



MOx Depletion Calculation Benchmark

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Nuclear Science

MOx Depletion Calculation Benchmark

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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. 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.

In 2013 EGRPANS published a report that investigated fuel depletion effects in a Pressurised Water Reactor (PWR). This was entitled “International Comparison of a Depletion Calculation Benchmark on Fuel Cycle Issues” NEA/NSC/DOC(2013)1 that documented a benchmark exercise for UO₂ fuel rods. This report documents a complementary benchmark exercise that focused on PuO₂/UO₂ Mixed Oxide (MO_x) fuel rods. The results are especially relevant to the back-end of the fuel cycle, including irradiated fuel transport, reprocessing, interim storage and waste repository.

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List of abbreviations and acronyms

AP	Activation Product
BWR	Boiling Water Reactor
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
EDF	Électricité de France
EGRPANS	Expert Group on Reactor Physics and Advanced Nuclear Systems
FP	Fission Product
MOX	Mixed oxide
NEA	Nuclear Energy Agency
NNL	National Nuclear Laboratory
NSC	Nuclear Science Committee
PIST	Pre-Irradiation Storage Time
PWR	Pressurised Water Reactor
RSD	Relative Standard Deviation
SD	Standard Deviation
UNIFI	University of Pisa
WPRS	Working Party on Scientific Issues of Reactor Systems

1. Introduction

Some years ago, the NEA Working Party on Scientific Issues in Reactor Systems (WPRS), which is overseen by the Nuclear Science Committee (NSC), began a depletion benchmark which involved the calculation of isotopic inventories in an irradiated PWR-MOx fuel assembly and derived quantities such as decay heat, neutron emissions and the build-up of activation products. Previously, the WPRS had undertaken a similar depletion benchmark for UOx fuel that constituted the first phase of the benchmark [1]. This MOx benchmark represents the second phase of the original study as originally planned.

The MOx benchmark was started shortly before the UOx benchmark was completed, but was brought to a halt by movements of staff within CEA who initiated and led the work. More recently the WPRS asked if the benchmark could be resumed, so as not to lose the effort that had been invested in it and CEA kindly offered to do so. Though some of the results are now dated, they are still relevant today and it is intended that this report will record them and provide a benchmark for any researchers who might wish to apply more modern codes and nuclear data to this problem.

As in the UOx phase, the objective of this benchmark is to compare existing depletion calculations obtained with various codes and data libraries applied to fuel and back-end cycle configuration: transport, reprocessing, interim storage and waste repository. The benchmark 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) [2].

A benchmark exercise should ideally be able to compare calculations with measured data from an experiment. Unfortunately this is not always possible, because experimental results are often constrained by commercial restrictions. Though a suitable set of experimental results have been obtained on fuel irradiated in the SAINT-LAURENT B1 (SLB1) reactor, it has not proved possible to release the full experimental results and supporting information. Instead, CEA offered to specify a benchmark based on the SLB1 irradiation experiment and to use this for code-to-code comparisons rather than direct comparison against measured data. CEA offered to provide their own calculations as a surrogate for the experimental data that would provide an indication of the degree of consistency between the various depletion schemes, codes and nuclear data. This approach cannot provide a means of validating the different codes, for which the full experimental datasets would be required. Nevertheless, the fact that CEA's calculation methods have been validated using the SLB1 data provides some degree of confidence that the surrogate data will not be very much in error and even with this limitation, the WPRS considered this benchmark to be a worthwhile exercise. The SLB1 problem specification was simplified somewhat to provide an approximate representation of the main fuel irradiation conditions, eliminating unnecessary detail while retaining the fundamental characterisation.

SAINT-LAURENT B1 (SLB1) was the first French reactor to use MOx assemblies. SLB1 is a 900 MWe PWR, with 30% MOx fuel loading. The standard MOx assemblies, used in Saint-Laurent B1 reactor, include three zones with different plutonium enrichments, high Pu

content (5.64%) in the centre zone, medium Pu content (4.42%) in the intermediate zone and low Pu content (2.91%) in the peripheral zone. The objective of the different plutonium enrichments is to flatten the power distribution within assemblies and to attenuate fission rate discontinuities at the MO_x-UO_x interface.

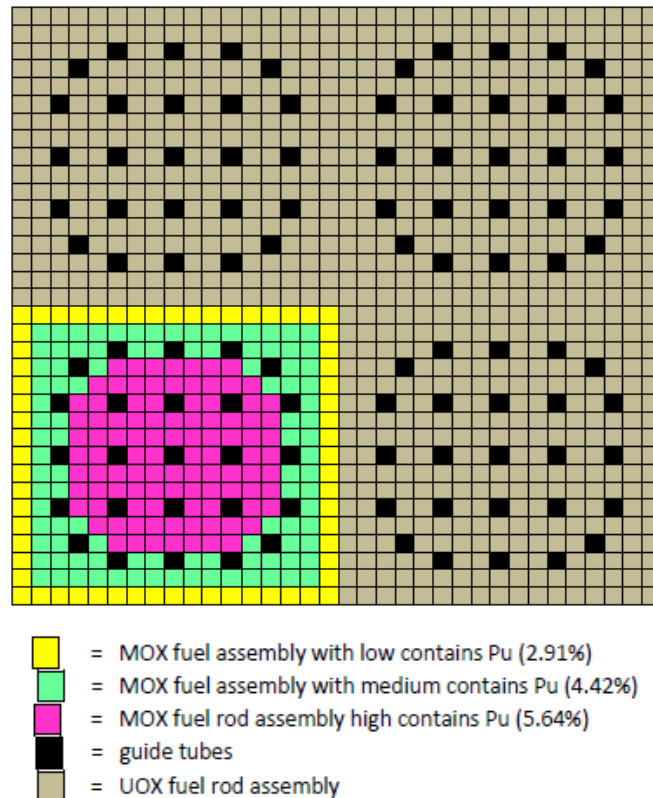
2. Description of the benchmark

2.1 Description of SAINT-LAURENT B1 reactor

The Saint Laurent Reactor is a PWR (Pressurised Water Reactor) which has a unit capacity of 900 MWe. There are two reactors in the Saint Laurent power plant, SLB1 and SLB2, which began commercial operation in 1983 and use the standard 17x17 PWR fuel rod assembly.

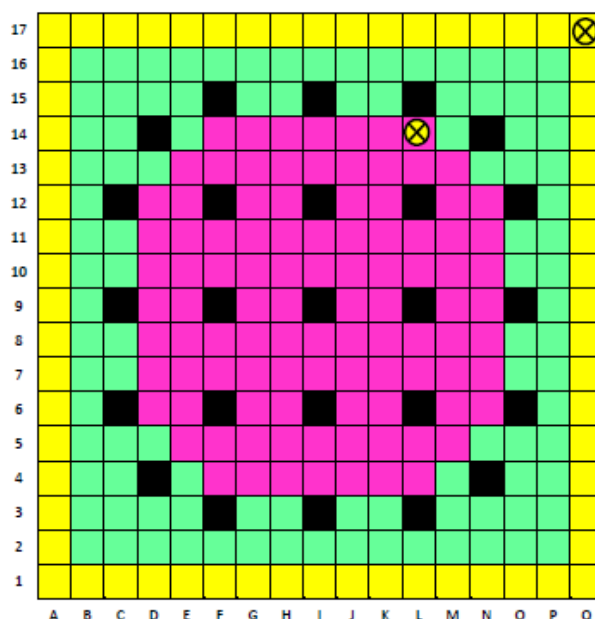
SLB1 is a production reactor which uses MOx fuel. The SLB1 core makes use of MOx and UO₂ (UOx) assemblies, with approximately 30% MOx and 70% UOx. In the MOx assembly used in SLB1, plutonium is distributed in three zones with different plutonium enrichments, as noted above. Figure 1 shows a super-cell cluster of four assemblies in the reactor (one MOx assembly with three UO₂ fuel assemblies). The MOx assembly has three zones with different plutonium contents (often referred to as enrichment zones), used to flatten the power peaking in peripheral fuel rods due to the diffusion of thermal neutrons from the UOx zones. The outer enrichment zone has the lowest plutonium enrichment, as indicated in the legend.

Figure 1. Four fuel assembly super-cell (MOx fuel assembly with UOx environment)



Each assembly (that includes both UO_x and MO_x) has 24 control rod guide tubes (in black in the Figure 2) and 1 instrument tube (central position). The benchmark is based on the two fuel pins which are located in the peripheral zone of the assembly (position Q17 in Figure 2) and in the central zone of assembly (position L14). Q17 contains 2.91% Pu (low enrichment) and L14 contains 5.64% Pu (high enrichment). The inventory calculation for Q17 is strongly influenced by the UO_x rods immediately adjacent to it in the UO_x neighbouring UO_x assembly in this mixed UO_x-MO_x core.

Figure 2. Location of the subject fuel pins Q17 and L14



2.2 Geometry and fuel composition data

The benchmark focuses on a fuel assembly which was irradiated to what was at the time a high burn-up of 40 GWd/t at discharge. As shown in Figure 2, the two subject fuel rods are located at positions Q17 (in the peripheral zone) and L14 (in the central zone).

2.2.1 MO_x fuel compositions

The initial MO_x composition selected is representative of realistic MO_x and UO₂ fuels irradiated in a mixed UO₂-MO_x PWR core. This MO_x fuel contains plutonium with an isotopic composition that is typical of plutonium derived from reprocessing of thermal reactor UO₂ fuels. The fuel has a stoichiometry of exactly 2.00 and a nominal density of 10.02 gm⁻³. Table 1 shows the plutonium isotopic composition, with the same isotopic composition used in all three Pu content zones. Table 2 shows the uranium isotopic composition in the MO_x pins. The initial MO_x fuel enrichments for these zones and the fuel composition are given in Tables 3 and 4.

Table 1. Plutonium isotopic composition in fresh MOx fuel

Nuclide	Isotopic composition (atom%)
²³⁸ Pu	0.8
²³⁹ Pu	66.7
²⁴⁰ Pu	20.6
²⁴¹ Pu	7.5
²⁴² Pu	2.9
²⁴¹ Am	1.5

Table 2. Uranium isotopic composition in fresh MOx fuel

Nuclide	Isotopic composition (atom%)
²³⁴ U	0.002
²³⁵ U	0.22
²³⁶ U	0.004
²³⁸ U	99.774

Table 3. Initial MOx fuel content

Pu content zone	MOx fuel plutonium content, w/o [Pu_total+Am]/[U+Pu+Am]
High	5.64
Medium	4.42
Low	2.91

Table 4. Initial MOx fuel compositions (atoms/barn.cm)

Nuclide	High	Medium	Low
²³⁴ U	4.2175E-07	4.2718E-07	4.3391E-07
²³⁵ U	4.9766E-05	4.8271E-05	4.9682E-05
²³⁶ U	4.2175E-07	8.5435E-07	8.6782E-07
²³⁸ U	2.1037E-02	2.1309E-02	2.1644E-02
²³⁸ Pu	1.0815E-05	8.1476E-06	5.4861E-06
²³⁹ Pu	8.3501E-04	6.5555E-04	4.3144E-04
²⁴⁰ Pu	2.5798E-04	2.0151E-04	1.3387E-04
²⁴¹ Pu	9.4430E-05	7.4065E-05	4.8185E-05
²⁴² Pu	3.6112E-05	2.7751E-05	1.8859E-05
²⁴¹ Am	1.7374E-05	1.4626E-05	9.1090E-06
¹⁶ O	4.4678E-02	4.4681E-02	4.4685E-02
Fuel density (gcm ⁻²)	10.020	10.020	10.020

2.2.2 UO₂ fuel compositions

For the calculations, the adjacent UO₂ fuel assemblies are modelled as previously burned. They have an initial enrichment of 3.25 w/o and are assumed to have a nominal burn-up of 24 GWd/t. The composition of this irradiated UO₂ fuel is presented in Table 5.

Table 5. Initial composition for irradiated UO₂ fuel (atoms/barn.cm)

²³⁵ U	3.0E-04
²³⁶ U	8.0E-05
²³⁸ U	2.0E-02
²³⁷ Np	7.1E-06
²³⁸ Pu	1.7E-06
²³⁹ Pu	1.2E-04
²⁴⁰ Pu	3.8E-05
²⁴¹ Pu	2.1E-05
²⁴² Pu	5.3E-06
²⁴¹ Am	4.2E-07
¹³¹ Xe	1.4E-05
¹³⁵ Xe	8.0E-09
¹⁵³ Eu	2.8E-06
¹⁴⁹ Sm	9.0E-08
¹⁰³ Rh	1.8E-05
¹⁴³ Nd	2.5E-05
¹³³ Cs	3.5E-05
¹⁵⁵ Gd	8.4E-10
⁹⁹ Tc	3.2E-05
⁹⁵ Mo	3.2E-05
¹⁴⁷ Pm	6.4E-06
¹⁵⁰ Sm	7.5E-06
¹⁵¹ Sm	4.1E-07
¹⁵² Sm	3.2E-06
¹⁶ O	4.51E-02

2.2.3 Geometry data

The assembly geometry relates to a typical 17 x 17 PWR fuel assembly, as detailed below:

- fuel pin pitch: 1.262 cm;
- fuel pin radius: 0.474 cm;
- fuel pellet radius: 0.4126 cm.

The air gap between fuel and cladding is not modelled. The inter-assembly water gap is 0.155 cm thick. In each assembly (both UO_x and MO_x assemblies), there are 24 guide tubes and 1 instrument tube modelled as water filled zircaloy tubes with the following dimensions:

- outer radius: 0.613 cm;
- inner radius: 0.571 cm.

2.2.4 Non-fissile material data

The cladding and guide tubes are composed of zircaloy-4, and the coolant (moderator) is light water with 550 ppm boron. These compositions are presented in Table 6.

Table 6. Cladding and guide tubes; coolant/moderator (550 ppm boron)

Nuclide	Atoms/barn.cm
Zr (natural)	3.955E-02
Fe (natural)	1.383E-04
Cr (natural)	7.072E-05
¹⁶ O	2.874E-04

Nuclide	Atoms/barn.cm
H	4.724E-02
¹⁶ O	2.362E-02
¹⁰ B	4.321E-06
¹¹ B	1.739E-05

2.2.5 Impurities for MOx fuels

The nominal number densities of impurities, analogous to those used in the UOx phase, are specified in Table 7. The activation products masses are derived from the specified initial fuel impurities used as the starting point.

Table 7. Initial fuel impurities

Isotopes	atoms/tHM	grams/tHM
¹ H	2.0491E+23	3.4026E-01
² H	3.0741E+19	1.0201E-04
¹⁰ B	6.2931E+21	1.0454E-01
¹¹ B	2.5331E+22	4.6268E-01
¹² C	5.6257E+24	1.1210E+02
¹³ C	6.2571E+22	1.3511E+00
¹⁴ N	4.8610E+23	1.1301E+01
¹⁵ N	1.7857E+21	4.4471E-02
³⁵ Cl	3.6473E+23	2.1198E+01
³⁷ Cl	1.1663E+23	7.1659E+00
⁴⁰ Ca	4.9532E+24	3.2900E+02
⁴² Ca	3.3058E+22	2.3055E+00
⁴³ Ca	6.8978E+21	4.9252E-01
⁴⁴ Ca	1.0658E+23	7.7869E+00
⁴⁶ Ca	2.0438E+20	1.5610E-02
⁴⁸ Ca	9.5547E+21	7.6153E-01
⁵⁴ Fe	3.5435E+23	3.1776E+01
⁵⁶ Fe	5.6040E+24	5.2112E+02
⁵⁷ Fe	1.3441E+23	1.2722E+01
⁵⁸ Fe	1.7106E+22	1.6476E+00
⁵⁹ Co	1.3896E+23	1.3614E+01
⁵⁸ Ni	2.3817E+24	2.2939E+02

Table 7. Initial fuel impurities (continued)

⁶⁰ Ni	9.1052E+23	9.0717E+01
⁶¹ Ni	3.9421E+22	3.9931E+00
⁶² Ni	1.2524E+23	1.2894E+01
⁶⁴ Ni	3.1746E+22	3.3739E+00
⁶³ Cu	7.4286E+23	7.7715E+01
⁶⁵ Cu	3.3110E+23	3.5739E+01
⁹⁰ Zr	3.8493E+23	5.7467E+01
⁹¹ Zr	8.3944E+22	1.2672E+01
⁹² Zr	1.2831E+23	1.9582E+01
⁹⁴ Zr	1.3003E+23	2.0277E+01
⁹⁶ Zr	2.0949E+22	3.3363E+00
⁹³ Nb	7.3465E+23	1.1334E+02
⁹² Mo	3.1677E+23	4.8356E+01
⁹⁴ Mo	1.9745E+23	3.0796E+01
⁹⁵ Mo	3.3982E+23	5.3568E+01
⁹⁶ Mo	3.5604E+23	5.6716E+01
⁹⁷ Mo	2.0385E+23	3.2811E+01
⁹⁸ Mo	5.1507E+23	8.3759E+01
¹⁰⁰ Mo	2.0556E+23	3.4111E+01
¹¹² Sn	5.5781E+21	1.0365E+00
¹¹⁴ Sn	3.7379E+21	7.0698E-01
¹¹⁵ Sn	2.0702E+21	3.9500E-01
¹¹⁶ Sn	8.3557E+22	1.6081E+01
¹¹⁷ Sn	4.4165E+22	8.5733E+00
¹¹⁸ Sn	1.3928E+23	2.7268E+01
¹¹⁹ Sn	4.9341E+22	9.7419E+00
¹²⁰ Sn	1.8741E+23	3.7314E+01
¹²² Sn	2.6626E+22	5.3896E+00
¹²⁴ Sn	3.3296E+22	6.8506E+00
¹⁶ O	5.0502E+27	1.3418E+05
¹⁷ O	1.9237E+24	5.4321E+01
¹⁸ O	1.0125E+25	3.0272E+02

2.3 Irradiation parameters and history

The benchmark uses a nominal fuel temperature of 900 K, a cladding temperature of 620 K and a moderator temperature of 582 K. The experimental data indicate that the assembly was irradiated for three cycles. The power histories were specified such that target burn-ups of 38 GWd/t and 42 GWd/t are attained for the two subject MOx fuel pins Q17 or L14, respectively. The neutronic calculation is performed with an infinite lattice of the cluster of four fuel assemblies (Figure 1). The boundary conditions are reflective at the boundary of the super-cell and all the depletion calculations are made considering a fixed B^2 buckling to simulate axial neutron leakage.

- Q17 MOx fuel pin:
 - cycle 1: 285 days full power, EOC (End Of Cycle) burn-up = 12 GWd/t, cooling time of 60 days;
 - cycle 2: 300 days full power, EOC burn-up = 25 GWd/t, cooling time of 40 days;
 - cycle 3: 280 days full power, EOC burn-up = 38 GWd/t;
- L14 MOx fuel pin:
 - cycle 1: 285 days full power, EOC burn-up = 12 GWd/t, cooling time of 60 days;
 - cycle 2: 300 days full power, EOC burn-up = 25 GWd/t, cooling time of 40 days;
 - cycle 3: 280 days full power, EOC burn-up = 42 GWd/t;

2.4 Required quantities

The required quantities of the benchmark are the masses of nuclides (actinides, fission products, and activation products), neutron emission, and decay heat. The results are compared at discharge (zero cooling time), 5 years, 50 years, 100 years and 300 years cooling time.

2.4.1 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 , $^{242\text{m}}\text{Am}$, ^{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 , $^{93\text{m}}\text{Nb}$, ^{95}Mo , ^{97}Mo , ^{99}Tc , ^{101}Ru , ^{106}Ru , ^{103}Rh , ^{107}Pd , $^{108\text{m}}\text{Ag}$, ^{109}Ag , $^{110\text{m}}\text{Ag}$, ^{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 , $^{166\text{m}}\text{Ho}$.

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 and these two contributions are evaluated separately for: ^3H , ^{10}Be , ^{14}C , ^{93}Zr , ^9Nb , $^{119\text{m}}\text{Sn}$, $^{121\text{m}}\text{Sn}$, ^{126}Sn , ^{125}Sb .

2.4.2 Neutron emission:

(α ,n) emission, spontaneous fission and total emission are calculated.

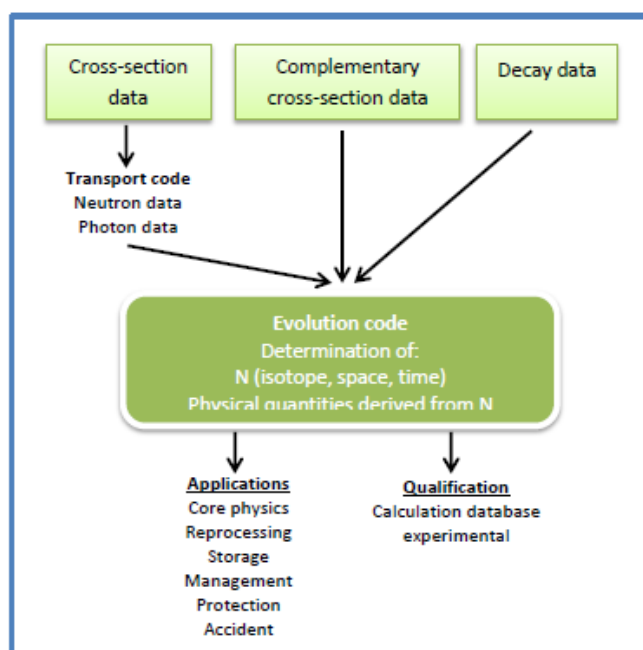
2.4.3 Decay heat:

α , β and γ decay heat are calculated as well as total decay heat.

3. The DARWIN package

The DARWIN package has been developed by CEA and its French partners (AREVA and EDF) to estimate the physical quantities characterising spent fuel from reactors: material balance, decay heat, activity, neutron, α , β , γ sources and spectrum, radiotoxicity [3,4]. DARWIN is applicable to all cycle studies, with current fuels (uranium oxide, mixed oxide) or innovative fuels and for every reactor type (Pressurised Water Reactor, Fast Breeder Reactor, Boiling Water Reactor, Advanced Reactors). DARWIN is also used in the back-end cycle for actinide incineration or long-term interim storage studies (Figure 3).

Figure 3. General outline and scope of DARWIN form



In the CEA calculations for the benchmark, the DARWIN2.3 version based on JEFF3.1.1 [5] nuclear data is used. A summary of the DARWIN2.3 validation for PWR and BWR fuel inventory and decay heat can be found in [6].

The simplified DARWIN structure, based on new codes and libraries is illustrated in Figure 4.

