3.67E-06	3.51E-06	3.51E-06
^{235}U	1.43E-04	1.35E-04	1.45E-04	1.38E-04	1.48E-04	1.43E-04	1.46E-04	1.43E-04	1.39E-04	1.45E-04	1.45E-04	1.44E-04	1.39E-04	1.44E-04
^{236}U	1.24E-04	1.26E-04	1.24E-04	1.25E-04	1.23E-04	1.24E-04	1.24E-04	1.24E-04	1.26E-04	1.25E-04	1.24E-04	1.23E-04	1.25E-04	1.24E-04
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02
^{237}Np	1.39E-05	1.42E-05	1.39E-05	1.42E-05	1.30E-05	1.40E-05	1.46E-05	1.40E-05	1.39E-05	1.43E-05	1.47E-05	1.41E-05	1.39E-05	1.45E-05
^{238}Pu	8.33E-06	8.35E-06	8.34E-06	7.22E-06	7.15E-06	7.16E-06	7.33E-06	7.37E-06	7.09E-06	7.38E-06	7.66E-06	8.51E-06	7.11E-06	7.32E-06
^{239}Pu	1.21E-04	1.16E-04	1.23E-04	1.21E-04	1.26E-04	1.26E-04	1.30E-04	1.25E-04	1.21E-04	1.20E-04	1.18E-04	1.21E-04	1.22E-04	1.26E-04
^{240}Pu	6.73E-05	6.59E-05	6.71E-05	6.75E-05	6.83E-05	6.95E-05	6.97E-05	7.31E-05	6.89E-05	6.91E-05	7.05E-05	6.80E-05	6.86E-05	6.71E-05
^{241}Pu	2.66E-05	2.57E-05	2.68E-05	2.65E-05	2.74E-05	2.70E-05	2.77E-05	2.65E-05	2.64E-05	2.67E-05	2.66E-05	2.68E-05	2.66E-05	2.74E-05
^{242}Pu	1.99E-05	2.01E-05	1.96E-05	1.93E-05	2.01E-05	1.92E-05	1.92E-05	1.93E-05	1.92E-05	1.96E-05	2.03E-05	2.00E-05	1.92E-05	1.91E-05
^{241}Am	8.72E-06	8.39E-06	8.79E-06	8.83E-06	9.01E-06	9.03E-06	9.27E-06	8.88E-06	8.81E-06	8.92E-06	8.66E-06	8.69E-06	8.87E-06	9.17E-06
^{243}Am	4.76E-06	4.54E-06	4.71E-06	5.24E-06	4.61E-06	5.26E-06	5.26E-06	5.28E-06	5.19E-06	5.30E-06	5.05E-06	4.84E-06	5.22E-06	5.25E-06
^{244}Cm	2.08E-06	2.02E-06	2.06E-06	2.03E-06	1.99E-06	2.03E-06	1.98E-06	2.03E-06	1.99E-06	2.05E-06	1.95E-06	2.15E-06	2.00E-06	2.01E-06
^{90}Sr	3.93E-05	3.94E-05	3.90E-05	3.93E-05	3.88E-05	3.90E-05	3.90E-05	3.93E-05	3.93E-05	3.91E-05	3.83E-05	3.97E-05	3.92E-05	3.99E-05
^{95}Mo	6.15E-05	6.16E-05	6.11E-05	6.10E-05	6.08E-05	6.07E-05	6.08E-05	6.11E-05	6.12E-05	6.08E-05	6.14E-05	6.15E-05	6.10E-05	6.12E-05
^{99}Tc	6.27E-05	6.21E-05	6.18E-05	6.14E-05	6.14E-05	6.23E-05	6.23E-05	6.37E-05	6.25E-05	6.16E-05	6.22E-05	6.29E-05	6.19E-05	6.10E-05
^{101}Ru	6.13E-05	6.10E-05	6.07E-05	6.08E-05	6.06E-05	6.06E-05	6.07E-05	6.15E-05	6.09E-05	6.07E-05	6.14E-05	6.13E-05	6.07E-05	6.09E-05
^{103}Rh	3.33E-05	3.36E-05	3.31E-05	3.30E-05	3.28E-05	3.32E-05	3.35E-05	3.34E-05	3.32E-05	3.31E-05	3.28E-05	3.31E-05	3.31E-05	3.31E-05
^{109}Ag	5.98E-06	6.00E-06	5.80E-06	5.83E-06	3.82E-06	5.89E-06	5.91E-06	5.85E-06	5.88E-06	4.26E-06	6.13E-06	5.93E-06	5.87E-06	4.16E-06
^{129}I	9.30E-06	9.26E-06	9.31E-06	9.72E-06	8.97E-06	9.72E-06	9.76E-06	9.74E-06	9.73E-06	9.59E-06	1.06E-05	9.29E-06	9.71E-06	9.79E-06
^{131}Xe	2.31E-05	2.37E-05	2.29E-05	2.38E-05	2.14E-05	2.35E-05	2.37E-05	2.30E-05	2.37E-05	2.34E-05	2.32E-05	2.30E-05	2.36E-05	2.35E-05
^{133}Cs	6.50E-05	6.55E-05	6.38E-05	6.41E-05	6.40E-05	6.41E-05	6.43E-05	6.52E-05	6.44E-05	6.52E-05	6.43E-05	6.54E-05	6.43E-05	6.43E-05
^{134}Cs	1.51E-06	1.47E-06	1.48E-06	1.47E-06	1.44E-06	1.44E-06	1.46E-06	1.34E-06	1.45E-06	1.47E-06	1.47E-06	1.52E-06	1.46E-06	1.46E-06
^{137}Cs	6.19E-05	6.19E-05	6.13E-05	6.17E-05	6.12E-05	6.15E-05	6.16E-05	6.17E-05	6.18E-05	6.16E-05	6.07E-05	6.19E-05	6.16E-05	6.30E-05
^{144}Ce	1.25E-07	1.25E-07	1.25E-07	1.24E-07	1.24E-07	1.24E-07	1.24E-07	1.25E-07	1.25E-07	1.25E-07	1.25E-07	1.24E-07	1.24E-07	1.24E-07
^{143}Nd	3.88E-05	3.84E-05	3.85E-05	3.83E-05	3.85E-05	3.85E-05	3.88E-05	3.87E-05	3.84E-05	3.89E-05	3.87E-05	3.87E-05	3.84E-05	3.84E-05

Table 3.14(1). All results for Case 12b (70% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.50E-05	3.49E-05	3.48E-05	3.45E-05	3.46E-05	3.44E-05	3.45E-05	3.52E-05	3.46E-05	3.45E-05	3.52E-05	3.50E-05	3.45E-05	3.46E-05
^{148}Nd	1.97E-05	1.98E-05	1.97E-05	1.99E-05	1.96E-05	1.98E-05	1.99E-05	1.97E-05	1.99E-05	1.99E-05	2.01E-05	1.98E-05	1.99E-05	1.99E-05
^{147}Sm	1.06E-05	1.03E-05	1.06E-05	1.04E-05	1.07E-05	1.05E-05	1.05E-05	1.05E-05	1.06E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.04E-05
^{149}Sm	9.68E-08	9.55E-08	1.05E-07	9.90E-08	1.06E-07	1.05E-07	1.08E-07	1.11E-07	1.02E-07	9.89E-08	1.03E-07	9.86E-08	9.86E-08	1.07E-07
^{150}Sm	1.48E-05	1.38E-05	1.49E-05	1.51E-05	1.35E-05	1.48E-05	1.49E-05	1.58E-05	1.48E-05	1.41E-05	1.48E-05	1.43E-05	1.50E-05	1.50E-05
^{151}Sm	4.34E-07	4.81E-07	4.43E-07	4.40E-07	5.22E-07	4.51E-07	4.63E-07	5.16E-07	4.38E-07	4.52E-07	4.78E-07	4.39E-07	4.46E-07	4.60E-07
^{152}Sm	4.73E-06	6.53E-06	4.70E-06	4.75E-06	5.22E-06	4.79E-06	4.77E-06	4.73E-06	4.86E-06	4.72E-06	4.89E-06	4.67E-06	4.86E-06	4.78E-06
^{153}Eu	6.02E-06	5.82E-06	5.98E-06	6.08E-06	6.44E-06	6.02E-06	6.06E-06	6.23E-06	6.03E-06	5.98E-06	6.10E-06	6.00E-06	6.05E-06	6.04E-06
^{154}Eu	8.95E-07	8.28E-07	8.98E-07	9.13E-07	9.34E-07	9.15E-07	9.22E-07	9.03E-07	8.99E-07	8.87E-07	7.67E-07	8.85E-07	9.09E-07	9.20E-07
^{155}Eu	2.11E-07	2.02E-07	2.08E-07	2.21E-07	2.22E-07	2.14E-07	2.15E-07	1.53E-07	2.15E-07	2.11E-07	2.14E-07	2.16E-07	2.15E-07	2.13E-07
^{155}Gd	2.57E-07	2.46E-07	2.54E-07	2.63E-07	2.70E-07	2.57E-07	2.58E-07	1.90E-07	2.55E-07	2.54E-07	2.60E-07	2.49E-07	2.57E-07	2.56E-07
^{156}Gd	9.60E-05	9.70E-05	9.60E-05	9.80E-05	9.74E-05	9.79E-05	9.78E-05	9.78E-05	9.76E-05	9.68E-05	9.77E-05	9.61E-05	9.75E-05	9.67E-05
^{157}Gd	3.91E-08	3.27E-08	3.88E-08	2.66E-08	3.27E-08	2.71E-08	2.85E-08	2.79E-08	2.66E-08	3.21E-08	3.12E-08	3.84E-08	2.78E-08	3.25E-08
^{158}Gd	1.15E-04	1.15E-04	1.15E-04	1.14E-04	1.15E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	1.15E-04	1.14E-04	1.15E-04	1.14E-04	1.15E-04

Table 3.14(2). All results for Case 12b (70% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b
^{234}U	3.17E-06	3.55E-06	3.51E-06	3.51E-06	3.49E-06	3.46E-06	3.48E-06	3.65E-06	3.54E-06	3.68E-06	3.49E-06	3.49E-06	3.50E-06	3.42E-06
^{235}U	1.45E-04	1.45E-04	1.44E-04	1.44E-04	1.51E-04	1.46E-04	1.59E-04	1.42E-04	1.45E-04	1.47E-04	1.50E-04	1.51E-04	1.42E-04	1.47E-04
^{236}U	1.24E-04	1.25E-04	1.25E-04	1.24E-04	1.20E-04	1.25E-04	1.15E-04	1.25E-04	1.24E-04	1.23E-04	1.25E-04	1.20E-04	1.25E-04	1.19E-04
^{238}U	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.06E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02
^{237}Np	1.36E-05	1.42E-05	1.44E-05	1.48E-05	1.41E-05	1.42E-05	1.72E-05	1.44E-05	1.43E-05	1.40E-05	1.41E-05	1.41E-05	1.44E-05	1.43E-05
^{238}Pu	7.12E-06	7.18E-06	7.38E-06	7.61E-06	7.45E-06	7.52E-06	8.94E-06	7.18E-06	7.19E-06	8.27E-06	7.48E-06	7.43E-06	7.33E-06	7.56E-06
^{239}Pu	1.21E-04	1.27E-04	1.23E-04	1.23E-04	1.23E-04	1.19E-04	1.42E-04	1.21E-04	1.24E-04	1.23E-04	1.23E-04	1.23E-04	1.24E-04	1.23E-04
^{240}Pu	6.61E-05	7.02E-05	6.85E-05	6.93E-05	6.59E-05	6.39E-05	6.48E-05	6.52E-05	6.81E-05	6.72E-05	6.56E-05	6.61E-05	6.81E-05	6.92E-05
^{241}Pu	2.64E-05	2.72E-05	2.70E-05	2.69E-05	2.72E-05	2.71E-05	3.18E-05	2.69E-05	2.67E-05	2.68E-05	2.75E-05	2.71E-05	2.68E-05	2.69E-05
^{242}Pu	1.80E-05	1.91E-05	1.95E-05	2.00E-05	1.87E-05	1.86E-05	2.03E-05	1.95E-05	1.90E-05	1.94E-05	1.86E-05	1.87E-05	1.93E-05	1.90E-05
^{241}Am	8.79E-06	9.12E-06	9.02E-06	8.77E-06	8.97E-06	8.92E-06	1.06E-05	8.95E-06	8.86E-06	8.72E-06	9.13E-06	8.94E-06	8.93E-06	8.83E-06
^{243}Am	4.83E-06	5.21E-06	5.30E-06	4.97E-06	4.36E-06	4.83E-06	4.95E-06	4.90E-06	5.14E-06	4.68E-06	4.79E-06	4.35E-06	5.30E-06	4.76E-06
^{244}Cm	1.86E-06	1.97E-06	2.04E-06	1.91E-06	1.76E-06	2.01E-06	1.79E-06	1.89E-06	1.97E-06	2.03E-06	1.98E-06	1.75E-06	2.06E-06	1.82E-06
^{90}Sr	3.88E-05	3.91E-05	3.99E-05	3.89E-05	3.90E-05	3.90E-05	3.85E-05	-	3.88E-05	3.87E-05	3.87E-05	3.90E-05	3.93E-05	3.92E-05
^{95}Mo	6.07E-05	6.10E-05	6.13E-05	6.18E-05	6.13E-05	6.05E-05	6.05E-05	6.06E-05	6.06E-05	6.09E-05	6.05E-05	6.13E-05	6.10E-05	6.19E-05
^{99}Tc	6.12E-05	6.22E-05	6.11E-05	6.13E-05	6.06E-05	5.95E-05	6.20E-05	5.99E-05	6.03E-05	6.10E-05	5.96E-05	6.06E-05	6.08E-05	6.23E-05
^{101}Ru	6.01E-05	6.07E-05	6.10E-05	6.17E-05	6.10E-05	6.04E-05	6.06E-05	6.01E-05	5.95E-05	6.00E-05	6.05E-05	6.11E-05	6.08E-05	6.16E-05
^{103}Rh	3.27E-05	3.34E-05	3.32E-05	3.28E-05	3.22E-05	3.28E-05	3.40E-05	3.24E-05	3.25E-05	3.27E-05	3.30E-05	3.23E-05	3.29E-05	3.22E-05
^{109}Ag	5.91E-06	5.90E-06	4.18E-06	6.03E-06	5.48E-06	5.68E-06	5.58E-06	5.72E-06	5.89E-06	5.92E-06	5.72E-06	5.48E-06	4.34E-06	5.73E-06
^{129}I	9.74E-06	9.59E-06	9.81E-06	1.08E-05	9.22E-06	7.94E-06	9.63E-06	9.49E-06	1.16E-05	1.16E-05	7.97E-06	9.22E-06	9.87E-06	1.14E-05
^{131}Xe	2.23E-05	2.36E-05	2.35E-05	2.34E-05	2.21E-05	2.06E-05	2.25E-05	2.33E-05	2.33E-05	2.29E-05	2.07E-05	2.21E-05	2.34E-05	2.38E-05
^{133}Cs	6.55E-05	6.47E-05	6.44E-05	6.34E-05	6.16E-05	6.37E-05	6.37E-05	6.44E-05	6.38E-05	6.34E-05	6.38E-05	6.16E-05	6.44E-05	6.31E-05
^{134}Cs	1.29E-06	1.44E-06	1.46E-06	1.46E-06	1.59E-06	1.50E-06	1.69E-06	1.39E-06	1.43E-06	1.47E-06	1.48E-06	1.58E-06	1.47E-06	1.47E-06
^{137}Cs	6.11E-05	6.13E-05	6.31E-05	6.20E-05	6.10E-05	6.14E-05	6.17E-05	6.13E-05	6.02E-05	6.02E-05	6.14E-05	6.10E-05	6.17E-05	6.15E-05
^{144}Ce	1.24E-07	1.24E-07	1.25E-07	1.25E-07	1.23E-07	1.24E-07	1.24E-07	1.25E-07	1.22E-07	1.22E-07	1.25E-07	1.24E-07	1.26E-07	1.25E-07
^{143}Nd	3.86E-05	3.87E-05	3.84E-05	3.82E-05	3.91E-05	3.87E-05	4.02E-05	3.83E-05	3.84E-05	3.85E-05	3.90E-05	3.91E-05	3.82E-05	3.90E-05

Table 3.14(2). All results for Case 12b (70% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.47E-05	3.45E-05	3.46E-05	3.54E-05	3.53E-05	3.51E-05	3.46E-05	3.41E-05	3.43E-05	3.47E-05	3.52E-05	3.53E-05	3.44E-05	3.52E-05
^{148}Nd	1.97E-05	1.99E-05	1.99E-05	2.01E-05	2.01E-05	1.98E-05	1.98E-05	1.98E-05	2.00E-05	1.99E-05	1.98E-05	2.01E-05	1.99E-05	2.01E-05
^{147}Sm	1.05E-05	1.06E-05	1.04E-05	1.05E-05	9.67E-06	9.55E-06	9.30E-06	9.96E-06	1.06E-05	1.06E-05	9.62E-06	9.68E-06	1.04E-05	1.06E-05
^{149}Sm	1.11E-07	1.06E-07	1.07E-07	1.08E-07	1.18E-07	1.17E-07	1.27E-07	1.04E-07	1.00E-07	9.99E-08	1.17E-07	1.17E-07	1.06E-07	1.12E-07
^{150}Sm	1.46E-05	1.49E-05	1.50E-05	1.55E-05	1.46E-05	1.45E-05	1.45E-05	1.47E-05	1.43E-05	1.44E-05	1.45E-05	1.46E-05	1.50E-05	1.55E-05
^{151}Sm	5.01E-07	4.54E-07	4.65E-07	4.80E-07	5.72E-07	5.60E-07	5.92E-07	4.50E-07	4.55E-07	4.47E-07	5.67E-07	5.68E-07	4.51E-07	4.80E-07
^{152}Sm	5.27E-06	4.81E-06	4.79E-06	4.96E-06	5.96E-06	5.89E-06	5.92E-06	4.88E-06	4.85E-06	4.80E-06	5.92E-06	5.97E-06	4.78E-06	4.95E-06
^{153}Eu	6.23E-06	6.05E-06	6.05E-06	6.15E-06	6.53E-06	6.32E-06	6.49E-06	5.67E-06	6.14E-06	6.11E-06	6.32E-06	6.53E-06	6.02E-06	6.30E-06
^{154}Eu	9.19E-07	9.15E-07	9.06E-07	7.87E-07	9.25E-07	9.36E-07	8.86E-07	8.44E-07	9.14E-07	9.12E-07	9.40E-07	9.22E-07	9.13E-07	1.54E-06
^{155}Eu	1.54E-07	2.15E-07	2.14E-07	2.18E-07	1.62E-07	1.60E-07	2.42E-07	1.97E-07	2.23E-07	2.23E-07	1.54E-07	1.62E-07	2.15E-07	2.26E-07
^{155}Gd	2.31E-08	2.54E-07	2.57E-07	2.63E-07	1.92E-07	1.88E-07	3.00E-07	2.38E-07	2.52E-07	2.56E-07	1.96E-07	1.93E-07	2.57E-07	2.59E-07
^{156}Gd	9.07E-05	9.74E-05	9.68E-05	9.77E-05	9.87E-05	9.80E-05	9.69E-05	9.75E-05	9.68E-05	9.62E-05	9.81E-05	9.89E-05	9.67E-05	9.69E-05
^{157}Gd	2.64E-08	2.81E-08	3.26E-08	3.05E-08	2.82E-08	2.84E-08	3.85E-08	2.79E-08	3.12E-08	3.96E-08	2.86E-08	2.78E-08	3.11E-08	3.09E-08
^{158}Gd	1.09E-04	1.14E-04	1.15E-04	1.14E-04	1.14E-04	1.15E-04	1.15E-04	1.15E-04	1.15E-04	1.15E-04	1.15E-04	1.14E-04	1.15E-04	1.14E-04

Table 3.14(3). All results for Case 12b (70% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants

	c	d	e	f	g	h	i	Average	2*σ	$2*σ^{(r)}$
^{234}U	3.56E-06	3.56E-06	3.48E-06	3.53E-06	3.03E-06	3.71E-06	3.54E-06	3.53E-06	2.86E-07	8.10E-02
^{235}U	1.46E-04	1.45E-04	1.38E-04	1.45E-04	1.40E-04	1.43E-04	1.47E-04	1.45E-04	8.64E-06	5.98E-02
^{236}U	1.24E-04	1.25E-04	1.24E-04	1.25E-04	1.24E-04	1.23E-04	1.19E-04	1.24E-04	4.44E-06	3.59E-02
^{238}U	2.06E-02	2.07E-02	2.06E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	2.07E-02	1.85E-05	8.95E-04
^{237}Np	1.46E-05	1.43E-05	1.47E-05	1.39E-05	1.44E-05	1.38E-05	1.35E-05	1.42E-05	1.27E-06	8.90E-02
^{238}Pu	7.38E-06	7.27E-06	7.91E-06	6.60E-06	7.21E-06	8.18E-06	7.05E-06	7.53E-06	1.02E-06	1.36E-01
^{239}Pu	1.30E-04	1.28E-04	1.25E-04	1.25E-04	1.23E-04	1.21E-04	1.24E-04	1.24E-04	8.80E-06	7.11E-02
^{240}Pu	7.03E-05	7.06E-05	6.95E-05	6.91E-05	6.84E-05	6.66E-05	6.71E-05	6.80E-05	3.86E-06	5.68E-02
^{241}Pu	2.80E-05	2.75E-05	2.69E-05	2.69E-05	2.65E-05	2.64E-05	2.73E-05	2.70E-05	1.87E-06	6.92E-02
^{242}Pu	1.93E-05	1.92E-05	2.01E-05	1.90E-05	1.93E-05	1.96E-05	1.91E-05	1.94E-05	1.05E-06	5.41E-02
^{241}Am	9.37E-06	9.19E-06	8.78E-06	8.99E-06	8.68E-06	8.65E-06	9.12E-06	8.95E-06	6.97E-07	7.78E-02
^{243}Am	5.33E-06	5.27E-06	5.08E-06	4.95E-06	4.55E-06	4.63E-06	4.64E-06	4.95E-06	5.91E-07	1.19E-01
^{244}Cm	2.05E-06	2.02E-06	1.99E-06	1.95E-06	1.78E-06	1.99E-06	1.81E-06	1.97E-06	1.97E-07	1.00E-01
^{90}Sr	3.91E-05	3.92E-05	3.87E-05	3.91E-05	3.90E-05	3.91E-05	3.98E-05	3.91E-05	7.21E-07	1.84E-02
^{95}Mo	6.10E-05	6.11E-05	6.20E-05	6.08E-05	6.07E-05	6.12E-05	6.10E-05	6.11E-05	7.79E-07	1.28E-02
^{99}Tc	6.16E-05	6.18E-05	6.21E-05	6.15E-05	5.96E-05	6.19E-05	6.21E-05	6.15E-05	1.95E-06	3.17E-02
^{101}Ru	6.09E-05	6.09E-05	6.22E-05	6.04E-05	6.01E-05	6.07E-05	5.97E-05	6.08E-05	1.12E-06	1.85E-02
^{103}Rh	3.37E-05	3.35E-05	3.32E-05	3.22E-05	3.12E-05	3.31E-05	3.21E-05	3.29E-05	1.10E-06	3.33E-02
^{109}Ag	5.98E-06	5.94E-06	6.44E-06	4.20E-06	5.33E-06	5.79E-06	6.57E-06	5.57E-06	1.39E-06	2.49E-01
^{129}I	9.81E-06	9.79E-06	1.08E-05	8.90E-06	9.14E-06	9.22E-06	1.06E-05	9.73E-06	1.64E-06	1.68E-01
^{131}Xe	2.37E-05	2.36E-05	2.33E-05	2.17E-05	2.34E-05	2.30E-05	2.32E-05	2.30E-05	1.67E-06	7.26E-02
^{133}Cs	6.46E-05	6.48E-05	6.41E-05	6.44E-05	6.34E-05	6.41E-05	6.47E-05	6.42E-05	1.75E-06	2.73E-02
^{134}Cs	1.47E-06	1.44E-06	1.50E-06	1.43E-06	1.43E-06	1.46E-06	1.38E-06	1.46E-06	1.35E-07	9.23E-02
^{137}Cs	6.18E-05	6.18E-05	6.22E-05	6.15E-05	6.16E-05	6.14E-05	6.25E-05	6.16E-05	1.20E-06	1.95E-02
^{144}Ce	1.25E-07	1.25E-07	1.26E-07	1.24E-07	1.24E-07	1.25E-07	1.25E-07	1.24E-07	1.84E-09	1.48E-02
^{143}Nd	3.90E-05	3.88E-05	3.81E-05	3.87E-05	3.80E-05	3.85E-05	3.87E-05	3.86E-05	7.84E-07	2.03E-02

Table 3.14(3). All results for Case 12b (70% void, 50 GWd/tHM, 5-year cooling) actinides and fission products [$10^{24}/cm^3$] reported by participants (continued)

^{145}Nd	3.45E-05	3.46E-05	3.55E-05	3.42E-05	3.38E-05	3.49E-05	3.54E-05	3.48E-05	8.25E-07	2.37E-02
^{148}Nd	1.99E-05	1.99E-05	2.03E-05	1.99E-05	1.99E-05	1.97E-05	1.99E-05	1.99E-05	2.87E-07	1.44E-02
^{147}Sm	1.05E-05	1.06E-05	1.05E-05	1.05E-05	8.27E-06	1.07E-05	1.06E-05	1.03E-05	1.00E-06	9.75E-02
^{149}Sm	1.04E-07	1.03E-07	9.52E-08	1.07E-07	8.92E-08	1.04E-07	1.07E-07	1.06E-07	1.51E-08	1.43E-01
^{150}Sm	1.51E-05	1.51E-05	1.42E-05	1.48E-05	1.40E-05	1.49E-05	1.50E-05	1.47E-05	9.41E-07	6.39E-02
^{151}Sm	4.65E-07	4.60E-07	4.46E-07	4.65E-07	4.25E-07	4.36E-07	4.66E-07	4.76E-07	9.02E-08	1.89E-01
^{152}Sm	4.89E-06	4.83E-06	4.83E-06	4.76E-06	4.70E-06	4.78E-06	5.10E-06	5.05E-06	9.64E-07	1.91E-01
^{153}Eu	6.10E-06	6.10E-06	6.08E-06	6.04E-06	5.51E-06	5.98E-06	6.01E-06	6.10E-06	4.24E-07	6.95E-02
^{154}Eu	9.33E-07	9.29E-07	9.14E-07	9.11E-07	8.30E-07	8.79E-07	7.82E-07	9.12E-07	2.36E-07	2.59E-01
^{155}Eu	2.22E-07	2.17E-07	2.14E-07	2.13E-07	1.97E-07	2.08E-07	2.09E-07	2.05E-07	4.69E-08	2.29E-01
^{155}Gd	2.66E-07	2.59E-07	2.58E-07	2.56E-07	2.42E-07	2.53E-07	2.52E-07	2.41E-07	9.09E-08	3.77E-01
^{156}Gd	9.78E-05	9.68E-05	9.77E-05	9.12E-05	9.66E-05	9.70E-05	9.57E-05	9.69E-05	3.32E-06	3.42E-02
^{157}Gd	2.89E-08	2.94E-08	2.80E-08	3.05E-08	3.00E-08	3.12E-08	3.54E-08	3.10E-08	7.75E-09	2.50E-01
^{158}Gd	1.14E-04	1.14E-04	1.14E-04	1.14E-04	1.15E-04	1.14E-04	1.16E-04	1.14E-04	2.01E-06	1.76E-02

Table 3.15. Two standard deviations (%) of all results

	Case1b	Case2a	Case2b	Case2c	Case3b	Case5b	Case5c	Case6b	Case8b	Case8c	Case9b	Case11b	Case11c	Case12b
	12G, 0%, 5yr	12G, 40%, 0yr	12G, 40%, 5yr	12G, 40%, 15yr	12G, 70%, 5yr	20G, 40%, 5yr	20G, 40%, 15yr	20G, 70%, 5yr	30G, 40%, 5yr	30G, 40%, 15yr	30G, 70%, 5yr	50G, 40%, 5yr	50G, 40%, 15yr	50G, 70%, 5yr
^{234}U	1.39	1.53	1.54	1.55	1.75	2.52	2.61	2.87	3.91	4.21	4.37	7.48	9.66	8.10
^{235}U	0.64	0.60	0.60	0.60	0.56	1.24	1.24	1.13	2.35	2.29	2.16	6.28	6.27	5.98
^{236}U	2.49	2.67	2.67	2.67	2.90	2.70	2.69	2.98	2.78	2.80	3.14	3.07	3.06	3.59
^{238}U	0.04	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.06	0.08	0.06	0.09	0.09	0.09
^{237}Np	7.98	7.81	7.67	7.62	9.27	6.75	6.77	8.71	6.67	6.72	8.76	6.77	6.85	8.90
^{238}Pu	9.27	8.91	9.21	9.21	11.05	9.63	9.64	11.10	10.81	10.80	11.72	13.95	13.95	13.56
^{239}Pu	4.34	3.93	3.92	3.93	3.95	4.65	4.65	4.64	5.15	5.13	5.35	6.07	6.07	7.11
^{240}Pu	4.07	4.02	4.02	4.02	4.35	4.20	4.20	4.46	4.58	4.60	4.81	5.14	5.17	5.68
^{241}Pu	3.71	3.22	3.22	3.32	4.15	3.91	4.02	5.48	4.63	4.71	6.14	5.17	5.23	6.92
^{242}Pu	7.51	7.29	7.29	7.29	7.60	5.88	5.88	6.50	5.35	5.35	6.19	4.71	4.71	5.41
^{241}Am	3.75	3.86	3.25	3.18	4.11	3.79	3.78	5.32	4.80	4.62	6.17	6.31	5.60	7.78
^{243}Am	15.99	15.33	15.41	15.41	15.05	14.24	14.25	13.82	13.37	13.38	12.99	12.09	12.08	11.93
^{244}Cm	16.33	16.23	16.11	16.12	16.69	13.89	13.90	14.18	12.28	12.28	12.36	10.35	10.36	10.04
^{90}Sr	1.62	1.57	1.58	1.71	1.59	1.64	1.77	1.63	1.66	1.80	1.71	1.72	1.88	1.84
^{95}Mo	1.44	1.52	1.38	3.77	1.36	1.27	1.27	1.22	1.18	1.18	1.16	1.16	1.17	1.28
^{99}Tc	3.46	3.35	3.45	3.43	3.35	3.31	3.31	3.25	3.04	3.07	3.00	2.96	3.03	3.17
^{101}Ru	1.75	1.68	1.68	1.68	1.66	1.74	1.74	1.70	1.74	1.75	1.72	1.78	1.79	1.85
^{103}Rh	2.65	2.63	2.60	2.60	2.60	2.60	2.60	2.58	2.71	2.72	2.74	3.32	3.33	3.33
^{109}Ag	31.47	31.52	31.50	31.50	31.42	30.87	30.87	30.46	29.30	29.31	28.65	25.82	25.83	24.94
^{129}I	21.02	19.29	20.45	20.45	19.97	19.62	19.62	19.19	18.58	18.58	18.23	16.98	16.99	16.81
^{131}Xe	1.72	1.76	1.80	1.80	1.93	2.46	2.46	2.75	3.48	3.50	4.06	6.03	6.03	7.26
^{133}Cs	2.07	1.96	1.99	1.99	2.00	2.07	2.07	2.02	2.11	2.12	2.13	2.52	2.52	2.73
^{134}Cs	8.42	8.85	8.85	8.91	9.84	8.99	9.02	9.78	8.85	8.85	9.62	8.34	8.28	9.23

Table 3.15. Two standard deviations (%) of all results (continued)

^{137}Cs	2.01	1.98	1.99	2.00	1.97	1.99	2.01	1.96	1.96	1.99	1.96	1.89	1.92	1.95
^{144}Ce	2.96	1.49	2.89	4.46	2.81	2.97	4.32	2.87	2.83	4.15	2.76	1.51	2.92	1.48
^{143}Nd	1.25	1.16	1.23	1.23	1.21	1.08	1.08	1.06	1.05	1.04	1.05	2.17	2.17	2.03
^{145}Nd	1.25	1.21	1.22	1.22	1.24	1.22	1.22	1.25	1.40	1.39	1.48	2.29	2.37	2.37
^{148}Nd	1.58	1.55	1.55	1.55	1.59	1.55	1.55	1.54	1.50	1.51	1.49	1.42	1.42	1.44
^{147}Sm	3.08	2.43	3.36	3.24	3.68	4.58	4.65	5.14	6.26	6.40	6.98	8.84	9.07	9.75
^{149}Sm	6.13	7.45	6.69	6.68	7.65	9.88	9.88	10.74	11.70	11.69	12.78	12.70	13.25	14.32
^{150}Sm	2.26	2.30	2.30	2.30	2.51	3.09	3.09	3.39	4.14	4.15	4.42	6.10	6.13	6.39
^{151}Sm	7.22	7.52	7.40	7.39	7.33	10.32	10.31	10.94	13.18	13.15	14.75	15.96	15.99	18.95
^{152}Sm	3.57	4.38	4.38	4.38	5.52	6.36	6.36	8.34	9.58	9.56	12.38	15.02	15.02	19.09
^{153}Eu	4.55	5.20	5.16	5.16	6.01	4.65	4.65	5.22	4.56	4.56	4.81	6.72	6.74	6.95
^{154}Eu	11.51	10.86	10.87	10.90	10.32	15.00	15.04	13.70	20.40	20.45	17.83	31.05	31.11	25.90
^{155}Eu	19.89	21.18	21.06	21.80	23.44	21.99	22.04	23.33	22.82	22.57	23.80	21.70	21.48	22.89
^{155}Gd	47.84	36.56	35.31	34.46	24.77	26.33	30.63	25.37	33.10	35.96	32.26	37.97	38.99	37.70
^{156}Gd	0.48	0.56	0.57	0.57	0.66	0.54	0.54	0.65	1.02	3.37	1.20	3.22	3.22	3.42
^{157}Gd	17.36	26.45	26.25	26.25	41.22	14.39	14.39	18.36	16.63	17.57	19.75	28.24	28.23	24.99
^{158}Gd	1.87	1.75	1.75	1.75	1.63	1.73	1.73	1.60	1.73	3.80	1.60	1.91	1.91	1.76

Figure 3.1. 2-sigma(r) (%) of nuclide density (all results)

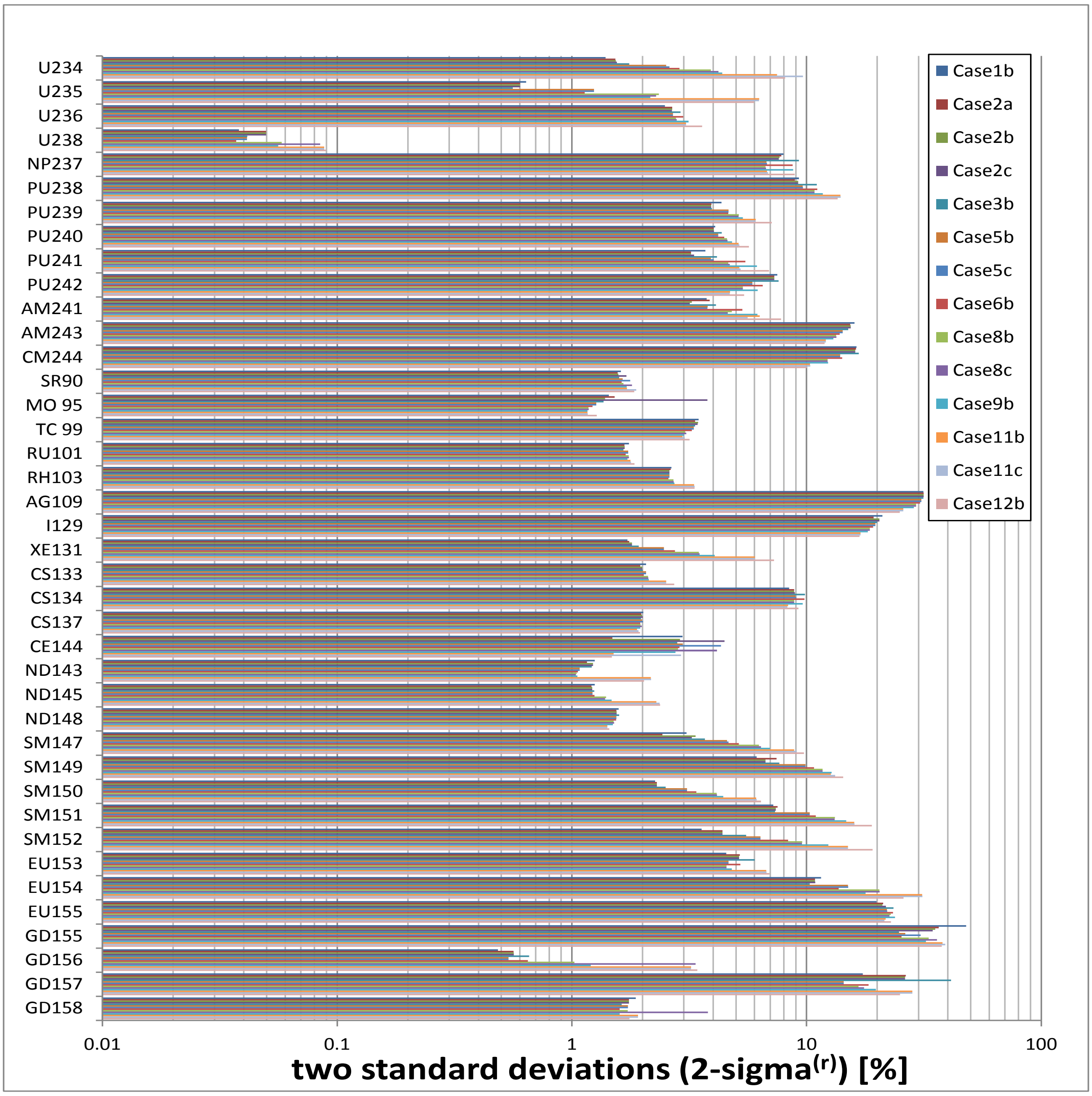


Figure 3.2. 2-sigma(r) (%) of nuclide density (all results) void fraction 40%, 15-year cooling for 12 20, 30 and 50 GWd/t

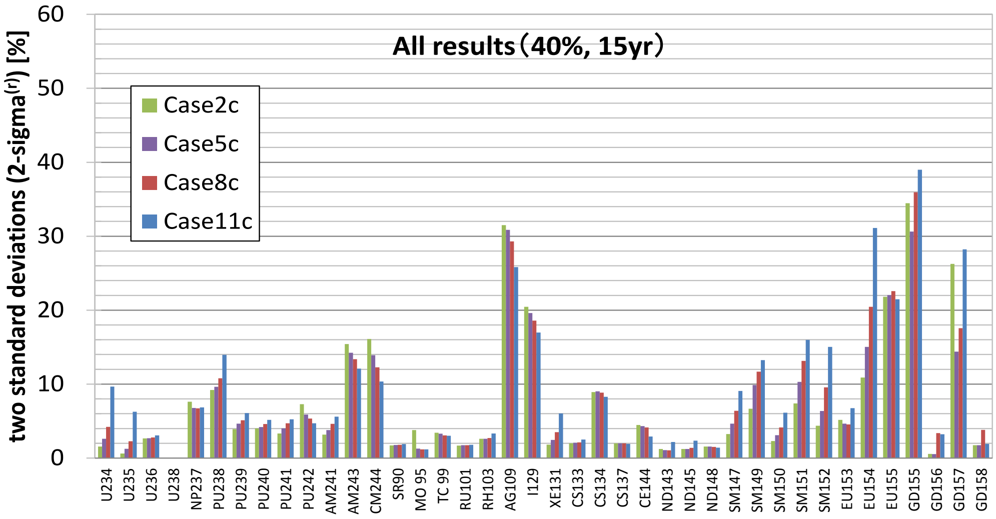


Figure 3.3. 2-sigma(r) (%) of nuclide density (all results) 12 GWd/t, 5-year cooling for void fraction 0, 40 and 70%

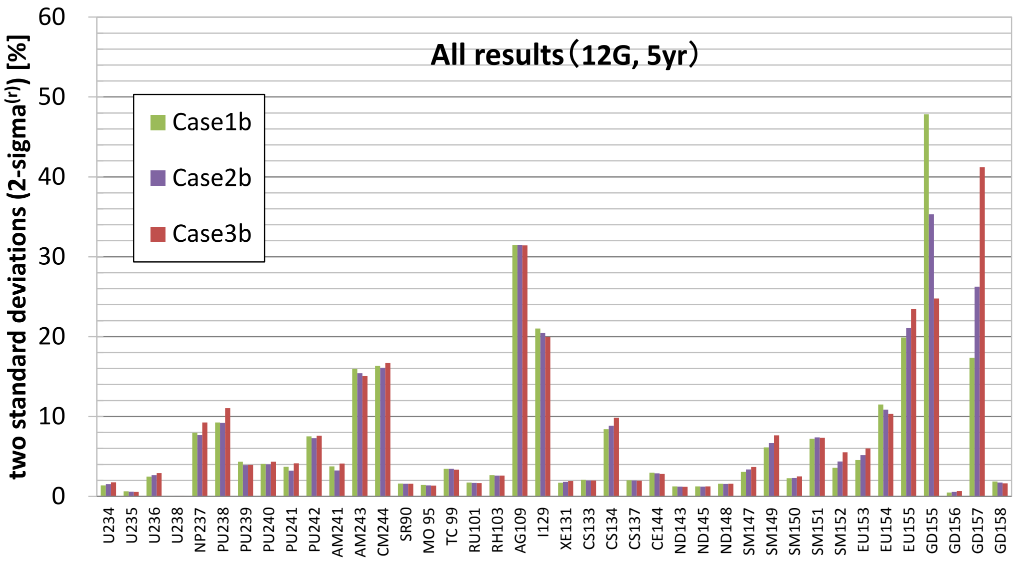


Figure 3.4. 2-sigma(r) (%) of nuclide density (all results) 12 GWd/t, void fraction 40% for 0, 5 and 15-year cooling

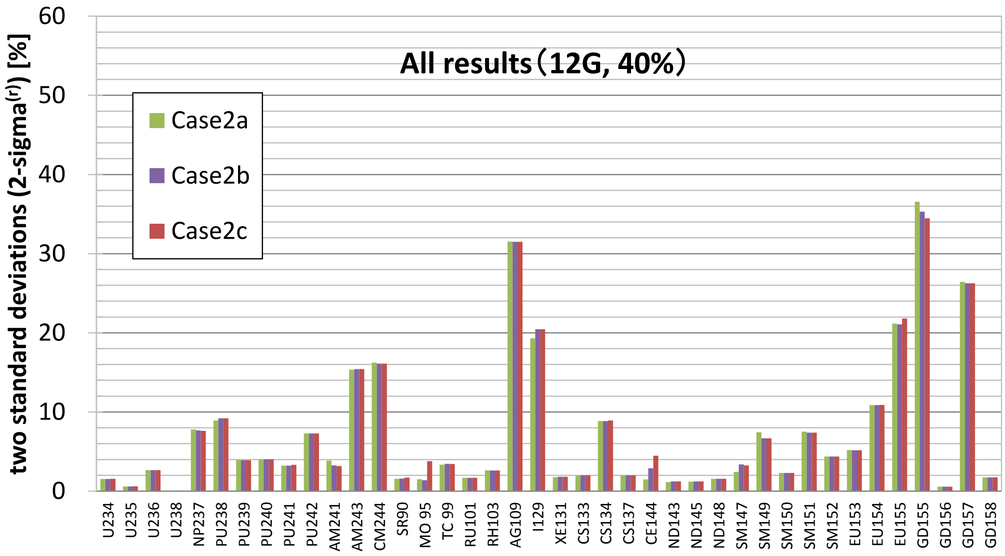
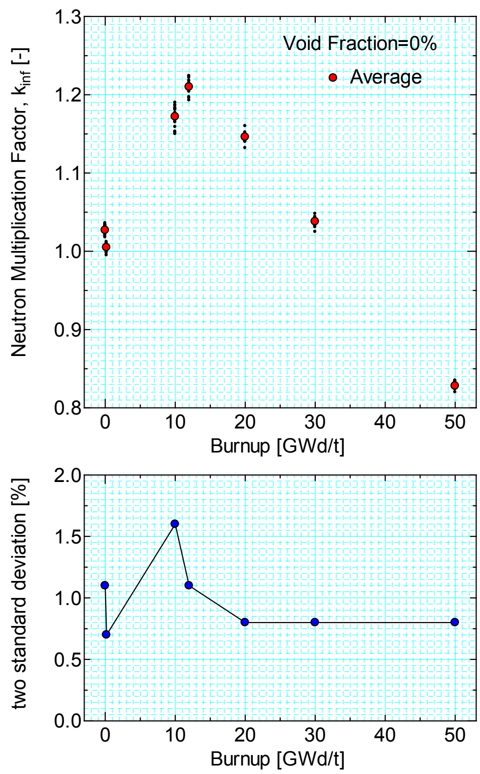
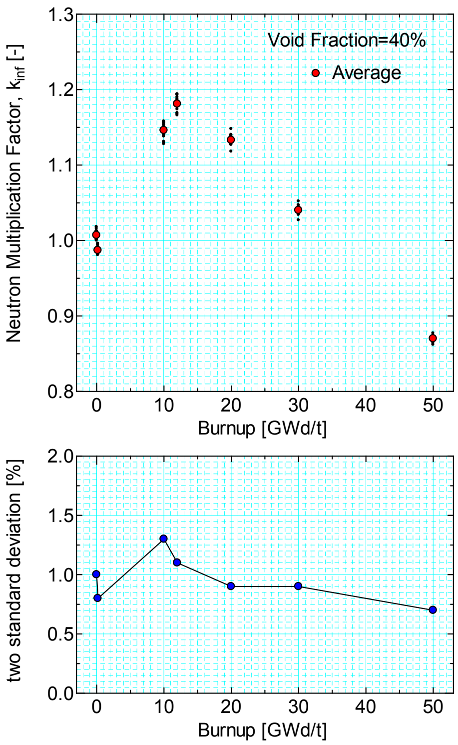


Figure 3.5. k_{inf} at each burn-up for void fraction 0%



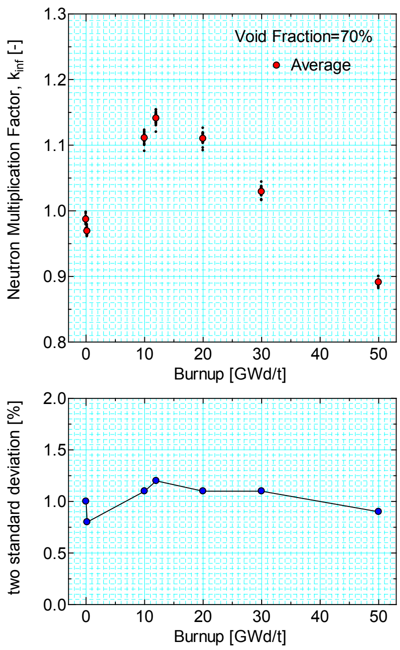
Black circles are k_{inf} of each participant.

