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International Comparison of a Depletion Calculation Benchmark on Fuel Cycle Issues

Results from Phase 1 on UOx Fuels

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Results from Phase 1 on UOx Fuels

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

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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, as well as
- 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

Under the auspices of the NEA Nuclear Science Committee (NSC), the Working Party on Scientific Issues of Reactor Systems (WPRS) has been established to study the reactor physics, fuel performance, radiation transport and shielding, and the uncertainties associated with modelling of these phenomena in present and future nuclear power systems. The WPRS has different expert groups to cover a wide range of scientific issues in these fields.

The Expert Group on Reactor Physics and Advanced Nuclear Systems (EGRPANS) was created in 2011 to perform specific tasks associated with reactor physics aspects of present and future nuclear power systems. The EGRPANS provides expert advice to the WPRS and the nuclear community on the development needs (data and methods, validation experiments, scenario studies) for different reactor systems and also provides specific technical information regarding:

core reactivity characteristics, including fuel depletion effects;

core power/flux distributions;

Core dynamics and reactivity control.

This report aims to create a reference case for UOx fuel and compare existing burn-up depletion calculations obtained with various codes and data libraries. These comparisons will be applied to fuel and back-end cycle configurations: transport, reprocessing, interim storage and waste repository.

Acknowledgements

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1. Introduction

Although there are many reactor system benchmarks in the literature, they mostly concentrate on the reactor system in isolation with only a few considering the fuel cycle. However, there is currently increased emphasis on the performance of reactor systems linked to their associated fuel cycle (Generation-IV for example). The published international benchmark studies which relate to burn-up depletion calculations are restricted to specific aspects of the fuel cycle:

- Burn-up credit benchmark [working party on nuclear criticality safety (WPNCS)] [1]: the nuclide density calculations focused mainly on the 15 most poisoning fission products and only a short cooling time (5 years) was studied.
- Benchmark on decay heat calculation [2]: this benchmark focused on calculations of decay heat due to ^{235}U fissions.

The NEA/OECD Working Party on Scientific Issues of Reactors Systems (WPRS) has defined a new benchmark investigating a broader range of isotopes, physical quantities and fuel types [3]. The objective is to compare existing burn-up depletion calculations obtained with various codes and data libraries, applied to fuel and back-end cycle configurations: transport, reprocessing, interim storage and waste repository. The benchmark concentrates on nuclide densities for the most important nuclides in the fuel cycle (actinides, fission products and activation products) and the associated fuel cycle quantities (masses, neutron emission rate and decay heat). Additional but optional calculations were also specified; they relate to sensitivity calculations linked to the assumptions made on irradiation parameters: the width of the half water gaps, the boron content, the fuel and moderator-coolant temperature and the irradiation history. The objective is that detected discrepancies between participants' results will enable us:

- to improve the calculation schemes (e.g. self-shielding, subdivisions in fuel or moderator etc.);
- to improve the knowledge of burn-up chains used in depletion calculations (maybe to recommend a chain for fuel cycle applications);
- to improve the knowledge of nuclear data (capture cross-sections, branching ratio, fission yields and decay constants) involved in fuel cycle studies.

This report is devoted to the first phase of the benchmark. The aim of this phase is to create a reference case for an UOx fuel. The benchmark uses experimental data from the Japanese Post-Irradiation Experiment in the Takahama-3 PWR. This experiment has already been used in French nuclear data studies [4]. The trends seen in this experiment are consistent with the trends in spent fuel experiments performed in France [5]. This experiment was also used by JAERI for the validation of the SWAT burn-up code system [6]. It is therefore possible to compare the calculational and experimental results for the major actinides and verify how accurate the predictions of the models of the experiment are for well-known isotopes (full details of these results and comparisons are included in Appendix A). The list of available experimental results and associated uncertainties are given at the end of Appendix C.

This report provides a description of the benchmark, summarises the international participants, the codes that they used and finally presents a comparison of their results.

2. Description of the benchmark

The detailed benchmark specification provided to the participants is included in Appendix B. The benchmark specification is based on the data included in the SFCOMPO database which was originally developed at JAERI and is now maintained at the NEA Data Bank [7-9]. A list of SFCOMPO chemical results and associated uncertainties is given in Appendix C.

The principal aspects of the benchmark (e.g. the Takahama experiment, geometry and fuel composition data, irradiation parameters and history and the required calculated quantities) are summarised below:

2.1 Outline of the Takahama experiment

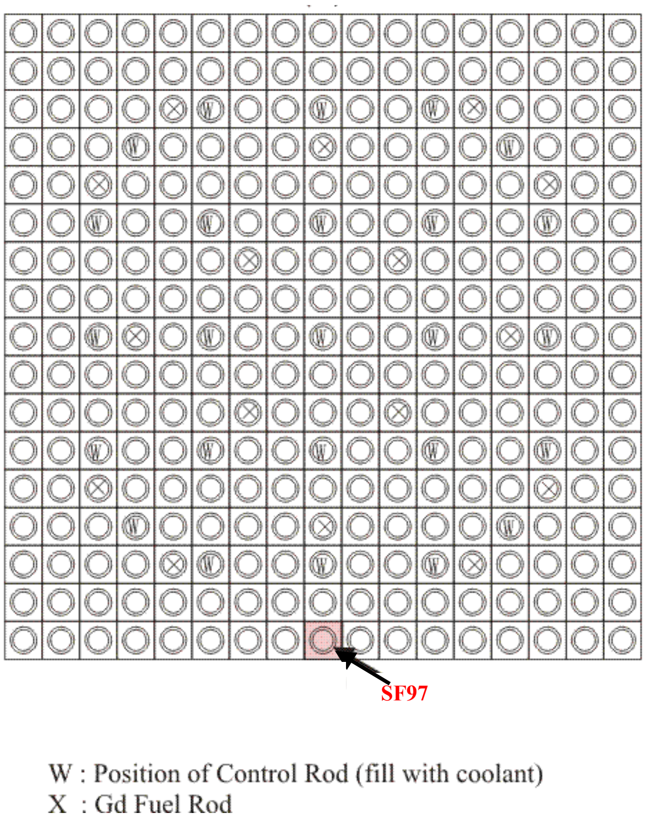
Takahama-3 is a 17x17 PWR operated by Kansai Electric Power Company in Japan. The PIE was conducted under the auspices of Science and Technology Agency of Japan. Sixteen samples were taken from two fuel assemblies, NT3G23 and NT3G24, and the isotopic composition was measured for the irradiated UO_2 and UO_2-^{203}Gd fuel.

Two calculations were undertaken: a simple cell calculation and an assembly calculation, where the analysed sample is explicitly modelled.

For the assembly calculation, the studied sample, SF97, comes from a UO_2 spent fuel pin located in the peripheral row of the assembly (see Figure 1). This assembly is the NT3G24 assembly which was loaded with 248 UO_2 fuel pins (4.1% wt ^{235}U enriched), 16 UO_2-^{203}Gd pins (2.6% wt ^{235}U enriched and with 6% wt Gd) and 25 water holes. However, as the SFCOMPO database is not complete, additional assumptions have had to be made concerning the experimental conditions for the cell and assembly calculations (for example: water gap dimension, temperature and boron contents).

The I-Q fuel pin from the NT3G24 assembly was cut into six sections (samples SF97-1 to SF97-6); the SF97-4 sample, was selected because it was located at mid-height in the core, so its burn-up condition was considered to better averaged than the other samples.

Figure 1: Position of the SF97 spent fuel pin in the NT3G24 assembly



2.2 Geometry and fuel composition data

All the geometry data for the pin-cell and/or the assembly calculations are explicitly given in the benchmark specification (see Appendix B). The pin-cell model assumes an equivalent volume ratio of fuel to moderator throughout the whole fuel assembly, including the water gap.

The fuel, clad and moderator composition data are also defined in the benchmark specification. Furthermore, where the aim of the benchmark is to enable a comparison of the activation product masses from initial impurities; proposed values for the impurities content are also specified.

2.3 Irradiation parameters and history

The fuel, clad and moderator temperature are specified in the benchmark. With regards to the irradiation history, the experimental data indicate that the assembly was irradiated for 3 cycles and that the SF97 experimental fuel pin, chosen for the benchmark, reached an average burn-up of roughly 47 GWd/t. In the JAERI-Tech 2000-071 report [10], the sample's burn-up value was evaluated by ^{148}Nd method giving 47.03 GWd/t. The effective fission yield of ^{148}Nd was evaluated by using the fission reactions of ^{235}U, ^{238}U, ^{239}Pu and ^{241}Pu based on the burn-up analyses performed by the SWAT system.

The irradiation cycles and the associated power modelled (see Appendix A) were determined in order to obtain an alternative commonly used indicator of the fuel sample burn-up giving 46.0 GWd/t. The evaluation of this fuel rod burn-up was done using the experimental (^{145}Nd+^{146}Nd) concentration value as an indicator of the burn-up.

The second burn-up indicator is used in this report which means that a burn-up value leading to a C/E equal to 1.0 has been calculated for the (^{145}Nd+^{146}Nd) concentration. The difference between this value and one presented in the JAERI report discussed above is 2.1%. This difference results from the uncertainties in the fission yields leading to neodymium isotopes. Although small, this difference in sample burn-up can lead to a significant difference in the ^{235}U concentration at the end of irradiation. Furthermore, this difference is enhanced if the fuel used is low-enriched and high-burned. Therefore, in order to take into account the uncertainties linked to the determination of the fuel sample burn-up discussed above, a sensitivity calculation was included in the benchmark.

2.4 Required quantities

The required quantities for the benchmark are:

Masses of the following nuclides:

Actinides:

^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{236}Np, ^{237}Np, ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{243}Pu, ^{244}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{229}Th, ^{230}Th, ^{232}Th, ^{252}Cf.

Fission products:

^{79}Se, ^{85}Kr, ^{85}Rb, ^{87}Rb, ^{88}Sr, ^{90}Sr, ^{93m}Nb, ^{95}Mo, ^{97}Mo, ^{99}Tc, ^{101}Ru, ^{106}Ru, ^{103}Rh, ^{107}Pd, ^{108m}Ag, ^{109}Ag, ^{110m}Ag, ^{127}I, ^{129}I, ^{130}Xe, ^{131}Xe, ^{132}Xe, ^{134}Xe, ^{136}Xe, ^{133}Cs, ^{134}Cs, ^{135}Cs, ^{137}Cs, ^{136}Ba, ^{138}Ba, ^{139}La, ^{140}Ce, ^{144}Ce, ^{142}Nd, ^{143}Nd, ^{144}Nd, ^{145}Nd, ^{146}Nd, ^{148}Nd, ^{150}Nd, ^{147}Pm, ^{146}Sm, ^{147}Sm, ^{148}Sm, ^{149}Sm, ^{150}Sm, ^{151}Sm, ^{152}Sm, ^{154}Sm, ^{153}Eu, ^{154}Eu, ^{155}Eu, ^{154}Gd, ^{155}Gd, ^{156}Gd, ^{166m}Ho.

Activation products:

^{36}Cl, ^{41}Ca, ^{53}Mn, ^{54}Mn, ^{55}Fe, ^{60}Fe, ^{60}Co, ^{59}Ni, ^{63}Ni, ^{93}Mo.

Some activation products are produced both by fission and activation reactions. These two contributions have been evaluated separately for the following isotopes: ^{3}H, ^{10}Be, ^{14}C, ^{93}Zr, ^{94}Nb, ^{119m}Sn, ^{121m}Sn, ^{126}Sn, ^{125}Sb.

Neutron emission: (alpha,n) emission, spontaneous fission and total emission.

Decay heat: alpha, beta and gamma decay heat and total decay heat.

The results are compared at discharge (zero cooling), 5, 50, 100 and 300 years cooling time.

3. Analysis method

An average value was calculated for each cell or assembly calculation, each isotope and each cooling time. The associated standard deviation (SD) and the relative standard deviation (RSD) of the calculated concentrations were also determined according to the following formula where N is the number of participant and x_n the nuclide densities (or another piece of data requested by the benchmark) calculated by the participant n:

$$\text{Average} = \frac{\sum_{n=1}^{N} x_n}{N}$$

The RSD indicates the degree of consistency between the results provided by participants: a small RSD for a given isotope indicates consistency between the various codes and data used, whereas a large RSD indicates a poor agreement. For this benchmark, it was assumed that a good agreement between participants has been obtained when the RSD is less than 10%. Conversely, if the quantities under comparison (e.g. the isotopic concentrations, decay heat or neutron emission results) have a RDS greater than 10%, this was considered to indicate a poor agreement between participant's results. It is noted that a low RSD does not mean that all the participants calculated the correct value; rather that they calculated a similar value.

Comparisons between the available experimental results and the participants'results are treated separately from the code to code comparisons described above. In this case, the reference value is the one from the experiment.

Some remarks concerning the conclusions that can be drawn from the tables in Appendix A (and summarised throughout the body of this report) are noted below. RSD is the relative standard deviation, A the average calculated value and Exp the experimental measurement.

- If RSD and (A-Exp)/Exp are both low that means that all the participants have made a consistent and accurate depletion calculation.
- If RSD is low and (A-Exp)/Exp high, we can conclude that the participants are consistent but not accurate (however, we must be mindful of the experimental uncertainty).
- If RSD is high and (A-Exp)/Exp high, that means that some participants are close to the experimental value; whereas, others are not.

4. Participants and the codes they used

Table 1 summarises the benchmark participants and methods used in their analyses. In total, seven contributions were submitted to this benchmark from six different organisations representing six countries. Six calculations were completed for the cell geometry model and six for the assembly model. Four participants performed the sensitivity calculations, of which only one performed the sensitivity study of the irradiation history and one completed a test of the sensitivity of the results to the boron concentration. It is noted that two different methods (deterministic and Monte-Carlo) were used to calculate the reaction rate required for the depletion calculation.

The summary in Table 1 is followed by a more detailed description of each analysis set, as provided by each participant along with their results.

Table 1: List of participants and codes used

Organisation label	Organisation	Codes used	Nuclear data library used	Calculations made
CEA-C	Commissariat à l'Énergie Atomique, France	CESAR	JEF2.2 (ACT,FP) EAF99 (AP)	Cell assembly
CEA-D	Commissariat à l'Énergie Atomique, France	DARWIN (APOLLO2-PEPIN2)	JEF2.2 (ACT,FP) EAF01 (AP)	Cell assembly sensitivities
GRS	Gesselschaft fûr Anlagen-und-Reaktorsicherheit, Germany	OREST(HAMMER + ORIGEN) KENOREST(HAMMER +KENO+OREST)	JEF2.2	Cell assembly boron sensitivities
JAEA	Japan Atomic Energy Agency Japan	ORIGEN2.2	ORLIBJ32 (based on JENDL3.2)	Cell sensitivity to irradiation history
JAEA	Japan Atomic Energy Agency Japan	ORIGEN2.2	ORLIBJ33 (based on JENDL3.3)	Cell sensitivity to irradiation history
NEXIA	Nexia Solutions UK	CASMO-4 FISPIN	JEF2.2	Assembly sensitivities
RRC KI	Russian Research Center Kurchatov Institue Russian Federation	MCU-REA /BURN-UP	DLC/MCUDAT -2.2	Cell assembly
VTT	VTT Processes, Nuclear Energy Finland	MONTEBURNS 1.0 (MCNP+ORIGEN-2)	JENDL3.2	Cell assembly sensitivities

CEA-C

Institute: Commissariat à l'Energie Atomique.

Country: France.

Participant: C. Riffard.

Neutron data library: JEF 2.2 and EAF99 for activation products calculation.

Neutron data processing code or method: NJOY.

Neutron energy groups: 172 groups (APOLLO2).

Description of the code system: CESAR .

CESAR [11] [12] is an industrial depletion code. This user-friendly industrial tool provides fast characterisations for all types of nuclear fuel (PWR / UOX or MOX or reprocessed uranium, BWR/UOX or MOX, MTR and SFR) and the wastes associated. CESAR can evaluate 100 heavy nuclides, 200 fission products and 150 activation products (with helium and tritium formation). It can also characterise the structural material of the fuel (zircalloy, stainless steel, M5 alloy). CESAR provides depletion calculations for any reactor irradiation history and from 3 months to 1 million years of cooling time.

The fuel behaviour is first modelised with a reference calculation code for neutron physics: APOLLO2 [13] for the thermal spectrum systems or ERANOS for the fast spectrum systems. The calculation schemes are specific for both the fuel type and the reactor type. The PWR calculation scheme is CEA93 which is described under the discussion regarding the DARWIN package below.

Cross-sections obtained at this step are then processed with the APOGENE tool where:

- a collapsing operation condenses the 172-group cross-sections into one energy group;
- a smoothing operation on each cross-section obtains a polynomial relating to the burn-up and the initial ^{235}U enrichment (for example);
- A formatting and ciphering operation which builds the data libraries (BBL) used in the CESAR code for each kind of fuel.

CESAR is then validated by comparison to the DARWIN reference code.

Geometry modelling: both the pin-cell and assembly geometry were modelled.

CEA-D

Institute: Commissariat à l'Energie Atomique.

Country: France.

Participant: B. Roque.

Neutron data library: JEF 2.2 and EAF01.

Neutron data processing code or method: NJOY.

Neutron energy groups: 172 groups (APOLLO2).

Description of the code system: The code system used is called "DARWIN" [14] [5] and is the French reference calculation package for fuel cycle studies. It estimates the physical quantities characterising the burn-up of fuels from reactors: material balance, decay heat, activity, neutron, γ, α, β sources and spectra and radiotoxicity. The PEPIN2 programme calculates nuclide depletion. The different libraries that can be used with this module are as follows:

- Neutronic data provided by the French assembly or transport codes, APOLLO2 [13] (for PWR and BWR studies) and the ECCO-ERANOS system (for FBR studies). These data are self-shielded cross-sections, neutron spectra and burn-up depletion.
- Nuclear data (decay data, fission and α, n yields) and evolution chains.
- Complementary cross-sections, missing from the transport code libraries, in particular activation product cross-sections. These are included in what is called the "cycle library".

For actinides and fission products, the basic nuclear data come from JEF2.2.

In the context of this benchmark on PWR assemblies, the neutronic data necessary for the depletion module are provided by the APOLLO2 code and its CEA93 library. APOLLO2 [13] solves the integral form of the Boltzmann equation through the collision probability method. This calculation route uses the CEA93 cross-section library in a 172-group structure processed from JEF2.2. The following aspects of the assembly optimisation calculation are of note:

- Discrete radial zones of the fuel pellet (in the form of four rings) were used in order to give a faithful representation of the resonant absorption of ^{238}U in the pin and of the actinide and fission product concentration profile.
- The spatial calculation used the UP1 HETE approximation. This enables the probability of leakage (P_{IS}) and the probability of transmission (P_{SS}) to be calculated for the true geometry assuming that the interface currents are considered to be linearly anisotropic.
- Cells with similar flux were grouped within a unique "physical cell".
- The self-shielding of resonant isotopes was included with a differentiated treatment for each one depending on the physical characteristics of their cross-sections.
- Optimised evolution steps.

The PEPIN2 evolution module then uses the results provided by APOLLO2 (i.e. the self-shielded cross-sections and 172-energy-group spectra described above), to supplement the collapsed library with the burn-up dependent cross-sections that are required in order to characterise the isotopes described in the depletion chains. For actinides and fission products not considered in the CEA93-APOLLO2 library, a complementary database of cross-sections and nuclear constants based also on the JEF2.2 evaluation are used by the PEPIN2 module.

For the activation products calculated as part of this benchmark, the nuclear data come from the EAF01 library. These EAF complementary cross-sections are collapsed from 172 to one energy group with the multi-group spectra provided by the APOLLO2 calculation.

The DARWIN version used is 2.0.

Geometry modelling: Both the pin-cell and assembly geometries were modelled.

Omitted nuclides: ^{146}Sm which is not in the JEF2.2 evaluation.

GRS

Institute: Gesellschaft fuer Anlagen- und Reaktorsicherheit GRS, Germany.

Participants: Robert Kilger, Siegfried Langenbuch.

Neutron library: JEF2.2 based library KORLIB-V4 for KENO-Va [15], 2001-Standard-library for OREST [16]-HAMMER [17].

Neutron data processing code and method: Condensing KORLIB-V4 from 292 group library JEF2.2 [18] for the infinite dilution case. Resonance treatment is done by the HAMMER code using resonance parameters [19].

Neutron energy groups: 83, 32 thermal groups up to 1,13 eV (KENO-Va), PL-order 3.

Description of the code system: KENOREST Version 03T01 [20] includes the KENO-Va code for two- or three-dimensional assembly calculations using the Monte-Carlo Method, coupled to the one-dimensional burn-up code system OREST Version 03T01 (HAMMER-ORIGEN [21]) for single rod burn-up calculations. The coupling in KENOREST uses conservation of flux and reaction rate with the the GRS FEC method [22]. The flux spectra and cross-section calculations for the fuel rods are performed by the HAMMER code (THERMOS-HAMLET) which uses the integral Boltzmann neutron transport calculation method and Nordheim resonance treatment in the resonance region. The cross-sections are fed directly back into KENO. For pin-cell calculations the burn-up code OREST 03T01 was used (as mentioned above). Alpha-n- and spontaneous fission neutron emissions were calculated for the specified nuclide set using the GRS code NGSRC [23] taken from the ANITABL code system [24].

Geometry modelling: the two-dimensional fuel element was modelled with KENOREST and the one-dimensional for pin-cell with OREST 03T01. As a result of OREST 03T01 calculation, the composition of the guide tubes contained steel, so the given structural nuclide densities were not used.

Omitted nuclides: None. Alpha- and beta decay heats are not available.

Cases: Obligatory pin-cell and assembly case, plus optional boron cases.

Note: decay heats and powers calculated by KENOREST and OREST are related to the complete set of nuclides in ORIGEN, and not just to those specified for the benchmark.

JAEA

Institute: JAEA (formerly JAERI).

Country: Japan.

Participants: Kenya Suyama, Yoshinori Miyoshi.

Neutron data library: ORLIBJ32 is a set of libraries based on JENDL-3.2. It was prepared using the current PWR and BWR design parameters. PWR41J32 is the library used in ORLIBJ32 for a PWR 17*17 assembly with an initial ^{235}U enrichment of 4.1%. ORLIBJ33 is a set of libraries based on JENDL-3.3. It was also prepared using current PWR and BWR design parameters. PWR41J33 is the library used in ORLIBJ33 for a PWR 17*17 assembly with an intitial ^{235}U enrichment of 4.1%.

Neutron data processing code or method: ORLIBJ32 and ORLIBJ33 were prepared by the burn-up analysis code system SWAT using JENDL-3.2 and JENDL-3.3 libraries respectively.

Description of code system: The computer code used is ORIGEN2.2. It is currently available as ORIGEN2.2UPJ, which is a package consisting of ORIGEN2.2 code together with ORLIBJ32 and ORLIBJ33 library sets.

Geometry modelling: A pin-cell geometry was used.

Omitted nuclides if any: No nuclides were omitted.

Omitted cases if any: The use of ORIGEN2.2 meant that the assembly calculation was not undertaken.

NEXIA:

Institute: National Nuclear Laboratory (previously known as NEXIA Solutions Ltd).

Country: United Kingdom.

Participant: Robert Gregg.

Neutron data library: JEF 2.2 and WIMS 6a (where the majority of activation products use JEF2.2 and the majority of the fission products use WIMS 6a).

Neutron data processing code or method: CASMO-4 and FISPIN v10.

Description of code system: A complete assembly is modelled with CASMO-4 (which was used to generate actinide cross-sections and fluxes) and depleted up to 50 GWd/tHM. Fluxes are extracted along with the three-group cross-sections for the majority of the nuclides and a select number of fission products for the single pin. The remaining three-group cross-sections are then calculated using the WIMS 6a library and the fluxes calculated by CASMO-4. Next, FISPIN uses these three-group cross-sections to determine the isotopics of the spent fuel and evolve the composition for a cooling time of up to 300 years. It is noted that the alpha decay energy includes recoil energy; that the beta decay energy includes all energy from electron interactions and that gamma decay includes X-ray energy.

Geometry modelling: 2-D assembly, infinite lattice.

Omitted nuclides if any: none omitted cases if any : Optional calculation 3.

Geometry modelling: assembly calculation.

Calculated pin burn-up: 46.0498 GWd/tHM.

RRC KI

Institute and Country: Russian Research Center "Kurchatov Institute", Moscow, Russian Federation.

Participants: Mikhail A. Kalugin, Mark S. Yudkevich.

Neutron data library: DLC/MCUDAT-2.2.

The MCU code uses its own neutron database: DLC/MCUDAT. This database incorporates nuclear data from FOND (Russian Federation), ENDF/B and other neutron data evaluated by the MCU team (i.e. the LIPAR library of the resonance parameters and TEPCON library of slow neutron data).

Neutron data processing code or method:

- NJOY, GRUCON (IPPE, Russian Federation);
- MCU group elaborations;
- TERMAC for the generation of the S(α,β) multi-group library;
- STEN for the generation of the S(α,β) pointwise library;
- RAPAN for the generation of the resonance cross-sections.

Neutron energy groups: MCU-REA uses both pointwise and step function representations of cross-sections.

Description of the code system used:

MCU-REA is a general-purpose continuous energy Monte-Carlo code for solving the neutron transport problems, including depletion ones. The current version combines the spectral part of the MCU code for neutron transport modelling and the burn-up module for depletion calculation. For neutron-nuclear interaction modelling MCU allows the following to be taken into account:

- the laws of scattering from evaluated nuclear data files;
- cross-section temperature dependence in the unresolved resonance region using a subgroup approximation;
- Doppler broadening of resonance cross-sections in the resolved resonance region using a continuous energy representation;
- the temperature dependence of the S(α,β) thermal neutron scattering law.

The MCU code uses a combinatorial geometry module. The burn-up module calculates the isotopic density of the reactor materials as a function of irradiation and post-radiation (cooling) time. Burn-up uses cross-sections and neutron flux averaged by the neutron spectrum of the material calculated using the Monte-Carlo method. It calculates the isotopic density at the end of a time interval and transfers the results to the spectral part of the MCU code. A predictor-corrector iterative procedure is used to describe the cross-sections time dependence. Approximately 1 100 nuclides can be considered: heavy nuclides from Tl to Fm, fission products, along with the main absorbers and structural reactor materials and their activation products. The nuclides decay parameters are taken from ENDF/B-V. Cumulative fission yield values from ENDF/B-VI are used for the majority of the fission products nuclides. For light nuclides (i.e. those with triple fission) data from JEF-2.2 are used.

Geometry modelling: Both the pin-cell model and assembly geometry were considered.

VTT

Institute: Technical Research Centre of Finland (VTT).

Country: Finland.

Participant: Anssu Ranta-aho.

Neutron data library: JENDL-3.2 based MCB multi-temperature library prepared by the Royal Institute of Technology (KTH, Sweden).

Neutron data processing code: NJOY.

Neutron energy groups: Continuous energy.

Description of the code system: Monteburns 1.0 is a burn-up code that links the MCNP4C transport code with the ORIGEN2 depletion code. The reaction rates are calculated with MCNP4C and transferred to ORIGEN2 which performs a 1-group depletion calculation using the matrix exponentialmethod.

Geometry modelling:

– Assembly geometry;

The defined assembly octave geometry with reflecting boundary conditions was modelled. Each fuel pin is considered as a separate burn-up region and burnable absorber rods are divided into five annular regions. The maximum number of burnable regions is limited to 39, thus burnable absorber rods are considered to be equivalent to each other.

– Pin-cell geometry;

The defined geometry with reflecting boundary conditions was modelled. The pin-cell was modelled as one burn-up region.

Omitted nuclides: ^{53}Mn, ^{60}Fe.

Omitted cases: The decay heat was not separated into its components (i.e. the alpha, beta, gamma contributions).

5. Results and comparison of calculated isotopic concentrations with experimental values

5.1 Assembly calculation results

Considering the very short half-life of ^{239}Np, we could not measure the amount of ^{239}Np at the time of the reactor shutdown. Therefore, as the Takahama-3 assay data is for a cooling time of zero (i.e. for the time of discharge), it is noted that the amount of ^{239}Pu measured in the Takahama-3 data is the sum of ^{239}Pu and ^{239}Np.

5.1.1 *Actinides results*

The results obtained by the participants for actinide isotopic concentrations are given in Table A.1. The RSD of the calculated values (given to 1 standard deviation, i.e. 1 sigma) and the comparison of the average for all calculations with the measured concentrations are plotted in Figure 2. The comparison between each participant's calculated concentration and the experimental value is given in Table A.2.

Tables A.1 and A.2 and Figure 2 show that there is a good agreement (i.e. a difference of less than 10%) between the experimental values and calculations and also between all the participants'calculations for the following isotopes: ^{234}U, ^{235}U, ^{236}U, ^{237}Np, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am and ^{242}Cm. However, it is noted that all participants slightly underestimate ^{236}U, ^{241}Pu and ^{242}Pu. The RSD and the (A-Exp/Exp) values indicate that all participants strongly underestimate (by approximately 20%) ^{238}Pu, ^{243}Am and ^{243}Cm.

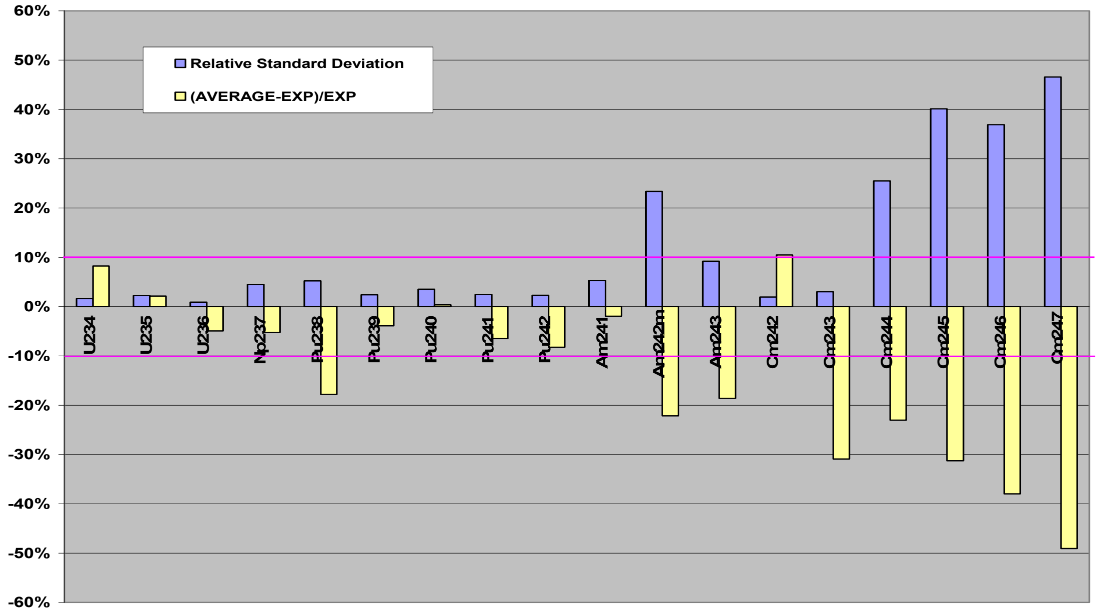
The large RSD observed on ^{242m}Am, ^{244}Cm, ^{245}Cm, ^{246}Cm and ^{247}Cm are linked to the VTT values. These VTT calculated values are very different from values given by other participants; however, they are closer to the experimental values.

For ^{242m}Am, this can be explained by the branching ratio values, which are reported in Table 2.

Table 2: Branching ratio values for $^{241}Am(n,\gamma)$ reaction

Participant	$^{241}Am \rightarrow {}^{242m}Am$
JAERI JENDL3.2	11%
JAERI JENDL3.3	11%
VTT	15.5%; 17.5%
CEA JEF2 DARWIN/CESAR	11.5%

Figure 2: Results for actinides in assembly calculation – comparison of calculated average values to measured values (at discharge)



The VTT code is the only one which generates time dependant fission yields: the other codes generate fixed branching ratios. The values used by VTT are obtained as follows. In the Monteburns 1.0 version that VTT use, there is no fixed branching ratio for the ^{241}Am (n,γ) reaction. Instead, the ^{241}Am (n,γ)^{242}Am cross-section is obtained via an MCNP calculation and the value for the ^{241}Am (n,γ)^{242m}Am reaction is obtained from the ORIGEN2 cross-section library. The cross-section of the first reaction changes with irradiation while the latter value remains constant through the entire burn-up calculation. Therefore, the branching ratio will also change with time. In the assembly calculation the branching ratio values at the start of irradiation were (15.5%; 84.5%) while the values at discharge were (17.5%; 82.5%).

The difference observed in ^{242m}Am is mainly due to the difference in the branching ratio values used. A sensitivity calculation which made use of the average branching ratio values calculated at the end of fuel's irradiation (i.e. 17.5%) by VTT was carried out using the CEA/DARWIN code system. The difference between the effect of the original value (11.5%) used in standard in French JEF2 calculations and 17.5% (the VTT value at discharge) is presented in Table 3 below.

Table 3: ^{242m}Am, ^{243}Am, ^{242}Cm, ^{243}Cm masses versus ^{241}Am branching ratio

	BR ^{241}Am →^{242m}Am 11.5% CEA	BR ^{241}Am →^{242m}Am 17.5% CEA	BR ^{241}Am →^{242m}Am 17.5% VTT	Exp meas.
^{242m}Am	7.528E-01	1.145E+00	1.307E+00	1.23E+00
^{243}Am	1.619E+02	1.623E+02	1.296E+02	1.92E+02
^{242}Cm	2.199E+01	2.050E+01	2.223E+01	2.04E+01
^{243}Cm	5.940E-01	5.538E-01	5.607E-01	8.72E-01

The use of a branching ratio of 17.5% increases the ^{242m}Am mass by 52%, leading to a value very close to the VTT one and also very close to the experimental measurement of ^{242m}Am.

This change of branching ratio also means that less ^{242}Cm is produced as it comes from ^{242f}Am, which is reduced by the change in branching ratio. It is noted that this is no longer consistent with the VTT values as the amount of ^{243}Cm (formed by capture from ^{242}Cm) also reduces. The fact that VTT calculates more ^{242}Cm and less ^{243}Cm raises the possibility that the actual capture cross-section for ^{243}Cm is different from the current values provided by the nuclear data libraries.

Another fundamental piece of data which could explain the differences is the capture cross-section of ^{241}Am itself. However, the VTT calculation uses a lower value for this than the CEA/JEF2 ones, which would tend to have the effect of reducing the quantity of ^{242}Am and not the inverse, as is observed here. Table 4 gives the ^{241}Am(n,γ) one-group cross-section for some participants.

Table 4: ^{241}Am(n,γ) one-group cross-section (end of irradiation)

Participant	^{241}Am(n,γ) (b)
JAERI JENDL3.2	88.47
JAERI JENDL3.3	95.12
VTT	98.14
CEA JEF2 DARWIN/CESAR	104.8

For curium isotopes (^{244}Cm, ^{245}Cm, ^{246}Cm and ^{247}Cm), the calculated values obtained by VTT are again closer to the experimental values as compared to the values obtained by the other participants. If the VTT values are removed from the average calculation the RSD decreases to 4%, 9%, 11% and 16% instead of 26%, 40%, 37% and 47% for ^{244}Cm, ^{245}Cm, ^{246}Cm and ^{247}Cm, respectively.

Results for the concentrations of all actinides in the assembly calculations at discharge, 5 years, 50 years, 100 years and 300 years of cooling are included in Tables A.13, A.14, A.15, A.16 and A.17, respectively. These data include the actinides discussed above along with ^{232}U, ^{233}U, ^{238}U, ^{236}Np, ^{236}Pu, ^{243}Pu, ^{244}Pu, ^{248}Cm, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{229}Th, ^{230}Th, ^{232}Th and ^{252}Cf. The trends in the RSD for each actinide at each cooling time are summarised in Table A.18.

5.1.2 Fission products results

Table A.3 gives the results of calculated concentrations of fission products at discharge, the corresponding experimental value, the average of all calculated values and the corresponding RSD (to 1 sigma). The comparison between the average of calculated values and the experimental values is also given in Table A.3. The RSD of the calculated values (given to 1 standard deviation, i.e. 1 sigma) and the comparison of the average for all calculations with the measured concentrations are plotted in Figure 3. A comparison between the assembly and cell calculations is for both the calculated RSD and (A-Exp)/Exp is plotted in Figure 4.

For most of the fission products, the calculated values are given at discharge because the majority of measured experimental values are given normalised at the date of the reactor discharge. For samarium isotopes the chemical results are given at a cooling time of 3.96 years. This is not an issue for stable isotopes such as ^{148}Sm, ^{149}Sm, ^{152}Sm and ^{154}Sm. For ^{147}Sm and ^{151}Sm we need to adjust the calculated values to give the concentration at 3.96 years. In principle, this can be done using the following formula:

$$[^{147}Sm]_{3.96y} = [^{147}Sm]_{discharge}+[[^{147}Pm+^{147}Nd]_{discharge}-[(^{147}Pm+^{147}Nd)\exp(-Ln2*3.96/2.62)],$$

where the second term represents the quantity of ^{147}Sm due to the decay of ^{147}Nd ($T_{1/2}$=10.98d) and ^{147}Pm ($T_{1/2}$ =2.62y).

$[^{151}Sm]_{3.96y} = [^{151}Sm+^{151}Pm]_{discharge} \cdot exp(-Ln2 \cdot 3.96/88.73)$.

Unfortunately, we do not have the ^{147}Nd and ^{151}Pm concentrations for all the participants' calculations. However, based on additional CEA calculations we estimate the effect of neglecting ^{147}Nd and ^{151}Pm decay leads to a 2% underestimation in the isotopic concentrations of ^{147}Sm and ^{151}Sm (see Table A.5). This factor was applied to the corresponding values provided by the other participants. Thus, the comparison in Table A.5 is given at 3.96 years.

The results show very good agreement for all participants between calculation and experiment values for ^{106}Ru, ^{137}Cs, ^{144}Ce, ^{143}Nd, ^{144}Nd, ^{145}Nd, ^{146}Nd, ^{148}Nd, ^{150}Nd, ^{147}Sm, ^{149}Sm, ^{150}Sm, ^{154}Sm. Higher discrepancies are observed for ^{154}Eu, ^{134}Cs, ^{148}Sm, ^{151}Sm, ^{152}Sm (see Table A.3). The discrepancies for these isotopes are discussed below.

The results for ^{154}Eu show that the NEXIA and CEA calculations overestimate this isotope by roughly the same amount. This suggests that the overestimation is probably linked to a problem with the existing nuclear data for ^{154}Eu. JEF2 used by both the CEA and NEXIA is known to contain an erroneous capture cross-section for ^{154}Eu. On the other hand, the other participants seem to underestimate the ^{154}Eu concentration by about 15%.

For ^{134}Cs, we see good agreement for GRS and RRC-KI, but significant underestimates (9-18%) for the other participants. This includes the CEA and NEXIA who are both using JEF2.2 data and VTT who are using JENDL3.2.

The results for ^{148}Sm vary significantly between participants (-17% to +46%). The variation appears to result from some source other than simply the nuclear data since the GRS result (46% overprediction) uses the same data library (JEF2.2) as NEXIA and CEA which shows a 16% and 17% underprediction, respectively.

The results for ^{151}Sm and ^{152}Sm show slightly less variation (-16% to 35%) than for ^{148}Sm. The best agreement is seen for the GRS calculation with NEXIA and CEA giving over predictions of 35% and 12% respectively.

Figure 3: Results for fission products in assembly calculation – comparison of calculated average values to measured values

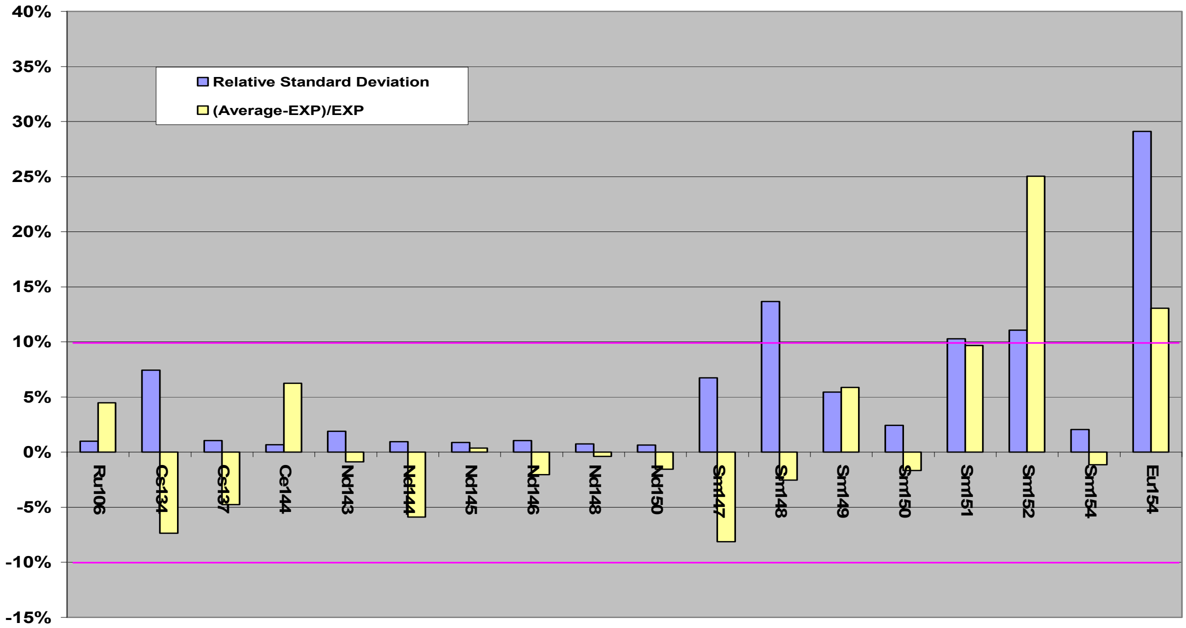
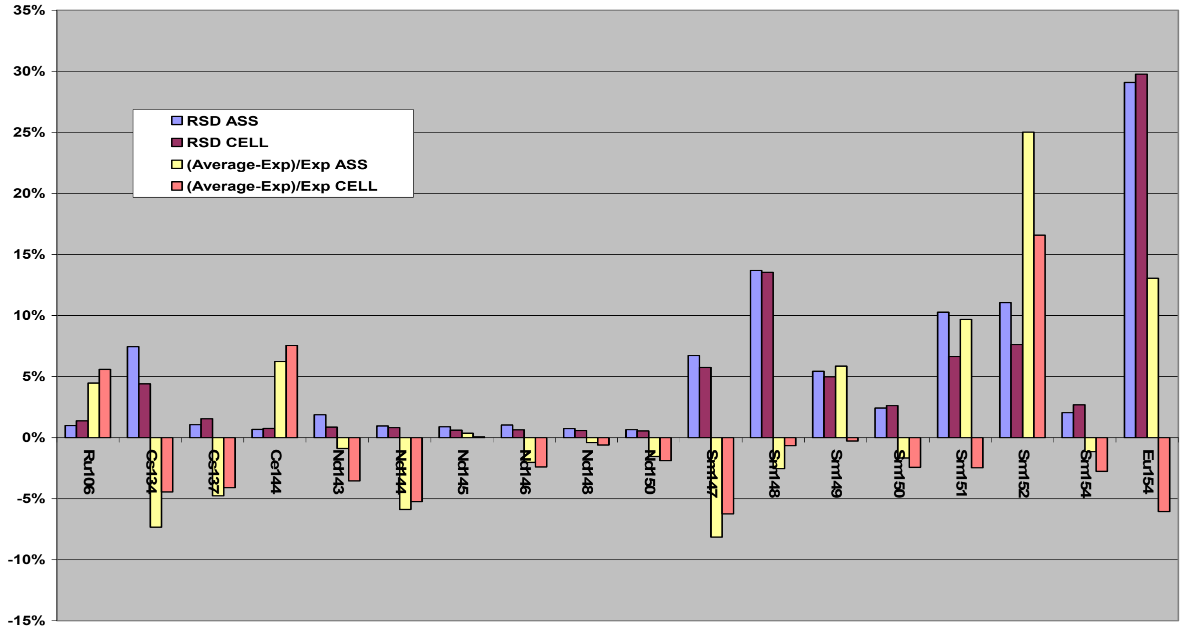


Figure 4: Results for fission products in cell and assembly calculations – comparison of RSD and (Average-Exp/Exp)



5.2 Pin-cell calculation results

It is difficult to compare the experimental results and calculated model results for pin-cell calculations as differences may result not only from inadequacies in nuclear data but also as a result of differences between the benchmark depletion model and the actual configuration of the sample pin during reactor operation. It is nonetheless interesting to note that most participants who completed the pin-cell calculation also completed the assembly one. This allows a comparison to be made between the measured isotopic concentrations and the calculation results of the two models (see Figures 5 and 6). Two participants (JAERI and NEXIA) only modelled one or the other of the benchmark cases. The JAERI model only used libraries from there pin-cell model and NEXIA only modelled the assembly configuration.