The PEPIN2 programme performs the nuclide depletion calculations. Different libraries feed this module:

- neutronics data provided by French assembly transport codes APOLLO2 [7] (for Pressurised Water Reactor studies), ECCO-ERANOS system (for Fast Breeder Reactor studies): these are self-shielded cross-sections and neutron spectra;

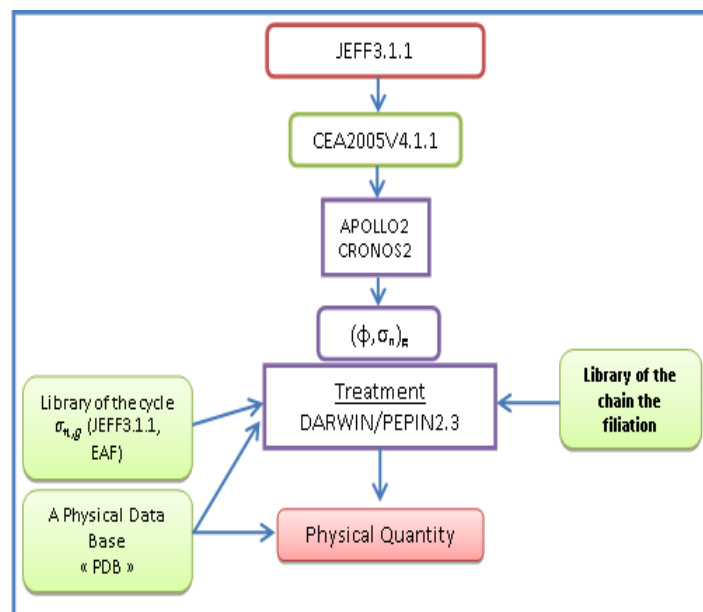
- nuclear data (decay data, fission and (α, n) yields) and evolution chains;
- complementary cross-sections, missing from the transport codes libraries, especially for activation products.

The basic nuclear data come from the JEFF-3.1.1 European evaluation; in the scope of our study, the neutronics data required for the depletion module are provided by the APOLLO2 [7] code and its CEA2005 library and benefits from its extensive experimental validation, for Pressurised Water Reactor (PWR) lattices. For PWR modelling, the CYCLE2008 [4] calculation scheme uses the CEA2005 cross-section library with the SHEM 281 group structure [8], which is processed from the JEFF3.1.1 evaluation. The neutron energy spectrum is calculated in 2D assembly geometry, using a Pij multi-cell model, specifically the UP1 Interface Current method based on linearly anisotropic interface fluxes. The fuel pellets are split into 4 rings (50%, 30% 15% and 5% of total volume), the objective is to give an accurate representation of absorption of ^{238}U as well as the Fission Product (FP) concentration profile.

The local spectrum calculation is performed in the SHEM 281 energy group structure. Space dependent self-shielding (used only above 23eV which is the upper limit of the fine mesh in SHEM) is repeated at recommended burn-up steps, optimised consistently with the 'REL2005' recommendations (0, 4, 8, 12, 24, 36, 48, 60, 72 and 84 GWd/t). There are different self-shielding calculations depending of fuel location, five locations in the MOx and four location in UOx. Refined burn-up steps (units MWd/tHM) are used for the depletion calculation (0, 9.375, 18.75, 37.5, 75, 112.5, 150, 237.5, 325, 412.5, 500, 625, 750, 1000, each 250 up to 2000, each 500 up to 20000, and then each 2000). In MOx assembly calculations, the UO₂ environment is taken into account.

DARWIN also enables the retrieval of cumulative reaction rates during irradiation so as to obtain the origin of every isotope build-up. Furthermore, a perturbation module for the main nuclear data, such as capture cross-section, initial isotopic composition, flux, is also available and allows sensitivity studies.

Figure 4. General diagram of DARWIN package



4. Analysis method

For each dataset comprising N solutions from the various participants, the average value of each isotope and each cooling time, with Standard Deviation (SD) and Relative Standard Deviation (RSD) are calculated. The average and standard deviation are defined below:

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

$$SD = \sqrt{\frac{\sum_{n=1}^N (x_n - A)^2}{N - 1}}$$

According to the equations above, N is the number of the participants and x is the nuclide density (or another data requested by the benchmark). To find the degree of consistency between the entire participants, the Relative Standard Deviation (RSD) is calculated:

$$RSD = \frac{SD}{\text{average}} \times 100\%$$

The Relative Standard Deviation indicates the degree of consistency between the results provided by the participants:

- a small RSD given by isotope indicates good agreement. It means that there is consistency between the various codes and data used (the value obtained by each participant is almost the same);
- a large RSD indicates poor agreement.

As in the first phase, in this benchmark it is assumed that good agreement between participants has been obtained when the RSD is less than 10%. Otherwise, if the quantities under comparison have a RSD greater than 10%, this was considered to indicate poor agreement between participant's results. It should be understood that a small RSD does not mean that all participants calculate the correct value, but just they calculate the same value.

In some instances where one or more of the solutions are strongly discrepant with the other solutions, comparisons with the median are used instead because the median is less biased by outliers than the average.

5. Participants and codes used

Six contributions were submitted to this benchmark exercise, from five different organisations and five countries. Six calculations were complete for assembly model calculation. They represented both deterministic and Monte-Carlo methods in their calculations. In the table below we summarised the participants, the organisations, codes and nuclear data libraries used.

Table 8. List of the participants and codes used

No	Organisation Label	Organisation	Codes used	Nuclear data library used
1.	CEA	Commissariat à l'énergie atomique et aux énergies alternatives, France	DARWIN 2.3 (APOLLO2-PEPIN2)	JEFF3.1.1 EAF (Activation Products)
2.	NNL	National Nuclear Laboratory, United Kingdom	FISPIN	JEF2.2
3.	KURCHATOV	Kurchatov-Institut Russia	MCU Monte Carlo Universal	RUSFOND Library
4.	GRNSPG (UNIFI)	San Piero a Grado Nuclear Research Group (GRNSPG) University of Pisa, Italy	TRITON sequence of the SCALE 6.0 code package (NEWT+ORIGEN-S codes)	ENDF B-VII.0 (data library of the SCALE 6.0 code package)
5.	GRS-KENOREST	Gesellschaft für Anlagen-und-Reactorsicherheit, Germany	GRS KENOREST 2004	JEF2.2
6.	GRS-TRITON	Gesellschaft für Anlagen-und-Reactorsicherheit, Germany	TRITON (SCALE 5.0)	ENDF/B-V

5.1. CEA (Commissariat à l'énergie atomique et aux énergies alternatives, France)

Institute: Commissariat à l'énergie atomique et aux énergies alternatives.

Country: France

Neutron data library: JEFF3.1.1

Neutron energy group: 281 groups (APOLLO2)

Neutron data processing code or method: APOLLO2-PEPIN2

Description of the code system: DARWIN2.3 (see Section 3.4).

5.2 NNL

Institute: National Nuclear Laboratory

Country: United Kingdom

Participant: Christopher Grove

Nuclear data library: JEF2.2

Neutron energy group: 70 groups (CASMO-4)

Description of the code system: CASMO-4/CAS2FIS/FISPIN

Geometry modelling:

2D representation of the complete full assembly with reflective boundary conditions, but with smearing of the MOx and UOx neutron spectra, following the standard calculation route used for industrial applications of FISPIN.

Omitted nuclides: None.

Cases: obligatory cases of Rod L14 and Rod Q17; no optional cases.

5.3. KURCHATOV

Institute: Kurchatov-Institut

Country: Russia

Participant: Mark S. Yudkevich

Nuclear data library: RUSFOND Library

Neutron energy group: unknown

Description of the code system: MCU Monte Carlo Universal

5.4. GRNSPG (UNIPI)

Institute: San Piero a Grado Nuclear Research Group (GRNSPG), University of Pisa

Country: Italy

Participant: Carlo Parisi

Nuclear data library: ENDF B-VII.0 (data library of SCALE 6.0)

Neutron energy group: 238

Neutron data processing code or method: CENTRM 1D code for resonance self-shielding and MCDANCOFF for Dancoff factors calculations.

Description of the code system: TRITON sequence taken from SCALE 6.0

The calculation of GRNSPG/UNIPI is using TRITON taken from SCALE6.0 code package. The neutron transport code was the NEWT code coupled with the depletion code ORIGEN-S.

Geometry modelling: four assembly modelling (3 UO_x and 1 MO_x) with white boundary conditions imposed (periodic boundary conditions, as requested by benchmark specifications, not available for NEWT code).

5.5. GRS-KENOREST [9] [10] [11] [12] [13] [14] [15] [16] [17] [18]

Institute: Gesellschaft für Anlagen-und-Reactorsicherheit

Country: Germany

Participant: Robert Kilger, Ulrich Hesse, Siegfried Langenbuch

Neutron library: JEF2.2 based on the library KORLIB-V4 for KENO-Va; GRS-extended libraries for OREST-HAMMER -ORIGEN, based on JEF2.2/ENDFB-VI, JENDL3.2 and EAF97 for 500 Isotopes.

Neutron data processing code or method: Condensing KORLIB-V4 from 292 group library JEF2.2 for the infinite dilution case; Nordheim resonance treatment is done by the HAMMER code using resonance parameters. 83 neutron energy groups are used, herein 32 thermal groups up to 1,13 eV (KENO-Va); PL-order is 3.

Description of the code system: GRS KENOREST 2004

KENOREST Version 2004 includes 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 2004 (HAMMER/GRS-ORIGEN-X) for single rod burn-up calculations. The coupling in KENOREST is realised using flux and reaction rate conservation with the FEC method of GRS. The flux spectra and cross-sections calculations for the fuel rods are performed by the HAMMER code (THERMOS-HAMLET) using the method of integral Boltzmann neutron transport calculation and Nordheim resonance treatment in the resonance region. The cross-sections are directly fed back to KENO.

Notes:

First, decay heat and powers calculated by KENOREST are related to the complete set of nuclides in GRS-ORIGEN-X, not only to those specified for the benchmark.

Second, (α ,n)- and spontaneous fission neutron emissions were calculated for the specified nuclide set of interest using the GRS code NGSRC taken from GRS ANITABL code system (thus not being part of KENOREST).

Geometry modelling:

2D full fuel element plus UO_x environment with periodic boundaries; details exactly as proposed by specification. UO_x environment was not depleted but was included in flux and reactivity calculations during burn-up.

Omitted nuclides: None.

Cases: Obligatory assembly cases L14 and Q17; no optional cases.

5.6. GRS-TRITON [19]

Institute: Gesellschaft für Anlagen-und-Reactorsicherheit, Germany

Country: Germany

Participant: Robert Kilger, Ulrich Hesse, Siegfried Langenbuch

Neutron library:

ENDF/B-V based 44GROUPNDF5 library of SCALE 5.0; no activation data file included, thus no activation products being calculated.

Neutron data processing code or method:

Cross-section processing and Nordheim resonance treatment by BONAMI-NITAWL sequence of SCALE 5.0.

Description of the code system: TRITON taken from SCALE 5.0

The following modules are being part of the SCALE 5.0 code package: TRITON-sequence using BONAMI-NITAWL for pre-processing; two-dimensional discrete ordinates transport algorithm NEWT for 2D flux calculations, and ORIGEN-S depletion calculation code for single rod burn-up and decay steps. Flux coupling between NEWT and ORIGEN-S performed by the COUPLE module. OPUS module was used for refining the resulting data.

Geometry modelling:

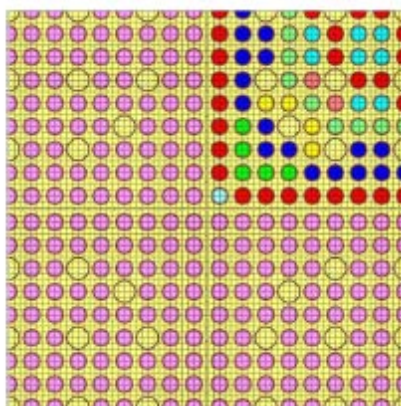
2D quarter fuel element and respective UO_x environment with reflective boundaries (see Figure 5). The UO_x environment was not depleted but was included in flux and reactivity calculations during burn-up.

Omitted nuclides:

Due to omittance in the neutron library these nuclides were not used in the input file: fuel impurities C-13/14, O-17/18, Cl-35/37; all Ca, Fe, Ni, Cu. As a result of these omissions, the respective activation products in the results are not valid. Decay heats and neutron emission are not available up to now.

Cases: obligatory assembly cases L14 and Q17; no optional cases.

Figure 5. NEWT/TRITON geometry model of benchmark case Q17



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

6.1. Actinides results

6.1.1. Q17 Fuel rod

The actinides results for rod Q17 are listed in Appendix A, Tables A.1-A.6. These tables give the relative standard deviation (RSD) at different cooling times. Figure 6 shows RSD versus cooling time for selected actinides. Table 9 below summarises the main trends obtained for RSD, grouping the various nuclides into those with <10% RSD and >10% RSD.

Figure 6. RSD versus cooling time for actinides in Q17 fuel rod

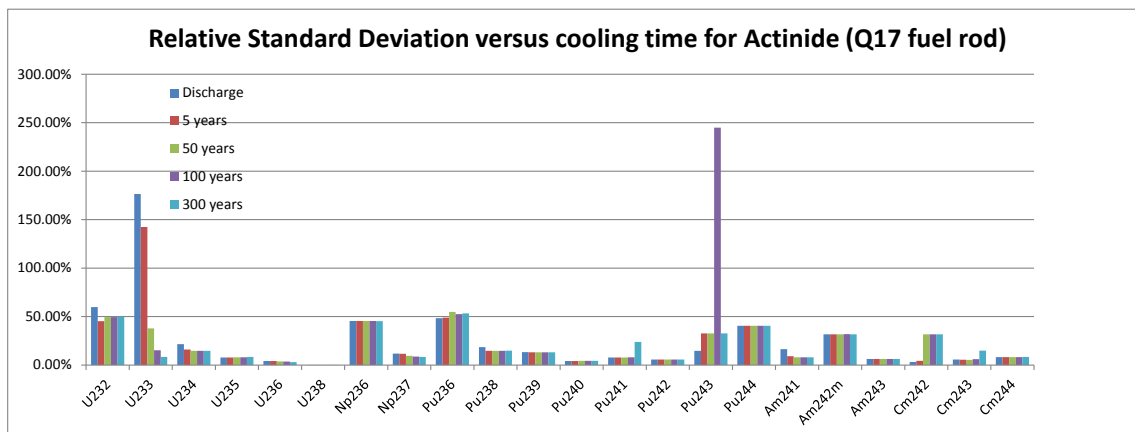


Table 9. Summary of RSD major trends at discharge for the actinides in Q17 fuel rod

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

Most of the actinides have a RSD in excess of 10%. As this is a relatively poor level of agreement, the following analysis focuses on some of the more important actinides:

^{235}U , ^{238}U , ^{239}Pu :

Table 10 shows the discharge inventories for ^{235}U , ^{238}U , and ^{239}Pu .

Table 11 shows the comparison between calculated results for ^{235}U , ^{238}U , ^{239}Pu and median value at discharge. We can see that results are consistent between all the participants. For ^{235}U , most of the values are close to the median. At least, for ^{238}U all participants are very consistent.

Table 10. Results at discharge for ^{235}U , ^{238}U and ^{239}Pu (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	MEDIAN	SD	RSD
^{235}U	5.946E+02	6.180E+02	5.896E+02	7.085E+02	5.852E+02	5.857E+02	5.921E+02	4.81E+01	7.83%
^{238}U	9.395E+05	9.394E+05	9.391E+05	9.352E+05	9.390E+05	9.387E+05	9.391E+05	1.63E+03	0.17%
^{239}Pu	6.819E+03	7.054E+03	7.053E+03	9.489E+03	7.239E+03	7.133E+03	7.094E+03	1.00E+03	13.42%

Table 11. Comparison for ^{235}U , ^{238}U and ^{239}Pu to the median value (M) at discharge

	MEDIAN	(CEA-M)/M	(NNL-M)/M	(KURCH-M)/M	(UNIPI-M)/M	(GRSK-M)/M	(GRST-M)/M
^{235}U	5.921E+02	0%	4%	0%	20%	-1%	-1%
^{238}U	9.391E+05	0%	0%	0%	0%	0%	0%
^{239}Pu	7.094E+03	-4%	-1%	-1%	34%	2%	1%

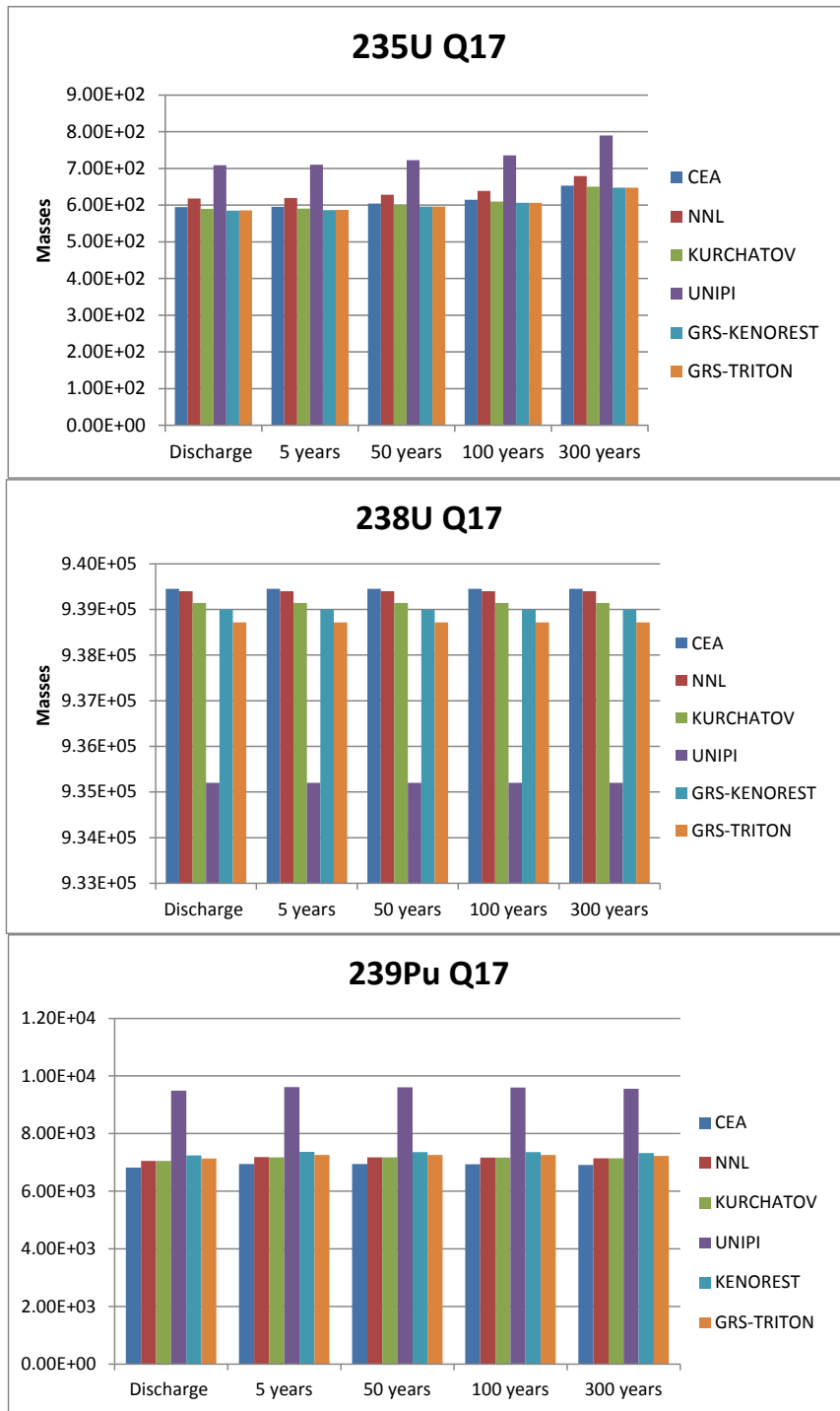
Table 12 shows RSD versus cooling time for ^{235}U , ^{238}U , ^{239}Pu . For ^{235}U and ^{238}U the RSD is less than 10% for all cooling times considered, implying good agreement between the participants for these actinides. For ^{239}Pu , RSD is about 13%.

Table 12. Trends on RSD with cooling time for actinides in Q17 fuel rod

	Discharge	5 years	50 years	100 years	300 years
U235	7.83%	7.85%	7.92%	7.99%	8.28%
U238	0.17%	0.17%	0.17%	0.17%	0.17%
Pu239	13.42%	13.18%	13.17%	13.17%	13.14%

Even though these results are broadly consistent, we can see different trends on these major actinides due to the different modelling approaches. Figure 7 shows the calculated masses for ^{235}U , ^{238}U , ^{239}Pu . We can see that for ^{238}U , UNIPI has lower values than the others. Because of a greater capture in ^{238}U for UNIPI calculations, we can observe a greater conversion into ^{239}Pu and a lower consumption of ^{235}U . These discrepancies are probably due to a different calculated spectrum in this rod due to a combination of: inconsistent self-shielding treatment; or incorrect modelling of the environment of the fuel rod. As Rod Q17 rod is located at the corner of the assembly, the depletion of actinides is very sensitive to the environment and it is important that the neutron spectrum takes account of the varying thermal neutron spectra in the MOx and UOx assemblies. For example, due to a limitation with the NEWT code, UNIPI is forced to use white boundary conditions instead of periodic ones and this could be one of the reasons why differences are seen. In the case of the NNL calculations, the spectra of the UOx and MOx regions were smeared, following the standard calculation method used in industrial applications. The thermal neutron spectrum for Rod Q17 is therefore harder than it should be, which results in slightly increased ^{239}Pu production and a slightly slower depletion rate for ^{235}U . These effects are consistent with the data shown in Figure 7. Due to a limitation of the NEWT code, white boundary conditions were used in the UNIPI solution instead of the periodic boundary conditions specified. The trends for ^{235}U , ^{238}U and ^{239}Pu for the UNIPI solution are in the same sense as those of the NNL results and the boundary conditions may be a contributory factor.

Figure 7. Masses (g/tHMI) calculated by the participants for ²³⁵U, ²³⁸U and ²³⁹Pu



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

These three isotopes are connected as shown with the chain below (see Figure 8). Table 13, shows that ^{236}Np and ^{236}Pu each has an RSD around 50% and for ^{232}U , RSD is almost 60%, indicating that there is poor agreement between the participants. The ^{237}Np calculations are satisfactory with a RSD of 12%.

Figure 8. Decay scheme of ^{237}Np , ^{236}Np , ^{236}Pu and ^{232}U

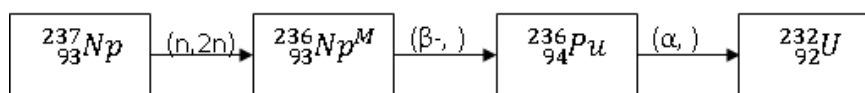


Table 13. Results at discharge for ^{237}Np , ^{236}Np , ^{236}Pu and ^{232}U (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	MEDIAN	RSD
^{237}Np	1.343E+02	1.238E+02	1.327E+02	1.686E+02	1.271E+02	1.360E+02	1.335E+02	11.75%
^{236}Np	1.304E-04	2.246E-04	1.678E-04	2.916E-04	1.402E-04	7.071E-05	1.540E-04	45.39%
^{236}Pu	4.618E-04	8.322E-04	6.618E-04	1.217E-03	4.735E-04	3.401E-04	5.677E-04	48.36%
^{232}U	9.120E-05	2.873E-04	1.290E-04	2.624E-04	9.090E-05	7.855E-05	1.101E-04	59.73%

Table 14 shows that calculated results for ^{237}Np are consistent between the participants. In MOx fuel, the major production route for ^{237}Np is from the (n,2n) reaction with ^{238}U . This implies that this reaction is well calculated by all the participants. For the other isotopes (^{236}Np , ^{236}Pu and ^{232}U), CEA, KURCHATOV and GRS-KENOREST inventories are close to the median.