Figure 3.6. k_{inf} at each burn-up for void fraction 40%



Black circles are k_{inf} of each participant.

Figure 3.7. k_{inf} at each burn-up for void fraction 70%



Black circles are k_{inf} of each participant.

Table 3.16. k_{inf} for the case of void fraction 0%

	Burn-up [GWd/t]						
ID	0	0.2	10	12	20	30	50
A	1.033	1.009	1.174	1.212	1.152	1.044	0.834
B	1.034	1.011	1.186	1.224	1.160	1.048	0.829
C	1.033	1.009	1.170	1.207	1.146	1.037	0.827
D	1.030	1.006	1.182	1.222	1.151	1.040	0.824
E	1.030	1.007	1.172	1.208	1.145	1.038	0.832
F	1.030	1.006	1.187	1.224	1.151	1.040	0.827
G	1.025	1.002	1.169	1.209	1.142	1.033	0.828
H	1.018	0.995	1.150	1.193	1.141	1.036	0.833
I	1.026	1.003	1.165	1.208	1.150	1.042	0.827
J	1.024	1.002	1.183	1.218	1.147	1.039	0.828
K	1.020	0.998	1.181	1.214	1.143	1.035	0.824
L	1.028	1.006	1.181	1.213	1.148	1.038	0.825
M	1.027	1.004	1.159	1.204	1.148	1.039	0.830
N	1.028	1.005	1.166	1.206	1.145	1.039	0.835
O	1.006	1.004	1.152	1.197	1.150	1.043	0.831
P	1.028	1.004	1.177	1.215	1.147	1.038	0.830
Q	1.027	1.004	1.169	1.208	1.146	1.037	0.829
R	1.026	1.003	1.168	1.207	1.144	1.035	0.826
S	1.028	1.005	1.172	1.209	1.146	1.040	0.832
T	1.025	1.002	1.172	1.208	1.143	1.036	0.826
U	1.029	1.006	1.190	1.212	1.132	1.025	0.828
V	1.025	1.001	1.183	1.218	1.147	1.038	0.831
W	1.028	1.006	1.175	1.214	1.147	1.040	0.830
X	1.031	1.007	1.170	1.208	1.146	1.040	0.829
Y	1.022	0.999	1.169	1.205	1.141	1.036	0.828
Z	1.028	1.005	1.172	1.209	1.146	1.040	0.831
a	1.029	1.006	1.169	1.209	1.146	1.035	0.824
b	1.031	1.009	1.169	1.208	1.147	1.039	0.829
c	1.023	1.000	1.169	1.207	1.140	1.032	0.825
d	1.026	1.002	1.168	1.207	1.140	1.032	0.826
e	1.029	1.004	1.153	1.196	1.143	1.031	0.820
f	1.023	1.000	1.175	1.210	1.141	1.034	0.830
g	1.036	1.012	1.171	1.210	-	-	-
h	1.031	1.007	1.179	1.215	1.150	1.041	0.830
i	1.033	1.010	1.173	1.211	1.147	1.039	0.832
Average	1.027	1.005	1.172	1.210	1.146	1.038	0.828
2-sigma[r] [%]]	1.1	0.7	1.6	1.1	0.8	0.8	0.8

Table 3.17. k_{inf} for the case of void fraction 40%

	Burn-up [GWd/t]						
ID	0	0.2	10	12	20	30	50
A	1.012	0.991	1.149	1.184	1.140	1.047	0.877
B	1.018	0.996	1.158	1.194	1.148	1.052	0.874
C	1.012	0.991	1.145	1.179	1.133	1.040	0.869
D	1.012	0.991	1.156	1.194	1.140	1.044	0.868
E	1.010	0.989	1.145	1.178	1.132	1.040	0.872
F	1.010	0.989	1.157	1.193	1.138	1.043	0.871
G	1.006	0.985	1.142	1.179	1.129	1.036	0.869
H	1.002	0.981	1.128	1.166	1.129	1.038	0.872
I	1.009	0.988	1.141	1.180	1.139	1.045	0.871
J	1.004	0.984	1.155	1.188	1.134	1.040	0.868
K	1.000	0.981	1.153	1.185	1.130	1.036	0.864
L	1.011	0.988	1.153	1.185	1.134	1.041	0.868
M	1.001	0.988	1.138	1.177	1.136	1.043	0.872
N	1.008	0.987	1.142	1.178	1.131	1.040	0.872
O	0.990	0.989	1.130	1.168	1.137	1.044	0.871
P	1.008	0.987	1.150	1.186	1.134	1.041	0.871
Q	1.007	0.986	1.144	1.179	1.132	1.039	0.869
R	1.005	0.984	1.143	1.178	1.131	1.037	0.866
S	1.009	0.988	1.144	1.178	1.132	1.041	0.872
T	1.006	0.985	1.144	1.178	1.129	1.037	0.866
U	1.008	0.989	1.157	1.181	1.118	1.027	0.871
V	1.004	0.983	1.156	1.190	1.135	1.040	0.871
W	1.008	0.987	1.149	1.184	1.134	1.041	0.870
X	1.011	0.989	1.146	1.180	1.134	1.041	0.870
Y	1.002	0.981	1.140	1.174	1.127	1.036	0.868
Z	1.009	0.988	1.144	1.178	1.132	1.040	0.871
a	1.008	0.988	1.145	1.181	1.132	1.037	0.865
b	1.012	0.991	1.146	1.181	1.134	1.041	0.870
c	1.003	0.982	1.142	1.178	1.127	1.034	0.867
d	1.005	0.983	1.143	1.178	1.128	1.035	0.867
e	1.008	0.986	1.131	1.169	1.130	1.035	0.862
f	1.003	0.982	1.145	1.180	1.128	1.036	0.870
g	1.016	0.994	1.144	1.180	1.134	1.041	0.873
h	1.014	0.992	1.150	1.184	1.137	1.043	0.871
i	1.013	0.991	1.147	1.182	1.135	1.041	0.872
Average	1.007	0.987	1.146	1.181	1.133	1.040	0.870
2-sigma[(r)] [%]	1.0	0.8	1.3	1.1	0.9	0.9	0.7

Table 3.18. k_{inf} for the case of void fraction 70%

	Burn-up [GWd/t]						
ID	0	0.2	10	12	20	30	50
A	0.990	0.971	1.116	1.146	1.117	1.037	0.900
B	0.998	0.979	1.123	1.154	1.126	1.044	0.900
C	0.990	0.970	1.111	1.141	1.111	1.030	0.891
D	0.992	0.973	1.120	1.154	1.118	1.035	0.893
E	0.988	0.968	1.091	1.120	1.096	1.017	0.882
F	0.988	0.969	1.116	1.149	1.113	1.033	0.895
G	0.986	0.967	1.107	1.138	1.106	1.026	0.890
H	0.987	0.968	1.102	1.134	1.112	1.031	0.892
I	0.992	0.973	1.112	1.144	1.119	1.037	0.894
J	0.984	0.966	1.118	1.148	1.110	1.029	0.889
K	0.979	0.961	1.115	1.144	1.106	1.024	0.884
L	0.986	0.968	1.116	1.145	1.112	1.030	0.890
M	0.991	0.972	1.110	1.143	1.117	1.035	0.894
N	0.986	0.968	1.108	1.140	1.108	1.029	0.891
O	0.973	0.972	1.101	1.134	1.115	1.034	0.893
P	0.987	0.968	1.115	1.147	1.112	1.031	0.890
Q	0.986	0.967	1.110	1.141	1.109	1.028	0.889
R	0.984	0.965	1.109	1.139	1.107	1.026	0.886
S	0.989	0.970	1.110	1.139	1.109	1.029	0.891
T	0.986	0.967	1.110	1.140	1.107	1.026	0.886
U	0.985	0.970	1.105	1.130	1.092	1.016	0.892
V	0.982	0.964	1.121	1.151	1.112	1.030	0.891
W	0.986	0.968	1.114	1.146	1.110	1.029	0.889
X	0.988	0.970	1.112	1.141	1.110	1.030	0.891
Y	0.981	0.963	1.105	1.135	1.104	1.024	0.888
Z	0.989	0.970	1.110	1.139	1.109	1.029	0.891
a	0.987	0.968	1.111	1.142	1.109	1.027	0.886
b	0.990	0.972	1.113	1.143	1.111	1.030	0.891
c	0.982	0.963	1.106	1.137	1.103	1.023	0.888
d	0.984	0.964	1.108	1.140	1.105	1.024	0.888
e	0.986	0.967	1.100	1.132	1.107	1.025	0.884
f	0.981	0.962	1.109	1.140	1.106	1.026	0.890
g	0.996	0.976	1.109	1.140	1.112	1.032	0.895
h	0.994	0.975	1.116	1.146	1.115	1.034	0.893
i	0.990	0.972	1.113	1.144	1.112	1.031	0.894
Average	0.987	0.969	1.111	1.141	1.110	1.029	0.891
2-sigma[(r)][%]	1.0	0.8	1.1	1.2	1.1	1.1	0.9

Table 3.19. Peak k_{inf} and corresponding burn-up

Void Fraction[%]	0%		40%		70%	
Results ID	Burn-up[GWd/t]	k_{inf}	Burn-up[GWd/t]	k_{inf}	Burn-up[GWd/t]	k_{inf}
A	13.0	1.216	13.5	1.191	14.0	1.157
B	13.0	1.227	13.5	1.201	14.0	1.166
C	13.0	1.212	13.5	1.187	14.0	1.152
D	12.5	1.224	13.0	1.199	13.5	1.164
E	13.0	1.212	13.5	1.185	14.5	1.133
F	12.5	1.225	13.1	1.197	13.8	1.158
G	12.7	1.212	13.4	1.185	14.2	1.149
H	13.0	1.201	14.0	1.178	14.0	1.150
I	13.0	1.215	14.0	1.190	14.0	1.159
J	12.5	1.219	13.0	1.193	13.5	1.156
K	12.5	1.215	13.0	1.188	14.0	1.152
L	13.0	1.217	13.0	1.189	14.0	1.155
M	13.3	1.211	13.8	1.188	14.3	1.158
N	13.0	1.211	13.5	1.186	14.0	1.151
O	14.0	1.207	14.0	1.182	14.0	1.148
P	13.0	1.216	13.0	1.191	14.0	1.153
Q	13.0	1.212	13.3	1.187	14.0	1.152
R	12.8	1.211	13.3	1.185	13.8	1.150
S	13.0	1.212	13.5	1.185	14.0	1.150
T	12.5	1.211	13.0	1.184	14.0	1.150
U	12.0	1.212	14.0	1.175	14.0	1.136
V	13.0	1.219	13.0	1.194	14.0	1.159
W	12.5	1.217	13.0	1.191	14.0	1.154
X	13.0	1.213	13.0	1.187	14.0	1.152
Y	12.7	1.208	13.3	1.180	13.9	1.145
Z	12.8	1.213	13.3	1.185	14.0	1.150
a	12.9	1.213	13.2	1.188	13.7	1.153
b	13.0	1.213	13.2	1.188	13.9	1.153
c	12.4	1.210	13.4	1.183	14.0	1.147
d	12.4	1.209	13.4	1.183	13.9	1.149
e	13.3	1.206	13.8	1.181	14.4	1.147
f	12.5	1.212	13.0	1.185	14.0	1.149
g	-	-	13.5	1.187	14.2	1.152
h	12.8	1.218	13.3	1.191	14.0	1.157
i	13.0	1.215	13.3	1.190	14.3	1.154
average	12.8	1.214	13.4	1.187	14.0	1.152
2-sigma	0.70	0.010	0.65	0.011	0.39	0.013
2-sigma(r) [%]	5.5	0.9	4.9	0.9	2.8	1.1

Table 3.20. Burn-up distribution – void fraction 0%

Results ID	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
A	12	11.6	13.7	13.5	14.1	13.7	11.9	6.6	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.4	31.2	31.8	33.3	32.9	29.5	23.3	29.5	23.2	31.4	32.0	33.1	30.0
	50	43.7	49.9	51.5	54.0	53.7	49.0	42.9	50.2	42.8	53.3	52.8	53.9	50.0
B	12	11.2	13.5	13.4	14.1	13.8	12.0	6.7	11.6	6.6	12.4	13.2	13.8	12.0
	30	25.7	30.8	31.7	33.4	33.0	29.6	23.2	29.8	23.1	31.9	32.1	33.2	30.0
	50	42.9	49.5	51.5	54.2	53.9	49.2	42.3	50.6	42.2	54.0	53.1	54.1	50.0
C	12	11.6	13.7	13.5	14.0	13.7	11.9	6.7	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.4	31.2	31.8	33.2	32.9	29.5	23.4	29.5	23.3	31.4	32.0	33.0	30.0
	50	43.8	49.9	51.4	53.9	53.6	49.0	43.0	50.1	42.9	53.2	52.7	53.8	50.0
D	12	11.4	13.6	13.4	14.0	13.6	12.0	7.5	11.6	7.4	12.2	13.2	13.7	12.1
	30	25.9	30.8	31.3	32.9	32.5	29.5	24.4	29.6	24.2	31.3	31.7	32.6	29.9
	50	43.2	49.3	50.7	53.3	53.0	48.9	44.3	50.2	44.2	52.9	52.2	53.2	49.8
E	12	11.5	13.7	13.4	14.0	13.7	11.9	6.7	11.5	6.7	12.3	13.2	13.8	12.0
	30	26.2	31.1	31.7	33.3	32.9	29.5	23.5	29.6	23.3	31.5	32.0	33.0	30.0
	50	43.5	49.8	51.4	54.0	53.7	49.0	43.1	50.3	42.9	53.4	52.7	53.8	50.0
F	12	11.3	13.5	13.3	13.9	13.6	11.9	7.4	11.4	7.3	12.1	12.9	13.3	12.0
	30	26.0	30.8	31.5	33.0	32.6	29.6	24.2	29.4	23.9	31.2	31.5	32.3	29.9
	50	43.4	49.4	51.0	53.5	53.2	49.2	43.6	49.9	43.4	52.8	52.1	53.0	49.7
G	12	11.5	13.7	13.6	14.2	13.8	12.1	6.5	11.7	6.4	12.4	13.3	13.9	12.1
	30	26.4	31.3	32.0	33.6	33.2	29.9	22.4	30.0	22.3	31.9	32.3	33.3	30.1
	50	44.0	50.2	51.9	54.5	54.2	49.6	40.9	50.9	40.8	53.9	53.3	54.4	50.1
H	12	11.1	13.3	13.2	13.9	13.6	11.8	7.5	11.5	7.9	12.2	13.0	13.5	12.0
	30	25.7	30.6	31.3	32.9	32.5	29.4	24.5	29.5	26.7	31.4	31.6	32.5	30.0
	50	42.8	49.1	50.8	53.3	52.9	48.9	44.2	49.9	50.2	52.9	52.1	52.9	50.0
I	12	11.1	13.3	13.2	13.9	13.6	11.8	7.5	11.5	7.5	12.2	13.1	13.6	12.0
	30	25.8	30.6	31.4	33.1	32.8	29.4	24.5	29.6	24.4	31.5	31.8	32.8	30.0
	50	43.1	49.3	51.1	53.7	53.5	48.9	44.2	50.3	44.1	53.3	52.5	53.5	50.0
J	12	11.4	13.6	13.4	14.0	13.7	12.0	6.8	11.5	6.7	12.3	13.2	13.7	12.0
	30	26.2	31.1	31.7	33.2	32.8	29.6	23.6	29.6	23.4	31.5	31.9	33.0	30.0
	50	43.4	49.7	51.4	53.9	53.6	49.0	43.2	50.3	43.0	53.4	52.7	53.8	50.0
K	12	11.4	13.6	13.4	14.0	13.7	12.0	6.8	11.6	6.8	12.3	13.2	13.7	12.0
	30	26.1	31.0	31.7	33.2	32.8	29.6	23.6	29.6	23.4	31.6	31.9	33.0	30.0
	50	43.4	49.7	51.4	53.9	53.6	49.0	43.2	50.3	43.0	53.4	52.7	53.8	50.0
L	12	11.4	13.6	13.4	14.0	13.6	11.9	7.0	11.5	6.9	12.2	13.1	13.7	12.0
	30	26.2	31.0	31.6	33.2	32.8	29.5	23.8	29.6	23.6	31.5	31.9	33.0	30.0
	50	43.7	49.7	51.4	53.9	53.6	49.0	43.2	50.3	43.1	53.3	52.7	53.8	50.0
M	12	11.2	13.5	13.3	14.0	13.7	11.8	7.1	11.4	7.1	12.0	13.1	13.6	12.0
	30	25.9	30.8	31.5	33.1	32.8	29.3	24.0	29.5	24.0	31.2	31.8	32.7	29.9
	50	43.1	49.4	51.1	53.7	53.4	48.7	43.7	50.0	43.7	52.8	52.4	53.4	49.8
N	12	11.6	13.7	13.5	14.1	13.7	11.9	6.6	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.4	31.2	31.8	33.3	32.9	29.5	23.4	29.5	23.2	31.4	32.0	33.1	30.0
	50	43.6	49.9	51.4	54.0	53.7	49.0	43.0	50.1	42.8	53.2	52.7	53.8	50.0
O	12	11.5	13.7	13.5	14.1	13.8	12.0	6.5	11.6	6.5	12.3	13.2	13.8	12.0
	30	26.2	31.1	31.7	33.3	32.9	29.6	23.4	29.7	23.3	31.6	32.0	33.0	30.0
	50	43.5	49.7	51.4	54.0	53.7	49.0	43.0	50.3	42.9	53.4	52.7	53.7	50.0
P	12	11.4	13.6	13.3	13.9	13.6	11.8	7.1	11.4	7.1	12.1	13.1	13.6	12.0
	30	26.3	31.0	31.6	33.1	32.7	29.3	23.8	29.4	23.6	31.2	31.8	32.8	29.9
	50	43.6	49.7	51.2	53.7	53.4	48.8	43.2	49.9	43.1	52.9	52.5	53.6	49.8

Table 3.20. Burn-up distribution – void fraction 0% (continued)

Q	12	11.5	13.7	13.5	14.0	13.7	11.9	6.7	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.7	33.2	32.9	29.5	23.5	29.6	23.3	31.5	32.0	33.0	30.0
	50	43.6	49.8	51.4	53.9	53.6	49.0	43.1	50.2	42.9	53.3	52.7	53.8	50.0
R	12	11.5	13.7	13.5	14.0	13.7	11.9	6.7	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.7	33.2	32.9	29.5	23.5	29.6	23.3	31.5	32.0	33.0	30.0
	50	43.6	49.8	51.4	53.9	53.6	49.0	43.1	50.2	42.9	53.3	52.7	53.8	50.0
S	12	11.5	13.6	13.5	14.1	13.7	11.9	6.7	11.5	6.7	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.8	33.3	32.9	29.4	23.5	29.5	23.3	31.4	32.0	33.0	30.0
	50	43.6	49.8	51.5	54.0	53.7	48.8	43.1	50.1	43.0	53.2	52.7	53.9	50.0
T	12	11.4	13.6	13.5	14.1	13.7	11.9	6.7	11.5	6.7	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.8	33.3	32.9	29.4	23.5	29.5	23.4	31.4	32.0	33.0	30.0
	50	43.6	49.8	51.5	54.0	53.7	48.8	43.1	50.1	43.0	53.2	52.7	53.9	50.0
U	12	11.3	13.5	13.3	13.9	13.5	11.8	7.6	11.4	7.6	12.0	13.0	13.6	12.0
	30	25.9	31.2	31.6	33.1	32.7	29.5	24.3	29.4	24.1	31.2	31.8	32.9	30.0
	50	42.8	49.8	51.3	53.7	53.4	49.2	44.0	50.1	43.8	53.1	52.5	53.6	50.0
V	12	11.5	13.7	13.5	14.1	13.7	11.9	6.8	11.4	6.7	12.1	13.2	13.7	12.0
	30	26.3	31.2	31.8	33.3	32.9	29.5	23.5	29.4	23.3	31.4	31.9	32.9	30.0
	50	43.8	49.9	51.6	54.1	53.8	48.9	43.0	50.1	42.8	53.1	52.6	53.6	50.0
W	12	11.5	13.7	13.5	14.0	13.7	12.0	6.7	11.5	6.7	12.2	13.2	13.8	12.0
	30	26.3	31.2	31.8	33.2	32.9	29.6	23.6	29.5	23.3	31.5	32.0	33.0	30.0
	50	43.7	49.8	51.5	54.0	53.6	49.1	43.1	50.2	42.9	53.3	52.8	53.8	50.0
X	12	11.6	13.7	13.4	14.0	13.7	11.9	6.7	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.5	31.2	31.8	33.2	32.8	29.5	23.4	29.5	23.2	31.4	32.0	33.1	30.0
	50	43.8	49.9	51.4	53.9	53.7	49.0	43.0	50.1	42.8	53.3	52.8	53.8	50.0
Y	12	11.5	13.6	13.5	14.1	13.7	11.9	6.7	11.5	6.7	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.8	33.3	32.9	29.4	23.5	29.5	23.4	31.4	32.0	33.0	30.0
	50	43.7	49.8	51.5	54.0	53.7	48.8	43.1	50.1	43.0	53.2	52.7	53.9	50.0
Z	12	11.4	13.6	13.5	14.1	13.7	11.9	6.7	11.5	6.7	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.8	33.3	32.9	29.4	23.5	29.5	23.4	31.4	32.0	33.0	30.0
	50	43.6	49.8	51.5	54.0	53.7	48.8	43.1	50.1	43.0	53.2	52.7	53.9	50.0
a	12	11.6	13.8	13.5	14.1	13.8	12.0	6.6	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.4	31.3	31.9	33.5	33.1	29.7	23.6	29.7	23.4	31.7	32.2	33.2	30.2
	50	43.9	50.2	51.8	54.4	54.1	49.4	43.4	50.6	43.2	53.8	53.2	54.3	50.4
b	12	11.6	13.8	13.5	14.1	13.7	12.0	6.6	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.5	31.4	31.9	33.5	33.1	29.7	23.6	29.7	23.4	31.6	32.2	33.2	30.2
	50	44.0	50.2	51.9	54.4	54.1	49.4	43.4	50.6	43.2	53.7	53.2	54.3	50.4
c	12	11.7	13.8	13.5	14.1	13.8	12.0	6.7	11.5	6.6	12.2	13.3	13.8	12.1
	30	26.8	31.5	32.0	33.5	33.1	29.8	22.5	29.7	22.4	31.6	32.2	33.3	30.1
	50	44.3	50.5	52.0	54.5	54.1	49.5	41.0	50.5	40.9	53.5	53.2	54.3	50.1
d	12	11.7	13.8	13.5	14.1	13.8	12.0	6.6	11.5	6.6	12.2	13.3	13.9	12.1
	30	26.9	31.5	32.0	33.6	33.0	29.8	22.5	29.7	22.3	31.6	32.2	33.5	30.1
	50	44.5	50.4	52.0	54.6	53.7	49.6	41.0	50.5	40.7	53.7	53.1	54.7	50.1
e	12	11.7	13.7	13.5	14.1	13.7	12.0	6.5	11.5	6.5	12.2	13.2	13.8	12.0
	30	26.5	31.2	31.7	33.2	32.8	29.5	23.5	29.5	23.3	31.4	31.9	33.0	30.0
	50	44.0	49.9	51.4	53.8	53.5	49.0	43.2	50.1	43.1	53.2	52.6	53.7	50.0
f	12	11.4	13.6	13.4	14.0	13.7	12.0	6.8	11.6	6.7	12.3	13.2	13.7	12.0
	30	26.1	31.0	31.7	33.2	32.9	29.5	23.6	29.6	23.4	31.6	32.0	33.0	30.0
	50	43.3	49.7	51.4	53.9	53.6	49.1	43.2	50.3	43.0	53.5	52.7	53.8	50.0
g	12	11.8	13.9	13.5	14.1	13.7	11.8	6.4	11.4	6.3	11.9	13.3	13.9	12.0
	30	-	-	-	-	-	-	-	-	-	-	-	-	-
	50	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.20. Burn-up distribution – void fraction 0% (continued)

h	12	11.3	13.5	13.4	14.0	13.7	11.9	6.8	11.6	6.8	12.4	13.2	13.9	12.0
	30	25.9	30.9	31.6	33.2	32.9	29.5	23.5	29.7	23.4	31.8	32.1	33.2	30.0
	50	43.2	49.5	51.3	53.9	53.7	49.0	42.9	50.4	42.9	53.7	53.0	54.1	50.0
i	12	11.6	13.7	13.5	14.0	13.7	11.9	6.7	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.4	31.2	31.7	33.3	32.9	29.5	23.4	29.5	23.3	31.4	32.0	33.1	30.0
	50	43.8	49.9	51.4	54.0	53.6	49.0	43.0	50.1	42.9	53.2	52.7	53.8	50.0

Table 3.21. Burn-up distribution – void fraction 40%

Results ID	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
A	12	11.8	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.4	31.5	31.9	33.2	32.8	29.5	23.4	29.2	23.2	31.1	31.7	33.0	30.0
	50	45.4	50.7	51.8	54.0	53.7	48.9	42.6	49.5	42.4	52.5	52.4	53.9	50.0
B	12	11.4	13.5	13.4	14.0	13.7	12.0	6.9	11.6	6.8	12.3	13.1	13.7	12.0
	30	26.8	31.2	31.9	33.3	32.9	29.5	23.2	29.4	23.0	31.5	31.9	33.1	30.0
	50	44.7	50.3	51.9	54.3	53.9	49.0	42.0	49.8	41.8	53.1	52.7	54.1	50.0
C	12	11.8	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.4	31.5	31.8	33.1	32.7	29.5	23.5	29.2	23.3	31.1	31.7	32.9	30.0
	50	45.6	50.7	51.8	53.9	53.6	48.9	42.7	49.4	42.5	52.4	52.3	53.8	50.0
D	12	11.6	13.6	13.3	13.9	13.5	12.1	7.7	11.6	7.6	12.2	13.0	13.6	12.1
	30	26.9	31.1	31.4	32.8	32.4	29.5	24.5	29.4	24.2	30.9	31.4	32.5	29.9
	50	44.9	50.1	51.0	53.3	52.9	49.0	44.0	49.7	43.8	52.1	51.9	53.1	49.8
E	12	11.7	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.6	12.0
	30	27.2	31.5	31.8	33.1	32.7	29.5	23.5	29.3	23.2	31.2	31.7	32.9	30.0
	50	45.2	50.6	51.8	54.0	53.6	48.9	42.7	49.5	42.5	52.6	52.4	53.8	50.0
F	12	11.5	13.5	13.3	13.8	13.5	11.9	7.6	11.4	7.5	12.0	12.7	13.2	12.0
	30	27.1	31.2	31.6	32.9	32.6	29.5	24.2	29.1	23.8	30.9	31.3	32.2	29.9
	50	45.2	50.3	51.4	53.6	53.3	49.0	43.2	49.3	42.9	52.1	51.8	52.9	49.8
G	12	11.7	13.7	13.5	14.1	13.7	12.1	6.7	11.7	6.6	12.3	13.1	13.8	12.1
	30	27.4	31.7	32.1	33.5	33.1	29.8	22.4	29.7	22.2	31.5	32.0	33.3	30.1
	50	45.9	51.1	52.3	54.5	54.1	49.4	40.5	50.1	40.3	53.1	53.0	54.4	50.1
H	12	11.2	13.3	13.2	13.8	13.5	11.9	7.8	11.5	8.3	12.1	12.9	13.4	12.0
	30	26.4	30.8	31.4	32.8	32.4	29.4	24.6	29.2	27.2	31.0	31.4	32.3	30.0
	50	44.0	49.7	51.0	53.2	52.7	48.8	44.0	49.4	50.9	52.2	51.7	52.7	50.0
I	12	11.3	13.3	13.2	13.8	13.5	11.8	7.8	11.5	7.7	12.2	12.9	13.5	12.0
	30	26.7	31.0	31.5	33.0	32.7	29.3	24.5	29.4	24.4	31.1	31.6	32.7	30.0
	50	44.7	50.1	51.4	53.7	53.5	48.8	44.0	49.7	43.8	52.4	52.2	53.5	50.0
J	12	11.6	13.6	13.4	13.9	13.6	12.0	7.1	11.5	7.0	12.3	13.0	13.6	12.0
	30	27.1	31.4	31.8	33.1	32.7	29.5	23.6	29.3	23.4	31.3	31.7	32.9	30.0
	50	45.2	50.5	51.7	53.9	53.6	48.9	42.9	49.6	42.6	52.6	52.4	53.7	50.0
K	12	11.6	13.6	13.4	13.9	13.6	12.0	7.1	11.6	7.0	12.3	13.0	13.6	12.0
	30	27.1	31.4	31.8	33.1	32.7	29.5	23.7	29.3	23.4	31.3	31.7	32.9	30.0
	50	45.2	50.5	51.7	53.9	53.6	48.9	42.9	49.6	42.7	52.6	52.4	53.7	50.0
L	12	11.6	13.6	13.3	13.9	13.6	12.0	7.3	11.5	7.2	12.2	12.9	13.6	12.0
	30	27.2	31.4	31.7	33.1	32.7	29.5	23.8	29.3	23.6	31.2	31.7	32.9	30.0
	50	45.4	50.5	51.7	53.9	53.6	48.9	42.9	49.5	42.7	52.6	52.3	53.7	50.0
M	12	11.4	13.4	13.3	13.9	13.6	11.8	7.5	11.4	7.4	12.0	12.9	13.5	12.0
	30	26.7	31.1	31.6	33.0	32.7	29.2	24.1	29.2	24.0	30.9	31.5	32.6	29.9
	50	44.6	50.1	51.4	53.7	53.4	48.6	43.5	49.4	43.5	52.1	52.1	53.4	49.8

Table 3.21. Burn-up distribution – void fraction 40% (continued)

N	12	11.7	13.7	13.4	13.9	13.6	12.0	6.9	11.5	6.8	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.8	33.1	32.7	29.5	23.5	29.3	23.2	31.2	31.7	32.9	30.0
	50	45.4	50.7	51.8	54.0	53.6	48.9	42.7	49.5	42.5	52.4	52.4	53.8	50.0
O	12	11.6	13.6	13.4	13.9	13.6	12.0	6.8	11.6	6.8	12.3	13.1	13.7	12.0
	30	27.2	31.4	31.8	33.1	32.7	29.5	23.4	29.3	23.2	31.3	31.8	33.0	30.0
	50	45.3	50.5	51.7	53.9	53.6	48.8	42.7	49.6	42.6	52.6	52.5	53.8	50.0
P	12	11.6	13.5	13.3	13.8	13.5	11.9	7.4	11.4	7.3	12.1	12.9	13.5	12.0
	30	27.3	31.3	31.7	33.0	32.6	29.3	23.9	29.1	23.7	30.9	31.5	32.7	29.9
	50	45.5	50.5	51.6	53.8	53.4	48.6	42.9	49.2	42.7	52.1	52.2	53.5	49.9
Q	12	11.7	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.8	33.1	32.7	29.5	23.6	29.3	23.3	31.2	31.7	32.9	30.0
	50	45.4	50.6	51.7	53.9	53.6	48.9	42.8	49.5	42.6	52.5	52.4	53.8	50.0
R	12	11.7	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.2	31.4	31.8	33.1	32.7	29.5	23.6	29.3	23.3	31.2	31.7	32.9	30.0
	50	45.4	50.6	51.7	53.9	53.6	48.9	42.8	49.5	42.6	52.5	52.4	53.8	50.0
S	12	11.6	13.6	13.4	14.0	13.6	11.9	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.9	33.2	32.8	29.3	23.5	29.2	23.3	31.1	31.7	33.0	30.0
	50	45.5	50.7	51.9	54.0	53.7	48.6	42.7	49.3	42.5	52.4	52.4	53.9	50.0
T	12	11.6	13.6	13.4	14.0	13.6	11.9	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.9	33.2	32.8	29.3	23.5	29.2	23.3	31.1	31.7	33.0	30.0
	50	45.4	50.6	51.8	54.0	53.7	48.6	42.8	49.4	42.5	52.4	52.4	53.9	50.0
U	12	11.3	13.5	13.2	13.7	13.4	11.9	7.9	11.4	7.8	12.1	12.8	13.5	12.0
	30	26.7	31.5	31.7	32.9	32.5	29.6	24.5	29.1	24.2	31.0	31.5	32.8	30.0
	50	44.2	50.6	51.6	53.6	53.2	49.3	44.0	49.5	43.6	52.3	52.1	53.5	50.0
V	12	11.8	13.8	13.4	13.9	13.5	12.0	7.1	11.3	6.9	12.0	13.0	13.6	12.0
	30	27.4	31.6	31.9	33.2	32.7	29.5	23.5	29.1	23.1	31.0	31.7	32.8	30.0
	50	45.6	50.9	51.9	54.0	53.6	48.9	42.7	49.3	42.2	52.3	52.3	53.6	50.0
W	12	11.7	13.7	13.4	13.9	13.5	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.8	33.1	32.7	29.5	23.6	29.3	23.3	31.2	31.7	32.9	30.0
	50	45.4	50.7	51.8	53.9	53.6	48.9	42.8	49.5	42.5	52.5	52.3	53.8	50.0
X	12	11.8	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.4	31.6	31.9	33.1	32.7	29.5	23.5	29.2	23.2	31.2	31.7	32.9	30.0
	50	45.6	50.7	51.8	54.0	53.5	48.8	42.7	49.5	42.5	52.5	52.4	53.8	50.0
Y	12	11.7	13.6	13.4	13.9	13.6	11.9	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.4	31.5	31.9	33.2	32.8	29.3	23.5	29.2	23.3	31.1	31.7	33.0	30.0
	50	45.6	50.7	51.9	54.0	53.7	48.6	42.7	49.3	42.5	52.3	52.4	53.9	50.0
Z	12	11.6	13.6	13.4	14.0	13.6	11.9	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.9	33.2	32.8	29.3	23.5	29.2	23.3	31.1	31.7	33.0	30.0
	50	45.5	50.7	51.9	54.0	53.7	48.6	42.7	49.3	42.5	52.4	52.4	53.9	50.0
a	12	11.7	13.7	13.4	13.9	13.6	12.0	6.9	11.5	6.8	12.2	13.0	13.7	12.0
	30	27.4	31.6	32.0	33.3	32.9	29.7	23.6	29.4	23.3	31.3	31.8	33.1	30.1
	50	45.6	50.9	52.1	54.3	53.9	49.2	43.0	49.8	42.7	52.9	52.7	54.1	50.3
b	12	11.7	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.4	31.7	32.0	33.3	32.9	29.6	23.6	29.4	23.3	31.3	31.8	33.1	30.1
	50	45.7	51.0	52.1	54.3	53.9	49.2	43.0	49.8	42.7	52.8	52.7	54.2	50.3
c	12	11.8	13.8	13.5	14.0	13.7	12.1	7.0	11.5	6.9	12.2	13.1	13.7	12.1
	30	27.7	31.9	32.1	33.4	33.0	29.7	22.6	29.4	22.4	31.3	31.9	33.2	30.1
	50	46.2	51.3	52.3	54.5	54.1	49.3	40.7	49.8	40.5	52.7	52.8	54.3	50.1

Table 3.21. Burn-up distribution – void fraction 40% (continued)

d	12	11.8	13.8	13.5	14.0	13.7	12.1	7.0	11.5	6.9	12.2	13.1	13.7	12.1
	30	27.7	31.9	32.1	33.4	33.0	29.7	22.6	29.4	22.4	31.3	31.9	33.2	30.1
	50	46.2	51.3	52.3	54.5	54.1	49.3	40.7	49.8	40.5	52.7	52.8	54.3	50.1
e	12	11.8	13.7	13.4	13.9	13.6	12.0	6.9	11.5	6.8	12.2	13.0	13.7	12.0
	30	27.5	31.5	31.8	33.1	32.7	29.5	23.6	29.2	23.3	31.1	31.7	32.9	30.0
	50	45.8	50.7	51.7	53.8	53.5	48.9	42.9	49.4	42.7	52.4	52.3	53.7	50.0
f	12	11.6	13.6	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.3	13.0	13.6	12.0
	30	27.1	31.4	31.8	33.1	32.7	29.5	23.6	29.3	23.3	31.3	31.7	32.9	30.0
	50	45.0	50.5	51.7	54.0	53.6	48.9	42.8	49.6	42.6	52.7	52.4	53.8	50.0
g	12	12.1	13.9	13.5	13.9	13.6	11.9	6.8	11.4	6.6	11.8	13.2	13.8	12.0
	30	27.8	31.8	31.9	33.2	32.6	29.3	23.3	29.1	22.9	30.5	32.0	33.1	30.0
	50	46.0	51.0	51.9	54.0	53.4	48.7	42.6	49.3	42.1	51.7	52.6	53.9	50.0
h	12	11.6	13.6	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.3	13.0	13.7	12.0
	30	27.1	31.4	31.8	33.1	32.8	29.5	23.5	29.3	23.3	31.3	31.7	32.9	30.0
	50	45.2	50.5	51.7	54.0	53.7	48.8	42.6	49.6	42.4	52.7	52.5	53.9	50.0
i	12	11.7	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.4	31.5	31.8	33.1	32.7	29.5	23.5	29.2	23.2	31.1	31.7	32.9	30.0
	50	45.6	50.7	51.8	53.9	53.6	48.9	42.7	49.4	42.5	52.4	52.3	53.8	50.0