It is noted that the comparison between calculation and experiment is generally unchanged by the switch from an assembly calculation to a pin cell model. The exceptions to this are ^{151}Sm, ^{152}Sm and ^{154}Eu, where the cell calculations give significantly lower values of (A-Exp)/Exp. In all but one of these cases the cell calculation shows better agreement than the assembly calculation.

The data associated with these calculations are presented in Tables A.7 to A.12.

Figure 5: Results for actinides in cell calculation – comparison of calculated average values to measured values (at discharge)

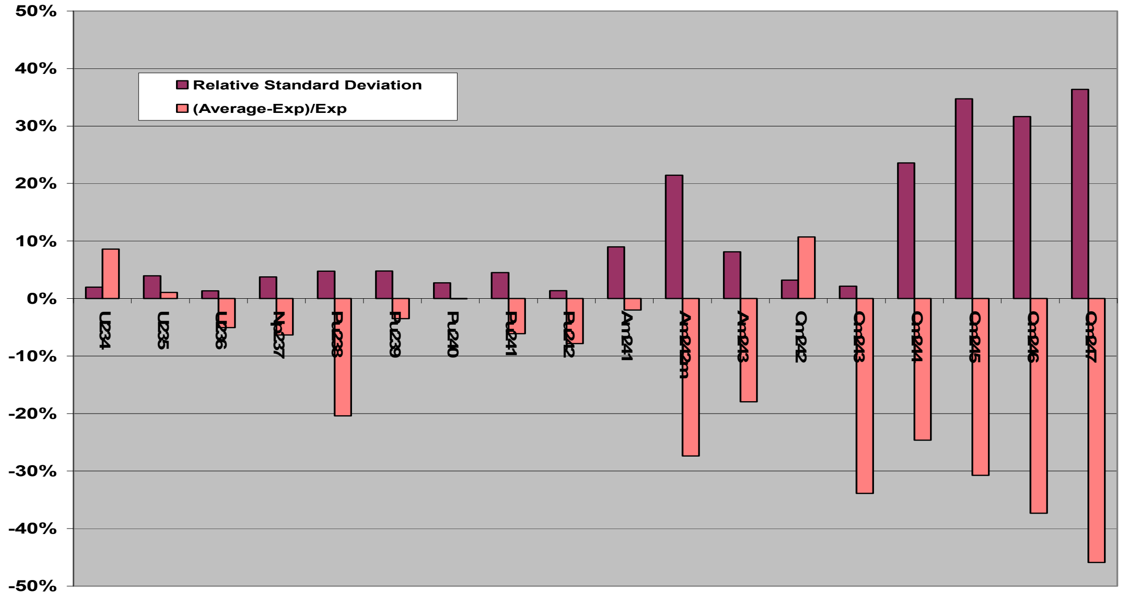
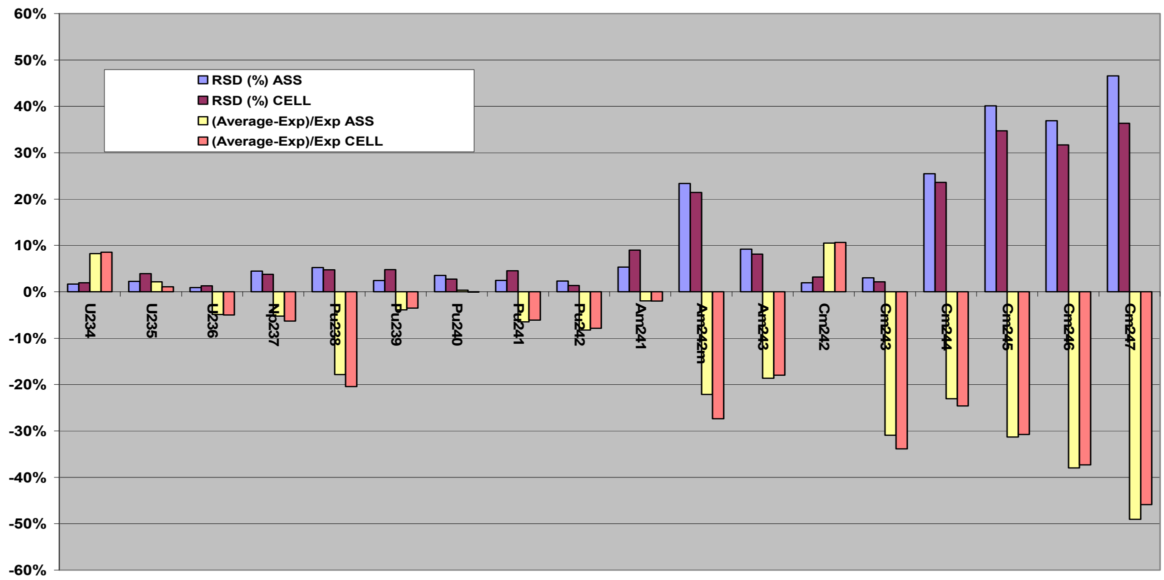


Figure 6: Results for actinides in cell and assembly calculations – comparison of RSD and (Average-Exp/Exp)



6. Results and code-to-code comparison for isotopic concentrations

6.1 Assembly calculation results

6.1.1 Actinides results

The results are listed in Table A.13 through Table A.17. These tables give the relative standard deviation (RDS) versus cooling time. The following table (Table 5) summarises the major trends obtained, in terms of the RSD (see also Figure 7).

Figure 7: Results of RSD versus cooling time for actinides – code-to-code comparison

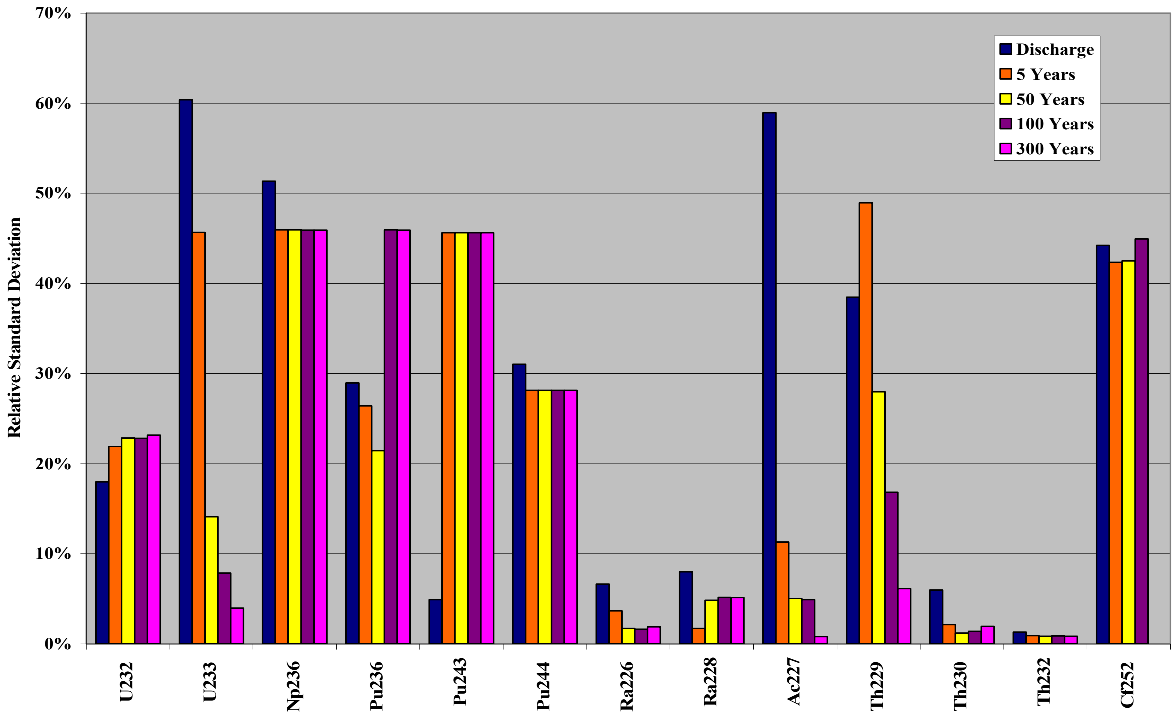


Table 5: Summary of the major trends obtained in terms of RSD for the actinides in the assembly calculation

Relative standard deviation	<±10%	>±10%
Isotopes	^{234}U, ^{235}U, ^{236}U, ^{238}U ^{237}Np ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{243}Pu ^{241}Am, ^{243}Am, ^{242}Cm, ^{243}Cm ^{226}Ra, ^{228}Ra ^{230}Th, ^{232}Th	^{232}U, ^{233}U ^{236}Np ^{236}Pu, ^{244}Pu ^{242m}Am ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm ^{227}Ac ^{229}Th ^{252}Cf

A discussion of the discrepancies which are greater than 10% is presented below for some of these isotopes. The one-group cross-sections are compared at the end of irradiation.

^{232}U, ^{236}Np and ^{236}Pu

These three isotopes are clearly connected. The depletion scheme used in the CEA/DARWIN package is given in Figure 8. (Note the CEA calculations do not take the $^{237}Np(\gamma, n)$ reaction into account). The results for these isotopes are presented in Table 6, which includes both the cell and assembly results. As the results obtained from the two calculations are very similar with the discrepancies between the cell and assembly calculations being low compared to the RSD value, we have included the Japanese results as assembly results in Table 6.

Table 6: Results at discharge for ^{237}Np, ^{236}Np, ^{236}Pu and ^{232}U (cell and assembly calculations)

	CEA-D	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	stand dev (RSD)
^{237}Np	6.003E+02	6.664E+02	6.159E+02	6.408E+02	6.240E+02	6.480E+02	5.917E+02	4%
^{236}Np	1.800E-03	7.515E-04	6.313E-04	7.238E-04	9.440E-04	7.433E-04	2.486E-03	61%
^{236}Pu	1.985E-03	2.334E-03	2.401E-03	2.464E-03	1.080E-03	2.717E-03	1.632E-03	15%
^{232}U	7.842E-04	8.854E-04	1.063E-03	1.092E-03	5.680E-04	1.004E-03	9.175E-04	12%

The comparison of each participant's result with the average calculated value is presented in Table 7.

Table 7: Comparison for ^{232}U, ^{236}Pu, ^{236}Np to the average calculated value (A)

	Average (A)	(CEAD-A)/A	(GRS-A)/A	(J32-A)/A	(J33-A)/A	(NEXIA-A)/A	(RRCKI-A)/A	(VTT-A)/A
Np237	6.267E+02	-4%	6%	-2%	2%	0%	3%	-6%
Np236	1.154E-03	56%	-35%	-45%	-37%	-18%	-36%	115%
Pu236	2.088E-03	-5%	12%	15%	18%	-48%	30%	-22%
U232	9.021E-04	-13%	-2%	18%	21%	-37%	11%	2%

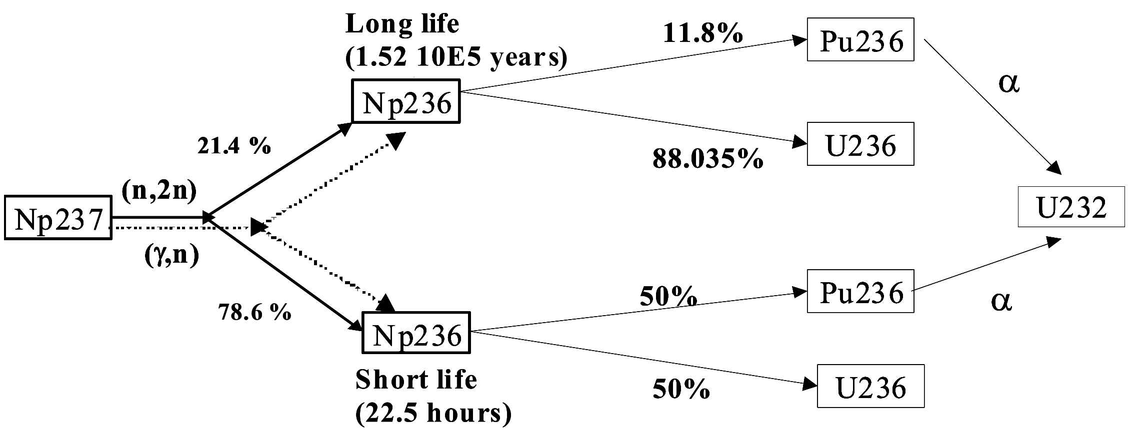
Table 7 shows that the calculated results for ^{237}Np are consistent between all the participants. The results for the other three isotopes (^{236}Np, ^{236}Pu and ^{232}U) fall into three categories:

- Those where the ^{236}Np result is greater than the average but the ^{236}Pu and ^{232}U results are lower (CEA and VTT results).
- Those where the ^{236}Np result is lower than the average and the ^{236}Pu and ^{232}U results are higher (JAERI, RRC-KI and GRS results).
- The NEXIA result where the all three isotopes were lower than the average value.

An important difference between the various participants'models could be the inclusion of the ^{236}Np (n,γ) reaction in the calculation. Furthermore the following feedback reaction is included in some calculations: $^{236}Np(n,\gamma) \rightarrow {}^{237}Np(n,2n) \rightarrow {}^{236}Np$.

The discrepancy in ^{236}Pu may be also due to a difference in branching ratios as illustrated by the Darwin scheme below.

Figure 8: Depletion scheme used in the DARWIN package for ^{232}U build up



The CEA package accounts for the ^{232}U production via the following route at discharge:

$^{234}U(\alpha) \rightarrow {}^{230}Th\ (n,\gamma) \rightarrow {}^{231}Th\ (\beta\text{-}) \rightarrow {}^{231}Pa(n,\gamma) \rightarrow {}^{232}Pa\ (\beta\text{-}) \rightarrow {}^{232}U$.

This represents almost 42% of the ^{232}U formation.

Table 8 gives the trend of the relative standard deviation (RDS) versus cooling time.

Table 8: RSD versus cooling time for ^{232}U, ^{236}Np, ^{236}Pu (assembly calculation)

	Discharge	5 Years	50 Years	100 Years	300 Years
^{232}U	18%	22%	23%	23%	23%
^{236}Np	51%	46%	46%	46%	46%
^{236}Pu	29%	26%	21%	46%	46%

The discrepancy in ^{232}U is constant, with the exception of the value at discharge which may be due to production from the ^{234}U route.

^{233}U

The results for the ^{233}U calculation are given in Table 9 along with the comparison of these results with the calculation average in Table 10. These tables include cell and assembly results. As for the previous isotopes, we have verified that the difference between the cell and assembly model results is low compared to the RSD obtained on the calculated values.

Table 9: Results at discharge for ^{233}U calculation (cell and assembly calculations)

	CEA-D/JEF2	CEA-D/EAF01	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	Average	RSD
^{233}U	2.413E-03	3.383E-03	4.556E-03	7.021E-03	7.796E-03	1.360E-03	2.213E-03	7.354E-03	5.050E-03	48%

Table 10: Comparison for ^{233}U to the average calculated value (A)

	(CEADJEF2-A)/A	(CEADEAF-A)/A	(GRS-A)/A	(J32-A)/A	(J33-A)/A	(NEXIA-A)/A	(RRCKI-A)/A	(VTT-A)/A
^{233}U	-52%	-33%	-10%	39%	54%	-73%	-56%	46%

The CEA, RRC-KI and NEXIA results are 50 to 70% lower relative to the averaged computed concentration. The GRS result is 10% lower than the average. Whereas the VTT and JAERI results are 40 to 55% higher.

At discharge and at a cooling time of five years, one of the main production routes for ^{233}U is the $^{234}U(n,2n)$ reaction. ^{233}U is also produced by the $^{235}U(n,3n)$ and $^{232}U(n,\gamma)$ reactions. The decay of ^{237}Np also produces ^{233}U. This latter route increases with cooling, hence at a cooling time of 300 years, the RSD on ^{233}U is similar to the RSD on ^{237}Np (see Table 11).

Table 11: RSD versus cooling time for ^{233}U (assembly calculation)

	Discharge	5 Years	50 Years	100 Years	300 Years
^{233}U	60%	46%	14%	8%	4%
^{237}Np	4%	4%	4%	4%	3%

The data in Tables 12 and 13 show the one-group cross-section values used by the participants for the $^{234}U(n,2n)$ and the $^{235}U(n,3n)$ reactions.

Table 12: Comparison of $^{234}U(n,2n)$ one-group cross-section

Participant	(n,2n) value (millibarns)
JAERI JENDL3.2	1.646
JAERI JENDL3.3	1.815
VTT	1.78
RRC-KI	
CEA JEF2 DARWIN/CESAR	0.590
CEA EAF01	0.590
GRS	
NEXIA	

Table 13: Comparison of $^{235}U(n,3n)$ one-group cross-section

Participant	(n,3n) value (millibarns)
JAERI JENDL3.2	2.690E-06
JAERI JENDL3.3	3.144E-06
VTT	
RRC-KI	
CEA JEF2 DARWIN/CESAR	0
CEA EAF01	0.44E-02
GRS	
NEXIA	

A CEA calculation using the EAF01 evaluation in which the (n,3n) reactions are explicitly described in the depletion chains indicates that the $^{235}U(n,3n)$ reaction increases the ^{233}U concentration by a factor of 1.4 (see Table 9). It is concluded that the difference between the participants'^{233}U results is due to the difference in their $^{234}U(n,2n)$ and $^{235}U(n,3n)$ cross-sections.

^{243}Pu, ^{244}Pu

The results for ^{243}Pu and ^{244}Pu mass calculations are listed in Table 14, which includes the cell and assembly results. As for the previous isotopes, the difference between the isotopic concentrations from the cell and assembly models is low compared to the RSD obtained.

Table 14: Results at discharge for ^{243}Pu and ^{244}Pu calculation (cell and assembly calculations)

	CEA-D/JEF2	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	Average	RSD
^{243}Pu	1.993E-01	1.975E-01	2.017E-01	2.011E-01	1.800E-01	2.009E-01	2.098E-01	1.986E-01	4%
^{244}Pu	5.292E-02	4.868E-02	5.863E-02	5.839E-02	5.160E-02	2.524E-02	7.471E-02	5.288E-02	26%

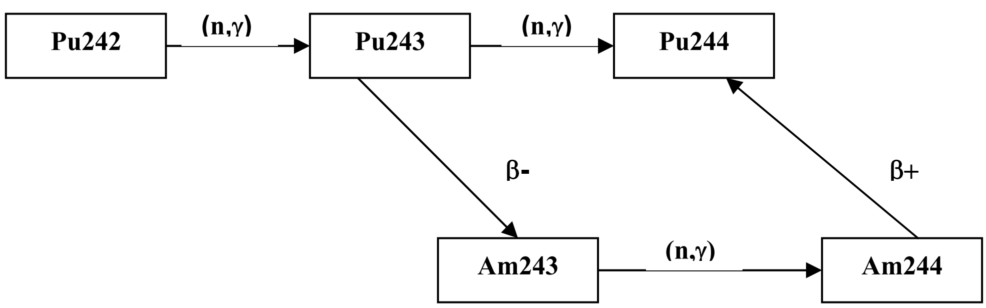
Table 15: Comparison for ^{243}Pu and ^{244}Pu to the average calculated value (A)

	(CEADJEF2-A)/A	(GRS-A)/A	(J32-A)/A	(J33-A)/A	(NEXIA-A)/A	(RRCKI-A)/A	(VTT-A)/A
^{243}Pu	0%	-1%	2%	1%	-9%	1%	6%
^{244}Pu	0%	-8%	11%	10%	-2%	-52%	41%

The results are consistent for the ^{243}Pu calculation relative to the averaged computed concentration, with the exception of a slight underestimation for the NEXIA result and an overestimation for VTT one. For the ^{244}Pu calculation, JAERI and VTT are respectively 10% and 40% higher than the average result and RRC-KI is 50% lower than the average (see Table 15).

The ^{243}Pu and ^{244}Pu production route is represented in Figure 9.

Figure 9: Depletion scheme for ^{243}Pu and ^{244}Pu build-up



The ^{244}Pu build-up is due to the ^{243}Pu(n,γ) reaction (which accounts for approximately 50% of the build-up in the CEA calculation) and to the ^{243}Am(n,γ) reaction (which accounts for approximately 50% of the build up in the CEA calculation). The differences observed between the calculated results could be linked to either the ^{243}Pu(n,γ) or the ^{244}Pu(n,γ) values.

Tables 16 and 17 list the one-group cross-section data provided by some of the participants.

Table 16: Comparison of $^{243}Pu(n,\gamma)$ one-group cross-section

Participant	(n,γ) value (barns)
JAERI JENDL3.2	13.6
JAERI JENDL3.3	13.6
VTT	23.5
RRC-KI	
CEA JEF2 DARWIN/CESAR	12.3
GRS	
NEXIA	

Table 17: Comparison of $^{244}Pu(n,\gamma)$ one-group cross-section

Participant	(n,γ) value (barns)
JAERI JENDL3.2	1.195
JAERI JENDL3.3	1.195
VTT	2.45
RRC-KI	
CEA JEF2 DARWIN/CESAR	2.95
GRS	
NEXIA	

The higher value calculated by VTT is due not only to the higher cross-section used for $^{243}Pu(n,\gamma)$ cross-section but probably also to a difference in the $^{243}Am(n,\gamma)$ cross-section. This can be observed by comparing the mass ratio of $^{244}Pu/^{243}Am$ and $^{243}Am/^{242}Pu$ (see Table 18).

Table 18: Mass ratio comparisons for ^{242}Pu, ^{243}Pu, ^{244}Pu and ^{243}Am

	CEA-D/JEF2	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT
$^{244}Pu/^{243}Pu$	2.656E-01	2.465E-01	2.907E-01	2.903E-01	2.867E-01	1.256E-01	3.562E-01
$^{244}Pu/^{243}Am$	3.264E-04	2.954E-04	3.560E-04	3.531E-04	3.329E-04	1.474E-04	5.758E-04
$^{243}Am/^{242}Pu$	2.188E-01	2.134E-01	2.183E-01	2.186E-01	2.115E-01	2.198E-01	1.711E-01

Table 18 indicates that the $^{243}Am(n,\gamma)$ cross-sections used by GRS, RRC-KI and VTT are very different. The $^{243}Am/^{242}Pu$ ratio is similar for almost all the participants, except for VTT. This lower ratio leads to a lower concentration result for ^{243}Am for VTT as compared to the other participants' results. Consequently this also leads to a lower ^{244}Pu concentration for VTT.

It is noted that for ^{243}Pu there is quite a good agreement at discharge. However, the discrepancies increase with increasing cooling time. This is due to the fact that ^{243}Pu is produced from ^{247}Cm and this production depends on the cooling time; therefore, the discrepancies observed in ^{243}Pu reflect the ones obtained for ^{247}Cm as shown in Table 19.

Table 19: RSD versus cooling time for ^{243}Pu (assembly calculation)

	Discharge	5 Years	50 Years	100 Years	300 Years
^{243}Pu	5%	46%	46%	46%	46%
^{247}Cm	47%	43%	43%	43%	43%

^{227}Ac

The results for the ^{227}Ac mass calculations are listed in Table 20, which includes both the cell and assembly results.

Table 20: Results at discharge for ^{227}Ac calculation (cell and assembly calculations)

	CEA-D/JEF2	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	Average	RSD
^{227}Ac	2.099E-08	4.606E-09	7.688E-09	7.680E-09	6.290E-09	9.478E-09	7.856E-09	9.227E-09	54%

^{227}Ac decays with a half-life of 22 years and is produced by via the two routes shown below (in the CEA calculations):

- ^{234}U (α)$\rightarrow$ ^{230}Th (n,γ) $\rightarrow$ ^{231}Th (β-) $\rightarrow$ ^{231}Pa (α) $\rightarrow$ ^{227}Ac
- ^{235}U (α)$\rightarrow$ ^{231}Th (β-) $\rightarrow$ ^{231}Pa (α) $\rightarrow$ ^{227}Ac

Table A.13 shows that the different participants'results for ^{230}Th are consistent (RSD=6%). Table 21 demonstrates that the range in the ^{227}Ac results decreases with cooling time. This implies that the production of ^{227}Ac via ^{231}Th and ^{231}Pa decay is similar between the different participants and also that the calculation of ^{227}Ac decay is similiar for the different participants.

Table 21: RSD versus cooling time for ^{227}Ac (assembly calculation)

	Discharge	5 Years	50 Years	100 Years	300 Years
^{227}Ac	59%	11%	5%	5%	1%

Table 20 shows that the CEA/JEF2 result is much higher than the other participants' results. This is linked to the fact that the capture cross-section for ^{227}Ac has not been taken into account. The same model using the CEA code system with the EAF01 library (which includes this cross-section) rather than JEF2, gives a ^{227}Ac mass of 1.18E-8 at discharge. This reduces the difference between this calculation and the average calculated result to 27%. However, this is still a relatively large variation which is probably due to the different capture cross-section values used by the various participants (see Table 22).

Table 22: Comparison of ^{227}Ac (n,g) one-group cross-section

Participant	(n,γ) value (barns)
JAERI JENDL3.2	125.2
JAERI JENDL3.3	124.8
VTT	
RRC-KI	
CEA JEF2 DARWIN/CESAR	0
CEA EAF01 DARWIN	65.5
GRS	
NEXIA	

^{229}Th

The results for ^{229}Th mass calculations are listed in Table 23, which includes both the cell and assembly results.

Table 23: Results at discharge for ^{229}Th calculation (cell and assembly calculations)

	CEA-D/JEF2	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	Average	RSD
^{229}Th	2.961E-07	1.520E-06	1.666E-06	1.743E-06	1.300E-06	1.537E-06	1.321E-06	1.341E-06	34%

All the participants obtained a higher value for the mass of ^{229}Th than the CEA/JEF2 calculation. This is because the ^{228}Th(n,γ) cross-section is not included in JEF2. If the CEA value is removed from the average calculation, the RSD decreases to 11%. The result of a CEA calculation using the EAF01 library (instead of JEF2), which takes into account the ^{228}Th(n,γ) cross-section, is presented in Table 24.

Table 24: Results at discharge for ^{229}Th calculation using EAF01 instead of JEF2

	CEA-D/EAF01	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	Average	RSD
^{229}Th	1.209E-06	1.520E-06	1.666E-06	1.743E-06	1.300E-06	1.537E-06	1.321E-06	1.471E-06	13%

This CEA/EAF01 result is more consistent with the other participants'results. The remaining RSD is possibly due to the different ^{228}Th(n,γ) values used (see Table 25). Equally plausible is the hypothesis that the discrepancy is linked to the ^{229}Th(n,γ) cross-section as the ratio of $^{230}Th/^{229}Th$ also varies between the different participants' results (see Table 26). Hence, the values of ^{229}Th(n,γ) have also been compared (see Table 27).

Table 25: Comparison of ^{228}Th (n,γ) one-group cross-section

Participant	(n,γ) value (barns)
JAERI JENDL3.2	35.39
JAERI JENDL3.3	35.18
VTT	29.97
RRC-KI	
CEA JEF2 DARWIN/CESAR	0
CEA EAF01 DARWIN	37.6
GRS	
NEXIA	

Table 26: Comparison of ^{230}Th/^{229}Th ratio (cell and assembly calculations)

	CEA-D/JEF2	CEA-D/EAF01	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT
^{230}Th/^{229}Th	6.61E+03	1.42E+03	1.14E+03	1.05E+03	1.00E+03	1.51E+03	1.40E+03	1.47E+03

Table 27: Comparison of ^{229}Th (n,γ) one-group cross-section

Participant	(n,γ) value (barns)
JAERI JENDL3.2	38.66
JAERI JENDL3.3	38.34
VTT	
RRC-KI	
CEA JEF2 DARWIN/CESAR	0
CEA EAF01 DARWIN	50.6
GRS	
NEXIA	

It is noted that the difference in the ^{229}Th results depends on the cooling time. As the cooling time increases, ^{229}Th is produced by ^{233}U decay (which itself comes from ^{237}Np) and so the discrepancy decreases (Table 28).

Table 28: RSD versus cooling time for ^{229}Th (assembly calculation)

	Discharge	5 Years	50 Years	100 Years	300 Years
^{237}Np	4%	4%	4%	4%	3%
^{233}U	60%	46%	14%	8%	4%
^{229}Th	38%	49%	28%	17%	6%

^{252}Cf

There is a large discrepancy between the participants' results for this isotope. The results are presented in Tables 29 and 30 below.

Table 29: Results at discharge for ^{252}Cf calculation (cell and assembly calculations)

	CEA-D/JEF2	GRS	JAERI (J32)	JAERI (J33)	NEXIA	RRC-KI	VTT	Average	RSD
^{252}Cf	3.212E-07	2.739E-07	6.093E-07	6.814E-07	1.850E-07	6.273E-07	5.905E-07	4.698E-07	40%

Table 30: Comparison of ^{252}Cf to the average calculated value (A) for each participant

	(CEADJEF2-A)/A	(GRS-A)/A	(J32-A)/A	(J33-A)/A	(NEXIA-A)/A	(RRCKI-A)/A	(VTT-A)/A
^{252}Cf	-32%	-42%	30%	45%	-61%	34%	26%

The results can be divided into two groups relative to the averaged concentration:

- a group with a lower concentration than the average (CEA, GRS and NEXIA);
- a group with a higher concentration than the average (formed by the other participants).

This seems to indicate that the JEF2 evaluation used both by CEA, GRS and NEXIA is probably at the origin of the difference.

The discrepancy in ^{248}Cm explains a part of the discrepancy in ^{252}Cf, because ^{252}Cf is only produced via ^{248}Cm as shown below using the INVERSION model from the CEA/DARWIN package.

$^{238}U(n,\gamma) \rightarrow {}^{239}U\ (\beta\text{-}) \rightarrow {}^{239}Np\ (\beta\text{-}) \rightarrow {}^{239}Pu\ (n,\gamma) \rightarrow {}^{240}Pu\ (n,\gamma) \rightarrow {}^{241}Pu\ (n,\gamma) \rightarrow {}^{242}Pu\ (n,\gamma) \rightarrow {}^{243}Pu\ (\beta\text{-}) \rightarrow {}^{243}Am\ (n,\gamma) \rightarrow {}^{244}Am\ (\beta\text{–}) \rightarrow {}^{244}Cm\ (n,\gamma) \rightarrow {}^{245}Cm\ (n,\gamma) \rightarrow {}^{246}Cm\ (n,\gamma) \rightarrow {}^{247}Cm\ (n,\gamma) \rightarrow {}^{248}Cm\ (n,\gamma) \rightarrow {}^{249}Cm\ (\beta\text{-}) \rightarrow {}^{249}Bk\ (n,\gamma) \rightarrow {}^{250}Bk\ (\beta\text{-}) \rightarrow {}^{250}Cf\ (n,\gamma) \rightarrow {}^{251}Cf\ (n,\gamma) \rightarrow {}^{252}Cf$

However, the cross-sections used for ^{249}Bk, ^{250}Cf and ^{251}Cf may also explain this discrepancy in some part. The spread of the results could also reflect a small discrepancy in the flux, which increases along the depletion chain. Table 31 compares the one-group cross-sections for ^{249}Bk, ^{250}Cf and ^{251}Cf used by two of the participants, which are very consistent.

Table 31: Comparison of $^{249}Bk(n,\gamma)$ one-group cross-section

Participant	(n,γ) value (barns)
JAERI JENDL3.2	335.2
JAERI JENDL3.3	333.4
VTT	
RRC-KI	
CEA JEF2 DARWIN/CESAR	
GRS	
NEXIA	

^{226}Ra

It is noted that the CEA/JEF2 calculation gives a higher results than the other participants'calculations at discharge. This is due to the fact that DARWIN uses the JEF2.2 library to calculate this isotope and this library does not contain the $^{226}Ra(n,\gamma)$ cross-section. The discrepancy disappears with cooling time because the ^{226}Ra is only produced from ^{230}Th decay for which we have a good agreement between participants.

The discrepancies on ^{242m}Am, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm have been already discussed in the paragraph dedicated to comparison with experimental values (see Section 5.1.1).

6.1.2 Fission products results

Of the 56 calculated fission products, only 6 have a RSD distinctly above 10%, these are ^{108m}Ag, ^{130}Xe, ^{146}Sm, ^{154}Eu and its daughter ^{154}Gd, ^{166m}Ho (see Table A.19). Other isotopes such as ^{109}Ag, ^{110m}Ag, ^{127}I, ^{142}Nd, ^{148}Sm, ^{151}Sm, ^{152}Sm, ^{156}Gd have a RSD of around 10%. Comparisons between participants results for fission yields, decay constants, branching ratios and capture cross-sections have been performed in order to explain the large RSD, particularly for silver isotopes.

^{108m}Ag

In order to explain the discrepancy obtained for this isotope, the fission yields calculated by the participants have been compared (see Table 32 to Table 34). Furthermore, ^{108m}Ag is produced by the $^{109}Ag(n,2n)$ reaction. These nuclear data are compared in Table 33. The decay and therefore disappearance of ^{108m}Ag could also explain the discrepancies which increase with cooling time. The decay constants are compared in Table 34.

Table 32: Comparison of cumulative fission yields for ^{108m}Ag

Cumulative fission yields (%)						
	CEA/D	GRS	NEXIA	JAERI	RRC-KI	VTT
^{235}U				4.22E-10		
^{238}U				1.16E-11		
^{239}Pu				1.28E-07		
^{241}Pu				4.09E-09		

Table 33: Comparison of ^{109}Ag (n,2n) one-group cross-section

Participant	(n,2n) value (barns)
JAERI JENDL3.2	3.957E-04
JAERI JENDL3.3	4.388E-04
VTT	
RRC-KI	
CEA JEF2 DARWIN/CESAR	0
GRS	
NEXIA	

Table 34: Comparison of ^{108m}Ag decay constant

Participant	$T_{1/2}$ (years)
JAERI JENDL3.2	4.008E+09
JAERI JENDL3.3	1.320E+10
VTT	
RRC-KI	
CEA JEF2 DARWIN/CESAR	418 y
GRS	
NEXIA	

Table A.19 to Table A.24 detail the isotopic concentrations and trends in RSD with cooling time for the fission products calculated. Other than the silver isotopes discussed above only the following isotopes had a RSD greater than 10% at discharge: ^{127}I, ^{130}Xe, ^{142}Nd, ^{146}Sm, ^{148}Sm, ^{151}Sm, ^{152}Sm, ^{154}Eu, ^{154}Gd, ^{156}Gd and ^{166m}Ho (see Table A.19). These RSD remain fairly constant with cooling time (Table A.24).

6.1.3 Activation products results

Table A.25 to Table A.30 detail the isotopic concentrations and trends in RSD with cooling time for the activation products calculated by the participants. With the exception of ^{136}C and ^{63}Ni, all activation products have an RSD greater than 10% regardless of the cooling time (see summary in Table A.30).

6.1.4 Activation-fission product results

Table A.31 to Table A.36 detail the isotopic concentrations and trends in RSD with cooling time for the activation-fission products calculated by the participants. With the exception of ^{3}H, ^{93}Zr and ^{94}Nb, all "activation-fission" products have an RSD greater than 10% at discharge. Whereas ^{93}Zr and ^{94}Nb maintain an RSD of less than 10% as cooling time increases, the RSD of ^{3}H increases to ~46% for later cooling times (see Table A.36).

6.2 Pin-cell calculation results

6.2.1 Actinides results

Table A.37 to Table A.42 detail the isotopic concentrations and trends in RSD with cooling time for the actinides calculated by the participants as part of the cell calculations. Table 35 summarises which of these results are in good agreement (i.e. with an RSD < 10%).

Table 35: Summary of actinide RSD results for cell calculations

RSD < 10% regardless of cooling time	RSD sometimes < 10% and sometimes >10% depending on cooling time	RSD > 10% regardless of cooling time
^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{241}Am, ^{243}Am, ^{226}Ra, ^{230}Th, ^{232}Th	Increasing RSD with cooling time: ^{241}Pu, ^{243}Pu, ^{242}Cm, ^{243}Cm Peak in RSD in intermediate cooling times: ^{236}Pu, ^{228}Ra Decreasing RSD with cooling time: ^{233}U, ^{227}Ac, ^{229}Th, ^{252}Cf	^{232}U, ^{236}Np, ^{244}Pu, ^{242m}Am, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm,

6.2.2 Fission products results

Table A.43 to Table A.48 detail the isotopic concentrations and trends in RSD with cooling time for the fission products calculated by the participants. With the exception of ^{85}Kr, ^{85}Rb, ^{108m}Ag, ^{110m}Ag, ^{127}I, ^{130}Xe, ^{146}Sm, ^{148}Sm, ^{154}Eu, ^{154}Gd and ^{166m}Ho, all fission products have an RSD of less than 10% at discharge. ^{106}Ra, ^{134}Cs, ^{144}Ce, ^{147}Pm and ^{155}Eu have an RSD which increases above 10% with increased cooling time. All other isotopes have an RSD which remains below 10% regardless of the cooling time (see Table A.48).

6.2.3 Activation products results

Table A.49 to Table A.54 detail the isotopic concentrations and trends in RSD with cooling time for the fission products calculated by the participants. With the exception ^{63}Ni and ^{54}Mn, all activation products have an RSD > 10% at all cooling times. ^{63}Ni has an RSD < 10% regardless of the cooling time; whereas, ^{54}Mn has an RSD which decreases with cooling time (see Table A.54).

6.2.4 Activation-fission products results

Table A.55 to Table A.60 detail the isotopic concentrations and trends in RSD with cooling time for the activation-fission products calculated by the participants. With the exception of ^{3}H and ^{93}Zr, all activation-fission products have an RSD greater than 10% at discharge. Whereas ^{93}Zr maintains an RSD of less than 10% as cooling time increases, the RSD of ^{3}H increases to ~50% for later cooling times (see Table A.60).

7. Results and code-to-code comparison for decay heat and neutron emission calculations

7.1 Results and code-to-code comparison for decay heat calculations

Table A.61 to Table A.72 detail the decay heat calculated by the participants for each cooling time and also for both the assembly and cell calculation. The data for the cell calculation are not complete; however, both assembly calculation and cell calculation results are consistent for their respective models. This leads to a consistent breakdown in alpha, beta and gamma as well as the total decay heat. This consistency may be due to the use of same data library – JEF2.2. Data from participants who used different libraries (i.e. versions of JENDL or DLC/MCUDAT) were not available.

7.2 Results and code-to-code comparison for neutron emission calculations

Table A.73 to Table A.84 detail the neutron emission rate calculated by the participants for each cooling time and also for both the assembly and cell calculation. There is moderate consistency between participants for both the assembly and cell models for the (alpha, n) emission rate, the spontaneous fission rate and the total emission rate. However, the (alpha, n) emission rate is the quantity which remains in good agreement across the participants for both types of model.

8. Summary and conclusions

This report focuses on nuclide densities for the most important nuclides in the fuel cycle (actinides, fission products and activation products) and the associated fuel cycle quantities (masses, neutron emission rate and decay heat). It takes assay data from the Takahama-3 experiment and compares it with the results from both cell and assembly models which have been produced by a number of participants. The model results have been compared with each other and also against the experimental results and the following overarching conclusions can be drawn:

- In comparision with experimental results:
  - The assembly and cell models were consistent overall with the assay results for all actinides except for ^{238}Pu, ^{242m}Am, ^{243}Am and isotopes of curium.
  - The assembly and cell models were consistent overall with the assay results for all fission products except for ^{154}Eu in the case of the assembly models.
- In comparison between participants'models:
  - The evolution of actinide quantities at different cooling times has been calculated for both the assembly and cell models. The results between the two types of model remain fairly consistent.
  - Actinides and other quantities with good agreement between the various models at discharge tend to remain in good agreement with increased cooling time. The exceptions are discussed in the body of this report.
  - Whereas the majority of the models are in good agreement with each other for roughly 50% of actinides calculated and for the majority of the fission products, the agreement between models for activation products and fission-activation products is much poorer for both assembly and cell calculations.
  - There is good agreement between participants decay heat values where these are available. However, this could be due to the available data being calculated using the same nuclear data library.
  - There is moderate consistency between participants for both the assembly and cell models for neutron emission.