Table 14. Masses comparison for ^{237}Np , ^{236}Np , ^{236}Pu and ^{232}U to the median value (M) at discharge

	MEDIAN	(CEA-M)/M	(NNL-M)/M	(KURCH-M)/M	(UNIPI-M)/M	(GRSK-M)/M	(GRST-M)/M
^{237}Np	1.371E+02	1%	-7%	-1%	26%	-5%	2%
^{236}Np	1.709E-04	-15%	46%	9%	89%	-9%	-54%
^{236}Pu	6.644E-04	-19%	47%	17%	114%	-17%	-40%
^{232}U	1.566E-04	-17%	161%	17%	138%	-17%	-29%

Table 15 shows RSD versus cooling time for ^{236}Np , ^{236}Pu and ^{232}U . The RSD at each cooling time is almost the same.

Table 15. RSD versus cooling time for ^{236}Np , ^{236}Pu and ^{232}U

	Discharge	5 years	50 years	100 years	300 years
^{232}U	59.73%	45.32%	49.41%	49.50%	49.86%
^{236}Np	45.39%	45.38%	45.38%	45.38%	45.36%
^{236}Pu	48.36%	48.93%	54.74%	52.52%	53.40%

Due to the significant discrepancies observed, it may be misleading to use the median or average as the reference and Table 16 compares the various discharge inventories against the CEA calculations instead. We can see that GRS-KENOREST calculations are in closest agreement with CEA.

Table 16. Comparison for ^{237}Np , ^{236}Np , ^{236}Pu and ^{232}U to the CEA value at discharge

	(NNL-CEA) /CEA	KURCHATOV-CEA) /CEA	(UNIPI-CEA) /CEA	(GRS'K-CEA) /CEA	(GRS'T-CEA) /CEA
^{237}Np	-8%	-1%	26%	-5%	1%
^{236}Np	72%	29%	124%	8%	-46%
^{236}Pu	80%	43%	164%	3%	-26%
^{232}U	215%	41%	188%	0%	-14%

The fact that ^{237}Np is in good agreement between the participants shows that the cross-sections for $^{238}\text{U}(n,2n)^{237}\text{Np}$ are reasonably consistent. However, the poor agreement for ^{236}Np and ^{236}Pu indicates inconsistencies in the cross-sections for $^{237}\text{Np}(n,2n)^{236}\text{Np}$. ^{236}Np and ^{236}Pu are quite closely correlated, as would be expected since they are linked by beta decay. The correlation for ^{232}U is quite close to that for ^{236}Np and ^{236}Pu , except for the NNL result. There are multiple production routes for ^{232}U , one of which depends on the Pre-Irradiation Storage Time (PIST) which may have been treated differently by the different participants.

 ^{243}Pu :

Figure 6 shows surprising behaviour of the RSD at 100 years cooling time for ^{243}Pu . The discrepancy is larger than at discharge, 5 years, 50 years and 300 years cooling time. The large RSD is due to the value of GRS-TRITON which is very different, in order 10^{-5} , while the others are in order 10^{-12} (see Table 17). Since the GRS-TRITON results for other cooling times are not so discrepant, the value at 100 years is likely to be a simple transcription error.

Table 17. Masses (g/tHMI) and RSD at 100 years cooling time for ^{243}Pu

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	MEDIAN	RSD
^{243}Pu	3.340E-12	1.934E-12	2.743E-12	4.916E-12	2.826E-12	6.892E-05	2.826E-12	35.13%

 ^{238}Pu , ^{240}Pu , ^{241}Pu , ^{242}Pu :

Figure 9 shows the masses calculated by the participants for ^{238}Pu , ^{240}Pu , ^{241}Pu and ^{242}Pu . In MOx fuels, ^{238}Pu is produced by decay of ^{242}Cm (which in turn comes from ^{241}Am neutron capture, followed by ^{242}Am decay). ^{242}Cm is calculated with good agreement between the participants (RSD=3% at discharge). ^{238}Pu is consistent between the participants except for the UNIPI calculations where it is overestimated. ^{240}Pu , ^{241}Pu and ^{242}Pu are calculated consistently by the participants with RSDs below 10%. ^{240}Pu is produced by neutron capture from ^{239}Pu . The UNIPI calculations overestimate the inventory of ^{239}Pu and this leads to a corresponding overestimate of ^{240}Pu .

^{241}Pu is produced by neutron capture from ^{240}Pu and good agreement is obtained between the participants. ^{242}Pu is mainly produced by neutron capture from ^{241}Pu and there are some discrepancies between the participants.

Figure 9. Masses (g/tHMI) calculated by the participants for ^{238}Pu , ^{240}Pu , ^{241}Pu and ^{242}Pu

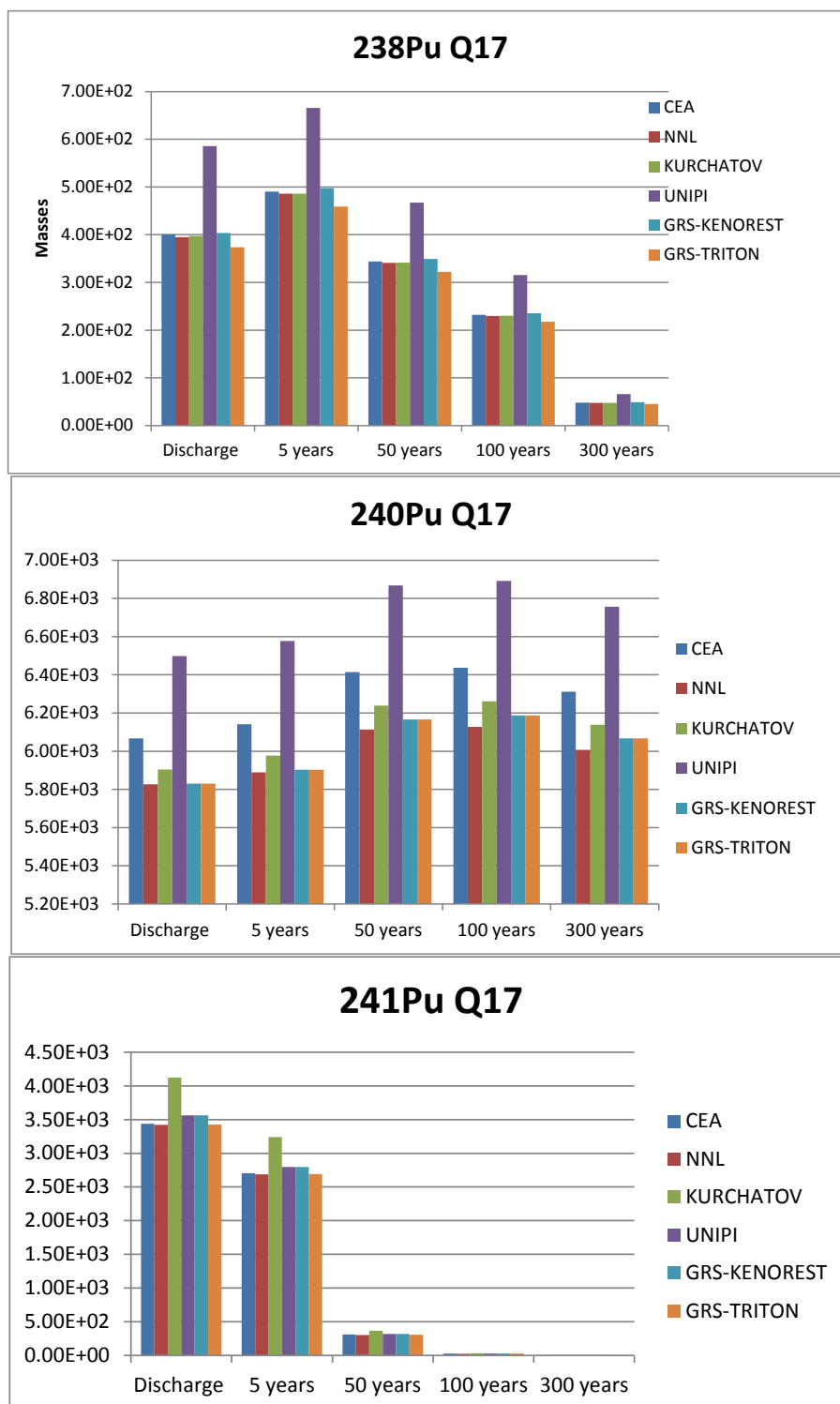
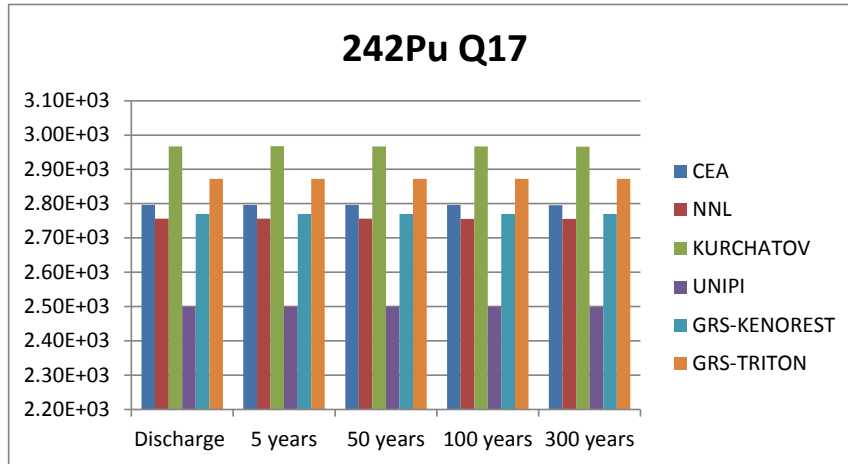


Figure 9. Masses (g/tHMI) calculated by the participants for ^{238}Pu , ^{240}Pu , ^{241}Pu and ^{242}Pu (continued)



^{241}Am , $^{242\text{m}}\text{Am}$:

Figure 10 shows masses obtained by the participants for ^{241}Am and $^{242\text{m}}\text{Am}$. At this burn-up, ^{241}Am is mainly produced by ^{241}Pu decay. At discharge the RSD is 16.5% and this falls below 10% after cooling. For $^{242\text{m}}\text{Am}$ the RSD is about 30% irrespective of the cooling time.

Figure 10. Masses (g/tHMI) calculated by the participants for ^{241}Am and $^{242\text{m}}\text{Am}$

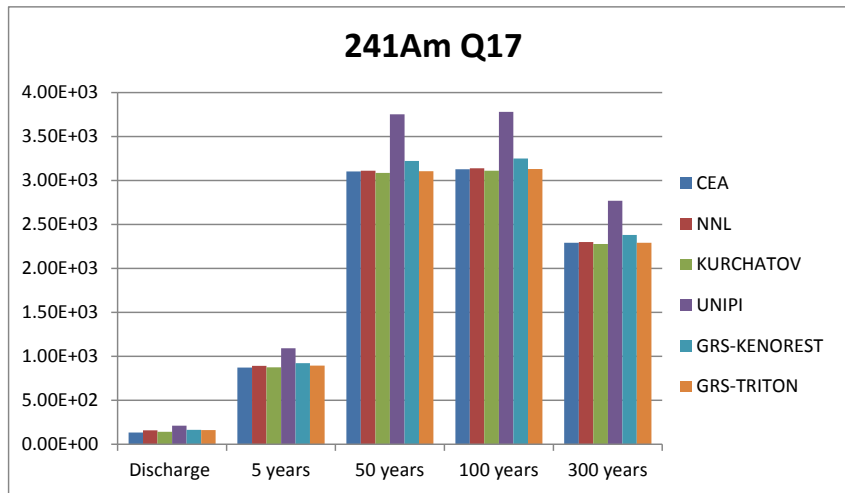
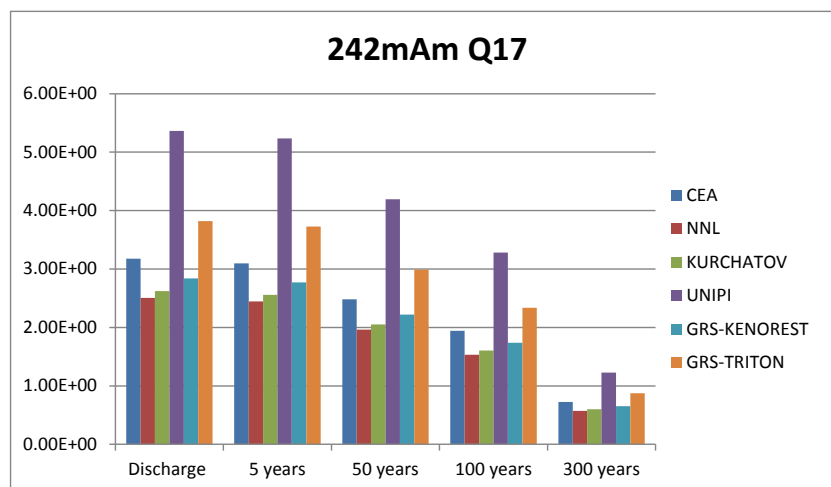


Figure 10. Masses (g/tHMI) calculated by the participants for ^{241}Am and ^{242m}Am (continued)



^{242}Cm , ^{234}Cm , ^{244}Cm and ^{245}Cm :

Results for these isotopes are shown in Figure 11. ^{242}Cm , ^{234}Cm and ^{244}Cm are consistent at discharge (RSD<10%). From ^{245}Cm and beyond, there is an overestimation by the UNIFI calculations which explains why the RSD increases.

Figure 11. Masses (g/tHMI) calculated by the participants for Cm isotopes

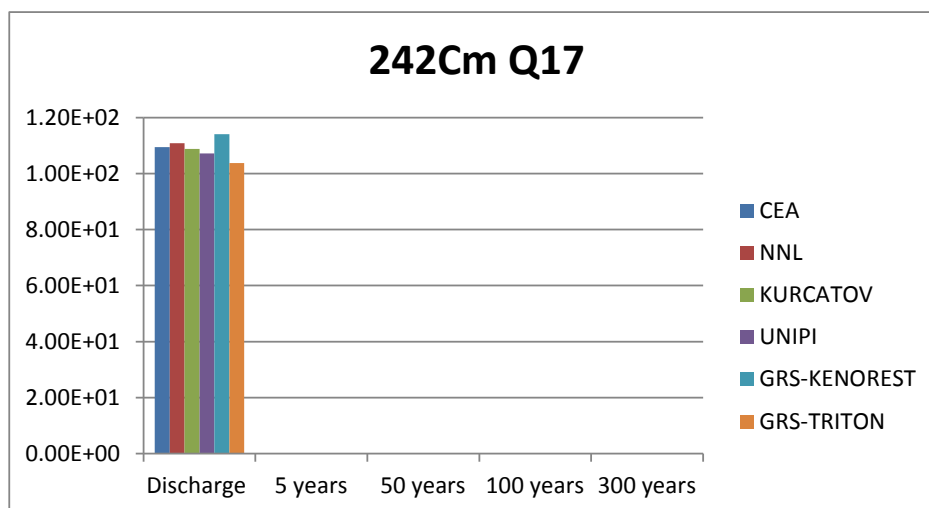


Figure 11. Masses (g/tHMI) calculated by the participants for Cm isotopes (continued)

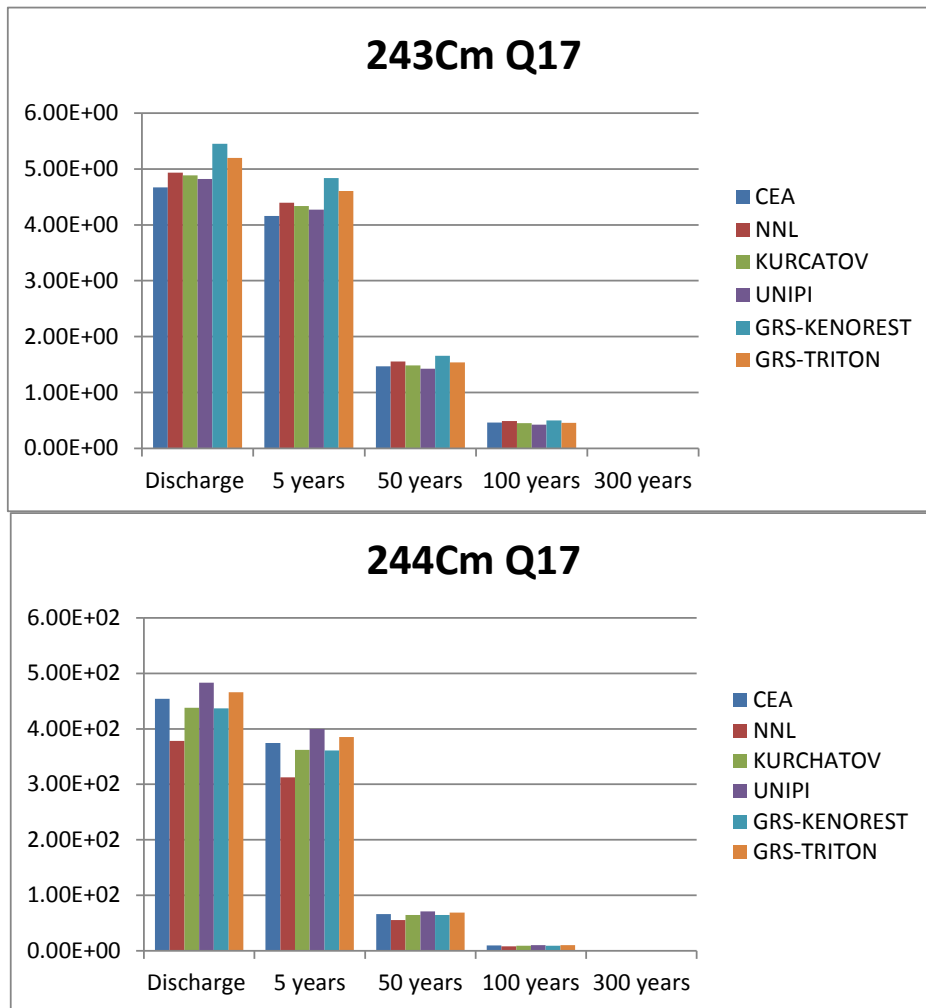
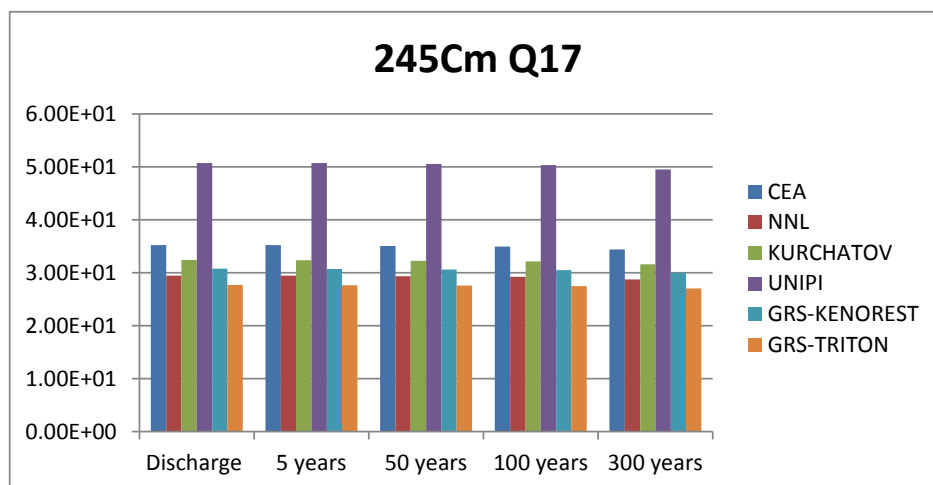


Figure 11. Masses (g/tHMI) calculated by the participants for Cm isotopes (continued)



6.1.2. L14 Fuel rod

The actinide results of L14 are listed in Appendix B, Tables B.1-B.7. These tables give masses and the relative standard deviations (RSD) versus cooling times. Figure 12 shows RSD versus cooling time for a selection of actinides. Table 18 summarises the major trends obtained in terms of the RSD.

Figure 12. RSD versus cooling time for actinides in L14 fuel rod

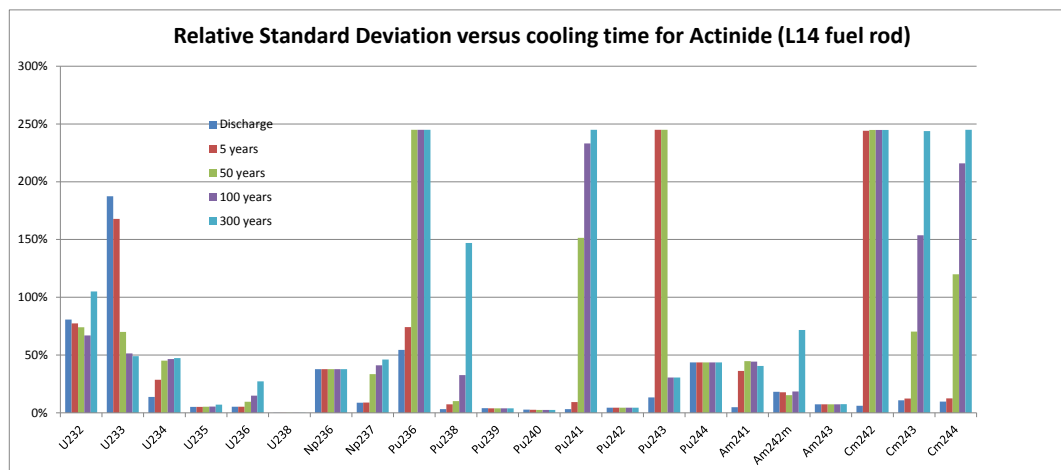


Table 18. Summary of RSD major trends at discharge for the actinides in L14 fuel rod

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

RSD values greater than 10%, imply poor agreement between the participants.

We can see that results are less satisfactory for this rod than for Q17, because many of the actinides have higher RSD (see Table 18), even though the spectral uncertainties should be less than for the corner rod Q17. It can be explained by some inconsistencies: In the Kurchatov calculations, we can see that ^{241}Pu and $^{242\text{m}}\text{Am}$ do not have beta decay. ^{238}Pu does not decrease to ^{234}U . The problem is the same for the Cm isotopes (see Figure 14).