Table 3.22. Burn-up distribution – void fraction 70%

Results ID	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
A	12	11.8	13.6	13.3	13.8	13.5	12.0	7.3	11.5	7.1	12.2	12.8	13.6	12.0
	30	28.4	31.8	31.9	33.0	32.6	29.4	23.5	29.0	23.2	30.9	31.5	33.0	30.0
	50	47.5	51.5	52.2	54.0	53.6	48.6	42.2	48.7	41.9	51.8	52.1	54.0	50.0
B	12	11.6	13.5	13.4	13.9	13.5	12.0	7.2	11.5	7.1	12.3	12.9	13.6	12.0
	30	27.9	31.6	31.9	33.2	32.7	29.5	23.3	29.1	23.0	31.2	31.7	33.1	30.0
	50	46.8	51.2	52.2	54.2	53.7	48.7	41.7	48.9	41.5	52.2	52.5	54.2	50.0
C	12	11.8	13.6	13.3	13.8	13.5	12.0	7.3	11.5	7.2	12.2	12.8	13.6	12.0
	30	28.4	31.8	31.9	33.0	32.6	29.4	23.6	29.0	23.3	30.9	31.4	32.9	30.0
	50	47.6	51.5	52.1	53.9	53.5	48.6	42.3	48.7	42.0	51.7	52.0	53.9	50.0
D	12	11.7	13.5	13.2	13.8	13.5	12.1	8.0	11.6	7.9	12.2	12.9	13.6	12.1
	30	27.9	31.3	31.4	32.6	32.3	29.5	24.4	29.2	24.1	30.7	31.3	32.6	29.9
	50	47.0	50.9	51.3	53.3	52.9	48.9	43.4	49.3	43.2	51.3	51.7	53.3	49.9
E	12	12.2	13.9	13.5	13.9	13.6	12.0	7.0	11.3	6.9	12.0	12.9	13.6	12.0
	30	28.7	32.2	32.1	33.2	32.7	29.4	23.2	28.6	22.9	30.5	31.5	33.0	30.0
	50	47.7	51.8	52.3	54.1	53.6	48.7	42.1	48.4	41.7	51.3	52.0	53.9	50.0
F	12	11.7	13.4	13.2	13.7	13.4	11.9	7.8	11.4	7.7	12.1	12.6	13.2	12.0
	30	28.2	31.5	31.7	32.9	32.5	29.2	24.1	28.9	23.7	30.7	31.1	32.2	29.9
	50	47.4	51.2	51.9	53.7	53.4	48.3	42.6	48.6	42.2	51.4	51.6	53.0	49.8
G	12	11.8	13.6	13.5	14.0	13.7	12.1	7.0	11.7	6.9	12.4	13.0	13.8	12.1
	30	28.5	32.0	32.2	33.4	33.0	29.6	22.3	29.4	22.1	31.3	31.9	33.4	30.1
	50	48.0	51.9	52.7	54.6	54.2	49.0	39.9	49.3	39.7	52.3	52.7	54.6	50.1
H	12	11.2	13.2	13.1	13.7	13.4	11.9	8.1	11.5	8.6	12.2	12.7	13.4	12.0
	30	26.9	30.9	31.4	32.6	32.2	29.3	24.7	29.1	27.8	30.9	31.1	32.3	30.0
	50	45.0	50.1	51.1	53.0	52.6	48.7	43.9	49.0	51.7	51.7	51.3	52.7	50.0
I	12	11.4	13.2	13.2	13.8	13.5	11.8	8.0	11.5	7.9	12.2	12.8	13.5	12.0
	30	27.6	31.2	31.6	32.9	32.6	29.2	24.6	29.1	24.4	30.9	31.4	32.7	30.0
	50	46.4	50.8	51.7	53.7	53.5	48.5	43.7	49.0	43.5	51.7	51.9	53.5	50.0

Table 3.22. Burn-up distribution – void fraction 70% (continued)

J	12	11.7	13.5	13.3	13.8	13.5	12.1	7.3	11.6	7.2	12.3	12.9	13.6	12.0
	30	28.1	31.7	31.8	33.0	32.6	29.4	23.7	29.1	23.4	31.0	31.5	32.9	30.0
	50	47.3	51.4	52.1	53.9	53.5	48.6	42.4	48.8	42.2	51.8	52.0	53.8	50.0
K	12	11.7	13.5	13.3	13.8	13.4	12.1	7.4	11.6	7.3	12.3	12.8	13.6	12.0
	30	28.1	31.6	31.8	33.0	32.6	29.4	23.7	29.1	23.4	31.0	31.5	32.9	30.0
	50	47.3	51.3	52.0	53.9	53.5	48.6	42.5	48.8	42.2	51.8	52.0	53.8	50.0
L	12	11.7	13.5	13.3	13.7	13.4	12.0	7.6	11.5	7.4	12.3	12.8	13.6	12.0
	30	28.2	31.6	31.8	32.9	32.6	29.4	23.8	29.1	23.5	31.0	31.5	32.9	30.0
	50	47.4	51.4	52.0	53.9	53.5	48.6	42.5	48.8	42.2	51.7	52.1	53.9	50.0
M	12	11.4	13.3	13.2	13.8	13.5	11.8	7.8	11.5	7.7	12.1	12.8	13.5	12.0
	30	27.5	31.2	31.6	33.0	32.7	29.1	24.3	29.0	24.1	30.7	31.3	32.7	29.9
	50	46.3	50.7	51.7	53.7	53.5	48.3	43.3	48.8	43.2	51.5	51.7	53.5	49.9
N	12	11.8	13.6	13.3	13.8	13.5	12.1	7.2	11.5	7.1	12.3	12.9	13.6	12.0
	30	28.3	31.7	31.9	33.0	32.6	29.4	23.5	29.0	23.2	31.0	31.5	33.0	30.0
	50	47.5	51.5	52.1	53.9	53.5	48.6	42.3	48.7	42.0	51.7	52.0	53.9	50.0
O	12	11.7	13.5	13.3	13.8	13.5	12.0	7.2	11.6	7.1	12.3	13.0	13.7	12.0
	30	28.2	31.6	31.8	32.9	32.6	29.4	23.5	29.0	23.3	31.1	31.7	33.1	30.0
	50	47.3	51.3	52.0	53.8	53.5	48.5	42.4	48.8	42.2	51.9	52.3	54.0	50.0
P	12	11.7	13.4	13.2	13.7	13.4	11.9	7.7	11.4	7.6	12.1	12.8	13.5	12.0
	30	28.3	31.5	31.7	32.9	32.6	29.1	23.8	28.8	23.7	30.7	31.4	32.8	29.9
	50	47.5	51.3	52.0	53.9	53.6	48.2	42.4	48.4	42.3	51.3	51.9	53.7	49.9
Q	12	11.8	13.6	13.3	13.8	13.5	12.1	7.3	11.5	7.2	12.3	12.9	13.6	12.0
	30	28.2	31.7	31.8	33.0	32.6	29.4	23.6	29.0	23.3	31.0	31.5	32.9	30.0
	50	47.4	51.4	52.1	53.9	53.5	48.6	42.4	48.7	42.1	51.8	52.0	53.9	50.0
R	12	11.8	13.6	13.3	13.8	13.5	12.1	7.3	11.5	7.2	12.3	12.9	13.6	12.0
	30	28.2	31.7	31.8	33.0	32.6	29.4	23.6	29.0	23.3	31.0	31.5	32.9	30.0
	50	47.4	51.4	52.1	53.9	53.5	48.6	42.4	48.7	42.1	51.8	52.0	53.9	50.0
S	12	11.8	13.6	13.4	13.8	13.5	12.0	7.3	11.5	7.1	12.2	12.9	13.6	12.0
	30	28.4	31.8	32.0	33.1	32.7	29.2	23.5	28.8	23.2	30.9	31.6	33.0	30.0
	50	47.7	51.5	52.3	54.1	53.7	48.2	42.2	48.4	41.9	51.6	52.2	54.1	50.0
T	12	11.8	13.6	13.4	13.8	13.5	12.0	7.3	11.5	7.2	12.3	12.9	13.6	12.0
	30	28.3	31.7	31.9	33.1	32.7	29.2	23.5	28.9	23.2	30.9	31.6	33.0	30.0
	50	47.6	51.5	52.2	54.1	53.7	48.2	42.3	48.5	41.9	51.7	52.2	54.1	50.0
U	12	11.4	13.4	13.1	13.6	13.3	12.0	8.2	11.4	8.1	12.1	12.7	13.4	12.0
	30	27.4	31.6	31.6	32.7	32.3	29.6	24.6	29.0	24.3	30.8	31.3	32.7	30.0
	50	45.8	51.3	51.8	53.5	53.0	49.2	43.9	48.9	43.4	51.6	51.7	53.5	50.0
V	12	12.0	13.8	13.4	13.7	13.3	12.0	7.4	11.3	7.1	12.1	12.9	13.5	12.0
	30	28.5	32.1	32.0	32.9	32.3	29.5	23.6	28.7	23.0	30.8	31.5	32.8	30.0
	50	47.8	51.9	52.3	53.9	53.3	48.7	42.3	48.4	41.6	51.6	52.0	53.6	50.0
W	12	11.8	13.6	13.3	13.8	13.4	12.1	7.3	11.5	7.2	12.3	12.8	13.6	12.0
	30	28.3	31.8	31.8	33.0	32.6	29.4	23.6	29.0	23.3	31.0	31.5	32.9	30.0
	50	47.5	51.5	52.0	53.9	53.5	48.6	42.4	48.7	42.1	51.8	52.0	53.9	50.0
X	12	11.9	13.6	13.3	13.8	13.4	12.0	7.3	11.5	7.2	12.3	12.8	13.6	12.0
	30	28.4	31.8	31.8	33.0	32.5	29.4	23.5	29.0	23.3	31.0	31.4	33.0	30.0
	50	47.7	51.5	52.1	53.9	53.4	48.6	42.3	48.7	42.0	51.7	52.0	53.9	50.0
Y	12	11.8	13.6	13.4	13.8	13.5	12.0	7.3	11.5	7.2	12.2	12.9	13.6	12.0
	30	28.4	31.8	32.0	33.1	32.7	29.2	23.5	28.8	23.2	30.9	31.6	33.0	30.0
	50	47.7	51.5	52.3	54.1	53.7	48.2	42.2	48.4	41.9	51.6	52.2	54.1	50.0
Z	12	11.8	13.6	13.4	13.8	13.5	12.0	7.3	11.5	7.1	12.2	12.9	13.6	12.0
	30	28.4	31.8	32.0	33.1	32.7	29.2	23.5	28.8	23.2	30.9	31.6	33.0	30.0
	50	47.6	51.5	52.3	54.1	53.7	48.2	42.2	48.4	41.9	51.6	52.2	54.1	50.0

Table 3.22. Burn-up distribution – void fraction 70% (continued)

a	12	11.8	13.6	13.4	13.8	13.5	12.1	7.2	11.5	7.1	12.3	12.9	13.6	12.0
	30	28.3	31.8	32.0	33.1	32.7	29.5	23.6	29.1	23.3	31.1	31.6	33.1	30.1
	50	47.6	51.7	52.3	54.2	53.8	48.8	42.5	49.0	42.2	52.0	52.3	54.1	50.2
b	12	11.8	13.6	13.3	13.8	13.5	12.1	7.3	11.5	7.1	12.3	12.9	13.6	12.0
	30	28.4	31.9	32.0	33.1	32.7	29.5	23.6	29.1	23.3	31.0	31.6	33.1	30.1
	50	47.7	51.7	52.3	54.2	53.8	48.8	42.5	48.9	42.2	52.0	52.3	54.2	50.2
c	12	11.9	13.7	13.4	13.9	13.6	12.1	7.2	11.6	7.1	12.2	12.9	13.7	12.1
	30	28.8	32.1	32.2	33.3	32.9	29.6	22.5	29.2	22.3	31.1	31.8	33.3	30.1
	50	48.4	52.2	52.7	54.5	54.1	49.0	40.1	49.0	39.8	52.0	52.6	54.6	50.1
d	12	11.9	13.7	13.4	13.9	13.6	12.1	7.2	11.6	7.1	12.2	12.9	13.7	12.1
	30	28.8	32.1	32.2	33.3	32.9	29.6	22.5	29.2	22.3	31.1	31.8	33.3	30.1
	50	48.4	52.2	52.7	54.5	54.1	49.0	40.1	49.0	39.8	52.0	52.6	54.6	50.1
e	12	11.9	13.6	13.4	13.8	13.5	12.1	7.2	11.5	7.1	12.2	12.8	13.6	12.0
	30	28.5	31.8	31.9	33.0	32.6	29.4	23.6	29.0	23.3	30.9	31.4	32.9	30.0
	50	47.8	51.5	52.1	53.9	53.5	48.6	42.5	48.6	42.2	51.6	52.0	53.8	50.0
f	12	11.7	13.6	13.4	13.8	13.5	12.1	7.3	11.5	7.1	12.3	12.9	13.6	12.0
	30	28.0	31.7	31.9	33.0	32.6	29.5	23.5	29.1	23.2	31.1	31.5	32.9	30.0
	50	46.9	51.3	52.1	54.0	53.5	48.7	42.3	48.8	41.9	52.1	52.2	53.9	50.0
g	12	12.3	13.9	13.4	13.8	13.5	12.0	7.0	11.4	6.8	11.8	13.1	13.8	12.0
	30	29.1	32.2	32.0	33.0	32.4	29.3	23.2	28.7	22.7	30.1	31.8	33.1	30.0
	50	48.5	52.0	52.3	53.9	53.3	48.4	42.0	48.4	41.5	50.7	52.4	54.0	50.0
h	12	11.7	13.5	13.3	13.8	13.5	12.0	7.3	11.5	7.2	12.3	12.9	13.6	12.0
	30	28.2	31.6	31.8	33.0	32.6	29.4	23.5	29.0	23.2	31.1	31.6	33.0	30.0
	50	47.4	51.3	52.0	54.0	53.6	48.5	42.2	48.8	41.9	51.9	52.2	54.0	50.0
i	12	11.8	13.6	13.3	13.8	13.5	12.0	7.3	11.5	7.1	12.2	12.8	13.6	12.0
	30	28.4	31.8	31.9	33.0	32.6	29.4	23.5	29.0	23.2	30.9	31.5	32.9	30.0
	50	47.6	51.5	52.1	53.9	53.5	48.6	42.3	48.6	42.0	51.7	52.0	53.9	50.0

Table 3.23. Burn-up distribution of all results – void fraction 0%

	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
Average [GWd/t]	12	11.5	13.6	13.4	14.0	13.7	11.9	6.8	11.5	6.8	12.2	13.2	13.7	12.0
	30	26.2	31.1	31.7	33.2	32.9	29.5	23.6	29.6	23.5	31.5	32.0	33.0	30.0
	50	43.6	49.8	51.4	54.0	53.6	49.1	43.0	50.2	43.1	53.3	52.7	53.8	50.0
sigma [GWd/t]	12	0.3	0.3	0.2	0.1	0.1	0.1	0.6	0.1	0.7	0.2	0.2	0.2	0.1
	30	0.5	0.4	0.3	0.3	0.3	0.3	1.0	0.3	1.5	0.3	0.3	0.5	0.1
	50	0.8	0.6	0.6	0.6	0.6	0.5	1.6	0.4	3.0	0.6	0.6	0.7	0.3
2-sigma[r] [%]	12	2.9	1.9	1.2	1.0	1.0	1.1	9.4	1.2	10.3	1.7	1.2	1.7	0.5
	30	2.1	1.4	1.1	1.0	0.9	0.9	4.2	0.9	6.3	1.1	1.0	1.4	0.4
	50	1.8	1.2	1.1	1.1	1.0	0.9	3.7	0.9	6.9	1.1	1.1	1.4	0.5

Table 3.24. Burn-up distribution of all results – void fraction 40%

	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
Average [GWd/t]	12	11.6	13.6	13.4	13.9	13.6	12.0	7.1	11.5	7.0	12.2	13.0	13.6	12.0
	30	27.2	31.4	31.8	33.1	32.7	29.5	23.6	29.3	23.4	31.1	31.7	32.9	30.0
	50	45.3	50.6	51.8	54.0	53.6	48.9	42.7	49.5	42.7	52.5	52.4	53.8	50.0
sigma [GWd/t]	12	0.3	0.2	0.2	0.1	0.1	0.1	0.6	0.1	0.7	0.2	0.2	0.2	0.1
	30	0.6	0.5	0.3	0.3	0.3	0.3	1.0	0.3	1.6	0.4	0.3	0.4	0.1
	50	1.0	0.7	0.6	0.6	0.6	0.4	1.6	0.4	3.3	0.6	0.5	0.7	0.2
2-sigma(r) [%]	12	2.8	1.8	1.2	0.9	0.9	1.1	8.7	1.2	10.2	1.7	1.2	1.7	0.4
	30	2.3	1.4	1.1	0.9	0.9	0.9	4.2	0.9	6.9	1.2	1.0	1.4	0.3
	50	2.1	1.3	1.1	1.0	1.0	0.9	3.8	0.8	7.7	1.1	1.0	1.3	0.4

Table 3.25. Burn-up distribution of all results – void fraction 70%

	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
Average [GWd/t]	12	11.8	13.6	13.3	13.8	13.5	12.0	7.4	11.5	7.3	12.2	12.9	13.6	12.0
	30	28.2	31.7	31.9	33.0	32.6	29.4	23.6	29.0	23.4	30.9	31.5	32.9	30.0
	50	47.4	51.4	52.1	53.9	53.5	48.6	42.3	48.7	42.2	51.7	52.1	53.9	50.0
sigma [GWd/t]	12	0.4	0.3	0.2	0.1	0.1	0.1	0.6	0.2	0.8	0.2	0.2	0.2	0.1
	30	0.8	0.5	0.4	0.3	0.3	0.3	1.1	0.3	1.9	0.4	0.3	0.5	0.1
	50	1.4	0.8	0.7	0.6	0.6	0.5	1.8	0.5	3.8	0.6	0.6	0.8	0.2
2-sigma(r) [%]	12	3.5	2.1	1.2	1.0	1.0	1.2	8.5	1.5	10.4	2.0	1.3	1.7	0.4
	30	2.9	1.7	1.2	1.0	1.0	1.0	4.5	1.0	7.9	1.4	1.1	1.4	0.3
	50	2.9	1.6	1.3	1.1	1.1	1.1	4.2	1.0	8.9	1.1	1.1	1.4	0.3

**Table 3.26. Burn-up distribution of results
(except results ID D, F, G, H, I, M, P, U, c, d and g) – void fraction 0% -**

	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
Average [GWd/t]	12	11.5	13.7	13.5	14.0	13.7	11.9	6.7	11.5	6.6	12.2	13.2	13.8	12.0
	30	26.3	31.1	31.7	33.3	32.9	29.5	23.5	29.6	23.3	31.5	32.0	33.0	30.0
	50	43.6	49.8	51.5	54.0	53.7	49.0	43.1	50.3	42.9	53.4	52.8	53.9	50.0
sigma [GWd/t]	12	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.0
	30	0.4	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.1
	50	0.5	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.3	0.3	0.2
2-sigma(r) [%]	12	2.1	1.1	0.5	0.4	0.4	0.6	3.4	0.9	3.3	1.6	0.6	0.7	0.1
	30	1.3	0.8	0.5	0.4	0.4	0.5	0.9	0.6	0.8	0.9	0.4	0.5	0.3
	50	1.2	0.7	0.5	0.5	0.5	0.6	1.0	0.7	0.9	0.8	0.6	0.6	0.5

Table 3.27. Burn-up distribution of results (except Results ID D, F, G, H, I, M, P, U, c, d and g) – void fraction 40%

	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
Average [GWd/t]	12	11.7	13.7	13.4	13.9	13.6	12.0	7.0	11.5	6.9	12.2	13.0	13.7	12.0
	30	27.3	31.5	31.8	33.1	32.7	29.5	23.5	29.3	23.3	31.2	31.7	32.9	30.0
	50	45.4	50.7	51.8	54.0	53.6	48.9	42.7	49.5	42.5	52.5	52.4	53.8	50.0
sigma [GWd/t]	12	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.0
	30	0.4	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.1
	50	0.5	0.3	0.2	0.2	0.2	0.3	0.4	0.3	0.4	0.5	0.3	0.3	0.2
2-sigma$^{(r)}$ [%]	12	1.9	1.0	0.4	0.4	0.5	0.6	2.6	0.9	2.8	1.6	0.7	0.7	0.1
	30	1.3	0.7	0.4	0.4	0.4	0.6	1.0	0.7	1.1	1.1	0.5	0.5	0.2
	50	1.1	0.6	0.4	0.4	0.5	0.6	0.9	0.6	0.9	0.9	0.5	0.5	0.3

Table 3.28. Burn-up distribution of results (except Results ID D, F, G, H, I, M, P, U, c, d and g) – void fraction 70%

	Assembly Average Burn-up [GWd/t]	Burn-up Region Number												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
Average [GWd/t]	12	11.8	13.6	13.3	13.8	13.5	12.0	7.3	11.5	7.1	12.2	12.9	13.6	12.0
	30	28.3	31.8	31.9	33.0	32.6	29.4	23.5	29.0	23.2	30.9	31.5	33.0	30.0
	50	47.5	51.5	52.2	54.0	53.6	48.6	42.3	48.7	42.0	51.7	52.1	54.0	50.0
sigma [GWd/t]	12	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.0
	30	0.5	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.2	0.2	0.1
	50	0.6	0.4	0.2	0.2	0.2	0.4	0.3	0.4	0.4	0.6	0.3	0.3	0.1
2-sigma$^{(r)}$ [%]	12	2.6	1.5	0.6	0.5	0.7	0.6	3.1	1.4	3.2	2.0	0.8	0.8	0.0
	30	1.7	1.0	0.5	0.4	0.5	0.7	1.2	0.9	1.5	1.4	0.6	0.5	0.2
	50	1.3	0.7	0.4	0.4	0.5	0.8	0.8	0.7	1.1	1.1	0.5	0.5	0.2

3.4 Comparison among SCALE 6.1 results

In this section, the results of participants using SCALE 6.1 are compared.

In this benchmark, many users submitted results by adopting the SCALE6.1 system. Eight results (*Results ID D, F, G, H, I, M, P and c*) adopted TRITON, T-DEPL sequence with NEWT. Only one result (*Result ID d*) used SCALE6 TRITON-6 sequence with KENO-VI. Results ID H uses a cross-section data library based on the ENDF/B-V and others used ENDF/B-VII. Figure 3.8 presents the 2-sigma$^{(r)}$ (%) of each nuclide of all results of SCALE6.1 for void fraction of 40% and a cooling time of 15 years, with the exception of *Result ID d*, as TRITON-6 sequence is used.

Concerning fission products, there are few nuclides whose 2-sigma$^{(r)}$ value is larger than 5%. The 2-sigma$^{(r)}$ (%) obtained after excluding the results of participants ID H from those in the previous paragraph shown in Table 3.29 and Figure 3.9. The difference between Figure 3.8 and Figure 3.9 is the result of the improvement of cross-section data libraries from ENDF/B-V to ENDF/B-VII. It is clear that the change of the 2-sigma$^{(r)}$ value of nuclide densities is small for actinides but those for fission products such as ^{151}Sm (9%),

^{154}Gd (18%) and ^{155}Gd (17%) are large. This is due to the fact that the effects of the revision of the cross-section data of uranium and plutonium are small but data concerning fission product generation have been considerably improved from ENDF/B-V to ENDF/B-VII.

The nuclides which have large 2-sigma$^{(r)}$ (%) have large sensitivity to their own neutron cross-section and that of their parent nuclides. The differences shown in Figure 3.9 can be explained by the use of different parameters in the associated burn-up calculation such as burn-up step size, multi-group cross-section processing options and adopted data libraries. Burn-up calculation results should be carefully examined based on the adopted calculation model and credibility of input data and library, even if a well-qualified calculation code such as SCALE is being used. This is a general rule for all computer simulations.

3.5 Comparison among CASMO-4E results

CASMO is a widely used code; six results of CASMO are submitted. However, the adopted library is not unified. JEF-2.2 (two participants), ENDF/B-VI (two participants), ENDF/B-VII.0 (one participant) and JENDL-4 (one participant) are used. The results obtained by the same system and the same library might have the same (or almost the same) results under ideal conditions. Figure 3.10 shows the 2-sigma$^{(r)}$ (%) of CASMO-4E results using JEF-2.2. The results using the same library agree very well, generally having 2-sigma$^{(r)}$ less than 2%, except for ^{144}Ce and ^{157}Gd. This good agreement may be explained by the fact that CASMO is a commercially supported code, and has a well-qualified input output control for a typical burn-up problem. The reason why ^{144}Ce and ^{157}Gd have larger 2-sigma$^{(r)}$ (%) values than other nuclides is not certain.

Figure 3.11 shows the 2-sigma$^{(r)}$ (%) of the CASMO-4E results using ENDF/B-VI. Generally, the agreement is good but shows more variations than the case using JEF-2.2, with a ^{235}U 2-sigma$^{(r)}$ of 3.5%. ^{144}Ce has a great difference, which is almost the same as shown in Figure 3.10, ^{155}Eu also has a great difference. As *Results ID S and T* use ORIGEN2 code for decay calculation, it should be secured that the treatment of the data should go well. *Results ID T and* Y use the ENDF/B-VI library but participants sent a different library subversion number, which should be checked when further comparison among CASMO users is needed.

3.6 Comparison among codes using the deterministic method

Several deterministic codes, including SCALE 6.1 and CASMO, are used in this benchmark. Figure 3.12 presents the 2-sigma$^{(r)}$ (%) of the deterministic codes. For main heavy nuclides such as uranium and plutonium except for ^{234}U and ^{238}Pu, 2-sigma$^{(r)}$ is generally less than 6%. For ^{243}Am and ^{244}Cm, 2-sigma$^{(r)}$ is greater than 10%.

Fission products except ^{109}Ag, ^{129}I and gadolinium isotopes have relatively small 2-sigma$^{(r)}$ (%). This is a remarkable progress from the previous benchmark Phase III-B. The larger 2-sigma$^{(r)}$ (%) of gadolinium isotopes for lower burn-up cases comes from the treatment of the gadolinium burning problem because residual ^{155}Gd still exists and has a large sensitivity to Gd rod treatment in the burn-up calculation. Several users adopted a limited number of Gd rod divisions and a small number of burn-up steps. For a higher burn-up case, the accumulated ^{155}Eu affects the amount of ^{155}Gd during the cooling time. In this case, ^{155}Gd in Gd rods is already depleted and the contribution through beta decay of ^{155}Eu generated by the fission reaction may be dominant in determining the amount of ^{155}Gd in the fuel assembly. It should be noted that this is the case for longer cooling times. In this case, the dependency of ^{155}Gd on the adopted cross-section data library will be clearly observed. Figure 3.13 shows the ^{155}Gd nuclide density of all cases against the adopted cross-section data libraries. Old libraries show a different trend of the ^{155}Gd number density as compared to the new libraries. This is a common problem for all participants, both deterministic and continuous-energy codes. The neutron cross-section, fission yield and decay data related to the ^{155}Gd generation should be examined for further improvement.

Table 3.29. Effect of cross-section data library between ENDF/B-V and -VII SCALE6.1 results Case 11c (50GWd/t, 40%, 15 years)

	average of nuclide density [$10^{24}/cm^3$]		B/A	2σ(%)		Δ 2σ(%) Between (C) and (D)
	D,F,G,H,I,M,P and c (A)	D,F,G,I,M,P and c (B)		D,F,G,H,I,M,P and c (C)	D,F,G,M,P and c (D)	
^{234}U	4.00E-06	4.00E-06	1.00	1.6	1.4	0.2
^{235}U	1.13E-04	1.12E-04	0.99	5.3	4.8	0.5
^{236}U	1.24E-04	1.24E-04	1.00	0.8	0.9	0.0
^{238}U	2.07E-02	2.07E-02	1.00	0.0	0.0	0.0
^{237}Np	1.31E-05	1.31E-05	1.00	3.3	3.5	0.2
^{238}Pu	5.56E-06	5.53E-06	0.99	4.0	2.6	1.3
^{239}Pu	9.92E-05	9.88E-05	1.00	5.5	5.4	0.1
^{240}Pu	6.45E-05	6.42E-05	0.99	4.0	2.7	1.2
^{241}Pu	1.38E-05	1.38E-05	1.00	4.1	4.2	0.1
^{242}Pu	2.04E-05	2.03E-05	1.00	1.5	0.7	0.8
^{241}Am	1.59E-05	1.58E-05	1.00	4.1	4.2	0.1
^{243}Am	4.93E-06	4.90E-06	1.00	3.0	1.5	1.4
^{244}Cm	1.15E-06	1.14E-06	1.00	4.2	3.7	0.5
^{90}Sr	3.15E-05	3.15E-05	1.00	0.5	0.5	0.0
^{95}Mo	6.19E-05	6.19E-05	1.00	0.4	0.4	0.0
^{99}Tc	6.27E-05	6.25E-05	1.00	2.1	1.3	0.8
^{101}Ru	6.13E-05	6.12E-05	1.00	0.9	0.4	0.4
^{103}Rh	3.27E-05	3.27E-05	1.00	1.4	1.3	0.1
^{109}Ag	5.74E-06	5.73E-06	1.00	1.7	1.6	0.2
^{129}I	9.48E-06	9.47E-06	1.00	1.5	1.5	0.0
^{131}Xe	2.39E-05	2.40E-05	1.00	2.1	0.6	1.4
^{133}Cs	6.53E-05	6.51E-05	1.00	1.1	0.7	0.4
^{134}Cs	4.76E-08	4.81E-08	1.01	5.5	1.6	3.6
^{137}Cs	4.90E-05	4.90E-05	1.00	0.6	0.6	0.0
^{144}Ce	1.74E-11	1.73E-11	1.00	1.5	1.4	0.1
^{143}Nd	3.59E-05	3.58E-05	1.00	1.9	1.7	0.2
^{145}Nd	3.50E-05	3.49E-05	1.00	1.4	0.4	1.0
^{148}Nd	1.99E-05	1.99E-05	1.00	1.0	0.5	0.4
^{147}Sm	1.27E-05	1.27E-05	1.00	0.8	0.8	0.0
^{149}Sm	8.78E-08	8.68E-08	0.99	7.9	5.3	2.5
^{150}Sm	1.48E-05	1.47E-05	0.99	3.9	1.9	1.9
^{151}Sm	3.42E-07	3.34E-07	0.98	13.4	3.5	9.2
^{152}Sm	5.23E-06	5.23E-06	1.00	1.8	1.9	0.1
^{153}Eu	6.08E-06	6.05E-06	1.00	2.9	1.2	1.6
^{154}Eu	3.42E-07	3.42E-07	1.00	2.0	1.9	0.1
^{155}Eu	4.69E-08	4.86E-08	1.04	21.2	2.2	17.8
^{155}Gd	3.90E-07	4.04E-07	1.04	20.0	2.2	16.7
^{156}Gd	9.86E-05	9.86E-05	1.00	0.3	0.3	0.0
^{157}Gd	1.82E-08	1.80E-08	0.99	7.7	7.3	0.4
^{158}Gd	1.14E-04	1.14E-04	1.00	0.0	0.0	0.0

3.7 Comparison among the codes adopting the continuous-energy Monte Carlo method

Inter-comparison among burn-up calculation codes based on continuous-energy Monte Carlo techniques may directly show the effect of the difference of the neutron cross-section library. Continuous-energy Monte Carlo codes use point-wise cross-section data, and therefore do not need a special processing step to make effective multigroup cross-section data for neutron transport calculation, a step which requires careful consideration and which may be a source of added discrepancy. However, the issue of time step size, particularly as it influences the gadolinium isotopes near peak reactivity, is still a difficulty that must be considered. The summary of the results is shown in Figure 3.14.

Figure 3.14 shows that many heavy nuclides have 2-sigma$^{(r)}$ of less than 4% and many fission products have that of less than approximately 5%. Some heavy nuclides, i.e. ^{238}Pu, ^{243}Am and ^{244}Cm have 2-sigma$^{(r)}$ larger than 10% but still less than 15%. These relatively larger 2-sigma$^{(r)}$ (%) values result from different adopted neutron cross-section data. ^{109}Ag and ^{129}I have large 2-sigma$^{(r)}$ larger than 15%. This is a consequence of the difference in the fission yield data as shown in Section 3.7.1.

Samarium, europium and gadolinium isotopes have large 2-sigma$^{(r)}$ (%) value.^{154}Eu has an extremely large value and the heavy burn-up dependency is clearly shown. The reason for this is the fact that the calculation code adopting JEF-2.2 (result ID b) gives a relatively large result of ^{154}Eu. With the exception of results ID b, ^{154}Eu has 2-sigma$^{(r)}$ of less than 15%. An earlier study [8] showed that the burn-up calculation results of JEF-2.2 were almost 1.7 times larger than that of JENDL-3.2 because effective one-group cross-section data of ^{154}Eu neutron capture reaction in JEF-2.2 is almost half that of JENDL-3.2.

Using the continuous-energy Monte Carlo code, the uncertainty of the results due to the statistical error requires attention. Figure 3.15 shows the 2-sigma$^{(r)}$ (%) of 50 results of SWAT4 which was obtained by changing the initial random numbers of the continuous-energy Monte Carlo code MVP adopted in SWAT4 as the neutron transport calculation solver. It is clearly shown that the uncertainty of the burn-up calculation results based on the continuous-energy Monte Carlo code is rather small, generally 0.1% (the worst case is 0.3% for ^{157}Gd). In this calculation, the effective neutron history is 10,000,000 (10,000 particles per cycle simulated for a total of 1100 cycles including 100 inactive cycles). This result provides the general view on the figure of the uncertainty of the averaged nuclide density by the burn-up calculation codes based on the continuous-energy Monte Carlo code.

3.7.1 Comparison among the codes adopting the continuous-energy Monte Carlo method – same library but different codes

Four results, ID, A, C, L and X adopted JENDL-4 and used different code systems, SWAT4, MVP-BURN, MCNP-BURN2 and MONTEBURNS2. Figure 3.16 presents their 2-sigma$^{(r)}$ (%), except for a few isotopes, each code agrees very well with a 2-sigma$^{(r)}$ of 2-4%, generally less than 5%.

For ^{244}Cm, ^{109}Ag, ^{129}I and ^{155}Eu, relatively large 2-sigma$^{(r)}$ (%) is observed because *Result ID X* is relatively different from the others. MONTEBURNS2 is a similar code system to SWAT4 combining the continuous-energy Monte Carlo code and ORIGEN2. SWAT4 uses ORIGEN2 for burn-up calculation module. However, this is not the original ORIGEN2 but ORIGEN22UPJ [9], an updated version of ORIGEN2, adopting JENDL-3.3 fission yield data. Even when the continuous-energy Monte Carlo code is used, a difference in the nuclides whose cross-section data are replaced by the results of the continuous-energy Monte Carlo code can be observed. Participant X sent us new results using MONTEBURNS2 adopting JENDL-4 and ORLIBJ40 [10], which uses the cross-section data library based on JENDL-4. This result (ID X-A) is shown in Table 3.30. Figure 3.17 shows the 2-sigma$^{(r)}$ (%) of the continuous-energy Monte Carlo codes using JENDL-4 after replacing *Result ID X by X-A*. It is shown that 2-sigma(r) (%) of fission products is generally improved and ^{109}Ag and ^{129}I show considerably improved results. This clearly shows that the difference in *Result ID X* comes from the old fission yield data in ORIGEN2. The difference between *Results ID X and X-A* is shown based on reports by the participants. These results show that even in the case of the latest burn-up calculation code system based on the continuous-energy Monte Carlo code adopting the latest cross-section data libraries, focus should be placed on the actually adopted data because the Monte Carlo calculation will not replace the fission yield data.

For the ^{155}Gd at 12GWd/t case, this large 2-sigma(r) (%) comes from the small data of result ID L. As *Result ID L* shows almost the same data for the other nuclides at 12 GWd/t, a problem arises in the burnout of Gd.

3.7.2 Comparison among the codes adopting the continuous-energy Monte Carlo method – same library and same code

Concerning the SERPENT code, three results (*Results ID N, Q and a*) use ENDF/B-VII. It is expected that these results agree well with each other. *Results ID N and* Q have identical versions. Figure 3.18 presents an inter-comparison between N and Q. The result for the major actinides is typically a 2-sigma(r) between 1 and 4%. Many fission products have approximately less than 1% difference except for a few isotopes. The effect of the "difference of the users" is expected to be smaller if codes based on the continuous-energy Monte Carlo code are used because it treats a precise geometrical model and eliminates the need to generate effective cross-section data of each burn-up region through the adequate process. It should be noted that for ^{155}Gd and ^{157}Gd at 12GWd/t, 2-sigma(r) is almost 10%. This might be a consequence of the difference in the number of burn-up steps as the number of division within the UO_2-Gd_2O_3 rod is the same among ID, N and Q.

3.8 Comparison selected codes representing the group of the continuous-energy Monte Carlo method and the deterministic codes

Several calculation results adopting the latest nuclear data libraries, i.e. JENDL-4, ENDF/B-VII and JEF-3.1.1, were obtained and compared. For the group of the continuous-energy Monte Carlo method, we have selected A, C, J, K, L, N, Q, R, X-A, a, e and g. For the deterministic method, B, D, E, F, G, I, M, P, V, c, f and h have been selected.

Figures 3.19 and 3.20 show the 2-sigma(r) (%) of each group. Because many deterministic codes, except for SCALE6, adopt an old cross-section data library such as JEF-2.2, SCALE6 using ENDF/B-VII is dominant in the deterministic codes. The general trends of 2-sigma(%) values of the selected code groups are similar to each other. Similar trends of 2-sigma(%) are shown in two figures. For many actinides, 2-sigma(r) (%) values are less than 4% but increase for ^{238}Pu and ^{243}Am and ^{244}Cm. For fission products, ^{109}Ag and ^{129}I have a large difference, as shown in Section 3.7.1, resulting from the difference in the fission yield data. Samarium and gadolinium isotopes have larger values, as shown in previous comparisons.

Figure 3.21 shows the difference in the assembly-averaged nuclide density between the selected deterministic codes and the continuous-energy Monte Carlo codes. This figure shows that the differences between these two groups are small, generally less than 2-5%. For ^{155}Gd and ^{157}Gd, larger differences than for other nuclides are shown, but still less than 15%.

Generally, these results show that the current burn-up calculation code adopting the continuous-energy Monte Carlo code and the deterministic code agrees well with each other except for a few nuclides.