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Appendix A: Tables providing detailed results

Table A.1: Results for actinides in assembly calculation–comparison to measured values (at discharge)

	Experimental measurement (Exp)	CEA-D	GRS	NEXIA	RRC-KI	VTT	Average (A)	RSD	(A-Exp)/Exp	Experimental uncertainty (1σ)
U234	1.872E+02	2.008E+02	1.977E+02	2.020E+02	2.073E+02	2.053E+02	2.026E+02	2%	8%	1%
U235	8.179E+03	8.235E+03	8.323E+03	8.720E+03	8.202E+03	8.288E+03	8.354E+03	2%	2%	N/A
U236	5.528E+03	5.285E+03	5.179E+03	5.270E+03	5.318E+03	5.232E+03	5.257E+03	1%	-5%	2%
U238	9.246E+05	9.265E+05	9.261E+05	9.270E+05	9.256E+05	9.267E+05	9.264E+05	0%	0%	N/A
Np237	6.604E+02	6.003E+02	6.664E+02	6.240E+02	6.480E+02	5.917E+02	6.261E+02	4%	-5%	10%
Pu238	3.199E+02	2.534E+02	2.841E+02	2.660E+02	2.677E+02	2.435E+02	2.629E+02	5%	-18%	1%
Pu239	6.037E+03	5.663E+03	5.951E+03	5.820E+03	5.958E+03	5.624E+03	5.803E+03	2%	-4%	N/A
Pu240	2.668E+03	2.672E+03	2.630E+03	2.550E+03	2.838E+03	2.697E+03	2.678E+03	4%	0%	N/A
Pu241	1.770E+03	1.601E+03	1.722E+03	1.640E+03	1.674E+03	1.639E+03	1.655E+03	2%	-6%	N/A
Pu242	8.246E+02	7.410E+02	7.721E+02	7.330E+02	7.790E+02	7.582E+02	7.567E+02	2%	-8%	N/A
Am241	5.311E+01	5.134E+01	5.482E+01	5.420E+01	5.295E+01	4.704E+01	5.207E+01	5%	-2%	2%
Am242m	1.233E+00	7.767E-01	9.929E-01	7.740E-01	8.764E-01	1.379E+00	9.597E-01	23%	-22%	10%
Am243	1.924E+02	1.622E+02	1.648E+02	1.550E+02	1.712E+02	1.298E+02	1.566E+02	9%	-19%	1%
Cm242	2.044E+01	2.231E+01	2.210E+01	2.280E+01	2.334E+01	2.237E+01	2.258E+01	2%	10%	10%
Cm243	8.721E-01	6.061E-01	5.949E-01	6.130E-01	6.262E-01	5.719E-01	6.024E-01	3%	-31%	2%
Cm244	8.810E+01	6.304E+01	5.949E+01	5.610E+01	5.831E+01	1.021E+02	6.781E+01	26%	-23%	2%
Cm245	6.042E+00	3.823E+00	3.109E+00	3.210E+00	3.176E+00	7.446E+00	4.153E+00	40%	-31%	2%
Cm246	7.440E-01	4.494E-01	3.365E-01	3.550E-01	3.728E-01	7.933E-01	4.614E-01	37%	-38%	1%
Cm247	1.098E-02	5.268E-03	4.182E-03	3.320E-03	4.537E-03	1.064E-02	5.590E-03	47%	-49%	10%

Table A.2: Results for actinides in assembly calculation–comparison to measured values for each participant (at discharge)

	Experimental measurement (Exp)	Experimental uncertainty (1σ)	(CEAD-Exp)/Exp	(GRS-Exp)/Exp	(NEXIA-Exp)/Exp	(RRCKI-Exp)/Exp	(VTT-Exp)/Exp
U234	1.872E+02	1.0%	7%	6%	8%	11%	10%
U235	8.179E+03	0.1%	1%	2%	7%	0%	1%
U236	5.528E+03	2.0%	-4%	-6%	-5%	-4%	-5%
U238	9.246E+05	0.1%	0%	0%	0%	0%	0%
Np237	6.604E+02	10.0%	-9%	1%	-6%	-2%	-10%
Pu238	3.199E+02	0.5%	-21%	-11%	-17%	-16%	-24%
Pu239	6.037E+03	0.3%	-6%	-1%	-4%	-1%	-7%
Pu240	2.668E+03	0.3%	0%	-1%	-4%	6%	1%
Pu241	1.770E+03	0.3%	-10%	-3%	-7%	-5%	-7%
Pu242	8.246E+02	0.3%	-10%	-6%	-11%	-6%	-8%
Am241	5.311E+01	2.0%	-3%	3%	2%	0%	-11%
Am242m	1.233E+00	10.0%	-37%	-19%	-37%	-29%	12%
Am243	1.924E+02	0.5%	-16%	-14%	-19%	-11%	-33%
Cm242	2.044E+01	10.0%	9%	8%	12%	14%	9%
Cm243	8.721E-01	2.0%	-30%	-32%	-30%	-28%	-34%
Cm244	8.810E+01	2.0%	-28%	-32%	-36%	-34%	16%
Cm245	6.042E+00	2.0%	-37%	-49%	-47%	-47%	23%
Cm246	7.440E-01	0.5%	-40%	-55%	-52%	-50%	7%
Cm247	1.098E-02	10.0%	-52%	-62%	-70%	-59%	-3%

Table A.3: Results for fission products in assembly calculation–comparison to measured values (at discharge)

	Experimental measurement (Exp)	CEA	GRS	NEXIA	RRC-KI	VTT	Average (A)	RSD	(A-Exp)/Exp	Experimental uncertainty (1σ)
Ru106	1.936E+02	2.012E+02	2.044E+02	1.988E+02	2.035E+02	2.034E+02	2.023E+02	1%	4%	5.0%
Cs134	2.139E+02	1.917E+02	2.149E+02	1.760E+02	2.143E+02	1.940E+02	1.982E+02	7%	-7%	3.0%
Cs137	1.749E+03	1.667E+03	1.644E+03	1.665E+03	1.696E+03	1.655E+03	1.666E+03	1%	-5%	3.0%
Ce144	3.756E+02	4.003E+02	4.023E+02	4.010E+02	3.959E+02	3.959E+02	3.991E+02	1%	6%	10.0%
Nd143	1.048E+03	1.023E+03	1.033E+03	1.076E+03	1.039E+03	1.024E+03	1.039E+03	2%	-1%	0.1%
Nd144	1.567E+03	1.465E+03	1.468E+03	1.466E+03	1.502E+03	1.474E+03	1.475E+03	1%	-6%	0.1%
Nd145	9.118E+02	9.120E+02	9.013E+02	9.233E+02	9.164E+02	9.226E+02	9.151E+02	1%	0%	0.1%
Nd146	1.008E+03	9.891E+02	9.933E+02	9.784E+02	1.003E+03	9.743E+02	9.875E+02	1%	-2%	0.1%
Nd148	5.204E+02	5.211E+02	5.111E+02	5.210E+02	5.204E+02	5.179E+02	5.183E+02	1%	0%	0.1%
Nd150	2.516E+02	2.478E+02	2.462E+02	2.458E+02	2.502E+02	2.485E+02	2.477E+02	1%	-2%	0.1%
Eu154	3.739E+01	5.903E+01	3.290E+01	5.549E+01	3.265E+01	3.129E+01	4.227E+01	29%	13%	3.0%

Table A.4: Results for fission products in assembly calculation – comparison to measured values for each participant (at discharge)

	Experimental measurement (Exp)	Experimental uncertainty (1σ)	(CEAD-Exp)/Exp	(GRS-Exp)/Exp	(NEXIA-Exp)/Exp	(RRCKI-Exp)/Exp	(VTT-Exp)/Exp
Ru106	1.936E+02	5.0%	4%	6%	3%	5%	5%
Cs134	2.139E+02	3.0%	-10%	0%	-18%	0%	-9%
Cs137	1.749E+03	3.0%	-5%	-6%	-5%	-3%	-5%
Ce144	3.756E+02	10.0%	7%	7%	7%	5%	5%
Nd143	1.048E+03	0.1%	-2%	-1%	3%	-1%	-2%
Nd144	1.567E+03	0.1%	-7%	-6%	-6%	-4%	-6%
Nd145	9.118E+02	0.1%	0%	-1%	1%	1%	1%
Nd146	1.008E+03	0.1%	-2%	-1%	-3%	-1%	-3%
Nd148	5.204E+02	0.1%	0%	-2%	0%	0%	0%
Nd150	2.516E+02	0.1%	-2%	-2%	-2%	-1%	-1%
Eu154	3.739E+01	3.0%	58%	-12%	48%	-13%	-16%

Table A.5: Results for samarium isotopes in assembly calculation – comparison to measured values (at 3.96 y)

	Experimental measurement (Exp)	CEA-D	GRS	NEXIA	RRC-KI	VTT	Average (A)	RSD	(A-Exp)/Exp	Experimental uncertainty (1σ)
Sm147 with decay from Nd147	2.468E+02	2.456E+02	2.313E+02	2.186E+02	2.364E+02	2.017E+02	2.267E+02	7%	-8%	0.1%
Sm147 no decay from Nd147		2.401E+02	2.268E+02	2.143E+02	2.318E+02	1.978E+02	2.221E+02			
Sm148	2.338E+02	1.936E+02	2.821E+02	2.375E+02	2.238E+02	2.026E+02	2.279E+02	14%	-3%	0.1%
Sm149	3.943E+00	4.214E+00	3.892E+00	4.491E+00	3.946E+00	4.328E+00	4.174E+00	5%	6%	0.1%
Sm150	4.074E+02	4.049E+02	4.144E+02	3.981E+02	3.846E+02	4.011E+02	4.006E+02	2%	-2%	0.1%
Sm151 with decay from Pm151	1.491E+01	1.560E+01	1.657E+01	1.922E+01	1.633E+01	1.405E+01	1.635E+01	10%	10%	0.1%
Sm151 no decay from Pm151		1.532E+01	1.628E+01	1.888E+01	1.604E+01	1.380E+01	1.606E+01			
Sm152	1.298E+02	1.454E+02	1.436E+02	1.933E+02	1.633E+02	1.658E+02	1.623E+02	11%	25%	0.1%
Sm154	5.252E+01	5.269E+01	5.299E+01	5.232E+01	5.000E+01	5.159E+01	5.192E+01	2%	-1%	0.1%

Table A.6: Results for samarium isotopes – assembly calculation – comparison to measured values for each participant (at 3.96 y)

	Experimental measurement (Exp)	Experimental uncertainty (1σ)	(CEAD-Exp)/Exp	(GRS-Exp)/Exp	(NEXIA-Exp)/Exp	(RRC-KI-Exp)/Exp	(VTT-Exp)/Exp
Sm147 (with decay from Nd147)	2.468E+02	0.1%	0%	-6%	-11%	-4%	-18%
Sm148	2.338E+02	0.1%	-17%	46%	-16%	-6%	-9%
Sm149	3.943E+00	0.1%	7%	-8%	15%	-12%	10%
Sm150	4.074E+02	0.1%	-1%	2%	-4%	-3%	4%
Sm151 (with decay from Pm151)	1.491E+01	0.1%	5%	6%	16%	-15%	-14%
Sm152	1.298E+02	0.1%	12%	-1%	35%	-16%	2%
Sm154	5.252E+01	0.1%	0%	1%	-1%	-4%	3%

Table A.7: Results for actinides in cell calculation – comparison to measured values

	Experimental Measurement (Exp)	CEA-D	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average (A)	RSD	(A-Exp)/Exp	Experimental uncertainty (1σ)
U234	1.872E+02	2.014E+02	1.980E+02	2.020E+02	2.020E+02	2.107E+02	2.056E+02	2.033E+02	2%	9%	1.0%
U235	8.179E+03	8.031E+03	7.950E+03	8.749E+03	8.690E+03	8.048E+03	8.140E+03	8.268E+03	4%	1%	0.1%
U236	5.528E+03	5.279E+03	5.169E+03	5.168E+03	5.360E+03	5.296E+03	5.229E+03	5.250E+03	1%	-5%	2.0%
U238	9.246E+05	9.269E+05	9.267E+05	9.257E+05	9.255E+05	9.269E+05	9.268E+05	9.264E+05	0%	0%	0.1%
Np237	6.604E+02	5.949E+02	6.552E+02	6.159E+02	6.408E+02	6.161E+02	5.895E+02	6.187E+02	4%	-6%	10.0%
Pu238	3.199E+02	2.482E+02	2.773E+02	2.522E+02	2.623E+02	2.468E+02	2.407E+02	2.546E+02	5%	-20%	0.5%
Pu239	6.037E+03	5.588E+03	5.700E+03	6.193E+03	6.221E+03	5.739E+03	5.510E+03	5.825E+03	5%	-4%	0.3%
Pu240	2.668E+03	2.622E+03	2.538E+03	2.721E+03	2.733E+03	2.740E+03	2.644E+03	2.666E+03	3%	0%	0.3%
Pu241	1.770E+03	1.581E+03	1.661E+03	1.762E+03	1.757E+03	1.577E+03	1.634E+03	1.662E+03	5%	-6%	0.3%
Pu242	8.246E+02	7.447E+02	7.778E+02	7.544E+02	7.563E+02	7.604E+02	7.659E+02	7.599E+02	1%	-8%	0.3%
Am241	5.311E+01	5.015E+01	5.194E+01	5.957E+01	5.647E+01	4.812E+01	4.606E+01	5.205E+01	9%	-2%	2.0%
Am242m	1.233E+00	7.528E-01	9.242E-01	7.899E-01	8.177E-01	7.822E-01	1.307E+00	8.957E-01	21%	-27%	10.0%
Am243	1.924E+02	1.619E+02	1.659E+02	1.647E+02	1.653E+02	1.593E+02	1.296E+02	1.578E+02	8%	-18%	0.5%
Cm242	2.044E+01	2.199E+01	2.168E+01	2.279E+01	2.370E+01	2.334E+01	2.223E+01	2.262E+01	3%	11%	10.0%
Cm243	8.721E-01	5.940E-01	5.799E-01	5.599E-01	5.825E-01	5.826E-01	5.607E-01	5.766E-01	2%	-34%	2.0%
Cm244	8.810E+01	6.226E+01	5.963E+01	6.227E+01	6.119E+01	5.242E+01	1.006E+02	6.639E+01	24%	-25%	2.0%
Cm245	6.042E+00	3.705E+00	3.028E+00	4.281E+00	4.215E+00	2.708E+00	7.173E+00	4.185E+00	35%	-31%	2.0%
Cm246	7.440E-01	4.399E-01	3.389E-01	4.541E-01	4.697E-01	3.235E-01	7.715E-01	4.663E-01	32%	-37%	0.5%
Cm247	1.098E-02	5.088E-03	4.119E-03	6.178E-03	6.333E-03	3.677E-03	1.026E-02	5.942E-03	36%	-46%	10.0%

Table A.8: Results for actinides in cell calculation – comparison to measured values for each participant (at discharge)

	Experimental measurement (Exp)	Experimental uncertainty (1σ)	(CEAD-Exp)/Exp	(GRS-Exp)/Exp	(J32-Exp)/Exp	(J33-Exp)/Exp	(RRCKI-Exp)/Exp	(VTT-Exp)/Exp
U234	1.872E+02	1.0%	8%	6%	8%	8%	13%	10%
U235	8.179E+03	0.1%	-2%	-3%	7%	6%	-2%	0%
U236	5.528E+03	2.0%	-5%	-6%	-7%	-3%	-4%	-5%
U238	9.246E+05	0.1%	0%	0%	0%	0%	0%	0%
Np237	6.604E+02	10.0%	-10%	-1%	-7%	-3%	-7%	-11%
Pu238	3.199E+02	0.5%	-22%	-13%	-21%	-18%	-23%	-25%
Pu239	6.037E+03	0.3%	-7%	-6%	3%	3%	-5%	-9%
Pu240	2.668E+03	0.3%	-2%	-5%	2%	2%	3%	-1%
Pu241	1.770E+03	0.3%	-11%	-6%	0%	-1%	-11%	-8%
Pu242	8.246E+02	0.3%	-10%	-6%	-9%	-8%	-8%	-7%
Am241	5.311E+01	2.0%	-6%	-2%	12%	6%	-9%	-13%
Am242m	1.233E+00	10.0%	-39%	-25%	-36%	-34%	-37%	6%
Am243	1.924E+02	0.5%	-16%	-14%	-14%	-14%	-17%	-33%
Cm242	2.044E+01	10.0%	8%	6%	12%	16%	14%	9%
Cm243	8.721E-01	2.0%	-32%	-34%	-36%	-33%	-33%	-36%
Cm244	8.810E+01	2.0%	-29%	-32%	-29%	-31%	-40%	14%
Cm245	6.042E+00	2.0%	-39%	-50%	-29%	-30%	-55%	19%
Cm246	7.440E-01	0.5%	-41%	-54%	-39%	-37%	-57%	4%
Cm247	1.098E-02	10.0%	-54%	-62%	-44%	-42%	-67%	-7%

Table A.9: Results for fission products in cell calculation – comparison to measured values (at discharge)

	Experimental measurement (Exp)	CEA-D	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average (A)	RSD	(A-Exp)/Exp	Experimental uncertainty (1σ)
Ru106	1.940E+02	2.007E+02	2.038E+02	2.075E+02	2.090E+02	2.027E+02	2.054E+02	2.049E+02	1%	6%	5%
Cs134	2.140E+02	1.911E+02	2.179E+02	2.068E+02	2.063E+02	2.098E+02	1.949E+02	2.045E+02	4%	-4%	3%
Cs137	1.750E+03	1.666E+03	1.647E+03	1.713E+03	1.713E+03	1.673E+03	1.657E+03	1.678E+03	2%	-4%	3%
Ce144	3.760E+02	4.005E+02	4.036E+02	4.077E+02	4.085E+02	4.053E+02	4.010E+02	4.044E+02	1%	8%	10%
Nd143	1.050E+03	1.016E+03	1.022E+03	1.001E+03	1.000E+03	1.019E+03	1.020E+03	1.013E+03	1%	-4%	0.1%
Nd144	1.570E+03	1.473E+03	1.489E+03	1.504E+03	1.503E+03	1.482E+03	1.476E+03	1.488E+03	1%	-5%	0.1%
Nd145	9.120E+02	9.127E+02	9.047E+02	9.126E+02	9.127E+02	9.094E+02	9.232E+02	9.125E+02	1%	0%	0.1%
Nd146	1.010E+03	9.877E+02	9.965E+02	9.847E+02	9.848E+02	9.853E+02	9.750E+02	9.856E+02	1%	-2%	0.1%
Nd148	5.200E+02	5.204E+02	5.124E+02	5.186E+02	5.189E+02	5.130E+02	5.178E+02	5.168E+02	1%	-1%	0.1%
Nd150	2.520E+02	2.469E+02	2.460E+02	2.484E+02	2.489E+02	2.452E+02	2.482E+02	2.473E+02	1%	-2%	0.1%
Eu154	3.740E+01	5.837E+01	3.215E+01	2.803E+01	3.039E+01	3.095E+01	3.094E+01	3.514E+01	30%	-6%	3%

Table A.10: Results for fission products in cell calculation – comparison to measured values for each participant (at discharge)

	Experimental measurement (Exp)	Experimental uncertainty (1σ)	(CEAD-Exp)/Exp	(GRS-Exp)/Exp	(J32-Exp)/Exp	(J33-Exp)/Exp	(RRCKI-Exp)/Exp	(VTT-Exp)/Exp
Ru106	1.940E+02	5%	3%	5%	7%	8%	5%	6%
Cs134	2.140E+02	3%	-11%	2%	-3%	-4%	-2%	-9%
Cs137	1.750E+03	3%	-5%	-6%	-2%	-2%	-4%	-5%
Ce144	3.760E+02	10%	7%	7%	8%	9%	8%	7%
Nd143	1.050E+03	0.1%	-3%	-3%	-5%	-5%	-3%	-3%
Nd144	1.570E+03	0.1%	-6%	-5%	-4%	-4%	-6%	-6%
Nd145	9.120E+02	0.1%	0%	-1%	0%	0%	0%	1%
Nd146	1.010E+03	0.1%	-2%	-1%	-3%	-2%	-2%	-3%
Nd148	5.200E+02	0.1%	0%	-1%	0%	0%	-1%	0%
Nd150	2.520E+02	0.1%	-2%	-2%	-1%	-1%	-3%	-2%
Eu154	3.740E+01	3%	56%	-14%	-25%	-19%	-17%	-17%

Table A.11: Results for samarium isotopes – cell calculation – comparison to measured values (at 3.96 y)

	Experimental measurement (Exp)	CEA-D	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average (A)	RSD	(A-Exp)/Exp	Experimental uncertainty (1σ)
Sm147 (with decay from Nd147)	2.468E+02	2.459E+02	2.327E+02	2.346E+02	2.352E+02	2.367E+02	2.031E+02	2.314E+02	6%	-6%	0.1%
Sm147 (no decay from Nd147)		2.404E+02	2.272E+02	2.292E+02	2.297E+02	2.313E+02	1.976E+02	2.259E+02			
Sm148	2.338E+02	1.925E+02	2.022E+02	2.494E+02	2.491E+02	2.168E+02	2.837E+02	2.323E+02	14%	-1%	0.1%
Sm149	3.943E+00	4.180E+00	4.201E+00	3.724E+00	3.715E+00	3.910E+00	3.864E+00	3.932E+00	5%	0%	0.1%
Sm150	4.074E+02	4.039E+02	4.017E+02	3.937E+02	3.940E+02	3.793E+02	4.127E+02	3.975E+02	3%	-2%	0.1%
Sm151 (with decay from Pm151)	1.491E+01	1.534E+01	1.581E+01	1.345E+01	1.372E+01	1.532E+01	1.361E+01	1.454E+01	7%	-2%	0.1%
Sm151 (no decay from Pm151)		1.505E+01	1.552E+01	1.344E+01	1.342E+01	1.502E+01	1.361E+01	1.434E+01			
Sm152	1.298E+02	1.459E+02	1.667E+02	1.572E+02	1.331E+02	1.614E+02	1.436E+02	1.513E+02	8%	17%	0.1%
Sm154	5.252E+01	5.241E+01	5.136E+01	5.042E+01	5.068E+01	4.868E+01	5.284E+01	5.106E+01	3%	-3%	0.1%

Table A.12: Results for samarium isotopes in cell calculation – comparison to measured values for each participant (at 3.96 y)

	Experimental measurement (Exp)	Experimental uncertainty (1σ)	(CEAD-Exp)/Exp	(GRS-Exp)/Exp	(J32-Exp)/Exp	(J33-Exp)/Exp	(RRCKI-Exp)/Exp	(VTT-Exp)/Exp
Sm147 (with decay from Nd147)	2.468E+02	0.1%	0%	-6%	-5%	-5%	-4%	-18%
Sm148	2.338E+02	0.1%	-18%	-14%	7%	6%	-7%	21%
Sm149	3.943E+00	0.1%	6%	7%	-5%	-6%	-1%	-2%
Sm150	4.074E+02	0.1%	-1%	-1%	-3%	-3%	-7%	1%
Sm151 (with decay from Pm151)	1.491E+01	0.1%	3%	6%	-10%	-8%	3%	-9%
Sm152	1.298E+02	0.1%	12%	14%	-6%	-15%	21%	-11%
Sm154	5.252E+01	0.1%	0%	-2%	-2%	1%	-4%	9%

Table A.13: Results for actinides in assembly calculation at discharge (g/tHMI)

	CEA-D	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
U232	7.842E-04	8.854E-04	5.680E-04	1.004E-03	9.175E-04	8.319E-04	1.50E-04	18%
U233	2.413E-03	4.556E-03	1.360E-03	2.213E-03	7.354E-03	3.579E-03	2.16E-03	60%
U234	2.008E+02	1.977E+02	2.020E+02	2.073E+02	2.053E+02	2.026E+02	3.36E+00	2%
U235	8.235E+03	8.323E+03	8.720E+03	8.202E+03	8.288E+03	8.354E+03	1.88E+02	2%
U236	5.285E+03	5.179E+03	5.270E+03	5.318E+03	5.232E+03	5.257E+03	4.76E+01	1%
U238	9.265E+05	9.261E+05	9.270E+05	9.256E+05	9.267E+05	9.264E+05	4.90E+02	0%
Np236	1.800E-03	7.515E-04	9.440E-04	7.433E-04	2.486E-03	1.345E-03	6.91E-04	51%
Np237	6.003E+02	6.664E+02	6.240E+02	6.480E+02	5.917E+02	6.261E+02	2.82E+01	4%
Pu236	1.985E-03	2.334E-03	1.080E-03	2.717E-03	1.632E-03	1.950E-03	5.65E-04	29%
Pu238	2.534E+02	2.841E+02	2.660E+02	2.677E+02	2.435E+02	2.629E+02	1.38E+01	5%
Pu239	5.663E+03	5.951E+03	5.820E+03	5.958E+03	5.624E+03	5.803E+03	1.40E+02	2%
Pu240	2.672E+03	2.630E+03	2.550E+03	2.838E+03	2.697E+03	2.678E+03	9.46E+01	4%
Pu241	1.601E+03	1.722E+03	1.640E+03	1.674E+03	1.639E+03	1.655E+03	4.06E+01	2%
Pu242	7.410E+02	7.721E+02	7.330E+02	7.790E+02	7.582E+02	7.567E+02	1.76E+01	2%
Pu243	1.993E-01	1.975E-01	1.800E-01	2.009E-01	2.098E-01	1.975E-01	9.71E-03	5%
Pu244	5.292E-02	4.868E-02	5.160E-02	2.524E-02	7.471E-02	5.063E-02	1.57E-02	31%
Am241	5.134E+01	5.482E+01	5.420E+01	5.295E+01	4.704E+01	5.207E+01	2.78E+00	5%
Am242m	7.767E-01	9.929E-01	7.740E-01	8.764E-01	1.379E+00	9.597E-01	2.24E-01	23%
Am243	1.622E+02	1.648E+02	1.550E+02	1.712E+02	1.298E+02	1.566E+02	1.44E+01	9%
Cm242	2.231E+01	2.210E+01	2.280E+01	2.334E+01	2.237E+01	2.258E+01	4.43E-01	2%
Cm243	6.061E-01	5.949E-01	6.130E-01	6.262E-01	5.719E-01	6.024E-01	1.83E-02	3%
Cm244	6.304E+01	5.949E+01	5.610E+01	5.831E+01	1.021E+02	6.781E+01	1.73E+01	26%
Cm245	3.823E+00	3.109E+00	3.210E+00	3.176E+00	7.446E+00	4.153E+00	1.67E+00	40%
Cm246	4.494E-01	3.365E-01	3.550E-01	3.728E-01	7.933E-01	4.614E-01	1.70E-01	37%
Cm247	5.268E-03	4.182E-03	3.320E-03	4.537E-03	1.064E-02	5.590E-03	2.60E-03	47%
Cm248	3.500E-04	2.340E-04	2.150E-04	4.175E-04	7.328E-04	3.899E-04	1.87E-04	48%
Ra226	4.290E-08	3.775E-08	3.970E-08	3.774E-08	3.520E-08	3.866E-08	2.56E-09	7%
Ra228	2.074E-14	1.999E-14	1.690E-14	2.153E-14	2.042E-14	1.992E-14	1.59E-15	8%
Ac227	2.099E-08	4.606E-09	6.290E-09	9.478E-09	7.856E-09	9.844E-09	5.80E-09	59%
Th229	2.961E-07	1.520E-06	1.300E-06	1.537E-06	1.321E-06	1.195E-06	4.60E-07	38%
Th230	1.919E-03	1.969E-03	2.150E-03	1.947E-03	1.787E-03	1.954E-03	1.17E-04	6%
Th232	3.422E-04	3.379E-04	3.430E-04	3.514E-04	3.411E-04	3.431E-04	4.50E-06	1%
Cf252	3.212E-07	2.739E-07	1.850E-07	6.273E-07	5.905E-07	3.996E-07	1.77E-07	44%

Table A.14: Results for actinides in assembly calculation at 5 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
U232	2.076E-03	2.082E-03	2.421E-03	1.260E-03	2.763E-03	1.978E-03	2.097E-03	4.59E-04	22%
U233	3.389E-03	3.389E-03	5.639E-03	2.400E-03	3.265E-03	8.316E-03	4.400E-03	2.01E-03	46%
U234	2.113E+02	2.113E+02	2.094E+02	2.130E+02	2.183E+02	2.153E+02	2.131E+02	2.95E+00	1%
U235	8.236E+03	8.239E+03	8.324E+03	8.720E+03	8.207E+03	8.289E+03	8.336E+03	1.76E+02	2%
U236	5.286E+03	5.286E+03	5.180E+03	5.270E+03	5.318E+03	5.234E+03	5.262E+03	4.45E+01	1%
U238	9.265E+05	9.265E+05	9.261E+05	9.270E+05	9.256E+05	9.267E+05	9.264E+05	4.48E+02	0%
Np236	1.800E-03	1.799E-03	7.514E-04	9.440E-04	7.433E-04	2.486E-03	1.421E-03	6.53E-04	46%
Np237	6.142E+02	6.139E+02	6.819E+02	6.380E+02	6.627E+02	6.059E+02	6.361E+02	2.80E+01	4%
Pu236	6.039E-04	6.057E-04	6.962E-04	3.270E-04	8.228E-04	4.865E-04	5.904E-04	1.56E-04	26%
Pu238	2.669E+02	2.670E+02	2.964E+02	2.790E+02	2.815E+02	2.573E+02	2.747E+02	1.26E+01	5%
Pu239	5.759E+03	5.758E+03	6.049E+03	5.910E+03	6.052E+03	5.722E+03	5.875E+03	1.37E+02	2%
Pu240	2.682E+03	2.694E+03	2.639E+03	2.550E+03	2.846E+03	2.713E+03	2.687E+03	8.87E+01	3%
Pu241	1.259E+03	1.263E+03	1.361E+03	1.290E+03	1.315E+03	1.289E+03	1.296E+03	3.45E+01	3%
Pu242	7.410E+02	7.442E+02	7.722E+02	7.330E+02	7.790E+02	7.582E+02	7.546E+02	1.67E+01	2%
Pu243	1.831E-13	1.842E-13	1.491E-13	1.150E-13	*-6.4E-38*	3.795E-13	2.022E-13	9.22E-14	46%
Pu244	5.292E-02	5.313E-02	4.868E-02	5.160E-02	2.524E-02	7.471E-02	5.105E-02	1.44E-02	28%
Am241	3.920E+02	3.934E+02	4.143E+02	4.040E+02	4.101E+02	3.957E+02	4.016E+02	8.51E+00	2%
Am242m	7.579E-01	7.604E-01	9.705E-01	7.550E-01	8.555E-01	1.348E+00	9.078E-01	2.11E-01	23%
Am243	1.623E+02	1.629E+02	1.650E+02	1.560E+02	1.713E+02	1.299E+02	1.579E+02	1.33E+01	8%
Cm242	1.146E-02	1.153E-02	1.177E-02	1.160E-02	1.218E-02	1.294E-02	1.191E-02	5.14E-04	4%
Cm243	5.400E-01	5.437E-01	5.268E-01	5.460E-01	5.548E-01	5.065E-01	5.363E-01	1.57E-02	3%
Cm244	5.207E+01	5.230E+01	4.914E+01	4.630E+01	4.818E+01	8.444E+01	5.540E+01	1.32E+01	24%
Cm245	3.821E+00	3.839E+00	3.108E+00	3.210E+00	3.175E+00	7.444E+00	4.099E+00	1.53E+00	37%
Cm246	4.491E-01	4.516E-01	3.362E-01	3.550E-01	3.725E-01	7.928E-01	4.595E-01	1.55E-01	34%
Cm247	5.268E-03	5.298E-03	4.182E-03	3.320E-03	4.537E-03	1.064E-02	5.541E-03	2.38E-03	43%
Cm248	3.503E-04	3.524E-04	2.342E-04	2.150E-04	4.180E-04	7.332E-04	3.838E-04	1.71E-04	45%
Ra226	1.933E-07	1.933E-07	1.866E-07	2.010E-07	1.914E-07	1.781E-07	1.906E-07	7.01E-09	4%
Ra228	1.507E-13	*0.000E+00*	1.478E-13	1.490E-13	1.531E-13	1.549E-13	1.511E-13	2.59E-15	2%
Ac227	8.276E-08	*0.000E+00*	6.762E-08	5.830E-08	6.827E-08	7.187E-08	6.976E-08	7.89E-09	11%
Th229	3.580E-07	3.582E-07	1.629E-06	1.340E-06	1.595E-06	1.489E-06	1.128E-06	5.52E-07	49%
Th230	4.774E-03	4.776E-03	4.802E-03	5.030E-03	4.894E-03	4.714E-03	4.832E-03	1.04E-04	2%
Th232	1.111E-03	1.111E-03	1.091E-03	1.110E-03	1.125E-03	1.102E-03	1.108E-03	1.02E-05	1%
Cf252	8.664E-08	8.733E-08	7.370E-08	4.990E-08	1.693E-07	1.589E-07	1.043E-07	4.42E-08	42%

Table A.15: Results for actinides in assembly calculation at 50 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
U232	1.724E-03	1.729E-03	2.029E-03	1.020E-03	2.308E-03	1.606E-03	1.736E-03	3.96E-04	23%
U233	1.267E-02	1.266E-02	1.591E-02	1.210E-02	1.325E-02	1.747E-02	1.401E-02	1.98E-03	14%
U234	2.898E+02	2.899E+02	2.965E+02	2.960E+02	3.011E+02	2.910E+02	2.940E+02	4.17E+00	1%
U235	8.244E+03	8.247E+03	8.332E+03	8.730E+03	8.215E+03	8.296E+03	8.344E+03	1.77E+02	2%
U236	5.299E+03	5.299E+03	5.193E+03	5.290E+03	5.335E+03	5.247E+03	5.277E+03	4.57E+01	1%
U238	9.265E+05	9.265E+05	9.261E+05	9.270E+05	9.256E+05	9.267E+05	9.264E+05	4.48E+02	0%
Np236	1.800E-03	1.798E-03	7.512E-04	9.440E-04	7.433E-04	2.486E-03	1.420E-03	6.52E-04	46%
Np237	6.924E+02	6.923E+02	7.652E+02	7.180E+02	7.443E+02	6.856E+02	7.163E+02	2.96E+01	4%
Pu236	1.693E-08	1.698E-08	1.409E-08	9.090E-09	1.939E-08	1.423E-08	1.512E-08	3.24E-09	21%
Pu238	1.871E+02	1.872E+02	2.079E+02	1.960E+02	1.975E+02	1.806E+02	1.927E+02	8.88E+00	5%
Pu239	5.753E+03	5.752E+03	6.043E+03	5.910E+03	6.038E+03	5.716E+03	5.869E+03	1.36E+02	2%
Pu240	2.711E+03	2.724E+03	2.666E+03	2.580E+03	2.872E+03	2.768E+03	2.720E+03	8.95E+01	3%
Pu241	1.443E+02	1.448E+02	1.632E+02	1.480E+02	1.499E+02	1.479E+02	1.497E+02	6.34E+00	4%
Pu242	7.410E+02	7.442E+02	7.721E+02	7.330E+02	7.790E+02	7.582E+02	7.546E+02	1.67E+01	2%
Pu243	1.831E-13	1.842E-13	1.491E-13	1.150E-13	*-6.37E-38*	3.795E-13	2.022E-13	9.22E-14	46%
Pu244	5.292E-02	5.313E-02	4.868E-02	5.160E-02	2.524E-02	7.471E-02	5.105E-02	1.44E-02	28%
Am241	1.427E+03	1.432E+03	1.527E+03	1.470E+03	1.492E+03	1.456E+03	1.467E+03	3.47E+01	2%
Am242m	6.075E-01	6.095E-01	7.906E-01	6.050E-01	6.857E-01	1.098E+00	7.327E-01	1.76E-01	24%
Am243	1.616E+02	1.622E+02	1.643E+02	1.550E+02	1.707E+02	1.294E+02	1.572E+02	1.33E+01	8%
Cm242	1.587E-03	1.593E-03	1.909E-03	1.580E-03	1.792E-03	2.658E-03	1.853E-03	3.80E-04	21%
Cm243	1.909E-01	1.922E-01	1.765E-01	1.930E-01	1.859E-01	1.697E-01	1.847E-01	8.75E-03	5%
Cm244	9.293E+00	9.335E+00	8.789E+00	8.270E+00	8.608E+00	1.510E+01	9.899E+00	2.36E+00	24%
Cm245	3.807E+00	3.825E+00	3.096E+00	3.200E+00	3.164E+00	7.417E+00	4.085E+00	1.52E+00	37%
Cm246	4.462E-01	4.486E-01	3.340E-01	3.520E-01	3.698E-01	7.876E-01	4.564E-01	1.55E-01	34%
Cm247	5.268E-03	5.298E-03	4.182E-03	3.320E-03	4.537E-03	1.064E-02	5.541E-03	2.38E-03	43%
Cm248	3.503E-04	3.524E-04	2.343E-04	2.150E-04	4.181E-04	7.333E-04	3.839E-04	1.71E-04	45%
Ra226	8.152E-06	8.154E-06	8.041E-06	8.350E-06	8.404E-06	8.043E-06	8.191E-06	1.40E-07	2%
Ra228	2.721E-12	0.000E+00	2.666E-12	2.720E-12	2.737E-12	3.042E-12	2.777E-12	1.35E-13	5%
Ac227	4.745E-07	0.000E+00	4.661E-07	4.140E-07	4.465E-07	4.744E-07	4.551E-07	2.30E-08	5%
Th229	1.881E-06	1.880E-06	3.674E-06	2.710E-06	3.155E-06	3.953E-06	2.875E-06	8.05E-07	28%
Th230	3.631E-02	3.632E-02	3.680E-02	3.710E-02	3.756E-02	3.671E-02	3.680E-02	4.38E-04	1%
Th232	8.042E-03	8.041E-03	7.880E-03	8.020E-03	8.093E-03	7.960E-03	8.006E-03	6.87E-05	1%
Cf252	6.551E-13	6.608E-13	5.442E-13	3.770E-13	1.294E-12	1.174E-12	7.841E-13	3.33E-13	43%

Table A.16: Results for actinides in assembly calculation at 100 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
U232	1.049E-03	1.053E-03	1.252E-03	6.220E-04	1.405E-03	9.928E-04	1.062E-03	2.42E-04	23%
U233	2.459E-02	2.459E-02	2.906E-02	2.450E-02	2.604E-02	2.931E-02	2.635E-02	2.07E-03	8%
U234	3.498E+02	3.499E+02	3.632E+02	3.580E+02	3.644E+02	3.489E+02	3.557E+02	6.47E+00	2%
U235	8.252E+03	8.255E+03	8.340E+03	8.740E+03	8.229E+03	8.304E+03	8.353E+03	1.77E+02	2%
U236	5.313E+03	5.313E+03	5.206E+03	5.300E+03	5.353E+03	5.261E+03	5.291E+03	4.66E+01	1%
U238	9.265E+05	9.265E+05	9.261E+05	9.270E+05	9.256E+05	9.267E+05	9.264E+05	4.48E+02	0%
Np236	1.799E-03	1.798E-03	7.510E-04	9.440E-04	7.433E-04	2.485E-03	1.420E-03	6.52E-04	46%
Np237	8.072E+02	8.076E+02	8.885E+02	8.370E+02	8.645E+02	8.028E+02	8.346E+02	3.24E+01	4%
Pu236	4.052E-09	4.049E-09	1.657E-09	2.120E-09	1.669E-09	5.545E-09	3.182E-09	1.46E-09	46%
Pu238	1.261E+02	1.262E+02	1.402E+02	1.320E+02	1.331E+02	1.218E+02	1.299E+02	5.97E+00	5%
Pu239	5.745E+03	5.744E+03	6.035E+03	5.900E+03	6.029E+03	5.708E+03	5.860E+03	1.36E+02	2%
Pu240	2.704E+03	2.717E+03	2.659E+03	2.570E+03	2.864E+03	2.766E+03	2.713E+03	9.04E+01	3%
Pu241	1.301E+01	1.306E+01	1.548E+01	1.340E+01	1.342E+01	1.336E+01	1.362E+01	8.47E-01	6%
Pu242	7.409E+02	7.441E+02	7.721E+02	7.330E+02	7.790E+02	7.582E+02	7.546E+02	1.67E+01	2%
Pu243	1.831E-13	1.842E-13	1.491E-13	1.150E-13	*-6.371E-38*	3.795E-13	2.022E-13	9.22E-14	46%
Pu244	5.292E-02	5.313E-02	4.868E-02	5.160E-02	2.524E-02	7.471E-02	5.105E-02	1.44E-02	28%
Am241	1.441E+03	1.447E+03	1.549E+03	1.480E+03	1.507E+03	1.471E+03	1.482E+03	3.68E+01	2%
Am242m	4.751E-01	4.767E-01	6.295E-01	4.730E-01	5.362E-01	8.741E-01	5.774E-01	1.44E-01	25%
Am243	1.608E+02	1.615E+02	1.635E+02	1.540E+02	1.699E+02	1.287E+02	1.564E+02	1.32E+01	8%
Cm242	1.242E-03	1.246E-03	1.520E-03	1.230E-03	1.402E-03	2.115E-03	1.459E-03	3.12E-04	21%
Cm243	6.014E-02	6.055E-02	5.234E-02	6.080E-02	5.512E-02	5.033E-02	5.655E-02	4.19E-03	7%
Cm244	1.370E+00	1.376E+00	1.298E+00	1.220E+00	1.270E+00	2.231E+00	1.461E+00	3.49E-01	24%
Cm245	3.792E+00	3.809E+00	3.084E+00	3.180E+00	3.152E+00	7.386E+00	4.067E+00	1.51E+00	37%
Cm246	4.429E-01	4.453E-01	3.316E-01	3.500E-01	3.668E-01	7.818E-01	4.531E-01	1.53E-01	34%
Cm247	5.268E-03	5.298E-03	4.182E-03	3.320E-03	4.537E-03	1.064E-02	5.541E-03	2.38E-03	43%
Cm248	3.503E-04	3.524E-04	2.342E-04	2.150E-04	4.181E-04	7.332E-04	3.839E-04	1.71E-04	45%
Ra226	3.389E-05	3.390E-05	3.376E-05	3.460E-05	3.507E-05	3.345E-05	3.411E-05	5.49E-07	2%
Ra228	5.824E-12	5.816E-12	5.705E-12	5.810E-12	5.859E-12	6.617E-12	5.938E-12	3.07E-13	5%
Ac227	7.738E-07	6.767E-07	7.692E-07	7.160E-07	7.418E-07	7.777E-07	7.425E-07	3.64E-08	5%
Th229	5.815E-06	5.814E-06	8.422E-06	6.560E-06	7.299E-06	8.916E-06	7.138E-06	1.20E-06	17%
Th230	8.090E-02	8.092E-02	8.299E-02	8.270E-02	8.394E-02	8.149E-02	8.215E-02	1.14E-03	1%
Th232	1.576E-02	1.576E-02	1.544E-02	1.570E-02	1.586E-02	1.560E-02	1.569E-02	1.35E-04	1%
Cf252	1.336E-18	1.348E-18	1.081E-18	7.680E-19	2.662E-18	-	1.439E-18	6.47E-19	45%

Table A.17: Results for actinides in assembly calculation at 300 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
U232	1.441E-04	1.445E-04	1.813E-04	8.530E-05	1.935E-04	1.451E-04	1.490E-04	3.45E-05	23%
U233	8.906E-02	8.914E-02	9.970E-02	9.120E-02	9.462E-02	9.373E-02	9.291E-02	3.69E-03	4%
U234	4.482E+02	4.484E+02	4.726E+02	4.610E+02	4.681E+02	4.440E+02	4.571E+02	1.08E+01	2%
U235	8.284E+03	8.287E+03	8.374E+03	8.770E+03	8.273E+03	8.336E+03	8.387E+03	1.75E+02	2%
U236	5.369E+03	5.369E+03	5.261E+03	5.350E+03	5.410E+03	5.318E+03	5.346E+03	4.69E+01	1%
U238	9.265E+05	9.265E+05	9.261E+05	9.270E+05	9.256E+05	9.267E+05	9.264E+05	4.48E+02	0%
Np236	1.798E-03	1.796E-03	7.501E-04	9.430E-04	7.433E-04	2.482E-03	1.419E-03	6.51E-04	46%
Np237	1.199E+03	1.201E+03	1.311E+03	1.240E+03	1.273E+03	1.203E+03	1.238E+03	4.23E+01	3%
Pu236	4.049E-09	4.045E-09	1.655E-09	2.120E-09	1.669E-09	5.538E-09	3.179E-09	1.46E-09	46%
Pu238	2.607E+01	2.608E+01	2.906E+01	2.730E+01	2.758E+01	2.531E+01	2.690E+01	1.24E+00	5%
Pu239	5.716E+03	5.714E+03	6.003E+03	5.870E+03	5.980E+03	5.678E+03	5.827E+03	1.31E+02	2%
Pu240	2.649E+03	2.662E+03	2.605E+03	2.520E+03	2.811E+03	2.711E+03	2.660E+03	8.95E+01	3%
Pu241	7.084E-03	7.117E-03	6.435E-03	6.110E-03	6.030E-03	1.302E-02	7.632E-03	2.45E-03	32%
Pu242	7.407E+02	7.439E+02	7.719E+02	7.320E+02	7.790E+02	7.580E+02	7.543E+02	1.69E+01	2%
Pu243	1.831E-13	1.842E-13	1.491E-13	1.150E-13	-6.371E-38	3.795E-13	2.022E-13	9.22E-14	46%
Pu244	5.292E-02	5.313E-02	4.868E-02	5.160E-02	2.524E-02	7.471E-02	5.105E-02	1.44E-02	28%
Am241	1.056E+03	1.060E+03	1.136E+03	1.090E+03	1.104E+03	1.078E+03	1.087E+03	2.73E+01	3%
Am242m	1.778E-01	1.784E-01	2.530E-01	1.770E-01	2.009E-01	3.514E-01	2.231E-01	6.33E-02	28%
Am243	1.578E+02	1.585E+02	1.605E+02	1.510E+02	1.669E+02	1.264E+02	1.535E+02	1.30E+01	8%
Cm242	4.645E-04	4.660E-04	6.111E-04	4.610E-04	5.249E-04	8.499E-04	5.629E-04	1.39E-04	25%
Cm243	5.920E-04	5.961E-04	4.053E-04	5.980E-04	4.281E-04	3.898E-04	5.015E-04	9.45E-05	19%
Cm244	6.462E-04	6.491E-04	6.182E-04	5.750E-04	6.051E-04	1.062E-03	6.926E-04	1.67E-04	24%
Cm245	3.730E+00	3.748E+00	3.034E+00	3.130E+00	3.105E+00	7.267E+00	4.002E+00	1.49E+00	37%
Cm246	4.301E-01	4.325E-01	3.220E-01	3.400E-01	3.554E-01	7.593E-01	4.399E-01	1.49E-01	34%
Cm247	5.269E-03	5.298E-03	4.182E-03	3.320E-03	4.537E-03	1.064E-02	5.542E-03	2.38E-03	43%
Cm248	3.501E-04	3.522E-04	2.342E-04	2.150E-04	4.181E-04	7.330E-04	3.838E-04	1.71E-04	45%
Ra226	3.636E-04	3.637E-04	3.695E-04	3.730E-04	3.777E-04	3.566E-04	3.673E-04	6.90E-06	2%
Ra228	1.832E-11	1.832E-11	1.846E-11	1.880E-11	1.842E-11	2.103E-11	1.889E-11	9.69E-13	5%
Ac227	1.823E-06	1.823E-06	1.829E-06	1.820E-06	1.788E-06	1.834E-06	1.819E-06	1.47E-08	1%
Th229	5.220E-05	5.222E-05	6.103E-05	5.380E-05	5.657E-05	5.940E-05	5.587E-05	3.43E-06	6%
Th230	3.087E-01	3.088E-01	3.230E-01	3.170E-01	3.214E-01	3.086E-01	3.146E-01	6.14E-03	2%
Th232	4.684E-02	4.684E-02	4.589E-02	4.670E-02	4.711E-02	4.637E-02	4.663E-02	3.96E-04	1%
Cf252	2.313E-41	2.333E-41			4.600E-35	-	1.533E-35	2.17E-35	

Table A.18: Trends of relative standard deviation with cooling time for actinides in assembly calculation

	Discharge	5 Years	50 Years	100 Years	300 Years
U232	18%	22%	23%	23%	23%
U233	60%	46%	14%	8%	4%
U234	2%	1%	1%	2%	2%
U235	2%	2%	2%	2%	2%
U236	1%	1%	1%	1%	1%
Np236	51%	46%	46%	46%	46%
Np237	4%	4%	4%	4%	3%
Pu236	29%	26%	21%	46%	46%
Pu238	5%	5%	5%	5%	5%
Pu239	2%	2%	2%	2%	2%
Pu240	4%	3%	3%	3%	3%
Pu241	2%	3%	4%	6%	32%
Pu242	2%	2%	2%	2%	2%
Pu243	5%	46%	46%	46%	46%
Pu244	31%	28%	28%	28%	28%
Am241	5%	2%	2%	2%	3%
Am242m	23%	23%	24%	25%	28%
Am243	9%	8%	8%	8%	8%
Cm242	2%	4%	21%	21%	25%
Cm243	3%	3%	5%	7%	19%
Cm244	26%	24%	24%	24%	24%
Cm245	40%	37%	37%	37%	37%
Cm246	37%	34%	34%	34%	34%
Cm247	47%	43%	43%	43%	43%
Cm248	48%	45%	45%	45%	45%
Ra226	7%	4%	2%	2%	2%
Ra228	8%	2%	5%	5%	5%
Ac227	59%	11%	5%	5%	1%
Th229	38%	49%	28%	17%	6%
Th230	6%	2%	1%	1%	2%
Th232	1%	1%	1%	1%	1%
Cf252	44%	42%	43%	45%	