Figure 13. Masses (g/tHMI) calculated by the participants for ^{235}U , ^{238}U , ^{239}Pu and ^{240}Pu

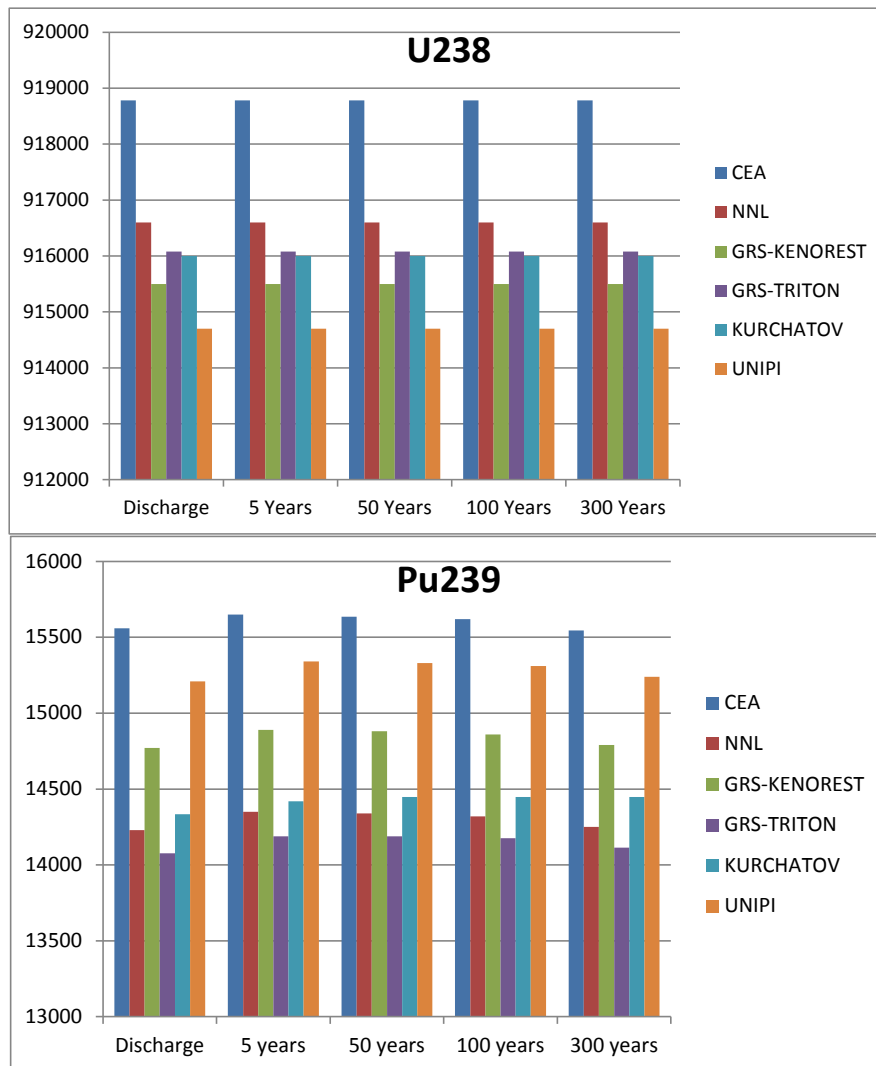


Figure 13. Masses (g/tHMI) calculated by the participants for ^{235}U , ^{238}U , ^{239}Pu and ^{240}Pu (continued)

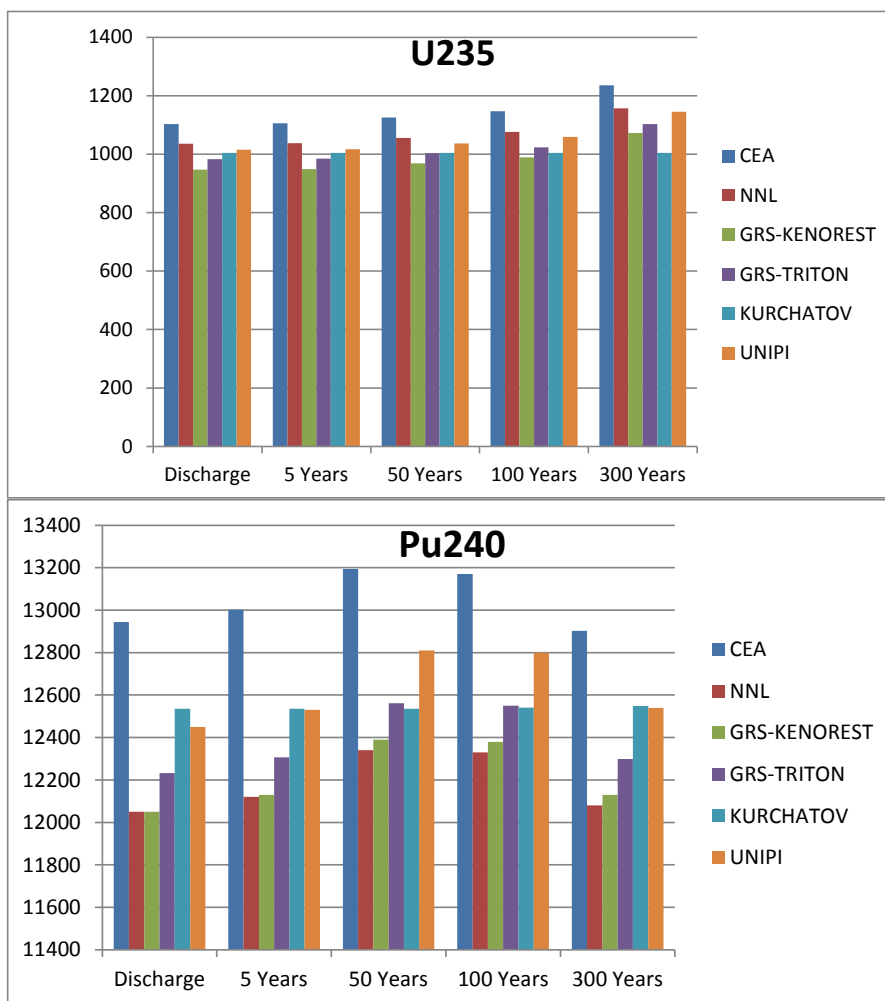


Figure 14. Masses (g/tHMI) calculated by the participants for ^{234}U , ^{238}Pu , ^{241}Pu , ^{241}Am , $^{242\text{m}}\text{Am}$ and ^{244}Cm

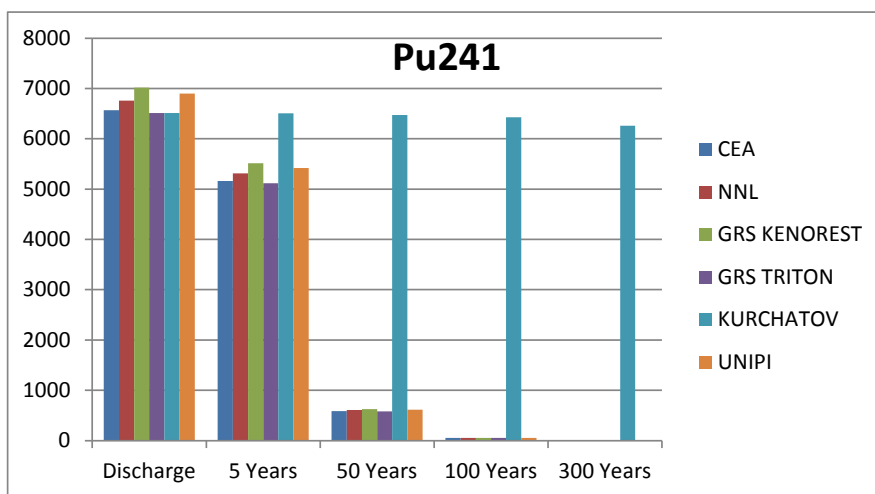


Figure 14. Masses (g/tHMI) calculated by the participants for ^{234}U , ^{238}Pu , ^{241}Pu , ^{241}Am , $^{242\text{m}}\text{Am}$ and ^{244}Cm (continued)

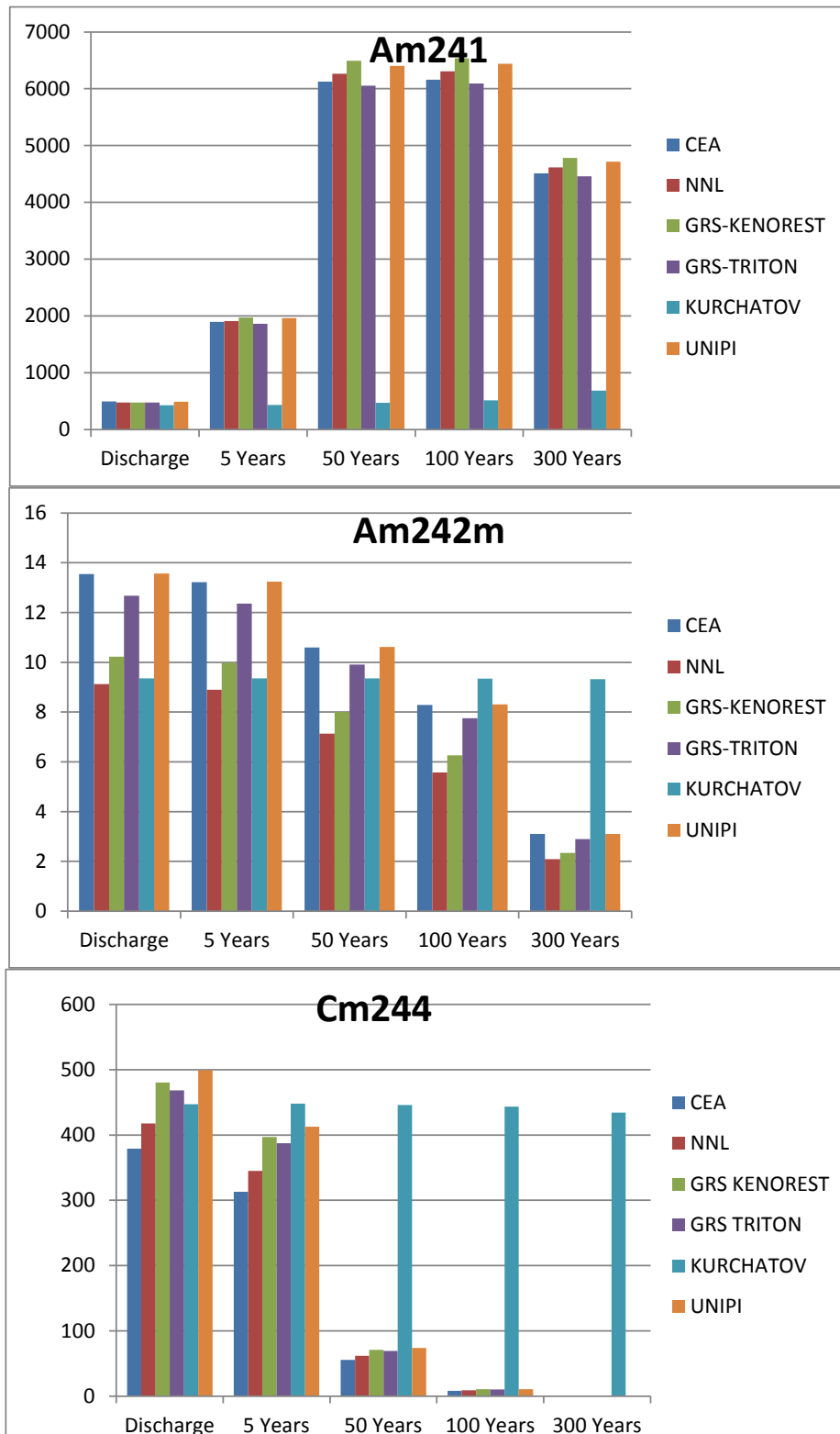
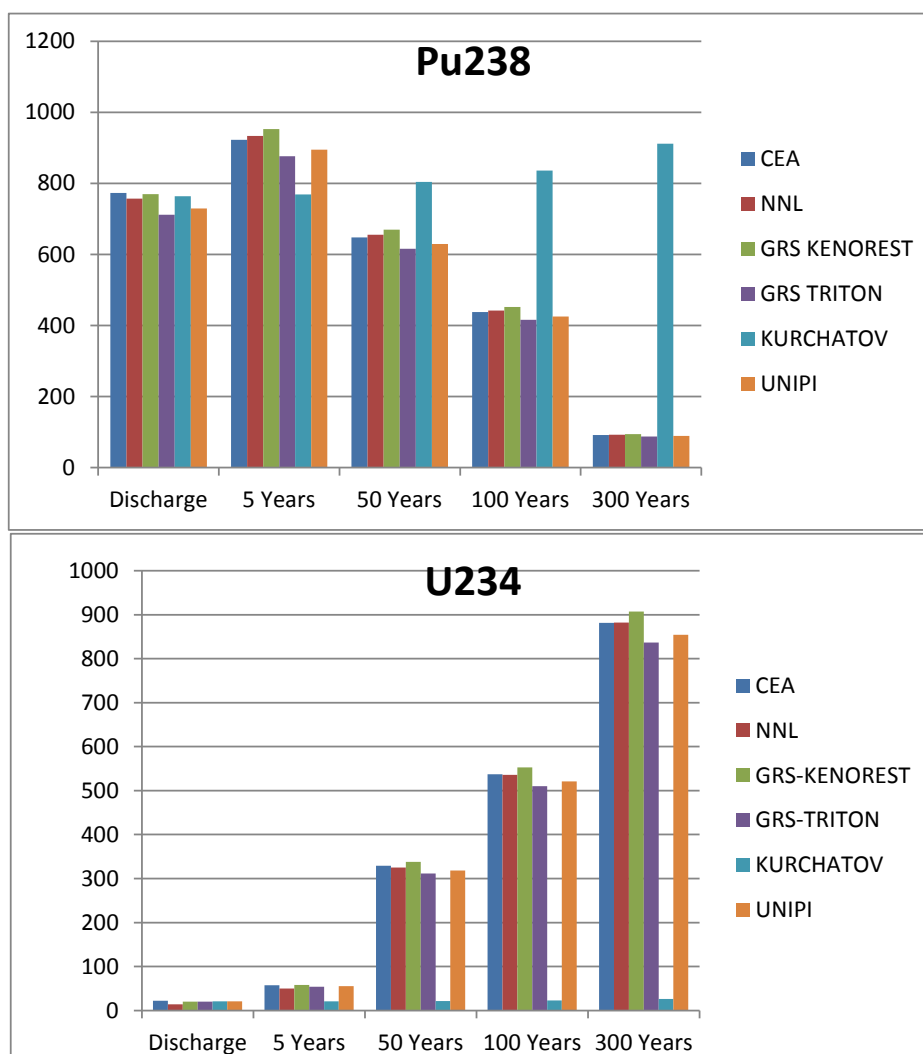
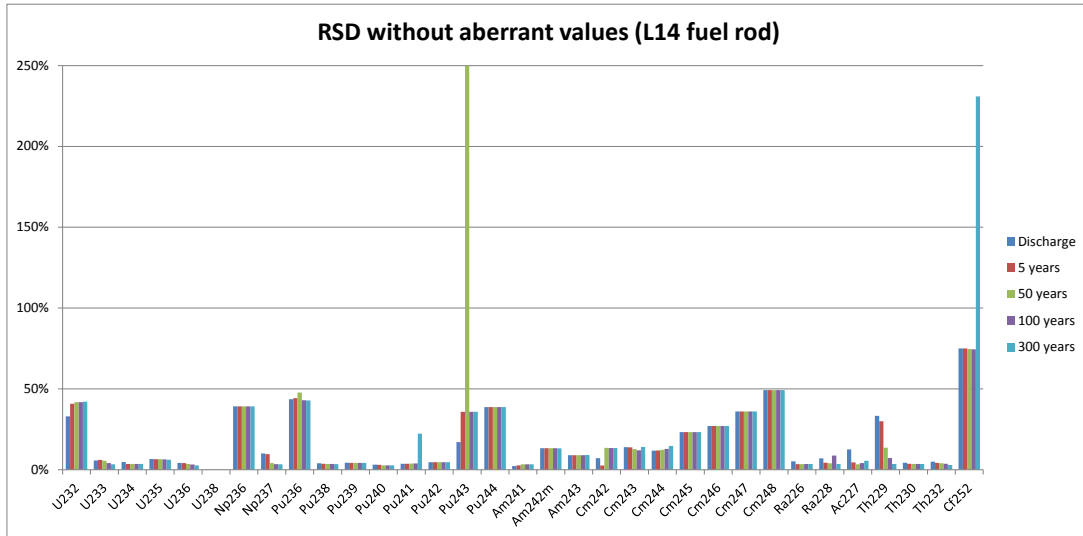


Figure 14. Masses (g/tHMI) calculated by the participants for ^{234}U , ^{238}Pu , ^{241}Pu , ^{241}Am , $^{242\text{m}}\text{Am}$ and ^{244}Cm (continued)



As shown in Figure 15, RSD is quite satisfactory for actinides if we exclude the aberrant values.

Figure 15. Result of RSD versus cooling time for actinides code-to-code comparison without aberrant values



6.2. Fission product results

6.2.1. Q17 Fuel rod

Tables A.7-A.12 (Appendix A) detail the isotopic concentrations and RSD versus cooling time for the fission products. Figure 16 shows RSD versus cooling times for some fission products. Table 19 summarises the main trends obtained for RSD.

Figure 16. RSD versus cooling time for some fission products in Q17 rod

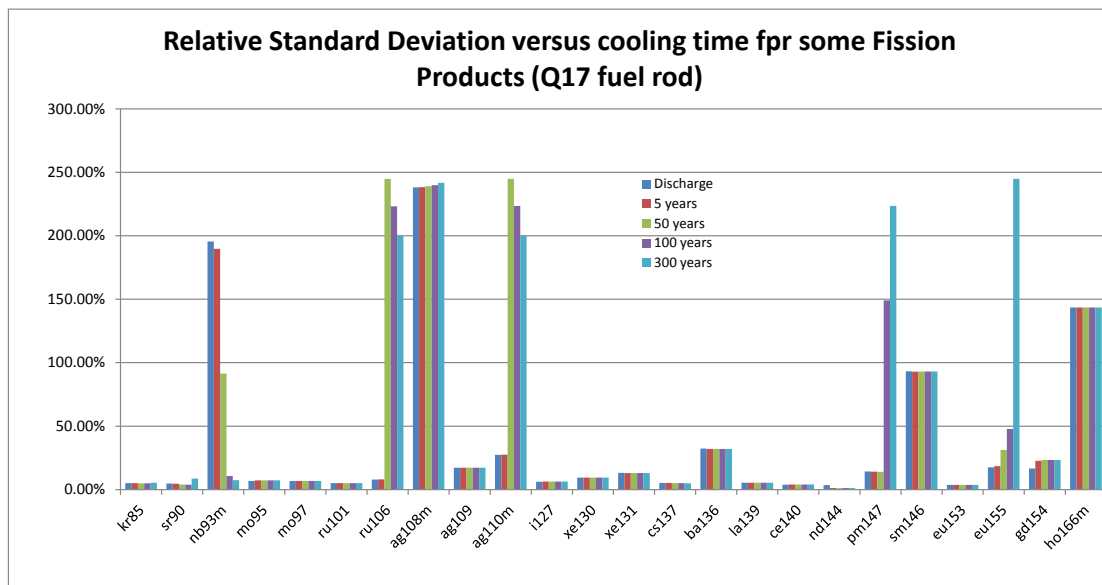


Table 19. Summary of the main RSD trends for the fission products in Q17 fuel rod

Relative standard deviation	≤ 10%	> 10%
Isotopes	^{79}Se , ^{85}Kr , ^{85}Rb , ^{87}Rb , ^{88}Sr , ^{90}Sr , ^{95}Mo , ^{97}Mo , ^{99}Tc , ^{101}Ru , ^{107}Pd , ^{127}I , ^{129}I , ^{132}Xe , ^{134}Xe , ^{136}Xe , ^{133}Cs , ^{134}Cs , ^{137}Cs , ^{138}Ba , ^{139}La , ^{140}Ce , ^{144}Ce , ^{142}Nd , ^{143}Nd , ^{144}Nd , ^{145}Nd , ^{146}Nd , ^{148}Nd , ^{150}Nd , ^{147}Sm , ^{148}Sm , ^{154}Sm , ^{153}Eu , ^{156}Gd	$^{93\text{m}}\text{Nb}$, ^{95}Mo , ^{106}Ru , ^{103}Rh , $^{108\text{m}}\text{Ag}$, ^{109}Ag , $^{110\text{m}}\text{Ag}$, ^{130}Xe , ^{131}Xe , ^{135}Cs , ^{136}Ba , ^{147}Pm , ^{146}Sm , ^{149}Sm , ^{150}Sm , ^{151}Sm , ^{152}Sm , ^{154}Eu , ^{155}Eu , ^{154}Gd , ^{155}Gd , $^{166\text{m}}\text{Ho}$

A lot of isotopes have a RSD greater than 10%, therefore just a few are analysed here. There are, however, some discrepancies, as shown in Figure 17. In some cases, these discrepancies are probably due to inappropriate decay data (^{106}Ru , $^{110\text{m}}\text{Ag}$) or fission yields leading to incoherent values.