Figure 3.8. 2-sigma(r) (%) of each nuclide by SCALE6.1 code, TRITON, T-DEPL sequence (void fraction 40%, 15-year cooling) for 12 20, 30 and 50 GWd/t D, F, G, H, I, M, P and c (*Results ID H*: ENDF/B-V, others: ENDF/B-VII)

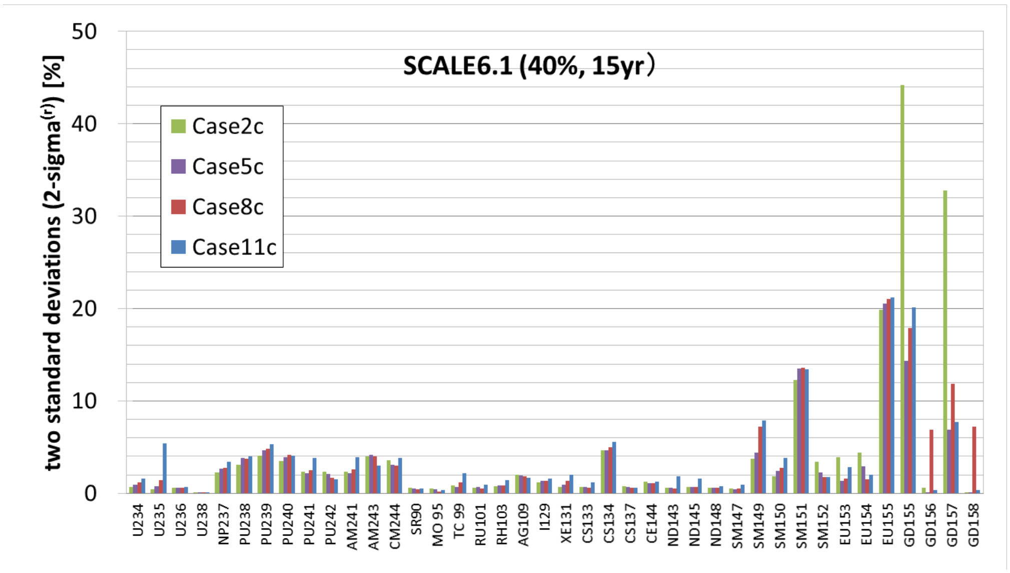


Figure 3.9. 2-sigma(r) (%) of each nuclide by SCALE6.1 code, TRITON, T-DEPL sequence (void fraction 40%, 15-year cooling) for 12 20, 30 and 50 GWd/t D, F, G, I, M, P and c (ENDF/B-VII)

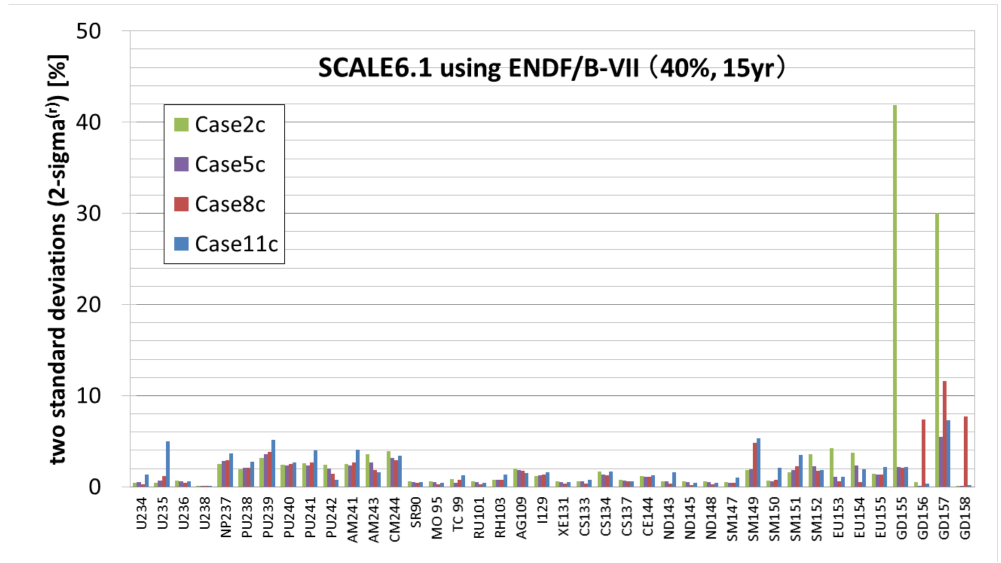


Figure 3.10. 2-sigma(r) (%) of each nuclide by CASMO-4E using JEF-2.2 (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t S and Z

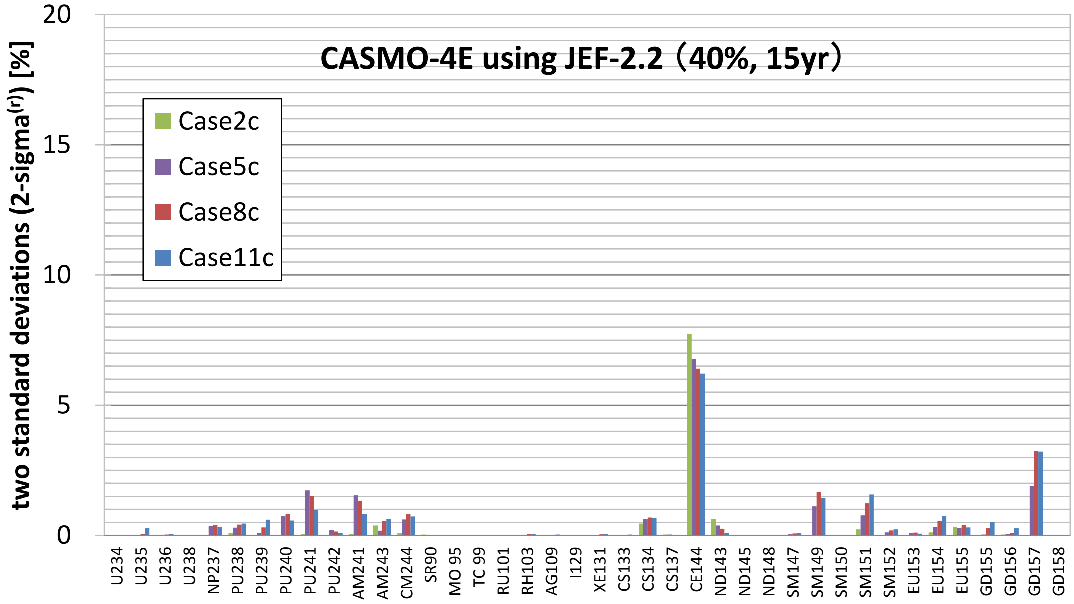


Figure 3.11. 2-sigma(r) (%) of each nuclide by CASMO-4E using ENDF/B-VI (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t T and Y

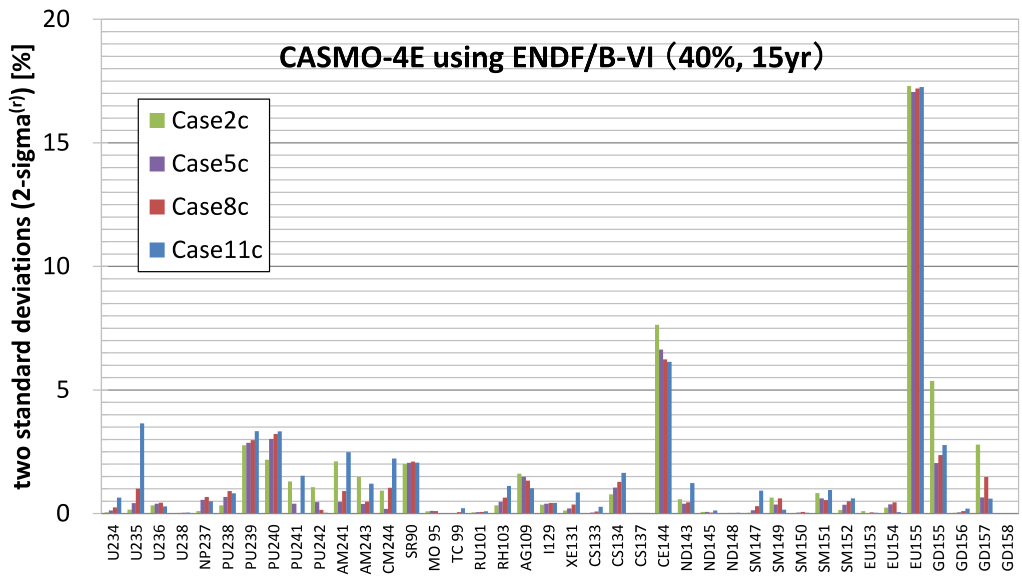


Figure 3.12. 2-sigma(r) (%) of each nuclide by deterministic code (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t B, D, E, F, G, H, I, M, O, P, S, T, V, Y, Z, c, f and h

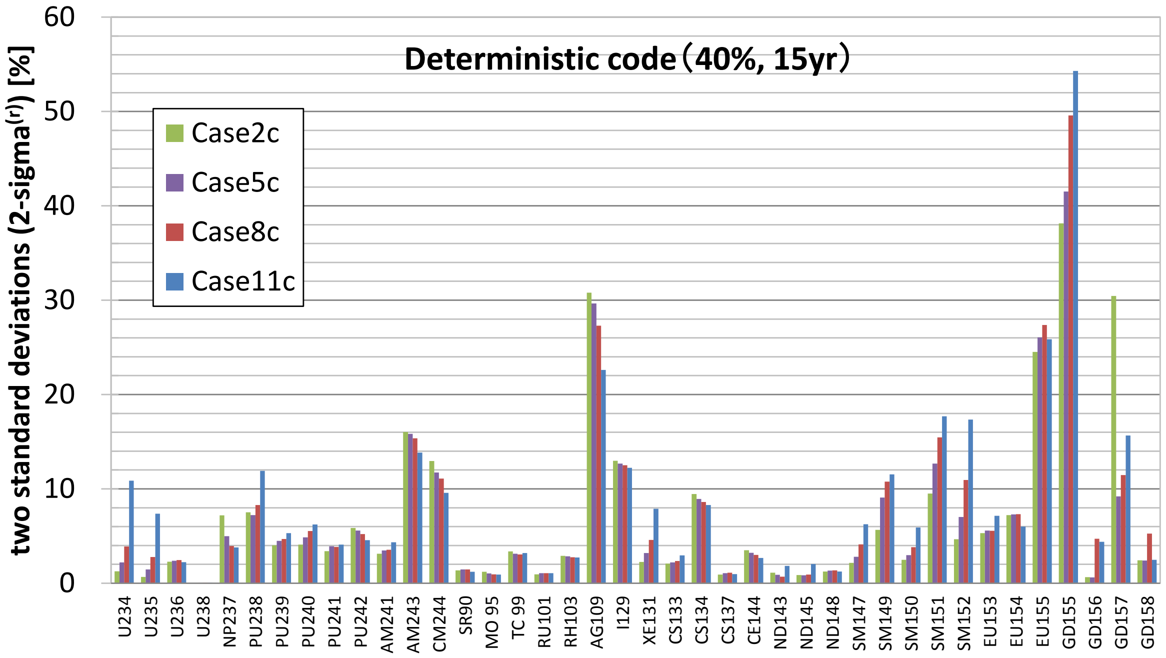


Figure 3.13. Nuclide density of ^{155}Gd (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t

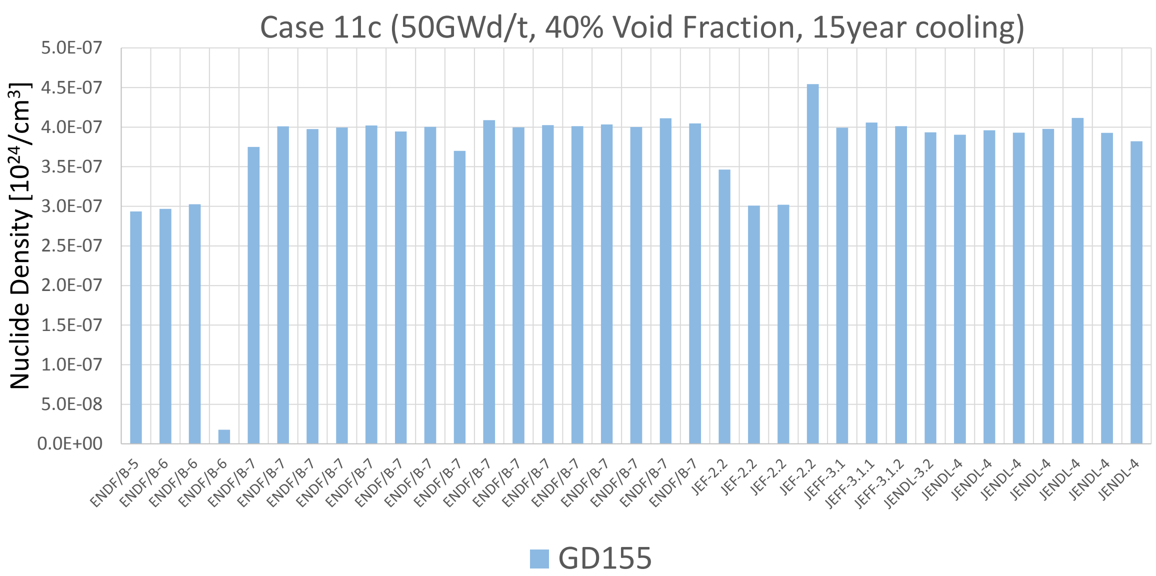


Figure 3.14. 2-sigma(r) (%) of each nuclide by the continuous-energy Monte Carlo Code (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t A, C, J, K, L, N, Q, R, W, X, a, b, e, g and i

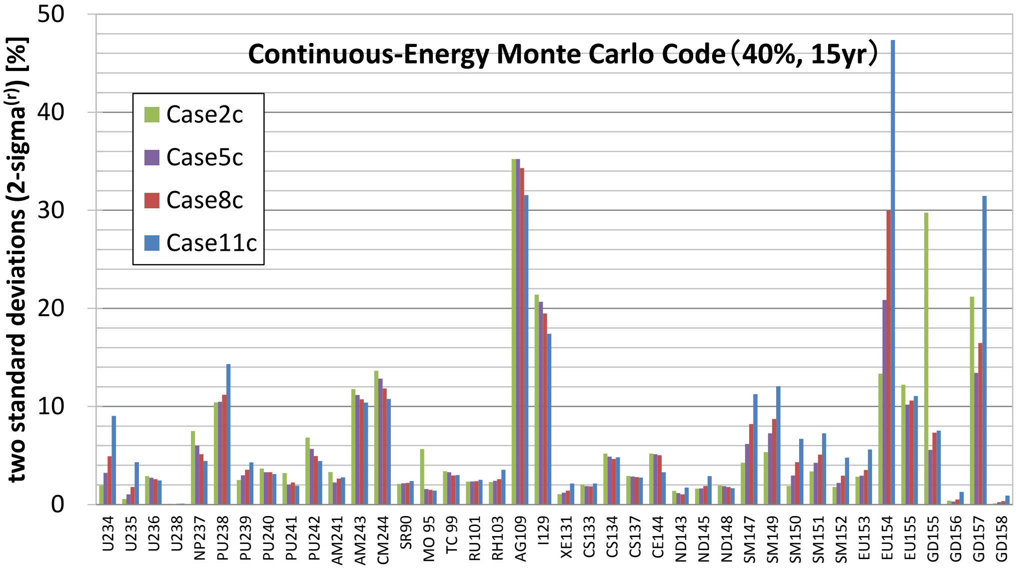


Figure 3.15. 2-sigma(r) (%) of 50 results of SWAT4 (void fraction 40%, 15-year cooling, 50 GWd/t) obtained by changing initial random number adopted in MVP input data

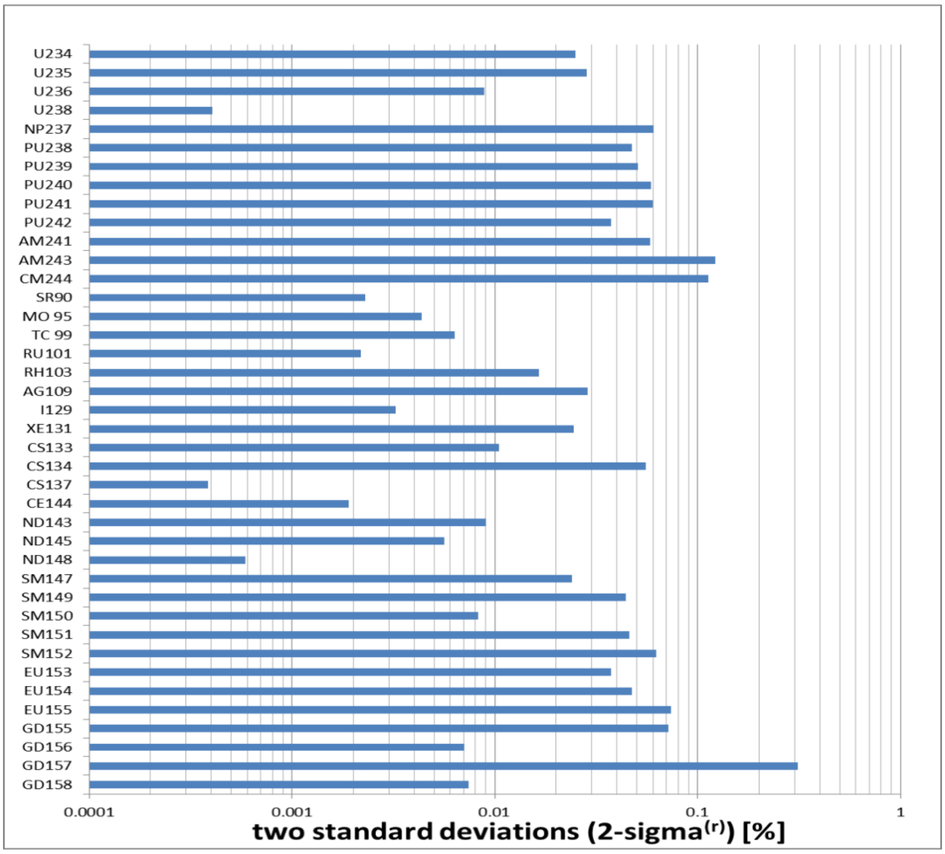


Figure 3.16. 2-sigma[(r)] (%) of each nuclide by the continuous-energy Monte Carlo Code using JENDL-4 (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t A, C, L and X

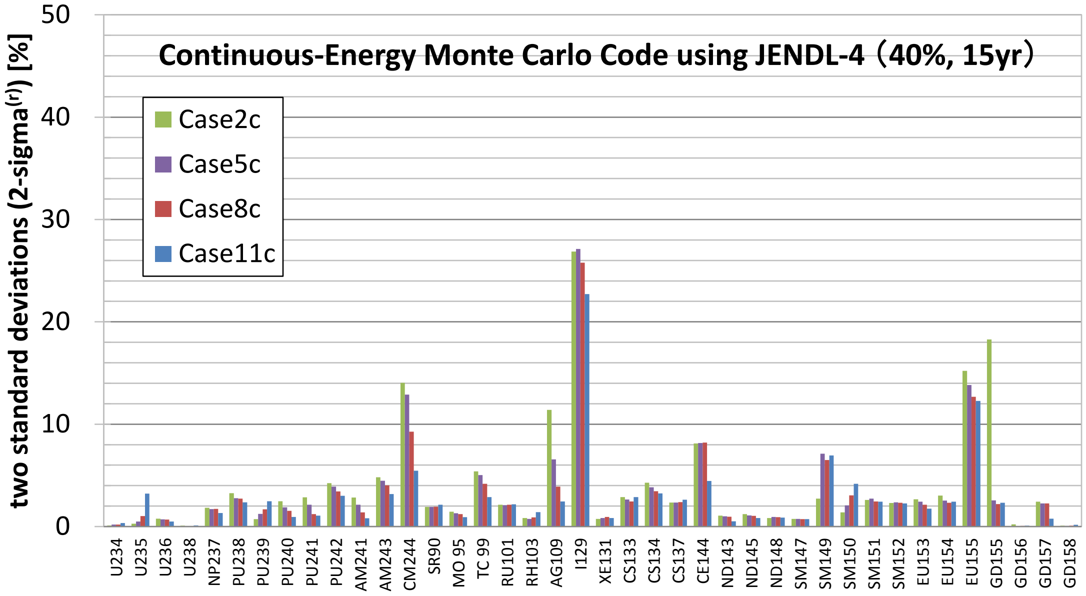


Table 3.30. Additional results ID X-A (adopting ORLIB40 and origen2j40) from participants ID X

	Case1b	Case2a	Case2b	Case2c	Case3b	Case5b	Case5c	Case6b	Case8b	Case8c	Case9b	Case11b	Case11c	Case12b
^{234}U	5.98E-06	5.88E-06	5.89E-06	5.90E-06	5.79E-06	5.36E-06	5.42E-06	5.24E-06	4.75E-06	4.91E-06	4.63E-06	3.70E-06	4.23E-06	3.67E-06
^{235}U	6.14E-04	6.21E-04	6.21E-04	6.21E-04	6.27E-04	4.73E-04	4.73E-04	4.87E-04	3.21E-04	3.21E-04	3.42E-04	1.17E-04	1.17E-04	1.47E-04
^{236}U	4.85E-05	4.92E-05	4.92E-05	4.92E-05	5.02E-05	7.37E-05	7.37E-05	7.45E-05	9.73E-05	9.73E-05	9.76E-05	1.23E-04	1.23E-04	1.23E-04
^{238}U	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.13E-02	2.12E-02	2.12E-02	2.12E-02	2.11E-02	2.11E-02	2.10E-02	2.08E-02	2.08E-02	2.07E-02
^{237}Np	1.71E-06	1.97E-06	2.04E-06	2.08E-06	2.39E-06	4.04E-06	4.11E-06	4.65E-06	6.94E-06	7.06E-06	7.84E-06	1.27E-05	1.29E-05	1.40E-05
^{238}Pu	1.62E-07	2.08E-07	2.14E-07	1.98E-07	2.78E-07	7.44E-07	6.88E-07	9.50E-07	2.07E-06	1.91E-06	2.55E-06	6.97E-06	6.45E-06	8.27E-06
^{239}Pu	6.77E-05	7.72E-05	7.81E-05	7.81E-05	9.02E-05	9.36E-05	9.36E-05	1.10E-04	1.01E-04	1.00E-04	1.21E-04	9.74E-05	9.73E-05	1.23E-04
^{240}Pu	1.25E-05	1.36E-05	1.36E-05	1.36E-05	1.46E-05	2.59E-05	2.59E-05	2.77E-05	4.03E-05	4.03E-05	4.32E-05	6.14E-05	6.19E-05	6.72E-05
^{241}Pu	3.38E-06	5.36E-06	4.21E-06	2.59E-06	5.05E-06	9.32E-06	5.74E-06	1.09E-05	1.53E-05	9.40E-06	1.78E-05	2.21E-05	1.36E-05	2.67E-05
^{242}Pu	4.53E-07	5.43E-07	5.43E-07	5.43E-07	6.20E-07	2.24E-06	2.24E-06	2.43E-06	6.34E-06	6.34E-06	6.50E-06	2.04E-05	2.04E-05	1.94E-05
^{241}Am	9.96E-07	9.18E-08	1.24E-06	2.82E-06	1.49E-06	2.86E-06	6.37E-06	3.36E-06	4.86E-06	1.06E-05	5.68E-06	7.16E-06	1.55E-05	8.75E-06
^{243}Am	1.89E-08	2.78E-08	2.79E-08	2.79E-08	3.91E-08	2.00E-07	1.99E-07	2.63E-07	8.56E-07	8.56E-07	1.04E-06	4.35E-06	4.35E-06	4.68E-06
^{244}Cm	1.07E-09	2.28E-09	1.89E-09	1.29E-09	3.13E-09	2.33E-08	1.59E-08	3.64E-08	1.66E-07	1.14E-07	2.39E-07	1.67E-06	1.14E-06	2.02E-06
^{90}Sr	1.27E-05	1.40E-05	1.24E-05	9.78E-06	1.22E-05	1.96E-05	1.54E-05	1.92E-05	2.75E-05	2.16E-05	2.68E-05	3.98E-05	3.13E-05	3.89E-05
^{95}Mo	1.73E-05	1.21E-05	1.71E-05	1.71E-05	1.70E-05	2.77E-05	2.77E-05	2.74E-05	4.01E-05	4.01E-05	3.95E-05	6.17E-05	6.17E-05	6.09E-05
^{99}Tc	1.68E-05	1.66E-05	1.67E-05	1.67E-05	1.67E-05	2.73E-05	2.73E-05	2.71E-05	4.00E-05	4.00E-05	3.98E-05	6.29E-05	6.29E-05	6.26E-05
^{101}Ru	1.48E-05	1.48E-05	1.48E-05	1.48E-05	1.49E-05	2.47E-05	2.47E-05	2.47E-05	3.70E-05	3.70E-05	3.70E-05	6.10E-05	6.10E-05	6.08E-05
^{103}Rh	9.42E-06	8.20E-06	9.56E-06	9.56E-06	9.69E-06	1.56E-05	1.56E-05	1.58E-05	2.24E-05	2.24E-05	2.26E-05	3.26E-05	3.26E-05	3.31E-05
^{109}Ag	5.99E-07	6.59E-07	6.61E-07	6.61E-07	7.20E-07	1.44E-06	1.44E-06	1.55E-06	2.65E-06	2.65E-06	2.81E-06	5.58E-06	5.58E-06	5.75E-06
^{129}I	1.82E-06	1.85E-06	1.86E-06	1.86E-06	1.91E-06	3.30E-06	3.30E-06	3.40E-06	5.18E-06	5.18E-06	5.32E-06	9.05E-06	9.05E-06	9.30E-06
^{131}Xe	7.75E-06	7.47E-06	7.70E-06	7.70E-06	7.63E-06	1.22E-05	1.22E-05	1.20E-05	1.69E-05	1.69E-05	1.66E-05	2.32E-05	2.32E-05	2.29E-05
^{133}Cs	1.82E-05	1.78E-05	1.81E-05	1.81E-05	1.80E-05	2.94E-05	2.94E-05	2.92E-05	4.24E-05	4.24E-05	4.20E-05	6.44E-05	6.44E-05	6.38E-05
^{134}Cs	1.05E-07	6.42E-07	1.20E-07	4.20E-09	1.36E-07	2.92E-07	1.02E-08	3.28E-07	5.92E-07	2.07E-08	6.52E-07	1.40E-06	4.89E-08	1.48E-06
^{137}Cs	1.53E-05	1.72E-05	1.53E-05	1.22E-05	1.53E-05	2.53E-05	2.01E-05	2.53E-05	3.76E-05	2.99E-05	3.76E-05	6.13E-05	4.87E-05	6.13E-05
^{144}Ce	1.02E-07	8.54E-06	1.01E-07	1.40E-11	9.99E-08	1.22E-07	1.70E-11	1.21E-07	1.30E-07	1.80E-11	1.28E-07	1.25E-07	1.74E-11	1.24E-07
^{143}Nd	1.45E-05	1.38E-05	1.45E-05	1.45E-05	1.45E-05	2.22E-05	2.22E-05	2.22E-05	2.94E-05	2.94E-05	2.99E-05	3.58E-05	3.58E-05	3.86E-05
^{145}Nd	1.03E-05	1.03E-05	1.03E-05	1.03E-05	1.02E-05	1.65E-05	1.65E-05	1.63E-05	2.35E-05	2.35E-05	2.32E-05	3.50E-05	3.50E-05	3.47E-05
^{148}Nd	4.76E-06	4.77E-06	4.77E-06	4.77E-06	4.79E-06	7.92E-06	7.92E-06	7.94E-06	1.18E-05	1.18E-05	1.19E-05	1.96E-05	1.96E-05	1.97E-05
^{147}Sm	4.11E-06	7.46E-07	4.03E-06	5.14E-06	3.94E-06	6.23E-06	7.74E-06	6.04E-06	8.40E-06	1.02E-05	8.11E-06	1.09E-05	1.27E-05	1.05E-05
^{149}Sm	9.47E-08	7.87E-08	1.05E-07	1.05E-07	1.18E-07	1.02E-07	1.02E-07	1.16E-07	9.76E-08	9.76E-08	1.13E-07	8.75E-08	8.75E-08	1.05E-07
^{150}Sm	3.24E-06	3.27E-06	3.27E-06	3.27E-06	3.31E-06	5.67E-06	5.67E-06	5.75E-06	8.73E-06	8.73E-06	8.85E-06	1.46E-05	1.46E-05	1.49E-05
^{151}Sm	2.81E-07	3.21E-07	3.14E-07	2.90E-07	3.52E-07	3.27E-07	3.03E-07	3.78E-07	3.40E-07	3.15E-07	4.04E-07	3.56E-07	3.30E-07	4.44E-07
^{152}Sm	1.63E-06	1.58E-06	1.58E-06	1.58E-06	1.53E-06	2.61E-06	2.61E-06	2.49E-06	3.64E-06	3.64E-06	3.42E-06	5.09E-06	5.09E-06	4.69E-06

Table 3.30. Additional results ID X-A (adopting ORLIB40 and origen2j40) from participants ID X (continued)

^{153}Eu	8.41E-07	8.85E-07	8.95E-07	8.95E-07	9.48E-07	1.83E-06	1.83E-06	1.93E-06	3.21E-06	3.21E-06	3.33E-06	5.96E-06	5.96E-06	5.97E-06
^{154}Eu	5.39E-08	9.63E-08	6.43E-08	2.87E-08	7.78E-08	1.69E-07	7.57E-08	2.04E-07	3.53E-07	1.58E-07	4.24E-07	7.45E-07	3.33E-07	8.89E-07
^{155}Eu	2.52E-08	5.39E-08	2.60E-08	6.05E-09	2.68E-08	5.03E-08	1.17E-08	5.31E-08	9.48E-08	2.21E-08	9.95E-08	2.03E-07	4.72E-08	2.10E-07
^{155}Gd	7.86E-07	1.26E-06	1.28E-06	1.30E-06	2.12E-06	8.66E-08	1.25E-07	1.00E-07	1.31E-07	2.04E-07	1.44E-07	2.41E-07	3.96E-07	2.56E-07
^{156}Gd	9.59E-05	9.52E-05	9.52E-05	9.52E-05	9.41E-05	9.61E-05	9.61E-05	9.57E-05	9.59E-05	9.59E-05	9.53E-05	9.72E-05	9.72E-05	9.61E-05
^{157}Gd	2.16E-08	3.44E-08	3.46E-08	3.46E-08	6.80E-08	2.64E-08	2.64E-08	3.82E-08	2.61E-08	2.61E-08	3.87E-08	2.67E-08	2.67E-08	3.88E-08
^{158}Gd	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.12E-04	1.13E-04	1.13E-04	1.13E-04	1.15E-04	1.15E-04	1.15E-04

Figure 3.17. 2-sigma(r) (%) of each nuclide by the continuous-energy Monte Carlo Code using JENDL-4 (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t A, C, L and X-A(adopting ORLIB40 and origen2j40)

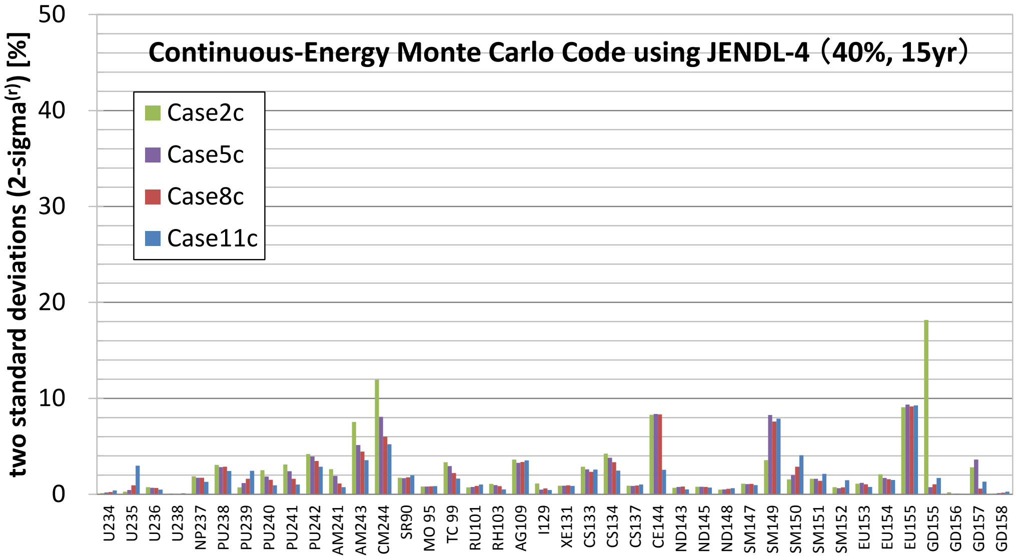


Figure 3.18. 2-sigma(r) (%) of each nuclide by SERPENT (version 1.1.18) using ENDF/B-VII (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t N and Q

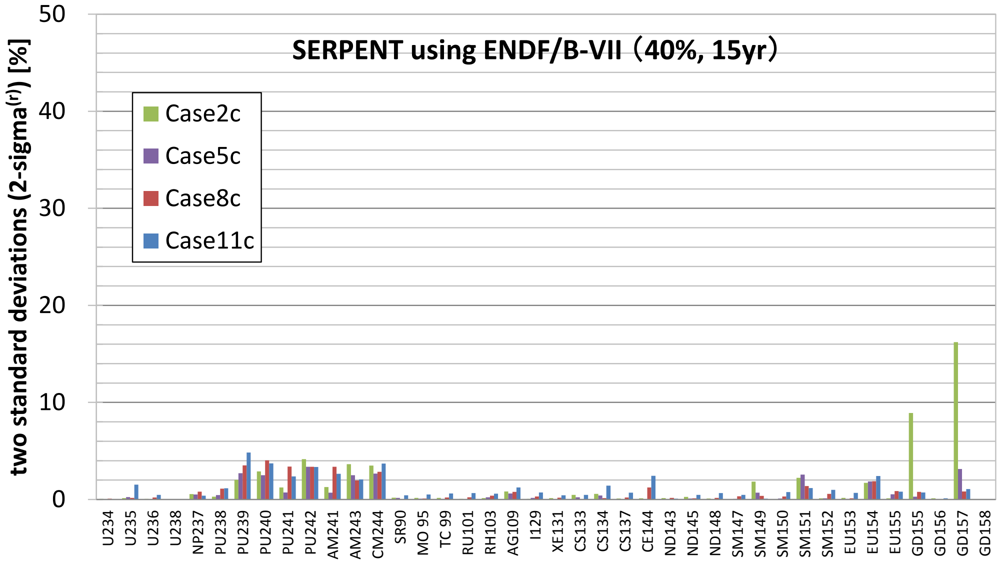


Figure 3.19. 2-sigma(r) (%) of each nuclide by the continuous-energy Monte Carlo Code (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t A, C, J, K, L, N, Q, R, X-A, a, e and g (CE-MC code using JENDL-4, ENDF/B-VII)

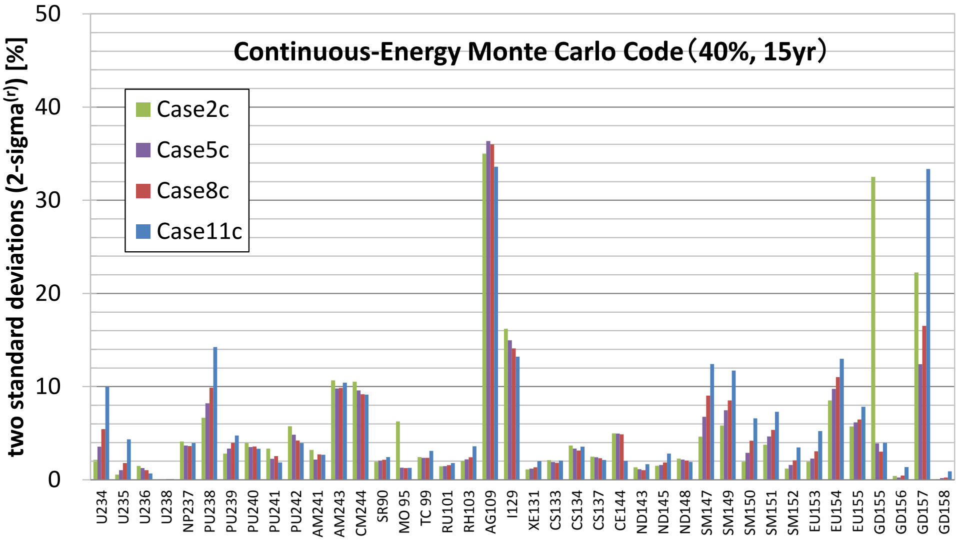


Figure 3.20. 2-sigma(r) (%) of each nuclide by deterministic code (void fraction 40%, 15-year cooling) for 12, 20, 30 and 50 GWd/t B, D, E, F, G, I, M, P, V, c, f and h

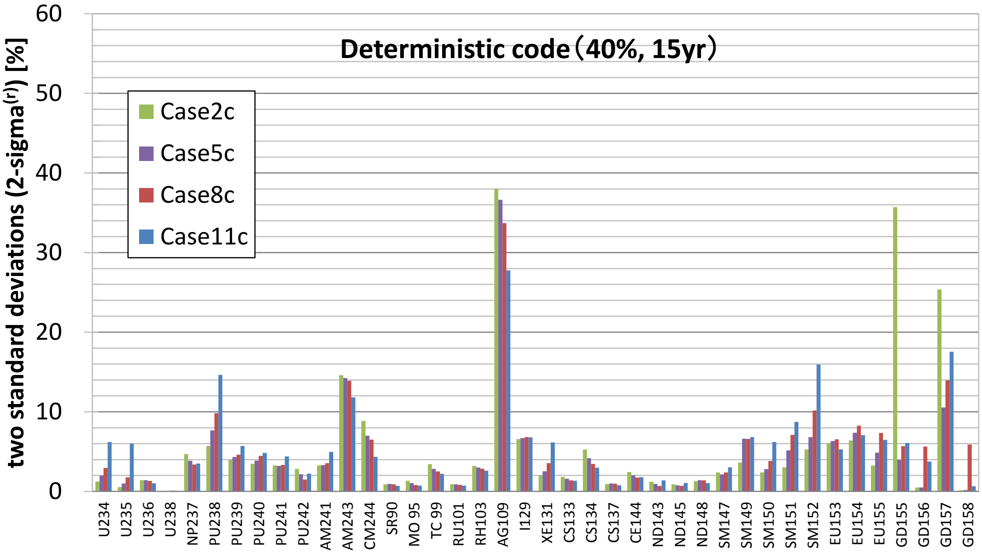
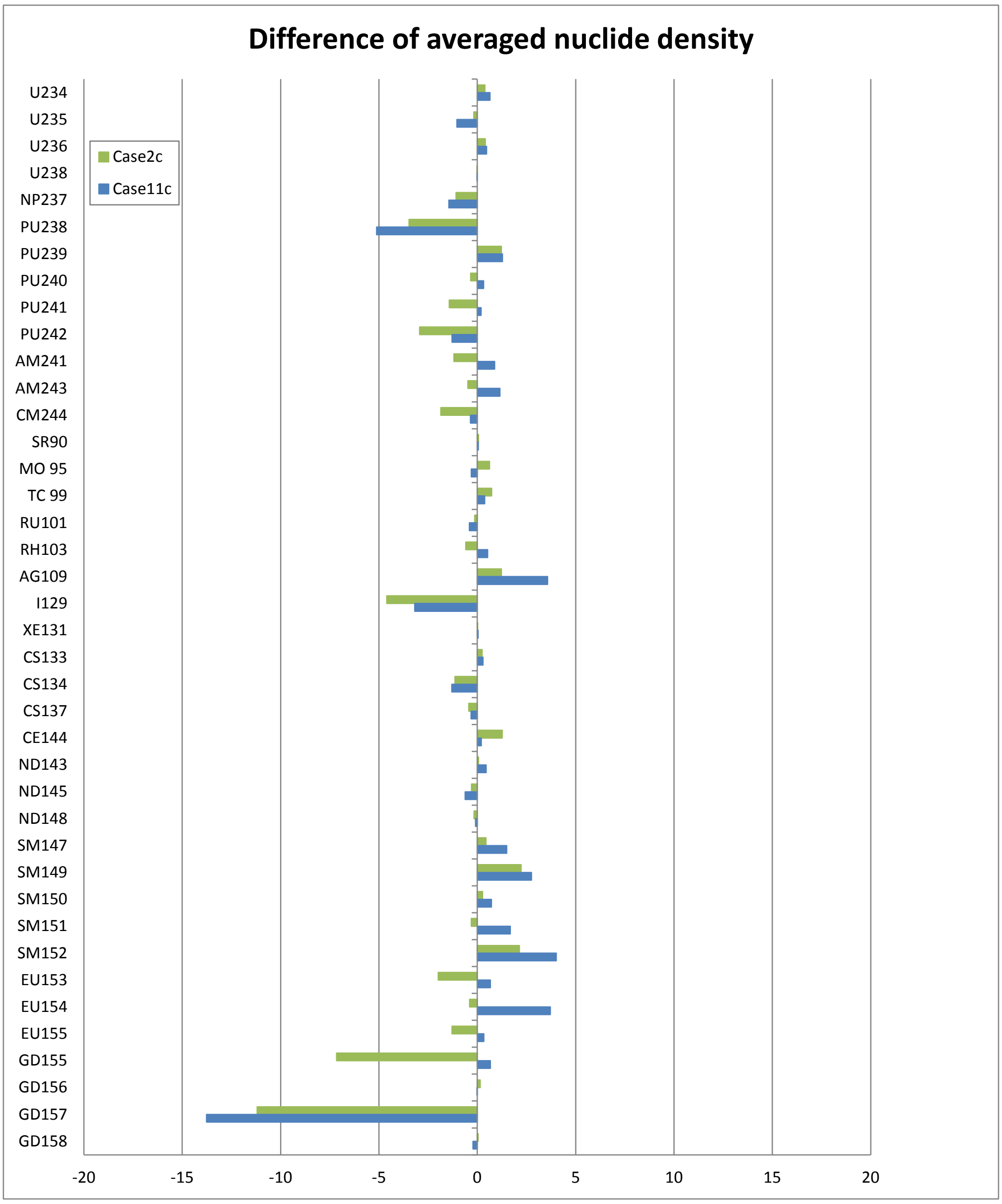


Figure 3.21: Difference of averaged nuclide density obtained by the codes based on the deterministic method to ones based on the continuous-energy Monte Carlo method void fraction 40%, 15-year cooling for 12 GWd/t and 50 GWd/t continuous-energy Monte Carlo Code; A, C, J, K, L, N, Q, R, X-A, a, e and g deterministic code; B, D, E, F, G, I, M, P, V, c, f and h



Chapter 4. Effects of the difference in burn-up calculation methods on the neutron multiplication factor

Chapter 4 discusses the status of the burn-up calculation for the BWR fuel assembly. Through the introduction of the continuous-energy Monte Carlo codes, mutual-agreement among burn-up calculation results is improved over the previous Phase III-B benchmark. Considering the objective of this benchmark, it is necessary to evaluate the effect of the difference in burn-up calculation results on the neutron multiplication factor. Participants have adopted different nuclides in their criticality calculation model and some codes use lumped (virtual) FP in order to correct the reactivity effect of fission products. The cross-section data libraries used are also different.

For a direct comparison of the impact on the neutron multiplication factor imposed by the deviation of the nuclide density data, we carried out an independent criticality calculation for each nuclide density data of each result ID with MVP, a continuous-energy Monte Carlo code. The library adopted for this exercise was JENDL-4. In this calculation, selected actinides and fission products in past EGBUC benchmarks are adopted. To assess the reactivity effect of fission products, cases without fission products are also considered. The geometry for the criticality calculation is the same as in Figure 1.1, and all fuel rods (i.e. burn-up region) are filled with the averaged nuclide density submitted by the participants. The temperature of each region is set at 300 K. The effective neutron history of the calculation is 10,000,000 (10,000 neutrons per cycle; 1,100 cycles run; and 100 initial cycles were discarded from the tallying process).