Table A.19: Results for fission products in assembly calculation at discharge (g/tHMI)

	CEA-D	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Se79	6.675E+00	6.726E+00	6.453E+00	6.674E+00	7.526E+00	6.811E+00	3.70E-01	5%
Kr85	3.338E+01	3.315E+01	3.352E+01	3.280E+01	3.205E+01	3.298E+01	5.25E-01	2%
Rb85	1.391E+02	1.333E+02	1.396E+02	1.409E+02	1.358E+02	1.377E+02	2.79E+00	2%
Rb87	3.293E+02	3.419E+02	3.306E+02	3.379E+02	3.371E+02	3.354E+02	4.71E+00	1%
Sr88	4.585E+02	4.809E+02	4.597E+02	4.709E+02	4.844E+02	4.709E+02	1.06E+01	2%
Sr 90	7.281E+02	7.311E+02	7.328E+02	7.324E+02	7.298E+02	7.308E+02	1.74E+00	0%
Nb93m	8.127E-04	8.580E-04	7.509E-04	8.391E-04	8.051E-04	8.132E-04	3.64E-05	4%
Mo95	9.205E+02	9.624E+02	9.022E+02	9.259E+02	9.164E+02	9.255E+02	2.01E+01	2%
Mo97	1.092E+03	1.156E+03	1.095E+03	1.120E+03	1.113E+03	1.115E+03	2.30E+01	2%
Tc99	1.076E+03	1.100E+03	1.079E+03	1.074E+03	1.090E+03	1.084E+03	9.90E+00	1%
Ru101	1.079E+03	1.048E+03	1.068E+03	1.089E+03	1.069E+03	1.070E+03	1.36E+01	1%
Ru106	2.012E+02	2.044E+02	1.988E+02	2.035E+02	2.034E+02	2.023E+02	2.02E+00	1%
Rh103	5.497E+02	5.736E+02	5.547E+02	5.779E+02	5.355E+02	5.583E+02	1.57E+01	3%
Pd107	3.032E+02	3.116E+02	2.960E+02	3.094E+02	3.118E+02	3.064E+02	6.06E+00	2%
Ag108m	2.959E-06	5.079E-06	2.766E-06	4.249E-06	1.650E-06	3.340E-06	1.20E-06	36%
Ag109	1.007E+02	1.141E+02	7.516E+01	1.165E+02	1.059E+02	1.025E+02	1.48E+01	14%
Ag110m	1.338E+00	1.418E+00	1.808E+00	1.114E+00	1.338E+00	1.403E+00	2.26E-01	16%
I 127	5.959E+01	5.807E+01	5.830E+01	6.346E+01	7.667E+01	6.322E+01	7.00E+00	11%
I 129	2.457E+02	2.424E+02	2.432E+02	2.414E+02	2.488E+02	2.443E+02	2.66E+00	1%
Xe130	1.266E+01	1.259E+01	1.270E+01	1.078E+01	1.778E+01	1.330E+01	2.35E+00	18%
Xe131	5.362E+02	5.303E+02	4.707E+02	5.416E+02	5.540E+02	5.265E+02	2.90E+01	6%
Xe132	1.533E+03	1.563E+03	1.632E+03	1.556E+03	1.545E+03	1.566E+03	3.46E+01	2%
Xe134	2.075E+03	2.095E+03	2.073E+03	2.136E+03	2.056E+03	2.087E+03	2.75E+01	1%
Xe136	3.142E+03	3.212E+03	3.114E+03	3.459E+03	3.173E+03	3.220E+03	1.24E+02	4%
Cs133	1.479E+03	1.471E+03	1.543E+03	1.498E+03	1.489E+03	1.496E+03	2.53E+01	2%
Cs134	1.917E+02	2.149E+02	1.760E+02	2.143E+02	1.940E+02	1.982E+02	1.48E+01	7%
Cs135	5.107E+02	5.285E+02	5.273E+02	5.270E+02	5.301E+02	5.247E+02	7.09E+00	1%
Cs137	1.667E+03	1.644E+03	1.665E+03	1.696E+03	1.655E+03	1.666E+03	1.75E+01	1%
Ba136	3.095E+01	3.194E+01	3.630E+01	2.896E+01	3.293E+01	3.222E+01	2.41E+00	8%
Ba138	1.805E+03	1.810E+03	1.805E+03	1.818E+03	1.783E+03	1.804E+03	1.17E+01	1%
La139	1.676E+03	1.672E+03	1.674E+03	1.698E+03	1.697E+03	1.683E+03	1.17E+01	1%
Ce140	1.659E+03	1.696E+03	1.754E+03	1.687E+03	1.670E+03	1.693E+03	3.28E+01	2%
Ce144	4.003E+02	4.023E+02	4.010E+02	3.959E+02	3.959E+02	3.991E+02	2.68E+00	1%
Nd142	3.259E+01	3.244E+01	3.095E+01	3.402E+01	4.151E+01	3.430E+01	3.73E+00	11%
Nd143	1.023E+03	1.033E+03	1.076E+03	1.039E+03	1.024E+03	1.039E+03	1.95E+01	2%
Nd144	1.465E+03	1.468E+03	1.466E+03	1.502E+03	1.474E+03	1.475E+03	1.39E+01	1%
Nd145	9.120E+02	9.013E+02	9.233E+02	9.164E+02	9.226E+02	9.151E+02	8.05E+00	1%
Nd146	9.891E+02	9.933E+02	9.784E+02	1.003E+03	9.743E+02	9.875E+02	1.02E+01	1%
Nd148	5.211E+02	5.111E+02	5.210E+02	5.204E+02	5.179E+02	5.183E+02	3.79E+00	1%
Nd150	2.478E+02	2.462E+02	2.458E+02	2.502E+02	2.485E+02	2.477E+02	1.62E+00	1%

Table A.19: Results for fission products in assembly calculation at discharge (g/tHMI) (continued)

	CEA-D	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Pm147	2.092E+02	1.957E+02	1.774E+02	1.962E+02	1.650E+02	1.887E+02	1.56E+01	8%
Sm146			3.071E-08	5.724E-07	4.268E-03	1.423E-03	2.01E-03	141%
Sm147	1.043E+02	9.965E+01	9.907E+01	1.043E+02	9.055E+01	9.958E+01	5.03E+00	5%
Sm148	1.905E+02	1.994E+02	2.341E+02	2.204E+02	2.783E+02	2.246E+02	3.10E+01	14%
Sm149	2.547E+00	2.677E+00	2.787E+00	2.468E+00	2.416E+00	2.579E+00	1.36E-01	5%
Sm150	4.049E+02	4.011E+02	3.981E+02	3.846E+02	4.144E+02	4.006E+02	9.72E+00	2%
Sm151	1.580E+01	1.679E+01	1.948E+01	1.654E+01	1.424E+01	1.657E+01	1.71E+00	10%
Sm152	1.454E+02	1.658E+02	1.933E+02	1.633E+02	1.436E+02	1.623E+02	1.79E+01	11%
Sm154	5.269E+01	5.159E+01	5.232E+01	5.000E+01	5.299E+01	5.192E+01	1.06E+00	2%
Eu153	1.752E+02	1.694E+02	1.707E+02	1.704E+02	1.633E+02	1.698E+02	3.83E+00	2%
Eu154	5.903E+01	3.290E+01	5.549E+01	3.265E+01	3.129E+01	4.227E+01	1.23E+01	29%
Eu155	1.243E+01	1.307E+01	1.175E+01	1.246E+01	1.191E+01	1.233E+01	4.67E-01	4%
Gd154	5.055E+00	3.127E+00	4.560E+00	3.222E+00	3.117E+00	3.816E+00	8.25E-01	22%
Gd155	9.206E-02	9.076E-02	9.460E-02	9.048E-02	8.256E-02	9.009E-02	4.04E-03	4%
Gd156	1.114E+02	1.268E+02	1.028E+02	1.335E+02	1.328E+02	1.215E+02	1.22E+01	10%
Ho166m	7.811E-03	1.440E-03	8.299E-03	4.082E-04	2.549E-03	4.101E-03	3.30E-03	81%
total	3.072E+04	3.105E+04	3.092E+04	3.146E+04	3.089E+04	3.101E+04	2.50E+02	1%

Table A.20: Results for fission products in assembly calculation at 5 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Se79	6.675E+00	6.714E+00	6.726E+00	6.453E+00	6.674E+00	7.526E+00	6.795E+00	3.39E-01	5%
Kr85	2.416E+01	2.445E+01	2.400E+01	2.427E+01	2.375E+01	2.320E+01	2.397E+01	4.07E-01	2%
Rb85	1.483E+02	1.492E+02	1.425E+02	1.489E+02	1.501E+02	1.446E+02	1.473E+02	2.74E+00	2%
Rb87	3.294E+02	3.317E+02	3.419E+02	3.306E+02	3.379E+02	3.371E+02	3.348E+02	4.50E+00	1%
Sr88	4.585E+02	4.618E+02	4.809E+02	4.598E+02	4.709E+02	4.845E+02	4.694E+02	1.02E+01	2%
Sr90	6.464E+02	6.513E+02	6.492E+02	6.506E+02	6.476E+02	6.480E+02	6.488E+02	1.72E+00	0%
Nb93m	2.639E-03	2.784E-03	2.739E-03	2.613E-03	2.675E-03	2.521E-03	2.662E-03	8.54E-05	3%
Mo95	1.041E+03	1.094E+03	1.081E+03	1.115E+03	1.040E+03	1.035E+03	1.068E+03	3.08E+01	3%
Mo97	1.093E+03	1.135E+03	1.157E+03	1.096E+03	1.120E+03	1.113E+03	1.119E+03	2.22E+01	2%
Tc99	1.080E+03	1.088E+03	1.104E+03	1.083E+03	1.077E+03	1.094E+03	1.088E+03	8.99E+00	1%
Ru101	1.079E+03	1.081E+03	1.048E+03	1.068E+03	1.089E+03	1.069E+03	1.072E+03	1.31E+01	1%
Ru106	6.465E+00	6.474E+00	6.580E+00	6.387E+00	6.755E+00	6.550E+00	6.535E+00	1.16E-01	2%
Rh103	6.033E+02	6.051E+02	6.261E+02	6.081E+02	6.313E+02	5.887E+02	6.104E+02	1.44E+01	2%
Pd107	3.032E+02	3.042E+02	3.117E+02	2.960E+02	3.094E+02	3.118E+02	3.060E+02	5.61E+00	2%
Ag108m	2.935E-06	2.916E-06	4.942E-06	2.744E-06	4.133E-06	1.605E-06	3.213E-06	1.07E-06	33%
Ag109	1.009E+02	1.013E+02	1.144E+02	7.534E+01	1.165E+02	1.061E+02	1.024E+02	1.35E+01	13%
Ag110m	8.442E-03	8.520E-03	8.980E-03	1.141E-02	7.043E-03	8.473E-03	8.811E-03	1.31E-03	15%
I 127	6.193E+01	6.218E+01	6.009E+01	6.063E+01	6.574E+01	7.887E+01	6.491E+01	6.50E+00	10%
I 129	2.477E+02	2.488E+02	2.445E+02	2.451E+02	2.431E+02	2.506E+02	2.466E+02	2.60E+00	1%
Xe130	1.268E+01	1.273E+01	1.260E+01	1.271E+01	1.078E+01	1.780E+01	1.322E+01	2.16E+00	16%
Xe131	5.452E+02	5.469E+02	5.392E+02	4.799E+02	5.502E+02	5.628E+02	5.374E+02	2.67E+01	5%
Xe132	1.538E+03	1.548E+03	1.568E+03	1.637E+03	1.561E+03	1.550E+03	1.567E+03	3.28E+01	2%
Xe134	2.076E+03	2.088E+03	2.095E+03	2.073E+03	2.136E+03	2.056E+03	2.087E+03	2.51E+01	1%
Xe136	3.142E+03	3.162E+03	3.212E+03	3.114E+03	3.459E+03	3.173E+03	3.210E+03	1.15E+02	4%
Cs133	1.492E+03	1.504E+03	1.484E+03	1.557E+03	1.509E+03	1.502E+03	1.508E+03	2.33E+01	2%
Cs134	3.571E+01	3.614E+01	4.007E+01	3.278E+01	3.995E+01	3.616E+01	3.680E+01	2.54E+00	7%
Cs135	5.115E+02	5.154E+02	5.293E+02	5.281E+02	5.278E+02	5.309E+02	5.238E+02	7.48E+00	1%
Cs137	1.486E+03	1.494E+03	1.466E+03	1.484E+03	1.511E+03	1.474E+03	1.486E+03	1.45E+01	1%
Ba136	3.193E+01	3.222E+01	3.296E+01	3.741E+01	2.963E+01	3.395E+01	3.357E+01	1.83E+00	7%
Ba138	1.805E+03	1.817E+03	1.810E+03	1.805E+03	1.818E+03	1.783E+03	1.806E+03	1.17E+01	1%
La139	1.676E+03	1.685E+03	1.672E+03	1.674E+03	1.698E+03	1.698E+03	1.684E+03	1.08E+01	1%
Ce140	1.687E+03	1.699E+03	1.725E+03	1.781E+03	1.710E+03	1.698E+03	1.717E+03	3.12E+01	2%
Ce144	4.707E+00	4.712E+00	4.707E+00	4.713E+00	4.678E+00	4.623E+00	4.690E+00	3.24E-02	1%
Nd142	3.267E+01	3.312E+01	3.251E+01	3.102E+01	3.402E+01	4.160E+01	3.416E+01	3.45E+00	10%
Nd143	1.048E+03	1.053E+03	1.058E+03	1.101E+03	1.061E+03	1.048E+03	1.061E+03	1.84E+01	2%
Nd144	1.860E+03	1.874E+03	1.865E+03	1.862E+03	1.893E+03	1.865E+03	1.870E+03	1.13E+01	1%
Nd145	9.123E+02	9.178E+02	9.016E+02	9.236E+02	9.164E+02	9.229E+02	9.157E+02	7.40E+00	1%
Nd146	9.891E+02	9.956E+02	9.933E+02	9.784E+02	1.003E+03	9.743E+02	9.889E+02	9.76E+00	1%
Nd148	5.211E+02	5.241E+02	5.111E+02	5.210E+02	5.204E+02	5.179E+02	5.193E+02	4.07E+00	1%
Nd150	2.478E+02	2.491E+02	2.462E+02	2.458E+02	2.502E+02	2.485E+02	2.479E+02	1.56E+00	1%

Table A.20: Results for fission products in assembly calculation at 5 years cooling (g/tHMI) (continued)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Pm147	5.809E+01	5.815E+01	5.452E+01	4.958E+01	5.455E+01	4.635E+01	5.354E+01	4.30E+00	8%
Sm146				1.098E-07	7.591E-07	5.340E-03	1.780E-03	2.52E-03	141%
Sm147	2.638E+02	2.648E+02	2.493E+02	2.354E+02	2.540E+02	2.177E+02	2.475E+02	1.65E+01	7%
Sm148	1.936E+02	1.953E+02	2.026E+02	2.375E+02	2.238E+02	2.821E+02	2.225E+02	3.10E+01	14%
Sm149	4.214E+00	4.160E+00	4.328E+00	4.491E+00	3.946E+00	3.892E+00	4.172E+00	2.07E-01	5%
Sm150	4.049E+02	4.072E+02	4.011E+02	3.981E+02	3.846E+02	4.144E+02	4.017E+02	9.21E+00	2%
Sm151	1.548E+01	1.547E+01	1.644E+01	1.902E+01	1.592E+01	1.399E+01	1.605E+01	1.52E+00	9%
Sm152	1.454E+02	1.456E+02	1.658E+02	1.933E+02	1.633E+02	1.436E+02	1.595E+02	1.75E+01	11%
Sm154	5.269E+01	5.296E+01	5.159E+01	5.232E+01	5.000E+01	5.299E+01	5.209E+01	1.05E+00	2%
Eu153	1.766E+02	1.774E+02	1.707E+02	1.721E+02	1.718E+02	1.645E+02	1.722E+02	4.23E+00	2%
Eu154	3.945E+01	3.971E+01	2.199E+01	3.708E+01	2.182E+01	2.092E+01	3.016E+01	8.63E+00	29%
Eu155	6.180E+00	6.143E+00	6.504E+00	5.838E+00	5.947E+00	5.925E+00	6.090E+00	2.21E-01	4%
Gd154	2.463E+01	2.480E+01	1.403E+01	2.296E+01	1.406E+01	1.349E+01	1.900E+01	5.17E+00	27%
Gd155	6.347E+00	6.308E+00	6.661E+00	6.004E+00	6.608E+00	6.070E+00	6.333E+00	2.45E-01	4%
Gd156	1.171E+02	1.169E+02	1.332E+02	1.081E+02	1.399E+02	1.392E+02	1.257E+02	1.23E+01	10%
Ho166m	7.788E-03	7.841E-03	1.435E-03	8.275E-03	4.070E-04	2.542E-03	4.715E-03	3.31E-03	70%
Total	3.039E+04	3.066E+04	3.070E+04	3.070E+04	3.109E+04	3.056E+04	3.068E+04	2.11E+02	1%

Table A.21: Results for fission products in assembly calculation at 50 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Se79	6.675E+00	6.714E+00	6.723E+00	6.450E+00	6.674E+00	7.522E+00	6.793E+00	3.39E-01	5%
Kr85	1.317E+00	1.333E+00	1.311E+00	1.322E+00	1.298E+00	1.267E+00	1.308E+00	2.11E-02	2%
Rb85	1.712E+02	1.723E+02	1.652E+02	1.718E+02	1.729E+02	1.666E+02	1.700E+02	2.97E+00	2%
Rb87	3.294E+02	3.317E+02	3.419E+02	3.306E+02	3.379E+02	3.371E+02	3.348E+02	4.50E+00	1%
Sr88	4.585E+02	4.618E+02	4.809E+02	4.598E+02	4.709E+02	4.845E+02	4.694E+02	1.02E+01	2%
Sr90	2.215E+02	2.232E+02	2.226E+02	2.229E+02	2.141E+02	2.222E+02	2.211E+02	3.17E+00	1%
Nb93m	9.239E-03	9.619E-03	8.566E-03	9.340E-03	9.233E-03	7.841E-03	8.973E-03	5.97E-04	7%
Mo95	1.041E+03	1.094E+03	1.081E+03	1.115E+03	1.040E+03	1.035E+03	1.068E+03	3.08E+01	3%
Mo97	1.093E+03	1.135E+03	1.157E+03	1.096E+03	1.120E+03	1.113E+03	1.119E+03	2.22E+01	2%
Tc99	1.080E+03	1.087E+03	1.104E+03	1.083E+03	1.077E+03	1.094E+03	1.088E+03	9.02E+00	1%
Ru101	1.079E+03	1.081E+03	1.048E+03	1.068E+03	1.089E+03	1.069E+03	1.072E+03	1.31E+01	1%
Ru106	1.982E-08	2.368E-13	2.445E-13	0.000E+00	3.323E-13	2.435E-13	3.304E-09	7.39E-09	
Rh103	6.033E+02	6.051E+02	6.261E+02	6.081E+02	6.313E+02	5.887E+02	6.104E+02	1.44E+01	2%
Pd107	3.032E+02	3.042E+02	3.117E+02	2.960E+02	3.094E+02	3.118E+02	3.060E+02	5.61E+00	2%
Ag108m	2.724E-06	2.707E-06	3.866E-06	2.546E-06	3.234E-06	1.256E-06	2.722E-06	7.91E-07	29%
Ag109	1.009E+02	1.013E+02	1.144E+02	7.534E+01	1.165E+02	1.061E+02	1.024E+02	1.35E+01	13%
Ag110m	2.121E-12	1.358E-22	1.471E-22	0.000E+00	1.142E-22	-	4.242E-13	8.48E-13	
I 127	6.193E+01	6.218E+01	6.009E+01	6.063E+01	6.574E+01	7.887E+01	6.491E+01	6.50E+00	10%
I 129	2.477E+02	2.488E+02	2.445E+02	2.451E+02	2.431E+02	2.506E+02	2.466E+02	2.60E+00	1%
Xe130	1.268E+01	1.273E+01	1.260E+01	1.271E+01	1.078E+01	1.780E+01	1.322E+01	2.16E+00	16%
Xe131	5.452E+02	5.469E+02	5.392E+02	4.799E+02	5.502E+02	5.628E+02	5.374E+02	2.67E+01	5%
Xe132	1.538E+03	1.548E+03	1.568E+03	1.637E+03	1.561E+03	1.550E+03	1.567E+03	3.28E+01	2%
Xe134	2.076E+03	2.088E+03	2.095E+03	2.073E+03	2.136E+03	2.056E+03	2.087E+03	2.51E+01	1%
Xe136	3.142E+03	3.162E+03	3.212E+03	3.114E+03	3.459E+03	3.173E+03	3.210E+03	1.15E+02	4%
Cs133	1.492E+03	1.504E+03	1.484E+03	1.557E+03	1.509E+03	1.502E+03	1.508E+03	2.33E+01	2%
Cs134	9.624E-06	9.748E-06	1.091E-05	8.822E-06	1.091E-05	9.842E-06	9.976E-06	7.38E-07	7%
Cs135	5.115E+02	5.154E+02	5.293E+02	5.281E+02	5.278E+02	5.309E+02	5.238E+02	7.49E+00	1%
Cs137	5.252E+02	5.283E+02	5.216E+02	5.245E+02	5.348E+02	5.216E+02	5.260E+02	4.56E+00	1%
Ba136	3.193E+01	3.222E+01	3.296E+01	3.741E+01	2.963E+01	3.395E+01	3.302E+01	1.07E+01	7%
Ba138	1.805E+03	1.817E+03	1.810E+03	1.805E+03	1.818E+03	1.783E+03	1.806E+03	1.17E+01	1%
La139	1.676E+03	1.685E+03	1.672E+03	1.674E+03	1.698E+03	1.698E+03	1.684E+03	1.08E+01	1%
Ce140	1.687E+03	1.699E+03	1.725E+03	1.781E+03	1.710E+03	1.698E+03	1.717E+03	3.12E+01	2%
Ce144	2.022E-08	2.030E-17	1.937E-17	0.000E+00	2.110E-17	1.617E-17	3.371E-09	7.54E-09	
Nd142	3.267E+01	3.312E+01	3.251E+01	3.102E+01	3.402E+01	4.160E+01	3.416E+01	3.45E+00	10%
Nd143	1.048E+03	1.053E+03	1.058E+03	1.101E+03	1.061E+03	1.048E+03	1.061E+03	1.84E+01	2%
Nd144	1.865E+03	1.878E+03	1.870E+03	1.867E+03	1.898E+03	1.869E+03	1.875E+03	1.13E+01	1%
Nd145	9.123E+02	9.178E+02	9.016E+02	9.236E+02	9.164E+02	9.229E+02	9.157E+02	7.40E+00	1%
Nd146	9.891E+02	9.956E+02	9.933E+02	9.784E+02	1.003E+03	9.743E+02	9.889E+02	9.76E+00	1%
Nd148	5.211E+02	5.241E+02	5.111E+02	5.210E+02	5.204E+02	5.179E+02	5.193E+02	4.07E+00	1%
Nd150	2.478E+02	2.491E+02	2.462E+02	2.458E+02	2.502E+02	2.485E+02	2.479E+02	1.56E+00	1%

Table A.21: Results for fission products in assembly calculation at 50 years cooling (g/tHMI) (continued)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Pm147	3.979E-04	3.985E-04	3.763E-04	3.392E-04	3.775E-04	3.207E-04	3.684E-04	2.90E-05	8%
Sm146				2.001E-07	9.727E-07	6.559E-03	2.187E-03	3.09E-03	141%
Sm147	3.219E+02	3.229E+02	3.038E+02	2.850E+02	3.084E+02	2.641E+02	3.010E+02	2.08E+01	7%
Sm148	1.936E+02	1.953E+02	2.026E+02	2.375E+02	2.238E+02	2.821E+02	2.225E+02	3.10E+01	14%
Sm149	4.214E+00	4.160E+00	4.328E+00	4.491E+00	3.946E+00	3.892E+00	4.172E+00	2.07E-01	5%
Sm150	4.049E+02	4.072E+02	4.011E+02	3.981E+02	3.846E+02	4.144E+02	4.017E+02	9.21E+00	2%
Sm151	1.089E+01	1.088E+01	1.163E+01	1.338E+01	1.126E+01	9.895E+00	1.132E+01	1.06E+00	9%
Sm152	1.455E+02	1.456E+02	1.658E+02	1.933E+02	1.633E+02	1.436E+02	1.595E+02	1.75E+01	11%
Sm154	5.270E+01	5.296E+01	5.159E+01	5.233E+01	5.000E+01	5.299E+01	5.209E+01	1.05E+00	2%
Eu153	1.766E+02	1.774E+02	1.707E+02	1.721E+02	1.718E+02	1.645E+02	1.722E+02	4.23E+00	2%
Eu154	1.049E+00	1.057E+00	5.863E-01	9.860E-01	5.799E-01	5.578E-01	8.026E-01	2.29E-01	29%
Eu155	1.143E-02	1.137E-02	1.215E-02	1.079E-02	7.626E-03	1.104E-02	1.073E-02	1.45E-03	14%
Gd154	6.303E+01	6.345E+01	3.544E+01	5.905E+01	3.531E+01	3.385E+01	4.835E+01	1.36E+01	28%
Gd155	1.252E+01	1.244E+01	1.315E+01	1.183E+01	1.255E+01	1.198E+01	1.241E+01	4.27E-01	3%
Gd156	1.171E+02	1.169E+02	1.332E+02	1.081E+02	1.399E+02	1.392E+02	1.257E+02	1.23E+01	10%
Ho166m	7.589E-03	7.640E-03	1.399E-03	8.063E-03	3.964E-04	2.477E-03	4.594E-03	3.23E-03	70%
Total	2.896E+04	2.922E+04	2.927E+04	2.927E+04	2.963E+04	2.913E+04	2.925E+04	2.11E+02	1%

Table A.22: Results for fission products in assembly calculation at 100 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Se79	6.675E+00	6.714E+00	6.719E+00	6.446E+00	6.674E+00	7.518E+00	6.791E+00	3.38E-01	5%
Kr85	5.194E-02	5.257E-02	5.180E-02	5.213E-02	5.129E-02	5.008E-02	5.163E-02	7.91E-04	2%
Rb85	1.724E+02	1.736E+02	1.664E+02	1.731E+02	1.741E+02	1.678E+02	1.712E+02	3.00E+00	2%
Rb87	3.294E+02	3.317E+02	3.419E+02	3.306E+02	3.379E+02	3.371E+02	3.348E+02	4.50E+00	1%
Sr88	4.585E+02	4.618E+02	4.809E+02	4.598E+02	4.709E+02	4.845E+02	4.694E+02	1.02E+01	2%
Sr90	6.736E+01	6.789E+01	6.775E+01	6.779E+01	6.254E+01	6.764E+01	6.683E+01	1.92E+00	3%
Nb93m	1.026E-02	1.067E-02	9.166E-03	1.038E-02	1.021E-02	8.391E-03	9.845E-03	8.00E-04	8%
Mo95	1.041E+03	1.094E+03	1.081E+03	1.115E+03	1.040E+03	1.035E+03	1.068E+03	3.08E+01	3%
Mo97	1.093E+03	1.135E+03	1.157E+03	1.096E+03	1.120E+03	1.113E+03	1.119E+03	2.22E+01	2%
Tc99	1.080E+03	1.087E+03	1.104E+03	1.083E+03	1.077E+03	1.094E+03	1.088E+03	9.05E+00	1%
Ru101	1.079E+03	1.081E+03	1.048E+03	1.068E+03	1.089E+03	1.069E+03	1.072E+03	1.31E+01	1%
Ru106	2.926E-09	3.535E-09		0.000E+00	5.394E-28	-	1.615E-09	1.63E-09	
Rh103	6.033E+02	6.051E+02	6.261E+02	6.081E+02	6.313E+02	5.887E+02	6.104E+02	1.44E+01	2%
Pd107	3.032E+02	3.042E+02	3.117E+02	2.960E+02	3.094E+02	3.118E+02	3.060E+02	5.61E+00	2%
Ag108m	2.507E-06	2.491E-06	2.944E-06	2.344E-06	2.462E-06	9.561E-07	2.284E-06	6.23E-07	27%
Ag109	1.009E+02	1.013E+02	1.144E+02	7.534E+01	1.165E+02	1.061E+02	1.024E+02	1.35E+01	13%
Ag110m	3.129E-13	2.267E-13		0.000E+00	5.192E-36	-	1.349E-13	1.38E-13	
I 127	6.193E+01	6.218E+01	6.009E+01	6.063E+01	6.574E+01	7.887E+01	6.491E+01	6.50E+00	10%
I 129	2.477E+02	2.488E+02	2.445E+02	2.451E+02	2.431E+02	2.506E+02	2.466E+02	2.60E+00	1%
Xe130	1.268E+01	1.273E+01	1.260E+01	1.271E+01	1.078E+01	1.780E+01	1.322E+01	2.16E+00	16%
Xe131	5.452E+02	5.469E+02	5.392E+02	4.799E+02	5.502E+02	5.628E+02	5.374E+02	2.67E+01	5%
Xe132	1.538E+03	1.548E+03	1.568E+03	1.637E+03	1.561E+03	1.550E+03	1.567E+03	3.28E+01	2%
Xe134	2.076E+03	2.088E+03	2.095E+03	2.073E+03	2.136E+03	2.056E+03	2.087E+03	2.51E+01	1%
Xe136	3.142E+03	3.162E+03	3.212E+03	3.114E+03	3.459E+03	3.173E+03	3.210E+03	1.15E+02	4%
Cs133	1.492E+03	1.504E+03	1.484E+03	1.557E+03	1.509E+03	1.502E+03	1.508E+03	2.33E+01	2%
Cs134	5.414E-13	4.098E-12	5.534E-13	4.421E-13	5.540E-13	4.994E-13	1.115E-12	1.33E-12	
Cs135	5.115E+02	5.154E+02	5.293E+02	5.280E+02	5.278E+02	5.309E+02	5.238E+02	7.49E+00	1%
Cs137	1.654E+02	1.664E+02	1.655E+02	1.652E+02	1.686E+02	1.644E+02	1.659E+02	1.33E+00	1%
Ba136	3.193E+01	3.222E+01	3.296E+01	3.741E+01	2.963E+01	3.395E+01	3.302E+01	2.27E+01	7%
Ba138	1.805E+03	1.817E+03	1.810E+03	1.805E+03	1.818E+03	1.783E+03	1.806E+03	1.17E+01	1%
La139	1.676E+03	1.685E+03	1.672E+03	1.674E+03	1.698E+03	1.698E+03	1.684E+03	1.08E+01	1%
Ce140	1.687E+03	1.699E+03	1.725E+03	1.781E+03	1.710E+03	1.698E+03	1.717E+03	3.12E+01	2%
Ce144	2.983E-09	1.941E-09		0.000E+00	7.743E-36	-	1.231E-09	1.29E-09	
Nd142	3.267E+01	3.312E+01	3.251E+01	3.102E+01	3.402E+01	4.160E+01	3.416E+01	3.45E+00	10%
Nd143	1.048E+03	1.053E+03	1.058E+03	1.101E+03	1.061E+03	1.048E+03	1.061E+03	1.84E+01	2%
Nd144	1.865E+03	1.878E+03	1.870E+03	1.867E+03	1.898E+03	1.869E+03	1.875E+03	1.13E+01	1%
Nd145	9.123E+02	9.178E+02	9.016E+02	9.236E+02	9.164E+02	9.229E+02	9.157E+02	7.40E+00	1%
Nd146	9.891E+02	9.956E+02	9.933E+02	9.784E+02	1.003E+03	9.743E+02	9.889E+02	9.76E+00	1%
Nd148	5.211E+02	5.241E+02	5.111E+02	5.210E+02	5.204E+02	5.179E+02	5.193E+02	4.07E+00	1%
Nd150	2.478E+02	2.491E+02	2.462E+02	2.458E+02	2.502E+02	2.485E+02	2.479E+02	1.56E+00	1%

Table A.22: Results for fission products in assembly calculation at 100 years cooling (g/tHMI) (continued)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Pm147	8.857E-09	3.722E-09	6.935E-10	6.191E-10	6.960E-10	5.925E-10	2.530E-09	3.04E-09	
Sm146				2.005E-07	9.733E-07	6.563E-03	2.188E-03	3.09E-03	141%
Sm147	3.219E+02	3.229E+02	3.038E+02	2.850E+02	3.084E+02	2.641E+02	3.010E+02	2.08E+01	7%
Sm148	1.936E+02	1.953E+02	2.026E+02	2.375E+02	2.238E+02	2.821E+02	2.225E+02	3.10E+01	14%
Sm149	4.214E+00	4.160E+00	4.328E+00	4.491E+00	3.946E+00	3.892E+00	4.172E+00	2.07E-01	5%
Sm150	4.049E+02	4.072E+02	4.011E+02	3.981E+02	3.846E+02	4.144E+02	4.017E+02	9.21E+00	2%
Sm151	7.370E+00	7.365E+00	7.916E+00	9.055E+00	7.661E+00	6.734E+00	7.683E+00	7.11E-01	9%
Sm152	1.455E+02	1.457E+02	1.658E+02	1.933E+02	1.633E+02	1.436E+02	1.595E+02	1.75E+01	11%
Sm154	5.270E+01	5.296E+01	5.159E+01	5.233E+01	5.000E+01	5.299E+01	5.210E+01	1.05E+00	2%
Eu153	1.766E+02	1.774E+02	1.707E+02	1.721E+02	1.718E+02	1.645E+02	1.722E+02	4.23E+00	2%
Eu154	1.866E-02	1.878E-02	1.045E-02	1.752E-02	1.029E-02	9.942E-03	1.427E-02	4.07E-03	29%
Eu155	1.051E-05	1.045E-05	1.127E-05	9.914E-06	4.662E-06	1.023E-05	9.507E-06	2.21E-06	23%
Gd154	6.406E+01	6.449E+01	3.601E+01	6.002E+01	3.588E+01	3.440E+01	4.914E+01	1.38E+01	28%
Gd155	1.253E+01	1.245E+01	1.316E+01	1.184E+01	1.255E+01	1.199E+01	1.242E+01	4.27E-01	3%
Gd156	1.171E+02	1.169E+02	1.332E+02	1.081E+02	1.399E+02	1.392E+02	1.257E+02	1.23E+01	10%
Ho166m	7.373E-03	7.423E-03	1.359E-03	7.833E-03	3.852E-04	2.406E-03	4.463E-03	3.14E-03	70%
Total	2.844E+04	2.870E+04	2.876E+04	2.875E+04	2.911E+04	2.862E+04	2.873E+04	2.20E+02	1%

Table A.23: Results for fission products in assembly calculation at 300 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Se79	6.674E+00	6.713E+00	6.705E+00	6.433E+00	6.674E+00	7.502E+00	6.783E+00	3.35E-01	5%
Kr85	1.257E-07	1.272E-07	1.264E-07	1.260E-07	1.261E-07	1.223E-07	1.256E-07	1.57E-09	1%
Rb85	1.725E+02	1.737E+02	1.665E+02	1.731E+02	1.741E+02	1.678E+02	1.713E+02	2.98E+00	2%
Rb87	3.294E+02	3.317E+02	3.419E+02	3.306E+02	3.379E+02	3.371E+02	3.348E+02	4.50E+00	1%
Sr88	4.585E+02	4.618E+02	4.809E+02	4.598E+02	4.709E+02	4.845E+02	4.694E+02	1.02E+01	2%
Sr90	5.767E-01	5.812E-01	5.818E-01	5.801E-01	4.571E-01	5.811E-01	5.597E-01	4.59E-02	8%
Nb93m	1.039E-02	1.080E-02	9.202E-03	1.052E-02	1.034E-02	8.438E-03	9.948E-03	8.40E-04	8%
Mo95	1.041E+03	1.094E+03	1.081E+03	1.115E+03	1.040E+03	1.035E+03	1.068E+03	3.08E+01	3%
Mo97	1.093E+03	1.135E+03	1.157E+03	1.096E+03	1.120E+03	1.113E+03	1.119E+03	2.22E+01	2%
Tc99	1.080E+03	1.086E+03	1.103E+03	1.082E+03	1.077E+03	1.093E+03	1.087E+03	8.73E+00	1%
Ru101	1.079E+03	1.081E+03	1.048E+03	1.068E+03	1.089E+03	1.069E+03	1.072E+03	1.31E+01	1%
Ru106	3.556E-12	3.818E-12		0.000E+00	7.421E-36	-	1.844E-12	1.85E-12	
Rh103	6.033E+02	6.051E+02	6.261E+02	6.081E+02	6.313E+02	5.887E+02	6.104E+02	1.44E+01	2%
Pd107	3.032E+02	3.042E+02	3.116E+02	2.960E+02	3.094E+02	3.118E+02	3.060E+02	5.60E+00	2%
Ag108m	1.799E-06	1.788E-06	9.888E-07	1.682E-06	8.277E-07	3.212E-07	1.235E-06	5.61E-07	45%
Ag109	1.009E+02	1.013E+02	1.144E+02	7.534E+01	1.165E+02	1.061E+02	1.024E+02	1.35E+01	13%
Ag110m	3.129E-13	6.321E-16		0.000E+00	5.192E-36	-	7.838E-14	1.35E-13	
I 127	6.193E+01	6.218E+01	6.009E+01	6.063E+01	6.574E+01	7.887E+01	6.491E+01	6.50E+00	10%
I 129	2.477E+02	2.488E+02	2.445E+02	2.451E+02	2.431E+02	2.505E+02	2.466E+02	2.59E+00	1%
Xe130	1.268E+01	1.273E+01	1.260E+01	1.271E+01	1.078E+01	1.780E+01	1.322E+01	2.16E+00	16%
Xe131	5.452E+02	5.469E+02	5.392E+02	4.799E+02	5.502E+02	5.628E+02	5.374E+02	2.67E+01	5%
Xe132	1.538E+03	1.548E+03	1.568E+03	1.637E+03	1.561E+03	1.550E+03	1.567E+03	3.28E+01	2%
Xe134	2.076E+03	2.088E+03	2.095E+03	2.073E+03	2.136E+03	2.056E+03	2.087E+03	2.51E+01	1%
Xe136	3.142E+03	3.162E+03	3.212E+03	3.114E+03	3.459E+03	3.173E+03	3.210E+03	1.15E+02	4%
Cs133	1.492E+03	1.504E+03	1.484E+03	1.557E+03	1.509E+03	1.502E+03	1.508E+03	2.33E+01	2%
Cs134	2.094E-15	2.545E-14		0.000E+00	1.908E-35	-	6.886E-15	1.08E-14	
Cs135	5.114E+02	5.154E+02	5.293E+02	5.280E+02	5.278E+02	5.308E+02	5.238E+02	7.50E+00	1%
Cs137	1.629E+00	1.638E+00	1.677E+00	1.626E+00	1.669E+00	1.623E+00	1.644E+00	2.15E-02	1%
Ba136	3.193E+01	3.222E+01	3.296E+01	3.741E+01	2.963E+01	3.395E+01	3.302E+01	7.07E+01	7%
Ba138	1.805E+03	1.817E+03	1.810E+03	1.805E+03	1.818E+03	1.783E+03	1.806E+03	1.17E+01	1%
La139	1.676E+03	1.685E+03	1.672E+03	1.674E+03	1.698E+03	1.698E+03	1.684E+03	1.08E+01	1%
Ce140	1.687E+03	1.699E+03	1.725E+03	1.781E+03	1.710E+03	1.698E+03	1.717E+03	3.12E+01	2%
Ce144	2.617E-12	1.906E-12		0.000E+00	7.743E-36	-	1.131E-12	1.16E-12	
Nd142	3.267E+01	3.312E+01	3.251E+01	3.102E+01	3.402E+01	4.160E+01	3.416E+01	3.45E+00	10%
Nd143	1.048E+03	1.053E+03	1.058E+03	1.101E+03	1.061E+03	1.048E+03	1.061E+03	1.84E+01	2%
Nd144	1.865E+03	1.878E+03	1.870E+03	1.867E+03	1.898E+03	1.869E+03	1.875E+03	1.13E+01	1%
Nd145	9.123E+02	9.178E+02	9.016E+02	9.236E+02	9.164E+02	9.229E+02	9.157E+02	7.40E+00	1%
Nd146	9.891E+02	9.956E+02	9.933E+02	9.784E+02	1.003E+03	9.743E+02	9.889E+02	9.76E+00	1%
Nd148	5.211E+02	5.241E+02	5.111E+02	5.210E+02	5.204E+02	5.179E+02	5.193E+02	4.07E+00	1%
Nd150	2.478E+02	2.491E+02	2.462E+02	2.458E+02	2.502E+02	2.485E+02	2.479E+02	1.56E+00	1%

Table A.23: Results for fission products in assembly calculation at 300 years cooling (g/tHMI) (continued)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Pm147	5.522E-12	2.553E-12		0.000E+00	8.286E-33	-	2.019E-12	2.28E-12	
Sm146				2.005E-07	9.733E-07	6.563E-03	2.188E-03	3.09E-03	141%
Sm147	3.219E+02	3.229E+02	3.038E+02	2.850E+02	3.084E+02	2.641E+02	3.010E+02	2.08E+01	7%
Sm148	1.936E+02	1.953E+02	2.026E+02	2.375E+02	2.238E+02	2.821E+02	2.225E+02	3.10E+01	14%
Sm149	4.214E+00	4.160E+00	4.328E+00	4.491E+00	3.946E+00	3.892E+00	4.172E+00	2.07E-01	5%
Sm150	4.049E+02	4.072E+02	4.011E+02	3.981E+02	3.846E+02	4.144E+02	4.017E+02	9.21E+00	2%
Sm151	1.545E+00	1.544E+00	1.698E+00	1.898E+00	1.645E+00	1.445E+00	1.629E+00	1.45E-01	9%
Sm152	1.455E+02	1.457E+02	1.658E+02	1.933E+02	1.633E+02	1.436E+02	1.595E+02	1.75E+01	11%
Sm154	5.270E+01	5.296E+01	5.159E+01	5.233E+01	5.000E+01	5.299E+01	5.210E+01	1.05E+00	2%
Eu153	1.766E+02	1.774E+02	1.707E+02	1.721E+02	1.718E+02	1.645E+02	1.722E+02	4.23E+00	2%
Eu154	1.863E-09	1.876E-09	1.055E-09	1.747E-09	1.029E-09	1.004E-09	1.429E-09	4.02E-10	28%
Eu155	2.106E-12	1.127E-12	8.352E-18	0.000E+00	6.608E-19	6.736E-18	5.387E-13	8.13E-13	
Gd154	6.407E+01	6.451E+01	3.602E+01	6.004E+01	3.588E+01	3.441E+01	4.915E+01	1.38E+01	28%
Gd155	1.253E+01	1.245E+01	1.316E+01	1.184E+01	1.255E+01	1.199E+01	1.242E+01	4.27E-01	3%
Gd156	1.171E+02	1.169E+02	1.332E+02	1.081E+02	1.399E+02	1.392E+02	1.257E+02	1.23E+01	10%
Ho166m	6.568E-03	6.613E-03	1.211E-03	6.978E-03	3.433E-04	2.144E-03	3.976E-03	2.80E-03	70%
Total	2.821E+04	2.846E+04	2.852E+04	2.851E+04	2.887E+04	2.838E+04	2.849E+04	2.64E+02	1%

Table A.24: Trends of relative standard deviation with cooling time for fission products in assembly calculation

	Discharge	5 Years	50 Years	100 Years	300 Years
Se79	5%	5%	5%	5%	5%
Kr85	2%	2%	2%	2%	1%
Rb85	2%	2%	2%	2%	2%
Rb87	1%	1%	1%	1%	1%
Sr88	2%	2%	2%	2%	2%
Sr90	0%	0%	1%	3%	8%
Nb93m	4%	3%	7%	8%	8%
Mo95	2%	3%	3%	3%	3%
Mo97	2%	2%	2%	2%	2%
Tc99	1%	1%	1%	1%	1%
Ru101	1%	1%	1%	1%	1%
Ru106	1%	2%			
Rh103	3%	2%	2%	2%	2%
Pd107	2%	2%	2%	2%	2%
Ag108m	36%	33%	29%	27%	45%
Ag109	14%	13%	13%	13%	13%
Ag110m	16%	15%			
I 127	11%	10%	10%	10%	10%
I 129	1%	1%	1%	1%	1%
Xe130	18%	16%	16%	16%	16%
Xe131	6%	5%	5%	5%	5%
Xe132	2%	2%	2%	2%	2%
Xe134	1%	1%	1%	1%	1%
Xe136	4%	4%	4%	4%	4%
Cs133	2%	2%	2%	2%	2%
Cs134	7%	7%	7%		
Cs135	1%	1%	1%	1%	1%
Cs137	1%	1%	1%	1%	1%
Ba136	8%	7%	7%	7%	7%
Ba138	1%	1%	1%	1%	1%
La139	1%	1%	1%	1%	1%
Ce140	2%	2%	2%	2%	2%
Ce144	1%	1%			
Nd142	11%	10%	10%	10%	10%
Nd143	2%	2%	2%	2%	2%
Nd144	1%	1%	1%	1%	1%
Nd145	1%	1%	1%	1%	1%
Nd146	1%	1%	1%	1%	1%
Nd148	1%	1%	1%	1%	1%
Nd150	1%	1%	1%	1%	1%