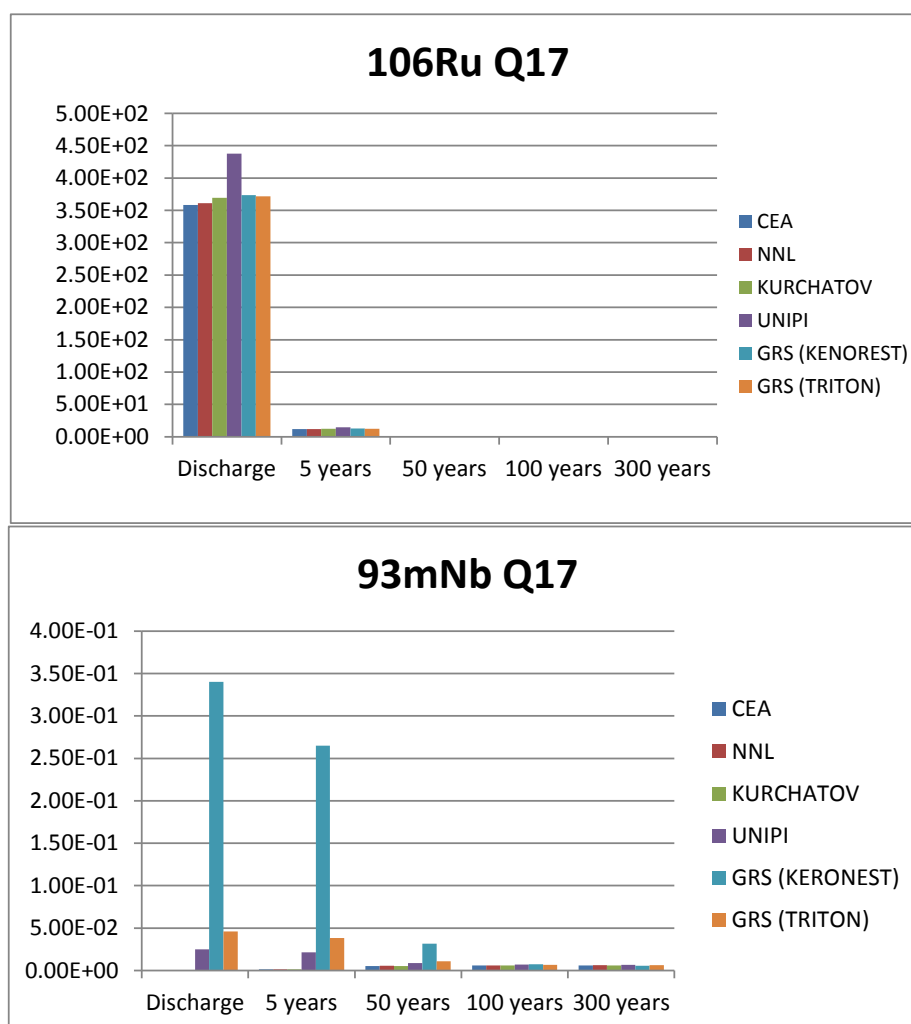
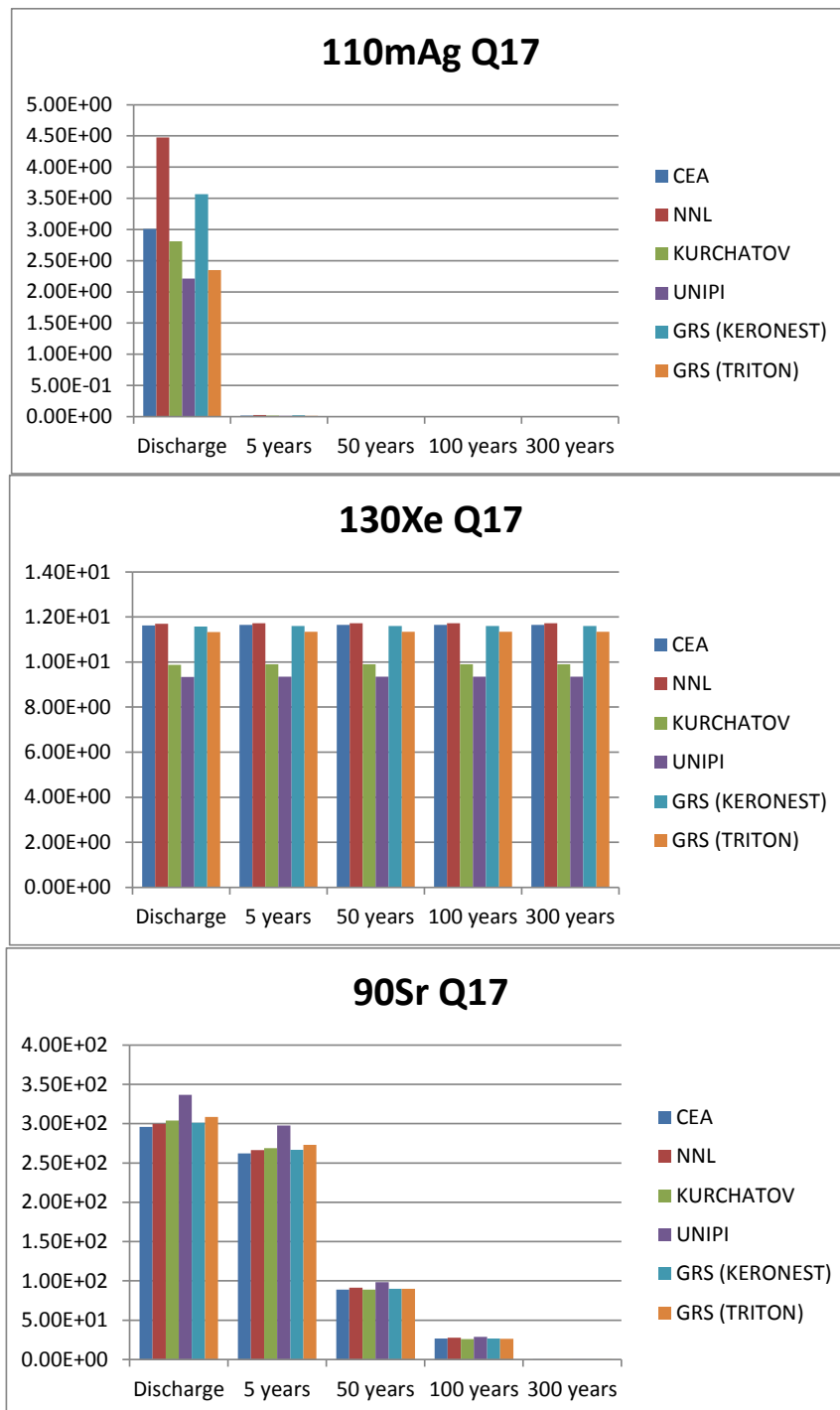
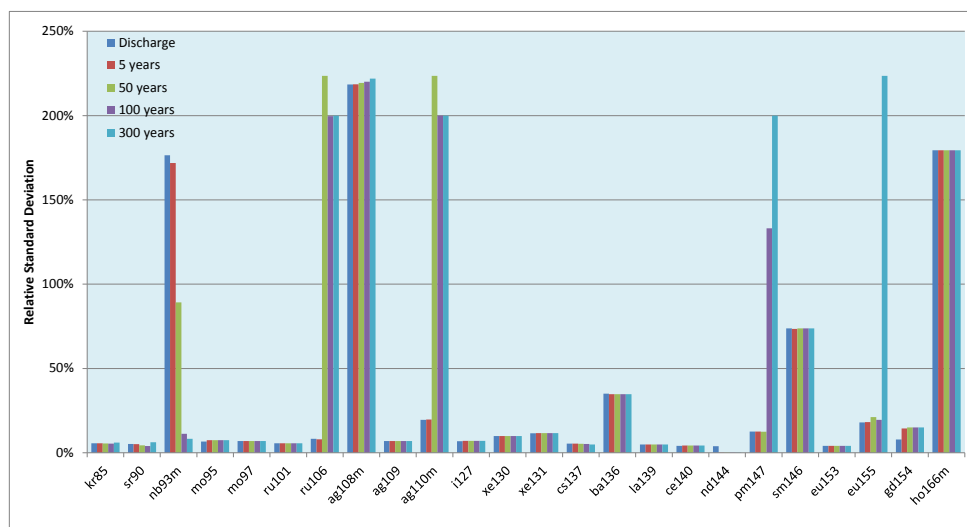
Figure 17. Masses (g/tHMI) for some fission products in Q17 fuel rod

Figure 17. Masses (g/tHMI) for some fission products in Q17 fuel rod (continued)

Most fission products are in good agreement, meaning that the RSD is lower than 10%. Figure 18 shows RSD versus cooling time for fission products. The results are satisfactory for a large part of fission products, though there are some discrepancies.

Figure 18. RSD versus cooling time for some fission products



6.2.2. L14 Fuel rod

Tables B.8-B.14 (Appendix B) give the isotopic concentrations and RSD trends versus cooling time for the fission products calculated. Figure 19 presents RSD versus cooling times for selected fission products. Table 20 summarises the main RSD trends.

Figure 19. RSD versus cooling time for some fission products in L14 rod

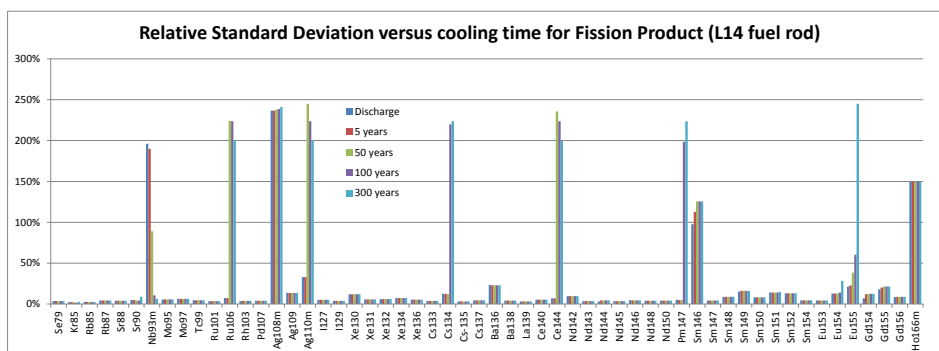
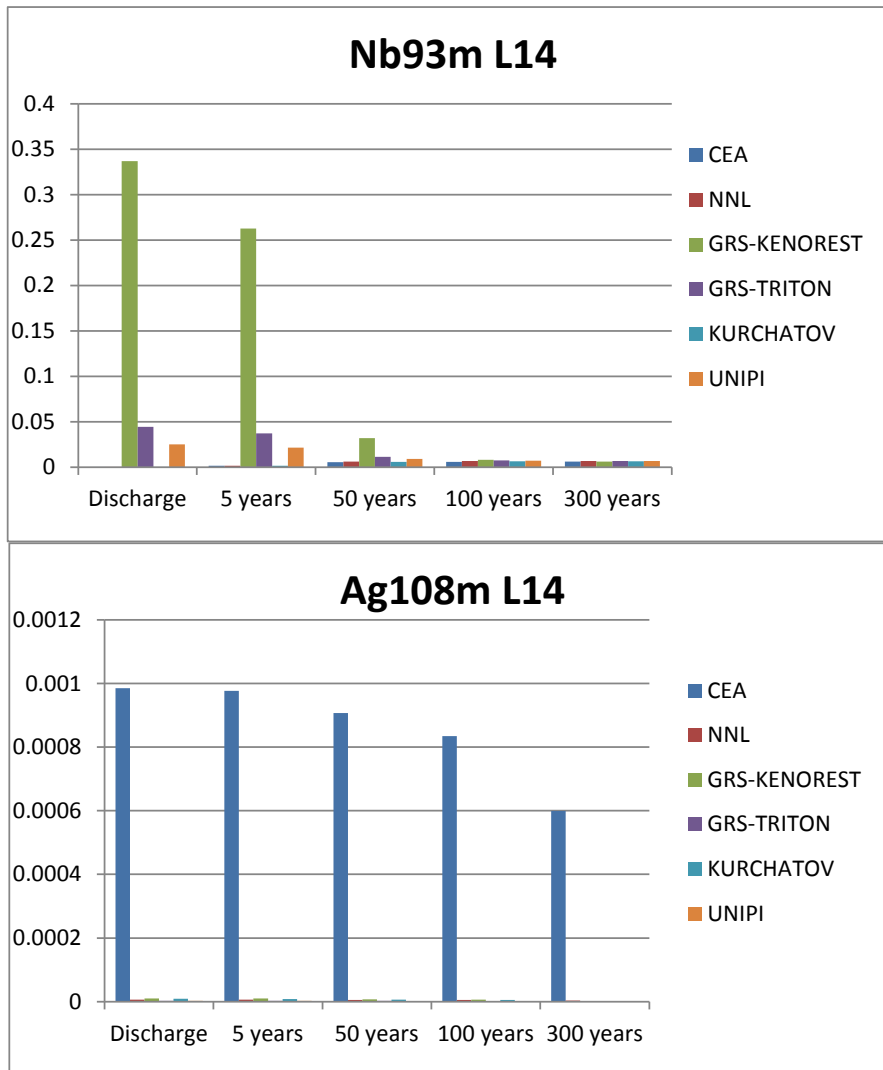


Table 20. Summary of the main RSD trends for the fission products in L14 fuel rod

Relative standard deviation	≤ 10%	> 10%
Isotopes	^{79}Se , ^{85}Kr , ^{85}Rb , ^{87}Rb , ^{88}Sr , ^{90}Sr , ^{95}Mo , ^{97}Mo , ^{99}Tc , ^{101}Ru , ^{107}Ru , ^{103}Rh , ^{107}Pd , ^{127}I , ^{129}I , ^{131}Xe , ^{132}Xe , ^{134}Xe , ^{136}Xe , ^{133}Cs , ^{135}Cs , ^{137}Cs , ^{138}Ba , ^{139}La , ^{140}Ce , ^{144}Ce , ^{142}Nd , ^{143}Nd , ^{144}Nd , ^{145}Nd , ^{146}Nd , ^{148}Nd , ^{150}Nd , ^{147}Sm , ^{148}Sm , ^{150}Sm , ^{154}Sm , ^{153}Eu , ^{156}Gd	$^{93\text{m}}\text{Nb}$, ^{95}Mo , ^{106}Ru , ^{103}Rh , $^{108\text{m}}\text{Ag}$, ^{109}Ag , $^{110\text{m}}\text{Ag}$, ^{130}Xe , ^{134}Cs , ^{136}Ba , ^{147}Pm , ^{146}Sm , ^{149}Sm , ^{151}Sm , ^{152}Sm , ^{154}Eu , ^{155}Eu , ^{154}Gd , ^{155}Gd , $^{166\text{m}}\text{Ho}$

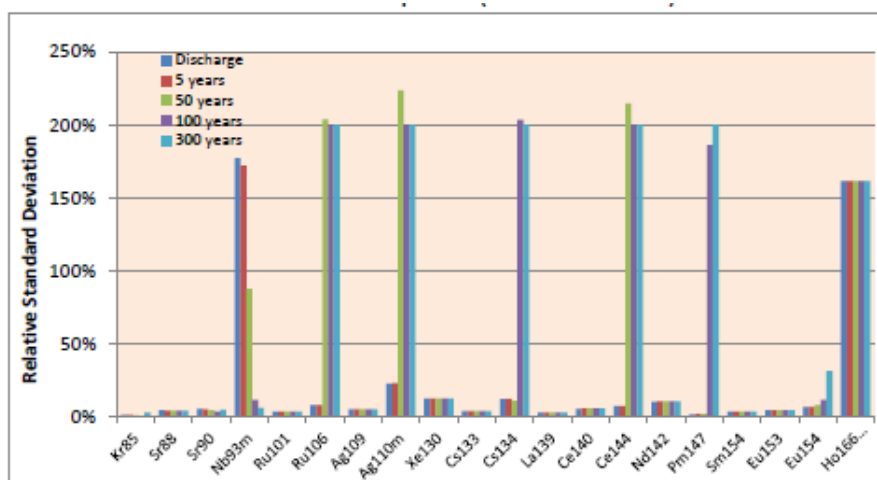
A number of fission products have RSD in excess of 10%, but we analyse only some fission products which have RSD more than 50% (see Figure 20). For the L14 fuel rod, the reasons are the same as for the Q17 fuel rod.

Figure 20. Masses (g/tHMI) of some fission products which have RSD $>\pm 50\%$ (^{93m}Nb and ^{109m}Ag)



Most fission products are in good agreement, meaning that the RSD is lower than 10%. Figure 21 shows RSD versus cooling time for fission products. There are only six fission products which have RSD significantly more than 20% at discharge i.e. ^{93m}Nb , ^{108m}Ag , ^{110m}Ag , ^{136}Ba , ^{146}Sm and ^{166m}Ho .

Figure 21. RSD versus cooling time for selected fission products



6.3. Activation products results

6.3.1. Q17 Fuel rod

Tables A.13-A.18 (Appendix A) detail the activation products results obtained by the participants at each cooling time. All participants calculated these isotopes except GRS-TRITON.

Figure 22. RSD versus cooling time for activation products

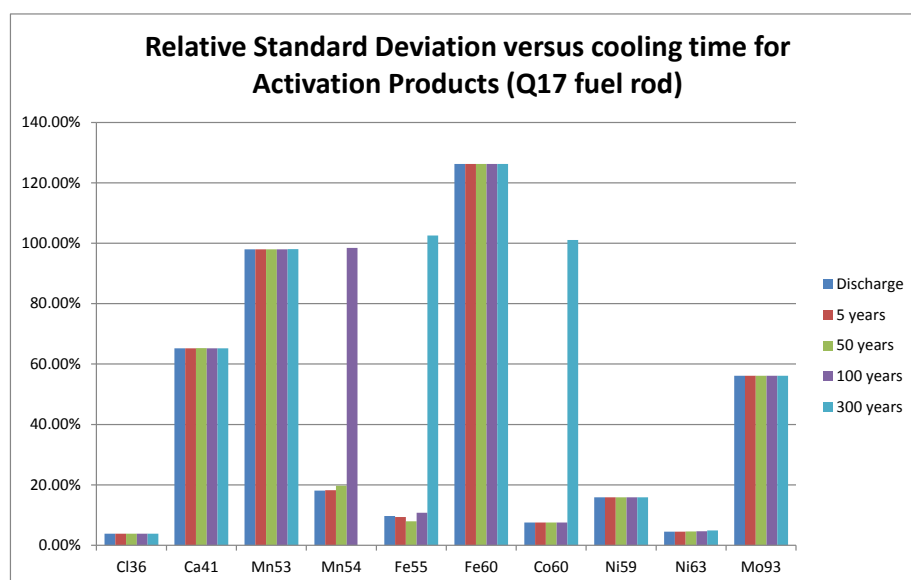


Figure 22 shows RSD versus cooling time for activation products. With the exception of ^{36}Cl , ^{55}Fe , ^{60}Co and ^{63}Ni , the activation products have RSD greater than 10% at discharge. However, the RSD of ^{55}Fe and ^{60}Co increase around 120% at 300 years cooling time. Tables 21 and 22 show results for ^{55}Fe and ^{60}Co at 300 years and ^{54}Mn at 100 years but the RSDs are not significant because of the very low masses considered.

Table 21. ^{55}Fe and ^{60}Co masses (g/tHMI) and RSD at 300 years cooling time

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	MEDIAN	SD	RSD
^{55}Fe	1.112E-34	3.631E-35	1.222E-34	0.000E+00	0.000E+00	1.112E-34	4.674E-35	51.99%
^{60}Co	4.742E-11	5.044E-11	1.057E-17	1.170E-17	4.625E-11	4.625E-11	2.636E-11	91.44%

Table 22. ^{54}Mn masses (g/tHMI) and RSD at 100 years cooling time

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	MEDIAN	SD	RSD
^{54}Mn	6.305E-38	1.109E-37	7.116E-38	0.000E+00	0.000E+00	7.116E-38	2.561E-38	31.34%

Figure 23 shows the calculated masses for ^{41}Ca , ^{53}Mn , ^{60}Fe and ^{93}Mo . The participants used different libraries for their calculations. Unlike actinides or fission products, little work has been done up to now to validate these cross-sections.

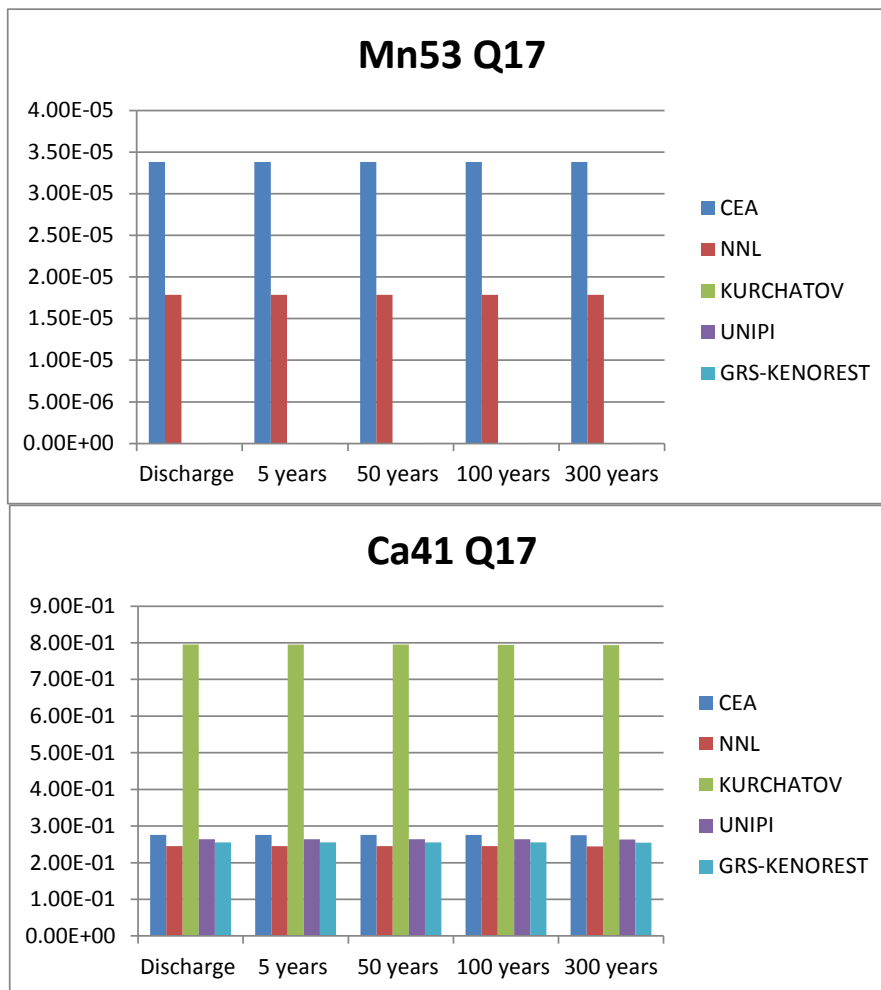
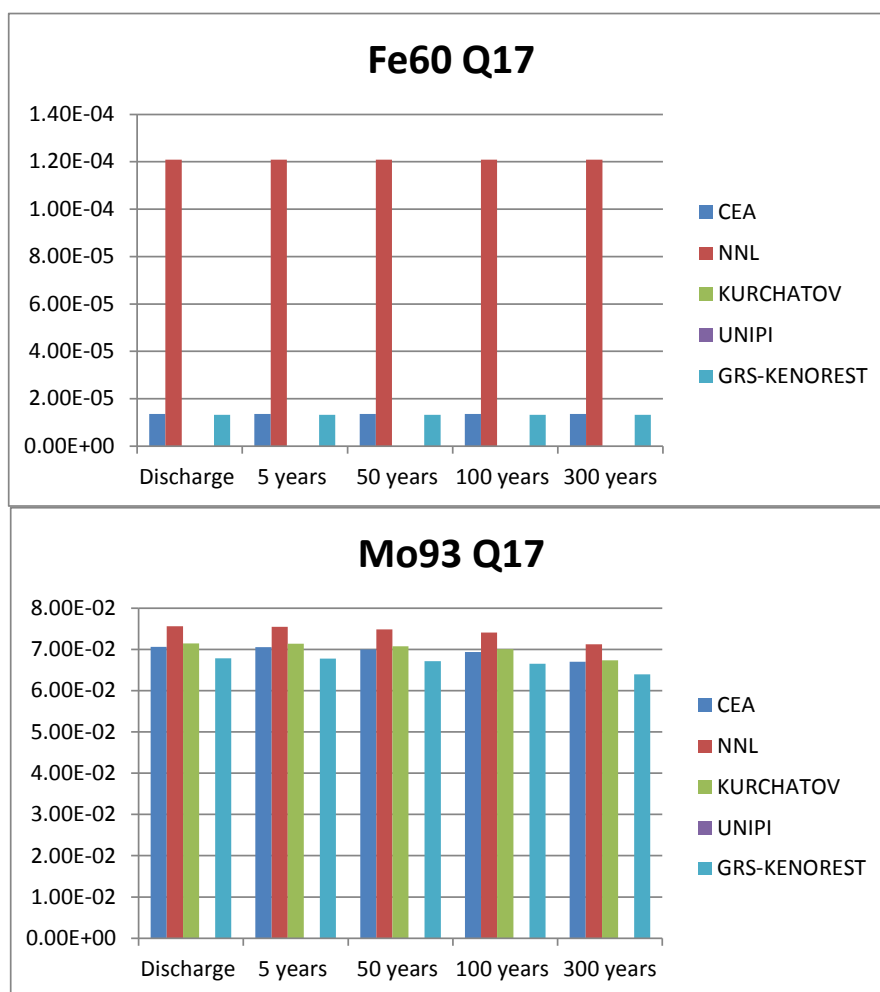
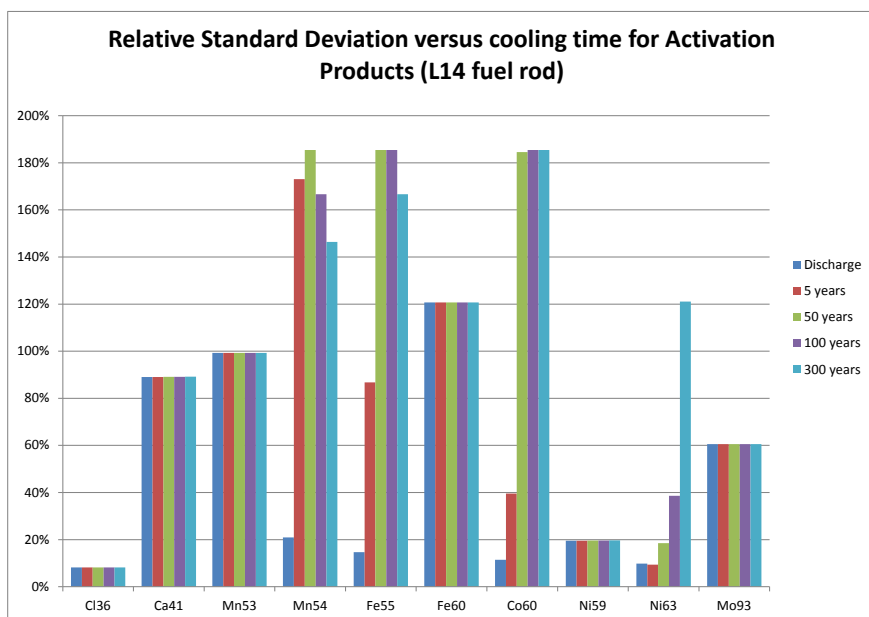
Figure 23. Calculated masses (g/tHMI) for some activations products which have RSD $>\pm 50\%$ (^{41}Ca , ^{53}Mn , ^{60}Fe and ^{93}Mo)

Figure 23. Calculated masses (g/tHMI) for some activations products which have RSD >±50% (^{41}Ca , ^{53}Mn , ^{60}Fe and ^{93}Mo) (continued)



6.3.2. L14 Fuel rod

Tables B.15-B.20 (Appendix B) detail the activation products masses obtained by the participants at each cooling time and the associated RSD. All participants calculated these concentrations except GRS-TRITON. Figure 24 shows RSD versus cooling time for activation products. The RSD values tend to be larger at cooling times >5 years than at discharge.