Tables 4.1 to 4.6 summarise the neutron multiplication factor, while Tables 4.4 to 4.6 show the neutron multiplication factor without fission products. It should be noted that the nuclide densities adopted in this analysis are the averaged values over whole fuel pins. Thus, fission products include gadolinium isotopes generated as fission products in all fuel pins and residual gadolinium isotopes in Gd rods. Table 4.7 shows 2-sigma$^{(r)}$ (%) of k_{inf}. Figures 4.1 to 4.6 show the neutron multiplication factor against the burn-up value.

For the cases including fission products, 2-sigma$^{(r)}$ at 12 GWd/t is almost 2% and decreases at 20 and 30 GWd/t, and then increases again, but less than 3% at 50 GWd/t. Due to the difficulties of the burn-up calculation of gadolinium isotopes, the cases of the actinides plus fission products at low burn-up (12 GWd/t) before burnout of gadolinium show a large difference in the neutron multiplication factor. After the burnout of gadolinium, 2-sigma$^{(r)}$ (%) becomes small, and then increases again at high burn-up cases due to an increase in the difference of the amount of the actinide isotopes.

When fission products are excluded from the criticality calculation, 2-sigma$^{(r)}$ is almost 0.1% at low burn-up (12 GWd/t) and becomes larger as the burn-up value increases. This can be explained by the fact that the difference of the burn-up calculation of the heavy isotope is small for the low burn-up and becomes larger for higher burn-up.

Using this criticality calculation, the impact of the difference of the current burn-up calculation code systems on criticality calculations is generally less than 3% when considering only actinides and fission products, as specified in the EGBUC benchmarks. This value is less than 2% when fission products are excluded. This analysis shows the expected uncertainty of the criticality calculation results by quantifying the spread in the multiplication factor introduced by using different burn-up calculation methodologies.

4.1 Comparison of the neutron multiplication factor obtained by using nuclide density data of the deterministic method

Table 4.8 shows 2-sigma(r) (%) of the cases using the nuclide density data by the deterministic codes. Figures 4.7 and 4.8 show the neutron multiplication factor. For the cases including fission products, 2-sigma(r) is almost 2% at 12 GWd/t and less than 3% at 50 GWd/t. For the cases when fission products are excluded from the criticality calculation, 2-sigma(r) is almost 0.2% at 12 GWd/t. The difference of the neutron multiplication factor appears prominently at 12 GWd/t, which is due to the difficulty of the process required for making the effective cross-section data especially for gadolinium burning.

4.2 Comparison of the neutron multiplication factor obtained by using nuclide density data by the continuous-energy Monte Carlo method

Table 4.9 shows the 2-sigma(r) (%) of the cases using nuclide density data with the continuous-energy Monte Carlo methods. Figures 4.9 and 4.10 show the neutron multiplication factor. Using nuclide density data obtained with the continuous-energy Monte Carlo methods, smaller 2-sigma(r) (%) values are obtained than in the cases that use nuclide density data obtained by deterministic codes. For the cases including fission products, 2-sigma(r) is less than 2% during the burn-up. For the cases when fission products are excluded from the criticality calculation, 2-sigma(r) is almost 0.1% at 12 GWd/t and becomes larger at higher burn-up even if nuclide data obtained by the continuous-energy Monte Carlo code are used.

Table 4.1. Neutron multiplication factor void fraction 40%, 5-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

Results ID	case2b	case5b	case8b	case11b
	BU [GWd/t]			
	12	20	30	50
A	1.223	1.218	1.108	0.887
B	1.225	1.214	1.101	0.871
C	1.222	1.218	1.110	0.893
D	1.243	1.214	1.102	0.880
E	1.225	1.218	1.111	0.896
F	1.245	1.215	1.105	0.887
G	1.231	1.217	1.109	0.899
H	1.210	1.218	1.112	0.901
I	1.221	1.217	1.107	0.886
J	1.246	1.216	1.106	0.887
K	1.243	1.213	1.102	0.879
L	1.235	1.216	1.107	0.888
M	1.209	1.216	1.107	0.890
N	1.222	1.219	1.113	0.902
O	1.200	1.223	1.119	0.909
P	1.242	1.217	1.109	0.896
Q	1.226	1.217	1.108	0.891
R	1.227	1.216	1.107	0.888
S	1.229	1.221	1.117	0.903
T	1.234	1.219	1.112	0.896
U	1.245	1.218	1.114	0.917
V	1.247	1.218	1.109	0.895
W	1.237	1.219	1.111	0.895
X	1.223	1.219	1.111	0.896
Y	1.232	1.220	1.115	0.901
Z	1.229	1.221	1.116	0.902
a	1.232	1.218	1.109	0.891
b	1.226	1.218	1.110	0.894
c	1.238	1.217	1.110	0.898
d	1.239	1.217	1.110	0.897
e	1.203	1.215	1.105	0.887
f	1.241	1.218	1.109	0.897
g	1.230	1.218	1.111	0.895
h	1.227	1.218	1.109	0.891
i	1.228	1.219	1.111	0.897
Average	1.230	1.218	1.109	0.894
2-sigma	0.024	0.004	0.008	0.017
2-sigma(r) [%]	1.9	0.3	0.7	1.9

Table 4.2. Neutron multiplication factor void fraction 40%, 15-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

Results ID	case2c	case5c	case8c	case11c
	BU [GWd/t]			
	12	20	30	50
A	1.217	1.203	1.080	0.836
B	1.220	1.200	1.074	0.821
C	1.215	1.203	1.083	0.843
D	1.237	1.199	1.074	0.828
E	1.219	1.204	1.084	0.845
F	1.239	1.200	1.079	0.836
G	1.224	1.202	1.082	0.848
H	1.204	1.204	1.086	0.854
I	1.214	1.202	1.080	0.835
J	1.239	1.201	1.079	0.836
K	1.237	1.198	1.075	0.828
L	1.229	1.201	1.079	0.837
M	1.203	1.202	1.079	0.838
N	1.216	1.204	1.085	0.851
O	1.195	1.211	1.098	0.870
P	1.236	1.202	1.082	0.845
Q	1.220	1.202	1.081	0.840
R	1.221	1.201	1.079	0.837
S	1.224	1.207	1.091	0.856
T	1.227	1.205	1.086	0.847
U	1.239	1.202	1.085	0.863
V	1.241	1.203	1.082	0.844
W	1.231	1.204	1.083	0.844
X	1.217	1.204	1.084	0.845
Y	1.226	1.206	1.089	0.853
Z	1.223	1.207	1.091	0.854
a	1.226	1.203	1.081	0.840
b	1.220	1.203	1.084	0.845
c	1.232	1.202	1.082	0.847
d	1.232	1.202	1.082	0.846
e	1.196	1.200	1.077	0.836
f	1.235	1.203	1.082	0.847
g	1.224	1.204	1.084	0.846
h	1.221	1.203	1.082	0.840
i	1.222	1.204	1.084	0.846
Average	1.223	1.203	1.083	0.844
2-sigma	0.024	0.005	0.009	0.019
2-sigma$^{(r)}$ [%]	1.9	0.4	0.9	2.3

Table 4.3. Neutron multiplication factor void fraction 70%, 5-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

Results ID	case3b	case6b	case9b	case12b
	BU [GWd/t]			
	12	20	30	50
A	1.188	1.230	1.135	0.954
B	1.185	1.235	1.128	0.939
C	1.185	1.230	1.136	0.960
D	1.207	1.227	1.130	0.950
E	1.164	1.231	1.138	0.965
F	1.206	1.228	1.134	0.960
G	1.192	1.230	1.137	0.967
H	1.173	1.227	1.134	0.957
I	1.185	1.229	1.132	0.950
J	1.211	1.228	1.133	0.954
K	1.209	1.225	1.129	0.947
L	1.198	1.229	1.134	0.956
M	1.176	1.228	1.133	0.953
N	1.188	1.231	1.137	0.965
O	1.166	1.234	1.143	0.971
P	1.197	1.230	1.137	0.963
Q	1.191	1.229	1.135	0.958
R	1.194	1.228	1.133	0.955
S	1.191	1.233	1.141	0.967
T	1.196	1.230	1.137	0.959
U	1.179	1.232	1.146	0.992
V	1.214	1.229	1.135	0.958
W	1.203	1.230	1.137	0.961
X	1.187	1.231	1.138	0.963
Y	1.194	1.231	1.141	0.965
Z	1.190	1.232	1.141	0.966
a	1.200	1.230	1.135	0.958
b	1.192	1.229	1.135	0.958
c	1.202	1.230	1.138	0.968
d	1.206	1.230	1.137	0.964
e	1.170	1.228	1.132	0.955
f	1.204	1.230	1.136	0.962
g	1.191	1.230	1.137	0.962
h	1.189	1.229	1.135	0.956
i	1.192	1.231	1.138	0.963
Average	1.192	1.230	1.136	0.960
2-sigma	0.025	0.004	0.008	0.017
2-sigma$^{(r)}$ [%]	2.1	0.3	0.7	1.8

Table 4.4. Neutron multiplication factor void fraction 40%, 5-year cooling, actinide only

Results ID	case2b	case5b	case8b	case11b
	BU[GWd/t]			
	12	20	30	50
A	1.356	1.292	1.205	1.018
B	1.355	1.289	1.200	1.003
C	1.356	1.293	1.208	1.024
D	1.355	1.289	1.201	1.011
E	1.357	1.293	1.209	1.028
F	1.354	1.290	1.203	1.018
G	1.356	1.292	1.208	1.030
H	1.356	1.293	1.210	1.030
I	1.356	1.292	1.206	1.016
J	1.355	1.290	1.203	1.016
K	1.354	1.288	1.201	1.010
L	1.355	1.291	1.204	1.018
M	1.356	1.291	1.205	1.020
N	1.357	1.293	1.210	1.032
O	1.357	1.294	1.210	1.025
P	1.356	1.292	1.207	1.026
Q	1.355	1.292	1.206	1.022
R	1.355	1.291	1.205	1.020
S	1.358	1.297	1.215	1.034
T	1.357	1.295	1.211	1.026
U	1.356	1.295	1.215	1.054
V	1.356	1.291	1.206	1.024
W	1.356	1.293	1.208	1.024
X	1.357	1.293	1.209	1.026
Y	1.358	1.296	1.213	1.032
Z	1.358	1.297	1.214	1.032
a	1.356	1.292	1.206	1.022
b	1.356	1.293	1.207	1.024
c	1.356	1.292	1.207	1.030
d	1.356	1.292	1.207	1.028
e	1.355	1.290	1.203	1.017
f	1.356	1.292	1.207	1.028
g	1.356	1.292	1.206	1.020
h	1.356	1.292	1.207	1.022
i	1.357	1.294	1.209	1.029
Average	1.356	1.292	1.207	1.024
2-sigma	0.002	0.004	0.008	0.017
2-sigma(r) [%]	0.1	0.3	0.6	1.7

Table 4.5. Neutron multiplication factor void fraction 40%, 15-year cooling, actinide only

Results ID	case2c	case5c	case8c	case11c
	BU [GWd/t]			
	12	20	30	50
A	1.351	1.279	1.182	0.973
B	1.350	1.277	1.177	0.959
C	1.351	1.280	1.185	0.980
D	1.350	1.277	1.177	0.966
E	1.352	1.281	1.186	0.985
F	1.349	1.277	1.181	0.974
G	1.351	1.279	1.184	0.986
H	1.351	1.281	1.187	0.986
I	1.351	1.279	1.183	0.973
J	1.349	1.277	1.180	0.972
K	1.348	1.275	1.177	0.966
L	1.350	1.278	1.181	0.974
M	1.351	1.279	1.181	0.976
N	1.351	1.280	1.186	0.988
O	1.352	1.282	1.187	0.982
P	1.351	1.279	1.183	0.983
Q	1.350	1.279	1.182	0.978
R	1.350	1.278	1.182	0.976
S	1.353	1.284	1.191	0.990
T	1.352	1.282	1.187	0.981
U	1.351	1.281	1.190	1.008
V	1.351	1.279	1.183	0.979
W	1.351	1.281	1.185	0.981
X	1.351	1.281	1.186	0.983
Y	1.352	1.283	1.190	0.987
Z	1.353	1.284	1.191	0.989
a	1.351	1.280	1.183	0.977
b	1.351	1.280	1.185	0.980
c	1.351	1.280	1.184	0.985
d	1.351	1.280	1.184	0.984
e	1.350	1.277	1.179	0.973
f	1.351	1.280	1.184	0.984
g	1.351	1.279	1.183	0.977
h	1.351	1.280	1.184	0.978
i	1.352	1.281	1.186	0.984
Average	1.351	1.280	1.184	0.980
2-sigma	0.002	0.004	0.007	0.017
2-sigma$^{(r)}$ [%]	0.1	0.3	0.6	1.7

Table 4.6. Neutron multiplication factor void fraction 70%, 5-year cooling, actinide only

Results ID	case3b	case6b	case9b	case12b
	BU [GWd/t]			
	12	20	30	50
A	1.362	1.305	1.232	1.084
B	1.361	1.310	1.227	1.072
C	1.362	1.306	1.233	1.090
D	1.361	1.302	1.228	1.080
E	1.363	1.307	1.236	1.097
F	1.361	1.304	1.232	1.090
G	1.362	1.306	1.235	1.097
H	1.362	1.304	1.231	1.085
I	1.362	1.304	1.231	1.080
J	1.361	1.303	1.230	1.083
K	1.360	1.301	1.227	1.079
L	1.361	1.304	1.231	1.085
M	1.362	1.304	1.230	1.083
N	1.362	1.306	1.234	1.094
O	1.363	1.307	1.235	1.088
P	1.362	1.305	1.234	1.093
Q	1.362	1.305	1.232	1.088
R	1.361	1.304	1.231	1.086
S	1.364	1.309	1.240	1.098
T	1.363	1.307	1.236	1.090
U	1.364	1.311	1.247	1.128
V	1.362	1.304	1.232	1.088
W	1.362	1.306	1.233	1.090
X	1.362	1.307	1.235	1.092
Y	1.363	1.308	1.240	1.097
Z	1.364	1.309	1.239	1.097
a	1.362	1.305	1.232	1.088
b	1.363	1.306	1.234	1.090
c	1.362	1.306	1.235	1.098
D	1.362	1.305	1.234	1.094
E	1.361	1.303	1.229	1.084
F	1.362	1.305	1.233	1.092
G	1.362	1.304	1.232	1.086
H	1.362	1.305	1.233	1.086
I	1.363	1.306	1.235	1.094
Average	1.362	1.305	1.233	1.090
2-sigma	0.002	0.004	0.008	0.018
2-sigma$^{(r)}$ [%]	0.1	0.3	0.6	1.7

Table 4.7. 2-sigma(r) (%) of k_{inf} (all results) fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

Void Fraction / Cooling time	Burn-up [GWd/t]							
	Actinide + FP				Actinide only			
	12	20	30	50	12	20	30	50
40%/5 year	1.9	0.3	0.7	1.9	0.1	0.3	0.6	1.7
40%/15 year	1.9	0.4	0.9	2.3	0.1	0.3	0.6	1.7
70%/5 year	2.1	0.3	0.7	1.8	0.1	0.3	0.6	1.7

Table 4.8. 2-sigma(r) (%) of k_{inf} (using nuclide density data by deterministic method) fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

Void Fraction / Cooling time	Burn-up [GWd/t]							
	Actinide + FP				Actinide only			
	12	20	30	50	12	20	30	50
40%/5 year	2.2	0.4	0.8	2.0	0.2	0.4	0.7	1.6
40%/15 year	2.1	0.5	1.1	2.6	0.2	0.4	0.7	1.7
70%/5 year	2.4	0.3	0.7	1.7	0.1	0.3	0.6	1.4

Table 4.9. 2-sigma(r) (%) of k_{inf} (using nuclide density data by continuous-energy Monte Carlo method) fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

Void Fraction / Cooling time	Burn-up [GWd/t]							
	Actinide + FP				Actinide only			
	12	20	30	50	12	20	30	50
40%/5 year	1.7	0.3	0.5	1.3	0.1	0.2	0.4	1.1
40%/15 year	1.7	0.3	0.5	1.4	0.1	0.3	0.5	1.1
70%/5 year	1.7	0.3	0.4	0.9	0.1	0.2	0.4	0.8

Figure 4.1. Neutron multiplication factor against burn-up void fraction 40%, 5-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

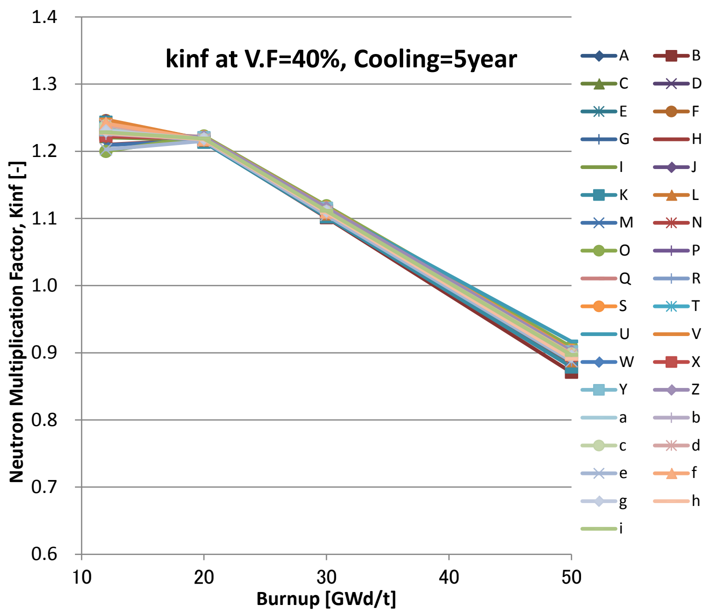


Figure 4.2. Neutron multiplication factor against burn-up void fraction 40%, 15-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

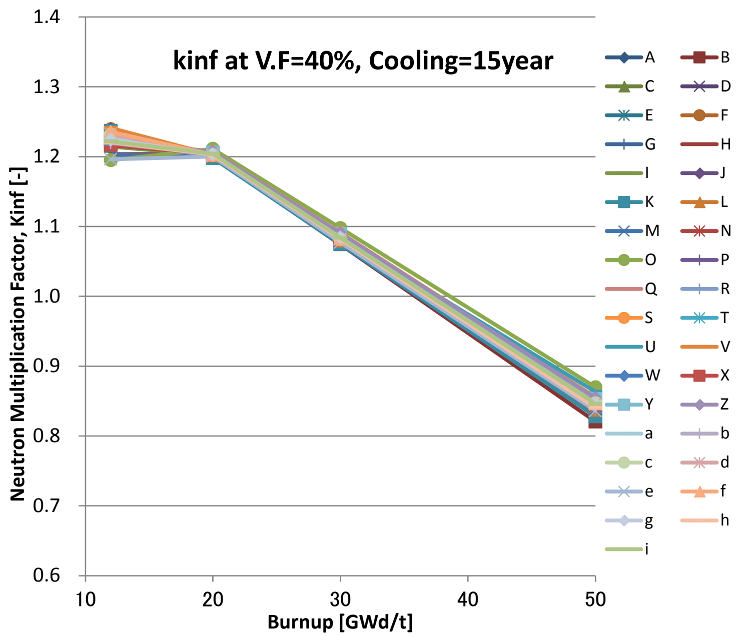


Figure 4.3. Neutron multiplication factor against burn-up void fraction 70%, 5-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

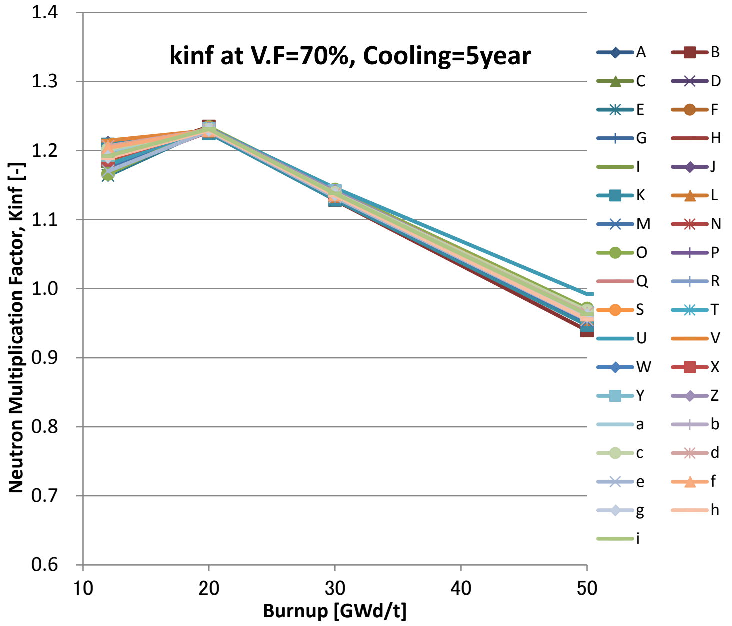


Figure 4.4. Neutron multiplication factor against burn-up void fraction 40%, 5-year cooling, actinide only

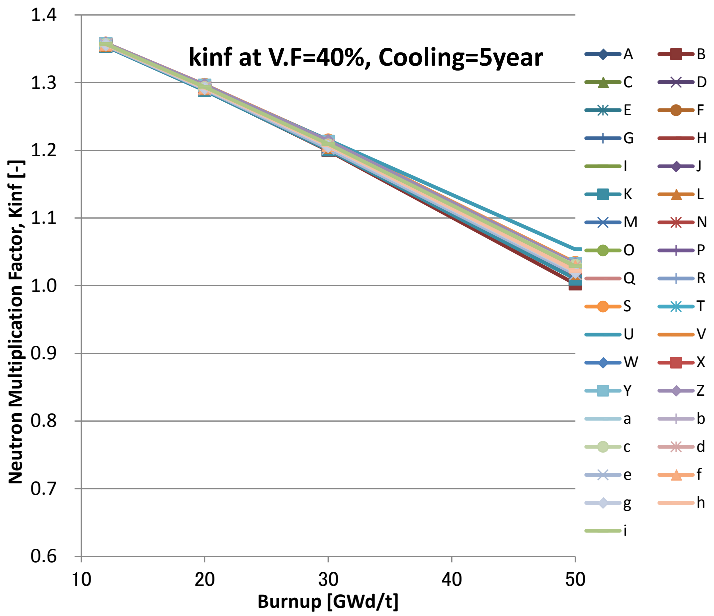


Figure 4.5. Neutron multiplication factor against burn-up void fraction 40%, 15-year cooling, actinide only

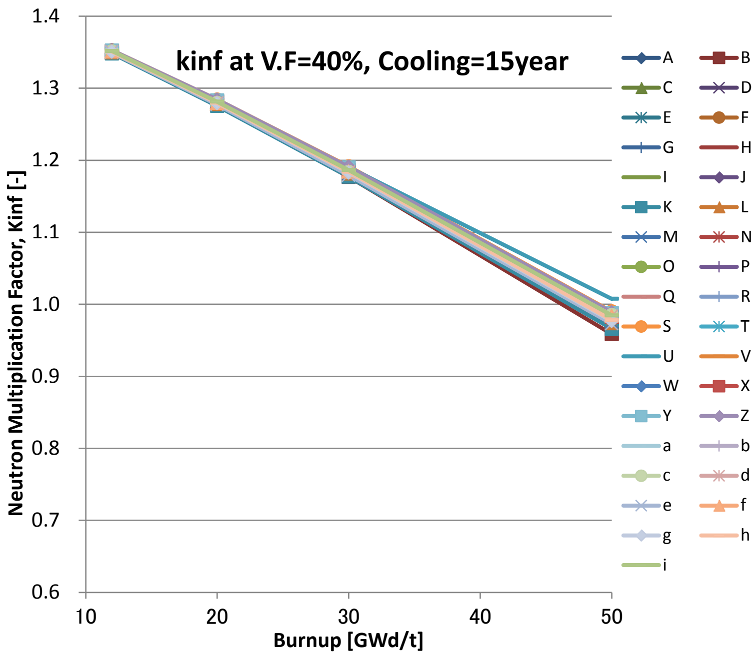


Figure 4.6. Neutron multiplication factor against burn-up void fraction 70%, 5-year cooling, actinide only

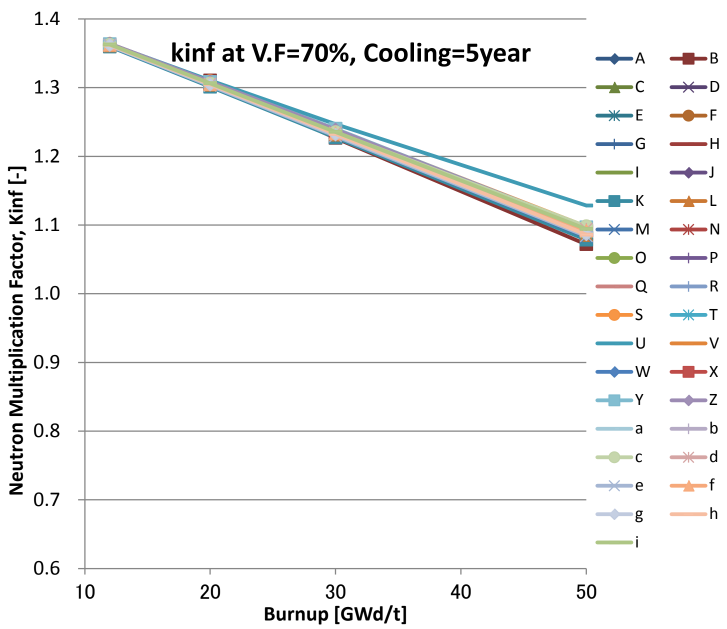


Figure 4.7. Neutron multiplication factor against burn-up using nuclide density data by deterministic method void fraction 40%, 15-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

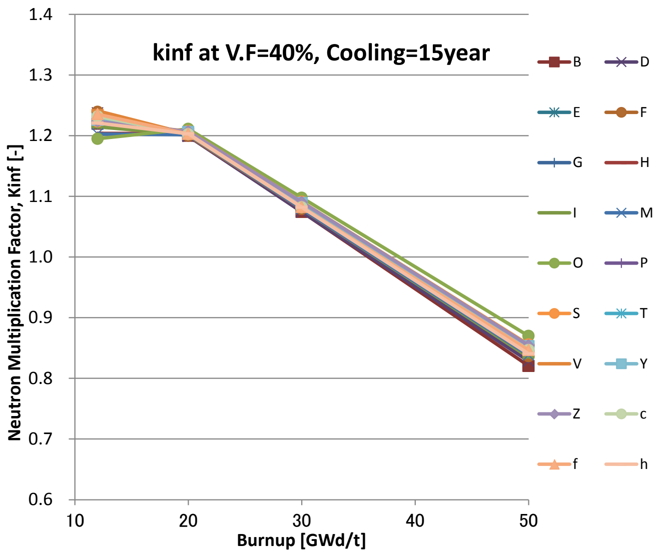


Figure 4.8. Neutron multiplication factor against burn-up using nuclide density data by deterministic method void fraction 40%, 15-year cooling, actinide only

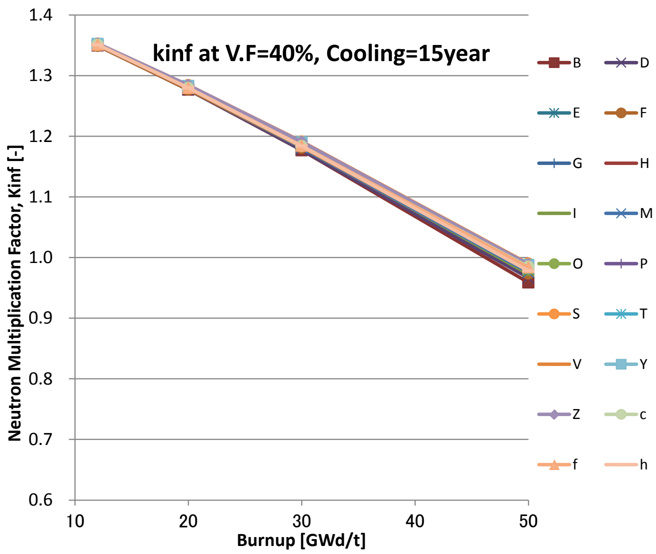


Figure 4.9. Neutron multiplication factor against burn-up using nuclide density data by continuous-energy Monte Carlo method void fraction 40%, 15-year cooling, actinide + fission products include Gd isotopes generated by fission and residue Gd isotopes in Gd rods

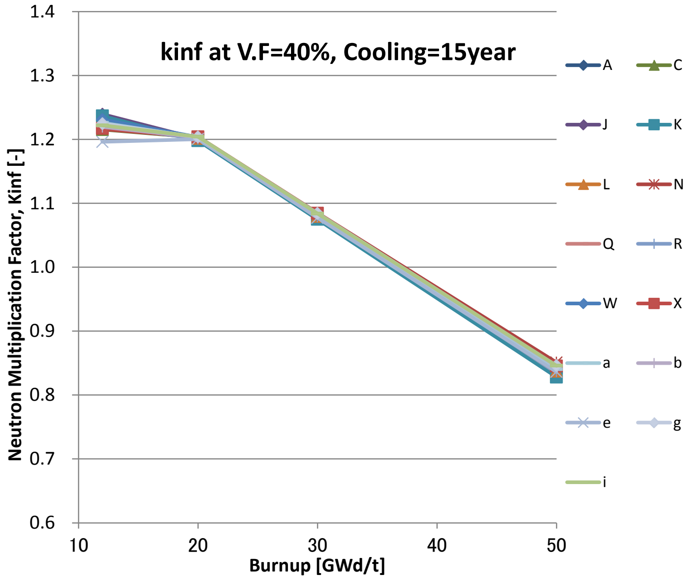
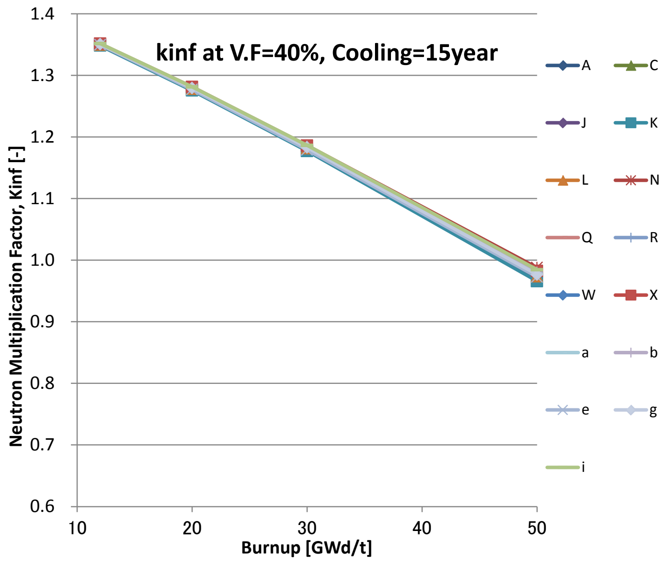


Figure 4.10. Neutron multiplication factor against burn-up using nuclide density data by continuous-energy Monte Carlo method void fraction 40%, 15-year cooling, actinide only



Chapter 5. Conclusion

5.1 Nuclide density

The 2-sigma$^{(r)}$ of ^{235}U is less than 6% and that of $^{239, 240, 241}$Pu is less than 7%. For minor actinides, i.e. ^{237}Np, ^{241,243}Am and ^{244}Cm, 2-sigma$^{(r)}$ becomes larger than 10%. This is a consequence of the difference in the evaluated nuclear data adopted by each calculation code. For fission products isotopes which are important for reactivity evaluation, i.e. ^{95}Mo, ^{99}Tc, ^{101}Ru, ^{103}Rh, ^{109}Ag, ^{133}Cs, $^{147, 149, 150, 151, 152}$Sm, $^{143, 145}$Nd, ^{153}Eu and ^{155}Gd, in general, 2-sigma$^{(r)}$ is less than 7%, except for ^{109}Ag(<30%), ^{147}Sm(<10%), $^{149, 151, 152}$Sm(<20%) and ^{155}Gd(<50%). Concerning ^{155}Gd and ^{109}Ag, the results seem to belong to one of two groups.

In general, the mutual-agreement of nuclide density has improved since the Phase III-B benchmark.

Other fission products which are important for severe accident analysis such as ^{90}Sr, ^{129}I and ^{137}Cs have 2-sigma$^{(r)}$ of approximately 20%. ^{134}Cs also has a relatively large 2-sigma$^{(r)}$ (%) value. The reason for this is that JENDL-4 adopted a new evaluation of ^{133}Cs neutron capture cross-section.

5.2 Neutron multiplication factor

Concerning the neutron multiplication factors, 2-sigma$^{(r)}$ is less than 0.6% for lower burn-up, and becomes about 1.6% at 10 GWd/t and gets smaller at 30 and 50 GWd/t. This might be a sufficient agreement considering the adopted nuclide for the criticality calculation. Comparison of peak k_{inf} shows that it has approximately 2-sigma$^{(r)}$ of 1% and it becomes larger in cases of higher void fraction.

5.3 Burn-up distribution

Comparison of the burn-up distribution is not the main purpose of this benchmark, but confirmation of the credibility of the calculation. Generally, good agreement of the burn-up distribution is shown. But the many SCALE results show a great difference in the burn-up distribution from the burn-up calculation code based on the continuous-energy Monte Carlo code or other production codes, such as CASMO. This may be explained by the fact that the burn-up problem of the gadolinium isotope is still difficult and some uncertainty remains depending on the code and participants.

5.4 Comparison of nuclide density data among SCALE6.1 results

The averaged nuclide density obtained by the same system has the same (or almost the same) results under ideal conditions. As many users submitted results in this benchmark by adopting the SCALE6.1 system, a mutual comparison of SCALE6.1 results was carried out. The 2-sigma$^{(r)}$ of heavy isotopes is approximately 4%. In fission products, there are few nuclides which have a larger 2-sigma$^{(r)}$ value than 5%.

In fission products, there are several nuclides which have 2-sigma$^{(r)}$ values larger than 5%. By excluding the ENDF/B-V-based results, the 2-sigma$^{(r)}$ value of nuclide densities of fission products, especially for ^{151}Sm, ^{154}Gd and ^{155}Gd, became small. This is due to the fact that data relevant to fission product generation had been considerably improved from ENDF/B-V to ENDF/B-VII.

The nuclides with large 2-sigma$^{(r)}$ (%) have large sensitivity to the neutron cross-section of themselves and their parent nuclides. The difference among nuclide densities results from the characteristic of the parameter settings of burn-up calculation such as burn-up step,adopted data libraries and geometry modelling. This fact implies that the evaluation results should be well examined based on the adopted calculation model and the credibility of input data and libraries, even if a well-qualified calculation code and a library such as the widely used SCALE are used.

5.5 Comparison of nuclide density data among CASMO-4E results

Six results of CASMO are submitted but the adopted library is not unified. The averaged nuclide density results using the same library agree very well, generally having 2-sigma$^{(r)}$ less than 2%, except for ^{144}Ce and ^{157}Gd. This is due to the fact that CASMO is a commercially supported code and a well-qualified input output control may be organised to obtain the same calculation results for this typical burn-up problem. The reason why ^{144}Ce and ^{157}Gd have larger 2-sigma$^{(r)}$ (%) values than other cases should be explored. Generally the agreement of the CASMO-4E results using a library based on ENDF/B-VI is good, but not as good as the results using a library based on JEF-2.2.

5.6 Comparison of nuclide density data among the codes adopting the deterministic method

Including SCALE6.1 and CASMO, the evaluation of the 2-sigma$^{(r)}$ (%) of the deterministic codes shows that for main heavy nuclides such as uranium and plutonium, except for ^{238}Pu, 2-sigma$^{(r)}$ is generally less than 6% except ^{234}U(11%). Fission products except ^{109}Ag, ^{129}I and gadolinium isotopes have relatively small 2-sigma$^{(r)}$ (%).This is remarkable progress from the previous benchmark Phase III-B. The larger 2-sigma$^{(r)}$ (%) of gadolinium isotopes for lower burn-up case comes from the difference in the treatment of the gadolinium burning problem because several code users adopted a limited number of Gd rod divisions and burn-up steps. For the higher burn-up case, the accumulated ^{155}Eu affects the amount of ^{155}Gd during the cooling time. There is a dependency of ^{155}Gd nuclide density on the adopted cross-section data libraries. For further improvement, the neutron cross-section, fission yield and decay data related to the ^{155}Gd generation should be examined as a common problem for all participants.

5.7 Comparison of nuclide density data among the codes adopting the continuous-energy Monte Carlo method

The analysis shows that many heavy nuclides have 2-sigma$^{(r)}$ of less than 4% and many fission products have that of less than approximately 5%. Some heavy nuclides, i.e. ^{238}Pu, ^{243}Am and ^{244}Cm, have 2-sigma$^{(r)}$ of larger than 10% but they are still less than 15%. These relatively larger 2-sigma$^{(r)}$ (%) values result from the difference in the adopted neutron cross-section data. ^{109}Ag and ^{129}I have 2-sigma$^{(r)}$ larger than 15%, which are due to the difference in the fission yield data.

Europium and gadolinium isotopes have large 2-sigma$^{(r)}$ (%).^{154}Eu has extremely large values and the heavy burn-up dependency is clearly shown. This is due to the fact that a calculation code adopting JEF-2.2 gives a relatively large result. With the exception of the results using JEF-2.2, ^{154}Eu has 2-sigma$^{(r)}$ of less than 15%, a result expected based on an earlier study [8].

5.8 Comparison of nuclide density data among the codes adopting the continuous-energy Monte Carlo method – same library but different codes

A few participants used different code systems such as SWAT4, MVP-BURN, MCNP-BURN2 and MONTEBURNS2 and the same library, JENDL-4. Except for a few isotopes, each code agrees very well with a 2-sigma$^{(r)}$ of 2-4%. For ^{244}Cm, ^{109}Ag, ^{129}I and ^{155}Eu, a relatively large 2-sigma$^{(r)}$ (%) is observed. By the complementary calculation, the 2-sigma$^{(r)}$ (%) of fission products could be improved and ^{109}Ag and ^{129}I could also be improved considerably. This follows from the revision of the adopted fission yield data. These results show that focus should be placed on the adopted fission yield data for further improvement of the burn-up calculation code.

5.9 Comparison of nuclide density data among the codes adopting the continuous-energy Monte Carlo method –same library and code

Three participants used ENDF/B-VII for the SERPENT code. It is expected that these results agree very well with each other. Two results used the identical version of the code. The results for major actinides are typically a 2-sigma$^{(r)}$ between 1 and 4% and many fission products have approximately less than 1% except for a few isotopes. The effect of the "difference of the users" is small if codes based on the continuous-energy Monte Carlo code are used because it treats a precise geometrical model and no complex procedures are needed to generate effective cross-section data of each burn-up region. For ^{155}Gd and ^{157}Gd at 12GWd/t, 2-sigma$^{(r)}$ is almost higher than 10%. This might be a consequence of the difference in the burn-up step number.

5.10 Comparison of the selected codes representing the group of the continuous-energy Monte Carlo method and the deterministic codes

Several calculation results adopting the latest nuclear data libraries, i.e. JENDL-4, ENDF/B-VII and JEF-3.1.1, have been compared across the codes based on the continuous-energy Monte Carlo method and the deterministic method.

Comparison of the assembly-averaged nuclide density data shows that the differences between the selected deterministic codes and the continuous-energy Monte Carlo codes are small, generally less than 5%. For ^{155}Gd and ^{157}Gd, larger differences than other nuclides are shown, but still less than 15%. Generally, these results show that the current burn-up calculation code adopting the continuous-energy Monte Carlo code and the deterministic code agree well with each other, except for a few nuclides.

5.11 Evaluation of the neutron multiplication factor using averaged nuclide density data from each participant

For the direct comparison of the difference of the neutron multiplication factor which derives from the difference in the burn-up calculation results, an independent criticality calculation was carried out by using nuclide density data of each *Result ID* by using MVP, a continuous-energy Monte Carlo code, adopting the cross-section data library of JENDL-4.

For the cases including fission products, 2-sigma$^{(r)}$ at 12GWd/t is almost 2% and decreases at 20 and 30 GWd/t, and then increases again, but less than 3% at 50 GWd/t. When fission products are excluded from the criticality calculation, 2-sigma$^{(r)}$ is almost 0.1% at low burn-up (12 GWd/t) and becomes larger as the burn-up value increases.

Using this criticality calculation, the impact of the difference in the current burn-up calculation code systems on criticality calculations is generally less than 3% when considering only actinides and fission products, as specified in the EGBUC benchmarks. Criticality calculation is less than 2% when fission products are excluded. This analysis shows the possible uncertainty of the criticality calculation results which derives from the difference of the burn-up calculation results obtained by the different burn-up calculation systems.

5.12 Summary

The present benchmark confirms substantial progress in the burn-up calculation capabilities if compared to the 2002 Phase III-B benchmark. Introduction of the continuous-energy Monte Carlo codes has a clear advantage in treating the multi-dimensional burn-up calculation problem, even if it requires longer CPU time. The treatment of the gadolinium rod is, however, still a key issue. Since current PWR fuel assemblies may use gadolinium rods to suppress initial excess reactivity, this benchmark may be of interest to PWR fuel vendors seeking to evaluate their capability to model gadolinium fuel burn-up.

Even using the continuous-energy Monte Carlo codes, fission product isotopes showed relatively large differences among participants as a result of some codes using old fission yield data. To improve accuracy of burn-up calculation codes, focus should be placed on the nuclear data libraries used, not only on neutron cross-section data, but also on decay and fission yield data.