Table A.24: Trends of relative standard deviation with cooling time for fission products in assembly calculation (continued)

	Discharge	5 Years	50 Years	100 Years	300 Years
Pm147	8%	8%	8%		
Sm146	141%	141%	141%	141%	141%
Sm147	5%	7%	7%	7%	7%
Sm148	14%	14%	14%	14%	14%
Sm149	5%	5%	5%	5%	5%
Sm150	2%	2%	2%	2%	2%
Sm151	10%	9%	9%	9%	9%
Sm152	11%	11%	11%	11%	11%
Sm154	2%	2%	2%	2%	2%
Eu153	2%	2%	2%	2%	2%
Eu154	29%	29%	29%	29%	28%
Eu155	4%	4%	14%	23%	
Gd154	22%	27%	28%	28%	28%
Gd155	4%	4%	3%	3%	3%
Gd156	10%	10%	10%	10%	10%
Ho166m	81%	70%	70%	70%	70%
Total	1%	1%	1%	1%	1%

Table A.25: Results for activation products in assembly calculation at discharge (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Cl36	2.039E+00		2.019E+00	2.000E+00	1.958E+00	1.978E+00	1.999E+00	2.88E-02	1%
Ca41	3.335E-01		8.833E-01	3.010E-01	9.139E-01	3.406E-01	5.545E-01	2.81E-01	51%
Mn53	8.084E-05			1.760E-05			4.922E-05	3.16E-05	64%
Mn54	1.073E-02		8.399E-03	1.360E-02	3.128E-02	5.601E-03	1.392E-02	9.07E-03	65%
Fe55	1.333E-01		1.548E-01	1.520E-01	1.568E-01	1.193E-01	1.432E-01	1.46E-02	10%
Fe60	1.376E-05			9.900E-05			5.638E-05	4.26E-05	76%
Co60	1.541E+00		1.526E+00	1.390E+00	1.568E+00	2.139E+00	1.633E+00	2.60E-01	16%
Ni59	2.163E+00		2.272E+00	2.160E+00	2.964E+00	1.949E+00	2.302E+00	3.47E-01	15%
Ni63	4.287E-01		4.078E-01	3.900E-01	4.374E-01	4.107E-01	4.149E-01	1.67E-02	4%
Mo93	7.409E-02		7.551E-02	8.150E-02	7.627E-02	2.441E-02	6.636E-02	2.11E-02	32%

Table A.26: Results for activation products in assembly calculation at 5 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Cl36	2.039E+00	2.070E+00	2.019E+00	2.000E+00	1.958E+00	1.978E+00	2.011E+00	3.74E-02	2%
Ca41	3.335E-01	3.380E-01	8.833E-01	3.010E-01	9.139E-01	3.406E-01	5.184E-01	2.69E-01	52%
Mn53	8.084E-05	8.150E-05		1.760E-05			5.998E-05	3.00E-05	50%
Mn54	1.869E-04	1.800E-04	1.466E-04	2.370E-04	5.418E-04	9.778E-05	2.317E-04	1.45E-04	63%
Fe55	3.694E-02	3.750E-02	4.292E-02	4.220E-02	4.403E-02	3.147E-02	3.918E-02	4.36E-03	11%
Fe60	1.376E-05	1.360E-05		9.900E-05			4.212E-05	4.02E-05	95%
Co60	7.981E-01	7.960E-01	7.913E-01	7.190E-01	8.121E-01	1.109E+00	8.375E-01	1.25E-01	15%
Ni59	2.163E+00	2.190E+00	2.272E+00	2.160E+00	2.964E+00	1.949E+00	2.283E+00	3.20E-01	14%
Ni63	4.141E-01	4.220E-01	3.934E-01	3.770E-01	4.226E-01	3.955E-01	4.041E-01	1.68E-02	4%
Mo93	7.401E-02	7.540E-02	7.542E-02	8.140E-02	7.620E-02	2.439E-02	6.780E-02	1.96E-02	29%

Table A.27: Results for activation products in assembly calculation at 50 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Cl36	2.038E+00	2.070E+00	2.019E+00	2.000E+00	1.957E+00	1.977E+00	2.010E+00	3.75E-02	2%
Ca41	3.334E-01	3.380E-01	8.830E-01	3.010E-01	9.139E-01	3.405E-01	5.183E-01	2.69E-01	52%
Mn53	8.083E-05	8.150E-05		1.760E-05			5.998E-05	3.00E-05	50%
Mn54	2.747E-20	2.650E-20	2.208E-20		7.591E-20		3.799E-20	2.20E-20	58%
Fe55	3.552E-07	3.600E-07	4.157E-07	4.050E-07	4.806E-07	1.956E-07	3.687E-07	8.78E-08	24%
Fe60	1.376E-05	1.360E-05		9.900E-05			4.212E-05	4.02E-05	95%
Co60	2.140E-03	2.130E-03	2.139E-03	1.930E-03	2.186E-03	2.992E-03	2.253E-03	3.40E-04	15%
Ni59	2.162E+00	2.190E+00	2.271E+00	2.160E+00	2.963E+00	1.948E+00	2.282E+00	3.19E-01	14%
Ni63	3.032E-01	3.090E-01	2.843E-01	2.760E-01	3.094E-01	2.818E-01	2.940E-01	1.36E-02	5%
Mo93	7.336E-02	7.480E-02	7.463E-02	8.070E-02	7.552E-02	2.418E-02	6.720E-02	1.94E-02	29%

Table A.28: Results for activation products in assembly calculation at 100 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Cl36	2.038E+00	2.070E+00	2.019E+00	2.000E+00	1.957E+00	1.977E+00	2.010E+00	3.75E-02	2%
Ca41	3.333E-01	3.380E-01	8.827E-01	3.000E-01	9.131E-01	3.403E-01	5.179E-01	2.69E-01	52%
Mn53	8.083E-05	8.150E-05		1.760E-05			5.998E-05	3.00E-05	50%
Mn54	7.032E-38	6.790E-38			1.841E-37		1.075E-37	5.42E-38	50%
Fe55	9.461E-13	9.600E-13	1.116E-12	1.080E-12	1.474E-12	3.209E-13	9.828E-13	3.44E-13	35%
Fe60	1.376E-05	1.360E-05		9.900E-05			4.212E-05	4.02E-05	95%
Co60	2.972E-06	2.960E-06	2.991E-06	2.670E-06	3.049E-06	4.184E-06	3.138E-06	4.83E-07	15%
Ni59	2.161E+00	2.190E+00	2.270E+00	2.160E+00	2.961E+00	1.948E+00	2.282E+00	3.19E-01	14%
Ni63	2.144E-01	2.180E-01	1.982E-01	1.950E-01	2.188E-01	1.934E-01	2.063E-01	1.09E-02	5%
Mo93	7.263E-02	7.400E-02	7.377E-02	7.990E-02	7.479E-02	2.394E-02	6.650E-02	1.92E-02	29%

Table A.29: Results for activation products in assembly calculation at 300 years cooling (g/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Cl36	2.037E+00	2.070E+00	2.018E+00	2.000E+00	1.957E+00	1.976E+00	2.010E+00	3.76E-02	2%
Ca41	3.328E-01	3.370E-01	8.815E-01	3.000E-01	9.123E-01	3.398E-01	5.172E-01	2.69E-01	52%
Mn53	8.083E-05	8.150E-05		1.760E-05			5.998E-05	3.00E-05	50%
Mn54	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000E+00	0.00E+00	
Fe55	4.763E-35	4.830E-35	0.000E+00	0.000E+00	1.303E-34		4.525E-35	4.76E-35	105%
Fe60	1.376E-05	1.360E-05		9.900E-05			4.212E-05	4.02E-05	95%
Co60	9.653E-12	1.100E-17	1.151E-17	6.940E-11	1.153E-17	1.520E-17	1.318E-11	2.54E-11	193%
Ni59	2.157E+00	2.190E+00	2.265E+00	2.150E+00	2.956E+00	1.944E+00	2.277E+00	3.19E-01	14%
Ni63	5.363E-02	5.460E-02	4.680E-02	4.880E-02	5.479E-02	4.291E-02	5.025E-02	4.45E-03	9%
Mo93	6.981E-02	7.120E-02	7.042E-02	7.680E-02	7.188E-02	2.301E-02	6.385E-02	1.84E-02	29%

Table A.30: Trends of relative standard deviation with cooling time for activation products in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
Cl36	1%	2%	2%	2%	2%
Ca41	51%	52%	52%	52%	52%
Mn53	64%	50%	50%	50%	50%
Mn54	65%	63%	58%	50%	
Fe55	10%	11%	24%	35%	_
Fe60	76%	95%	95%	95%	95%
Co60	16%	15%	15%	15%	-
Ni59	15%	14%	14%	14%	14%
Ni63	4%	4%	5%	5%	9%
Mo93	32%	29%	29%	29%	29%

Table A.31: Results for activation-fission products in assembly calculation at discharge (g/tHMI)

		CEA/D	CEA/C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD(%)
H 3	FP	8.245E-02			6.416E-02	7.731E-02	7.826E-02	7.555E-02	6.85E-03	9%
	AP	9.011E-04			1.778E-07		8.166E-08	3.004E-04	4.25E-04	141%
	FP+AP	8.335E-02		8.300E-02	6.416E-02	7.731E-02	7.826E-02	7.722E-02	6.97E-03	9%
Be10	FP	1.254E-02			1.298E-02	1.529E-02	1.820E-04	1.025E-02	5.90E-03	58%
	AP	1.735E-03			1.353E-06	1.456E-06	9.014E-05	4.569E-04	7.39E-04	162%
	FP+AP	1.427E-02		1.605E-04	1.298E-02	1.529E-02	2.722E-04	8.594E-03	6.88E-03	80%
C 14	FP	3.942E-03			4.009E-03	9.811E+02	3.680E-05	2.453E+02	4.25E+02	173%
	AP	1.205E-01			1.620E-01	2.672E-02	5.238E-02	9.039E-02	5.37E-02	59%
	FP+AP	1.244E-01		1.580E-01	1.660E-01	9.811E+02	5.242E-02	1.963E+02	3.92E+02	200%
Zr93	FP	9.705E+02			9.808E+02	9.825E+02	9.988E+02	9.832E+02	1.01E+01	1%
	AP	2.803E-02			2.599E-02	2.675E-02	5.213E-02	3.323E-02	1.09E-02	33%
	FP+AP	9.706E+02		9.985E+02	9.808E+02	9.825E+02	9.988E+02	9.863E+02	1.09E+01	1%
Nb94	FP	5.814E-04			6.588E-04	7.044E-04	1.042E-03	7.466E-04	1.76E-04	24%
	AP	1.491E+00			1.494E+00	1.672E+00	1.444E+00	1.525E+00	8.69E-02	6%
	FP+AP	1.492E+00		1.441E+00	1.494E+00	1.672E+00	1.445E+00	1.509E+00	8.48E-02	6%
Sn119m	FP	1.488E-02			7.722E-03	9.599E-02	6.346E-02	4.551E-02	3.62E-02	79%
	AP	1.143E-02			5.083E-03	9.075E-02	4.351E-02	3.769E-02	3.39E-02	90%
	FP+AP	2.631E-02		7.092E-02	1.280E-02	1.867E-01	1.070E-01	8.075E-02	6.26E-02	78%
Sn121m	FP	7.127E-01			6.374E-01	3.956E-02	4.879E-03	3.486E-01	3.28E-01	94%
	AP	9.394E-04			4.818E-04	5.125E-04	3.715E-04	5.763E-04	2.16E-04	38%
	FP+AP	7.137E-01		7.055E-03	6.379E-01	4.007E-02	5.250E-03	2.808E-01	3.24E-01	115%
Sn126	FP	3.962E+01			3.938E+01	3.021E+01	3.853E+01	3.693E+01	3.90E+00	11%
	AP	3.966E-07			4.476E-06	1.234E-05	no data	5.736E-06	4.95E-06	86%
	FP+AP	3.962E+01		3.069E+01	3.938E+01	3.021E+01	3.853E+01	3.568E+01	4.29E+00	12%
Sb125	FP	1.774E+01			1.806E+01	1.012E+01	1.789E+01	1.595E+01	3.37E+00	21%
	AP	3.315E-02			2.524E-02	3.799E-02	5.985E-02	3.906E-02	1.28E-02	33%
	FP+AP	1.777E+01		9.758E+00	1.808E+01	1.015E+01	1.795E+01	1.474E+01	3.91E+00	27%

Table A.32: Results for activation-fission products in assembly calculation at 5 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	NEXIA	RRC-KI	VTT	average	SD	RSD(%)
H3	FP	6.225E-02			4.844E-02	5.760E-02	5.912E-02	5.685E-02	5.14E-03	9%
	AP	6.803E-04			1.342E-07		6.169E-08	2.268E-04	3.21E-04	141%
	FP+AP	6.293E-02	1.474E-01	6.270E-02	4.844E-02	5.760E-02	5.912E-02	7.303E-02	3.36E-02	46%
Be10	FP	1.276E-02			1.298E-02	1.500E-02	1.820E-04	1.023E-02	5.87E-03	57%
	AP	1.735E-03			1.353E-06	1.281E-06	9.014E-05	4.568E-04	7.39E-04	162%
	FP+AP	1.450E-02	1.318E-02	1.605E-04	1.298E-02	1.500E-02	2.722E-04	9.347E-03	6.49E-03	69%
C14	FP	3.939E-03			4.007E-03	4.834E-03	3.677E-05	3.204E-03	1.86E-03	58%
	AP	1.203E-01			1.619E-01	1.375E-01	5.235E-02	1.180E-01	4.07E-02	34%
	FP+AP	1.242E-01	1.249E-01	1.579E-01	1.659E-01	1.423E-01	5.238E-02	1.279E-01	3.71E-02	29%
Zr93	FP	9.710E+02			9.813E+02	9.735E+02	9.992E+02	9.812E+02	1.11E+01	1%
	AP	2.803E-02			2.599E-02	4.590E-01	5.213E-02	1.413E-01	1.84E-01	130%
	FP+AP	9.710E+02	9.777E+02	9.990E+02	9.813E+02	9.739E+02	9.993E+02	9.837E+02	1.14E+01	1%
Nb94	FP	5.813E-04			6.587E-04	6.805E-04	1.042E-03	7.406E-04	1.78E-04	24%
	AP	1.491E+00			1.494E+00	1.585E+00	1.444E+00	1.503E+00	5.09E-02	3%
	FP+AP	1.492E+00	1.504E+00	1.440E+00	1.494E+00	1.585E+00	1.445E+00	1.493E+00	4.79E-02	3%
Sn119m	FP	1.978E-04			1.026E-04	1.177E-03	3.634E-04	4.603E-04	4.24E-04	92%
	AP	1.519E-04			6.755E-05	9.614E-04	2.491E-04	3.575E-04	3.55E-04	99%
	FP+AP	3.498E-04	6.557E-05	4.059E-04	1.702E-04	2.139E-03	6.125E-04	6.238E-04	6.99E-04	112%
Sn121m	FP	6.650E-01			5.947E-01	3.601E-02	4.552E-03	3.251E-01	3.06E-01	94%
	AP	8.765E-04			4.495E-04	4.579E-04	3.466E-04	5.326E-04	2.03E-04	38%
	FP+AP	6.659E-01	6.716E-01	6.624E-03	5.952E-01	3.646E-02	4.899E-03	3.301E-01	3.15E-01	95%
Sn126	FP	3.962E+01			3.938E+01	2.943E+01	3.853E+01	3.674E+01	4.24E+00	12%
	AP	3.797E-07			4.476E-06	1.183E-05	no data	5.561E-06	4.74E-06	85%
	FP+AP	3.962E+01	3.994E+01	3.069E+01	3.938E+01	2.943E+01	3.853E+01	3.626E+01	4.42E+00	12%
Sb125	FP	5.068E+00			5.155E+00	2.842E+00	5.164E+00	4.557E+00	9.91E-01	22%
	AP	9.162E-03			7.157E-03	1.052E-02	1.735E-02	1.105E-02	3.83E-03	35%
	FP+AP	5.077E+00	5.111E+00	2.828E+00	5.162E+00	2.853E+00	5.181E+00	4.369E+00	1.08E+00	25%

Table A.33: Results for activation-fission products in assembly calculation at 50 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	NEXIA	RRC-KI	VTT	average	SD	RSD(%)
H3	FP	5.014E-03			3.859E-03	4.592E-03	4.737E-03	4.551E-03	4.27E-04	9%
	AP	5.421E-05			1.069E-08		4.943E-09	1.807E-05	2.55E-05	141%
	FP+AP	5.069E-03	1.175E-02	5.025E-03	3.859E-03	4.592E-03	4.737E-03	5.838E-03	2.67E-03	46%
Be10	FP	1.276E-02			1.298E-02	1.500E-02	1.820E-04	1.023E-02	5.87E-03	57%
	AP	1.735E-03			1.353E-06	1.281E-06	9.014E-05	4.568E-04	7.39E-04	162%
	FP+AP	1.450E-02	1.317E-02	1.605E-04	1.298E-02	1.500E-02	2.721E-04	9.347E-03	6.49E-03	69%
C14	FP	3.918E-03			3.985E-03	4.808E-03	3.658E-05	3.187E-03	1.85E-03	58%
	AP	1.197E-01			1.610E-01	1.367E-01	5.206E-02	1.174E-01	4.05E-02	34%
	FP+AP	1.236E-01	1.242E-01	1.570E-01	1.650E-01	1.415E-01	5.210E-02	1.272E-01	3.69E-02	29%
Zr93	FP	9.710E+02			9.812E+02	9.735E+02	9.992E+02	9.812E+02	1.11E+01	1%
	AP	2.803E-02			2.599E-02	4.590E-01	5.212E-02	1.413E-01	1.84E-01	130%
	FP+AP	9.710E+02	9.777E+02	9.990E+02	9.813E+02	9.739E+02	9.992E+02	9.837E+02	1.14E+01	1%
Nb94	FP	5.804E-04			6.577E-04	6.794E-04	1.040E-03	7.394E-04	1.77E-04	24%
	AP	1.489E+00			1.491E+00	1.582E+00	1.442E+00	1.501E+00	5.09E-02	3%
	FP+AP	1.489E+00	1.502E+00	1.438E+00	1.492E+00	1.583E+00	1.443E+00	1.491E+00	4.78E-02	3%
Sn119m	FP	8.648E-12			0.000E+00	1.548E-20	-			
	AP	1.958E-21			0.000E+00	1.264E-20	-			
	FP+AP	8.648E-12	8.534E-22	0.000E+00	0.000E+00	2.811E-20	-			
Sn121m	FP	3.564E-01			3.187E-01	2.043E-02	2.440E-03	1.745E-01	1.64E-01	94%
	AP	4.697E-04			2.409E-04	2.597E-04	1.858E-04	2.890E-04	1.08E-04	37%
	FP+AP	3.568E-01	3.599E-01	3.758E-03	3.189E-01	2.069E-02	2.626E-03	1.771E-01	1.69E-01	95%
Sn126	FP	3.960E+01			3.936E+01	2.943E+01	3.851E+01	3.673E+01	4.23E+00	12%
	AP	3.795E-07			4.475E-06	1.183E-05	no data	5.560E-06	4.74E-06	85%
	FP+AP	3.960E+01	3.993E+01	3.068E+01	3.936E+01	2.943E+01	3.851E+01	3.625E+01	4.42E+00	12%
Sb125	FP	5.489E-05			5.577E-05	3.102E-05	6.694E-05	5.215E-05	1.31E-05	25%
	AP	9.923E-08			7.743E-08	1.148E-07	2.249E-07	1.291E-07	5.69E-08	44%
	FP+AP	5.499E-05	5.539E-05	3.667E-05	5.585E-05	3.113E-05	6.716E-05	5.020E-05	1.24E-05	25%

Table A.34: Results for activation-fission products in assembly calculation at 100 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD (%)
H3	FP	2.984E-04			2.321E-04	2.762E-04	2.867E-04	2.734E-04	2.51E-05	9%
	AP	3.261E-06			6.430E-10		2.992E-10	1.087E-06	1.54E-06	141%
	FP+AP	3.017E-04	7.066E-04	3.042E-04	2.321E-04	2.762E-04	2.867E-04	3.513E-04	1.61E-04	46%
Be10	FP	1.276E-02			1.298E-02	1.500E-02	1.820E-04	1.023E-02	5.87E-03	57%
	AP	1.735E-03			1.353E-06	1.281E-06	9.014E-05	4.568E-04	7.39E-04	162%
	FP+AP	1.450E-02	1.317E-02	1.605E-04	1.298E-02	1.500E-02	2.721E-04	9.347E-03	6.49E-03	69%
C14	FP	3.894E-03			3.961E-03	4.779E-03	3.636E-05	3.168E-03	1.84E-03	58%
	AP	1.189E-01			1.601E-01	1.359E-01	5.175E-02	1.167E-01	4.02E-02	34%
	FP+AP	1.228E-01	1.235E-01	1.561E-01	1.640E-01	1.407E-01	5.179E-02	1.265E-01	3.67E-02	29%
Zr93	FP	9.709E+02			9.812E+02	9.735E+02	9.992E+02	9.812E+02	1.10E+01	1%
	AP	2.803E-02			2.599E-02	4.590E-01	5.212E-02	1.413E-01	1.84E-01	130%
	FP+AP	9.710E+02	9.776E+02	9.989E+02	9.812E+02	9.739E+02	9.992E+02	9.836E+02	1.13E+01	1%
Nb94	FP	5.794E-04			6.566E-04	6.783E-04	1.038E-03	7.382E-04	1.77E-04	24%
	AP	1.486E+00			1.489E+00	1.580E+00	1.439E+00	1.498E+00	5.08E-02	3%
	FP+AP	1.486E+00	1.499E+00	1.436E+00	1.489E+00	1.580E+00	1.440E+00	1.489E+00	4.76E-02	3%
Sn119m	FP	1.275E-12			0.000E+00	0.000E+00	-			
	AP	3.382E-40			0.000E+00	0.000E+00	-			
	FP+AP	1.275E-12	1.474E-40	0.000E+00	0.000E+00	0.000E+00	-			
Sn121m	FP	1.782E-01			1.593E-01	1.088E-02	1.220E-03	8.741E-02	8.17E-02	93%
	AP	2.349E-04			1.204E-04	1.383E-04	9.288E-05	1.466E-04	5.35E-05	36%
	FP+AP	1.784E-01	1.800E-01	2.002E-03	1.595E-01	1.102E-02	1.313E-03	8.870E-02	8.42E-02	95%
Sn126	FP	3.959E+01			3.935E+01	2.943E+01	3.850E+01	3.672E+01	4.23E+00	12%
	AP	3.794E-07			4.473E-06	1.182E-05	no data	5.558E-06	4.73E-06	85%
	FP+AP	3.959E+01	3.992E+01	3.067E+01	3.935E+01	2.943E+01	3.850E+01	3.624E+01	4.41E+00	12%
Sb125	FP	2.116E-10			1.694E-10	9.514E-11	2.485E-10	1.812E-10	5.70E-11	31%
	AP	3.017E-13			2.351E-13	3.521E-13	8.351E-13	4.310E-13	2.37E-13	55%
	FP+AP	2.119E-10	3.569E-10	1.362E-10	1.696E-10	9.549E-11	2.494E-10	2.032E-10	8.47E-11	42%

Table A.35: Results for activation-fission products in assembly calculation at 300 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD(%)
H3	FP	3.908E-09			3.037E-09	3.617E-09	3.850E-09	3.603E-09	3.45E-10	10%
	AP	4.271E-11			8.413E-15		4.017E-15	1.424E-11	2.01E-11	141%
	FP+AP	3.951E-09	9.255E-09	4.088E-09	3.037E-09	3.617E-09	3.850E-09	4.633E-09	2.09E-09	45%
Be10	FP	1.276E-02			1.297E-02	1.500E-02	1.820E-04	1.023E-02	5.87E-03	57%
	AP	1.735E-03			1.353E-06	1.280E-06	9.013E-05	4.568E-04	7.39E-04	162%
	FP+AP	1.450E-02	1.317E-02	1.604E-04	1.298E-02	1.500E-02	2.721E-04	9.346E-03	6.49E-03	69%
C14	FP	3.801E-03			3.866E-03	4.664E-03	3.549E-05	3.092E-03	1.80E-03	58%
	AP	1.162E-01			1.562E-01	1.326E-01	5.052E-02	1.139E-01	3.93E-02	34%
	FP+AP	1.200E-01	1.205E-01	1.523E-01	1.601E-01	1.373E-01	5.055E-02	1.235E-01	3.58E-02	29%
Zr93	FP	9.708E+02			9.811E+02	9.735E+02	9.991E+02	9.811E+02	1.10E+01	1%
	AP	2.803E-02			2.599E-02	4.590E-01	5.212E-02	1.413E-01	1.84E-01	130%
	FP+AP	9.709E+02	9.776E+02	9.988E+02	9.811E+02	9.739E+02	9.991E+02	9.836E+02	1.13E+01	1%
Nb94	FP	5.755E-04			6.521E-04	6.736E-04	1.031E-03	7.331E-04	1.76E-04	24%
	AP	1.476E+00			1.479E+00	1.569E+00	1.430E+00	1.488E+00	5.05E-02	3%
	FP+AP	1.476E+00	1.489E+00	1.426E+00	1.479E+00	1.570E+00	1.431E+00	1.478E+00	4.74E-02	3%
Sn119m	FP	6.329E-16			0.000E+00	0.000E+00	-			
	AP	0.000E+00			0.000E+00	0.000E+00	-			
	FP+AP	6.329E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-			
Sn121m	FP	1.114E-02			9.957E-03	8.752E-04	7.628E-05	5.512E-03	5.06E-03	92%
	AP	1.468E-05			7.526E-06	1.113E-05	5.807E-06	9.784E-06	3.42E-06	35%
	FP+AP	1.115E-02	1.125E-02	1.613E-04	9.964E-03	8.864E-04	8.208E-05	5.583E-03	5.23E-03	94%
Sn126	FP	3.954E+01			3.929E+01	2.938E+01	3.845E+01	3.666E+01	4.22E+00	12%
	AP	3.789E-07			4.467E-06	1.180E-05	no data	5.550E-06	4.73E-06	85%
	FP+AP	3.954E+01	3.986E+01	3.063E+01	3.929E+01	2.938E+01	3.845E+01	3.619E+01	4.41E+00	12%
Sb125	FP	1.234E-13			0.000E+00	8.412E-33	-	4.114E-14	5.82E-14	141%
	AP	2.579E-35			0.000E+00	3.114E-35	-	1.897E-35	1.36E-35	72%
	FP+AP	1.234E-13	1.929E-13	0.000E+00	0.000E+00	8.444E-33	-	6.325E-14	8.05E-14	127%

Table A.36: Trends of relative standard deviation with cooling time for fission-activation products in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
H 3	9%	46%	46%	46%	45%
Be10	80%	69%	69%	69%	69%
C14	200%	29%	29%	29%	29%
Zr93	1%	1%	1%	1%	1%
Nb94	6%	3%	3%	3%	3%
Sn119m	78%	112%			
Sn121m	115%	95%	95%	95%	94%
Sn126	12%	12%	12%	12%	12%
Sb125	27%	25%	25%	42%	127%

Table A.37: Results for actinides in cell calculation at discharge (g/tHMI)

	CEA/D	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	average	SD	RSD(%)
U232	7.665E-04	8.609E-04	1.063E-03	1.092E-03	9.161E-04	9.047E-04	9.339E-04	1.13E-04	12%
U233	2.361E-03	4.320E-03	7.021E-03	7.796E-03	2.087E-03	7.304E-03	5.148E-03	2.34E-03	46%
U234	2.014E+02	1.980E+02	2.020E+02	2.020E+02	2.107E+02	2.056E+02	2.033E+02	3.99E+00	2%
U235	8.031E+03	7.950E+03	8.749E+03	8.690E+03	8.048E+03	8.140E+03	8.268E+03	3.24E+02	4%
U236	5.279E+03	5.169E+03	5.168E+03	5.360E+03	5.296E+03	5.229E+03	5.250E+03	6.91E+01	1%
U238	9.269E+05	9.267E+05	9.257E+05	9.255E+05	9.269E+05	9.268E+05	9.264E+05	5.70E+02	0%
Np236	1.749E-03	7.004E-04	6.313E-04	7.238E-04	6.731E-04	2.453E-03	1.155E-03	7.00E-04	61%
Np237	5.949E+02	6.552E+02	6.159E+02	6.408E+02	6.161E+02	5.895E+02	6.187E+02	2.33E+01	4%
Pu236	1.938E-03	2.238E-03	2.401E-03	2.464E-03	2.478E-03	1.600E-03	2.186E-03	3.21E-04	15%
Pu238	2.482E+02	2.773E+02	2.522E+02	2.623E+02	2.468E+02	2.407E+02	2.546E+02	1.21E+01	5%
Pu239	5.588E+03	5.700E+03	6.193E+03	6.221E+03	5.739E+03	5.510E+03	5.825E+03	2.80E+02	5%
Pu240	2.622E+03	2.538E+03	2.721E+03	2.733E+03	2.740E+03	2.644E+03	2.666E+03	7.29E+01	3%
Pu241	1.581E+03	1.661E+03	1.762E+03	1.757E+03	1.577E+03	1.634E+03	1.662E+03	7.49E+01	5%
Pu242	7.447E+02	7.778E+02	7.544E+02	7.563E+02	7.604E+02	7.659E+02	7.599E+02	1.03E+01	1%
Pu243	1.997E-01	1.984E-01	2.017E-01	2.011E-01	1.920E-01	2.099E-01	2.005E-01	5.29E-03	3%
Pu244	5.251E-02	4.929E-02	5.863E-02	5.839E-02	2.422E-02	7.492E-02	5.299E-02	1.52E-02	29%
Am241	5.015E+01	5.194E+01	5.957E+01	5.647E+01	4.812E+01	4.606E+01	5.205E+01	4.67E+00	9%
Am242m	7.528E-01	9.242E-01	7.899E-01	8.177E-01	7.822E-01	1.307E+00	8.957E-01	1.92E-01	21%
Am243	1.619E+02	1.659E+02	1.647E+02	1.653E+02	1.593E+02	1.296E+02	1.578E+02	1.28E+01	8%
Cm242	2.199E+01	2.168E+01	2.279E+01	2.370E+01	2.334E+01	2.223E+01	2.262E+01	7.24E-01	3%
Cm243	5.940E-01	5.799E-01	5.599E-01	5.825E-01	5.826E-01	5.607E-01	5.766E-01	1.24E-02	2%
Cm244	6.226E+01	5.963E+01	6.227E+01	6.119E+01	5.242E+01	1.006E+02	6.639E+01	1.57E+01	24%
Cm245	3.705E+00	3.028E+00	4.281E+00	4.215E+00	2.708E+00	7.173E+00	4.185E+00	1.45E+00	35%
Cm246	4.399E-01	3.389E-01	4.541E-01	4.697E-01	3.235E-01	7.715E-01	4.663E-01	1.48E-01	32%
Cm247	5.088E-03	4.119E-03	6.178E-03	6.333E-03	3.677E-03	1.026E-02	5.942E-03	2.16E-03	36%
Cm248	3.366E-04	2.320E-04	4.550E-04	4.935E-04	3.259E-04	6.847E-04	4.213E-04	1.46E-04	35%
Ra226	4.319E-08	3.807E-08	3.476E-08	3.483E-08	3.869E-08	3.544E-08	3.750E-08	2.97E-09	8%
Ra228	2.073E-14	1.989E-14	1.981E-14	2.056E-14	2.065E-14	2.007E-14	2.029E-14	3.73E-16	2%
Ac227	2.077E-08	4.456E-09	7.688E-09	7.680E-09	9.312E-09	7.806E-09	9.619E-09	5.20E-09	54%
Th229	2.927E-07	1.468E-06	1.666E-06	1.743E-06	1.366E-06	1.276E-06	1.302E-06	4.79E-07	37%
Th230	1.935E-03	1.985E-03	1.747E-03	1.751E-03	1.996E-03	1.794E-03	1.868E-03	1.07E-04	6%
Th232	3.423E-04	3.371E-04	3.343E-04	3.469E-04	3.415E-04	3.371E-04	3.399E-04	4.17E-06	1%
Cf252	3.044E-07	2.741E-07	6.093E-07	6.814E-07	4.782E-07	5.202E-07	4.779E-07	1.48E-07	31%

Table A.38: Results for actinides in cell calculation at 5 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
U232	2.027E-03	2.037E-03	2.333E-03	2.636E-03	2.707E-03	2.520E-03	1.944E-03	2.315E-03	2.92E-04	13%
U233	3.328E-03	3.329E-03	5.384E-03	8.021E-03	8.836E-03	3.087E-03	8.261E-03	5.749E-03	2.39E-03	42%
U234	2.116E+02	2.116E+02	2.095E+02	2.125E+02	2.129E+02	2.209E+02	2.155E+02	2.135E+02	3.46E+00	2%
U235	8.032E+03	8.023E+03	7.951E+03	8.750E+03	8.690E+03	8.048E+03	8.140E+03	8.233E+03	3.12E+02	4%
U236	5.280E+03	5.281E+03	5.170E+03	5.170E+03	5.361E+03	5.296E+03	5.230E+03	5.255E+03	6.48E+01	1%
U238	9.269E+05	9.268E+05	9.267E+05	9.257E+05	9.255E+05	9.269E+05	9.268E+05	9.265E+05	5.44E+02	0%
Np236	1.749E-03	1.751E-03	7.004E-04	6.312E-04	7.238E-04	6.731E-04	2.453E-03	1.240E-03	6.80E-04	55%
Np237	6.089E+02	6.091E+02	6.706E+02	6.302E+02	6.555E+02	6.303E+02	6.033E+02	6.297E+02	2.36E+01	4%
Pu236	5.895E-04	5.923E-04	6.674E-04	7.159E-04	7.349E-04	7.504E-04	4.771E-04	6.468E-04	9.16E-05	14%
Pu238	2.615E+02	2.621E+02	2.895E+02	2.661E+02	2.768E+02	2.605E+02	2.545E+02	2.673E+02	1.10E+01	4%
Pu239	5.685E+03	5.685E+03	5.798E+03	6.292E+03	6.321E+03	5.837E+03	5.607E+03	5.889E+03	2.73E+02	5%
Pu240	2.632E+03	2.645E+03	2.546E+03	2.730E+03	2.742E+03	2.748E+03	2.659E+03	2.672E+03	6.81E+01	3%
Pu241	1.242E+03	1.248E+03	1.312E+03	1.385E+03	1.381E+03	1.239E+03	1.285E+03	1.299E+03	5.86E+01	5%
Pu242	7.447E+02	7.490E+02	7.778E+02	7.544E+02	7.563E+02	7.604E+02	7.659E+02	7.584E+02	1.02E+01	1%
Pu243	1.769E-13	1.789E-13	1.469E-13	2.202E-13	2.258E-13	-6.371E-38	3.656E-13	1.878E-13	1.01E-13	54%
Pu244	5.252E-02	5.289E-02	4.929E-02	5.863E-02	5.839E-02	2.422E-02	7.492E-02	5.298E-02	1.41E-02	27%
Am241	3.864E+02	3.880E+02	3.987E+02	4.342E+02	4.301E+02	3.845E+02	3.936E+02	4.022E+02	1.95E+01	5%
Am242m	7.345E-01	7.371E-01	9.034E-01	7.721E-01	7.993E-01	7.631E-01	1.278E+00	8.553E-01	1.80E-01	21%
Am243	1.620E+02	1.630E+02	1.660E+02	1.648E+02	1.655E+02	1.594E+02	1.298E+02	1.586E+02	1.20E+01	8%
Cm242	1.127E-02	1.135E-02	1.143E-02	1.173E-02	1.218E-02	1.218E-02	1.271E-02	1.184E-02	4.98E-04	4%
Cm243	5.292E-01	5.340E-01	5.135E-01	4.958E-01	5.159E-01	5.157E-01	4.965E-01	5.144E-01	1.35E-02	3%
Cm244	5.143E+01	5.181E+01	4.926E+01	5.144E+01	5.055E+01	4.330E+01	8.318E+01	5.442E+01	1.21E+01	22%
Cm245	3.703E+00	3.734E+00	3.027E+00	4.279E+00	4.213E+00	2.708E+00	7.170E+00	4.119E+00	1.35E+00	33%
Cm246	4.396E-01	4.441E-01	3.387E-01	4.538E-01	4.694E-01	3.233E-01	7.710E-01	4.628E-01	1.37E-01	30%
Cm247	5.088E-03	5.146E-03	4.119E-03	6.178E-03	6.333E-03	3.677E-03	1.026E-02	5.828E-03	2.02E-03	35%
Cm248	3.368E-04	3.412E-04	2.322E-04	4.554E-04	4.939E-04	3.262E-04	6.851E-04	4.101E-04	1.38E-04	34%
Ra226	1.945E-07	1.944E-07	1.877E-07	1.750E-07	1.753E-07	1.955E-07	1.788E-07	1.859E-07	8.65E-09	5%
Ra228	1.506E-13	0.000E+00	1.475E-13	1.522E-13	1.579E-13	1.505E-13	1.538E-13	1.304E-13	5.33E-14	41%
Ac227	8.213E-08	0.000E+00	6.707E-08	7.524E-08	7.515E-08	6.882E-08	7.277E-08	6.303E-08	2.61E-08	41%
Th229	3.534E-07	3.536E-07	1.571E-06	1.827E-06	1.921E-06	1.421E-06	1.443E-06	1.270E-06	6.04E-07	48%
Th230	4.798E-03	4.796E-03	4.821E-03	4.633E-03	4.639E-03	4.985E-03	4.725E-03	4.771E-03	1.12E-04	2%
Th232	1.110E-03	1.110E-03	1.089E-03	1.086E-03	1.126E-03	1.112E-03	1.098E-03	1.104E-03	1.33E-05	1%
Cf252	8.211E-08	8.358E-08	7.375E-08	1.639E-07	1.833E-07	1.290E-07	1.400E-07	1.222E-07	4.02E-08	33%

Table A.39: Results for actinides in cell calculation at 50 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	average	SD	RSD(%)
U232	1.683E-03	1.692E-03	1.952E-03	2.185E-03	2.243E-03	2.105E-03	1.578E-03	1.920E-03	2.49E-04	13%
U233	1.252E-02	1.253E-02	1.547E-02	1.757E-02	1.874E-02	1.258E-02	1.738E-02	1.526E-02	2.51E-03	16%
U234	2.886E+02	2.887E+02	2.946E+02	2.908E+02	2.943E+02	2.975E+02	2.904E+02	2.921E+02	3.13E+00	1%
U235	8.039E+03	8.030E+03	7.958E+03	8.758E+03	8.698E+03	8.062E+03	8.148E+03	8.242E+03	3.12E+02	4%
U236	5.292E+03	5.293E+03	5.182E+03	5.182E+03	5.374E+03	5.309E+03	5.243E+03	5.268E+03	6.49E+01	1%
U238	9.269E+05	9.268E+05	9.267E+05	9.257E+05	9.255E+05	9.269E+05	9.268E+05	9.265E+05	5.44E+02	0%
Np236	1.748E-03	1.751E-03	7.002E-04	6.311E-04	7.236E-04	6.731E-04	2.452E-03	1.240E-03	6.80E-04	55%
Np237	6.860E+02	6.865E+02	7.508E+02	7.165E+02	7.413E+02	7.075E+02	6.827E+02	7.102E+02	2.55E+01	4%
Pu236	1.651E-08	1.658E-08	1.346E-08	1.419E-08	1.474E-08	1.767E-08	1.399E-08	1.531E-08	1.48E-09	10%
Pu238	1.834E+02	1.838E+02	2.030E+02	1.867E+02	1.941E+02	1.827E+02	1.786E+02	1.875E+02	7.74E+00	4%
Pu239	5.678E+03	5.678E+03	5.792E+03	6.285E+03	6.313E+03	5.824E+03	5.600E+03	5.882E+03	2.73E+02	5%
Pu240	2.660E+03	2.674E+03	2.574E+03	2.759E+03	2.770E+03	2.770E+03	2.714E+03	2.703E+03	6.70E+01	2%
Pu241	1.424E+02	1.431E+02	1.574E+02	1.590E+02	1.586E+02	1.412E+02	1.475E+02	1.499E+02	7.54E+00	5%
Pu242	7.447E+02	7.490E+02	7.778E+02	7.544E+02	7.563E+02	7.604E+02	7.659E+02	7.583E+02	1.02E+01	1%
Pu243	1.769E-13	1.789E-13	1.469E-13	2.202E-13	2.258E-13	-6.371E-38	3.656E-13	1.878E-13	1.01E-13	54%
Pu244	5.252E-02	5.289E-02	4.929E-02	5.863E-02	5.839E-02	2.422E-02	7.492E-02	5.298E-02	1.41E-02	27%
Am241	1.408E+03	1.414E+03	1.472E+03	1.573E+03	1.566E+03	1.404E+03	1.450E+03	1.470E+03	6.70E+01	5%
Am242m	5.888E-01	5.909E-01	7.359E-01	6.290E-01	6.511E-01	6.119E-01	1.041E+00	6.926E-01	1.50E-01	22%
Am243	1.614E+02	1.623E+02	1.653E+02	1.641E+02	1.648E+02	1.588E+02	1.292E+02	1.580E+02	1.19E+01	8%
Cm242	1.539E-03	1.544E-03	1.777E-03	1.521E-03	1.575E-03	1.792E-03	2.520E-03	1.752E-03	3.31E-04	19%
Cm243	1.871E-01	1.888E-01	1.720E-01	1.661E-01	1.728E-01	1.729E-01	1.663E-01	1.751E-01	8.54E-03	5%
Cm244	9.179E+00	9.248E+00	8.811E+00	9.201E+00	9.041E+00	7.740E+00	1.488E+01	9.728E+00	2.16E+00	22%
Cm245	3.690E+00	3.720E+00	3.016E+00	4.264E+00	4.198E+00	2.697E+00	7.144E+00	4.104E+00	1.35E+00	33%
Cm246	4.367E-01	4.412E-01	3.364E-01	4.508E-01	4.663E-01	3.213E-01	7.659E-01	4.598E-01	1.36E-01	30%
Cm247	5.088E-03	5.147E-03	4.119E-03	6.178E-03	6.333E-03	3.677E-03	1.026E-02	5.828E-03	2.02E-03	35%
Cm248	3.369E-04	3.413E-04	2.322E-04	4.555E-04	4.941E-04	3.263E-04	6.852E-04	4.102E-04	1.38E-04	34%
Ra226	8.158E-06	8.157E-06	8.033E-06	7.963E-06	8.003E-06	8.455E-06	8.046E-06	8.116E-06	1.54E-07	2%
Ra228	2.718E-12	0.000E+00	2.661E-12	3.004E-12	3.115E-12	2.722E-12	3.038E-12	2.465E-12	1.02E-12	41%
Ac227	4.691E-07	0.000E+00	4.584E-07	5.000E-07	4.986E-07	4.478E-07	4.774E-07	4.073E-07	1.67E-07	41%
Th229	1.857E-06	1.857E-06	3.551E-06	4.270E-06	4.555E-06	2.902E-06	3.893E-06	3.269E-06	1.02E-06	31%
Th230	3.628E-02	3.628E-02	3.670E-02	3.645E-02	3.671E-02	3.758E-02	3.669E-02	3.667E-02	4.10E-04	1%
Th232	8.032E-03	8.033E-03	7.864E-03	7.860E-03	8.151E-03	8.050E-03	7.950E-03	7.991E-03	9.82E-05	1%
Cf252	6.209E-13	6.324E-13	5.446E-13	1.211E-12	1.354E-12	9.857E-13	1.034E-12	9.118E-13	2.94E-13	32%