Figure 24. RSD versus cooling time for activation products in L14 fuel rod

6.4. Activation-fission product results

6.4.1. Q17 Fuel rod

Tables A.19-A.24 (Appendix A) detail the activation-fission product results obtained by the participants at each cooling time. Figure 25 shows RSD versus cooling time for activation-fission products. Except for ^{94}Nb , the activation products have an RSD greater than 10%.

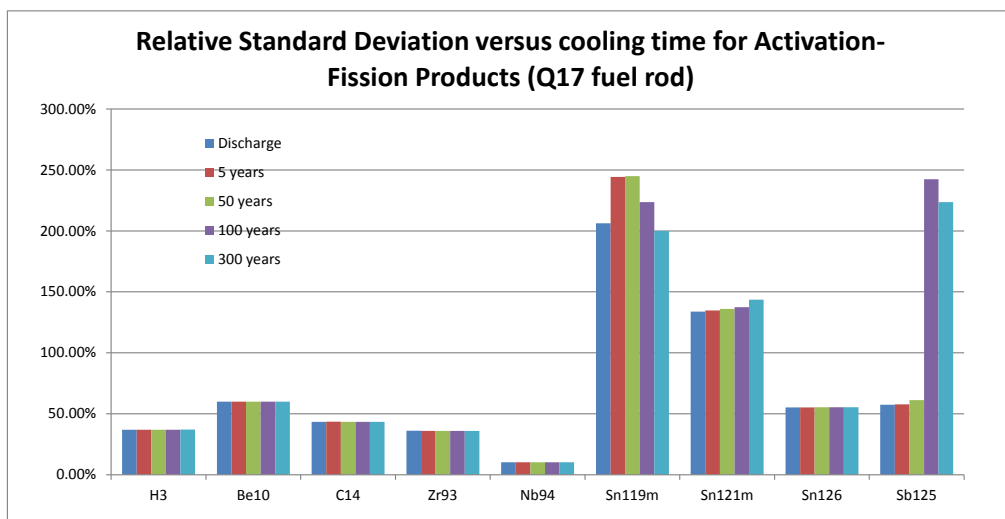
Figure 25. RSD versus cooling time for activation-fission products in Q17 fuel rod

Figure 26 shows calculated masses for $^{119\text{m}}\text{Sn}$, $^{121\text{m}}\text{Sn}$, ^{126}Sn and ^{125}Sb , which have RSD values greater than 50%. This figure suggests a decay data problem (period of $^{119\text{m}}\text{Sn}$ is 293 days) for $^{119\text{m}}\text{Sn}$ in the UNIPI calculation. For $^{121\text{m}}\text{Sn}$, ^{126}Sn and ^{125}Sb , the CEA values are greater than the others. The ^{125}Sb overestimation in CEA calculation is consistent with

DARWIN2.3 experimental validation. As CEA is the only participant using JEFF3.1.1, the relevant fission yields and cross-sections should be verified in that library.

Figure 26. Calculated masses (g/tHMI) for some activation-fission products which have RSD $>\pm 50\%$ (^{191m}Sn , ^{121m}Sn , ^{126}Sn and ^{125}Sb)

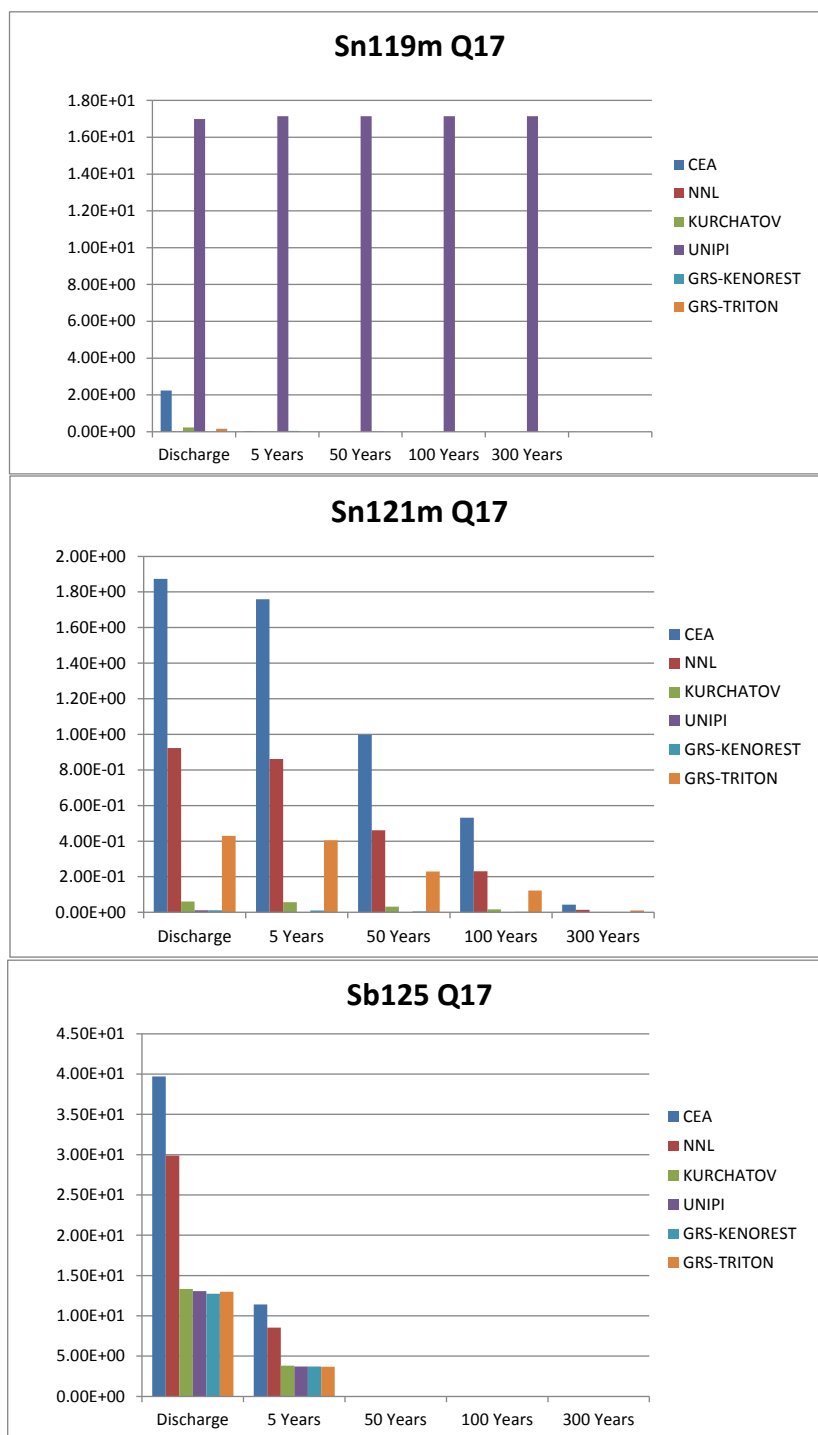
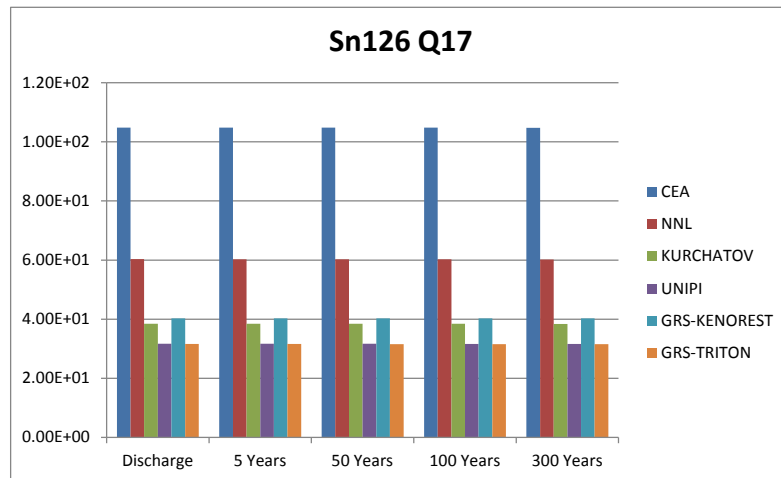


Figure 26. Calculated masses (g/HMI) for some activation-fission products which have RSD $>\pm 50\%$ (^{191m}Sn , ^{121m}Sn , ^{126}Sn and ^{125}Sb) (continued)



6.4.2. L14 Fuel rod

Tables B.21-B.27 (Appendix B) detail the activation-fission products results obtained by the participants at each cooling time and the associated RSDs. Figure 27 shows RSD versus cooling time for activation-fission products. All of them have RSDs greater than 25%. This implies poor agreement between the participants. The conclusions are the same as for Q17 rod. We can also observe some decay data problems concerning the Kurchatov calculations for ^3H and ^{125}Sb (Figure 28), which explain the high RSD values at longer cooling times. As shown in Table B.25, the Kurchatov calculations for some nuclides, notably ^3H , ^{14}C , ^{121m}Sn and ^{125}Sb do not show the expected decay behaviour, suggesting that some data in this table have been corrupted. The Kurchatov calculations for rod Q17 show more plausible decay behaviour (see Tables A.19-A.23), suggesting that these anomalies stem from errors in the data processing.

Figure 27. RSD versus cooling time for activation-fission products in L14 fuel rod

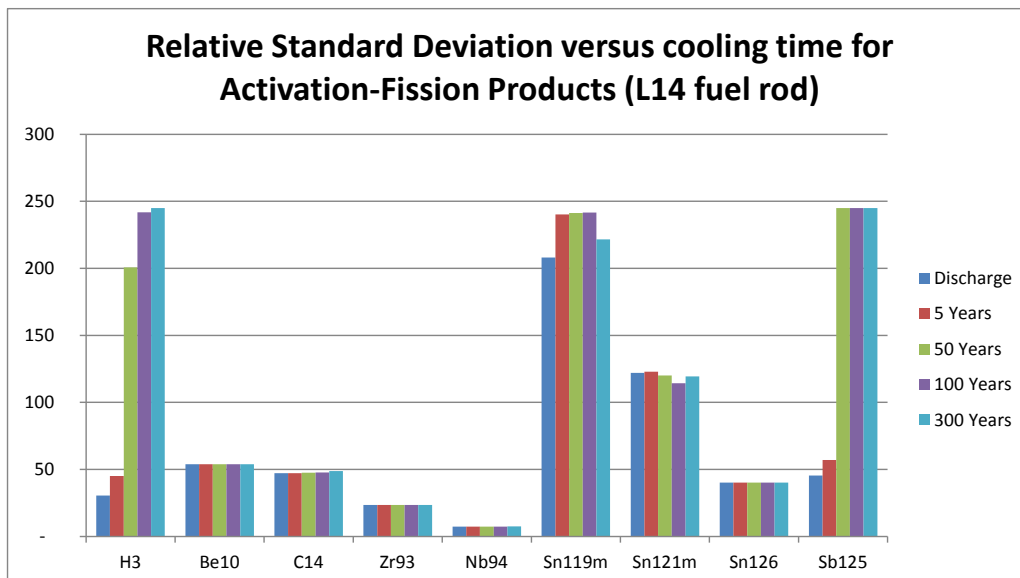
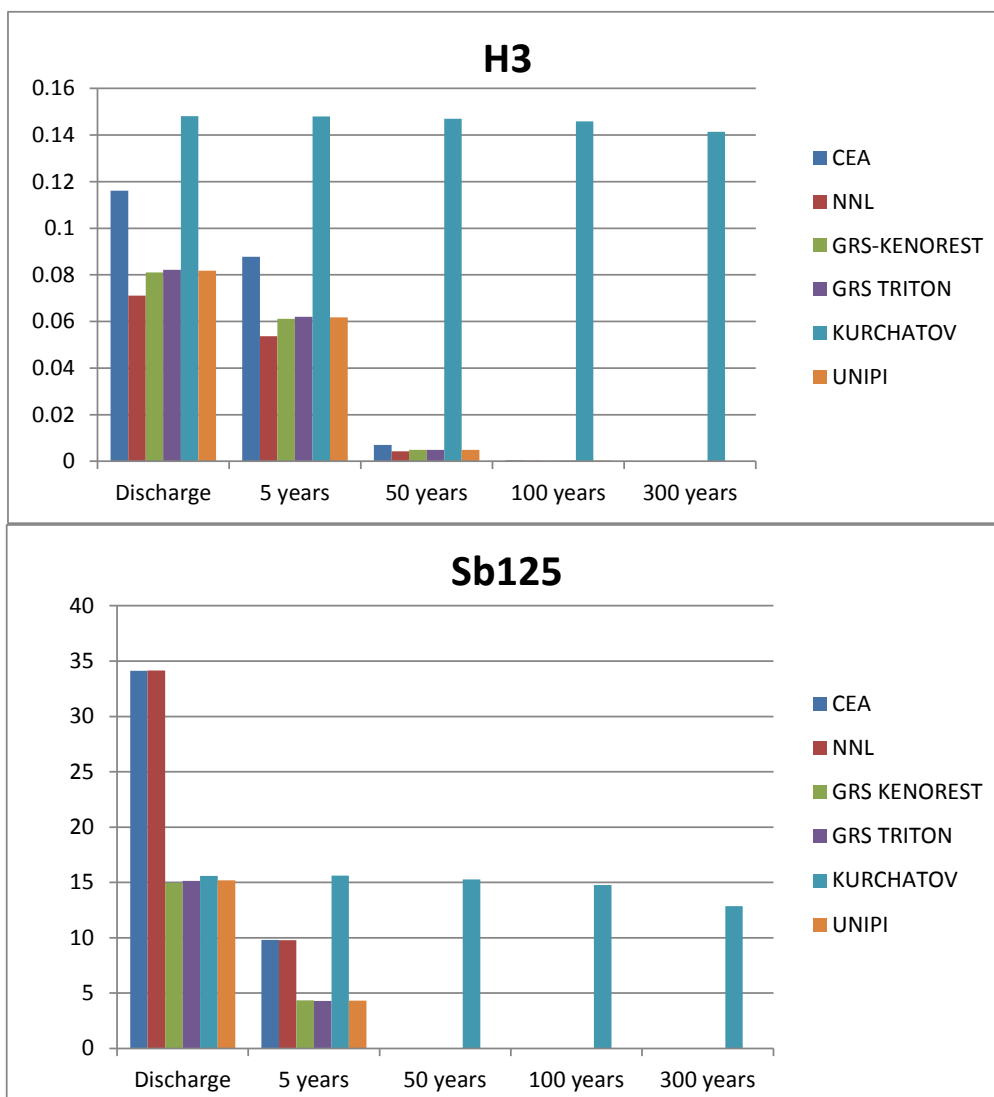


Figure 28. Calculated masses (g/tHMI) for some activation-fission products in L14 rod



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

7.1.1. Q17 Fuel rod

The decay heat results of the Q17 rod are listed in Tables A.25-A.30 (Appendix A). These tables provide the relative standard deviation (RSD) versus cooling time. There are five participants in this comparison without GRS (TRITON). Figure 29 shows RSD versus cooling times for decay heat. Gamma decay heat and total decay heat have RSD more than 50%. There is no breakdown of the UNIFI data into alpha, beta contributions and therefore the UNIFI data are only shown for gamma and total decay heat.

Figure 29. RSD versus cooling time for decay heat in Q17 fuel rod

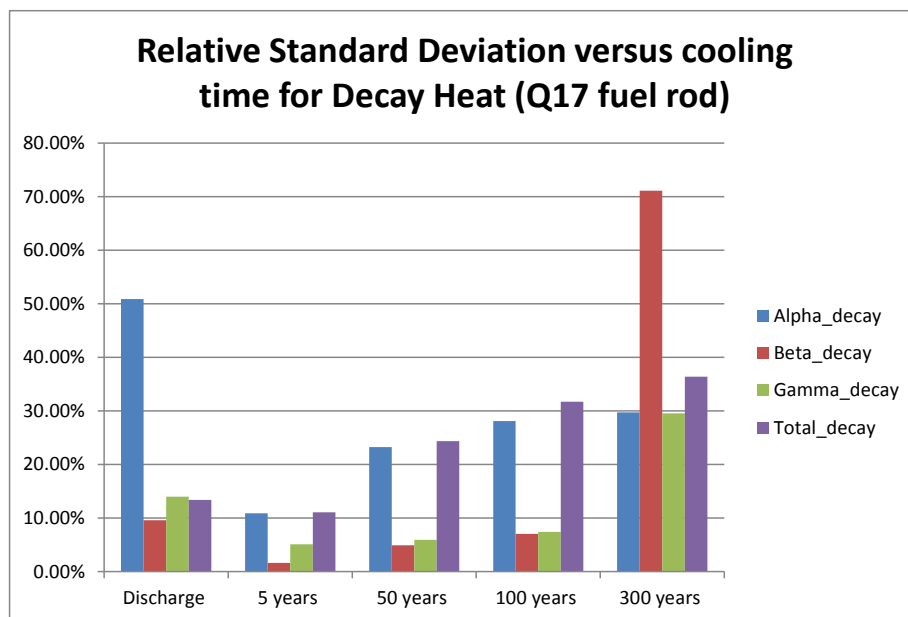


Figure 30. Calculated decay heat at each cooling time

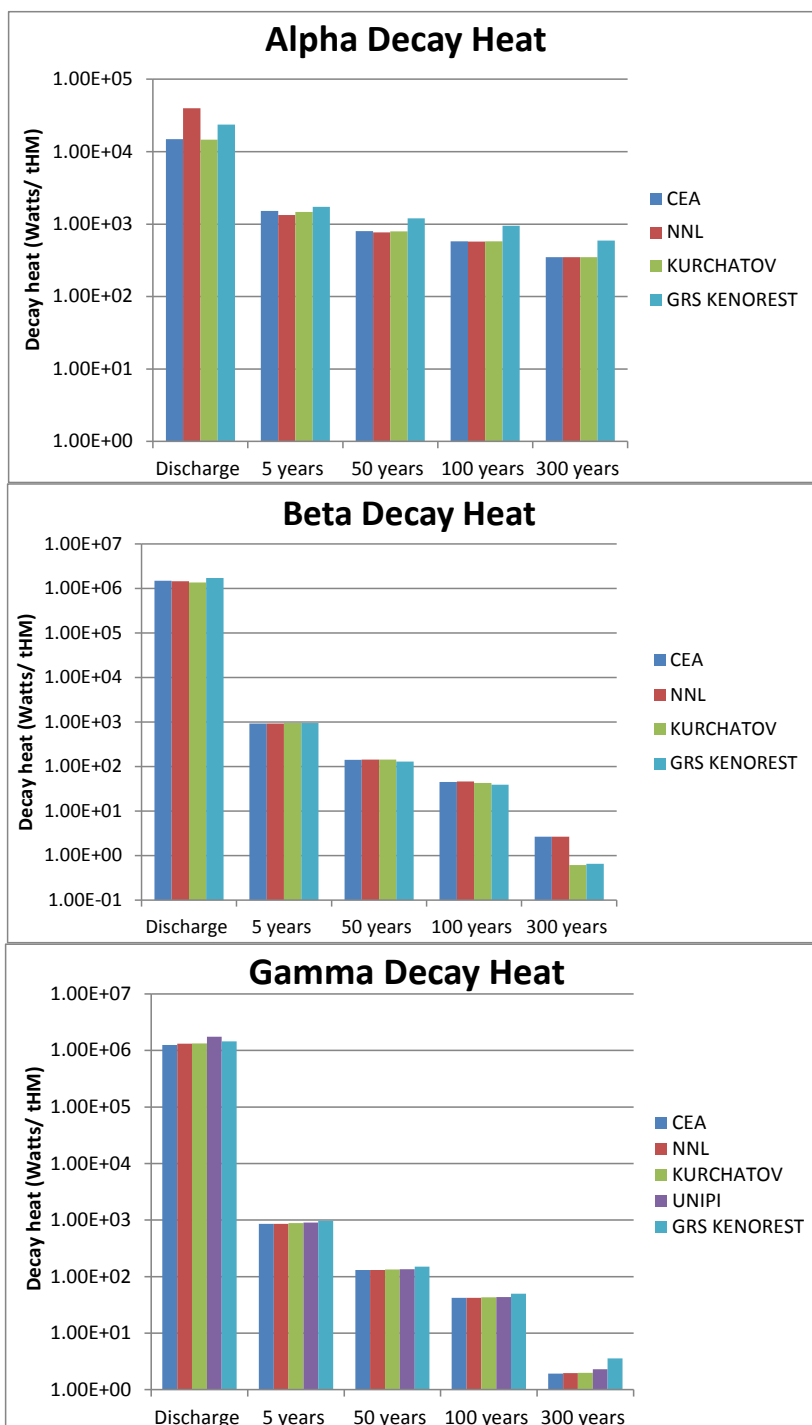
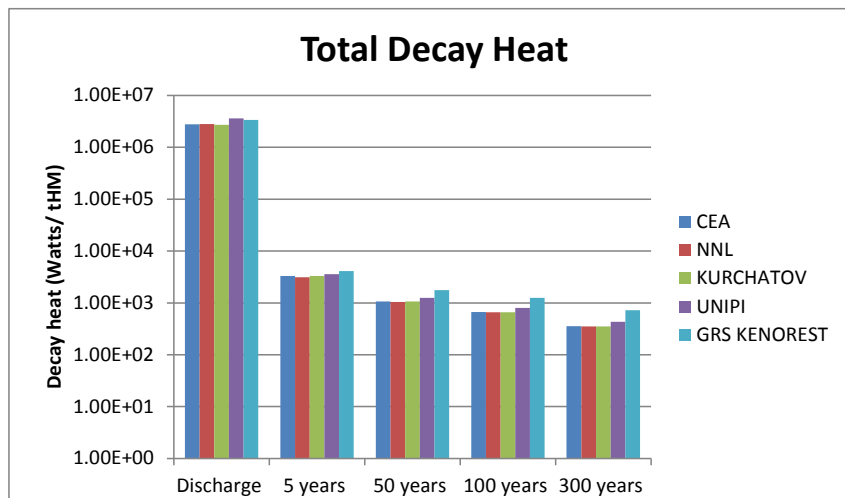