The difference in the neutron multiplication factor obtained by the different burn-up calculation results is less than 3% when the latest code system is used. These results show uncertainty in the estimation of the neutron multiplication factor which arises from the difference between the burn-up calculation code systems, used in the participant countries as the state-of-the-art system.

Chapter 6. Description of calculation methods used by the participants

< Result A>

Institute and country

JAEA, Japan

Participants

Yuriko Uchida, Kenya Suyama

Neutron data library

JENDL-4

Neutron data processing code or method

SWAT4 (MVP)

Number of neutron energy group

Continuous-Energy

Description of your code system

SWAT4 is a burn-up code system combining a point burn-up code (ORIGEN2) and continuous-energy Monte Carlo code (MVP or MCNP5) or deterministic code SRAC2006. SWAT4 executes the MVP/MCNP5/SRAC2006 and the ORIGEN2 codes. SWAT4 can treat the complex geometry due to the flexibility of the continuous-energy Monte Carlo code, and it can evaluate the detailed characteristics of spent nuclear fuel such as radioactivity, decay heat, and number of neutron emission using the function of the ORIGEN2 code.

SWAT4 is the latest version of SWAT, which has a capability to control SRAC2006. SWAT4 and SWAT3.1 provide the same results as when MVP and MCNP5 codes are used.

In this calculation SWAT4 drives MVP for neutron transport calculation.

Geometry modelling

1/8 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

radial: eight (of equal volume), azimuthal: one

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

200 MWd/t from 0 MWd/t to 200 MWd/t

300 MWd/t from 200 MWd/t to 500 MWd/t

250 MWd/t from 500 MWd/t to 1 GWd/t

500 MWd/t from 500 MWd/t to 15 GWd/t

1.5 GWd/t from 15 GWd/t to 18 GWd/t

2.0 GWd/t from 18 GWd/t to 20 GWd/t

2.5 GWd/t from 20 GWd/t to 50 GWd/t

Neutron history number

10000 particles per cycle were simulated for a total of 1100 cycles including 100 inactive cycles

Detail of fission yield data

JENDL-4

Detail of FP chain data

ORIGEN22UPJ

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN22UPJ and ORLIBJ40

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

K. Suyama et al. JAEA-Data/Code 2009-002 [in Japanese]

Date

2013/5/30

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Institute and country

JAEA, Japan

Participants

Yuriko Uchida, Kenya Suyama

Neutron data library

JENDL-4

Neutron data processing code or method

SWAT4 (SRAC2006)

Number of neutron energy group

107 groups

Description of your code system

SWAT4 is a burn-up code system combining a point burn-up code (ORIGEN2) and continuous-energy Monte Carlo code (MVP or MCNP5) or deterministic code SRAC2006. SWAT4 executes the MVP/MCNP5/SRAC2006 and the ORIGEN2 codes. SWAT4 can treat the complex geometry due to the flexibility of the continuous-energy Monte Carlo code, and it can evaluate the detailed characteristics of spent nuclear fuel such as radioactivity, decay heat, and number of neutron emission using the function of the ORIGEN2 code.

SWAT4 is the latest version of SWAT, which has a capability to control SRAC2006. SWAT4 and SWAT3.1 provide the same results as when MVP and MCNP5 codes are used.

SRAC is a code system applicable to the neutronics analysis of a variety of reactor types. SRAC integrates five elementary codes for neutron transport and diffusion calculation (PIJ, 1D and 2D SN transport, 1D and multi-D diffusion). PIJ is based on the collision probability method applicable to 16 kinds of lattice models.

In this calculation SWAT4 drives SRAC2006 for neutron transport calculation.

Geometry modelling

1/4 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

radial: eight (of equal volume), azimuthal: one

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

200 MWd/t from 0 MWd/t to 200 MWd/t

300 MWd/t from 200 MWd/t to 500 MWd/t

250 MWd/t from 500 MWd/t to 1 GWd/t

500 MWd/t from 500 MWd/t to 15 GWd/t

1.5 GWd/t from 15 GWd/t to 18 GWd/t

2.0 GWd/t from 18 GWd/t to 20 GWd/t

2.5 GWd/t from 20 GWd/t to 50 GWd/t

Detail of fission yield data

JENDL-4

Detail of FP chain data

ORIGEN22UPJ

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was selected

ORIGEN22UPJ and ORLIBJ40

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

–

Other related information

–

References

K. Suyama et al. JAEA-Data/Code 2009-002 [in Japanese]

K. OKUMURA et al. JAEA-Data/Code 2007-004

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Institute and country

JAEA, Japan

Participants

Yuriko Uchida, Kenya Suyama

Neutron data library

JENDL-4

Neutron data processing code or method

MVP-BURN

Number of neutron energy group

Continuous-Energy

Description of your code system

MVP-BURN is a burn-up code system based on a continuous-energy Monte Carlo code (MVP). MVP-BURN can treat the complex geometry due to the flexibility of the continuous-energy Monte Carlo code.

Geometry modelling

1/8 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

radial: eight (of equal volume), azimuthal: four

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

100 MWd/t from 0 MWd/t to 200 MWd/t

300 MWd/t from 200 MWd/t to 500 MWd/t

500 MWd/t from 500 MWd/t to 16 GWd/t

1.0 GWd/t from 16 GWd/t to 20 GWd/t

2.5 GWd/t from 20 GWd/t to 30 GWd/t

4.0GWd/t from 30 GWd/t to 50 GWd/t

Neutron history number

5000 particles per cycle were simulated for a total of 2100 cycles including 100 inactive cycles

Detail of fission yield data

u4cm6fp119bp14T_J40

Detail of FP chain data

u4cm6fp119bp14T_J40

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.02%dk/k (1 sigma)

Other related information

-

References

K. Okumura et al. (2000), Journal of Nuclear Science and Technology, 37[2], 128-138.

K. Shibata et al. (2011), Journal of Nuclear Science and Technology, 48[1], 1-30.

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Institute and country

US NRC, United States

Participants

Amrit Patel

Neutron data library

ENDF/B-VII

Neutron data processing code or method

SCALE 6.1.1 (TRITON, T-DEPL Sequence)

Number of neutron energy group

49 groups

Description of your code system

TRITON can be used to provide automated, problem-dependent cross-section processing followed by calculation of the neutron multiplication factor for a 2-D configuration using NEWT. In addition, this functionality can be iterated in tandem with ORIGEN-S depletion calculations to predict isotopic concentrations, source terms, and decay heat as a result of time-varying fluxes calculated in a two-dimensional deterministic fashion or in a three-dimensional stochastic approach.

Geometry modelling

1/4 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

five radial regions

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

3.1625 MWd/t	from	0	MWd/t	to	25.3	MWd/t
12.65 MWd/t	from	25.3	MWd/t	to	37.95	MWd/t
25.3 MWd/t	from	37.95	MWd/t	to	63.25	MWd/t
50.6 MWd/t	from	63.25	MWd/t	to	113.85	MWd/t
172.293 MWd/t	from	113.85	MWd/t	to	286.143	MWd/t
632.5 MWd/t	from	286.143	MWd/t	to	9773.643	MWd/t
452.617 MWd/t	from	9773.643	MWd/t	to	10226.26	MWd/t
632.5 MWd/t	from	10226.26	MWd/t	to	11491.26	MWd/t
445.28 MWd/t	from	11491.26	MWd/t	to	11936.54	MWd/t
126.5 MWd/t	from	11936.54	MWd/t	to	13201.54	MWd/t

632.5 MWd/t	from	13201.54 MWd/t	to	15731.54 MWd/t
3795 MWd/t	from	15731.54 MWd/t	to	19526.54 MWd/t
946.473 MWd/t	from	19526.54 MWd/t	to	21419.486 MWd/t
3795 MWd/t	from	21419.486 MWd/t	to	25214.486 MWd/t
3873.43 MWd/t	from	25214.486 MWd/t	to	40708.206 MWd/t
3795 MWd/t	from	40708.206 MWd/t	to	44503.206 MWd/t
2883.188 MWd/t	from	44503.206 MWd/t	to	47386.394 MWd/t
2613.606 MWd/t	from	47386.394 MWd/t	to	50000 MWd/t

Detail of fission yield data

Note that Dancoff factors were used

Detail of FP chain data

Note that a 49-group energy structure (collapsed from the standard 238-group energy structure) was used for depletion calculations

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

Other related information

-

References

Scale: A Comprehensive Modelling and Simulation Suite for Nuclear Safety Analysis and Design, ORNL/TM-2005/39, Version 6.1, Oak Ridge National Laboratory, Oak Ridge, Tennessee, June 2011.

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Institute and country

JNES, Japan

Participants

Tomohiro Sakai, Toshihisa Yamamoto

Neutron data library

JENDL-40

Neutron data processing code or method

CASMO5 ver.2.02.00

Number of neutron energy group

586 groups for micro group calculation, 19 groups for 2D calculation

Description of your code system

CASMO5 is a two-dimensional characteristics based neutron and gamma transport theory lattice physics code with depletion capability. CASMO5 can generate cross-sections and discontinuity factors for both BWR and PWR diffusion theory core analysis.

Geometry modelling

1/2 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 (radial)

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

0% void

100 MWd/t from 0 MWd/t to 200 MWd/t,

300 MWd/t from 200 MWd/t to 500 MWd/t,

500 MWd/t from 500 MWd/t to 14 GWd/t,

1000 MWd/t from 14 GWd/t to 15 GWd/t,

2500 MWd/t from 15 GWd/t to 50 GWd/t

40% void

100 MWd/t from 0 MWd/t to 200 MWd/t,

300 MWd/t from 200 MWd/t to 500 MWd/t,

500 MWd/t from 500 MWd/t to 15.5 GWd/t,

2000 MWd/t from 15.5 GWd/t to 17.5 GWd/t,

2500 MWd/t from 17.5 GWd/t to 50 GWd/t

70% void

100 MWd/t from 0 MWd/t to 200 MWd/t,

300 MWd/t from 200 MWd/t to 500 MWd/t,

500 MWd/t from 500 MWd/t to 17.5 GWd/t,

2500 MWd/t from 17.5 GWd/t to 50 GWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

1.0E-5 for eigenvalue, 1.0E-4 for flux

Other related information

-

References

“CASMO5 A FUEL ASSEMBLY BURNUP PROGRAM",SSP-07/431 Rev4

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Institute and country

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Participants

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

SCALE6.1 (BONAMI/CENTRM/PMC)

Number of neutron energy group

238 groups (scale.rev07.xn238v7)

Description of your code system

SCALE 6.1 suite. 2-D solution in TRITON with the T-DEPL sequence (T-NEWT for neutron flux calculation and depletion and decay module ORIGEN).

Geometry modelling

1/8 symmetric full assembly modelling

Number of burn-up regions in UO2-Gd2O3 rods

five rings, no azimuthal sectioning

Adopting Predictor-Corrector method or not

Adopting predictor-corrector method was used

Precise burn-up steps information

50	MWd/t from	0	MWd/t to	200	MWd/t
400	MWd/t from	200	MWd/t to	5000	MWd/t
417	MWd/t from	5000	MWd/t to	10000	MWd/t
250	MWd/t from	10000	MWd/t to	12000	MWd/t
667	MWd/t from	12000	MWd/t to	20000	MWd/t
833	MWd/t from	20000	MWd/t to	30000	MWd/t
667	MWd/t from	30000	MWd/t to	50000	MWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

flux: 1.0e-6, eigenvalue 1.0e-4

Other related information

-

References

http://scale.ornl.gov/

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

SCALE6.1.1

Number of neutron energy group

238 group and TRITON's parm=weight option was used to collapse the 238-group master library to a 49-group problem-dependent library

Description of your code system

TRITON multipurpose sequence of the SCALE code system, version 6.1, update 6.1.1, to perform cross-section coupled processing, transport, depletion and decay calculations. The 2-D NEWT code was used for the transport calculations and the ORIGEN-S code for isotopic depletion calculations.

Isotope transmutation and decay calculations were performed with the ORIGEN-S code, which uses a 1-group cross-section library. During depletion calculations, only cross-sections for isotopes included in the transport calculation are updated on the 1-group ORIGEN-S library. In order to control the nuclides added to all fuel mixtures in the transport calculation so that all nuclides that have a significant impact on flux are accounted for, TRITON allows setting the parameter addnux.

The option addnux=4 was used. This option adds a total of 388 nuclides (all nuclides in the ENDF-B/VII library) to the user-specified list in the transport calculations to update cross sections in the ORIGEN-S depletion calculations.

Geometry modelling

1/4 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

Five burn-up regions (five equal-area rings) were considered for UO_2-Gd_2O_3 rods. No azimuthal subdivision was considered.

MULTIREGION treatment was applied for resonance self-shielding processing of this kind of rods.

Adopting Predictor-Corrector method or not

SCALE6.1.1 uses a predictor-corrector method. However, although many codes belong to the group of predictor-corrector methods, the algorithms employed are very different. In the case of SCALE6.1.1, an irradiation calculation is performed until the middle-of-step. Then, a neutron transport problem is solved at middle of step and the flux and cross-sections are employed to compute the composition from beginning to end of step.

Precise burn-up steps information

TRITON performs the transport calculations only at middle-of-step, so that it provides k_{inf} values only at middle-of-step. However, it provides isotopics at end-of-step. Since both k_{inf} and isotopics were to be provided in the benchmark, different inputs, with a slightly different burn-up scheme, were run.

To provide isotopics, precise burn-up steps were:

1 step of 0.253 GWd/t from 0 to 0.253 GWd/t

1 step of 0.253 GWd/t from 0.253 to 0.506 GWd/t

1 step of 0.506 GWd/t from 0.506 to 1.012 GWd/t

35 steps of 0.828 GWd/t from 1.012 to 30.0 GWd/t

20 steps of 1.0 GWd/t from 30.0 to 50.0 GWd/t

That is, burn-up was performed until approximately 0.25, 0.50, and 1.0 GWd/t, and then, steps of about 0.8 GWd/t were set until an assembly-average burn-up of 30 GWd/t; steps of 1.0 GWd were set for larger burn-ups.

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.00001

Other related information

-

References

Scale: A Comprehensive Modelling and Simulation Suite for Nuclear Safety Analysis and Design, ORNL/TM-2005/39, Version 6.1, June 2011

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Neutron data library

ENDF/B-V

Neutron data processing code or method

SCALE 6.1 / TRITON (t-depl)

Number of neutron energy group

44 groups

Description of your code system

TRITON is the depletion module of SCALE that iterates between a steady state transport calculation and a zone by zone material depletion through the Bateman equations. The t-depl sequence of TRITON links NEWT, a multi-group discrete ordinates radiation transport code with flexible meshing capabilities that allows two-dimensional neutron transport calculations using complex geometric models, with the depletion code ORIGEN-S.

Geometry modelling

full assembly, 8 radial zones for Gd rods

Number of burn-up regions in UO_2-Gd_2O_3 rods

eight radial zones, 0 azimuthal zones.

Adopting Predictor-Corrector method or not

"The predictor-corrector process is introduced by performing a transport solution based on anticipated concentrations at a time halfway into a given cycle. Depletion calculations are then performed over the full cycle using fluxes and cross-sections predicted for mid-cycle. Depletion calculations are then extended to a point halfway into the next cycle, followed by another mid-cycle transport calculation. This process is repeated until depletion calculations are completed for all cycles in a depletion case. In order to start the process, a "bootstrap case" is required using initial isotopic concentrations for the initial transport solution. This solution is used as a basis for the first half-cycle isotopic estimate".

Extract of the SCALE manual.

Precise burn-up steps information

1 GWd/t from 0 GWd/t to 50 GWd/t.

Omitted nuclides, if any

None

Employed convergence limit or statistical errors for eigenvalue calculations

–

Other related information

-

References

S.M. Bowman (2011), “SCALE 6: Comprehensive Nuclear Safety Analysis Code System”, Nuclear Technology, 174(2), 126-148.

I.C. Gauld et al. (2011), “Isotopic Depletion and Decay Methods and Analysis Capabilities in SCALE”, Nuclear Technology, 174(2), 169-195.

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

SCALE 6.1 / TRITON (t-depl)

Number of neutron energy group

238 groups

Description of your code system

TRITON is the depletion module of SCALE that iterates between a steady state transport calculation and a zone by zone material depletion through the Bateman equations. The t-depl sequence of TRITON links NEWT, a multi-group discrete ordinates radiation transport code with flexible meshing capabilities that allows two-dimensional neutron transport calculations using complex geometric models, with the depletion code ORIGEN-S.

Geometry modelling

full assembly, eight radial zones for Gd rods

Number of burn-up regions in UO_2-Gd_2O_3 rods

eight radial zones, 0 azimuthal zones.

Adopting Predictor-Corrector method or not

"The predictor-corrector process is introduced by performing a transport solution based on anticipated concentrations at a time halfway into a given cycle. Depletion calculations are then performed over the full cycle using fluxes and cross sections predicted for mid-cycle. Depletion calculations are then extended to a point halfway into the next cycle, followed by another mid-cycle transport calculation. This process is repeated until depletion calculations are completed for all cycles in a depletion case. In order to start the process, a "bootstrap case" is required using initial isotopic concentrations for the initial transport solution. This solution is used as a basis for the first half-cycle isotopic estimate".

Extract of the SCALE manual.

Precise burn-up steps information

1 GWd/t from 0 GWd/t to 50 GWd/t.

Omitted nuclides, if any

None

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

S.M. Bowman (2011), “SCALE 6: Comprehensive Nuclear Safety Analysis Code System”, Nuclear Technology, 174(2), 126-148.

I.C. Gauld et al. (2011), “Isotopic Depletion and Decay Methods and Analysis Capabilities in SCALE”, Nuclear Technology, 174(2), 169-195.

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

VESTA 2.1.5

Number of neutron energy group

Continuous-Energy

Description of your code system

VESTA is a Monte Carlo depletion interface code that is currently under development at IRSN. With VESTA, the emphasis lies on both accuracy and performance, so that the code will be capable of providing accurate and complete answers in an acceptable amount of time compared to other Monte Carlo depletion codes. From its inception, VESTA is intended to be a generic interface code so that it will ultimately be capable of using any Monte-Carlo code or depletion module and that can be tailored to the user's needs on practically all aspects of the code such as the predictor-corrector algorithm (by offering multiple algorithms like e.g. a predictor only, the classic predictor-corrector or the midpoint approach), the nuclear data and physics models (e.g. a burn up dependent isomeric branching ratio treatment).

For the current version, VESTA 2.1.5 allows for the use of any version of MCNP(X) as the transport module and ORIGEN 2.2 or the built-in PHOENIX module as the depletion module (which is also developed at IRSN).

For the benchmark, we have used MCNPX 2.6.0 as the transport module and PHOENIX as the depletion module. All reactions and decay modes available in the JEFF 3.1 and ENDF/B-VII.0 nuclear data library are used for the depletion calculations in PHOENIX and a burn-up dependent isomeric branching ratio treatment is applied to all reactions for which data is available (e.g. neutron capture on ^{241}Am).

The geometrical model consists of a 1/8 symmetric 2D full assembly model where each pin is depleted separately without radial zoning except for Gd rods (5 radial zones are used in this case).

The irradiation history is modelled as steps of 0.5 MWd kgHM-1, with the exception of the first two steps (a first step of 0.2 MWd kgHM-1 followed by 0.3 MWd kgHM-1). A standard predictor-corrector algorithm is used for these calculations to correctly capture the fast spectral changes due to Gd burnout at the beginning of the irradiation.

The precision of the calculations are set so that k_{eff} values are calculated at 1 sigma ~ 20 pcm and local pin flux values are calculated with a statistical error < 0.1 % (1 sigma).

Geometry modelling

1/8 symmetric two-dimensional full assembly modelling, no radial zoning except for Gd rods (5 radial zones are used in this case)

Number of burn-up regions in UO_2-Gd_2O_3 rods

five radial zones were used corresponding to the following radii: r/2, 3r/4, 7r/8, 15r/16, r (with r the pellet radius).

Adopting Predictor-Corrector method or not

A standard predictor corrector algorithm was used:

- A transport calculation at the beginning of each time step provides the cross section and flux data for the predictor depletion step.

- A transport calculation at the end of each time step using the predictor composition provides the cross section and flux data for the corrector depletion step.

- The average composition of the predictor and corrector composition is set as the initial composition for the following time step.

Precise burn-up steps information

500 MWd/t from 0 GWd/t to 50 GWd/t (100 steps in total)

Neutron history number

15000 particles per cycle were simulated for a total of 350 cycles including 50 inactive cycles (for each transport calculation)

Detail of fission yield data

All available fission yield from the JEFF 3.1 library (^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{238}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm) or the ENDF/B-VII.0 library (^{227}Th, ^{229}Th, ^{232}Th, ^{231}Pa, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, ^{238}U, ^{237}Np, ^{238}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{248}Cm, ^{249}Cf, ^{251}Cf, ^{254}Es and ^{255}Fm) has been used depending on the calculation case. Fission products are not taken into account for actinides without fission yield data.

Detail of FP chain data

These are linked with the decay data. If the decay data contains the fission product in question, it is included in the depletion chains. It is possible that a daughter is generated that is not in the decay library. In that case, the chain stops at the parent. The decay data is taken from the JEFF 3.1 library (3851 nuclides) or the ENDF/B-VII.0 library (3837 nuclides) depending on the calculation case.

Which nuclide's cross-section data are prepared by Monte Carlo code calculation?

Single-group cross-section data was calculated for each reaction and each nuclide in the JEFF 3.1 library or ENDF/B-VII.0 library using an ultrafine multi-group spectrum calculated by MCNPX 2.6.0. The single-group cross-sections were calculated by collapsing this spectrum with the corresponding multi-group cross-sections (which were calculated from the linearised cross-sections given in the ace files).

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN was not used for these calculations.

Omitted nuclides, if any

None

Employed convergence limit or statistical errors for eigenvalue calculations

K_{eff} values at 1 sigma ~ 20 pcm, local pin flux values with a statistical error < 0.1 % (1 sigma)

Other related information

-

References

W. Haeck (2012), VESTA User's Manual – Version 2.1.0, IRSN Report DSU/SEC/T/2011-81 – Index A, Institut de Radioprotection et de Sûreté Nucléaire.

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Neutron data library

JEFF-3.1

Neutron data processing code or method

VESTA 2.1.5

Number of neutron energy group

Continuous-Energy

Description of your code system

VESTA is a Monte Carlo depletion interface code that is currently under development at IRSN. With VESTA, the emphasis lies on both accuracy and performance, so that the code will be capable of providing accurate and complete answers in an acceptable amount of time compared to other Monte Carlo depletion codes. From its inception, VESTA is intended to be a generic interface code so that it will ultimately be capable of using any Monte-Carlo code or depletion module and that can be tailored to the user's needs on practically all aspects of the code such as the predictor-corrector algorithm (by offering multiple algorithms like e.g. a predictor only, the classic predictor-corrector or the midpoint approach), the nuclear data and physics models (e.g. a burn-up dependent isomeric branching ratio treatment).

For the current version, VESTA 2.1.5 allows for the use of any version of MCNP(X) as the transport module and ORIGEN 2.2 or the built in PHOENIX module as the depletion module (which is also developed at IRSN).

For the benchmark, we have used MCNPX 2.6.0 as the transport module and PHOENIX as the depletion module. All reactions and decay modes available in the JEFF 3.1 and ENDF/B-VII.0 nuclear data library are used for the depletion calculations in PHOENIX and a burn-up dependent isomeric branching ratio treatment is applied to all reactions for which data is available (e.g. neutron capture on ^{241}Am).

The geometrical model consists of a 1/8 symmetric 2D full assembly model where each pin is depleted separately without radial zoning except for Gd rods (5 radial zones are used in this case).

The irradiation history is modelled as steps of 0.5 MWd kgHM-1, with the exception of the first two steps (a first step of 0.2 MWd kgHM-1 followed by 0.3 MWd kgHM-1). A standard predictor-corrector algorithm is used for these calculations to correctly capture the fast spectral changes due to Gd burn-out at the beginning of the irradiation.

The precision of the calculations are set so that k_{eff} values are calculated at 1 sigma ~ 20 pcm and local pin flux values are calculated with a statistical error < 0.1 % (1 sigma).

Geometry modelling

1/8 symmetric two-dimensional full assembly modelling, no radial zoning except for Gd rods (5 radial zones are used in this case)

Number of burn-up regions in UO_2-Gd_2O_3 rods

five radial zones were used corresponding to the following radii: r/2, 3r/4, 7r/8, 15r/16, r (with r the pellet radius).

Adopting Predictor-Corrector method or not

A standard predictor corrector algorithm was used:

- A transport calculation at the beginning of each time step provides the cross-section and flux data for the predictor depletion step.

- A transport calculation at the end of each time step using the predictor composition provides the cross section and flux data for the corrector depletion step.

- The average composition of the predictor and corrector composition is set as the initial composition for the following time step.

Precise burn-up steps information

500 MWd/t from 0 GWd/t to 50 GWd/t (100 steps in total)

Neutron history number

15 000 particles per cycle were simulated for a total of 350 cycles including 50 inactive cycles (for each transport calculation)

Detail of fission yield data

All available fission yield from the JEFF 3.1 library (^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{238}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm) or the ENDF/B-VII.0 library (^{227}Th, ^{229}Th, ^{232}Th, ^{231}Pa, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, ^{238}U, ^{237}Np, ^{238}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{248}Cm, ^{249}Cf, ^{251}Cf, ^{254}Es and ^{255}Fm) has been used depending on the calculation case. Fission products are not taken into account for actinides without fission yield data.

Detail of FP chain data

These are linked with the decay data. If the decay data contains the fission product in question, it is included in the depletion chains. It is possible that a daughter is generated that is not in the decay library. In that case, the chain stops at the parent. The decay data is taken from the JEFF 3.1 library (3851 nuclides) or the ENDF/B-VII.0 library (3837 nuclides) depending on the calculation case.

Which nuclide's cross-section data are prepared by Monte Carlo code calculation?

Single-group cross-section data was calculated for each reaction and each nuclide in the JEFF 3.1 library or ENDF/B-VII.0 library using an ultrafine multi-group spectrum calculated by MCNPX 2.6.0. The single-group cross-sections were calculated by collapsing this spectrum with the corresponding multi-group cross-sections (which were calculated from the linearised cross-sections given in the ace files).

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN was not used for these calculations.

Omitted nuclides, if any

None

Employed convergence limit or statistical errors for eigenvalue calculations

K_{eff} values at 1 sigma ~ 20 pcm, local pin flux values with a statistical error < 0.1% (1 sigma)

Other related information

-

References

W. Haeck, VESTA User's Manual – Version 2.1.0, IRSN Report DSU/SEC/T/2011-81 – Index A, Institut de Radioprotection et de Sûreté Nucléaire (2012)

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Neutron data library

JENDL-4

Neutron data processing code or method

MCNP-BURN2

Number of neutron energy group

Continuous-Energy

Description of your code system

MCNP-BURN2 is a burn-up code system developed by TOSHIBA. The code system is based on a continuous-energy Monte Carlo code (MCNP) and a point burn-up code (ORIGEN2). MCNP-BURN2 executes the MCNP and the ORIGEN2 codes. MCNP-BURN2 can treat the complex geometry due to the flexibility of the continuous-energy Monte Carlo code, and it can evaluate the detailed characteristics of spent nuclear fuel such as radioactivity, decay heat, and number of neutron emission using the function of the ORIGEN2 code.

Geometry modelling

1/8 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

radial: 10 (of equal volume), azimuthal:4

Precise burn-up steps information

0.0 0.2 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0 42.5 45.0 47.5 50.0

Neutron history number

10 000 particles per cycle were simulated for a total of 55 cycles including 5 inactive cycles

Detail of fission yield data

JENDL-4

Detail of FP chain data

ORIGEN2.1

Which nuclide's cross-section data are prepared by Monte Carlo code calculation?

^{1}H, ^{16}O, ^{153}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{154}Gd, ^{155}Gd, ^{156}Gd, ^{157}Gd

^{158}Gd, ^{160}Gd, ^{159}Tb, ^{147}Sm, ^{148}Sm, ^{149}Sm, ^{150}Sm, ^{151}Sm, ^{152}Sm, ^{147}Pm

^{148}Pm, ^{148}Mpm, ^{149}Gpm, ^{151}Pm, ^{143}Nd, ^{145}Nd, ^{147}Nd, ^{131}Xe, ^{132}Xe, ^{133}Xe

^{134}Xe, ^{135}Xe, ^{133}Cs, ^{134}Cs, ^{135}Cs, ^{131}I, ^{135}I, ^{109}Ag, ^{137}Cs, ^{140}Ba, ^{144}Ce

^{105}Pd, ^{107}Pd, ^{108}Pd, ^{103}Rh, ^{105}Rh, ^{99}Tc, ^{101}Ru, ^{103}Ru, ^{105}Ru, ^{106}Ru

^{113}Cd, ^{143}Pr, ^{83}Kr, ^{95}Zr, ^{99}Mo, ^{134}Ba, ^{137}Ba, ^{138}Ba, ^{110}Cd, ^{111}Cd,

^{140}Ce, ^{141}Ce, ^{142}Ce, ^{127}I, ^{129}I, ^{115}In, ^{139}La, ^{95}Mo, ^{96}Mo, ^{97}Mo, ^{98}Mo, ^{100}Mo

^{95}Nb, ^{142}Nd, ^{144}Nd, ^{146}Nd, ^{148}Nd, ^{150}Nd, ^{104}Pd, ^{106}Pd, ^{141}Pr, ^{85}Rb

^{100}Ru, ^{102}Ru, ^{104}Ru, ^{79}Se, ^{154}Sm, ^{129}Te, ^{136}Mxe, ^{89}Y, ^{91}Zr, ^{92}Zr, ^{93}Zr, ^{96}Zr

^{151}Eu, ^{125}Sb, ^{90}Sr, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, ^{238}U, ^{237}Np, ^{238}Np, ^{239}Np

^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{242}Am, ^{243}Am, ^{242}Cm, ^{244}Cm, ^{245}Cm

Changing (n,gamma),(n,f),(n,2n) to ORIGEN library

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was selected.

ORIGEN2.1 BWRLIB

Omitted nuclides, if any

-Employed convergence limit or statistical errors for eigenvalue calculations

<0.1%dk

Other related information

-

References

Y. Ando et al. (2003), "Development and verification of Monte Carlo burn-up calculation system", Proc. 7th Int. Conference on Nuclear Criticality Safety (ICNC2003), Tokai, Japan, Oct. 20–24, 2003, JAERI Conference 2003-019, 494-499.

K. Yoshioka, Y. Ando (2010), "Multi-group Scattering Matrix Generation Method Using Weight-to-Flux Ratio Based on a Continuous Energy Monte Carlo Technique", Journal of Nuclear Science and Technology, 47, 908-916.

K. Yoshioka et al. (2011), "Multi-Group Constants Generation System for 3D-Core Simulation using a Continuous Energy Monte Carlo Technique", Progress in Nuclear Science and Technology, Vol. 2, pp.334-340.

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

TRITON (SCALE 6.1.1), sequence t-depl with two-dimensional deterministic transport code NEWT

Number of neutron energy group

238 groups

Description of your code system

TRITON is a control module of the SCALE code system to support two- and three-dimensional transport and depletion calculations. Here, the depletion sequence t-depl was used. In this sequence the neutron transport calculation is performed using the two-dimensional deterministic transport code NEWT

Geometry modelling

1/8 symmetric full assembly modelling

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.0001

Other related information

-

References

Scale: A Comprehensive Modelling and Simulation Suite for Nuclear Safety Analysis and Design, ORNL/TM-2005/39, Version 6.1, June 2011. Available from Radiation Safety Information Computational Centre at Oak Ridge National Laboratory as CCC-785

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

SERPENT 1.1.18

Number of neutron energy group

Continuous-Energy

Description of your code system

SERPENT is a three-dimensional continuous-energy Monte Carlo reactor physics burn-up calculation code, developed at VTT Technical Research Centre of Finland since 2004. The code is specialized in two-dimensional lattice physics calculations, but the geometry description allows the modelling of complicated three-dimensional geometries as well.

Geometry modelling

1/8 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 radial burn-up regions

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

Time steps used (in GWd/tHM) 0.20 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 12.00 15.00 20.00 30.00 40.00 50.00

Neutron history number

8000 neutrons/cycle 4000 cycles, 500 initial cycles skipped

Detail of fission yield data

ENDF/B-VII

Detail of FP chain data

ENDF/B-VII

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.0003

Other related information

-

References

http://montecarlo.vtt.fi

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Neutron data library

ENDF/B-VI.8

Neutron data processing code or method

HELIOS 1.10

Number of neutron energy group

190 groups

Description of your code system

HELIOS 1.10

Geometry modelling

1/8th assembly model

Number of burn-up regions in UO_2-Gd_2O_3 rods

six radial zones (of equal area), 1 azimuthal zone

Adopting Predictor-Corrector method or not

predictor-corrector method is applied

Precise burn-up steps information

200 MWd/t from 0 to 200 MWd/t,

300 MWd/t from 200 MWd/t to 500 MWd/t,

500 MWd/t from 500 MWd/t to 1 GWd/t,

1000 MWd/t from 1 GWd/t to 12 GWd/t,

2000 MWd/t from 12 GWd/t to 30 GWd/t,

4000 MWd/t from 30 GWd/t to 50 GWd/t

Omitted nuclides, if any

None

Employed convergence limit or statistical errors for eigenvalue calculations

2.0E-05

Other related information

-

References

-

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Institute and country

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Participants

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

SCALE 6.1.2

Number of neutron energy group

238 groups

Description of your code system

SCALE 6.1.1 code is a comprehensive modelling and simulation suite for nuclear safety analysis and design that is developed, maintained, tested, and managed by the Reactor and Nuclear Systems Division (RNSD) of Oak Ridge National Laboratory (ORNL). SCALE provides a comprehensive, verified and validated, user-friendly tool set for criticality safety, reactor physics, radiation shielding, radioactive source term characterisation, and sensitivity and uncertainty analysis. The modules needed for these calculations included cross-section processing (CENTRM/PMC), multi-dimensional Sn neutron transport (NEWT), calculation of Dancoff factors via one-group Monte Carlo (MCDancoff), as well as depletion and decay (ORIGEN) analysis.

Geometry modelling

Full Assembly

Number of burn-up regions in UO_2-Gd_2O_3 rods

Gd rods modelled with 5 equal volume radial rings

Adopting Predictor-Corrector method or not

P-C method is used

Precise burn-up steps information

0.1 GWd/t 0 to 0.1 GWd/t

0.2 GWd/t 0.1 GWd/t to 0.5 GWd/t

0.5 GWd/t 0.5 GWd/t to 12 GWd/t

2.0 GWd/t 12 GWd/t to 50 GWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.00001

Other related information

-

References

SCALE: A Comprehensive Modelling and Simulation Suite for Nuclear Safety Analysis and Design. ORNL/TM-2005/39

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Participants

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

SERPENT 1.1.18

Number of neutron energy group

Continuous Energy

Description of your code system

SERPENT is a three-dimensional burn-up code system based on continuous-energy Monte Carlo transport calculations coupled with a burn-up depletion algorithm based on the matrix exponential method. It uses a predictor-corrector method: first, it performs a neutron transport calculation at beginning of step (BOS); second, it performs a provisional irradiation step (predictor step) until end of step (EOS); third, a neutron transport problem is solved at EOS, and the average fluxes and cross-sections between the BOS and EOS are employed to recalculate the EOS compositions (corrector step).

Geometry modelling

Full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

Gd pins were divided into 10 annular depletion zones of equal volume.

Adopting Predictor-Corrector method or not

For the coupled transport-depletion calculations, SERPENT uses a predictor-corrector method: first, it performs a neutron transport calculation at beginning of step (BOS); second, it performs a provisional irradiation step (predictor step) until end of step (EOS); third, a neutron transport problem is solved at EOS, and the average fluxes and cross-sections between the BOS and EOS are employed to recalculate the EOS compositions (corrector step).

Precise burn-up steps information

1 step of 0.250 GWd/t from 0 to 0.250 GWd/t

1 step of 0.250 GWd/t from 0.250 to 0.500 GWd/t

1 step of 0.500 GWd/t from 0.500 to 1.0 GWd/t

14 steps of 1.0 GWd/t from 1.0 to 15.0 GWd/t

7 steps of 5.0 GWd/t from 15.0 to 50.0 GWd/t

Neutron history number

Number of histories per cycle: 150 000

Number of active neutron cycles: 500 active cycles

Number of inactive cycles: 100 cycles

Number of total cycles: 600 cycles

Implicit estimate of k_{inf} (average statistical errors of 8 pcm)

Detail of fission yield data

Two set of calculations were performed:

-one using ENDF/B-VII.0 libraries (also ENDF/B-VII.0 fission yield library)

-other using the JEFF3.1.1 libraries (also JEFF3.1.1 fission yield library)

Regarding branching ratios in metastable isotopes, SERPENT takes by default constant values, not dependent on energy.

Which nuclide's cross section data are prepared by Monte Carlo code calculation?

SERPENT does not read any activation library. Then, only one-group cross-sections for isotopes given in the transport calculation are computed. All fission product and actinide cross-sections available in the cross-section transport library are included in the transport calculation. Two sets of calculations were performed:

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

PSG2/SERPENT – a Continuous-energy Monte Carlo Reactor Physics Burn-up Calculation Code. User's Manual, VTT Technical Research Centre of Finland, Jaakko Leppanen, version 1.1.18, 2012

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Participants

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Neutron data library

JEFF-3.1.1

Neutron data processing code or method

SERPENT 1.1.18

Number of neutron energy group

Continuous Energy

Description of your code system

SERPENT is a three-dimensional burn-up code system based on continuous-energy Monte Carlo transport calculations coupled with a burn-up depletion algorithm based on the matrix exponential method. It uses a predictor-corrector method: first, it performs a neutron transport calculation at beginning of step (BOS); second, it performs a provisional irradiation step (predictor step) until end of step (EOS); third, a neutron transport problem is solved at EOS, and the average fluxes and cross-sections between the BOS and EOS are employed to recalculate the EOS compositions (corrector step).

Geometry modelling

Full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

Gd pins were divided into 10 annular depletion zones of equal volume.

Adopting Predictor-Corrector method or not

For the coupled transport-depletion calculations, SERPENT uses a predictor-corrector method: first, it performs a neutron transport calculation at beginning of step (BOS); second, it performs a provisional irradiation step (predictor step) until end of step (EOS); third, a neutron transport problem is solved at EOS, and the average fluxes and cross-sections between the BOS and EOS are employed to recalculate the EOS compositions (corrector step).

Precise burn-up steps information

1 step of 0.250 GWd/t from 0 to 0.250 GWd/t

1 step of 0.250 GWd/t from 0.250 to 0.500 GWd/t

1 step of 0.500 GWd/t from 0.500 to 1.0 GWd/t

14 steps of 1.0 GWd/t from 1.0 to 15.0 GWd/t

7 steps of 5.0 GWd/t from 15.0 to 50.0 GWd/t

Neutron history number

Number of histories per cycle: 150 000

Number of active neutron cycles: 500 active cycles

Number of inactive cycles: 100 cycles

Number of total cycles: 600 cycles

Implicit estimate of k_{inf} (average statistical errors of 8 pcm)

Detail of fission yield data

Two set of calculations were performed:

-one using ENDF/B-VII.0 libraries (also ENDF/B-VII.0 fission yield library)

-other using the JEFF3.1.1 libraries (also JEFF3.1.1 fission yield library)

Regarding branching ratios in metastable isotopes, SERPENT takes by default constant values, not dependent on energy.

Which nuclide's cross-section data are prepared by Monte Carlo code calculation?

SERPENT does not read any activation library. Then, only one-group cross-sections for isotopes given in the transport calculation are computed. All fission product and actinide cross-sections available in the cross-section transport library are included in the transport calculation. Two sets of calculations were performed:

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

PSG2/SERPENT – a Continuous-energy Monte Carlo Reactor Physics Burn-up Calculation Code. User's Manual, VTT Technical Research Centre of Finland, Jaakko Leppanen, version 1.1.18, 2012

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Participants

Anssu Ranta-aho

Neutron data library

JEF-2.2

Neutron data processing code or method

CASMO-4E v2.10.22 and ORIGEN2.2 (decay calculation)

Number of neutron energy group

70 groups

Description of your code system

According to the user's manual, CASMO-4 and its extended version CASMO-4E are two-dimensional characteristics based neutron and gamma transport theory lattice physics codes with depletion capability. In addition to BWR/PWR designs, CASMO-4E can contain modules to calculate VVER, RBMK, Magnox and AGR reactor types. Predictor-corrector method is applied to burn-up calculation.

According to the user's manual, ORIGEN2.2 is an isotope generation and depletion code using matrix exponential method.

Geometry modelling

1/2 symmetry. Each fuel pin defined as a unique burnable region with 10 radial rings for the Gd fuel pins.

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 rings in UO_2-Gd_2O_3 rods, equal volumes

Adopting Predictor-Corrector method or not

Predictor-Corrector

Precise burn-up steps information

0% void: 0.1 MWd/kgU, 0.2 MWd/kgU

0.5 MWd/kgU steps from 0.5 MWd/kgU to 14 MWd/kgU

2.5 MWd/kgU steps from 15 MWd/kgU to 50 MWd/kgU

40% void: 0.1 MWd/kgU, 0.2 MWd/kgU

0.5 MWd/kgU steps from 0.5 MWd/kgU to 15 MWd/kgU

2.5 MWd/kgU steps from 17.5 MWd/kgU to 50 MWd/kgU

70% void: 0.1 MWd/kgU, 0.2 MWd/kgU

0.5 MWd/kgU steps from 0.5 MWd/kgU to 16.5 MWd/kgU

2.5 MWd/kgU steps from 17.5 MWd/kgU to 50 MWd/kgU

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN2.2 (5-4-2002) (only for decay calculation)

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.00001

Other related information

-

References

J. Rhodes, M. Edenius (2004), “CASMO-4: A Fuel Assembly Burn-up Program, User’s Manual”, Studsvik Scandpower Report SSP-01/400 Rev 4.