Table A.40: Results for actinides in cell calculation at 100 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
U232	1.025E-03	1.030E-03	1.205E-03	1.351E-03	1.387E-03	1.282E-03	9.754E-04	1.179E-03	1.57E-04	13%
U233	2.434E-02	2.435E-02	2.836E-02	2.997E-02	3.153E-02	2.472E-02	2.916E-02	2.749E-02	2.76E-03	10%
U234	3.474E+02	3.477E+02	3.597E+02	3.506E+02	3.565E+02	3.561E+02	3.476E+02	3.522E+02	4.73E+00	1%
U235	8.047E+03	8.038E+03	7.966E+03	8.767E+03	8.707E+03	8.070E+03	8.156E+03	8.250E+03	3.13E+02	4%
U236	5.306E+03	5.307E+03	5.196E+03	5.197E+03	5.389E+03	5.322E+03	5.257E+03	5.282E+03	6.49E+01	1%
U238	9.269E+05	9.268E+05	9.267E+05	9.257E+05	9.255E+05	9.269E+05	9.268E+05	9.265E+05	5.44E+02	0%
Np236	1.748E-03	1.750E-03	7.000E-04	6.309E-04	7.234E-04	6.731E-04	2.451E-03	1.240E-03	6.80E-04	55%
Np237	7.993E+02	8.003E+02	8.697E+02	8.431E+02	8.674E+02	8.201E+02	7.995E+02	8.285E+02	2.92E+01	4%
Pu236	3.937E-09	3.942E-09	1.545E-09	1.408E-09	1.614E-09	1.511E-09	5.470E-09	2.775E-09	1.53E-09	55%
Pu238	1.236E+02	1.239E+02	1.369E+02	1.259E+02	1.309E+02	1.232E+02	1.205E+02	1.264E+02	5.22E+00	4%
Pu239	5.671E+03	5.671E+03	5.784E+03	6.277E+03	6.305E+03	5.815E+03	5.593E+03	5.874E+03	2.73E+02	5%
Pu240	2.654E+03	2.667E+03	2.568E+03	2.752E+03	2.763E+03	2.761E+03	2.712E+03	2.697E+03	6.65E+01	2%
Pu241	1.284E+01	1.290E+01	1.493E+01	1.436E+01	1.432E+01	1.265E+01	1.332E+01	1.362E+01	8.37E-01	6%
Pu242	7.446E+02	7.489E+02	7.778E+02	7.543E+02	7.562E+02	7.604E+02	7.659E+02	7.583E+02	1.03E+01	1%
Pu243	1.769E-13	1.789E-13	1.469E-13	2.202E-13	2.258E-13	-6.371E-38	3.656E-13	1.878E-13	1.01E-13	54%
Pu244	5.252E-02	5.289E-02	4.929E-02	5.863E-02	5.839E-02	2.422E-02	7.492E-02	5.298E-02	1.41E-02	27%
Am241	1.422E+03	1.429E+03	1.493E+03	1.589E+03	1.582E+03	1.418E+03	1.466E+03	1.485E+03	6.78E+01	5%
Am242m	4.605E-01	4.621E-01	5.860E-01	5.008E-01	5.185E-01	4.787E-01	8.288E-01	5.479E-01	1.21E-01	22%
Am243	1.606E+02	1.616E+02	1.646E+02	1.633E+02	1.640E+02	1.580E+02	1.286E+02	1.572E+02	1.19E+01	8%
Cm242	1.203E-03	1.207E-03	1.415E-03	1.211E-03	1.254E-03	1.402E-03	2.005E-03	1.385E-03	2.67E-04	19%
Cm243	5.894E-02	5.948E-02	5.103E-02	4.927E-02	5.126E-02	5.130E-02	4.934E-02	5.294E-02	4.04E-03	8%
Cm244	1.353E+00	1.363E+00	1.301E+00	1.359E+00	1.336E+00	1.142E+00	2.198E+00	1.436E+00	3.19E-01	22%
Cm245	3.675E+00	3.705E+00	3.003E+00	4.246E+00	4.181E+00	2.685E+00	7.115E+00	4.087E+00	1.34E+00	33%
Cm246	4.335E-01	4.380E-01	3.340E-01	4.475E-01	4.629E-01	3.190E-01	7.603E-01	4.565E-01	1.35E-01	30%
Cm247	5.088E-03	5.147E-03	4.119E-03	6.178E-03	6.333E-03	3.677E-03	1.026E-02	5.828E-03	2.02E-03	35%
Cm248	3.368E-04	3.412E-04	2.322E-04	4.554E-04	4.940E-04	3.263E-04	6.851E-04	4.102E-04	1.38E-04	34%
Ra226	3.383E-05	3.383E-05	3.363E-05	3.328E-05	3.356E-05	3.496E-05	3.342E-05	3.379E-05	5.13E-07	2%
Ra228	5.816E-12	5.810E-12	5.694E-12	6.535E-12	6.777E-12	5.824E-12	6.611E-12	6.152E-12	4.30E-13	7%
Ac227	7.622E-07	6.657E-07	7.505E-07	8.199E-07	8.169E-07	7.392E-07	7.776E-07	7.617E-07	4.86E-08	6%
Th229	5.749E-06	5.752E-06	8.180E-06	9.310E-06	9.888E-06	6.836E-06	8.831E-06	7.792E-06	1.57E-06	20%
Th230	8.061E-02	8.064E-02	8.249E-02	8.134E-02	8.227E-02	8.308E-02	8.133E-02	8.168E-02	8.79E-04	1%
Th232	1.574E-02	1.574E-02	1.541E-02	1.541E-02	1.598E-02	1.577E-02	1.558E-02	1.566E-02	1.92E-04	1%
Cf252	1.266E-18	1.290E-18	1.082E-18	2.407E-18	2.692E-18	2.029E-18	-	1.794E-18	6.16E-19	34%

Table A.41: Results for actinides in cell calculation at 300 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
U232	1.407E-04	1.414E-04	1.745E-04	1.972E-04	2.025E-04	1.765E-04	1.425E-04	1.679E-04	2.47E-05	15%
U233	8.813E-02	8.827E-02	9.729E-02	9.806E-02	1.011E-01	8.970E-02	9.333E-02	9.370E-02	4.83E-03	5%
U234	4.439E+02	4.443E+02	4.665E+02	4.488E+02	4.586E+02	4.519E+02	4.416E+02	4.508E+02	8.34E+00	2%
U235	8.079E+03	8.070E+03	7.999E+03	8.802E+03	8.743E+03	8.119E+03	8.187E+03	8.286E+03	3.13E+02	4%
U236	5.361E+03	5.362E+03	5.248E+03	5.254E+03	5.445E+03	5.366E+03	5.313E+03	5.335E+03	6.47E+01	1%
U238	9.269E+05	9.268E+05	9.267E+05	9.257E+05	9.255E+05	9.269E+05	9.268E+05	9.265E+05	5.44E+02	0%
Np236	1.746E-03	1.749E-03	6.991E-04	6.301E-04	7.225E-04	6.731E-04	2.448E-03	1.238E-03	6.79E-04	55%
Np237	1.186E+03	1.189E+03	1.277E+03	1.276E+03	1.298E+03	1.205E+03	1.198E+03	1.233E+03	4.50E+01	4%
Pu236	3.933E-09	3.938E-09	1.543E-09	1.406E-09	1.612E-09	1.511E-09	5.463E-09	2.772E-09	1.52E-09	55%
Pu238	2.554E+01	2.560E+01	2.837E+01	2.606E+01	2.711E+01	2.552E+01	2.502E+01	2.618E+01	1.08E+00	4%
Pu239	5.642E+03	5.641E+03	5.754E+03	6.244E+03	6.272E+03	5.766E+03	5.563E+03	5.840E+03	2.72E+02	5%
Pu240	2.600E+03	2.613E+03	2.515E+03	2.696E+03	2.706E+03	2.707E+03	2.657E+03	2.642E+03	6.56E+01	2%
Pu241	6.881E-03	6.935E-03	6.255E-03	7.926E-03	7.816E-03	5.205E-03	1.257E-02	7.655E-03	2.18E-03	28%
Pu242	7.444E+02	7.487E+02	7.776E+02	7.541E+02	7.560E+02	7.604E+02	7.657E+02	7.581E+02	1.03E+01	1%
Pu243	1.769E-13	1.789E-13	1.469E-13	2.202E-13	2.258E-13	-6.371E-38	3.656E-13	1.878E-13	1.01E-13	54%
Pu244	5.252E-02	5.289E-02	4.929E-02	5.863E-02	5.839E-02	2.422E-02	7.492E-02	5.298E-02	1.41E-02	27%
Am241	1.042E+03	1.047E+03	1.095E+03	1.164E+03	1.159E+03	1.039E+03	1.074E+03	1.088E+03	4.97E+01	5%
Am242m	1.723E-01	1.729E-01	2.355E-01	2.013E-01	2.084E-01	1.793E-01	3.331E-01	2.147E-01	5.28E-02	25%
Am243	1.576E+02	1.586E+02	1.615E+02	1.603E+02	1.609E+02	1.550E+02	1.262E+02	1.543E+02	1.16E+01	8%
Cm242	4.501E-04	4.517E-04	5.688E-04	4.869E-04	5.041E-04	5.249E-04	8.058E-04	5.418E-04	1.14E-04	21%
Cm243	5.802E-04	5.855E-04	3.951E-04	3.816E-04	3.970E-04	3.982E-04	3.821E-04	4.456E-04	8.70E-05	20%
Cm244	6.382E-04	6.431E-04	6.197E-04	6.472E-04	6.359E-04	5.439E-04	1.047E-03	6.821E-04	1.52E-04	22%
Cm245	3.615E+00	3.645E+00	2.955E+00	4.178E+00	4.113E+00	2.637E+00	6.999E+00	4.020E+00	1.32E+00	33%
Cm246	4.210E-01	4.253E-01	3.243E-01	4.346E-01	4.496E-01	3.101E-01	7.383E-01	4.433E-01	1.31E-01	30%
Cm247	5.088E-03	5.147E-03	4.119E-03	6.178E-03	6.333E-03	3.677E-03	1.026E-02	5.828E-03	2.02E-03	35%
Cm248	3.367E-04	3.411E-04	2.321E-04	4.553E-04	4.938E-04	3.263E-04	6.849E-04	4.100E-04	1.38E-04	34%
Ra226	3.614E-04	3.616E-04	3.662E-04	3.578E-04	3.633E-04	3.703E-04	3.555E-04	3.623E-04	4.60E-06	1%
Ra228	1.829E-11	1.830E-11	1.842E-11	2.146E-11	2.225E-11	1.832E-11	2.101E-11	1.972E-11	1.64E-12	8%
Ac227	1.786E-06	1.783E-06	1.764E-06	1.935E-06	1.924E-06	1.764E-06	1.815E-06	1.824E-06	6.83E-08	4%
Th229	5.165E-05	5.171E-05	5.954E-05	6.177E-05	6.431E-05	5.357E-05	5.909E-05	5.738E-05	4.70E-06	8%
Th230	3.064E-01	3.067E-01	3.196E-01	3.105E-01	3.161E-01	3.133E-01	3.074E-01	3.114E-01	4.73E-03	2%
Th232	4.678E-02	4.679E-02	4.579E-02	4.580E-02	4.748E-02	4.685E-02	4.632E-02	4.654E-02	5.69E-04	1%
Cf252	2.192E-41	2.233E-41				4.600E-35		1.533E-35	2.17E-35	0%

Table A.42: Trends of relative standard deviation with cooling time for actinides in cell calculation

	Discharge	5 years	50 years	100 years	300 years
U232	12%	13%	13%	13%	15%
U233	46%	42%	16%	10%	5%
U234	2%	2%	1%	1%	2%
U235	4%	4%	4%	4%	4%
U236	1%	1%	1%	1%	1%
U238	0%	0%	0%	0%	0%
Np236	61%	55%	55%	55%	55%
Np237	4%	4%	4%	4%	4%
Pu236	15%	14%	10%	55%	55%
Pu238	5%	4%	4%	4%	4%
Pu239	5%	5%	5%	5%	5%
Pu240	3%	3%	2%	2%	2%
Pu241	5%	5%	5%	6%	28%
Pu242	1%	1%	1%	1%	1%
Pu243	3%	54%	54%	54%	54%
Pu244	29%	27%	27%	27%	27%
Am241	9%	5%	5%	5%	5%
Am242m	21%	21%	22%	22%	25%
Am243	8%	8%	8%	8%	8%
Cm242	3%	4%	19%	19%	21%
Cm243	2%	3%	5%	8%	20%
Cm244	24%	22%	22%	22%	22%
Cm245	35%	33%	33%	33%	33%
Cm246	32%	30%	30%	30%	30%
Cm247	36%	35%	35%	35%	35%
Cm248	35%	34%	34%	34%	34%
Ra226	8%	5%	2%	2%	1%
Ra228	2%	41%	41%	7%	8%
Ac227	54%	41%	41%	6%	4%
Th229	37%	48%	31%	20%	8%
Th230	6%	2%	1%	1%	2%
Th232	1%	1%	1%	1%	1%
Cf252	31%	33%	32%	34%	0%

Table A.43: Results for fission products in cell calculation at discharge (g/tHMI)

	CEA/D	GRS	JAERI(J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Se79	6.688E+00	6.741E+00	7.078E+00	7.073E+00	6.596E+00	7.516E+00	6.949E+00	3.13E-01	5%
Kr85	3.347E+01	3.339E+01	4.269E+01	4.322E+01	3.274E+01	3.214E+01	3.628E+01	4.75E+00	13%
Rb85	1.395E+02	1.342E+02	1.803E+02	1.794E+02	1.401E+02	1.360E+02	1.516E+02	2.01E+01	13%
Rb87	3.305E+02	3.444E+02	3.349E+02	3.344E+02	3.359E+02	3.378E+02	3.363E+02	4.24E+00	1%
Sr88	4.600E+02	4.845E+02	4.791E+02	4.783E+02	4.687E+02	4.855E+02	4.760E+02	9.00E+00	2%
Sr90	7.308E+02	7.368E+02	7.415E+02	7.404E+02	7.303E+02	7.320E+02	7.353E+02	4.52E+00	1%
Nb93m	8.134E-04	8.616E-04	7.760E-04	7.854E-04	8.128E-04	7.981E-04	8.079E-04	2.76E-05	3%
Mo95	9.217E+02	9.669E+02	9.136E+02	9.134E+02	9.126E+02	9.167E+02	9.241E+02	1.94E+01	2%
Mo97	1.092E+03	1.150E+03	1.107E+03	1.107E+03	1.106E+03	1.113E+03	1.113E+03	1.79E+01	2%
Tc99	1.076E+03	1.095E+03	1.058E+03	1.048E+03	1.062E+03	1.090E+03	1.071E+03	1.69E+01	2%
Ru101	1.078E+03	1.050E+03	1.072E+03	1.073E+03	1.074E+03	1.069E+03	1.069E+03	9.04E+00	1%
Ru106	2.007E+02	2.038E+02	2.075E+02	2.090E+02	2.027E+02	2.054E+02	2.049E+02	2.80E+00	1%
Rh103	5.474E+02	5.713E+02	5.250E+02	5.278E+02	5.652E+02	5.361E+02	5.455E+02	1.77E+01	3%
Pd107	3.013E+02	3.092E+02	3.121E+02	3.135E+02	2.990E+02	3.110E+02	3.077E+02	5.52E+00	2%
Ag108m	2.936E-06	5.022E-06	8.821E-06	8.898E-06	4.097E-06	1.639E-06	5.236E-06	2.76E-06	53%
Ag109	1.002E+02	1.135E+02	1.155E+02	1.160E+02	1.129E+02	1.057E+02	1.107E+02	5.76E+00	5%
Ag110m	1.329E+00	1.397E+00	1.748E+00	1.748E+00	1.086E+00	1.321E+00	1.438E+00	2.39E-01	17%
I127	5.941E+01	5.753E+01	5.695E+01	5.700E+01	6.189E+01	7.630E+01	6.151E+01	6.83E+00	11%
I129	2.452E+02	2.416E+02	2.504E+02	2.508E+02	2.365E+02	2.482E+02	2.455E+02	5.08E+00	2%
Xe130	1.277E+01	1.286E+01	1.182E+01	1.185E+01	1.060E+01	1.763E+01	1.292E+01	2.23E+00	17%
Xe131	5.369E+02	5.350E+02	5.271E+02	5.279E+02	5.394E+02	5.544E+02	5.368E+02	9.07E+00	2%
Xe132	1.529E+03	1.561E+03	1.595E+03	1.596E+03	1.523E+03	1.544E+03	1.558E+03	2.93E+01	2%
Xe134	2.076E+03	2.101E+03	2.103E+03	2.103E+03	2.107E+03	2.057E+03	2.091E+03	1.84E+01	1%
Xe136	3.150E+03	3.236E+03	3.196E+03	3.203E+03	3.421E+03	3.182E+03	3.231E+03	8.86E+01	3%
Cs133	1.478E+03	1.508E+03	1.505E+03	1.506E+03	1.483E+03	1.490E+03	1.495E+03	1.19E+01	1%
Cs134	1.911E+02	2.179E+02	2.068E+02	2.063E+02	2.098E+02	1.949E+02	2.045E+02	9.01E+00	4%
Cs135	5.003E+02	5.132E+02	5.011E+02	4.964E+02	5.068E+02	5.236E+02	5.069E+02	9.19E+00	2%
Cs137	1.666E+03	1.647E+03	1.713E+03	1.713E+03	1.673E+03	1.657E+03	1.678E+03	2.60E+01	2%
Ba136	3.014E+01	3.094E+01	3.004E+01	2.978E+01	2.769E+01	3.273E+01	3.022E+01	1.50E+00	5%
Ba138	1.806E+03	1.816E+03	1.790E+03	1.790E+03	1.795E+03	1.785E+03	1.797E+03	1.08E+01	1%
La139	1.675E+03	1.676E+03	1.684E+03	1.684E+03	1.677E+03	1.699E+03	1.683E+03	8.32E+00	0%
Ce140	1.661E+03	1.702E+03	1.747E+03	1.747E+03	1.664E+03	1.671E+03	1.699E+03	3.67E+01	2%
Ce144	4.005E+02	4.036E+02	4.077E+02	4.085E+02	4.053E+02	4.010E+02	4.044E+02	3.04E+00	1%
Nd142	3.271E+01	3.309E+01	3.477E+01	3.476E+01	3.359E+01	4.146E+01	3.506E+01	2.97E+00	8%
Nd143	1.016E+03	1.022E+03	1.001E+03	1.000E+03	1.019E+03	1.020E+03	1.013E+03	8.83E+00	1%
Nd144	1.473E+03	1.489E+03	1.504E+03	1.503E+03	1.482E+03	1.476E+03	1.488E+03	1.21E+01	1%
Nd145	9.127E+02	9.047E+02	9.126E+02	9.127E+02	9.094E+02	9.232E+02	9.125E+02	5.56E+00	1%
Nd146	9.877E+02	9.965E+02	9.847E+02	9.848E+02	9.853E+02	9.750E+02	9.856E+02	6.29E+00	1%
Nd148	5.204E+02	5.124E+02	5.186E+02	5.189E+02	5.130E+02	5.178E+02	5.168E+02	3.04E+00	1%
Nd150	2.469E+02	2.460E+02	2.484E+02	2.489E+02	2.452E+02	2.482E+02	2.473E+02	1.35E+00	1%

Table A.43: Results for fission products in cell calculation at discharge (g/tHMI) (continued)

	CEA/D	GRS	JAERI(J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Pm147	2.090E+02	1.954E+02	1.958E+02	1.963E+02	1.972E+02	1.657E+02	1.932E+02	1.32E+01	7%
Sm146	0.000E+00	0.000E+00	4.675E-03	5.134E-03	5.506E-07	4.250E-03	2.343E-03	2.36E-03	101%
Sm147	1.047E+02	1.003E+02	1.020E+02	1.022E+02	1.031E+02	8.994E+01	1.004E+02	4.84E+00	5%
Sm148	1.895E+02	1.990E+02	2.462E+02	2.459E+02	2.135E+02	2.799E+02	2.290E+02	3.13E+01	14%
Sm149	2.512E+00	2.539E+00	2.277E+00	2.267E+00	2.342E+00	2.372E+00	2.385E+00	1.06E-01	4%
Sm150	4.039E+02	4.017E+02	3.937E+02	3.940E+02	3.793E+02	4.127E+02	3.975E+02	1.04E+01	3%
Sm151	1.553E+01	1.601E+01	1.386E+01	1.385E+01	1.549E+01	1.404E+01	1.480E+01	8.98E-01	6%
Sm152	1.459E+02	1.667E+02	1.572E+02	1.331E+02	1.614E+02	1.436E+02	1.513E+02	1.15E+01	8%
Sm154	5.240E+01	5.136E+01	5.041E+01	5.068E+01	4.868E+01	5.284E+01	5.106E+01	1.37E+00	3%
Eu153	1.748E+02	1.697E+02	1.559E+02	1.686E+02	1.675E+02	1.634E+02	1.667E+02	5.86E+00	4%
Eu154	5.837E+01	3.215E+01	2.803E+01	3.039E+01	3.095E+01	3.094E+01	3.514E+01	1.05E+01	30%
Eu155	1.223E+01	1.303E+01	1.054E+01	1.138E+01	1.189E+01	1.184E+01	1.182E+01	7.61E-01	6%
Gd154	4.966E+00	3.041E+00	2.726E+00	2.996E+00	2.920E+00	3.031E+00	3.280E+00	7.61E-01	23%
Gd155	8.889E-02	8.498E-02	7.705E-02	8.594E-02	7.731E-02	7.919E-02	8.222E-02	4.58E-03	6%
Gd156	1.108E+02	1.279E+02	1.315E+02	1.404E+02	1.280E+02	1.326E+02	1.285E+02	8.95E+00	7%
Ho166m	7.762E-03	1.427E-03	2.630E-03	2.660E-03	3.731E-04	2.417E-03	2.878E-03	2.33E-03	81%

Table A.44: Results for fission products in cell calculation at 5 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Se79	6.688E+00	6.732E+00	6.741E+00	7.078E+00	7.073E+00	6.596E+00	7.515E+00	6.918E+00	3.00E-01	4%
Kr85	2.423E+01	2.451E+01	2.417E+01	3.092E+01	3.133E+01	2.370E+01	2.327E+01	2.602E+01	3.25E+00	12%
Rb85	1.488E+02	1.496E+02	1.435E+02	1.921E+02	1.913E+02	1.493E+02	1.449E+02	1.599E+02	2.02E+01	13%
Rb87	3.305E+02	3.328E+02	3.444E+02	3.350E+02	3.344E+02	3.359E+02	3.379E+02	3.358E+02	4.11E+00	1%
Sr88	4.601E+02	4.633E+02	4.845E+02	4.791E+02	4.783E+02	4.687E+02	4.855E+02	4.742E+02	9.45E+00	2%
Sr90	6.488E+02	6.535E+02	6.542E+02	6.566E+02	6.564E+02	6.458E+02	6.499E+02	6.522E+02	3.80E+00	1%
Nb93m	2.642E-03	2.784E-03	2.750E-03	2.487E-03	2.560E-03	2.639E-03	2.519E-03	2.626E-03	1.04E-04	4%
Mo95	1.042E+03	1.097E+03	1.085E+03	1.036E+03	1.035E+03	1.032E+03	1.037E+03	1.052E+03	2.50E+01	2%
Mo97	1.093E+03	1.136E+03	1.151E+03	1.108E+03	1.108E+03	1.107E+03	1.114E+03	1.117E+03	1.84E+01	2%
Tc99	1.080E+03	1.088E+03	1.099E+03	1.062E+03	1.053E+03	1.067E+03	1.094E+03	1.078E+03	1.61E+01	1%
Ru101	1.078E+03	1.082E+03	1.050E+03	1.072E+03	1.073E+03	1.074E+03	1.069E+03	1.071E+03	9.41E+00	1%
Ru106	6.449E+00	6.465E+00	6.560E+00	6.900E+00	7.073E+00	6.715E+00	6.612E+00	6.682E+00	2.15E-01	3%
Rh103	6.010E+02	6.031E+02	6.239E+02	5.797E+02	5.824E+02	6.203E+02	5.899E+02	6.001E+02	1.61E+01	3%
Pd107	3.013E+02	3.026E+02	3.092E+02	3.121E+02	3.135E+02	2.990E+02	3.110E+02	3.070E+02	5.41E+00	2%
Ag108m	2.912E-06	2.899E-06	4.887E-06	8.584E-06	8.825E-06	3.986E-06	1.595E-06	4.813E-06	2.64E-06	55%
Ag109	1.004E+02	1.010E+02	1.137E+02	1.158E+02	1.163E+02	1.131E+02	1.059E+02	1.095E+02	6.36E+00	6%
Ag110m	8.391E-03	8.486E-03	8.846E-03	1.117E-02	1.104E-02	6.841E-03	8.366E-03	9.020E-03	1.44E-03	16%
I127	6.175E+01	6.211E+01	5.955E+01	5.798E+01	5.803E+01	6.429E+01	7.851E+01	6.318E+01	6.61E+00	10%
I129	2.472E+02	2.486E+02	2.437E+02	2.516E+02	2.520E+02	2.385E+02	2.500E+02	2.474E+02	4.46E+00	2%
Xe130	1.278E+01	1.287E+01	1.288E+01	1.184E+01	1.187E+01	1.061E+01	1.765E+01	1.293E+01	2.07E+00	16%
Xe131	5.459E+02	5.480E+02	5.437E+02	5.362E+02	5.369E+02	5.487E+02	5.634E+02	5.461E+02	8.42E+00	2%
Xe132	1.534E+03	1.545E+03	1.566E+03	1.600E+03	1.601E+03	1.528E+03	1.549E+03	1.561E+03	2.78E+01	2%
Xe134	2.076E+03	2.089E+03	2.101E+03	2.103E+03	2.104E+03	2.107E+03	2.057E+03	2.091E+03	1.71E+01	1%
Xe136	3.150E+03	3.173E+03	3.236E+03	3.196E+03	3.203E+03	3.421E+03	3.182E+03	3.223E+03	8.44E+01	3%
Cs133	1.492E+03	1.504E+03	1.521E+03	1.518E+03	1.520E+03	1.496E+03	1.503E+03	1.508E+03	1.10E+01	1%
Cs134	3.560E+01	3.611E+01	4.062E+01	3.855E+01	3.855E+01	3.907E+01	3.634E+01	3.783E+01	1.71E+00	5%
Cs135	5.011E+02	5.054E+02	5.140E+02	5.019E+02	4.972E+02	5.076E+02	5.244E+02	5.073E+02	8.55E+00	2%
Cs137	1.485E+03	1.495E+03	1.469E+03	1.527E+03	1.527E+03	1.491E+03	1.476E+03	1.496E+03	2.14E+01	1%
Ba136	3.110E+01	3.146E+01	3.194E+01	3.099E+01	3.073E+01	2.835E+01	3.376E+01	3.119E+01	1.49E+00	5%
Ba138	1.806E+03	1.818E+03	1.816E+03	1.790E+03	1.790E+03	1.795E+03	1.785E+03	1.800E+03	1.25E+01	1%
La139	1.675E+03	1.687E+03	1.677E+03	1.685E+03	1.685E+03	1.677E+03	1.699E+03	1.683E+03	7.68E+00	0%
Ce140	1.689E+03	1.701E+03	1.730E+03	1.776E+03	1.776E+03	1.695E+03	1.699E+03	1.724E+03	3.52E+01	2%
Ce144	4.710E+00	4.714E+00	4.722E+00	4.761E+00	4.822E+00	4.773E+00	4.682E+00	4.740E+00	4.37E-02	1%
Nd142	3.278E+01	3.332E+01	3.316E+01	3.485E+01	3.483E+01	3.367E+01	4.156E+01	3.488E+01	2.82E+00	8%
Nd143	1.041E+03	1.046E+03	1.047E+03	1.026E+03	1.025E+03	1.044E+03	1.045E+03	1.039E+03	8.64E+00	1%
Nd144	1.869E+03	1.884E+03	1.888E+03	1.907E+03	1.906E+03	1.882E+03	1.872E+03	1.887E+03	1.39E+01	1%
Nd145	9.130E+02	9.189E+02	9.050E+02	9.129E+02	9.130E+02	9.096E+02	9.235E+02	9.137E+02	5.57E+00	1%
Nd146	9.877E+02	9.952E+02	9.965E+02	9.847E+02	9.848E+02	9.853E+02	9.750E+02	9.870E+02	6.71E+00	1%
Nd148	5.204E+02	5.238E+02	5.124E+02	5.186E+02	5.189E+02	5.130E+02	5.178E+02	5.178E+02	3.73E+00	1%
Nd150	2.469E+02	2.485E+02	2.460E+02	2.484E+02	2.489E+02	2.452E+02	2.482E+02	2.474E+02	1.32E+00	1%

Table A.44: Results for fission products in cell calculation at 5 years cooling (g/tHMI) (continued)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Pm147	5.805E+01	5.808E+01	5.445E+01	5.456E+01	5.471E+01	5.486E+01	4.657E+01	5.447E+01	3.55E+00	7%
Sm146	0.000E+00	0.000E+00	0.000E+00	5.892E-03	6.381E-03	5.506E-07	5.331E-03	2.515E-03	2.92E-03	116%
Sm147	2.641E+02	2.651E+02	2.498E+02	2.518E+02	2.523E+02	2.538E+02	2.177E+02	2.507E+02	1.46E+01	6%
Sm148	1.925E+02	1.946E+02	2.022E+02	2.494E+02	2.491E+02	2.168E+02	2.837E+02	2.269E+02	3.20E+01	14%
Sm149	4.180E+00	4.125E+00	4.201E+00	3.724E+00	3.715E+00	3.910E+00	3.864E+00	3.960E+00	1.93E-01	5%
Sm150	4.039E+02	4.066E+02	4.017E+02	3.937E+02	3.940E+02	3.793E+02	4.127E+02	3.988E+02	1.01E+01	3%
Sm151	1.522E+01	1.521E+01	1.570E+01	1.363E+01	1.361E+01	1.520E+01	1.380E+01	1.462E+01	8.35E-01	6%
Sm152	1.459E+02	1.461E+02	1.667E+02	1.572E+02	1.331E+02	1.614E+02	1.436E+02	1.506E+02	1.08E+01	7%
Sm154	5.241E+01	5.273E+01	5.136E+01	5.042E+01	5.068E+01	4.868E+01	5.284E+01	5.130E+01	1.40E+00	3%
Eu153	1.762E+02	1.772E+02	1.711E+02	1.572E+02	1.699E+02	1.689E+02	1.647E+02	1.693E+02	6.35E+00	4%
Eu154	3.901E+01	3.934E+01	2.149E+01	1.874E+01	2.030E+01	2.067E+01	2.068E+01	2.575E+01	8.53E+00	33%
Eu155	6.078E+00	6.052E+00	6.480E+00	5.241E+00	5.499E+00	5.671E+00	5.889E+00	5.844E+00	3.81E-01	7%
Gd154	2.432E+01	2.454E+01	1.370E+01	1.201E+01	1.308E+01	1.319E+01	1.329E+01	1.631E+01	5.16E+00	32%
Gd155	6.241E+00	6.213E+00	6.632E+00	5.373E+00	5.971E+00	6.301E+00	6.030E+00	6.109E+00	3.60E-01	6%
Gd156	1.164E+02	1.165E+02	1.344E+02	1.379E+02	1.471E+02	1.345E+02	1.391E+02	1.323E+02	1.07E+01	8%
Ho166m	7.740E-03	7.804E-03	1.423E-03	2.622E-03	2.652E-03	3.719E-04	2.410E-03	3.575E-03	2.76E-03	77%

Table A.45: Results for fission products in cell calculation at 50 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Se79	6.688E+00	6.732E+00	6.738E+00	7.075E+00	7.073E+00	6.596E+00	7.512E+00	6.916E+00	2.99E-01	4%
Kr85	1.320E+00	1.336E+00	1.320E+00	1.693E+00	1.727E+00	1.291E+00	1.271E+00	1.423E+00	1.83E-01	13%
Rb85	1.717E+02	1.728E+02	1.663E+02	2.213E+02	2.209E+02	1.719E+02	1.669E+02	1.845E+02	2.32E+01	13%
Rb87	3.305E+02	3.328E+02	3.444E+02	3.350E+02	3.344E+02	3.359E+02	3.379E+02	3.358E+02	4.11E+00	1%
Sr88	4.601E+02	4.633E+02	4.845E+02	4.791E+02	4.783E+02	4.687E+02	4.855E+02	4.742E+02	9.45E+00	2%
Sr90	2.223E+02	2.239E+02	2.243E+02	2.200E+02	2.219E+02	2.132E+02	2.228E+02	2.212E+02	3.51E+00	2%
Nb93m	9.250E-03	9.625E-03	8.600E-03	7.790E-03	8.895E-03	9.158E-03	7.853E-03	8.739E-03	6.49E-04	7%
Mo95	1.042E+03	1.097E+03	1.085E+03	1.036E+03	1.035E+03	1.032E+03	1.037E+03	1.052E+03	2.50E+01	2%
Mo97	1.093E+03	1.136E+03	1.151E+03	1.108E+03	1.108E+03	1.107E+03	1.114E+03	1.117E+03	1.84E+01	2%
Tc99	1.080E+03	1.088E+03	1.099E+03	1.062E+03	1.053E+03	1.067E+03	1.094E+03	1.077E+03	1.61E+01	1%
Ru101	1.078E+03	1.082E+03	1.050E+03	1.072E+03	1.073E+03	1.074E+03	1.069E+03	1.071E+03	9.41E+00	1%
Ru106	1.958E-08	2.365E-13	2.438E-13	3.425E-13	4.125E-13	3.216E-13	2.459E-13	2.798E-09	6.85E-09	245%
Rh103	6.010E+02	6.031E+02	6.239E+02	5.797E+02	5.824E+02	6.203E+02	5.899E+02	6.001E+02	1.61E+01	3%
Pd107	3.013E+02	3.026E+02	3.092E+02	3.121E+02	3.135E+02	2.990E+02	3.110E+02	3.070E+02	5.41E+00	2%
Ag108m	2.703E-06	2.691E-06	3.823E-06	6.716E-06	8.191E-06	3.119E-06	1.248E-06	4.070E-06	2.29E-06	56%
Ag109	1.004E+02	1.010E+02	1.137E+02	1.158E+02	1.163E+02	1.131E+02	1.059E+02	1.095E+02	6.36E+00	6%
Ag110m	2.095E-12	1.352E-22	1.449E-22	1.986E-22	1.766E-22	1.066E-22	0.000E+00	2.993E-13	7.33E-13	245%
I127	6.175E+01	6.211E+01	5.955E+01	5.798E+01	5.803E+01	6.429E+01	7.851E+01	6.318E+01	6.61E+00	10%
I129	2.472E+02	2.486E+02	2.437E+02	2.516E+02	2.520E+02	2.385E+02	2.500E+02	2.474E+02	4.46E+00	2%
Xe130	1.278E+01	1.287E+01	1.288E+01	1.184E+01	1.187E+01	1.061E+01	1.765E+01	1.293E+01	2.07E+00	16%
Xe131	5.459E+02	5.480E+02	5.437E+02	5.362E+02	5.369E+02	5.487E+02	5.634E+02	5.461E+02	8.42E+00	2%
Xe132	1.534E+03	1.545E+03	1.566E+03	1.600E+03	1.601E+03	1.528E+03	1.549E+03	1.561E+03	2.78E+01	2%
Xe134	2.076E+03	2.089E+03	2.101E+03	2.103E+03	2.104E+03	2.107E+03	2.057E+03	2.091E+03	1.71E+01	1%
Xe136	3.150E+03	3.173E+03	3.236E+03	3.196E+03	3.203E+03	3.421E+03	3.182E+03	3.223E+03	8.44E+01	3%
Cs133	1.492E+03	1.504E+03	1.521E+03	1.518E+03	1.520E+03	1.496E+03	1.503E+03	1.508E+03	1.10E+01	1%
Cs134	9.595E-06	9.740E-06	1.106E-05	1.049E-05	1.071E-05	1.053E-05	9.889E-06	1.029E-05	5.09E-07	5%
Cs135	5.010E+02	5.053E+02	5.140E+02	5.018E+02	4.972E+02	5.076E+02	5.244E+02	5.073E+02	8.55E+00	2%
Cs137	5.249E+02	5.285E+02	5.226E+02	5.435E+02	5.415E+02	5.271E+02	5.222E+02	5.301E+02	8.17E+00	2%
Ba136	3.110E+01	3.146E+01	3.194E+01	3.099E+01	3.073E+01	2.835E+01	3.376E+01	3.119E+01	1.49E+00	5%
Ba138	1.806E+03	1.818E+03	1.816E+03	1.790E+03	1.790E+03	1.795E+03	1.785E+03	1.800E+03	1.25E+01	1%
La139	1.675E+03	1.687E+03	1.677E+03	1.685E+03	1.685E+03	1.677E+03	1.699E+03	1.683E+03	7.68E+00	0%
Ce140	1.689E+03	1.701E+03	1.730E+03	1.776E+03	1.776E+03	1.695E+03	1.699E+03	1.724E+03	3.52E+01	2%
Ce144	1.997E-08	2.031E-17	1.943E-17	1.921E-17	2.146E-17	2.079E-17	1.958E-17	2.853E-09	6.99E-09	245%
Nd142	3.278E+01	3.332E+01	3.316E+01	3.485E+01	3.483E+01	3.367E+01	4.156E+01	3.488E+01	2.82E+00	8%
Nd143	1.041E+03	1.046E+03	1.047E+03	1.026E+03	1.025E+03	1.044E+03	1.045E+03	1.039E+03	8.64E+00	1%
Nd144	1.874E+03	1.889E+03	1.893E+03	1.912E+03	1.911E+03	1.887E+03	1.877E+03	1.892E+03	1.39E+01	1%
Nd145	9.130E+02	9.189E+02	9.050E+02	9.129E+02	9.130E+02	9.096E+02	9.235E+02	9.137E+02	5.57E+00	1%
Nd146	9.877E+02	9.952E+02	9.965E+02	9.847E+02	9.848E+02	9.853E+02	9.750E+02	9.870E+02	6.71E+00	1%
Nd148	5.204E+02	5.238E+02	5.124E+02	5.186E+02	5.189E+02	5.130E+02	5.178E+02	5.178E+02	3.73E+00	1%
Nd150	2.469E+02	2.485E+02	2.460E+02	2.484E+02	2.489E+02	2.452E+02	2.482E+02	2.474E+02	1.32E+00	1%

Table A.45: Results for fission products in cell calculation at 50 years cooling (g/tHMI) (continued)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Pm147	3.976E-04	3.981E-04	3.758E-04	3.763E-04	3.785E-04	3.758E-04	3.222E-04	3.749E-04	2.35E-05	6%
Sm146	0.000E+00	0.000E+00	0.000E+00	7.285E-03	7.808E-03	5.506E-07	6.559E-03	3.093E-03	3.59E-03	116%
Sm147	3.221E+02	3.231E+02	3.042E+02	3.063E+02	3.070E+02	3.087E+02	2.643E+02	3.051E+02	1.81E+01	6%
Sm148	1.925E+02	1.946E+02	2.022E+02	2.494E+02	2.491E+02	2.168E+02	2.837E+02	2.269E+02	3.20E+01	14%
Sm149	4.180E+00	4.125E+00	4.201E+00	3.724E+00	3.715E+00	3.910E+00	3.864E+00	3.960E+00	1.93E-01	5%
Sm150	4.039E+02	4.066E+02	4.017E+02	3.937E+02	3.940E+02	3.793E+02	4.127E+02	3.988E+02	1.01E+01	3%
Sm151	1.071E+01	1.070E+01	1.111E+01	9.640E+00	9.579E+00	1.075E+01	9.760E+00	1.032E+01	5.89E-01	6%
Sm152	1.459E+02	1.462E+02	1.667E+02	1.572E+02	1.331E+02	1.615E+02	1.436E+02	1.506E+02	1.08E+01	7%
Sm154	5.241E+01	5.273E+01	5.136E+01	5.042E+01	5.069E+01	4.868E+01	5.284E+01	5.130E+01	1.40E+00	3%
Eu153	1.762E+02	1.772E+02	1.711E+02	1.572E+02	1.699E+02	1.689E+02	1.647E+02	1.693E+02	6.35E+00	4%
Eu154	1.038E+00	1.047E+00	5.729E-01	4.996E-01	5.385E-01	5.476E-01	5.515E-01	6.849E-01	2.27E-01	33%
Eu155	1.124E-02	1.120E-02	1.208E-02	9.766E-03	7.871E-03	7.232E-03	1.097E-02	1.005E-02	1.71E-03	17%
Gd154	6.228E+01	6.283E+01	3.461E+01	3.025E+01	3.284E+01	3.332E+01	3.342E+01	4.136E+01	1.35E+01	33%
Gd155	1.231E+01	1.225E+01	1.310E+01	1.060E+01	1.146E+01	1.197E+01	1.191E+01	1.194E+01	7.17E-01	6%
Gd156	1.164E+02	1.165E+02	1.344E+02	1.379E+02	1.471E+02	1.345E+02	1.391E+02	1.323E+02	1.07E+01	8%
Ho166m	7.541E-03	7.604E-03	1.386E-03	2.555E-03	2.585E-03	3.622E-04	2.349E-03	3.483E-03	2.69E-03	77%

Table A.46: Results for fission products in cell calculation at 100 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Se79	6.688E+00	6.732E+00	6.734E+00	7.071E+00	7.072E+00	6.594E+00	7.508E+00	6.914E+00	2.98E-01	4%
Kr85	5.208E-02	5.268E-02	5.217E-02	6.711E-02	6.897E-02	5.094E-02	5.023E-02	5.631E-02	7.47E-03	13%
Rb85	1.730E+02	1.741E+02	1.676E+02	2.230E+02	2.226E+02	1.732E+02	1.681E+02	1.859E+02	2.34E+01	13%
Rb87	3.305E+02	3.328E+02	3.444E+02	3.350E+02	3.344E+02	3.359E+02	3.379E+02	3.358E+02	4.11E+00	1%
Sr88	4.601E+02	4.633E+02	4.845E+02	4.791E+02	4.783E+02	4.687E+02	4.855E+02	4.742E+02	9.45E+00	2%
Sr90	6.762E+01	6.812E+01	6.828E+01	6.525E+01	6.650E+01	6.225E+01	6.784E+01	6.655E+01	2.01E+00	3%
Nb93m	1.027E-02	1.068E-02	9.202E-03	8.339E-03	9.842E-03	1.013E-02	8.405E-03	9.552E-03	8.54E-04	9%
Mo95	1.042E+03	1.097E+03	1.085E+03	1.036E+03	1.035E+03	1.032E+03	1.037E+03	1.052E+03	2.50E+01	2%
Mo97	1.093E+03	1.136E+03	1.151E+03	1.108E+03	1.108E+03	1.107E+03	1.114E+03	1.117E+03	1.84E+01	2%
Tc99	1.080E+03	1.088E+03	1.099E+03	1.062E+03	1.052E+03	1.066E+03	1.094E+03	1.077E+03	1.62E+01	1%
Ru101	1.078E+03	1.082E+03	1.050E+03	1.072E+03	1.073E+03	1.074E+03	1.069E+03	1.071E+03	9.41E+00	1%
Ru106	2.890E-09	3.502E-09	0.000E+00	5.652E-28	8.145E-28	5.096E-28	0.000E+00	9.132E-10	1.45E-09	159%
Rh103	6.010E+02	6.031E+02	6.239E+02	5.797E+02	5.824E+02	6.203E+02	5.899E+02	6.001E+02	1.61E+01	3%
Pd107	3.013E+02	3.026E+02	3.092E+02	3.121E+02	3.135E+02	2.990E+02	3.110E+02	3.070E+02	5.41E+00	2%
Ag108m	2.487E-06	2.477E-06	2.911E-06	5.113E-06	7.540E-06	2.373E-06	9.499E-07	3.407E-06	2.04E-06	60%
Ag109	1.004E+02	1.010E+02	1.137E+02	1.158E+02	1.163E+02	1.131E+02	1.059E+02	1.095E+02	6.36E+00	6%
Ag110m	3.091E-13	2.245E-13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.623E-14	1.23E-13	161%
I127	6.175E+01	6.211E+01	5.955E+01	5.798E+01	5.803E+01	6.429E+01	7.851E+01	6.318E+01	6.61E+00	10%
I129	2.472E+02	2.486E+02	2.437E+02	2.516E+02	2.520E+02	2.385E+02	2.500E+02	2.474E+02	4.46E+00	2%
Xe130	1.278E+01	1.287E+01	1.288E+01	1.184E+01	1.187E+01	1.061E+01	1.765E+01	1.293E+01	2.07E+00	16%
Xe131	5.459E+02	5.480E+02	5.437E+02	5.362E+02	5.369E+02	5.487E+02	5.634E+02	5.461E+02	8.42E+00	2%
Xe132	1.534E+03	1.545E+03	1.566E+03	1.600E+03	1.601E+03	1.528E+03	1.549E+03	1.561E+03	2.78E+01	2%
Xe134	2.076E+03	2.089E+03	2.101E+03	2.103E+03	2.104E+03	2.107E+03	2.057E+03	2.091E+03	1.71E+01	1%
Xe136	3.150E+03	3.173E+03	3.236E+03	3.196E+03	3.203E+03	3.421E+03	3.182E+03	3.223E+03	8.44E+01	3%
Cs133	1.492E+03	1.504E+03	1.521E+03	1.518E+03	1.520E+03	1.496E+03	1.503E+03	1.508E+03	1.10E+01	1%
Cs134	5.391E-13	4.063E-12	5.610E-13	5.323E-13	5.563E-13	5.284E-13	5.017E-13	1.040E-12	1.23E-12	119%
Cs135	5.010E+02	5.053E+02	5.139E+02	5.018E+02	4.972E+02	5.076E+02	5.244E+02	5.073E+02	8.54E+00	2%
Cs137	1.653E+02	1.665E+02	1.658E+02	1.725E+02	1.712E+02	1.660E+02	1.646E+02	1.674E+02	2.85E+00	2%
Ba136	3.110E+01	3.146E+01	3.194E+01	3.099E+01	3.073E+01	2.835E+01	3.376E+01	3.119E+01	1.49E+00	5%
Ba138	1.806E+03	1.818E+03	1.816E+03	1.790E+03	1.790E+03	1.795E+03	1.785E+03	1.800E+03	1.25E+01	1%
La139	1.675E+03	1.687E+03	1.677E+03	1.685E+03	1.685E+03	1.677E+03	1.699E+03	1.683E+03	7.68E+00	0%
Ce140	1.689E+03	1.701E+03	1.730E+03	1.776E+03	1.776E+03	1.695E+03	1.699E+03	1.724E+03	3.52E+01	2%
Ce144	2.946E-09	1.923E-09	0.000E+00	9.055E-37	1.127E-36	1.057E-36	0.000E+00	6.956E-10	1.13E-09	163%
Nd142	3.278E+01	3.332E+01	3.316E+01	3.485E+01	3.483E+01	3.367E+01	4.156E+01	3.488E+01	2.82E+00	8%
Nd143	1.041E+03	1.046E+03	1.047E+03	1.026E+03	1.025E+03	1.044E+03	1.045E+03	1.039E+03	8.64E+00	1%
Nd144	1.874E+03	1.889E+03	1.893E+03	1.912E+03	1.911E+03	1.887E+03	1.877E+03	1.892E+03	1.39E+01	1%
Nd145	9.130E+02	9.189E+02	9.050E+02	9.129E+02	9.130E+02	9.096E+02	9.235E+02	9.137E+02	5.57E+00	1%
Nd146	9.877E+02	9.952E+02	9.965E+02	9.847E+02	9.848E+02	9.853E+02	9.750E+02	9.870E+02	6.71E+00	1%
Nd148	5.204E+02	5.238E+02	5.124E+02	5.186E+02	5.189E+02	5.130E+02	5.178E+02	5.178E+02	3.73E+00	1%
Nd150	2.469E+02	2.485E+02	2.460E+02	2.484E+02	2.489E+02	2.452E+02	2.482E+02	2.474E+02	1.32E+00	1%