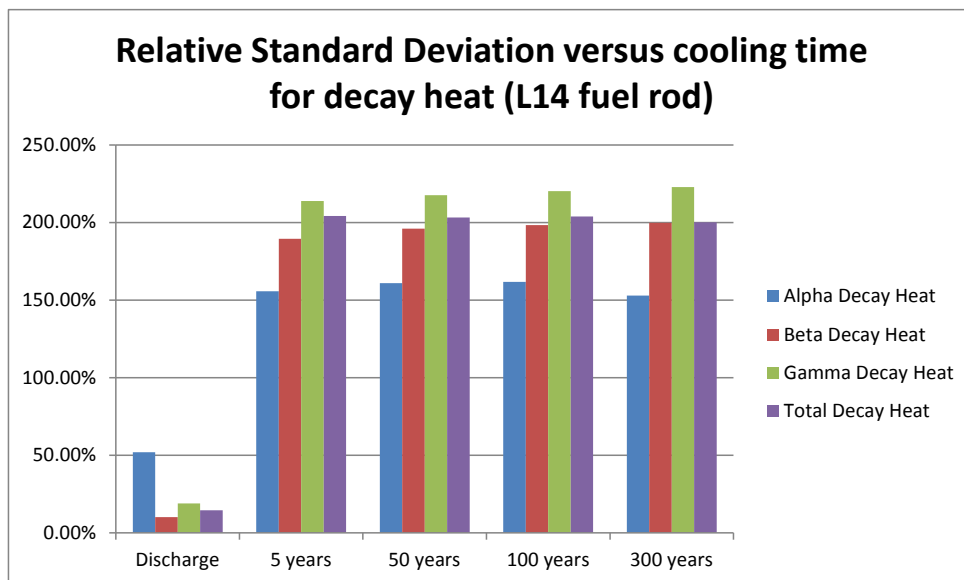
Figure 30. Calculated decay heat at each cooling time (continued)



7.1.2. L14 Rod fuel

Decay heat results for L14 are listed in Tables B.34-B.39 (Appendix B). These tables provide decay heat calculated values and the relative standard deviation (RSD) versus cooling time. As previously noted, there are only five participants, because GRS (TRITON) did not participate. Figure 31 shows results of RSD versus cooling time for decay heat. It should be noted that there is a better agreement between the participants at discharge than during cooling time. This is probably due to the decay data inconsistencies highlighted above.

Figure 31. RSD versus cooling time for decay heat in L14 fuel rod



7.2. Results and code-to-code comparison for neutron emissions calculations

7.2.1. Q17 Rod fuel

Tables A.31-A.36 (Appendix A) detail the neutron emission rate calculated by the participants at each cooling time. GRS (TRITON) did not participate. Figure 32 shows RSD versus cooling time for neutron emission rate. Figure 33 shows neutron emissions calculated at each cooling time.

Figure 32. RSD versus cooling time for neutron emission rate in Q17 fuel rod

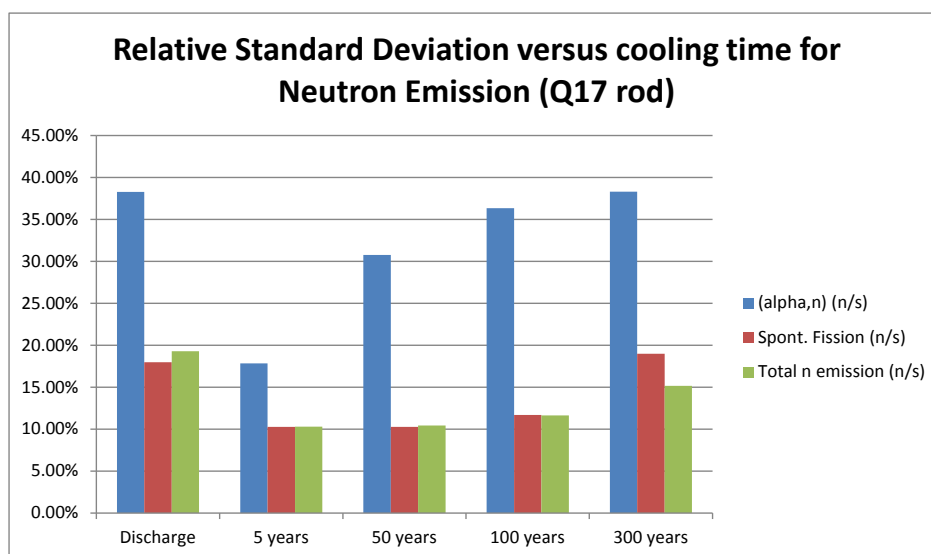


Figure 33. The neutron emission rate for each cooling time in Q17 fuel rod

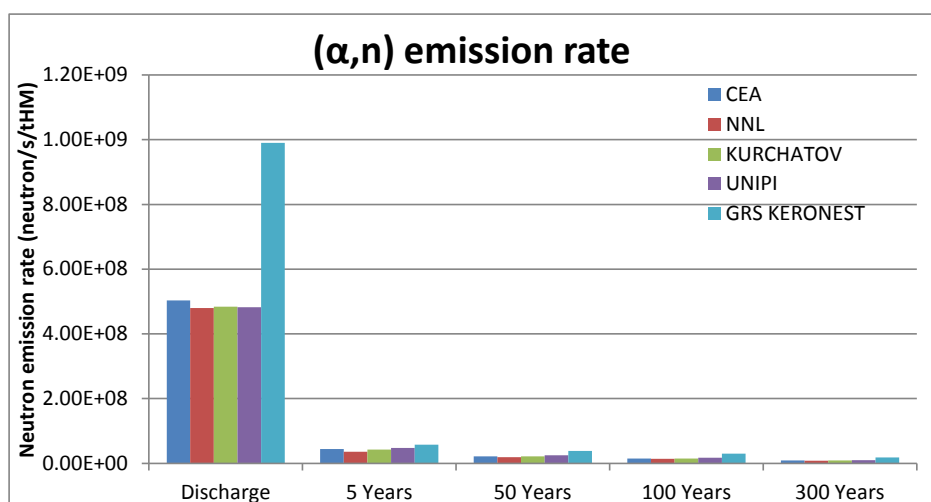
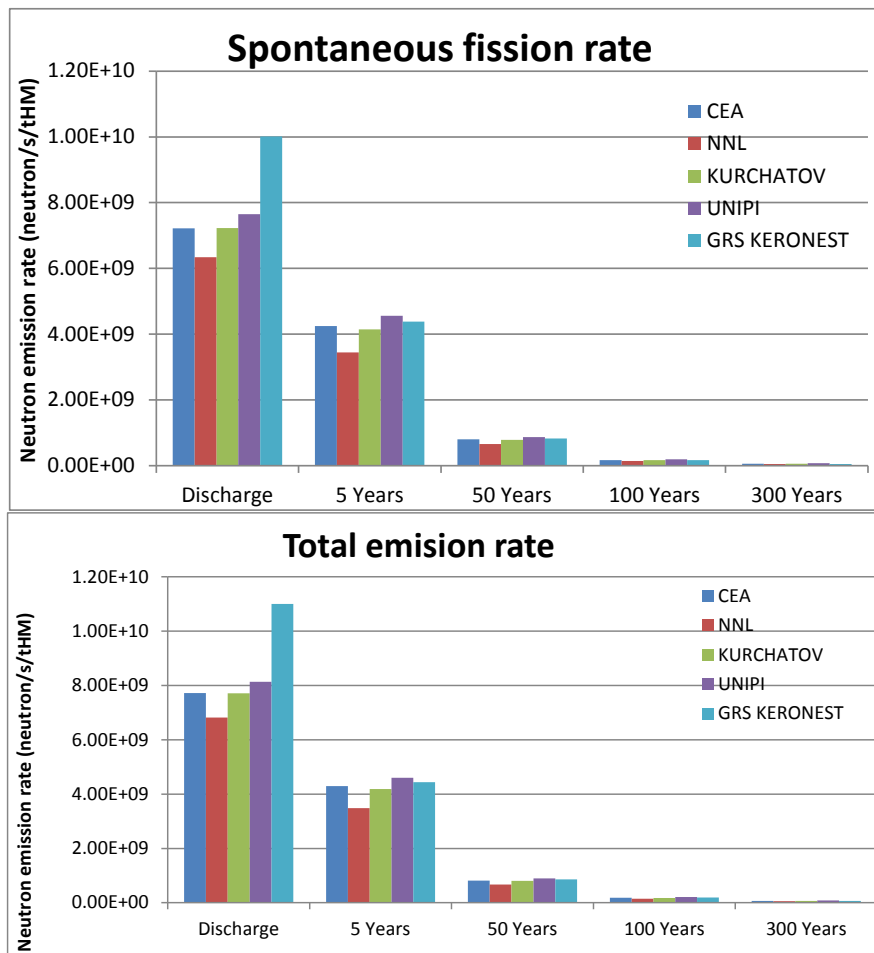
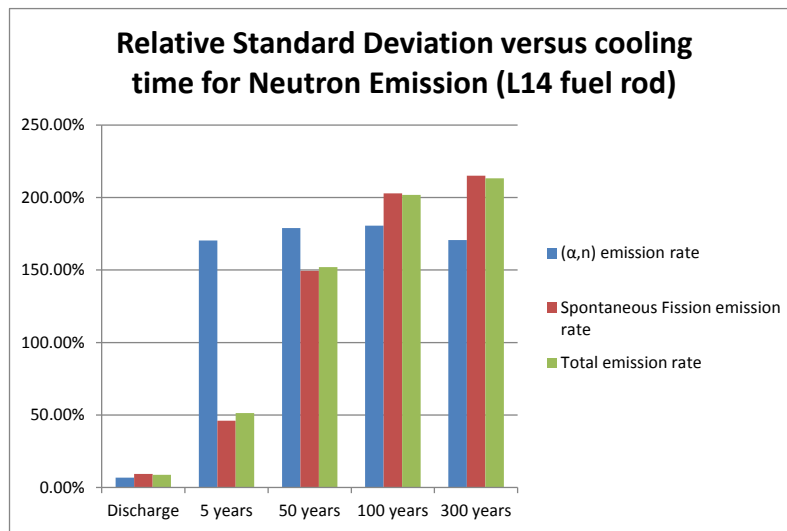


Figure 33. The neutron emission rate for each cooling time in Q17 fuel rod (continued)

7.2.2. L14 Rod fuel

Tables B.28-B.33 (Appendix B) detail the neutron emission rates calculated by the participants at each cooling time and the associated RSD. GRS (TRITON) did not participate. Figure 34 shows RSD versus cooling time for neutron emission rate. Almost perfect agreement is obtained at discharge.

Figure 34. RSD versus cooling time for neutron emission rate in L14 fuel rod

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 cycles quantities, i.e. masses, neutron emission rate and decay heat, from irradiated MOx fuel rods. There were six participants in this benchmark: CEA (France), NNL (UK), KURCHATOV (Russia), UNIPI (Italy), GRS-KENOREST (Germany) and GRS-TRITON (Germany).

Isotopic concentrations have been calculated for the MOx fuel rods at position Q17 and L14 irradiated in the SLB1 core, for actinides, fission products, activation products, and activation-fission products calculation. Code-to-code comparisons have been analysed. Most of the actinide and fission products have good agreement between the participants. In some cases (fission products), RSD (indicator of consistency) increased greatly, but if we exclude aberrant values, we have a good agreement between the participants.

The agreement between all participants for activation products and activation-fission products is much poorer than fission products and actinides. There is a lot uncertainty in the cross-sections for activation products and activation-fission products and the participants used different libraries for their calculations. Most of the time, little work has been done to obtain experimental validation of these cross-sections.

For decay heat, we observe some discrepancies between participants, partly due to manifest errors on decay data previously highlighted. But, with aberrant values excluded, there is good agreement between the participants.

There is moderate consistency between participants for neutron emission rates, i.e. RSD is around 55%-72% for Q17. Consistency for L14 is poor, which means RSD is around 60-200%.

Experimental measurements of irradiated fuel isotopic inventories are much more limited for LWR MOX fuel than for UO₂ fuel rods, and much of the measured data that exists is proprietary. Developers of nuclear inventory codes need to be able to test their methods and nuclear data against experimental measurements to estimate calculational uncertainties, but struggle to do so without access to proprietary MOX measurements. This benchmark is based on proprietary inventory measurements that were made on commercial PWR spent fuel, though without being able to provide the actual measured data. Instead, CEA kindly offered their own calculated data as a surrogate for the actual measured data. The benchmark provides an opportunity for code developers to compare their own calculations with those CEA's tested methods and with other methods from participants in the benchmark.

The benchmark does not purport to provide a reference solution, but potential users can be assured that CEA's calculations are unlikely to suffer from gross discrepancies relative to the measurements. Therefore it is hoped that this benchmark will be able to provide inventory code developers with a high degree of reassurance that their results are not grossly in error, if they fall within the range of the solutions presented here.

References

- [1] B. Roque et al. (2013), “International Comparison of a Depletion Calculation Benchmark Devoted to Fuel Cycle Issues Result from the Phase 1 Dedicated to PWR-UOX Fuels”.
- [2] B. Roque et al. (2007), “Specification for the Phase 2 of a Depletion Calculation Benchmark devoted to MOx Fuel Cycles”.
- [3] A. Tsilanizara et al. (1999), “DARWIN: An evolution code system for a large range of applications”, *Proceeding of ICRS-9*, Tsukuba, Japan.
- [4] L. San-Felice et al. (2012), “Experimental Validation of the Darwin2.3 Package for Fuel Cycle Application”, *PHYSOR 2012 – Advance in Reactor Physics – Linking Research, Industry, and Education*.
- [5] A. Santamarina et al. (2009), “The JEFF-3.1.1 nuclear data library”, JEFF Report 22, NEA n°6807, OECD, Paris.
- [6] L. San Felice, R. Eschbach, P. Bourdot (2013), “Experimental validation of the DARWIN2.3 package for fuel cycle applications”, *Nuclear Technology*, Vol. 184.
- [7] A. Santamarina, D. Bernard, P. Blaise, L. Erradi, P. Leconte, R. Le Tellier, C. Vaglio, J.F. Vidal (2009), “APOLLO2.8: A validated code package for PWR neutronics calculations”, *Proceedings of the International Conference ANFM 2009*, Hilton, Head, Island, US.
- [8] A. Santamarina, N.Hfaiedh (2007), “The SHEM energy mesh for accurate fuel depletion and BUC calculations”, *Proceedings of the International Conference on Safety-Criticality ICNC 2007*, St Peterburg (Russia), Vol. I pp. 446-452.
- [9] U. Hesse et al. (2004), KENOREST – a new criticality and inventory system based on KENO and OREST, *PHYSOR 2000*, (GRS-extended Version KENOREST).
- [10] L.M. Petrie, N.F. Landers (1983), KENO Va, an improved Monte Carlo Criticality Program with Supergrouping, *NUREG/CR-0200*, Volume 2, Section F11, ORNL Tennessee 37831.
- [11] U. Hesse, W. Denk, H. Deitenbeck (1986), OREST – Eine direkte Kopplung von HAMMER und ORIGEN zur Abbrandsimulation von LWR-Brennstoffen, *GRS-63*, (GRS-extended Version OREST 2004).
- [12] J.E. Suich, H.C. Honeck (1967), The HAMMER-System – heterogeneous analysis by multigroup methods of exponentials and reactors, *TID-4500*, (GRS-extended version, 2000).
- [13] M.J. Bell (1973), ORIGEN – The ORNL isotope generation and depletion code, *ORNL-4628*, UC-32-Mathematics and computers, (GRS extended Version GRS-ORIGEN-X 2004).

- [14] W. Bernnat, D. Lutz, J. Kleinert, M. Mattes (1994), Erstellung und Validierung von Wirkungsquerschnittsbibliotheken auf Basis der evaluierten Daten JEF-2 und ENDF/B-VI für Kritikalitäts- und Reaktorauslegungsrechnungen sowie Störfallanalysen, IKE Institut für Kerntechnik und Energiesysteme, Universität Stuttgart, IKE 6-189.
- [15] S.F. Mughabghab (1984), Neutron resonance parameters and thermal cross sections, Brookhaven National Laboratory, Upton New York, Academic Press, INC., Vol. 1.
- [16] U. Hesse, K. Hummelsheim (1993), Detaillierte dreidimensionale Abbrandrechnungen für ein SWR-Aatriumbrennelement, GRS-A-2116.
- [17] U. Quade, U. Hesse (1992), Optimierung von Verfahren zur Berechnung der Ortsdosisleistung von Plutonium und plutoniumhaltigen Brennelementen, GRS-A-1969.
- [18] U. Hesse, K. Hummelsheim, J. Sieberer (2001), Programmbeschreibung ANITABL-PC 2001, GRS-A-3004.
- [19] GRS-TRITON (2005), "TRITON: A two-dimensional depletion sequence for characterization of spent nuclear fuel," being part I/3/T1 of "SCALE 5.0: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation for Workstations and Personal Computers," ORNL/TM-2005/39 Version 5, Vol. I, II and III.

Appendix A: Tables providing detailed result of Q17 fuel

Table A.1. Results for actinides in assembly calculation at discharge (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
U232	9.120E-05	2.873E-04	1.290E-04	2.624E-04	9.090E-05	7.855E-05	1.566E-04	9.35E-05	59.73%
U233	2.832E-04	4.477E-03	1.630E-04	4.778E-04	2.404E-04	2.034E-04	9.741E-04	1.72E-03	176.52%
U234	1.524E+01	8.995E+00	1.509E+01	1.873E+01	1.466E+01	1.453E+01	1.454E+01	3.13E+00	21.55%
U235	5.946E+02	6.180E+02	5.896E+02	7.085E+02	5.852E+02	5.857E+02	6.136E+02	4.81E+01	7.83%
U236	3.063E+02	3.222E+02	2.993E+02	3.050E+02	2.834E+02	3.064E+02	3.037E+02	1.26E+01	4.14%
U238	9.395E+05	9.394E+05	9.391E+05	9.352E+05	9.390E+05	9.387E+05	9.385E+05	1.63E+03	0.17%
Np236	1.304E-04	2.246E-04	1.678E-04	2.916E-04	1.402E-04	7.071E-05	1.709E-04	7.76E-05	45.39%
Np237	1.343E+02	1.238E+02	1.327E+02	1.686E+02	1.271E+02	1.360E+02	1.371E+02	1.61E+01	11.75%
Pu236	4.618E-04	8.322E-04	6.618E-04	1.217E-03	4.735E-04	3.401E-04	6.644E-04	3.21E-04	48.36%
Pu238	4.007E+02	3.947E+02	3.975E+02	5.856E+02	4.036E+02	3.739E+02	4.260E+02	7.89E+01	18.52%
Pu239	6.819E+03	7.054E+03	7.053E+03	9.489E+03	7.239E+03	7.133E+03	7.464E+03	1.00E+03	13.42%
Pu240	6.067E+03	5.827E+03	5.904E+03	6.498E+03	5.831E+03	5.968E+03	6.016E+03	2.53E+02	4.20%
Pu241	3.451E+03	3.439E+03	3.423E+03	4.125E+03	3.561E+03	3.426E+03	3.571E+03	2.76E+02	7.74%
Pu242	2.796E+03	2.756E+03	2.967E+03	2.499E+03	2.770E+03	2.873E+03	2.777E+03	1.57E+02	5.66%
Pu243	8.107E-01	7.025E-01	7.879E-01	5.350E-01	7.248E-01	8.225E-01	7.306E-01	1.07E-01	14.65%
Pu244	3.668E-01	3.363E-01	1.531E-01	1.633E-01	3.449E-01	1.689E-01	2.556E-01	1.03E-01	40.44%
Am241	1.343E+02	1.592E+02	1.420E+02	2.104E+02	1.633E+02	1.625E+02	1.620E+02	2.65E+01	16.38%
Am242m	3.175E+00	2.507E+00	2.623E+00	5.364E+00	2.841E+00	3.821E+00	3.388E+00	1.08E+00	31.78%
Am243	7.842E+02	7.066E+02	7.847E+02	7.884E+02	7.425E+02	8.506E+02	7.762E+02	4.86E+01	6.26%
Cm242	1.094E+02	1.108E+02	1.088E+02	1.072E+02	1.141E+02	1.038E+02	1.090E+02	3.46E+00	3.18%
Cm243	4.671E+00	4.935E+00	4.886E+00	4.822E+00	5.447E+00	5.199E+00	4.993E+00	2.82E-01	5.64%
Cm244	4.538E+02	3.784E+02	4.378E+02	4.832E+02	4.368E+02	4.658E+02	4.426E+02	3.60E+01	8.14%
Cm245	3.522E+01	2.946E+01	3.239E+01	5.071E+01	3.075E+01	2.768E+01	3.437E+01	8.41E+00	24.47%
Cm246	5.199E+00	4.339E+00	5.034E+00	6.674E+00	4.575E+00	4.183E+00	5.001E+00	9.09E-01	18.17%
Cm247	9.609E-02	5.564E-02	7.693E-02	1.415E-01	7.926E-02	7.788E-02	8.788E-02	2.92E-02	33.28%
Cm248	7.722E-03	4.225E-03	9.105E-03	1.207E-02	5.284E-03	6.286E-03	7.449E-03	2.85E-03	38.26%
Ra226	1.108E-09	9.865E-10	1.103E-09	1.250E-09	1.054E-09	1.146E-09	1.108E-09	8.86E-11	8.00%
Ra228	6.573E-16	5.711E-16	6.308E-16	6.644E-16	6.134E-16	6.602E-16	6.329E-16	3.61E-17	5.71%
Ac227	2.997E-10	1.642E-10	2.914E-10	3.118E-10	3.170E-10	2.325E-10	2.694E-10	5.98E-11	22.20%
Th229	1.105E-07	5.990E-07	1.383E-07	4.126E-07	1.180E-07	1.160E-07	2.491E-07	2.08E-07	83.36%
Th230	8.562E-05	7.315E-05	8.505E-05	9.554E-05	8.516E-05	8.486E-05	8.490E-05	7.10E-06	8.36%
Th232	1.423E-05	1.501E-05	1.421E-05	1.455E-05	1.347E-05	1.460E-05	1.434E-05	5.19E-07	3.62%
Cf252	1.098E-05	5.625E-06	2.118E-05	2.219E-05	9.199E-06	1.185E-05	1.350E-05	6.69E-06	49.57%