J. Rhodes et al. (2004),”CASMO-4E: Extended Capability CASMO-4,User’s Manual”, Studsvik Scandpower Report SSP-01/401 Rev 2.

J. Rhodes (2005), “JEF 2.2 and ENDF/B-VI 70 Group Neutron Data Libraries” StudsvikScandpower Report SSP-04/454 Rev 2.

ORIGEN2.2 Isotope Generation and Depletion Code Matrix Exponential Method, RSICC Computer Code Collection, CCC-371, Oak Ridge National Laboratory.

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Participants

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Neutron data library

ENDF/B-VI

Neutron data processing code or method

CASMO-4E v2.10.22 and ORIGEN2.2 (decay calculation)

Number of neutron energy group

70 groups

Description of your code system

According to the user's manual, CASMO-4 and its extended version CASMO-4E are two-dimensional characteristics based neutron and gamma transport theory lattice physics codes with depletion capability. In addition to BWR/PWR designs, CASMO-4E can contain modules to calculate VVER, RBMK, Magnox and AGR reactor types. Predictor-corrector method is applied to burn-up calculation.

According to the user's manual, ORIGEN2.2 is an isotope generation and depletion code using matrix exponential method.

Geometry modelling

1/2 symmetry. Each fuel pin defined as a unique burnable region with 10 radial rings for the Gd fuel pins.

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 rings in UO_2-Gd_2O_3 rods, equal volumes

Adopting Predictor-Corrector method or not

Predictor-Corrector

Precise burn-up steps information

0% void: 0.1 MWd/kgU, 0.2 MWd/kgU

0.5 MWd/kgU steps from 0.5 MWd/kgU to 14 MWd/kgU

2.5 MWd/kgU steps from 15 MWd/kgU to 50 MWd/kgU

40% void: 0.1 MWd/kgU, 0.2 MWd/kgU

0.5 MWd/kgU steps from 0.5 MWd/kgU to 15 MWd/kgU

2.5 MWd/kgU steps from 17.5 MWd/kgU to 50 MWd/kgU

70% void: 0.1 MWd/kgU, 0.2 MWd/kgU

0.5 MWd/kgU steps from 0.5 MWd/kgU to 16.5 MWd/kgU

2.5 MWd/kgU steps from 17.5 MWd/kgU to 50 MWd/kgU

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN2.2 (5-4-2002) (only for decay calculation)

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.00001

Other related information

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References

J. Rhodes, M. Edenius (2004), "CASMO-4: A Fuel Assembly Burnup Program, User's Manual", Studsvik Scandpower Report SSP-01/400 Rev 4.

J. Rhodes, K. Smith, M. Edenius (2004), "CASMO-4E: Extended Capability CASMO-4, User's Manual", Studsvik Scandpower Report SSP-01/401 Rev 2.

J. Rhodes (2005), "JEF 2.2 and ENDF/B-VI 70 Group Neutron Data Libraries" StudsvikScandpower Report SSP-04/454 Rev 2.

ORIGEN2.2 Isotope Generation and Depletion Code Matrix Exponential Method, RSICC Computer Code Collection, CCC-371, Oak Ridge National Laboratory.

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Institute and country

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Participants

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Neutron data library

Based on JEF-2.2

Neutron data processing code or method

KENOREST-2006V.2

Number of neutron energy group

83 groups

Description of your code system

KENOREST is an integrated calculation tool for fuel assemblies. It consists of the three-dimensional KENO.Va code, coupled to the burn-up system OREST2008.

Geometry modelling

1/8 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

five radial zones

Adopting Predictor-Corrector method or not

Not

Precise burn-up steps information

-from 0 to 8 GWd/tHM : steps of 750 MWd/tHM (1st step at 2.5 MWd/tHM to ensure Xe-equilibrium)

- from 8 to 14 GWd/tHM : steps of 1.1 GWd/tHM
- from 14 to 30 GWd/tHM : steps of 2.5 GWd/tHM
- from 30 to 50 GWd/tHM : steps of 4.5 GWd/tHM

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.0005

Other related information

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References

U.Hesse et al. (2005), "The Status of the GRS Reactivity and Burn-Up Code System KENOREST", International Conference of Mathematics and Computation, Reactor Physics and Nuclear and Biological Applications, M&C 2005, Palais de Papes, Avignon, France, September 12-15.

R. Kilger et al. (2005), "Burnup Calculations with KENOREST 03T01 and Associated Criticality Studies for Spent Fuel Samples from Takahama-3 Reactor", NCSD TOPICAL MEETING -CD-ROM EDITION, American Nuclear Society.

R.Kilger et al. (2008), "Isotopic Inventory Calculations taking into account 2D/3D enviroment conditions during fuel irradiation", International Conference on Physics and Reactors, Interlaken, Switzerland.

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Institute and country

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Participants

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

LANCR01

Number of neutron energy group

35 groups

Description of your code system

LANCR employs a 190-group Bondarenko-type cross-section library based on ENDF/B-7.0 data, which is energy-condensed into a 35-group cross-section file for use by a two-dimensional transport calculation with an improved CCCP method. In depletion calculation, the predictor calculation is carried out by the fourth-order Runge-Kutta-Gill method with post corrector step. The F.P. chain model is employed to attain high accuracy in high exposure regions; 136 explicitly treated nuclides and two lumped pseudo-F.P. nuclides constitute the chain model.

Geometry modelling

full assembly modelling

Adopting Predictor-Corrector method or not

Yes

Omitted nuclides, if any

^{90}Sr

Employed convergence limit or statistical errors for eigenvalue calculations

1.0E-5 for flux

Other related information

-

References

K. Azekura et al. (2003), “Development of a BWR Lattice Analysis Code LANCR Based on an Improved CCCP Method”, Advances in Nuclear Fuel Management III, Hilton Head Island, South Carolina.

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Participants

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

MONTEBURNS2

Number of neutron energy group

Continuous-Energy

Description of your code system

MONTEBURNS2 is a burn-up code system based on a continuous-energy Monte Carlo code (MCNP5) and a point burn-up code (ORIGEN2). The principle function of MONTEBURNS2 is to transfer one-group cross-section and flux values from MCNP5 to ORIGEN2, and then transfer the resulting material compositions back to MCNP5 in a repeated, cyclic fashion.

Geometry modelling

full assembly modelling

Adopting Predictor-Corrector method or not

Yes (calculation is performed until the middle-of-step.)

Precise burn-up steps information

82 steps up to 70 GWd/t (del-E=0.25(<13 GWd/t), del-E=1.0(<30 GWd/t), del-E=0.5)

Neutron history number

10 000 particles/Cy, 250 Cycles, 50 Skip Cycles

Detail of fission yield data

ORIGEN BWRU.LIB + DELAY.LIB

Detail of FP chain data

ORIGEN2

Which nuclide's cross-section data are prepared by Monte Carlo code calculation?

IF=0.00005

SNG, SN2N, SN3N or SNA, SNF or SNP, SNGX

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN2.2 (o2_therm) + BWR-U

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

10 000 particles times 250 cycles (200 active) in the Monte Carlo calculations

Other related information

-

References

D. I. Poston et al. (1999), “User's Manual, Version 2.0 for MONTEBURNS, Version 1.0”, LA-UR-99-4999.

T. Ikehara et al. (2007), “Modification of MONTEBURNS2 to raise the limitation on the number of materials to irradiate”, AESJ ann. Mtg.

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Neutron data library

JENDL-4.0

Neutron data processing code or method

MONTEBURNS2

Number of neutron energy group

Continuous-Energy

Description of your code system

MONTEBURNS2 is a burn-up code system based on a continuous-energy Monte Carlo code (MCNP5) and a point burn-up code (ORIGEN2). The principle function of MONTEBURNS2 is to transfer one-group cross-section and flux values from MCNP5 to ORIGEN2, and then transfer the resulting material compositions back to MCNP5 in a repeated, cyclic fashion.

Geometry modelling

full assembly modelling

Adopting Predictor-Corrector method or not

Yes (calculation is performed until the middle-of-step.)

Precise burn-up steps information

82 steps up to 70 GWd/t (del-E=0.25(<13 GWd/t), del-E=1.0(<30 GWd/t), del-E=0.5)

Neutron history number

10000 particles/Cy, 250 Cycles, 50 Skip Cycles

Detail of fission yield data

ORIGEN BWRU.LIB + DELAY.LIB

Detail of FP chain data

ORIGEN2

Which nuclide's cross-section data are prepared by Monte Carlo code calculation?

IF=0.00005

SNG, SN2N, SN3N or SNA, SNF or SNP, SNGX

If ORIGEN2 is used as the burn-up calculation module, which version of ORIGEN2 was adopted and which data library of ORIGEN2 was chosen.

ORIGEN2.2 (o2_therm) + BWR-U

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

10000 particles times 250 cycles (200 active) in Monte Carlo calculations

Other related information

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References

D. I. Poston, et al. (1999), “User's Manual, Version 2.0 for MONTEBURNS, Version 1.0”, LA-UR-99-4999.

T. Ikehara et al. (2007),“Modification of MONTEBURNS2 to raise the limitation on the number of materials to irradiate”, AESJ ann. Mtg.

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Neutron data library

ENDF/B-VI

Neutron data processing code or method

CASMO-4E, v2.10.22

Number of neutron energy group

70 groups

Description of your code system

According to the user's manual, CASMO-4 and its extended version CASMO-4E are two-dimensional characteristics based neutron and gamma transport theory lattice physics codes with depletion capability. In addition to BWR/PWR designs, CASMO-4E can contain modules to calculate VVER, RBMK, MAGNOX and AGR reactor types. Predictor-corrector method is applied to burn-up calculation.

Geometry modelling

1/2 symmetry. Each fuel pin defined as a unique burnable region with 10 radial rings for the Gd fuel pins.

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 radial rings

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

For finding number densities at burn-ups of (Task 1)

12 MWd/kgU (cases 1 to3) steps 12x1 MWd/kgU

20 MWd/kgU (cases 4 to6) steps 20x1 MWd/kgU

30 MWd/kgU(cases 7 to 9) steps 60x0.5 MWd/kgU

50 MWd/kgU (cases 10 to 12) steps 100x0.5 MWd/kgU

For finding multiplication factor and burn-up of fuel pins (Task 2 and 4)

0.1 MWd/kgU,

0.2 MWd/kgU,

0.5 MWd/kgU and

steps 99x0.5MWd/kgU

For finding maximum multiplication factor and corresponding burn-up (Task 3):

32x0.25 MWd/kgU for the interval 0 to 8 MWd/kgU

100x0.1 MWd/kgU for the interval 8 to 18 MWd/kgU

2x16 MWd/kgU for the interval 18 to 50 MWd/kgU

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.00001

Other related information

-

References

J. Rhodes et al. (2004), "CASMO-4: A Fuel Assembly Burn-up Program, User's Manual", Studsvik Scandpower Report SSP-01/400 Rev 4.

J. Rhodes et al. (2004), "CASMO-4E: Extended Capability CASMO-4, User's Manual", Studsvik Scandpower Report SSP-01/401 Rev 2.

J. Rhodes (2005), "JEF 2.2 and ENDF/B-VI 70 Group Neutron Data Libraries" StudsvikScandpower Report SSP-04/454 Rev 2.

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Neutron data library

JEF-2.2

Neutron data processing code or method

CASMO-4E, v2.10.22

Number of neutron energy group

70 groups

Description of your code system

According to the user's manual, CASMO-4 and its extended version CASMO-4E are two-dimensional characteristics based neutron and gamma transport theory lattice physics codes with depletion capability. In addition to BWR/PWR designs, CASMO-4E can contain modules to calculate VVER, RBMK, MAGNOX and AGR reactor types. Predictor-corrector method is applied to burn-up calculation.

Geometry modelling

1/2 symmetry. Each fuel pin defined as a unique burnable region with 10 radial rings for the Gd fuel pins.

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 radial rings

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

For finding number densities at burn-ups of (Task 1)

12 MWd/kgU (cases 1 to3) steps 12x1 MWd/kgU

20 MWd/kgU (cases 4 to6) steps 20x1 MWd/kgU

30 MWd/kgU(cases 7 to 9) steps 60x0.5 MWd/kgU

50 MWd/kgU (cases 10 to 12) steps 100x0.5 MWd/kgU

For finding multiplication factor and burn-up of fuel pins (Task 2 and 4)

0.1 MWd/kgU,

0.2 MWd/kgU,

0.5 MWd/kgU and

then steps 99x0.5 MWd/kgU

For finding maximum multiplication factor and corresponding burn-up (Task 3):

32x0.25 MWd/kgU for the interval 0 to 8 MWd/kgU

100x0.1 MWd/kgU for the interval 8 to 18 MWd/kgU

2x16 MWd/kgU for the interval 18 to 50 MWd/kgU

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

0.00001

Other related information

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References

J. Rhodes et al. (2004), "CASMO-4: A Fuel Assembly Burn-up Program, User's Manual", Studsvik Scandpower Report SSP-01/400 Rev 4.

J. Rhodes et al. (2004), "CASMO-4E: Extended Capability CASMO-4, User's Manual", Studsvik Scandpower Report SSP-01/401 Rev 2.

J. Rhodes (2005), "JEF 2.2 and ENDF/B-VI 70 Group Neutron Data Libraries" StudsvikScandpower Report SSP-04/454 Rev 2.

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Neutron data library

ENDF/B-VII

Neutron data processing code or method

SERPENT 2.1.11

Number of neutron energy group

Continuous-Energy

Description of your code system

SERPENT is a three-dimensional continuous-energy Monte Carlo reactor physics burn-up calculation code, developed at VTT Technical Research Centre of Finland since 2004. The code is specialised in two-dimensional lattice physics calculations, but the geometry description allows the modelling of complicated three-dimensional geometries as well.

Geometry modelling

Full assembly, fuel pellet divided radially into 10 depletion zones of equal volume

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 radial burn-up regions of equal volume

Adopting Predictor-Corrector method or not

Predictor-Corrector method was used with linear extrapolation/interpolation between the predictor and corrector and five sub-steps on both predictor, and corrector depletion steps

Precise burn-up steps information:

100 MWd/t

200 MWd/t

500 MWd/t

1000 MWd/t

2000 MWd/t

3000 MWd/t

5000 MWd/t

7500 MWd/t

10000 MWd/t

11000 MWd/t

12000 MWd/t

13000 MWd/t

14000 MWd/t

15000 MWd/t

17500 MWd/t

20000 MWd/t

25000 MWd/t

30000 MWd/t

35000 MWd/t

40000 MWd/t

45000 MWd/t

50000 MWd/t

Neutron history number

550 total cycles per step, out of which 50 initial cycles were skipped. 20 000 neutrons per cycle

Detail of fission yield data

ENDF/B-VII Radioactive decay data file

Detail of FP chain data

ENDF/B-VII Neutron-induced fission product yields

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

The statistical errors in eigenvalue calculations was less than 20 pcm

Other related information

-

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Neutron data library

JEF-2.2

Neutron data processing code or method

SERPENT 2.1.11

Number of neutron energy group

Continuous-Energy

Description of your code system

SERPENT is a three-dimensional continuous-energy Monte Carlo reactor physics burn-up calculation code, developed at VTT Technical Research Centre of Finland since 2004. The code is specialised in two-dimensional lattice physics calculations, but the geometry description allows the modelling of complicated three-dimensional geometries as well.

Geometry modelling

Full assembly, fuel pellet divided radially into 10 depletion zones of equal volume

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 radial burn-up regions of equal volume

Adopting Predictor-Corrector method or not

Predictor-Corrector method was used with linear extrapolation/interpolation between the predictor and corrector and five sub-steps on both predictor, and corrector depletion steps.

Precise burn-up steps information

100 MWd/t

200 MWd/t

500 MWd/t

1000 MWd/t

2000 MWd/t

3000 MWd/t

5000 MWd/t

7500 MWd/t

10000 MWd/t

11000 MWd/t

12000 MWd/t

13000 MWd/t

14000 MWd/t

15000 MWd/t

17500 MWd/t

20000 MWd/t

25000 MWd/t

30000 MWd/t

35000 MWd/t

40000 MWd/t

45000 MWd/t

50000 MWd/t

Neutron history number

550 total cycles per step, out of which 50 initial cycles were skipped. 20 000 neutrons per cycle

Detail of fission yield data

JEF-2.2 Radioactive decay data

Detail of FP chain data

JEF-2.2 Neutron-induced fission product yields

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

The statistical errors in eigenvalue calculations was less than 20 pcm

Other related information

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

SCALE 6.1.1 (TRITON T-DEPL sequence)

Number of neutron energy group

238 groups, collapsed into 49 groups during the initial steps of the sequence T-DEPL (optional feature).

Description of your code system

SCALE 6.1.1 with the TRITON T-DEPL sequence. A predictor-corrector approach is adopted. The 238-group ENDF/B-VII.0 library is applied to the fresh fuel system and collapsed into 49 groups using a built-in procedure using the NEWT 2D transport code. This structure is then used for automatically in the NEWT flux and eigenvalue depletion calculations during the depletion sequence using NEWT/. The depletion is made by ORIGEN-S. The resonance self-shielding for non-Gd-containing fuel is based on Dancoff factors determined for fresh fuel with MCDANCOFF.

Geometry modelling

1/4 symmetric full assembly modelling. The cylinder geometry is changed from the default 12 sides to 24 sides. The cell mesh is increased to 12x12 for each full cell.

Number of burn-up regions in UO_2-Gd_2O_3 rods

The gadolinium pellets contain five concentric regions.

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

0.0253 MWd/t from	0 MWd/t to 0.0253 MWd/t
50.0 MWd/t from	0.0253 MWd/t to 200.0 MWd/t
900 MWd/t from	200.0 MWd/t to 2 000 MWd/t
1000 MWd/t from	2 000 MWd/t to 16 000 MWd/t
2000 MWd/t from	16 000 MWd/t to 20 000 MWd/t
2500 MWd/t from	20 000 MWd/t to 30 000 MWd/t
3333 MWd/t from	30 000 MWd/t to 50 000 MWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

1.00E-04 (default value)

Other related information

Sn-order increased from 6 to 12 in NEWT. The maximum preset number of actinide nuclides and fission products were selected in TRITON (ADDNUX=4). This means 388 such nuclides. The burn-up distribution appears to be based on the power fraction at the beginning of each step (error less than 1%). Depletion of Gd-fuel with Multi-Region option (no Dancoff, flux-based) while depletion of other fuel is based on lattice-cell (Dancoff, power-based).

References

SCALE 6.1.1 as released from RSICC and NEA Data Bank.

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

SCALE 6.1.1 (TRITON T6-DEPL sequence)

Number of neutron energy group

238 groups

Description of your code system

SCALE 6.1.1 with the T6-DEPL sequence. A predictor-corrector approach is adopted. The 238-group ENDF/B-VII.0 library is applied in KENO-VI and depletion is carried out by ORIGEN-S. The resonance self-shielding for non-Gd-containing fuel is based on Dancoff factors determined for fresh fuel with MCDANCOFF.

Geometry modelling

1/4 symmetric full assembly modelling.

Number of burn-up regions in UO_2-Gd_2O_3 rods

The gadolinium pellets contain five concentric regions.

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

0.0253 MWd/t from	0 MWd/t to 0.0253 MWd/t
50.0 MWd/t from	0.0253 MWd/t to 200.0 MWd/t
900 MWd/t from	200.0 MWd/t to 2 000 MWd/t
1000 MWd/t from	2 000 MWd/t to 16 000 MWd/t
2000 MWd/t from	16 000 MWd/t to 20 000 MWd/t
2500 MWd/t from	20 000 MWd/t to 30 000 MWd/t
3333 MWd/t from	30 000 MWd/t to 50 000 MWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

1 500 total generations with 10000 neutrons per generation. 500 generations skipped, leaving ten million active neutron histories. Standard deviation between 0.00015 and 0.00020.

Other related information

The maximum present number of actinide nuclides and fission products were selected in TRITON (ADDNUX=4). This means 388 such nuclides. The burn-up distribution appears to be based on the power fraction in each pin at the beginning of each step (error less than 1%). Depletion of Gd-fuel with Multi-Region option (no Dancoff, flux-based) while depletion of other fuel is based on lattice cell (Dancoff, power-based). An update to SCALE 6.1.2 changed compositions by about 1% for ^{235}U and for a few fission products up to 1.5%. This may be reported later.

References

SCALE 6.1.1 as released from RSICC and NEA Data Bank.

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Neutron data library

JEFF-3.1.2

Neutron data processing code or method

ALEPH 2.2

Number of neutron energy group

Continuous-Energy

Description of your code system

ALEPH code (version 2.2) (coupling any version of MCNP(X) (Version 2.7.0) to a depletion code))

Geometry modelling

The whole fuel assembly

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

A. Stankovsky, G. Van den Eynde (2011), "Aleph2.1: A Monte Carlo Burn-up Code", SCK•CEN-BLG-1075.

A. Santamarina et al. (2009), "The JEFF-3.1.1 Nuclear Data Library, JEFF Report 22", NEA No. 6807.

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

CASMO-5M, v1.07.01

Number of neutron energy group

586 groups. Neutron data library provided by Studsvik Scandpower

Description of your code system

CASMO-5M (v1.07.01) is a two-dimensional characteristic based neutron transport theory lattice physics codes with depletion capability.

Geometry modelling

Half assembly simulation with reflective boundary conditions

Number of burn-up regions in UO_2-Gd_2O_3 rods

10 radial zones.

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

100 MWd/t from 0 MWd/t to 200 MWd/t,

300 MWd/t from 200 MWd/t to 500 MWd/t,

500 MWd/t from 500 MWd/t to 15 GWd/t,

2 500 MWd/t from 15 GWd/t to 50 GWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

"CASMO-5/CASMO-5M A FUEL ASSEMBLY BURNUP PROGRAM User's Manual", Studsvik, SSP-07/431 Rev 0.

"ENDF/B-VII.0 586 Group Neutron Data Library for CASMO-5 and CASMO-5M", Studsvik, SSP-07/402 Rev 5".

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Neutron data library

ENDF/B-VII.0

Neutron data processing code or method

MCNPX 2.7.0

Number of neutron energy group

Continuous-Energy

Description of your code system

MCNPX is a general purpose Monte Carlo radiation transport code designed to track many particle types over broad ranges of energies.

Geometry modelling

1/8th assembly simulation with reflective (white) boundary conditions

Number of burn-up regions in UO_2-Gd_2O_3 rods

five radial zones.

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

After Xenon convergence,

0.20 GWd/MTU from ~0. to 14 GWd/MTU

0.75 GWd/MTU from 14 to 50 GWd/MTU

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

100000 neutron/cycle, 30 initial skip cycle, 130 total cycle numbers

Sigma=18pcm

Other related information

CINDER data library provided with MCNPX 2.7.0 for fission yield and chain data.

Isotopes for cross-section updated are given using ZAid nomenclature

92234 92235 92238 8016 64154 64155 64156 64157 64158 64160 95642

61548 47510 98252 96248 96247 96246 96245 96244 96243 96242 95243 95241 94244 94243 94242 94241 94240 94239 94238 94236 93239 93237 93236 92237 92236 92233 92232 90230 90229 89227 88226 63156 63155 63154 63153 62154 62152 62151 62150 62149 62148 62147 61151 61149 61148 61147 60150 60148 60147 60146 60145 60144 60143 60142 58144 58141 58140 57140 57139 56140 56138 56136 55137 55135 55134 55133 54135 54134 54133 54132 54131 54130 53135 53129 53127 48113 47109 46108 46107 46105 45105 45103 44106 44104 44103 44102 44101 43099 42100 42098 42097 42095 40096 40093 40091 38090 38088 37087 37085 36085 36083 34079

References

D.B. Pelowitz (2011), “MCNPX User’s Manual, Version 2.7.0”, LA-CP-11-00438, LANL.

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Neutron data library

JENDL-4

Neutron data processing code or method

MOSRA-SRAC ver.2013

Number of neutron energy group

200 groups

Description of your code system

MOSRA-SRAC is a burn-up calculation module of the MSORA system. It is based on the collision probability method for neutron transport calculation and based on the improved Bateman's method for isotope generation and depletion calculation.

Geometry modelling

1/4 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

radial: nine, azimuthal: one

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

100 MWd/t from 0 MWd/t to 200 MWd/t

150 MWd/t from 200 MWd/t to 500 MWd/t

250 MWd/t from 500 MWd/t to 20 GWd/t

5 GWd/t from 20 GWd/t to 50 GWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

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References

K. Okumura et al. (2012), “Development of Burn-up Calculation Modules in the MOSRA System”, Preprints 2012 Autumn Mtg.

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Neutron data library

JENDL-3.2

Neutron data processing code or method

MVP2.0-BURN v2.31

Number of neutron energy group

Continuous-Energy

Description of your code system

"u4cm6fp104bp12T" was used for burn-up chain library of MVP-BURN. JENDL-3.3 was used for Sn-112 - Sn-124 because JENDL-3.2 does not have libraries of those nuclides.

Geometry modelling

1/2 symmetric full assembly modelling

Number of burn-up regions in UO_2-Gd_2O_3 rods

radial: 10 (concentric regions), azimuthal:1

Adopting Predictor-Corrector method or not

Yes

Precise burn-up steps information

0.25 GWd/t from 0 MWd/t to 16 GWd/t

2.0 GWd/t from 16 GWd/t to 50 GWd/t

Omitted nuclides, if any

No

Employed convergence limit or statistical errors for eigenvalue calculations

-

Other related information

-

References

OECD/NEA (2015), Burn-up Credit Criticality Benchmark Phase III-C "Nuclide Composition and Neutron Multiplication Factor of a BWR Spent Fuel Assembly for Burn-up Credit and Criticality Control of Damaged Nuclear Fuel".

K. Okumura et al. (2000), "Validation of a Continuous-Energy Monte Carlo Burn-up Code MVP-BURN and Its Application to Analysis of Post Irradiation Experiment", Journal of Nuclear Science and Technology, 37, 128.

T. Nakagawa et al. (1995), "Japanese evaluated nuclear data library, Version 3 revision-2; JENDL-3.2", J. Nuclear Science and Technology, 32, 1259.

Y. Watanabe et al. (2002), "Japanese Evaluated Nuclear Data Library Version 3 Revision-3: JENDL-3.3", Journal of Nuclear Science and Technology, 39, 1125.

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References

[1] H. Okuno, et al. (2002), "OECD/NEA Burn-up Credit Criticality Benchmark Phase III-B Burn-up Calculations of BWR Spent Fuel Assemblies in Storage and Transport", *JAERI-Research* 2002-001.

[2] T. Nakagawa et al. (1995), "Japanese Evaluated Nuclear Data Library Version 3 Revision-2: JENDL-3.2", *Journal of Nuclear Science and Technology*, 32(12), pp.1259-1271.

[3] K. Shibata et al. (2011), "JENDL-4.0: A New Library for Nuclear Science and Engineering, *Journal of Nuclear Science and Technology*, 48(1), pp.1-30.

[4] C. Nordborg et al. (1994), "Status of the JEF Evaluated Data Library", *Proceedings of International Conference on Nuclear Data for Science and Technology*, Vol. 2, p.680.Gatlinburg, Teneessee, US.

[5] (Eds.) A. Santamarina et al. (2009), "The JEFF-3.1.1 Nuclear Data Library", JEFF Report 22.

[6] (Comp. and Ed.) P.F. Rose (1991), "ENDF-201, ENDF/B-VI Summary Documentation", *BNL-NCS-17541*, 4th Edition.

[7] M.B. Chadwick et al. (2011),"ENDF/B-VII.1 Nuclear Data for Science and Technology: Cross Sections, Covariances, Fission Product Yields and Decay Data", *Nucl. Data Sheets*, 112, pp.2887-2996.

[8] K. Suyama et al. (2002), "Comparison of Burn-up Calculation Results Using Several Evaluated Nuclear Data Libraries", *Journal of Nuclear Science and Technology,* 39(1), pp.82-89.

[9] http://www.oecd-nea.org/tools/abstract/detail/nea-1642.

[10]K. Okumura et al. "A Set of ORIGEN2 cross section libraries based on JENDL-4.0: ORLIBJ40," JAEA-Data/Code 2012-032.

Appendix A.
Benchmark specifications

A.1 Introduction

After the accident of the Fukushima Daiichi Nuclear Power Station), which occurred off the pacific coast of Japan on 11 March 2011, technical developments were started to recover the environment and the decommissioning of the damaged nuclear power reactors. The criticality control of the damaged nuclear fuel is one of the key issues to be controlled during the decommissioning operation. For this purpose, criticality parameters of the mixtures of damaged nuclear fuel and other materials such as iron or concrete should be evaluated. First of all, it requires the averaged isotopic composition of spent nuclear fuel as a function of the burn-up value.

The Expert Group on Burn-up Credit Criticality (EGBUC) has organised several international benchmarks to assess the accuracy of the burn-up calculation code systems. For BWR fuel, the Phase III-B benchmark [1] is a remarkable landmark providing general information on the burn-up properties of BWR spent fuel. That information is useful for considering the basic criticality parameters of the damaged fuel of the Fukushima accident. However, it is based on the 8x8 type fuel assembly adopting a large water rod. In 1FNPS, the 9x9 type fuel assemblies adopting updated fuel design were widely used. It has different geometry specification and assembly averaged ^{235}U enrichment. This type of fuel assembly is called “STEP-3 fuel” in Japan.

Since the Phase III-B benchmarks carried out more than 10 years ago, nuclear data libraries have been revised, i.e. in Japan from JENDL-3.2 to JENDL-4, in Europe from JEF-2.2 to JEFF-3.1 and in the US from ENDF/B-VI to ENDF/B-VII, and the method of burn-up calculation has also been improved by adopting continuous-energy Monte Carlo code or based on the modern neutronics method. Considering the importance of the isotopic composition of STEP-3 BWR fuel from the view point of the criticality control of damaged fuel, it is recommended that a new international burn-up calculation benchmark for BWR fuel assembly should be organised to carry out the inter-comparison of the averaged isotopic composition of the STEP-3 nuclear fuel and to obtain related factors to be of interest to the burn-up credit criticality safety community.

A.2 Geometry specification

Figure 1 shows a horizontal cross-section of a BWR fuel assembly of a typical 9 x 9 type. A large water channel is located in the centre of the fuel assembly. The dimensions of the fuel assembly are shown in Table 1. As there are several design parameters of the BWR fuel assembly, this benchmark specification has been defined based on the typical design parameters which was published in the opened reports in Japan. This means that this is a benchmark calculation model which is close to a real fuel assembly design, i.e. not identical with the real fuel assembly. In the calculation, the reflective boundary condition should be applied to the water regions outside the assembly and the axial direction is infinite.

Figure A.1. Fuel assembly of BWR – Axial direction is infinite

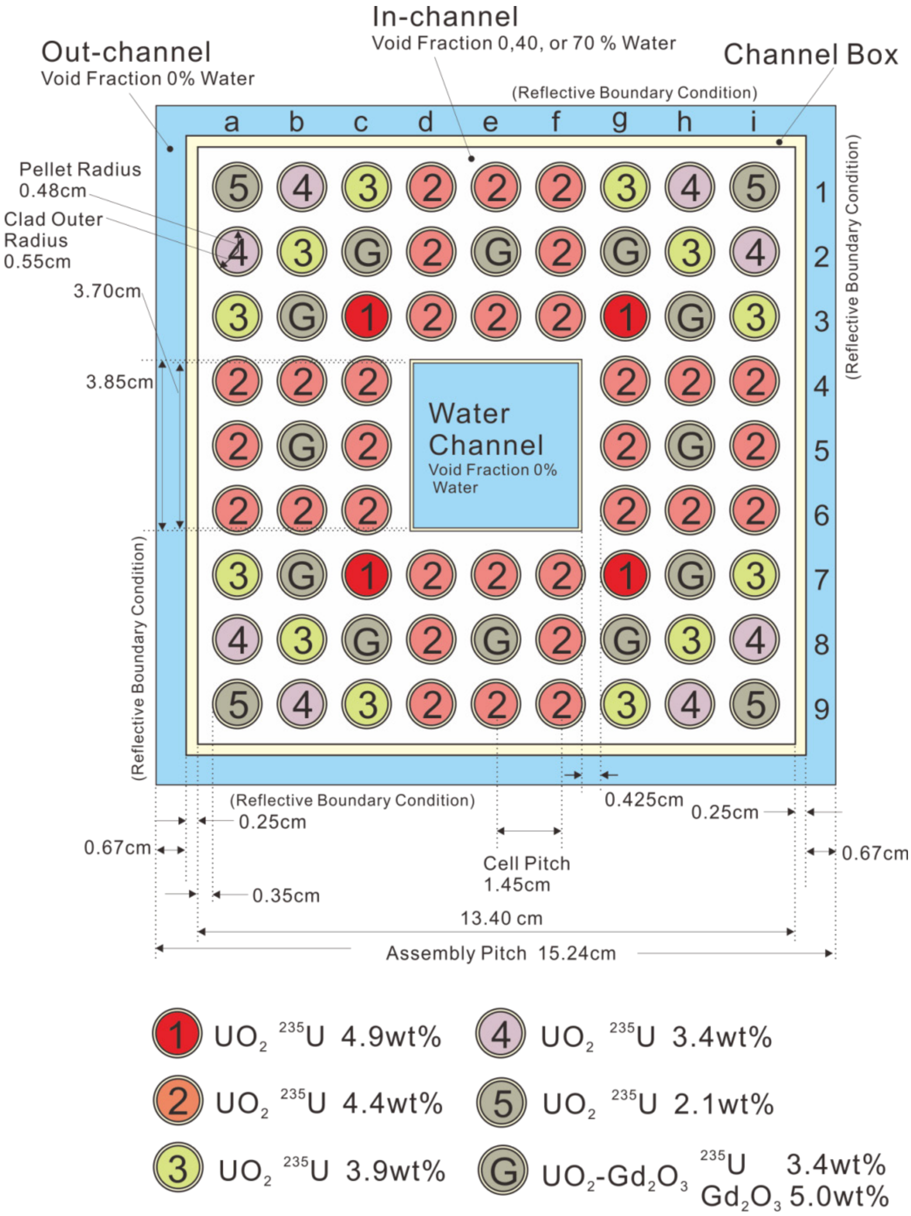


Table A.1. Specifications of fuel assembly and fuel rod

Fuel Assembly	
Lattice	9×9
Fuel rod pitch	1.45cm
Fuel assembly pitch	15.24cm
Number of fuel rods	72
Assembly average ^{235}U enrichment	3.9wt%
Fuel Rod	
Outer diameter	1.1cm
Cladding thickness	0.07cm
Cladding material	Zry-2
Pellet diameter	0.96cm
Pellet material	UO_2, UO_2-Gd_2O_3
Pellet ^{235}U enrichment	2.1 wt%(min.) to 4.9wt%(max.)
Gd_2O_3 content	5.0wt%
Water Channel	
Dimension (outside)	Square 3.85cm×3.85cm
Material	Zry-2
Channel thickness	0.075cm
Channel Box	
Dimension(outside)	Square 13.9cm×13.9cm
Material	Zry-2
Channel thickness	0.25cm

A.3 Material specification

The design of the fuel assembly of BWR is complex compared with the PWR assembly. As shown in Figure 1, it consists of five types of ^{235}U-enriched UO_2 rods, 4.9, 4.4, 3.9, 3.4 and 2.1 wt% without gadolinium and 3.4wt% ^{235}U-enriched UO_2 rods with 5.0 wt% Gd_2O_3 and a water channel. Table 2 shows the nuclide densities of each fresh rod. In this table, the number densities shown are the values averaged over the entire inner rod region (pellet + gap). Those of cladding and moderator are shown in Tables 3 and 4, respectively.

Table A.2. Initial isotopic composition of fuel and water channel (Temperature: fuel at 900 K and cladding and water channel at 559K.)

Rod Type ID	Enrichment	Gadolinium	Isotope	Number Density($10^{24}/cm^3$)
1	4.9wt%	-	^{234}U	8.5649×10^{-6}
			^{235}U	1.1221×10^{-3}
			^{238}U	2.1495×10^{-2}
			^{16}O	4.5252×10^{-2}
2	4.4wt%	-	^{234}U	7.6910×10^{-6}
			^{235}U	1.0076×10^{-3}
			^{238}U	2.1609×10^{-2}
			^{16}O	4.5249×10^{-2}
3	3.9wt%	-	^{234}U	6.8170×10^{-6}
			^{235}U	8.9315×10^{-4}
			^{238}U	2.1723×10^{-2}
			^{16}O	4.5247×10^{-2}
4	3.4wt%	-	^{234}U	5.9431×10^{-6}
			^{235}U	7.7865×10^{-4}
			^{238}U	2.1838×10^{-2}
			^{16}O	4.5244×10^{-2}
5	2.1wt%	-	^{234}U	3.6708×10^{-6}
			^{235}U	4.8094×10^{-4}
			^{238}U	2.2134×10^{-2}
			^{16}O	4.5238×10^{-2}
G	3.4wt%	5.0wt%	^{234}U	5.5429×10^{-6}
			^{235}U	7.2622×10^{-4}
			^{238}U	2.0367×10^{-2}
			^{16}O	4.4678×10^{-2}
			^{154}Gd	3.6051×10^{-5}
			^{155}Gd	2.4475×10^{-4}
			^{156}Gd	3.3852×10^{-4}
			^{157}Gd	2.5881×10^{-4}
			^{158}Gd	4.1079×10^{-4}
			^{160}Gd	3.6481×10^{-4}
Water Channel*	-	-	^{1}H	4.9316×10^{-2}
			^{16}O	2.4658×10^{-2}

* No void in the water channel region.

Table A.3. Cladding, water channel and channel box material – Zircalloy-2 (at 559 K)

Isotope	Number Density [$10^{24}/cm^3$]
Sn	4.9797×10^{-4}
Fe	9.1782×10^{-5}
Cr	7.5861×10^{-5}
Ni	4.0314×10^{-5}
Zr	4.2465×10^{-2}

Table A.4. Moderator – Water (at 559 K)

Region	Void Fraction [%]	Isotope	Number Density [$10^{24}/cm^3$]
in-channel	0	^{1}H	4.9316×10^{-2}
		^{16}O	2.4658×10^{-2}
	40	^{1}H	3.0588×10^{-2}
		^{16}O	1.5294×10^{-2}
	70	^{1}H	1.6542×10^{-2}
		^{16}O	8.2712×10^{-3}
out-channel*	0	^{1}H	4.9316×10^{-2}
		^{16}O	2.4658×10^{-2}

* No void in the out-channel region.

A.4 Parameters of the calculation

A.4.1 Case names and burn-up parameters

The nuclide composition and k_{inf} should be evaluated for three void fractions. Specific power is 25.3 MW/tHM for all cases, maximum fuel burn-up is 50 GWd/tHM, and the cooling time after burn-up is 0, 5 and 15 years. The relation of the case name and burn-up parameters is shown in Table 5. Participants are requested to compile averaged nuclide densities of each case number 1b, 2a, 2b, 2c, 3b, 5b, 5c, 6b, 8b, 8c, 9b, 11b, 11c and 12b, respectively. The temperatures of fuel and other components of the assembly are assumed to remain in the hot condition even in the cooling period.

Table A.5. Case name

Burn-up	12 GWd/t			20 GWd/t			30 GWd/t			50 GWd/t		
Cooling [Year]	0	5	15	0	5	15	0	5	15	0	5	15
0% V.F.*	1a	**1b**	1c	4a	4b	4c	7a	7b	7c	10a	10b	10c
40% V.F.	**2a**	**2b**	**2c**	5a	**5b**	**5c**	8a	**8b**	**8c**	11a	**11b**	**11c**
70% V.F.	3a	**3b**	3c	6a	**6b**	6c	9a	**9b**	9c	12a	**12b**	12c

* V.F. means Void Fraction

A.5 Benchmarked nuclides

Nuclides that should be benchmarked are 13 actinides and 26 fission products, as shown in Table 6.

Table A.6. Benchmarked nuclides

Actinides	^{234,235,236,238}U ^{237}Np ^{238,239,240,241,242}Pu ^{241,243}Am ^{244}Cm
FP	^{90}Sr, ^{95}Mo, ^{99}Tc, ^{101}Ru, ^{103}Rh, ^{109}Ag ^{129}I, ^{131}Xe, ^{133,134,137}Cs ^{144}Ce, ^{143,145,148}Nd ^{147,149,150,151,152}Sm ^{153,154,155}Eu ^{155,156,157,158}Gd

A.6 Requested data

For the 9x9 assembly, participants are requested to evaluate the following quantities:

- number densities of all nuclides including gadolinium isotopes specified in Table 6, which are averaged over all fuel rods, in the unit of $10^{24}/cm^3$, for selected case numbers 1b, 2a, 2b, 2c, 3b, 5b, 5c, 6b, 8b, 8c, 9b, 11b, 11c and 12b, respectively;

- neutron multiplication factors for the burn-up of 0, 0.2, 10, 12, 20, 30 and 50 GWd/t;
- maximum neutron multiplication factor and the corresponding burn-up, which should be evaluated by each participant,
- burn-up of each fuel pin shown in Figure 2, considering symmetrical array for an assembly averaged burn-up of 12, 30 and 50 GWd/t.

A.7 Results and media

An e-mail attaching Microsoft Excel file should be sent to: nea-nsc-wpncs-egbuc-phase3c@jaea.go.jp

Table 7 shows the recommended format of the Excel sheet for Case 1b. This sheet should be made for all submitted cases. Missing results should be indicated with the tag "NODATA".

k_{inf} at each burn-up (0, 0.2, 10, 12, 20, 30, 50 [GWd/tHM]), Peak k_{inf} and the corresponding burn-up [GWd/tHM] should be saved in the same Excel file. The format is shown in Table 8.