Table A.46: Results for fission products in cell calculation at 100 years cooling (g/tHMI) (continued)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Pm147	8.757E-09	3.693E-09	6.926E-10	6.932E-10	6.993E-10	6.864E-10	5.953E-10	2.259E-09	2.85E-09	126%
Sm146	0.000E+00	0.000E+00	0.000E+00	7.290E-03	7.813E-03	5.506E-07	6.564E-03	3.095E-03	3.59E-03	116%
Sm147	3.221E+02	3.231E+02	3.042E+02	3.063E+02	3.070E+02	3.087E+02	2.643E+02	3.051E+02	1.81E+01	6%
Sm148	1.925E+02	1.946E+02	2.022E+02	2.494E+02	2.491E+02	2.168E+02	2.837E+02	2.269E+02	3.20E+01	14%
Sm149	4.180E+00	4.125E+00	4.201E+00	3.724E+00	3.715E+00	3.910E+00	3.864E+00	3.960E+00	1.93E-01	5%
Sm150	4.039E+02	4.066E+02	4.017E+02	3.937E+02	3.940E+02	3.793E+02	4.127E+02	3.988E+02	1.01E+01	3%
Sm151	7.246E+00	7.241E+00	7.558E+00	6.560E+00	6.483E+00	7.314E+00	6.642E+00	7.006E+00	3.99E-01	6%
Sm152	1.459E+02	1.462E+02	1.667E+02	1.572E+02	1.331E+02	1.615E+02	1.436E+02	1.506E+02	1.08E+01	7%
Sm154	5.241E+01	5.273E+01	5.136E+01	5.042E+01	5.069E+01	4.868E+01	5.284E+01	5.130E+01	1.40E+00	3%
Eu153	1.762E+02	1.772E+02	1.711E+02	1.572E+02	1.699E+02	1.689E+02	1.647E+02	1.693E+02	6.35E+00	4%
Eu154	1.845E-02	1.861E-02	1.021E-02	8.906E-03	9.543E-03	9.687E-03	9.831E-03	1.218E-02	4.03E-03	33%
Eu155	1.034E-05	1.030E-05	1.120E-05	9.052E-06	5.443E-06	4.398E-06	1.017E-05	8.700E-06	2.48E-06	28%
Gd154	6.330E+01	6.386E+01	3.518E+01	3.074E+01	3.337E+01	3.386E+01	3.396E+01	4.204E+01	1.37E+01	33%
Gd155	1.232E+01	1.227E+01	1.311E+01	1.061E+01	1.147E+01	1.197E+01	1.192E+01	1.195E+01	7.17E-01	6%
Gd156	1.164E+02	1.165E+02	1.344E+02	1.379E+02	1.471E+02	1.345E+02	1.391E+02	1.323E+02	1.07E+01	8%
Ho166m	7.327E-03	7.387E-03	1.347E-03	2.482E-03	2.511E-03	3.520E-04	2.282E-03	3.384E-03	2.61E-03	77%

Table A.47: Results for fission products in cell calculation at 300 years cooling (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Se79	6.687E+00	6.731E+00	6.720E+00	7.056E+00	7.071E+00	6.591E+00	7.492E+00	6.907E+00	2.94E-01	4%
Kr85	1.261E-07	1.275E-07	1.273E-07	1.657E-07	1.756E-07	1.232E-07	1.227E-07	1.383E-07	2.07E-08	15%
Rb85	1.730E+02	1.741E+02	1.677E+02	2.230E+02	2.226E+02	1.733E+02	1.682E+02	1.860E+02	2.34E+01	13%
Rb87	3.305E+02	3.328E+02	3.444E+02	3.350E+02	3.344E+02	3.359E+02	3.379E+02	3.358E+02	4.11E+00	1%
Sr88	4.601E+02	4.633E+02	4.845E+02	4.791E+02	4.783E+02	4.687E+02	4.855E+02	4.742E+02	9.45E+00	2%
Sr90	5.789E-01	5.831E-01	5.863E-01	5.053E-01	5.364E-01	4.522E-01	5.828E-01	5.464E-01	4.78E-02	9%
Nb93m	1.041E-02	1.081E-02	9.239E-03	8.386E-03	9.968E-03	1.026E-02	8.451E-03	9.645E-03	8.93E-04	9%
Mo95	1.042E+03	1.097E+03	1.085E+03	1.036E+03	1.035E+03	1.032E+03	1.037E+03	1.052E+03	2.50E+01	2%
Mo97	1.093E+03	1.136E+03	1.151E+03	1.108E+03	1.108E+03	1.107E+03	1.114E+03	1.117E+03	1.84E+01	2%
Tc99	1.079E+03	1.087E+03	1.098E+03	1.061E+03	1.052E+03	1.066E+03	1.093E+03	1.076E+03	1.61E+01	1%
Ru101	1.078E+03	1.082E+03	1.050E+03	1.072E+03	1.073E+03	1.074E+03	1.069E+03	1.071E+03	9.41E+00	1%
Ru106	3.472E-12	3.736E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.030E-12	1.63E-12	158%
Rh103	6.010E+02	6.031E+02	6.239E+02	5.797E+02	5.824E+02	6.203E+02	5.899E+02	6.001E+02	1.61E+01	3%
Pd107	3.013E+02	3.026E+02	3.092E+02	3.121E+02	3.135E+02	2.990E+02	3.110E+02	3.070E+02	5.41E+00	2%
Ag108m	1.785E-06	1.778E-06	9.778E-07	1.718E-06	5.414E-06	7.968E-07	3.191E-07	1.827E-06	1.56E-06	85%
Ag109	1.004E+02	1.010E+02	1.137E+02	1.158E+02	1.163E+02	1.131E+02	1.059E+02	1.095E+02	6.36E+00	6%
Ag110m	2.827E-16	6.149E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.282E-16	2.21E-16	173%
I127	6.175E+01	6.211E+01	5.955E+01	5.798E+01	5.803E+01	6.429E+01	7.851E+01	6.318E+01	6.61E+00	10%
I129	2.472E+02	2.486E+02	2.437E+02	2.516E+02	2.520E+02	2.385E+02	2.500E+02	2.474E+02	4.46E+00	2%
Xe130	1.278E+01	1.287E+01	1.288E+01	1.184E+01	1.187E+01	1.061E+01	1.765E+01	1.293E+01	2.07E+00	16%
Xe131	5.459E+02	5.480E+02	5.437E+02	5.362E+02	5.369E+02	5.487E+02	5.634E+02	5.461E+02	8.42E+00	2%
Xe132	1.534E+03	1.545E+03	1.566E+03	1.600E+03	1.601E+03	1.528E+03	1.549E+03	1.561E+03	2.78E+01	2%
Xe134	2.076E+03	2.089E+03	2.101E+03	2.103E+03	2.104E+03	2.107E+03	2.057E+03	2.091E+03	1.71E+01	1%
Xe136	3.150E+03	3.173E+03	3.236E+03	3.196E+03	3.203E+03	3.421E+03	3.182E+03	3.223E+03	8.44E+01	3%
Cs133	1.492E+03	1.504E+03	1.521E+03	1.518E+03	1.520E+03	1.496E+03	1.503E+03	1.508E+03	1.10E+01	1%
Cs134	2.030E-15	2.470E-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.819E-15	8.56E-15	224%
Cs135	5.010E+02	5.053E+02	5.139E+02	5.018E+02	4.972E+02	5.076E+02	5.244E+02	5.073E+02	8.55E+00	2%
Cs137	1.628E+00	1.639E+00	1.680E+00	1.748E+00	1.708E+00	1.635E+00	1.625E+00	1.666E+00	4.39E-02	3%
Ba136	3.110E+01	3.146E+01	3.194E+01	3.099E+01	3.073E+01	2.835E+01	3.376E+01	3.119E+01	1.49E+00	5%
Ba138	1.806E+03	1.818E+03	1.816E+03	1.790E+03	1.790E+03	1.795E+03	1.785E+03	1.800E+03	1.25E+01	1%
La139	1.675E+03	1.687E+03	1.677E+03	1.685E+03	1.685E+03	1.677E+03	1.699E+03	1.683E+03	7.68E+00	0%
Ce140	1.689E+03	1.701E+03	1.730E+03	1.776E+03	1.776E+03	1.695E+03	1.699E+03	1.724E+03	3.52E+01	2%
Ce144	2.562E-12	1.867E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.327E-13	1.02E-12	161%
Nd142	3.278E+01	3.332E+01	3.316E+01	3.485E+01	3.483E+01	3.367E+01	4.156E+01	3.488E+01	2.82E+00	8%
Nd143	1.041E+03	1.046E+03	1.047E+03	1.026E+03	1.025E+03	1.044E+03	1.045E+03	1.039E+03	8.64E+00	1%
Nd144	1.874E+03	1.889E+03	1.893E+03	1.912E+03	1.911E+03	1.887E+03	1.877E+03	1.892E+03	1.39E+01	1%
Nd145	9.130E+02	9.189E+02	9.050E+02	9.129E+02	9.130E+02	9.096E+02	9.235E+02	9.137E+02	5.57E+00	1%
Nd146	9.877E+02	9.952E+02	9.965E+02	9.847E+02	9.848E+02	9.853E+02	9.750E+02	9.870E+02	6.71E+00	1%
Nd148	5.204E+02	5.238E+02	5.124E+02	5.186E+02	5.189E+02	5.130E+02	5.178E+02	5.178E+02	3.73E+00	1%
Nd150	2.469E+02	2.485E+02	2.460E+02	2.484E+02	2.489E+02	2.452E+02	2.482E+02	2.474E+02	1.32E+00	1%

Table A.47: Results for fission products in cell calculation at 300 years cooling (g/tHMI) (continued)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Pm147	5.423E-12	2.504E-12	0.000E+00	0.000E+00	0.000E+00	7.648E-33	0.000E+00	1.132E-12	1.95E-12	172%
Sm146	0.000E+00	0.000E+00	0.000E+00	7.290E-03	7.813E-03	5.506E-07	6.564E-03	3.095E-03	3.59E-03	116%
Sm147	3.221E+02	3.231E+02	3.042E+02	3.063E+02	3.070E+02	3.087E+02	2.643E+02	3.051E+02	1.81E+01	6%
Sm148	1.925E+02	1.946E+02	2.022E+02	2.494E+02	2.491E+02	2.168E+02	2.837E+02	2.269E+02	3.20E+01	14%
Sm149	4.180E+00	4.125E+00	4.201E+00	3.724E+00	3.715E+00	3.910E+00	3.864E+00	3.960E+00	1.93E-01	5%
Sm150	4.039E+02	4.066E+02	4.017E+02	3.937E+02	3.940E+02	3.793E+02	4.127E+02	3.988E+02	1.01E+01	3%
Sm151	1.519E+00	1.518E+00	1.621E+00	1.407E+00	1.361E+00	1.567E+00	1.425E+00	1.488E+00	8.67E-02	6%
Sm152	1.459E+02	1.462E+02	1.667E+02	1.572E+02	1.331E+02	1.615E+02	1.436E+02	1.506E+02	1.08E+01	7%
Sm154	5.241E+01	5.273E+01	5.136E+01	5.042E+01	5.069E+01	4.868E+01	5.284E+01	5.130E+01	1.40E+00	3%
Eu153	1.762E+02	1.772E+02	1.711E+02	1.572E+02	1.699E+02	1.689E+02	1.647E+02	1.693E+02	6.35E+00	4%
Eu154	1.842E-09	1.858E-09	1.030E-09	8.993E-10	9.410E-10	9.494E-10	9.927E-10	1.216E-09	4.03E-10	33%
Eu155	2.068E-12	1.105E-12	8.301E-18	6.680E-18	1.244E-18	6.005E-19	6.684E-18	4.533E-13	7.62E-13	168%
Gd154	6.332E+01	6.388E+01	3.519E+01	3.075E+01	3.338E+01	3.386E+01	3.397E+01	4.205E+01	1.37E+01	33%
Gd155	1.232E+01	1.227E+01	1.311E+01	1.061E+01	1.147E+01	1.197E+01	1.192E+01	1.195E+01	7.17E-01	6%
Gd156	1.164E+02	1.165E+02	1.344E+02	1.379E+02	1.471E+02	1.345E+02	1.391E+02	1.323E+02	1.07E+01	8%
Ho166m	6.527E-03	6.581E-03	1.200E-03	2.212E-03	2.238E-03	3.138E-04	2.033E-03	3.015E-03	2.33E-03	77%

Table A.48: Trends of relative standard deviation with cooling time for fission products in cell calculation

	Discharge	5 years	50 years	100 years	300 years
Se79	5%	4%	4%	4%	4%
Kr85	13%	12%	13%	13%	15%
Rb85	13%	13%	13%	13%	13%
Rb87	1%	1%	1%	1%	1%
Sr88	2%	2%	2%	2%	2%
Sr90	1%	1%	2%	3%	9%
Nb93m	3%	4%	7%	9%	9%
Mo95	2%	2%	2%	2%	2%
Mo97	2%	2%	2%	2%	2%
Tc99	2%	1%	1%	1%	1%
Ru101	1%	1%	1%	1%	1%
Ru106	1%	3%	245%	159%	158%
Rh103	3%	3%	3%	3%	3%
Pd107	2%	2%	2%	2%	2%
Ag108m	53%	55%	56%	60%	85%
Ag109	5%	6%	6%	6%	6%
Ag110m	17%	16%	245%	161%	173%
I127	11%	10%	10%	10%	10%
I129	2%	2%	2%	2%	2%
Xe130	17%	16%	16%	16%	16%
Xe131	2%	2%	2%	2%	2%
Xe132	2%	2%	2%	2%	2%
Xe134	1%	1%	1%	1%	1%
Xe136	3%	3%	3%	3%	3%
Cs133	1%	1%	1%	1%	1%
Cs134	4%	5%	5%	119%	224%
Cs135	2%	2%	2%	2%	2%
Cs137	2%	1%	2%	2%	3%
Ba136	5%	5%	5%	5%	5%
Ba138	1%	1%	1%	1%	1%
La139	0%	0%	0%	0%	0%
Ce140	2%	2%	2%	2%	2%
Ce144	1%	1%	245%	163%	161%
Nd142	8%	8%	8%	8%	8%
Nd143	1%	1%	1%	1%	1%
Nd144	1%	1%	1%	1%	1%
Nd145	1%	1%	1%	1%	1%
Nd146	1%	1%	1%	1%	1%
Nd148	1%	1%	1%	1%	1%
Nd150	1%	1%	1%	1%	1%

Table A.48: Trends of relative standard deviation with cooling time for fission products in cell calculation (continued)

	Discharge	5 years	50 years	100 years	300 years
Pm147	7%	7%	6%	126%	172%
Sm146	101%	116%	116%	116%	116%
Sm147	5%	6%	6%	6%	6%
Sm148	14%	14%	14%	14%	14%
Sm149	4%	5%	5%	5%	5%
Sm150	3%	3%	3%	3%	3%
Sm151	6%	6%	6%	6%	6%
Sm152	8%	7%	7%	7%	7%
Sm154	3%	3%	3%	3%	3%
Eu153	4%	4%	4%	4%	4%
Eu154	30%	33%	33%	33%	33%
Eu155	6%	7%	17%	28%	168%
Gd154	23%	32%	33%	33%	33%
Gd155	6%	6%	6%	6%	6%
Gd156	7%	8%	8%	8%	8%
Ho166m	81%	77%	77%	77%	77%

Table A.49: Results for activation products in cell calculation at discharge (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Cl36	2.112E+00		2.089E+00	2.221E+00	2.727E+00	1.999E+00	1.932E+00	2.180E+00	2.61E-01	12%
Ca41	3.448E-01		8.769E-01	3.688E-01	3.700E-01	8.778E-01	3.446E-01	5.305E-01	2.45E-01	46%
Mn53	8.035E-05							8.035E-05		
Mn54	1.024E-02		8.252E-03	9.706E-03	1.031E-02	1.023E-02	5.557E-03	9.050E-03	1.72E-03	19%
Fe55	1.331E-01		1.589E-01	1.395E-01	1.425E-01	1.571E-01	1.173E-01	1.414E-01	1.42E-02	10%
Fe60	1.364E-05							1.364E-05		
Co60	1.536E+00		1.536E+00	1.608E+00	1.612E+00	1.537E+00	2.101E+00	1.655E+00	2.02E-01	12%
Ni59	2.232E+00		2.336E+00	2.236E+00	2.300E+00	2.961E+00	1.909E+00	2.329E+00	3.15E-01	14%
Ni63	4.426E-01		4.220E-01	4.723E-01	4.745E-01	4.419E-01	4.011E-01	4.424E-01	2.60E-02	6%
Mo93	7.228E-02		7.267E-02	7.844E-02	7.854E-02	7.136E-02	2.381E-02	6.618E-02	1.92E-02	29%

Table A.50: Results for activation products in cell calculation at 5 years (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Cl36	2.112E+00	2.109E+00	2.089E+00	2.221E+00	2.727E+00	1.999E+00	1.932E+00	2.170E+00	2.43E-01	11%
Ca41	3.448E-01	3.440E-01	8.769E-01	3.687E-01	3.700E-01	8.778E-01	3.445E-01	5.038E-01	2.36E-01	47%
Mn53	8.035E-05	7.976E-05						8.005E-05	2.93E-07	0%
Mn54	1.783E-04	1.782E-04	1.441E-04	1.694E-04	1.801E-04	1.771E-04	9.701E-05	1.606E-04	2.85E-05	18%
Fe55	3.687E-02	3.796E-02	4.406E-02	3.682E-02	3.760E-02	4.415E-02	3.095E-02	3.834E-02	4.25E-03	11%
Fe60	1.364E-05	1.370E-05						1.367E-05	2.86E-08	0%
Co60	7.955E-01	7.968E-01	7.963E-01	8.334E-01	8.356E-01	7.966E-01	1.089E+00	8.490E-01	9.93E-02	12%
Ni59	2.231E+00	2.234E+00	2.336E+00	2.236E+00	2.300E+00	2.961E+00	1.909E+00	2.315E+00	2.94E-01	13%
Ni63	4.275E-01	4.290E-01	4.070E-01	4.549E-01	4.570E-01	4.269E-01	3.863E-01	4.269E-01	2.31E-02	5%
Mo93	7.221E-02	7.228E-02	7.259E-02	7.836E-02	7.847E-02	7.127E-02	2.379E-02	6.700E-02	1.79E-02	27%

Table A.51: Results for activation products in cell calculation at 50 years (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Cl36	2.112E+00	2.109E+00	2.089E+00	2.221E+00	2.726E+00	1.998E+00	1.932E+00	2.170E+00	2.43E-01	11%
Ca41	3.447E-01	3.439E-01	8.766E-01	3.686E-01	3.699E-01	8.778E-01	3.444E-01	5.037E-01	2.36E-01	47%
Mn53	8.035E-05	7.976E-05						8.005E-05	2.93E-07	0%
Mn54	2.622E-20	2.625E-20	2.169E-20	2.552E-20	2.712E-20	2.481E-20		2.527E-20	1.75E-21	7%
Fe55	3.545E-07	3.652E-07	4.268E-07	2.288E-07	2.337E-07	4.818E-07	1.923E-07	3.262E-07	1.02E-07	31%
Fe60	1.364E-05	1.370E-05						1.367E-05	2.86E-08	0%
Co60	2.133E-03	2.137E-03	2.152E-03	2.249E-03	2.255E-03	2.144E-03	2.938E-03	2.287E-03	2.70E-04	12%
Ni59	2.231E+00	2.233E+00	2.335E+00	2.235E+00	2.299E+00	2.960E+00	1.908E+00	2.314E+00	2.94E-01	13%
Ni63	3.130E-01	3.141E-01	2.942E-01	3.242E-01	3.257E-01	3.126E-01	2.753E-01	3.084E-01	1.65E-02	5%
Mo93	7.157E-02	7.164E-02	7.183E-02	7.766E-02	7.788E-02	7.065E-02	2.358E-02	6.640E-02	1.77E-02	27%

Table A.52: Results for activation products in cell calculation at 100 years (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Cl36	2.111E+00	2.109E+00	2.089E+00	2.221E+00	2.726E+00	1.998E+00	1.931E+00	2.169E+00	2.43E-01	11%
Ca41	3.446E-01	3.438E-01	8.763E-01	3.684E-01	3.697E-01	8.770E-01	3.443E-01	5.034E-01	2.36E-01	47%
Mn53	8.035E-05	7.976E-05						8.005E-05	2.93E-07	0%
Mn54	6.710E-38	6.720E-38		6.710E-38	7.131E-38	5.664E-38		6.587E-38	4.89E-39	7%
Fe55	9.443E-13	9.727E-13	1.146E-12	3.753E-13	3.833E-13	1.477E-12	3.155E-13	8.020E-13	4.17E-13	52%
Fe60	1.364E-05	1.370E-05						1.367E-05	2.85E-08	0%
Co60	2.963E-06	2.968E-06	3.018E-06	3.146E-06	3.154E-06	2.990E-06	4.110E-06	3.193E-06	3.82E-07	12%
Ni59	2.230E+00	2.232E+00	2.334E+00	2.234E+00	2.298E+00	2.959E+00	1.907E+00	2.313E+00	2.93E-01	13%
Ni63	2.214E-01	2.221E-01	2.051E-01	2.225E-01	2.235E-01	2.211E-01	1.889E-01	2.149E-01	1.22E-02	6%
Mo93	7.087E-02	7.094E-02	7.100E-02	7.690E-02	7.723E-02	6.995E-02	2.335E-02	6.575E-02	1.75E-02	27%

Table A.53: Results for activation products in cell calculation at 300 years (g/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD (%)
Cl36	2.110E+00	2.108E+00	2.088E+00	2.220E+00	2.725E+00	1.998E+00	1.930E+00	2.168E+00	2.42E-01	11%
Ca41	3.442E-01	3.433E-01	8.751E-01	3.678E-01	3.691E-01	8.763E-01	3.437E-01	5.028E-01	2.36E-01	47%
Mn53	8.034E-05	7.976E-05						8.005E-05	2.93E-07	0%
Mn54										
Fe55										
Fe60	1.364E-05	1.370E-05						1.367E-05	2.89E-08	0%
Co60	9.567E-12	1.104E-17	1.162E-17	1.204E-17	1.207E-17	1.132E-17	1.592E-17	1.367E-12	3.35E-12	245%
Ni59	2.230E+00	2.228E+00	2.330E+00	2.230E+00	2.294E+00	2.954E+00	1.904E+00	2.310E+00	2.93E-01	13%
Ni63	5.536E-02	5.556E-02	4.843E-02	4.935E-02	4.958E-02	5.536E-02	4.191E-02	5.079E-02	4.67E-03	9%
Mo93	6.811E-02	6.818E-02	6.777E-02	7.391E-02	7.467E-02	6.724E-02	2.244E-02	6.319E-02	1.69E-02	27%

Table A.54: Trends of relative standard deviation with cooling time for activation products in cell calculation

	Discharge	5 years	50 years	100 years	300 years
Cl36	12%	11%	11%	11%	11%
Ca41	46%	47%	47%	47%	47%
Mn53		0%	0%	0%	0%
Mn54	19%	18%	7%	7%	
Fe55	10%	11%	31%	52%	
Fe60		0%	0%	0%	0%
Co60	12%	12%	12%	12%	
Ni59	14%	13%	13%	13%	13%
Ni63	6%	5%	5%	6%	9%
Mo93	29%	27%	27%	27%	27%

Table A.55: Results for activation-fission products in cell calculation at discharge (g/tHMI)

		CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	average	SD	RSD(%)
H3	FP	8.301E-02			7.848E-02	7.867E-02	7.636E-02	7.822E-02	7.895E-02	2.19E-03	3%
	AP	8.859E-04			8.977E-10	9.040E-10		7.608E-08	2.215E-04	3.84E-04	173%
	FP+AP	8.389E-02		8.324E-02	7.848E-02	7.867E-02	7.636E-02	7.822E-02	7.981E-02	2.77E-03	3%
Be10	FP	1.276E-02			1.826E-04	1.826E-04	1.500E-02	1.821E-04	5.662E-03	6.75E-03	119%
	AP	1.708E-03			1.253E-04	1.323E-04	1.281E-06	8.610E-05	4.105E-04	6.90E-04	168%
	FP+AP	1.447E-02		1.513E-04	3.079E-04	3.149E-04	1.500E-02	2.682E-04	5.086E-03	6.83E-03	134%
C14	FP	3.942E-03			3.691E-05	3.692E-05	4.837E-03	3.682E-05	1.778E-03	2.15E-03	121%
	AP	1.204E-01			5.642E-02	5.849E-02	1.375E-01	5.110E-02	8.478E-02	2.83E-02	33%
	FP+AP	1.243E-01		1.575E-01	5.646E-02	5.853E-02	1.424E-01	5.113E-02	9.838E-02	4.41E-02	45%
Zr93	FP	9.705E+02			9.926E+02	9.890E+02	9.731E+02	1.000E+03	9.851E+02	1.15E+01	1%
	AP	2.764E-02			6.599E-02	6.326E-02	2.609E-02	5.061E-02	4.672E-02	1.51E-02	32%
	FP+AP	9.706E+02		1.004E+03	9.927E+02	9.890E+02	9.731E+02	1.000E+03	9.883E+02	1.26E+01	1%
Nb94	FP	5.814E-04			1.448E-03	1.542E-03	6.806E-04	1.041E-03	1.058E-03	3.89E-04	37%
	AP	1.464E+00			1.169E+00	1.167E+00	1.585E+00	1.411E+00	1.359E+00	1.36E-01	10%
	FP+AP	1.464E+00		1.406E+00	1.171E+00	1.169E+00	1.586E+00	1.412E+00	1.368E+00	1.52E-01	11%
Sn119m	FP	1.488E-02			1.317E-02	1.594E-02	8.842E-02	6.314E-02	3.911E-02	3.10E-02	79%
	AP	1.134E-02			2.434E-02	2.790E-02	7.222E-02	4.322E-02	3.580E-02	1.14E-02	32%
	FP+AP	2.622E-02		7.000E-02	3.751E-02	4.384E-02	1.606E-01	1.064E-01	7.409E-02	4.67E-02	63%
Sn121m	FP	7.127E-01			6.330E-02	6.344E-02	3.836E-02	4.872E-03	1.765E-01	2.69E-01	152%
	AP	9.394E-04			4.240E-04	4.242E-04	4.871E-04	3.625E-04	5.274E-04	2.33E-04	44%
	FP+AP	7.137E-01		6.963E-03	6.372E-02	6.386E-02	3.885E-02	5.235E-03	1.487E-01	2.54E-01	171%
Sn126	FP	3.962E+01			3.329E+01	3.340E+01	2.945E+01	3.820E+01	3.479E+01	3.68E+00	11%
	AP	3.797E-07			no data	no data	1.115E-05	no data	5.764E-06	5.38E-06	93%
	FP+AP	3.962E+01		3.049E+01	3.329E+01	3.340E+01	2.945E+01	3.820E+01	3.407E+01	1.98E+01	58%
Sb125	FP	1.774E+01			1.043E+01	1.043E+01	9.982E+00	1.779E+01	1.327E+01	3.67E+00	28%
	AP	3.261E-02			3.657E-02	3.640E-02	3.659E-02	5.881E-02	4.020E-02	1.03E-02	26%
	FP+AP	1.777E+01		9.713E+00	1.046E+01	1.047E+01	1.002E+01	1.785E+01	1.271E+01	3.61E+00	28%

Table A.56: Results for activation-fission products in cell calculation at 5 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	average	SD	RSD(%)
H3	FP	6.267E-02			5.928E-02	5.943E-02	5.760E-02	5.909E-02	5.961E-02	1.66E-03	3%
	AP	6.689E-04			6.781E-10	6.829E-10		5.747E-08	1.672E-04	2.90E-04	173%
	FP+AP	6.334E-02	1.457E-01	6.288E-02	5.928E-02	5.943E-02	5.760E-02	5.909E-02	6.027E-02	3.00E-02	50%
Be10	FP	1.276E-02			1.826E-04	1.826E-04	1.500E-02	1.821E-04	5.662E-03	6.75E-03	119%
	AP	1.708E-03			1.253E-04	1.323E-04	1.281E-06	8.610E-05	4.105E-04	6.50E-04	158%
	FP+AP	1.447E-02	1.319E-02	1.513E-04	3.079E-04	3.149E-04	1.500E-02	2.682E-04	6.243E-03	6.93E-03	111%
C14	FP	3.939E-03			3.689E-05	3.690E-05	4.834E-03	3.680E-05	1.777E-03	2.15E-03	121%
	AP	1.203E-01			5.639E-02	5.846E-02	1.375E-01	5.106E-02	8.473E-02	3.65E-02	43%
	FP+AP	1.242E-01	1.241E-01	1.574E-01	5.642E-02	5.850E-02	1.423E-01	5.110E-02	1.020E-01	4.18E-02	41%
Zr93	FP	9.710E+02			9.930E+02	9.894E+02	9.735E+02	1.001E+03	9.855E+02	1.15E+01	1%
	AP	2.764E-02			6.599E-02	6.326E-02	4.590E-01	5.061E-02	1.333E-01	1.63E-01	123%
	FP+AP	9.710E+02	9.796E+02	1.004E+03	9.931E+02	9.895E+02	9.739E+02	1.001E+03	9.874E+02	1.20E+01	1%
Nb94	FP	5.813E-04			1.447E-03	1.542E-03	6.805E-04	1.041E-03	1.058E-03	3.89E-04	37%
	AP	1.464E+00			1.169E+00	1.167E+00	1.585E+00	1.411E+00	1.359E+00	1.66E-01	12%
	FP+AP	1.464E+00	1.468E+00	1.406E+00	1.170E+00	1.169E+00	1.585E+00	1.412E+00	1.382E+00	1.45E-01	10%
Sn119m	FP	1.978E-04			7.542E-05	2.128E-04	1.177E-03	3.615E-04	4.050E-04	3.97E-04	98%
	AP	1.508E-04			1.394E-04	3.723E-04	9.614E-04	2.475E-04	3.743E-04	3.05E-04	82%
	FP+AP	3.486E-04	6.431E-05	4.006E-04	2.148E-04	5.851E-04	2.139E-03	6.090E-04	6.230E-04	6.44E-04	103%
Sn121m	FP	6.650E-01			5.944E-02	5.958E-02	3.601E-02	4.546E-03	1.649E-01	2.51E-01	152%
	AP	8.765E-04			3.981E-04	3.984E-04	4.579E-04	3.382E-04	4.938E-04	1.95E-04	39%
	FP+AP	6.659E-01	6.695E-01	6.538E-03	5.983E-02	5.997E-02	3.646E-02	4.884E-03	2.147E-01	2.87E-01	134%
Sn126	FP	3.962E+01			3.329E+01	3.340E+01	2.943E+01	3.820E+01	3.478E+01	3.68E+00	11%
	AP	3.797E-07			no data	no data	1.183E-05	no data	6.104E-06	5.72E-06	94%
	FP+AP	3.962E+01	3.983E+01	3.049E+01	3.329E+01	3.340E+01	2.943E+01	3.820E+01	3.489E+01	3.99E+00	11%
Sb125	FP	5.068E+00			3.002E+00	2.988E+00	2.842E+00	5.137E+00	3.807E+00	1.06E+00	28%
	AP	9.162E-03			1.060E-02	1.049E-02	1.052E-02	1.706E-02	1.157E-02	2.80E-03	24%
	FP+AP	5.077E+00	5.096E+00	2.815E+00	3.013E+00	2.998E+00	2.853E+00	5.154E+00	3.858E+00	1.09E+00	28%

Table A.57: Results for activation-fission products in cell calculation at 50 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
H3	FP	4.994E-03			4.750E-03	4.762E-03	4.592E-03	4.735E-03	4.766E-03	1.29E-04	3%
	AP	5.330E-05			5.434E-11	5.472E-11		4.605E-09	1.333E-05	2.31E-05	173%
	FP+AP	5.047E-03	1.161E-02	5.040E-03	4.750E-03	4.762E-03	4.592E-03	4.735E-03	4.821E-03	2.38E-03	49%
Be10	FP	1.276E-02			1.826E-04	1.826E-04	1.500E-02	1.821E-04	5.662E-03	6.75E-03	119%
	AP	1.708E-03			1.253E-04	1.323E-04	1.281E-06	8.609E-05	4.105E-04	6.50E-04	158%
	FP+AP	1.447E-02	1.319E-02	1.513E-04	3.079E-04	3.149E-04	1.500E-02	2.682E-04	6.243E-03	6.93E-03	111%
C14	FP	3.918E-03			3.669E-05	3.670E-05	4.808E-03	3.660E-05	1.767E-03	2.14E-03	121%
	AP	1.197E-01			5.608E-02	5.814E-02	1.367E-01	5.079E-02	8.427E-02	3.63E-02	43%
	FP+AP	1.236E-01	1.234E-01	1.565E-01	5.612E-02	5.818E-02	1.415E-01	5.082E-02	1.014E-01	4.16E-02	41%
Zr93	FP	9.710E+02			9.930E+02	9.894E+02	9.735E+02	1.001E+03	9.855E+02	1.15E+01	1%
	AP	2.764E-02			6.598E-02	6.326E-02	4.590E-01	5.061E-02	1.333E-01	1.63E-01	123%
	FP+AP	9.710E+02	9.796E+02	1.004E+03	9.931E+02	9.894E+02	9.739E+02	1.001E+03	9.874E+02	1.20E+01	1%
Nb94	FP	5.804E-04			1.445E-03	1.539E-03	6.794E-04	1.039E-03	1.057E-03	3.88E-04	37%
	AP	1.463E+00			1.167E+00	1.165E+00	1.582E+00	1.409E+00	1.357E+00	1.66E-01	12%
	FP+AP	1.464E+00	1.466E+00	1.404E+00	1.169E+00	1.167E+00	1.583E+00	1.410E+00	1.380E+00	1.45E-01	11%
Sn119m	FP	8.648E-12			4.990E-25	2.858E-21	1.548E-20	-	2.162E-12	3.74E-12	173%
	AP	1.958E-21			9.221E-25	5.000E-21	1.264E-20	-	4.900E-21	4.81E-21	98%
	FP+AP	8.648E-12	8.370E-22	0.000E+00	1.421E-24	7.858E-21	2.811E-20	-	1.441E-12	3.22E-12	224%
Sn121m	FP	3.564E-01			3.373E-02	3.385E-02	2.043E-02	2.436E-03	8.936E-02	1.34E-01	150%
	AP	4.697E-04			2.259E-04	2.263E-04	2.597E-04	1.813E-04	2.726E-04	1.02E-04	37%
	FP+AP	3.568E-01	3.588E-01	3.709E-03	3.395E-02	3.408E-02	2.069E-02	2.618E-03	1.158E-01	1.54E-01	133%
Sn126	FP	3.960E+01			3.328E+01	3.338E+01	2.943E+01	3.818E+01	3.478E+01	3.68E+00	11%
	AP	3.795E-07			no data	no data	1.183E-05	no data	6.103E-06	5.72E-06	94%
	FP+AP	3.960E+01	3.982E+01	3.048E+01	3.328E+01	3.338E+01	2.943E+01	3.818E+01	3.488E+01	3.99E+00	11%
Sb125	FP	5.489E-05			3.892E-05	3.692E-05	3.102E-05	6.659E-05	4.567E-05	1.31E-05	29%
	AP	9.923E-08			1.374E-07	1.297E-07	1.148E-07	2.211E-07	1.404E-07	4.24E-08	30%
	FP+AP	5.499E-05	5.522E-05	3.651E-05	3.906E-05	3.705E-05	3.113E-05	6.681E-05	4.582E-05	1.22E-05	27%

Table A.58: Results for activation-fission products in cell calculation at 100 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
H3	FP	3.004E-04			2.875E-04	2.882E-04	2.762E-04	2.866E-04	2.878E-04	7.67E-06	3%
	AP	3.206E-06			3.289E-12	3.312E-12		2.787E-10	8.016E-07	1.39E-06	173%
	FP+AP	3.036E-04	6.987E-04	3.051E-04	2.875E-04	2.882E-04	2.762E-04	2.866E-04	2.912E-04	1.43E-04	49%
Be10	FP	1.276E-02			1.826E-04	1.826E-04	1.500E-02	1.821E-04	5.662E-03	6.75E-03	119%
	AP	1.707E-03			1.253E-04	1.323E-04	1.281E-06	8.609E-05	4.105E-04	6.50E-04	158%
	FP+AP	1.447E-02	1.319E-02	1.513E-04	3.079E-04	3.149E-04	1.500E-02	2.682E-04	6.243E-03	6.93E-03	111%
C14	FP	3.894E-03			3.647E-05	3.648E-05	4.779E-03	3.637E-05	1.757E-03	2.13E-03	121%
	AP	1.189E-01			5.574E-02	5.779E-02	1.359E-01	5.048E-02	8.376E-02	3.61E-02	43%
	FP+AP	1.228E-01	1.227E-01	1.556E-01	5.578E-02	5.783E-02	1.407E-01	5.052E-02	1.008E-01	4.13E-02	41%
Zr93	FP	9.709E+02			9.930E+02	9.894E+02	9.735E+02	1.001E+03	9.855E+02	1.15E+01	1%
	AP	2.764E-02			6.598E-02	6.325E-02	4.590E-01	5.061E-02	1.333E-01	1.63E-01	123%
	FP+AP	9.710E+02	9.796E+02	1.004E+03	9.931E+02	9.894E+02	9.739E+02	1.001E+03	9.874E+02	1.20E+01	1%
Nb94	FP	5.794E-04			1.443E-03	1.537E-03	6.783E-04	1.037E-03	1.055E-03	3.87E-04	37%
	AP	1.461E+00			1.165E+00	1.163E+00	1.580E+00	1.406E+00	1.355E+00	1.66E-01	12%
	FP+AP	1.462E+00	1.463E+00	1.402E+00	1.167E+00	1.165E+00	1.580E+00	1.407E+00	1.378E+00	1.45E-01	11%
Sn119m	FP	1.275E-12			0.000E+00	5.121E-40	0.000E+00	-	3.187E-13	5.52E-13	173%
	AP	3.382E-40			0.000E+00	8.961E-40	0.000E+00	-	3.086E-40	3.66E-40	119%
	FP+AP	1.275E-12	1.445E-40	0.000E+00	0.000E+00	1.408E-39	0.000E+00	-	2.124E-13	4.75E-13	224%
Sn121m	FP	1.782E-01			1.797E-02	1.806E-02	1.088E-02	1.218E-03	4.526E-02	6.67E-02	147%
	AP	2.349E-04			1.204E-04	1.208E-04	1.383E-04	9.063E-05	1.410E-04	4.94E-05	35%
	FP+AP	1.784E-01	1.794E-01	1.976E-03	1.809E-02	1.818E-02	1.102E-02	1.309E-03	5.834E-02	7.65E-02	131%
Sn126	FP	3.959E+01			3.326E+01	3.337E+01	2.943E+01	3.817E+01	3.477E+01	3.68E+00	11%
	AP	3.794E-07			no data	no data	1.182E-05	no data	6.100E-06	5.72E-06	94%
	FP+AP	3.959E+01	3.980E+01	3.047E+01	3.326E+01	3.337E+01	2.943E+01	3.817E+01	3.487E+01	3.99E+00	11%
Sb125	FP	2.116E-10			1.445E-10	1.300E-10	9.514E-11	2.472E-10	1.657E-10	5.56E-11	34%
	AP	3.017E-13			5.100E-13	4.566E-13	3.521E-13	8.208E-13	4.882E-13	1.82E-13	37%
	FP+AP	2.119E-10	3.546E-10	1.356E-10	1.450E-10	1.304E-10	9.549E-11	2.480E-10	1.887E-10	8.31E-11	44%

Table A.59: Results for activation-fission products in cell calculation at 300 years cooling (g/tHMI)

		CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
H3	FP	3.935E-09			3.860E-09	3.869E-09	3.617E-09	3.848E-09	3.826E-09	1.08E-10	3%
	AP	4.200E-11			4.415E-17	4.446E-17		3.742E-15	1.050E-11	1.82E-11	173%
	FP+AP	3.977E-09	9.152E-09	4.099E-09	3.860E-09	3.869E-09	3.617E-09	3.848E-09	3.878E-09	1.85E-09	48%
Be10	FP	1.276E-02			1.825E-04	1.826E-04	1.500E-02	1.821E-04	5.661E-03	6.75E-03	119%
	AP	1.707E-03			1.253E-04	1.323E-04	1.280E-06	8.608E-05	4.105E-04	6.50E-04	158%
	FP+AP	1.447E-02	1.318E-02	1.513E-04	3.079E-04	3.149E-04	1.500E-02	2.682E-04	6.242E-03	6.92E-03	111%
C14	FP	3.801E-03			3.560E-05	3.561E-05	4.664E-03	3.551E-05	1.714E-03	2.07E-03	121%
	AP	1.161E-01			5.441E-02	5.641E-02	1.326E-01	4.927E-02	8.176E-02	3.52E-02	43%
	FP+AP	1.199E-01	1.197E-01	1.518E-01	5.445E-02	5.645E-02	1.373E-01	4.931E-02	9.842E-02	4.03E-02	41%
Zr93	FP	9.708E+02			9.929E+02	9.893E+02	9.735E+02	1.001E+03	9.854E+02	1.15E+01	1%
	AP	2.764E-02			6.598E-02	6.325E-02	4.590E-01	5.060E-02	1.333E-01	1.63E-01	123%
	FP+AP	9.709E+02	9.795E+02	1.004E+03	9.930E+02	9.893E+02	9.739E+02	1.001E+03	9.873E+02	1.20E+01	1%
Nb94	FP	5.755E-04			1.433E-03	1.526E-03	6.736E-04	1.030E-03	1.048E-03	3.85E-04	37%
	AP	1.459E+00			1.157E+00	1.156E+00	1.569E+00	1.397E+00	1.347E+00	1.65E-01	12%
	FP+AP	1.459E+00	1.453E+00	1.392E+00	1.159E+00	1.157E+00	1.570E+00	1.398E+00	1.370E+00	1.44E-01	11%
Sn119m	FP	6.329E-16			0.000E+00	0.000E+00	0.000E+00	-	1.582E-16	2.74E-16	173%
	AP	0.000E+00			0.000E+00	0.000E+00	0.000E+00	-	0.000E+00	0.00E+00	
	FP+AP	6.329E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-	1.055E-16	2.36E-16	224%
Sn121m	FP	1.114E-02			1.448E-03	1.464E-03	8.752E-04	7.617E-05	3.000E-03	4.10E-03	137%
	AP	1.468E-05			9.701E-06	9.790E-06	1.113E-05	5.666E-06	1.019E-05	2.89E-06	28%
	FP+AP	1.115E-02	1.121E-02	1.592E-04	1.458E-03	1.474E-03	8.864E-04	8.184E-05	3.775E-03	4.71E-03	125%
Sn126	FP	3.954E+01			3.322E+01	3.333E+01	2.938E+01	3.812E+01	3.472E+01	3.67E+00	11%
	AP	3.789E-07			no data	no data	1.180E-05	no data	6.092E-06	5.71E-06	94%
	FP+AP	3.954E+01	3.975E+01	3.043E+01	3.322E+01	3.333E+01	2.938E+01	3.812E+01	3.482E+01	3.98E+00	11%
Sb125	FP	1.234E-13			0.000E+00	0.000E+00	8.412E-33	-	3.085E-14	5.34E-14	173%
	AP	2.579E-35			0.000E+00	0.000E+00	3.114E-35	-	1.423E-35	1.44E-35	101%
	FP+AP	1.234E-13	1.888E-13	0.000E+00	0.000E+00	0.000E+00	8.444E-33	-	5.204E-14	7.60E-14	146%

Table A.60: Trends of relative standard deviation with cooling time for activation-fission products in cell calculation

	Discharge	5 years	50 years	100 years	300 years
H 3	3%	50%	49%	49%	48%
Be10	134%	111%	111%	111%	111%
C14	45%	41%	41%	41%	41%
Zr93	1%	1%	1%	1%	1%
Nb94	11%	10%	11%	11%	11%
Sn119m	63%	103%	224%	224%	224%
Sn121m	171%	134%	133%	131%	125%
Sn126	58%	11%	11%	11%	11%
Sb125	28%	28%	27%	44%	146%

Table A.61: Results for decay heat in assembly calculation at discharge (Watts/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Alpha decay	3.075E+03			3.116E+03			3.096E+03	2.07E+01	1%
Beta decay	1.231E+06			1.234E+06			1.232E+06	1.25E+03	0%
Gamma decay	1.123E+06		9.909E+05	1.126E+06	1.184E+06		1.106E+06	7.09E+04	6%
Total decay heat	2.357E+06		2.284E+06	2.385E+06	2.398E+06	2.251E+06	2.335E+06	5.78E+04	2%

Table A.62: Results for decay heat in assembly calculation at 5 years cooling (Watts/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Alpha decay	3.764E+02	3.774E+02		3.681E+02			3.769E+02	4.162E+00	1%
Beta decay	1.193E+03	1.192E+03		1.178E+03			1.188E+03	6.939E+00	1%
Gamma decay	9.925E+02	1.006E+03	1.005E+03	9.559E+02	1.029E+03		9.976E+02	2.389E+01	2%
Total decay heat	2.562E+03	2.576E+03	2.577E+03	2.502E+03	2.620E+03	2.605E+03	2.574E+03	3.745E+01	1%

Table A.63: Results for decay heat in assembly calculation at 50 years cooling (Watts/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Alpha decay	3.257E+02	3.266E+02		3.318E+02			3.261E+02	2.67E+00	1%
Beta decay	2.750E+02	2.747E+02		2.737E+02			2.745E+02	5.31E-01	0%
Gamma decay	1.573E+02	1.571E+02	1.543E+02	1.558E+02	1.587E+02		1.566E+02	1.49E+00	1%
Total decay heat	7.579E+02	7.585E+02	7.753E+02	7.612E+02	7.666E+02	7.686E+02	7.647E+02	6.17E+00	1%

Table A.64: Results for decay heat in assembly calculation at 100 years cooling (Watts/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Alpha decay	2.700E+02	2.709E+02		2.770E+02			2.704E+02	3.10E+00	1%
Beta decay	8.491E+01	8.484E+01		8.456E+01			8.477E+01	1.52E-01	0%
Gamma decay	4.956E+01	4.948E+01	4.927E+01	4.912E+01	5.025E+01		4.954E+01	3.90E-01	1%
Total decay heat	4.045E+02	4.052E+02	4.243E+02	4.108E+02	4.102E+02	4.062E+02	4.102E+02	6.74E+00	2%

Table A.65: Results for decay heat in assembly calculation at 300 years cooling (Watts/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
Alpha decay	1.652E+02	1.659E+02		1.687E+02			1.655E+02	1.521E+00	1%
Beta decay	1.751E+00	1.750E+00		1.771E+00			1.757E+00	9.616E-03	1%
Gamma decay	1.155E+00	1.150E+00	1.222E+00	1.168E+00	1.181E+00		1.175E+00	2.584E-02	2%
Total decay heat	1.681E+02	1.688E+02	1.792E+02	1.717E+02	1.721E+02	1.699E+02	1.716E+02	3.674E+00	2%

Table A.66: Trends of relative standard deviation with cooling time for decay heat in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
Alpha decay	1%	1%	1%	1%	1%
Beta decay	0%	1%	0%	0%	1%
Gamma decay	6%	2%	1%	1%	2%
Total decay heat	2%	1%	1%	2%	2%

Table A.67: Results for decay heat in cell calculation at discharge (Watts/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
Alpha decay	3.030E+03							3.030E+03		0%
Beta decay	1.231E+06							1.231E+06		0%
Gamma decay	1.122E+06		9.892E+05			1.212E+06		1.108E+06	9.13E+04	8%
Total decay heat	2.356E+06		2.280E+06	2.380E+06	2.393E+06	2.450E+06	2.271E+06	2.355E+06	5.84E+04	2%

Table A.68: Results for decay heat in cell calculation at 5 years cooling (Watts/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
Alpha decay	3.703E+02	3.721E+02						3.712E+02	8.61E-01	0%
Beta decay	1.194E+03	1.194E+03						1.194E+03	2.15E-01	0%
Gamma decay	9.902E+02	1.005E+03	1.011E+03			9.974E+02		1.001E+03	7.79E+00	0%
Total decay heat	2.555E+03	2.571E+03	2.582E+03	2.565E+03	2.561E+03	2.552E+03	2.607E+03	2.570E+03	5.84E+04	1%

Table A.69: Results for decay heat in cell calculation at 50 years cooling (Watts/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
Alpha decay	3.206E+02	3.219E+02						3.213E+02	6.18E-01	0%
Beta decay	2.758E+02	2.754E+02						2.756E+02	1.78E-01	0%
Gamma decay	1.572E+02	1.571E+02	1.546E+02			1.559E+02		1.562E+02	1.08E+00	1%
Total decay heat	7.536E+02	7.544E+02	7.671E+02	7.705E+02	7.669E+02	7.456E+02	7.663E+02	7.617E+02	5.84E+04	1%

Table A.70: Results for decay heat in cell calculation at 100 years cooling (Watts/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
Alpha decay	2.660E+02	2.670E+02						2.665E+02	5.02E-01	0%
Beta decay	8.515E+01	8.504E+01						8.509E+01	5.42E-02	0%
Gamma decay	4.953E+01	4.948E+01	4.933E+01			4.937E+01		4.943E+01	8.01E-02	0%
Total decay heat	4.006E+02	4.015E+02	4.155E+02	4.199E+02	4.201E+02	3.976E+02	4.044E+02	4.097E+02	5.84E+04	2%

Table A.71: Results for decay heat in cell calculation at 300 years cooling (Watts/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
Alpha decay	1.629E+02	1.636E+02						1.633E+02	3.28E-01	0%
Beta decay	1.740E+00	1.740E+00						1.740E+00	1.70E-04	0%
Gamma decay	1.146E+00	1.141E+00	1.199E+00			1.159E+00		1.161E+00	2.27E-02	2%
Total decay heat	1.658E+02	1.665E+02	1.730E+02	1.813E+02	1.814E+02	1.671E+02	1.686E+02	1.729E+02	5.84E+04	4%

Table A.72: Trends of relative standard deviation with cooling time for decay heat in cell calculation

	Discharge	5 years	50 years	100 years	300 years
Alpha decay	0%	0%	0%	0%	0%
Beta decay	0%	0%	0%	0%	0%
Gamma decay	8%	0%	1%	0%	2%
Total decay heat	2%	1%	1%	2%	4%

Table A.73: Results for neutron emission rate in assembly calculation at discharge (neutrons/s/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
(a,n) emission rate	1.031E+08		1.015E+08	9.980E+07	1.037E+08	1.136E+08	1.043E+08	1.51E+06	1%
Spontaneous fission emission rate	1.130E+09		1.124E+09	1.063E+09	1.130E+09	1.630E+09	1.215E+09	4.00E+08	33%
Total emission rate	1.233E+09		1.226E+09	1.162E+09	1.234E+09	1.744E+09	1.320E+09	1.69E+08	13%

Table A.74: Results for neutron emission rate in assembly calculation at 5 years cooling (neutrons/s/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
(a,n) emission rate	1.046E+07		1.054E+07	9.361E+06	1.037E+07	1.414E+07	1.097E+07	4.78E+05	4%
Spontaneous fission emission rate	5.736E+08		5.434E+08	5.106E+08	5.465E+08	9.513E+08	6.251E+08	2.13E+08	34%
Total emission rate	5.840E+08		5.539E+08	5.200E+08	5.569E+08	9.653E+08	6.360E+08	1.60E+08	25%

Table A.75: Results for neutron emission rate in assembly calculation at 50 years cooling (neutrons/s/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
(a,n) emission rate	8.626E+06		8.993E+06	8.052E+06	8.791E+06	9.918E+06	8.876E+06	3.502E+05	4%
Spontaneous fission emission rate	1.093E+08		1.031E+08	9.725E+07	1.041E+08	1.793E+08	1.186E+08	3.760E+07	32%
Total emission rate	1.179E+08		1.121E+08	1.053E+08	1.129E+08	1.893E+08	1.275E+08	2.720E+07	21%

Table A.76: Results for neutron emission rate in assembly calculation at 100 years cooling (neutrons/s/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
(a,n) emission rate	7.059E+06		7.414E+06	6.641E+06	7.281E+06	7.812E+06	7.241E+06	2.93E+05	4%
Spontaneous fission emission rate	2.317E+07		2.123E+07	2.058E+07	2.213E+07	3.598E+07	2.462E+07	5.66E+06	23%
Total emission rate	3.023E+07		2.864E+07	2.722E+07	2.942E+07	4.380E+07	3.186E+07	3.01E+06	9%

Table A.77: Results for neutron emission rate in assembly calculation at 300 years cooling (neutrons/s/tHMI)

	CEA-D	CEA-C	GRS	NEXIA	RRC-KI	VTT	Average	SD	RSD
(a,n) emission rate	4.261E+06		4.441E+06	3.991E+06	4.396E+06	4.718E+06	4.361E+06	1.76E+05	4%
Spontaneous fission emission rate	7.886E+06		6.644E+06	6.942E+06	7.550E+06	1.065E+07	7.934E+06	1.11E+06	14%
Total emission rate	1.215E+07		1.109E+07	1.093E+07	1.195E+07	1.536E+07	1.229E+07	5.87E+05	5%

Table A.78: Trends of relative standard deviation with cooling time for neutron emission rate in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
(a,n) emission rate	1%	4%	4%	4%	4%
Spontaneous fission emission rate	33%	34%	32%	23%	14%
Total emission rate	13%	25%	21%	9%	5%

Table A.79: Results for neutron emission rate in cell calculation at discharge (neutrons/s/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
(a,n) emission rate	1.016E+08		9.961E+07	1.121E+08	1.162E+08	9.895E+07	1.129E+08	1.069E+08	6.99E+06	7%
Spontaneous fission emission rate	1.115E+09		1.116E+09	1.194E+09	1.201E+09	1.043E+09	1.610E+09	1.213E+09	1.85E+08	15%
Total emission rate	1.217E+09		1.216E+09	1.306E+09	1.318E+09	1.142E+09	1.723E+09	1.320E+09	1.90E+08	14%

Table A.80: Results for neutron emission rate in cell calculation at 5 years cooling (neutrons/s/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	average	SD	RSD(%)
(a,n) emission rate	1.029E+07	1.034E+07	1.037E+07	1.139E+07	1.148E+07	9.467E+06	1.396E+07	1.117E+07	1.352E+06	12%
Spontaneous fission emission rate	5.664E+08	5.706E+08	5.446E+08	5.813E+08	5.716E+08	4.923E+08	9.370E+08	6.358E+08	1.367E+08	22%
Total emission rate	5.767E+08	5.810E+08	5.550E+08	5.927E+08	5.830E+08	5.017E+08	9.509E+08	6.470E+08	1.380E+08	22%

Table A.81: Results for neutron emission rate in cell calculation at 50 years cooling (neutrons/s/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
(a,n) emission rate	8.493E+06	8.526E+06	8.732E+06	9.883E+06	9.970E+06	8.272E+06	9.832E+06	9.202E+06	6.99E+05	8%
Spontaneous fission emission rate	1.079E+08	1.087E+08	1.032E+08	1.107E+08	1.091E+08	9.396E+07	1.766E+08	1.208E+08	2.54E+07	22%
Total emission rate	1.164E+08	1.172E+08	1.119E+08	1.206E+08	1.190E+08	1.022E+08	1.864E+08	1.300E+08	2.58E+07	21%

Table A.82: Results for neutron emission rate in cell calculation at 100 years cooling (neutrons/s/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
(a,n) emission rate	6.953E+06	6.979E+06	7.174E+06	8.209E+06	8.270E+06	6.864E+06	7.753E+06	7.541E+06	5.64E+05	8%
Spontaneous fission emission rate	2.285E+07	2.302E+07	2.120E+07	2.327E+07	2.317E+07	2.011E+07	3.537E+07	2.520E+07	4.72E+06	20%
Total emission rate	2.980E+07	3.000E+07	2.837E+07	3.148E+07	3.144E+07	2.697E+07	4.313E+07	3.274E+07	4.94E+06	16%

Table A.83: Results for neutron emission rate in cell calculation at 300 years cooling (neutrons/s/tHMI)

	CEA/D	CEA/C	GRS	JAERI (J32)	JAERI (J33)	RRC-KI	VTT	Average	SD	RSD(%)
(a,n) emission rate	4.202E+06	4.218E+06	4.285E+06	5.041E+06	5.044E+06	4.169E+06	4.685E+06	4.574E+06	3.67E+05	8%
Spontaneous fission emission rate	7.756E+06	7.815E+06	6.590E+06	7.714E+06	7.864E+06	6.964E+06	1.042E+07	8.208E+06	1.13E+06	14%
Total emission rate	1.196E+07	1.203E+07	1.088E+07	1.275E+07	1.291E+07	1.113E+07	1.511E+07	1.278E+07	1.31E+06	11%

Table A.84: Trends of relative standard deviation with cooling time for neutron emission rate in cell calculation

	Discharge	5 years	50 years	100 years	300 years
(a,n) emission rate	7%	12%	8%	8%	8%
Spontaneous fission emission rate	15%	22%	22%	20%	14%
Total emission rate	14%	22%	21%	16%	11%

Appendix B: Specifications for the Phase 1 of a depletion calculation Benchmark devoted to fuel cycles[1]

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1. Introduction

In the past, many reactor system benchmarks have been done but only a few concerning the fuel cycle, particularly with MOx fuel. Nowadays there is an emphasis on reactor systems linked with the associated fuel cycle (Generation-IV for example).

Benchmarks devoted to depletion calculations have already been undertaken but they were restricted to a specific issue of fuel cycle:

- Burn-up credit benchmark (working party on nuclear criticality safety (WPNCS) [1]: the nuclide densities calculations focused mainly on the 15 most poisoning fission products and for a short cooling time (5 years).
- Benchmark on decay heat calculation: this benchmark focuses on decay heat calculation due to 235 uranium fissions [2].

The proposed benchmark investigates a broader range of isotopes, physics quantities and fuel types. The objective is to compare existing depletion calculations obtained with various codes and data libraries (DARWIN/CESAR, FISPIN, FISPACT, SRAC, ORIGEN, etc.), applied to fuel and back-end cycle configurations: transport, reprocessing, interim storage and waste repository. We propose to focus on nuclide densities of the most important nuclides implied in fuel cycle: actinides, fission products and activation products and also on associated fuel cycle quantities: masses, neutron emission rate and decay heat.

Detected discrepancies between participants will enable us to improve the calculation schemes (self-shielding, subdivisions in fuel or moderator, etc.), to improve the knowledge of burn-up chains used in depletion calculations (maybe to recommend a chain for fuel cycle applications) and to improve the knowledge on nuclear data (capture cross-sections, branching ratio, fission yields, decay constants) involved in fuel cycle studies.

The following specification is devoted to the first phase of the Benchmark. The aim of this phase is to constitute a reference case on an UOx fuel. We propose to use the experimental information given by Japanese Post-Irradiation Experiment from the Takahama-3 PWR; thus we can compare the calculation and experimental results for the major actinides and verify for well-known isotopes how good our predictions are. The list of available experimental results and associated uncertainties is given in Appendix A.

[1] NEA/NSC/DOC(2004)11.

This experiment has been already used in French nuclear data studies [4] and it has been shown that the trends given by this experiment are consistent with the trends given by spent fuel experiments performed in France [5]. This experiment was also used by JAERI for the validation of the SWAT burn-up code system [6].

2. Specification

The specification of the benchmark is based on the data included in the SFCOMPO database originally developed at JAERI and now maintained at the NEA databank [7] [8] [9].

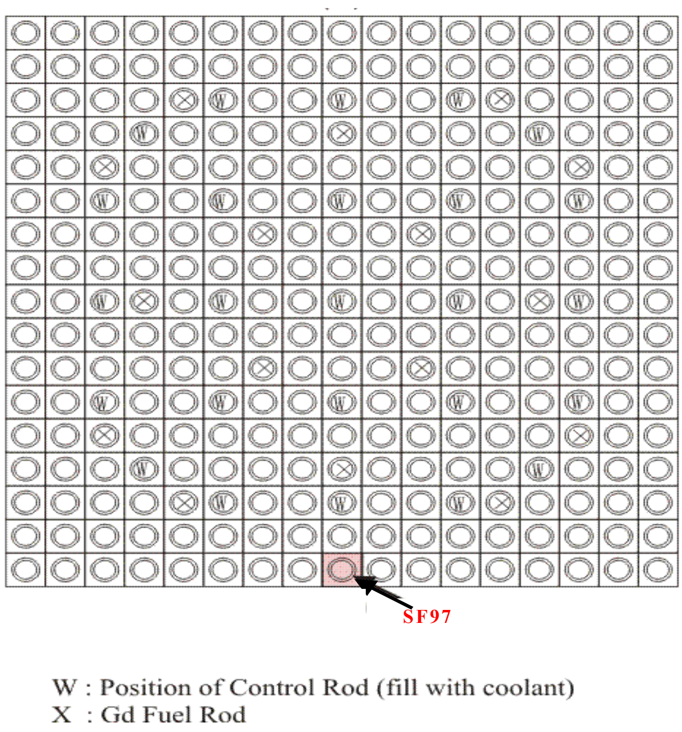
2.1 Outline of the Takahama experiment

TAKAHAMA-3 is a 17x17 PWR operated by Kansai Electric Power Company in Japan. The PIE was conducted under the auspices of Science and Technology Agency of Japan. From two fuel assemblies, named NT3G23 and NT3G24, 16 samples were taken and isotopic composition was measured for irradiated UO_2 and UO_2-Gd_2O_3 fuel.

We propose to make two calculations: a simple cell calculation or/and an assembly calculation where the analysed sample is explicitly described.

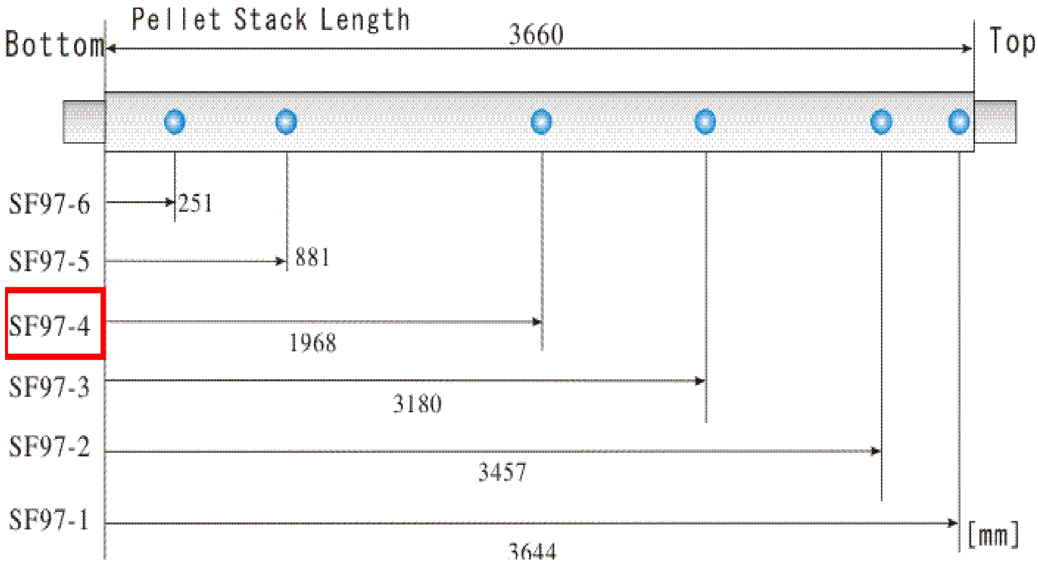
For the assembly calculation, the studied sample, named SF97, comes from a UO_2 spent fuel pin located in the peripheral row of the assembly. This assembly is the NT3G24 assembly loaded with 248 UO_2 fuel pins, 4.1%wt ^{235}U enriched, 16 UO_2-Gd_2O_3 pins (2.6% wt ^{235}U and 6% wt Gd) and 25 water holes. However, the SFCOMPO database is not fully complete and additional assumptions have to be made concerning the experimental conditions (water gap dimension, temperature, boron contents) for the cell and assembly calculations.

Figure B1: Position of the SF97 spent fuel pin in the NT3G24 assembly



The fuel pin has been cut in many sections (Figure B2); we selected the SF97-4 sample located at core mid-height.

Figure B2: Position of the SF97 spent fuel in the NT3G24 assembly



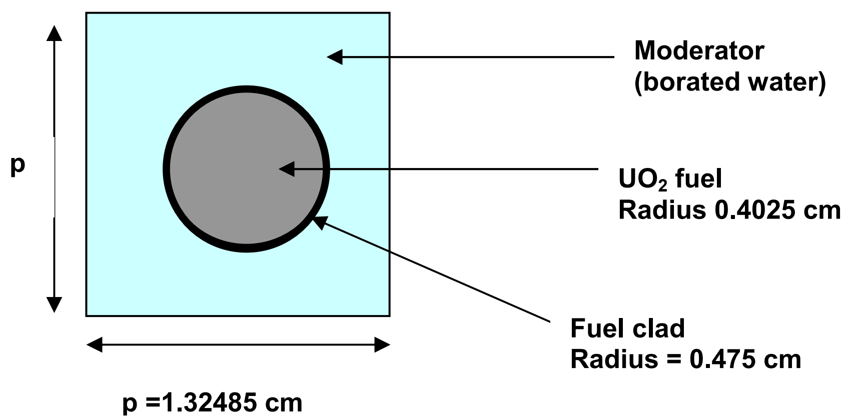
2.2 Geometry description

2.2.1 Cell calculation

The pincell model assumes an equivalent volume ratio of fuel to moderator with the whole fuel assembly, including the water gap. Figure B3 shows the geometry and associated dimensions for this model.

The proposed boundary condition is the reflection (infinite lattice).

Figure B3: Cell calculation geometry



The value of the equivalent cell radius is 0.7475 cm.

2.2.2 Assembly calculation

We propose to present the UOx assembly, as shown in Figure B1, with reflective boundary conditions.

The assembly geometry relates to a typical 17 x 17 PWR fuel assembly, as detailed below and in Figure B4 to Figure B6.

Fuel pin pitch: 1.265 cm

Fuel pin radius: 0.475 cm

Fuel pellet radius: 0.4025 cm

Cladding thickness: 0.0725 cm (no air gap between fuel and cladding)

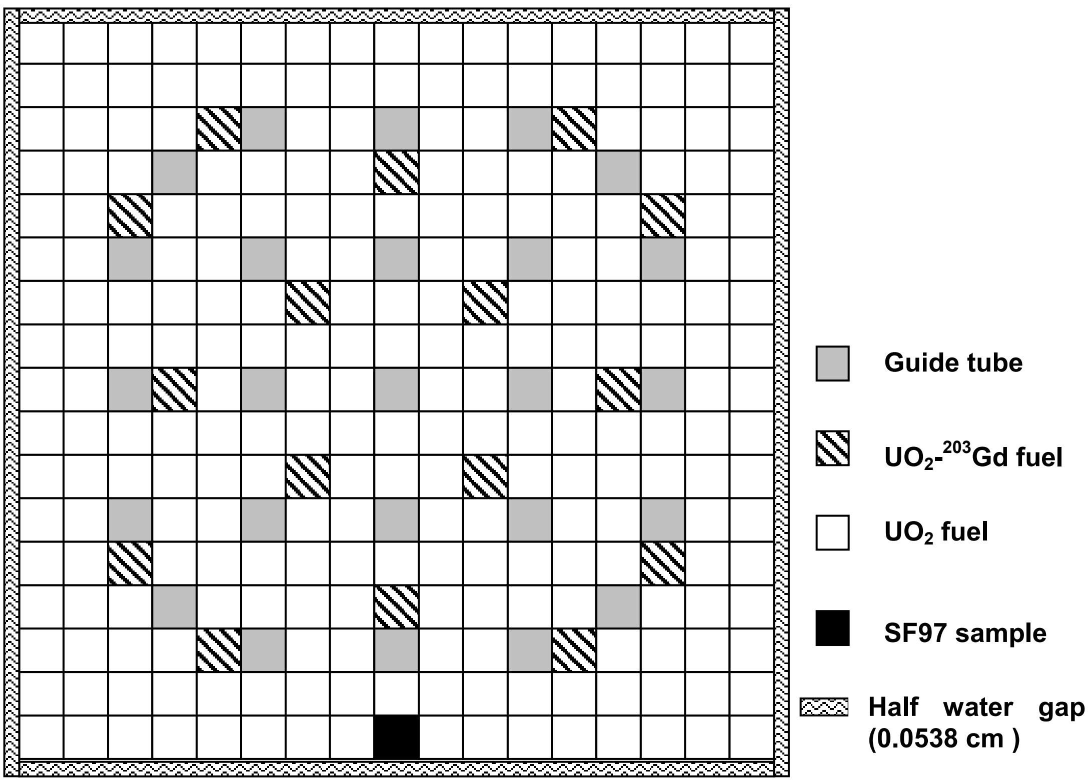
The 24 guide tubes and 1 instrument tube will be modelled as water filled zircalloy tubes with the following dimensions (see Figure B6):

Outer radius: 0.613 cm

Inner radius: 0.573 cm

The half water gap is 0.0538 cm thick.

Figure B4: Assembly geometry



The geometry of the various cells is defined in Figures B5 and B6.

Figure B5: Fuel cell geometry for the assembly calculation

UO_2 Fuel cell or UO_2-^{203}Gd fuel cell

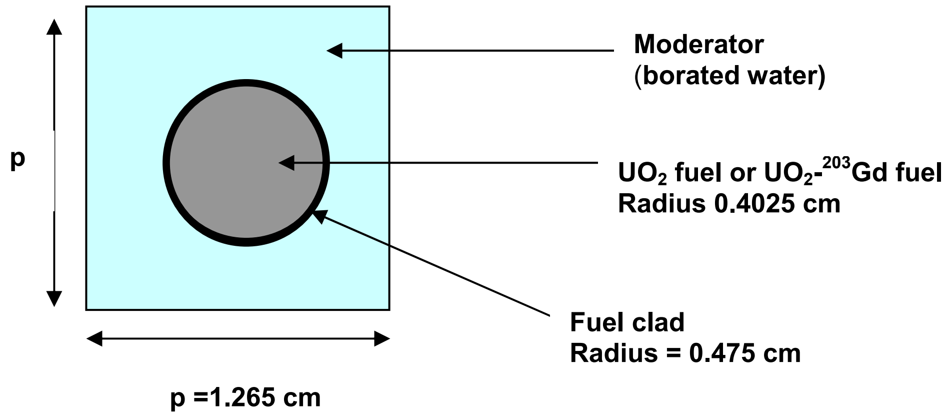
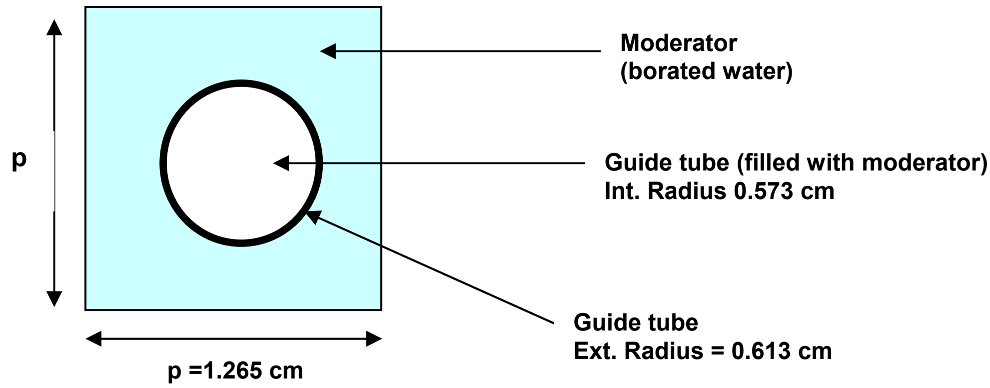


Figure B6: Guide tube geometry for the assembly calculation

Guide tube cell



2.3 UO_2 fuel composition (densities in atom/barn.cm)

The UO_2 fuel has an initial enrichment of 4.1 wt % ^{235}U. The composition to be used in the benchmark is presented in Table B.1.

Table B.1: Initial composition for UO_2 fuel

Nuclide	Atoms/barn.cm
U-234	9.1361E-06
U-235	9.3472E-04
U-238	2.1523E-02
O	4.4935E-02

This fuel composition is suitable for both the cell and the assembly calculation.

2.4 UO_2-^{203}Gd fuel composition (densities in atom/barn.cm)

The UO_2-^{203}Gd fuel is composed of 2.6% wt ^{235}U and 6% wt Gd. The composition is presented in Table B.2 and must be used for the assembly calculation.

Table B.2: Initial composition for UO_2-^{203}Gd fuel

Nuclide	Atoms/barn.cm
U-234	4.2940E-06
U-235	5.6226E-04
U-238	2.0549E-02
Gd-154	4.6173E-05
Gd-155	2.9711E-04
Gd-156	4.1355E-04
Gd-157	3.1518E-04
Gd-158	4.9786E-04
Gd-160	4.3764E-04
O	4.5243E-02

2.5 Non-fissile material composition (densities in atom/barn.cm)

For the purpose of the benchmark exercise, these non-fissile materials should be modelled as specified in Tables B.3 to B.5. A reduced density zircalloy has been used for the fuel pin cladding to take account of the air gap between the fuel and cladding.

The guide tubes should be modelled using the composition given in Table B.4.

Table B.3: Fuel clad composition

Nuclide	Atoms/barn.cm
Fe (natural)	1.3225E-04
Cr (natural)	6.7643E-05
Zr (natural)	3.8310E-02

Table B.4: Guide tube composition

Nuclide	Atoms/barn.cm
Fe (natural)	1.4838E-04
Cr (natural)	7.5891E-05
Zr (natural)	4.2982E-02

Table B.5: Coolant/Moderator composition

Nuclide	Atoms/barn.cm
H	4.8132E-02
O	2.4066E-02
B10	3.6487E-06
B11	1.4686E-05

These compositions are suitable for both the cell and the assembly calculation.

2.6 Impurities content for UOx fuels

In this benchmark, we propose to compare the activation products masses coming from initial impurities. The proposed values for the impurities content are specified in Table B.6.

Table B.6: Initial fuel impurities [atomes/tonnes heavy metal initial (tHMI)]

H1	2.0491E+23
H2	3.0741E+19
B10	6.2931E+21
B11	2.5331E+22
C12	5.6257E+24
C13	6.2571E+22
N14	4.8610E+23
N15	1.7857E+21
Cl35	3.6473E+23
Cl37	1.1663E+23
Ca40	4.9532E+24
Ca42	3.3058E+22
Ca43	6.8978E+21
Ca44	1.0658E+23
Ca46	2.0438E+20
Ca48	9.5547E+21
Fe54	3.5435E+23
Fe56	5.6040E+24
Fe57	1.3441E+23
Fe58	1.7106E+22
Co59	1.3896E+23
Ni58	2.3817E+24
Ni60	9.1052E+23

Table B.6: Initial fuel impurities [atomes/tonnes heavy metal initial (tHMI)] (continued)

Ni61	3.9421E+22
Ni62	1.2524E+23
Ni64	3.1746E+22
Cu63	7.4286E+23
Cu65	3.3110E+23
Zr90	3.8493E+23
Zr91	8.3944E+22
Zr92	1.2831E+23
Zr94	1.3003E+23
Zr96	2.0949E+22
Nb93	7.3465E+23
Mo92	3.1677E+23
Mo94	1.9745E+23
Mo95	3.3982E+23
Mo96	3.5604E+23
Mo97	2.0385E+23
Mo98	5.1507E+23
Mo100	2.0556E+23
Sn112	5.5781E+21
Sn114	3.7379E+21
Sn115	2.0702E+21
Sn116	8.3557E+22
Sn117	4.4165E+22
Sn118	1.3928E+23
Sn119	4.9341E+22
Sn120	1.8741E+23
Sn122	2.6626E+22
Sn124	3.3296E+22

Note: Do not forget to take into account the oxygen isotopes in your activation calculation.

2.7 Other parameters for depletion calculation

Fuel temperature: 900 K

Clad temperature: 600 K

Moderator temperature: 576 K

2.8 Irradiation histories

The assembly was irradiated for 3 cycles and the SF97 experimental fuel pin reached an average burn-up of roughly 46 GWd/t. Table B.7 presents the proposed irradiation cycles and the associated power to be modelled.

Table B.7: Irradiation history

Start	Stop	Days	Status	Power (W/gU)
26/01/90	15/02/91	385	Full power	38.6
15/02/91	14/05/91	88	Downtime	0
14/05/91	19/06/92	402	Full power	38.6
19/06/92	20/08/92	62	Downtime	0
20/08/92	30/09/93	406	Full power	38.6

2.9 Cooling:

The results are to be compared at discharge (zero cooling), 5, 50, 100 and 300 years cooling.

3. Nuclides and additional quantities required for comparison[2]

The required quantities are:

- Masses of the nuclides specified in the table above in grams/tHMl;
- Neutron emission: (alpha,n) emission, spontaneous fission and total emission in neutrons/seconde/tHMl;
- Decay heat: alpha, beta and gamma decay heat and total decay heat in Watts/tHMl.

The required quantities will be forwarded using the following tables.

Table B.8: Masses of activation products

Masses of activation products (g/tHMl)					
Nuclide	**Discharge**	**5 years**	**50 years**	**100 years**	**300 years**
Cl36					
Ca41					
Mn53					
Mn54					
Fe55					
Fe60					
Co60					
Ni59					
Ni63					
Mo93					

Some nuclides are produced both by fission reaction and activation reaction. We propose to evaluate separately the two contributions in the table above. If your fuel cycle code does not separate the two contributions, please replace the two lines FP and AP in the table above by only one line with FP+AP.

Table B.9: Masses of fission and activation products

Masses of fission and activation products (g/ tHMl)						
Nuclide		**Discharge**	**5 years**	**50 years**	**100 years**	**300 years**
H3	FP (fission)					
	AP (activation)					
Be10	FP					
	AP					
C14	FP					
	AP					
Zr93	FP					
	AP					
Nb94	FP					
	AP					
Sn119m	FP					

[2] The results are compiled by Dr Bénédicte ROQUE at CEA/Cadarache.

Table B.9: Masses of fission and activation products (continued)

	AP					
Sn121m	FP					
	AP					
Sn126	FP					
	AP					
Sb125	FP					
	AP					

Table B.10: Masses of fission products

Masses of fission products (g/ tHMI)					
Nuclide	**Discharge**	**5 years**	**50 years**	**100 years**	**300 years**
Se79					
Kr85					
Rb85					
Rb87					
Sr88					
Sr90					
Nb93m					
Mo95					
Mo97					
Tc99					
Ru101					
Ru106					
Rh103					
Pd107					
Ag108m					
Ag109					
Ag110m					
I127					
I129					
Xe130					
Xe131					
Xe132					
Xe134					
Xe136					
Cs133					
Cs134					
Cs135					
Cs137					
Ba136					
Ba138					
La139					
Ce140					
Ce144					
Nd142					
Nd143					

Table B.10: Masses of fission products (continued)

Nd144					
Nd145					
Nd146					
Nd148					
Nd150					
Pm147					
Sm146					
Sm147					
Sm148					
Sm149					
Sm150					
Sm151					
Sm152					
Sm154					
Eu153					
Eu154					
Eu155					
Gd154					
Gd155					
Gd156					
Ho166m					

Table B.11: Masses of actinides

Masses of actinides (g/ tHMI)					
Nuclide	**Discharge**	**5 years**	**50 years**	**100 years**	**300 years**
U232					
U233					
U234					
U235					
U236					
U238					
Np236					
Np237					
Pu236					
Pu238					
Pu239					
Pu240					
Pu241					
Pu242					
Pu243					
Pu244					
Am241					
Am242m					
Am243					
Cm242					
Cm243					
Cm244					

Table B.11: Masses of actinides (continued)

Cm245					
Cm246					
Cm247					
Cm248					
Ra226					
Ra228					
Ac227					
Th229					
Th230					
Th232					
Cf252					

Table B.12: Neutron emission rate

Neutron emission rate (neutrons/s/ tHMI)					
	Discharge	**5 years**	**50 years**	**100 years**	**300 years**
(α,n) emission rate					
Spontaneous fission emission rate					
Total emission rate					

Table B.13: Decay heat

Decay heat (Watts/ tHMI)					
	Discharge	**5 years**	**50 years**	**100 years**	**300 years**
Alpha decay heat					
Beta decay heat					
Gamma decay heat					
Total decay heat					

4. Optional calculations

Additional but optional calculations are suggested; they concern sensitivity calculations linked to the assumptions made on irradiation parameters.

These assumptions concern:

1) The half water gap thickness

The studied fuel rod is near the water gap; therefore the sensitivity of the fuel inventory to this parameter needs to be investigated. We propose to evaluate the sensitivity with two calculations:

- an assembly calculation with no water blade;
- an assembly calculation considering that the uncertainty on the water blade thickness is 45% (the new value of the water gap is then 0.078 cm).

2) The boron content

Two assumptions are made in the calculation. The first one is that a mean value is used during all the irradiation and the second one is the value itself. Concerning the first assumption, studies [6] [25] have shown that considering a constant boron content does not induce significant bias on the studied isotopes.

We therefore propose to focus on the second assumption. In the benchmark, it is suggested to use a mean value of 456 ppm; this is the value usually used in French calculations. The reference [9] gives a detailed boron history for the 5, 6 and 7 cycles of irradiation but no information for the previous cycles. The calculation of a mean value with these data gives a value of 484 ppm.

We suggest to use an uncertainty of 10% on the mean value of boron content in order to evaluate the sensitivity of fuel inventory to this parameter.

The new concentration of the moderator, corresponding to this uncertainty, is given in Table B.14:

Table B.14: Moderator concentration for sensitivity study on boron content

Nuclide	Atoms/barn.cm
H	4.8126E-02
O	2.4063E-02
B10	4.0141E-06
B11	1.6157E-05

3) The fuel and moderator-coolant temperature

It has been shown that a variation in the cladding temperature has no influence on the evolution of the isotopic inventory [25]. Therefore no sensitivity studies are needed for this parameter.

The fuel temperature is an important parameter in fuel inventory prediction [25]. However, a variation of 50°C in the fuel temperature leads to a degree of uncertainty of about 1% at 60 GWd/t for ^{239}Pu. For the purpose of the benchmark we propose to assume that the bias generated by this parameter is negligible.

The temperature variation of the moderator results both in a thermal spectrum shift and in a variation in density. The isotopes for which the fuel inventory is "deviated" are mainly ^{239}Pu and ^{241}Pu.

The temperature for the studied sample is determined assuming that the increase of temperature is proportional to the integrated power in the axial direction and that the axial power distribution has a cosine shape. Therefore the calculation of moderator-coolant temperature, at the height of the sample, depends on the difference ΔT between the inlet and outlet temperature of the core and on the precise knowledge of the sample height. The information given in reference [9] indicates ΔT= 37°C and a sample height of 1 968 mm (the thickness of the dissolved pellet is 0.5 mm). We propose to use, for sensitivities calculation, an uncertainty of 5°C for ΔT and to assume that the uncertainty on the sample height is negligible, this involved an uncertainty on the moderator-coolant temperature of 3°C leading to the concentration presented in Table B.15:

Table B.15: Moderator concentration for sensitivity study on temperature moderator

Nuclide	Atoms/barn.cm
H	4.8126E-02
O	2.4063E-02
B10	4.0141E-06
B11	1.61573E-05

4) The power history

The benchmark specification proposes to use a constant power irradiation of 38.6 W/g. This assumption leads to bias for isotopes depending on the power history such as ^{135}Xe,

^{149}Sm and also for isotopes strongly depending on the final burn-up value (isotopes of the end of the depletion chain such as ^{242}Pu).

In order to evaluate the sensitivity to these parameters we suggest two calculations.

The first one uses a mean value of the specific power for each cycle. The values were calculated using the reference [9]; the value for the third cycle is adjusted in order to reach the same burn-up as the one used in the benchmark. The proposed power history is the following:

Table B.16: Detailed power history for sensitivity calculation

Start	Stop	Days	Status	Power (W/gU)
26/01/90	15/02/91	385	Full power	39.26
15/02/91	14/05/91	88	Downtime	0
14/05/91	19/06/92	402	Full power	41.86
19/06/92	20/08/92	62	Downtime	0
20/08/92	30/09/93	406	Full power	34.75

The second study, devoted to evaluate the sensitivity of the irradiated sample to the final burn-up, proposes to perform a calculation with a constant power value of 39.4 W/g leading to an increase in the burn-up of roughly 2%. The corresponding irradiation history is:

Table B.17: New power value for sensitivity calculations

Start	Stop	Days	Status	Power (W/gU)
26/01/90	15/02/91	385	Full power	39.6
15/02/91	14/05/91	88	Downtime	0
14/05/91	19/06/92	402	Full power	39.6
19/06/92	20/08/92	62	Downtime	0
20/08/92	30/09/93	406	Full power	39.6

5. Other requested information

The description of analysis environment should include:

- institute and country;
- participants;
- neutron data library;
- neutron data processing code or method;
- neutron energy groups;
- description of your code system;
- geometry modelling;
- omitted nuclides if any;
- omitted cases if any.

6. Complementary information

After the results collection and in case of high discrepancies between participants, complementary data will be asked such as reaction rates, decay data used in depletion chain, detailed depletion chain, fission yields, branching ratio.

7. Schedule

February 2004:	Distribution of draft specification Phase-1 UOx fuel.
March 2004:	Comments on the specification Phase-1.
End of June 2004:	Distribution of the final specification Phase-1.
End of August 2004:	Gathering of results from all participants by CEA.
September 2004:	Presentation of the results and first analysis.
September 2004:	Distribution of draft specification Phase-2 –MOx fuel calculation.

Appendix C: List of available chemical results in SFCOMP and associated chemical analysis uncertainties

U234	1 %	
U235	0.1 %	
U236	2 %	
U238	0.1 %	
Pu238	0.5 %	determined by isotopic dilution mass spectrometry
Pu239	0.3 %	
Pu240	0.3 %	
Pu241	0.3 %	
Pu242	0.3 %	
Np237	10 %	determined by alpha-ray measurement
Am241	2 %	
Am242m	10 %	
Am243	0.5 %	
Cm242	10 %	
Cm243	2 %	determined by alpha and mass spectrometry
Cm244	2 %	
Cm245	2 %	
Cm246	0.5 %	
Cm247	10 %	
Nd143	0.1 %	
Nd144	0.1 %	
Nd145	0.1 %	determined by isotopic dilution mass spectrometry
Nd146	0.1 %	
Nd148	0.1 %	
Nd150	0.1 %	
Cs137	3 %	
Cs134	3 %	
Eu154	3 %	determined by gamma-ray spectrometry
Ce144	10 %	
Sb125	10 %	
Ru106	5 %	
Sm147	0.1 %	
Sm148	0.1 %	
Sm149	0.1 %	
Sm150	0.1%	determined by isotopic dilution mass spectrometry
Sm151	0.1 %	
Sm152	0.1 %	
Sm154	0.1 %	