The burn-up distribution data should be saved in the same Excel file. Its format is shown in Table 9.

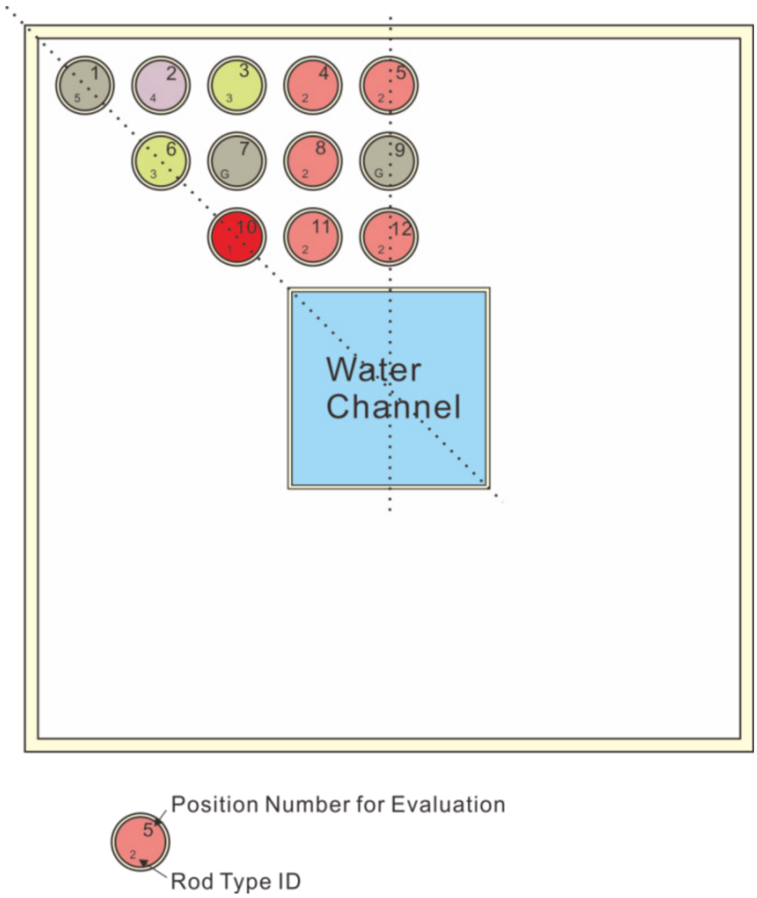
The description of the analysis environment should include the following:

- institute and country;
- participants;
- neutron data library;
- neutron data processing code or method;
- number of neutron energy group;
- description of your code system;
- geometry modelling;
- omitted nuclides, if any;
- employed convergence limit or statistical errors for eigenvalue calculations;
- other related information;
- references to your code system or library.

A.8 Schedule

- end of February 2013: deadline for participants to provide their results;
- end of May 2013: deadline for co-ordinators to compile the results into tables/figures;
- end of August 2013: deadline for co-ordinators to send the draft report to the participants.

Figure A.2. Position number of fuel rod for evaluation



Rod Type ID is shown in Figure 1.

Table A.7. Format of requested data for Case1b

Line Number	Data
1	Date
2	Institute
3	Contact person
4	E-mail address
5	Telefax number
6	Case name tag "Case1b:Burn-up=12GWd/t, V.F=0%, Cooling=5year"
7	Nuclide density of ^{234}U
8	Nuclide density of ^{235}U
9	Nuclide density of ^{236}U
10	Nuclide density of ^{238}U
11	Nuclide density of ^{237}Np
12	Nuclide density of ^{238}Pu
13	Nuclide density of ^{239}Pu
14	Nuclide density of ^{240}Pu
15	Nuclide density of ^{241}Pu
16	Nuclide density of ^{242}Pu
17	Nuclide density of ^{241}Am
18	Nuclide density of ^{243}Am
19	Nuclide density of ^{244}Cm
20	Nuclide density of ^{90}Sr
21	Nuclide density of ^{95}Mo
22	Nuclide density of ^{99}Tc
23	Nuclide density of ^{101}Ru
24	Nuclide density of ^{103}Rh
25	Nuclide density of ^{109}Ag
26	Nuclide density of ^{129}I
27	Nuclide density of ^{131}Xe
28	Nuclide density of ^{133}Cs
29	Nuclide density of ^{134}Cs
30	Nuclide density of ^{137}Cs
31	Nuclide density of ^{144}Ce
32	Nuclide density of ^{143}Nd
33	Nuclide density of ^{145}Nd
34	Nuclide density of ^{148}Nd
35	Nuclide density of ^{147}Sm
36	Nuclide density of ^{149}Sm
37	Nuclide density of ^{150}Sm
38	Nuclide density of ^{151}Sm
39	Nuclide density of ^{152}Sm
40	Nuclide density of ^{153}Eu
41	Nuclide density of ^{154}Eu
42	Nuclide density of ^{155}Eu
43	Nuclide density of ^{155}Gd
44	Nuclide density of ^{156}Gd
45	Nuclide density of ^{157}Gd
46	Nuclide density of ^{158}Gd

Table A.8. Format of requested data for peak k_{inf} and corresponding burn-up

Line Number	Data
1	Date
2	Institute
3	Contact person
4	E-mail address
5	Telefax number
6	peak k_{inf} and corresponding burn-up for Void Fraction 0% (save in sequential row)
7	peak k_{inf} and corresponding burn-up for Void Fraction 40% (save in sequential row)
8	peak k_{inf} and corresponding burn-up for Void Fraction 70% (save in sequential row)
9	k_{inf} at each burn-up(0, 0.2, 10, 12, 20, 30, 50 [GWd/tHM]) (save in sequential row) for Void Fraction 0%
	k_{inf} at each burn-up(0, 0.2, 10, 12, 20, 30, 50 [GWd/tHM]) (save in sequential row) for Void Fraction 40%
10	k_{inf} at each burn-up(0, 0.2, 10, 12, 20, 30, 50 [GWd/tHM]) (save in sequential row) for Void Fraction 70%
11	

Table A.9. Format of requested data for burn-up distribution

Line Number	Data
1	Date
2	Institute
3	Contact person
4	E-mail address
5	Telefax number
6	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 12 GWd/t for Void Fraction 0%
	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 12 GWd/t for Void Fraction 40%
7	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 12 GWd/t for Void Fraction 70%
	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 30 GWd/t for Void Fraction 0%
8	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 30 GWd/t for Void Fraction 40%
	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 30 GWd/t for Void Fraction 70%
9	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 50 GWd/t for Void Fraction 0%
	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 50 GWd/t for Void Fraction 40%
10	Burn-up [GWd/tHM] of each pin position 1, 2,...., 11, 12 (save in sequential row) at 50 GWd/t for Void Fraction 40%
11	
12	
13	
14	

Reference

[1] H. Okuno, Y. Naito, K. Suyama (2002), "OECD/NEA Burn-up Credit Criticality Benchmark Phase III-B Burn-up Calculations of BWR Spent Fuel Assemblies in Storage and Transport," *JAERI-Research* 2002-001, Japan Atomic Energy Research Institute.

Appendix B.
Report from JAEA on the Phase III-B Benchmark at the EGBUC meeting in September 2012

B.1 Introduction

The Expert Group on Burn-up Credit Criticality (EGBUC) has played an important role in the benchmark of the burn-up calculation codes. In the first phase of the benchmark activity started at the beginning of the 1990s, a simple burn-up calculation problem using the single pin-cell model was adopted for the PWR fuel. Then, in order to compare the predictability of computer codes and data libraries for BWR fuel, an assembly burn-up calculation benchmark "Phase III-B" was proposed [1].

Following the Fukushima accident, Japan has strived to evaluate the predictability of the isotopic composition of BWR spent fuel for the management of the damaged fuel. The final report of Phase III-B was published more than 10 years ago. Since then, the burn-up calculation codes and nuclear data libraries have been improved and revised. For example, the SWAT code system adopted by JAEA (JAERI) in the Phase III-B benchmark was revised to SWAT3.1 [2] in order to use the continuous energy Monte Carlo code, and other codes such as MONTEBURN [3] using MCNP are widely used now. Several participants in the Phase III-B benchmark updated the burn-up module, i.e. from SCALE4 to SCALE5. However, it would be difficult to evaluate the state-of-the-art of computer programs and data libraries to be used for the prediction of the isotopic composition of BWR fuel directly from the results of the previous benchmark.

In order to grasp the improvement or change of the burn-up calculation system, we have analysed again the Phase III-B problem by using the SWAT3.1 code system and comparing the results with previously reported data.

B.2 Analyses

Table 1 shows the participants in Phase III-B. From JAEA (JAERI), we participated in the benchmark using SWAT [4] and MKENO-BURN2 [5]. MKENO-BURN2 had a serious problem which could not be solved. It was a very old code developed on the mainframe machine and it could not produce the effective cross-section of Gd fuel correctly. The results of SWAT were clearly better than those of MKENO-BURN2. However, SWAT could not treat the multi-layer burn-up region dividing the fuel pellet region, which would be essential to treat the burn-up of gadolinium pins. Using the continuous-energy Monte Carlo code, SWAT3.1 is able to treat any geometry modelling.

The difference in the JAEA (JAERI) burn-up analyses code system from the time of the Phase III-B benchmark is the introduction of the continuous-energy Monte Carlo code in the burn-up calculation system. SWAT3.1 drives MVP (Monte Carlo Code for Vector Processor), which has been developed by JAERI, or MCNP in order to evaluate neutron reaction rates in the arbitrary burn-up regions. The system is shown in Figure 1. MVP was selected to evaluate the neutron reaction rates. In this analysis, the neutron numbers per cycle were 10,000 and 1,100 cycles were traced after the initial 100 cycles were excluded from the tallying process. JENDL-4 was adopted as a neutron cross-section library.

Figure B.1. Calculation flow of SWAT3.1

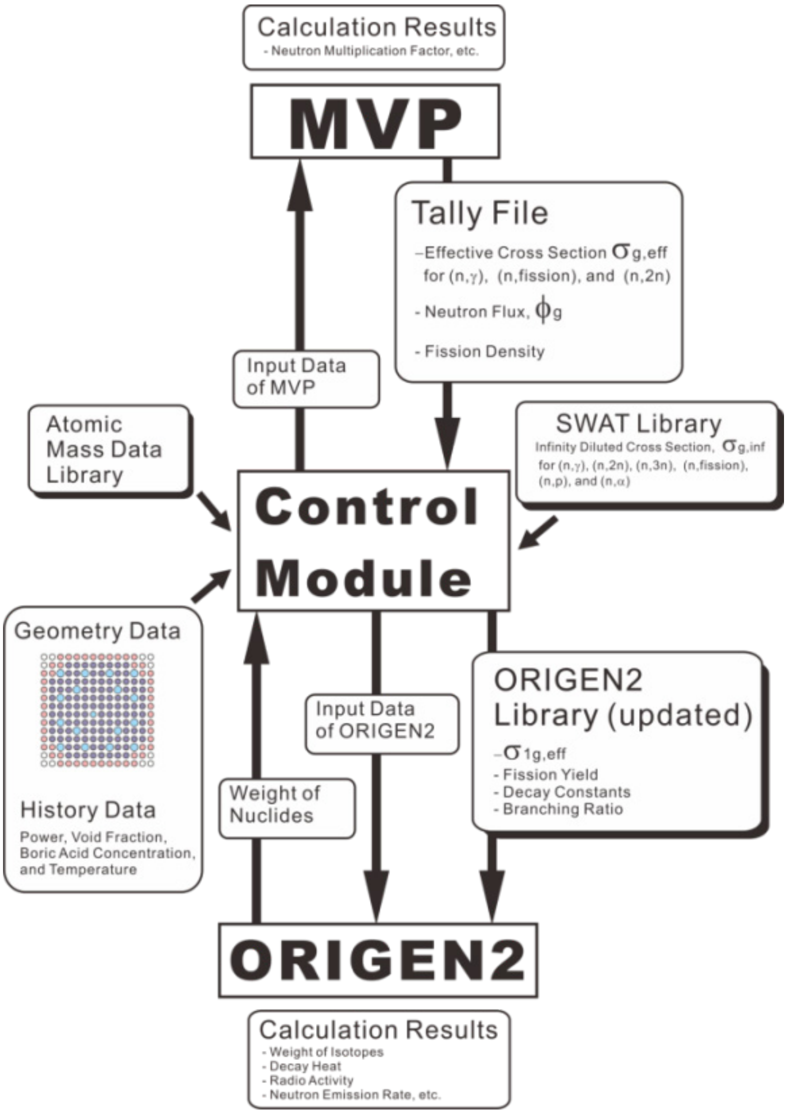


Table B.1. Participants in the Phase III-B Benchmark

ID	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R
Institute	NUPEC	BNFL	CEA	JAERI	PSI	CEA-SACLAY	Belgo nucleaire	Toshiba	Hitachi	ORNL	CRIEPI	JAERI	JAERI	PNC	ORNL	GRS
Country	Japan	UK	France	Japan	Switzerland	France	Belgium	Japan	Japan	US	Japan	Japan	Japan	Japan	US	Germany
Code	CASMO4	WIMS7	APOLLO2	MKENO-BURN2	BOXER	TRIPOLI4[*1]	WIMS7	TGBLA/ ORIGEN2.1	VMONT	HELIOS	FLEXBURN	SWAT	SWAT[*2]	SCALE4.3[*3]	SCALE4.4	KENOREST
Burn-up Calculation Method	Matrix Exponential	Bateman	Bateman	Bateman	Matrix Exponential	Fresh results only	Bateman	Matrix Exponential	Runge -Kutta -Gill	Bateman	Matrix Exponential	Matrix Exponential	Matrix Exponential	Matrix Exponential	Matrix Exponential	Matrix Exponential
Remarks	Do not treat Gd decay correctly.	A lack of an alpha-decay path of ^{242}Cm.		A serious inconsistency		Do not consider decay of FP nuclides	A lack of an alpha-decay path of ^{242}Cm.			A serious inconsistency (70% void cases)			Single pin-cell model	Multi-rods approximation	One-dimensional treatment	
Pin-wise BU													No data	No data	No data	
Gd densities in Gd pins	Do not consider decay during cooling time.						Do not include residual Gd of Gd pins				Incomplete decay chain treatment					
Nuclear Data	ENDF/B-4	JEF-2.2	JEF-2.2	JENDL-3.2	JEF-1, -2	JEF-2.2	JEF-2.2	ENDF/B-4, -5	ENDF/B-4 and JENDL-2	ENDF/B-6	JENDL-3.2	JENDL-3.2	JENDL-3.2	ENDF/B-5	ENDF/B-5, -6	JEF2.2

1. Fresh results only (i.e. no burn-up calculation).

2. Single pin-cell model.

3. Multi-rods approximation.

B.3 Results

As several participants in the Phase III-B benchmark did not adopt the assembly burn-up calculation, a few participants were selected i.e. A(CASMO4;NUPEC), B(WIMS7;BNFL), C(APOLLO2;CEA), E(BOXER;PSI), G(WIMS7;BN), H(TGBLA;Toshiba) and J(VMONT;Hitachi) to compare the results with each other.

B.3.1 Burn-up distribution

Tables B.2, B.3 and B.4 summarise the comparison of the burn-up distribution. It is shown that burn-up values by SWAT3.1 are almost within the standard deviation of participants A to J. These tables clearly show that participants B and C give slightly smaller values for rods #1 to #4 and larger values for #5 to #9. The burn-up values of SWAT3.1 are similar to the values of participants A, G, and J.

In Tables B.2, B.3 and B.4, the comparison of SWAT3.1 and the past results of M (SWAT) are also shown. M (SWAT) shows smaller burn-up values of fuel pin #1 and #6. #1 is the fuel pin at the corner of the fuel assembly and #6 is the UO_2-Gd_2O_3 pin. This tendency is fixed in the results of SWAT3.1.

Table B.2. Comparison of burn-up distribution – Case 1 (0% void fraction)

Rod ID	#1	#2	#3	#4	#5	#6	#7	#8	#9
A(CASMO4)	37.2	39.1	41.2	40.4	38.7	32.0	43.3	42.5	44.3
B(WIMS7)	35.9	38.3	40.8	40.1	38.9	32.3	44.2	43.5	44.8
C(APOLLO2)	36.0	38.2	40.5	39.9	38.6	33.4	43.8	43.2	44.9
E(BOXER)	37.1	39.0	41.1	40.4	38.9	32.2	43.3	42.6	44.2
G(WIMS7)	37.6	39.4	41.5	40.7	39.1	30.2	43.5	42.8	44.7
H(TGBLA)	36.8	38.8	41.0	40.3	38.7	32.0	43.5	42.6	44.6
J(VMONT)	37.8	39.5	41.3	40.5	39.2	31.3	43.3	42.6	44.3
Average$	36.9	38.9	41.1	40.3	38.9	31.9	43.6	42.8	44.5
σ(%)#	1.8	1.2	0.7	0.6	0.5	2.8	0.7	0.8	0.6
SWAT3.1	37.6	39.3	41.3	40.4	38.8	31.7	43.2	42.4	44.3
Difference(%)-1: SWAT3.1-Average*	1.8	1.0	0.5	0.2	-0.2	-0.5	-0.9	-1.1	-0.5
M(SWAT)	35.4	38.3	41.2	40.9	39.1	31.0	44.7	44.0	45.4
Difference(%)-2: SWAT3.1 - **M**	6.2	2.5	0.2	-1.2	-0.8	2.4	-3.4	-3.7	-2.3
Difference(%)-3: **M** - Average	-4.1	-1.5	0.3	1.4	0.6	-2.9	2.6	2.7	1.9

$: Average of Participants **A** to **J**

#: Standard deviation of Participants **A** to **J**

*: Difference (%) of SWAT3.1 from Average: (SWAT3.1-Average)/Average×100

Table B.3. Comparison of burn-up distribution – Case 2 (40% void fraction)

Rod ID	#1	#2	#3	#4	#5	#6	#7	#8	#9
A(CASMO4)	39.0	40.1	41.7	40.7	38.7	31.8	42.3	41.5	43.3
B(WIMS7)	37.8	39.4	41.4	40.5	38.9	32.0	43.1	42.2	43.7
C(APOLLO2)	38.3	39.5	41.0	40.2	38.5	32.9	42.5	41.7	44.1
E(BOXER)	38.6	39.9	41.3	40.4	39.1	32.3	42.6	41.8	43.3
G(WIMS7)	39.1	40.2	41.8	40.8	38.9	30.0	42.6	41.9	44.1
H(TGBLA)	38.4	39.8	41.5	40.6	38.9	31.9	42.7	41.6	43.4
J(VMONT)	39.4	40.3	41.7	40.8	39.3	31.3	42.5	41.7	43.2
Average$	38.7	39.9	41.5	40.6	38.9	31.7	42.6	41.8	43.6
σ(%)#	1.3	0.8	0.6	0.5	0.6	2.7	0.5	0.5	0.8
SWAT3.1	39.4	40.3	41.7	40.6	38.9	31.6	42.3	41.4	43.2
Difference(%)-1: SWAT3.1-Average*	1.9	1.0	0.6	0.2	0.0	-0.4	-0.8	-0.9	-0.9
M(SWAT)	37.3	39.4	41.9	41.4	39.0	30.6	43.6	42.7	44.2
Difference(%)-2: SWAT3.1 - **M**	5.6	2.2	-0.4	-1.8	-0.3	3.3	-3.0	-3.1	-2.3
Difference(%)-3: **M** - Average	-3.5	-1.2	1.0	2.0	0.3	-3.6	2.3	2.2	1.4

$: Average of Participants **A** to **J**

#: Standard deviation of Participants **A** to **J**

*: Difference (%) of SWAT3.1 from Average : (SWAT3.1-Average)/Average×100

Table B.4. Comparison of burn-up distribution – Case 3 (70% void fraction)

Rod ID	#1	#2	#3	#4	#5	#6	#7	#8	#9
A(CASMO4)	40.8	40.9	42.1	40.9	38.6	31.7	41.4	40.9	42.5
B(WIMS7)	39.6	40.3	41.9	40.8	38.8	31.6	42.1	41.3	42.9
C(APOLLO2)	40.8	40.7	41.7	40.6	38.4	32.3	41.1	40.3	43.2
E(BOXER)	39.9	40.3	41.4	40.4	39.2	32.4	42.2	41.2	42.7
G(WIMS7)	40.7	40.8	42.0	40.8	38.7	29.8	41.7	41.3	43.7
H(TGBLA)	40.1	40.7	41.9	40.8	39.1	31.8	42.0	40.7	42.4
J(VMONT)	41.0	41.1	41.9	40.9	39.2	31.2	41.8	41.1	42.4
Average$	40.4	40.7	41.8	40.7	38.9	31.5	41.8	41.0	42.8
σ(%)#	1.2	0.7	0.5	0.4	0.8	2.6	0.9	0.8	1.0
SWAT3.1	41.2	41.1	42.1	40.8	38.9	31.5	41.4	40.7	42.3
Difference(%)-1: SWAT3.1-Average*	2.0	1.1	0.5	0.1	0.0	-0.2	-0.8	-0.6	-1.3
M(SWAT)	39.3	40.5	42.5	41.9	38.8	30.1	42.4	41.4	43.0
Difference(%)-2: SWAT3.1 - **M**	4.9	1.5	-1.0	-2.7	0.2	4.6	-2.3	-1.6	-1.7
Difference(%)-3: **M** - Average	-2.8	-0.5	1.6	2.8	-0.1	-4.6	1.5	1.0	0.4

$: Average of Participants **A** to **J**

#: Standard deviation of Participants **A** to **J**

*: Difference (%) of SWAT3.1 from Average: (SWAT3.1-Average)/Average×100.

B.4 Neutron multiplication factor

Neutron multiplication factors are summarised in Tables B.5, B.6 and B.7. Taking into account the variety of codes, libraries and nuclides, the neutron multiplication factors of these participants show good agreement with each other. A comparison of M (SWAT) and average shows that M had the tendency of a smaller neutron multiplication factor in the low burn-up region and this is fixed for SWAT3.1. However, the neutron multiplication factor should be evaluated by using a unique calculation code and nuclear data library to investigate which nuclides have the largest impact on the difference of the neutron multiplication factor.

Table B.5. Comparison of neutron multiplication factor – Case 1 (0% void fraction)

Burn-up (GWd/t)	0.00	0.20	10.00	20.00	30.00	40.00	k_{inf} peak	
							k_{inf}	[GWd/tHM]
A(CASMO4)	1.09	1.06	1.18	1.13	1.02	0.91	1.20	12.00
B(WIMS7)	1.09	1.07	1.19	1.12	1.02	0.91	1.20	11.60
C(APOLLO2)	1.10	1.07	1.20	1.13	1.02	0.92	1.21	11.50
E(BOXER)	1.09	1.07	1.19	1.13	1.02	0.92	1.21	11.50
G(WIMS7)	1.10	1.07	1.18	1.13	1.02	0.92	1.20	12.20
H(TGBLA)	1.09	1.07	1.19	1.12	1.01	0.90	1.21	11.80
J(VMONT)	1.10	1.07	1.19	1.13	1.02	0.91	1.21	12.00
Average$	1.09	1.07	1.19	1.13	1.02	0.91	1.21	11.80
σ(%)#	0.2	0.2	0.5	0.3	0.4	0.5	0.3	2.2
SWAT3.1	1.10	1.08	1.19	1.13	1.02	0.92	1.21	12.50
Difference(%)-1: SWAT3.1-Average*	0.7	0.9	-0.1	0.6	0.3	0.3	0.1	5.9
M(SWAT)	1.08	1.06	1.20	1.14	1.03	0.93	1.22	11.50
Difference(%)-2: SWAT3.1 - **M**	1.9	2.1	-1.1	-0.3	-1.0	-1.7	-0.9	8.7
Difference(%)-3: **M** - Average	-1.2	-1.2	1.1	0.9	1.3	2.0	1.0	-2.5

$: Average of Participants **A** to **J**.

#: Standard deviation of Participants **A** to **J**.

*: Difference (%) of SWAT3.1 from Average: (SWAT3.1-Average)/Average×100.

Table B.6. Comparison of neutron multiplication factor – Case 2 (40% void fraction)

Burn-up (GWd/t)	0.00	0.20	10.00	20.00	30.00	40.00	k_{inf} peak	
							k_{inf}	[GWd/tHM]
A(CASMO4)	1.07	1.05	1.16	1.11	1.02	0.94	1.18	12.50
B(WIMS7)	1.08	1.06	1.16	1.10	1.01	0.93	1.17	12.10
C(APOLLO2)	1.08	1.06	1.17	1.12	1.03	0.94	1.18	12.10
E(BOXER)	1.07	1.05	1.16	1.11	1.02	0.94	1.18	12.00
G(WIMS7)	1.08	1.05	1.15	1.11	1.02	0.94	1.18	12.20
H(TGBLA)	1.07	1.04	1.16	1.11	1.01	0.92	1.18	12.10
J(VMONT)	1.07	1.05	1.16	1.12	1.03	0.93	1.18	12.00
Average$	1.08	1.05	1.16	1.11	1.02	0.93	1.18	12.14
σ(%)#	0.5	0.5	0.4	0.5	0.5	0.6	0.3	1.3
SWAT3.1	1.08	1.06	1.16	1.12	1.03	0.94	1.18	12.00
Difference(%)-1: SWAT3.1-Average*	0.6	0.6	0.3	0.6	0.7	0.8	0.2	-1.2
M(SWAT)	1.07	1.04	1.16	1.12	1.03	0.95	1.19	12.00
Difference(%)-2: SWAT3.1 - **M**	1.5	1.6	0.2	-0.1	-0.4	-1.1	-0.5	0.0
Difference(%)-3: **M** - Average	-0.9	-1.0	0.1	0.7	1.1	1.9	0.7	-1.2

$: Average of Participants **A** to **J**.

#: Standard deviation of Participants **A** to **J**.

*: Difference (%) of SWAT3.1 from Average: (SWAT3.1-Average)/Average×100.

Table B.7. Comparison of neutron multiplication factor – Case 3 (70% void fraction)

Burn-up (GWd/t)	0.00	0.20	10.00	20.00	30.00	40.00	k_{inf} peak	
							k_{inf}	[GWd/tHM]
A(CASMO4)	1.05	1.03	1.13	1.10	1.02	0.94	1.15	12.50
B(WIMS7)	1.07	1.05	1.13	1.08	1.00	0.93	1.14	12.40
C(APOLLO2)	1.07	1.05	1.13	1.10	1.02	0.94	1.15	13.00
E(BOXER)	1.05	1.03	1.13	1.10	1.02	0.94	1.15	12.50
G(WIMS7)	1.06	1.03	1.13	1.10	1.02	0.94	1.15	12.80
H(TGBLA)	1.05	1.03	1.13	1.09	1.01	0.93	1.15	12.60
J(VMONT)	1.06	1.03	1.14	1.11	1.02	0.94	1.16	12.00
Average$	1.06	1.03	1.13	1.10	1.01	0.94	1.15	12.54
σ(%)#	0.9	0.8	0.3	0.6	0.6	0.6	0.4	2.3
SWAT3.1	1.06	1.04	1.13	1.10	1.02	0.95	1.15	12.00
Difference(%)-1: SWAT3.1-Average*	-0.1	0.1	0.2	0.7	0.9	1.1	0.3	-4.3
M(SWAT)	1.05	1.02	1.12	1.10	1.02	0.96	1.15	13.00
Difference(%)-2: SWAT3.1 - M	1.0	1.2	1.0	0.2	0.0	-0.6	0.2	-7.7
Difference(%)-3: M - Average	-1.1	-1.1	-0.8	0.4	1.0	1.8	0.1	3.6

$: Average of Participants **A** to **J**.

#: Standard deviation of Participants **A** to **J**.

*: Difference (%) of SWAT3.1 from Average: (SWAT3.1-Average)/Average×100.

B.5 Nuclide density

Tables B.8, B.9 and B.10 show the difference of the averaged nuclide densities by SWAT3.1 considering the results of participants A, B, C, E, G, H, J and M. Several isotopes show a typical difference of nuclide density corresponding to adopted nuclear data libraries. For example, ^{238}Pu of M (SWAT) is smaller than that of C (APOLLO2). This is due to the difference of the neutron capture cross-sections of ^{237}Np and ^{238}Pu, and the (n,2n) cross-section of ^{238}U between JEF and JENDL-3.2, fixed in JENDL-4.

In fission product nuclides, ^{155}Eu shows a larger difference than other nuclides. In the Phase III-B report, large differences (2-sigma(r) (%) value was more than 90%) of Gd isotopes are shown. This must be studied for the further application of the burn-up calculation results because ^{155}Eu is the parent isotope of ^{155}Gd, which will be generated by the radioactive decay of ^{155}Eu.

In this result, an agreement of Gd isotopes has been improved since the Phase III-B benchmark. This is due to the fact that assembly burn-up codes were selected only for this comparison. Generally, the relative difference of nuclide density from selected calculation codes agree well with each other. A similar benchmark problem should be carried out in order to compare the current status of the assembly burn-up code for the predictability of the characteristics of the burnt BWR fuel assembly.

Table B.8. Difference (%) of nuclide density – Case 1 (0% void fraction)

	A(CASMO4)	**B**(WIMS7B)	**C**(APOLLO2)	**E**(BOXER)	**G**(WIMS7B)	**H**(TGBLA)	**J**(VMONT)	**M**(SWAT)
U-234	-1.5	-2.8	-4.0	-3.8	-2.5	-3.0	5.8	1.8
U-235	1.3	0.9	0.3	3.0	4.0	-0.1	-2.8	4.4
U-236	0.6	-1.1	-2.1	0.2	-1.5	0.3	1.7	-2.2
U-238	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Pu-238	-5.9	-19.3	-5.9	-3.0	-14.4	-4.9	-3.2	-13.9
Pu-239	3.0	5.5	2.6	5.7	8.2	0.2	1.6	3.0
Pu-240	-2.7	3.2	2.1	5.9	1.2	3.5	-1.6	5.5
Pu-241	1.1	1.2	1.5	1.8	2.7	2.8	1.7	7.6
Pu-242	-5.8	-7.2	-4.2	-8.8	-8.7	-3.9	-4.5	-0.9
Am-241	11.3	11.3	-1.1	6.4	14.2	12.2	13.3	21.5
Am-243	-3.5	-9.7	-4.1	-9.0	-5.2	-2.6	-6.7	-2.0
Np-237	8.9	-12.9	6.8	5.0	-6.3	6.8	10.6	1.2
Mo-95	No Data	0.4	-1.4	8.5	0.0	-1.6	1.0	-0.1
Tc-99	No Data	0.9	-0.3	-0.5	-0.7	0.7	-0.1	1.1
Ru-101	No Data	1.3	2.0	1.2	0.8	-0.4	-0.9	-0.7
Rh-103	-10.1	-1.8	-0.8	-2.7	-2.1	2.6	-2.3	0.5
Ag-109	-30.8	-17.8	-12.1	-15.6	-18.7	-11.6	-11.0	-0.4
Cs-133	-3.2	-2.4	-0.6	-3.4	-4.3	-1.4	-0.7	0.8
Sm-147	-0.4	-0.5	-11.8	0.8	-3.4	-1.6	1.6	2.0
Sm-149	10.4	1.6	7.2	12.2	3.7	3.8	1.3	0.7
Sm-150	-4.0	-6.1	-1.4	-0.7	-7.1	3.1	-5.1	-10.3
Sm-151	15.3	7.2	11.4	3.4	12.9	30.3	4.5	18.1
Sm-152	1.2	3.8	5.1	-3.3	9.6	15.5	15.9	22.0
Nd-143	3.4	1.3	1.1	0.9	1.1	2.9	6.8	3.4
Nd-145	-1.2	2.0	1.5	1.7	1.9	0.5	2.2	2.2
Eu-153	-4.1	3.6	6.8	1.9	2.1	-7.0	-11.4	-7.4
Eu-155	87.5	-23.5	-24.7	-19.7	-22.3	51.8	-14.2	-7.6
Gd-155	-14.4	-12.2	-9.7	1.7	N.A.	-16.7	-10.7	-0.2
Gd-156	-3.4	-1.3	-0.1	0.5	N.A	-1.7	0.0	0.1
Gd-157	-47.3	-13.6	-30.1	-22.7	N.A	-17.8	-19.3	-10.9
Gd-158	-1.7	0.4	-1.6	-0.9	N.A	-0.1	-0.6	-0.1
Xe-131	-1.2	0.2	2.2	1.0	-1.5	-1.1	5.2	3.6

N.A.: Participant **G** did not include residual gadolinium isotopes in Gd pin.

Table B.9. Difference (%) of nuclide density – Case 2 (40% void fraction)

	A(CASMO4)	B(WIMS7B)	C(APOLLO2)	E(BOXER)	G(WIMS7B)	H(TGBLA)	J(VMONT)	M (SWAT)
U-234	-2.5	-2.4	-3.8	-3.2	-2.7	-3.1	6.9	2.3
U-235	0.6	0.0	0.5	2.3	2.2	-0.4	-3.5	4.7
U-236	0.3	-1.2	-2.6	0.2	-1.5	0.2	1.8	-2.6
U-238	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Pu-238	-4.2	-20.4	-6.8	-0.3	-14.5	-4.1	-2.5	-12.8
Pu-239	1.8	4.0	2.6	4.2	7.6	-1.0	0.1	4.2
Pu-240	-3.6	2.8	2.0	6.1	1.8	3.3	-2.1	5.2
Pu-241	0.5	-0.5	0.8	1.8	1.5	3.0	1.0	7.7
Pu-242	-5.9	-7.8	-5.2	-8.1	-9.9	-4.4	-5.2	-1.1
Am-241	9.7	8.2	-2.8	3.6	11.6	10.7	11.2	21.4
Am-243	-2.1	-9.9	-5.5	-8.2	-5.6	-2.6	-6.8	-1.8
Np-237	10.2	-14.1	6.5	3.1	-6.0	6.9	11.1	1.9
Mo-95	No Data	0.3	-1.5	8.4	0.0	-1.7	1.1	-0.3
Tc-99	No Data	0.9	-0.4	-0.4	-1.0	0.7	-0.2	0.9
Ru-101	No Data	1.3	1.8	1.2	0.9	-0.5	-1.0	-0.8
Rh-103	-10.7	-2.0	-0.6	-2.6	-1.9	1.7	-2.3	1.0
Ag-109	-32.6	-18.1	-12.8	-15.2	-19.4	-11.4	-10.7	-0.1
Cs-133	-3.6	-2.1	-0.5	-3.0	-4.3	0.0	-0.4	0.9
Sm-147	-1.1	-0.3	-11.8	1.8	-4.1	-1.9	2.1	1.7
Sm-149	11.2	1.0	7.8	12.2	3.7	5.7	1.4	2.6
Sm-150	-3.8	-6.2	-1.8	-0.4	-7.3	1.8	-5.3	-10.8
Sm-151	17.9	7.8	13.1	3.1	15.2	27.6	4.1	20.6
Sm-152	2.6	5.7	6.5	-3.4	13.6	18.5	18.9	27.2
Nd-143	3.2	0.7	0.7	0.9	0.8	1.7	6.9	3.1
Nd-145	-2.0	1.7	1.0	1.6	1.7	-0.2	2.1	1.8
Eu-153	-2.4	3.1	6.7	1.7	2.0	-6.6	-11.4	-8.0
Eu-155	107.3	-13.3	-14.6	-6.6	-11.6	65.3	-15.4	-8.0
Gd-155	-15.7	-13.6	-9.5	3.1	N.A.	-21.0	-13.5	-0.9
Gd-156	-3.4	-1.6	-0.1	0.6	N.A.	-2.3	0.2	-0.1
Gd-157	-43.5	-8.3	-24.5	-18.1	N.A.	-9.9	-19.4	-4.4
Gd-158	-1.7	0.8	-1.5	-0.8	N.A.	0.1	-0.3	0.2
Xe-131	-2.3	-0.3	1.4	0.0	-2.4	-2.2	5.5	3.5

N.A.: Participant **G** did not include residual gadolinium isotopes in Gd pin.

Table B.10. Difference (%) of nuclide density – Case 3 (70% void fraction)

	A(CASMO4)	**B**(WIMS7B)	**C**(APOLLO2)	**E**(BOXER)	**G**(WIMS7B)	**H**(TGBLA)	**J**(VMONT)	**M**(SWAT)
U-234	-3.7	-1.3	-2.8	-1.2	-2.9	-3.0	8.1	2.8
U-235	-0.5	-1.7	0.4	1.4	0.3	-0.6	-4.3	5.0
U-236	0.1	-1.2	-3.1	0.5	-1.4	0.0	1.9	-3.0
U-238	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Pu-238	-2.6	-23.0	-9.8	2.8	-15.5	-3.3	-2.2	-11.7
Pu-239	-0.6	0.8	1.6	1.6	6.4	-3.4	-2.3	5.4
Pu-240	-4.8	1.7	1.6	5.5	2.5	2.9	-3.1	4.4
Pu-241	-0.8	-3.8	-1.7	2.1	-1.0	2.8	-0.2	7.8
Pu-242	-5.8	-8.7	-5.9	-7.9	-11.5	-4.4	-4.9	-1.3
Am-241	7.2	3.3	-6.4	0.0	8.0	9.0	9.1	21.3
Am-243	-0.8	-10.5	-7.1	-7.8	-6.7	-1.1	-8.4	-1.2
Np-237	11.5	-16.7	4.6	-1.1	-6.0	6.9	11.7	2.8
Mo-95	No Data	0.3	-1.7	8.2	0.0	-1.9	1.1	-0.6
Tc-99	No Data	1.1	-0.6	-0.1	-1.3	0.6	-0.4	0.6
Ru-101	No Data	1.3	1.5	1.1	1.0	-0.6	-1.1	-0.9
Rh-103	-11.4	-2.7	-0.6	-3.3	-1.9	0.5	-2.4	1.4
Ag-109	-35.1	-18.9	-14.0	-14.5	-20.7	-11.3	-11.2	-0.3
Cs-133	-4.2	-1.6	-0.4	-2.5	-4.5	-0.1	-0.1	0.9
Sm-147	-2.0	0.4	-11.6	3.6	-5.0	-2.4	2.7	1.4
Sm-149	13.4	0.1	8.7	13.9	4.3	10.3	2.9	6.7
Sm-150	-3.3	-6.2	-2.1	-0.2	-7.3	0.6	-5.0	-11.0
Sm-151	20.3	6.1	13.0	3.2	16.4	24.0	3.7	23.0
Sm-152	4.6	8.9	8.5	-3.8	18.7	21.9	22.1	33.0
Nd-143	3.0	-0.2	-0.1	0.7	0.3	0.5	6.9	2.7
Nd-145	-2.8	2.6	0.6	1.6	1.7	-1.0	2.0	1.5
Eu-153	-0.8	2.0	6.4	1.4	1.7	-6.0	-10.9	-8.4
Eu-155	129.0	-2.3	-3.1	11.5	1.0	81.2	-18.4	-8.2
Gd-155	-18.1	-17.0	-10.5	5.1	N.A	-24.5	-16.9	-2.0
Gd-156	-3.3	-2.0	-0.1	0.6	N.A.	-2.8	0.4	-0.2
Gd-157	-42.9	-7.4	-21.3	-14.6	N.A.	-2.9	-21.6	0.7
Gd-158	-1.7	1.3	-1.4	-0.8	N.A.	0.4	-0.1	0.4
Xe-131	-3.7	-0.5	0.5	-1.8	-3.7	-3.4	5.4	3.3

N.A.: Participant **G** did not include residual gadolinium isotopes in Gd pin.

B.6 Conclusion

In this report, we re-analysed the earlier benchmark problem "Phase III-B" by using the SWAT3.1 burn-up analysis code system, driving the continuous-energy Monte Carlo code MVP. SWAT3.1 shows generally consistent results with those of the assembly burn-up codes that participated in the Phase III-B benchmark. It seems that the selected assembly calculation codes agree well with each other.

At the time of the Phase III-B benchmark, it was not clearly specified what was the reason for the large discrepancy in the isotopic composition of a few isotopes. This was further complicated since some participants had adopted a single pin-cell model calculation which did not treat gadolinium depletion correctly. The results of the Phase III-B benchmark cannot be applied in the evaluation of the predictability of nuclide density of the "current" burn-up calculation code.

There are several updated code systems and revised data libraries. In order to compare the current status of the burn-up code for the predictability of the characteristics of the burnt BWR fuel assembly, a similar benchmark problem is proposed. Useful information could be gained on the capability of the state-of-the-art burn-up calculation systems. It should be noted that the current BWR fuel assembly has updated specifications, for example, the 9×9 fuel pin array is common in Japan and the geometry type of water channel was also modified in the new type of the assembly. Thus, a new benchmark on BWR fuel burn-up calculation is proposed for the criticality safety control of damaged fuel from Fukushima Daiichi NPS.

References

[1] H. Okuno, Y. Naito and K. Suyama (2002), "OECD/NEA Burn-up Credit Criticality Benchmark Phase III-B Burnup Calculations of BWR Spent Fuel Assemblies in Storage and Transport," *JAERI-Research* 2002-001.

[2] K. Suyama et al. (2009), "SWAT3.1 - The Integrated Burn-up Code System Driving Continuous Energy Monte Carlo Codes MVP and MCNP," JAEA-Data/Code 2009-002.

[3] D.L. Poston, H.R. Trellue (1999) User's Manual Version 2.0 for Monteburns 1.0. LAUR-99-4999.

[4] K. Suyama et al. (2000), The Integrated Burn-up Calculation Code System –, JAERI-Data/Code 2000-027, Japan Atomic Energy Research Institute.

[5] Y. Naito et al. (1996), "Burn-up Code for Fuel Assembly by Mote Carlo Code – MKENO-BURN -JAERI-Data/Code 96-037, Japan Atomic Energy Research Institute.