Table A.2. Results for actinides in assembly calculation at 5 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
U232	3.984E-04	8.283E-04	5.686E-04	2.624E-04	4.055E-04	3.021E-04	4.609E-04	2.09E-04	45.32%
U233	5.041E-04	4.681E-03	3.806E-04	7.604E-04	4.492E-04	4.320E-04	1.201E-03	1.71E-03	142.35%
U234	3.412E+01	2.770E+01	3.383E+01	4.458E+01	3.435E+01	3.220E+01	3.446E+01	5.55E+00	16.09%
U235	5.955E+02	6.191E+02	5.905E+02	7.099E+02	5.863E+02	5.867E+02	6.147E+02	4.82E+01	7.85%
U236	3.094E+02	3.252E+02	3.023E+02	3.084E+02	2.864E+02	3.096E+02	3.069E+02	1.26E+01	4.10%
U238	9.395E+05	9.394E+05	9.391E+05	9.352E+05	9.390E+05	9.387E+05	9.385E+05	1.63E+03	0.17%
Np236	1.304E-04	2.246E-04	1.678E-04	2.915E-04	1.402E-04	7.071E-05	1.709E-04	7.75E-05	45.38%
Np237	1.416E+02	1.311E+02	1.397E+02	1.774E+02	1.344E+02	1.434E+02	1.446E+02	1.67E+01	11.56%
Pu236	1.382E-04	2.524E-04	1.977E-04	3.698E-04	1.417E-04	1.034E-04	2.005E-04	9.81E-05	48.93%
Pu238	4.901E+02	4.857E+02	4.861E+02	6.658E+02	4.974E+02	4.588E+02	5.140E+02	7.55E+01	14.69%
Pu239	6.946E+03	7.181E+03	7.179E+03	9.614E+03	7.365E+03	7.262E+03	7.591E+03	1.00E+03	13.18%
Pu240	6.142E+03	5.889E+03	5.977E+03	6.577E+03	5.903E+03	6.045E+03	6.089E+03	2.57E+02	4.22%
Pu241	2.710E+03	2.704E+03	2.686E+03	3.240E+03	2.797E+03	2.691E+03	2.805E+03	2.17E+02	7.74%
Pu242	2.796E+03	2.756E+03	2.968E+03	2.499E+03	2.770E+03	2.873E+03	2.777E+03	1.57E+02	5.66%
Pu243	3.340E-12	1.934E-12	2.743E-12	4.916E-12	2.826E-12	2.706E-12	3.078E-12	1.01E-12	32.72%
Pu244	3.668E-01	3.363E-01	1.531E-01	1.633E-01	3.449E-01	1.689E-01	2.556E-01	1.03E-01	40.44%
Am241	8.716E+02	8.907E+02	8.748E+02	1.091E+03	9.224E+02	8.935E+02	9.240E+02	8.38E+01	9.07%
Am242m	3.098E+00	2.446E+00	2.559E+00	5.234E+00	2.772E+00	3.727E+00	3.306E+00	1.05E+00	31.78%
Am243	7.846E+02	7.070E+02	7.852E+02	7.886E+02	7.428E+02	8.511E+02	7.765E+02	4.86E+01	6.26%
Cm242	5.456E-02	5.339E-02	5.253E-02	5.922E-02	5.582E-02	5.383E-02	5.489E-02	2.40E-03	4.36%
Cm243	4.161E+00	4.397E+00	4.335E+00	4.270E+00	4.836E+00	4.605E+00	4.434E+00	2.46E-01	5.56%
Cm244	3.744E+02	3.125E+02	3.623E+02	3.997E+02	3.608E+02	3.853E+02	3.658E+02	2.99E+01	8.18%
Cm245	3.520E+01	2.945E+01	3.238E+01	5.069E+01	3.074E+01	2.766E+01	3.435E+01	8.41E+00	24.47%
Cm246	5.195E+00	4.336E+00	5.029E+00	6.669E+00	4.572E+00	4.178E+00	4.997E+00	9.08E-01	18.17%
Cm247	9.609E-02	5.564E-02	7.693E-02	1.415E-01	7.926E-02	7.788E-02	8.788E-02	2.92E-02	33.28%
Cm248	7.730E-03	4.229E-03	9.119E-03	1.209E-02	5.290E-03	6.294E-03	7.459E-03	2.86E-03	38.29%
Ra226	1.165E-08	8.994E-09	1.156E-08	1.407E-08	1.155E-08	1.131E-08	1.152E-08	1.61E-09	13.97%
Ra228	7.373E-15	7.756E-15	6.480E-15	7.471E-15	6.926E-15	7.498E-15	7.251E-15	4.65E-16	6.41%
Ac227	2.963E-09	1.971E-09	2.787E-09	3.495E-09	2.913E-09	2.815E-09	2.824E-09	4.91E-10	17.40%
Th229	1.189E-07	6.966E-07	1.440E-07	4.258E-07	1.254E-07	1.228E-07	2.722E-07	2.40E-07	88.08%
Th230	4.259E-04	3.256E-04	4.223E-04	5.328E-04	4.260E-04	4.069E-04	4.232E-04	6.61E-05	15.61%
Th232	5.848E-05	6.211E-05	5.795E-05	5.915E-05	5.489E-05	5.939E-05	5.866E-05	2.34E-06	3.99%
Cf252	2.961E-06	1.517E-06	5.711E-06	5.987E-06	2.483E-06	3.198E-06	3.643E-06	1.81E-06	49.56%

Table A.3. Results for actinides in assembly calculation at 50 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
U232	3.454E-04	6.954E-04	4.935E-04	9.224E-04	3.504E-04	2.612E-04	5.114E-04	2.53E-04	49.41%
U233	3.573E-03	7.617E-03	3.416E-03	4.574E-03	3.457E-03	3.543E-03	4.363E-03	1.65E-03	37.86%
U234	1.784E+02	1.707E+02	1.770E+02	2.406E+02	1.807E+02	1.673E+02	1.858E+02	2.73E+01	14.70%
U235	6.044E+02	6.282E+02	5.998E+02	7.221E+02	5.956E+02	5.959E+02	6.243E+02	4.94E+01	7.92%
U236	3.390E+02	3.535E+02	3.311E+02	3.400E+02	3.148E+02	3.386E+02	3.362E+02	1.27E+01	3.79%
U238	9.395E+05	9.394E+05	9.391E+05	9.352E+05	9.390E+05	9.387E+05	9.385E+05	1.63E+03	0.17%
Np236	1.303E-04	2.245E-04	1.678E-04	2.915E-04	1.402E-04	7.068E-05	1.708E-04	7.75E-05	45.38%
Np237	3.119E+02	3.023E+02	3.097E+02	3.844E+02	3.119E+02	3.146E+02	3.225E+02	3.06E+01	9.50%
Pu236	2.805E-09	5.882E-09	3.878E-09	8.542E-09	2.828E-09	2.364E-09	4.383E-09	2.40E-09	54.74%
Pu238	3.439E+02	3.407E+02	3.412E+02	4.673E+02	3.491E+02	3.220E+02	3.607E+02	5.30E+01	14.70%
Pu239	6.943E+03	7.177E+03	7.174E+03	9.608E+03	7.361E+03	7.259E+03	7.587E+03	1.00E+03	13.17%
Pu240	6.415E+03	6.113E+03	6.238E+03	6.868E+03	6.166E+03	6.326E+03	6.354E+03	2.74E+02	4.31%
Pu241	3.074E+02	3.099E+02	3.028E+02	3.686E+02	3.187E+02	3.061E+02	3.189E+02	2.49E+01	7.81%
Pu242	2.796E+03	2.756E+03	2.967E+03	2.499E+03	2.770E+03	2.873E+03	2.777E+03	1.57E+02	5.66%
Pu243	3.340E-12	1.934E-12	2.743E-12	4.916E-12	2.826E-12	2.706E-12	3.078E-12	1.01E-12	32.72%
Pu244	3.668E-01	3.363E-01	1.531E-01	1.633E-01	3.449E-01	1.689E-01	2.556E-01	1.03E-01	40.44%
Am241	3.101E+03	3.111E+03	3.085E+03	3.751E+03	3.221E+03	3.106E+03	3.229E+03	2.60E+02	8.06%
Am242m	2.483E+00	1.961E+00	2.051E+00	4.195E+00	2.222E+00	2.987E+00	2.650E+00	8.42E-01	31.78%
Am243	7.813E+02	7.040E+02	7.820E+02	7.852E+02	7.397E+02	8.474E+02	7.733E+02	4.84E+01	6.25%
Cm242	6.526E-03	5.124E-03	5.357E-03	1.093E-02	5.790E-03	7.783E-03	6.918E-03	2.19E-03	31.62%
Cm243	1.471E+00	1.554E+00	1.484E+00	1.429E+00	1.657E+00	1.541E+00	1.523E+00	8.03E-02	5.27%
Cm244	6.619E+01	5.578E+01	6.466E+01	7.133E+01	6.447E+01	6.877E+01	6.520E+01	5.31E+00	8.14%
Cm245	3.507E+01	2.934E+01	3.226E+01	5.051E+01	3.062E+01	2.756E+01	3.423E+01	8.38E+00	24.48%
Cm246	5.161E+00	4.307E+00	4.997E+00	6.625E+00	4.542E+00	4.151E+00	4.964E+00	9.02E-01	18.17%
Cm247	9.609E-02	5.564E-02	7.693E-02	1.415E-01	7.926E-02	7.788E-02	8.788E-02	2.92E-02	33.28%
Cm248	7.732E-03	4.230E-03	9.124E-03	1.209E-02	5.292E-03	6.296E-03	7.461E-03	2.86E-03	38.27%
Ra226	2.365E-06	2.148E-06	2.346E-06	3.148E-06	2.388E-06	2.225E-06	2.437E-06	3.61E-07	14.80%
Ra228	1.602E-13	1.699E-13	1.104E-13	1.620E-13	1.502E-13	1.621E-13	1.525E-13	2.15E-14	14.13%
Ac227	2.338E-08	1.896E-08	2.079E-08	2.788E-08	2.290E-08	2.276E-08	2.278E-08	3.00E-09	13.16%
Th229	4.699E-07	1.835E-06	4.682E-07	8.887E-07	4.588E-07	4.650E-07	7.643E-07	5.51E-07	72.12%
Th230	1.421E-02	1.323E-02	1.410E-02	1.904E-02	1.438E-02	1.335E-02	1.472E-02	2.17E-03	14.74%
Th232	4.778E-04	5.064E-04	4.726E-04	4.835E-04	4.481E-04	4.836E-04	4.787E-04	1.89E-05	3.95%
Cf252	2.239E-11	1.146E-11	4.319E-11	4.525E-11	1.892E-11	2.417E-11	2.756E-11	1.36E-11	49.46%

Table A.4. Results for actinides in assembly calculation at 100 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
U232	2.102E-04	4.232E-04	3.003E-04	5.615E-04	2.120E-04	1.589E-04	3.110E-04	1.54E-04	49.50%
U233	1.051E-02	1.443E-02	1.030E-02	1.309E-02	1.046E-02	1.054E-02	1.156E-02	1.76E-03	15.24%
U234	2.888E+02	2.801E+02	2.865E+02	3.906E+02	2.926E+02	2.709E+02	3.016E+02	4.43E+01	14.68%
U235	6.142E+02	6.383E+02	6.095E+02	7.356E+02	6.060E+02	6.063E+02	6.350E+02	5.08E+01	7.99%
U236	3.724E+02	3.853E+02	3.636E+02	3.758E+02	3.469E+02	3.717E+02	3.693E+02	1.30E+01	3.53%
U238	9.395E+05	9.394E+05	9.391E+05	9.352E+05	9.390E+05	9.387E+05	9.385E+05	1.63E+03	0.17%
Np236	1.303E-04	2.245E-04	1.678E-04	2.914E-04	1.402E-04	7.068E-05	1.708E-04	7.75E-05	45.38%
Np237	5.612E+02	5.525E+02	5.576E+02	6.860E+02	5.710E+02	5.643E+02	5.821E+02	5.13E+01	8.81%
Pu236	2.891E-10	5.054E-10	2.771E-10	6.541E-10	2.289E-10	1.694E-10	3.540E-10	1.86E-10	52.52%
Pu238	2.320E+02	2.297E+02	2.301E+02	3.154E+02	2.356E+02	2.174E+02	2.434E+02	3.58E+01	14.72%
Pu239	6.938E+03	7.171E+03	7.170E+03	9.599E+03	7.355E+03	7.254E+03	7.581E+03	9.98E+02	13.17%
Pu240	6.437E+03	6.127E+03	6.261E+03	6.892E+03	6.187E+03	6.351E+03	6.376E+03	2.76E+02	4.33%
Pu241	2.743E+01	2.796E+01	2.683E+01	3.300E+01	2.857E+01	2.738E+01	2.853E+01	2.27E+00	7.95%
Pu242	2.796E+03	2.755E+03	2.967E+03	2.499E+03	2.770E+03	2.873E+03	2.777E+03	1.57E+02	5.66%
Pu243	3.340E-12	1.934E-12	2.743E-12	4.916E-12	2.826E-12	6.892E-05	1.149E-05	2.81E-05	244.95%
Pu244	3.668E-01	3.363E-01	1.531E-01	1.633E-01	3.449E-01	1.689E-01	2.556E-01	1.03E-01	40.44%
Am241	3.128E+03	3.138E+03	3.109E+03	3.780E+03	3.248E+03	3.131E+03	3.256E+03	2.62E+02	8.04%
Am242m	1.942E+00	1.533E+00	1.604E+00	3.282E+00	1.738E+00	2.336E+00	2.073E+00	6.59E-01	31.80%
Am243	7.776E+02	7.007E+02	7.783E+02	7.815E+02	7.362E+02	8.434E+02	7.696E+02	4.81E+01	6.26%
Cm242	5.104E-03	4.007E-03	4.188E-03	8.547E-03	4.529E-03	6.100E-03	5.413E-03	1.71E-03	31.62%
Cm243	4.634E-01	4.896E-01	4.511E-01	4.237E-01	5.040E-01	4.568E-01	4.648E-01	2.86E-02	6.16%
Cm244	9.652E+00	8.219E+00	9.527E+00	1.052E+01	9.513E+00	1.014E+01	9.595E+00	7.82E-01	8.15%
Cm245	3.493E+01	2.922E+01	3.213E+01	5.030E+01	3.050E+01	2.746E+01	3.409E+01	8.34E+00	24.47%
Cm246	5.123E+00	4.276E+00	4.960E+00	6.576E+00	4.509E+00	4.121E+00	4.928E+00	8.95E-01	18.17%
Cm247	9.609E-02	5.564E-02	7.693E-02	1.415E-01	7.926E-02	7.788E-02	8.788E-02	2.92E-02	33.28%
Cm248	7.731E-03	4.230E-03	9.124E-03	1.209E-02	5.292E-03	6.296E-03	7.460E-03	2.86E-03	38.27%
Ra226	1.547E-05	1.457E-05	1.535E-05	2.078E-05	1.565E-05	1.452E-05	1.606E-05	2.36E-06	14.71%
Ra228	3.626E-13	3.829E-13	2.416E-13	4.038E-13	3.405E-13	3.664E-13	3.496E-13	5.70E-14	16.30%
Ac227	4.330E-08	3.861E-08	3.771E-08	5.167E-08	4.248E-08	4.236E-08	4.269E-08	4.95E-09	11.60%
Th229	1.900E-06	4.109E-06	1.860E-06	2.690E-06	1.870E-06	1.899E-06	2.388E-06	9.03E-07	37.81%
Th230	4.709E-02	4.496E-02	4.672E-02	6.346E-02	4.771E-02	4.417E-02	4.902E-02	7.20E-03	14.69%
Th232	9.890E-04	1.044E-03	9.779E-04	1.004E-03	9.291E-04	1.000E-03	9.907E-04	3.76E-05	3.79%
Cf252	4.567E-17	2.334E-17	8.806E-17	9.229E-17	3.892E-17	4.303E-17	7.171E-17	1.76E-17	244.93%

Table A.5. Results for actinides in assembly calculation at 300 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
U232	2.886E-05	5.808E-05	4.124E-05	7.708E-05	2.839E-05	2.182E-05	4.258E-05	2.12E-05	49.86%
U233	7.467E-02	7.819E-02	7.397E-02	9.119E-02	7.625E-02	7.498E-02	7.821E-02	6.53E-03	8.35%
U234	4.703E+02	4.597E+02	4.665E+02	6.376E+02	4.768E+02	4.409E+02	4.920E+02	7.24E+01	14.71%
U235	6.533E+02	6.788E+02	6.502E+02	7.898E+02	6.475E+02	6.472E+02	6.778E+02	5.61E+01	8.28%
U236	5.048E+02	5.113E+02	4.923E+02	5.176E+02	4.742E+02	5.023E+02	5.004E+02	1.54E+01	3.08%
U238	9.395E+05	9.394E+05	9.391E+05	9.352E+05	9.390E+05	9.387E+05	9.385E+05	1.63E+03	0.17%
Np236	1.302E-04	2.242E-04	1.676E-04	2.910E-04	1.401E-04	7.058E-05	1.706E-04	7.74E-05	45.36%
Np237	1.411E+03	1.405E+03	1.403E+03	1.713E+03	1.455E+03	1.415E+03	1.467E+03	1.22E+02	8.32%
Pu236	2.888E-10	5.049E-10	2.768E-10	6.533E-10	2.287E-10	1.584E-10	3.518E-10	1.88E-10	53.40%
Pu238	4.819E+01	4.763E+01	4.772E+01	6.567E+01	4.896E+01	4.528E+01	5.058E+01	7.50E+00	14.82%
Pu239	6.913E+03	7.143E+03	7.143E+03	9.558E+03	7.327E+03	7.227E+03	7.552E+03	9.92E+02	13.14%
Pu240	6.311E+03	6.007E+03	6.139E+03	6.757E+03	6.067E+03	6.227E+03	6.251E+03	2.71E+02	4.33%
Pu241	5.881E-02	4.983E-02	5.403E-02	8.442E-02	5.175E-02	4.668E-02	5.759E-02	1.38E-02	23.90%
Pu242	2.795E+03	2.755E+03	2.966E+03	2.498E+03	2.770E+03	2.873E+03	2.776E+03	1.57E+02	5.66%
Pu243	3.341E-12	1.934E-12	2.743E-12	4.917E-12	2.826E-12	2.706E-12	3.078E-12	1.01E-12	32.73%
Pu244	3.668E-01	3.363E-01	1.531E-01	1.633E-01	3.449E-01	1.689E-01	2.556E-01	1.03E-01	40.44%
Am241	2.291E+03	2.299E+03	2.277E+03	2.769E+03	2.379E+03	2.293E+03	2.385E+03	1.92E+02	8.04%
Am242m	7.265E-01	5.736E-01	6.004E-01	1.228E+00	6.508E-01	8.742E-01	7.756E-01	2.47E-01	31.79%
Am243	7.631E+02	6.876E+02	7.637E+02	7.670E+02	7.225E+02	8.277E+02	7.553E+02	4.73E+01	6.26%
Cm242	1.910E-03	1.494E-03	1.567E-03	3.198E-03	1.696E-03	2.277E-03	2.024E-03	6.41E-04	31.67%
Cm243	4.562E-03	4.817E-03	3.849E-03	3.270E-03	4.313E-03	3.525E-03	4.056E-03	6.07E-04	14.97%
Cm244	4.364E-03	3.875E-03	4.495E-03	4.960E-03	4.511E-03	4.782E-03	4.498E-03	3.74E-04	8.32%
Cm245	3.437E+01	2.875E+01	3.161E+01	4.948E+01	3.001E+01	2.701E+01	3.354E+01	8.20E+00	24.46%
Cm246	4.975E+00	4.152E+00	4.817E+00	6.387E+00	4.379E+00	4.002E+00	4.785E+00	8.70E-01	18.17%
Cm247	9.610E-02	5.564E-02	7.693E-02	1.415E-01	7.926E-02	7.788E-02	8.788E-02	2.92E-02	33.28%
Cm248	7.728E-03	4.228E-03	9.119E-03	1.208E-02	5.290E-03	6.294E-03	7.456E-03	2.85E-03	38.26%
Ra226	2.775E-04	2.683E-04	2.754E-04	3.752E-04	2.811E-04	2.602E-04	2.896E-04	4.26E-05	14.71%
Ra228	1.365E-12	1.421E-12	8.898E-13	1.450E-12	1.334E-12	1.425E-12	1.314E-12	2.12E-13	16.15%
Ac227	1.225E-07	1.207E-07	1.053E-07	1.469E-07	1.207E-07	1.207E-07	1.228E-07	1.34E-08	10.93%
Th229	3.423E-05	3.955E-05	3.384E-05	4.238E-05	3.473E-05	3.441E-05	3.652E-05	3.57E-06	9.76%
Th230	2.700E-01	2.624E-01	2.678E-01	3.655E-01	2.738E-01	2.532E-01	2.821E-01	4.15E-02	14.70%
Th232	3.512E-03	3.654E-03	3.470E-03	3.605E-03	3.318E-03	3.543E-03	3.517E-03	1.17E-04	3.34%
Cf252	7.905E-40	4.019E-40	0.000E+00	0.000E+00		7.438E-35	1.488E-35	3.33E-35	223.60%

Table A.6. Trends of relative standard deviation versus cooling time for actinides in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
U232	59.73%	45.32%	49.41%	49.50%	49.86%
U233	176.52%	142.35%	37.86%	15.24%	8.35%
U234	21.55%	16.09%	14.70%	14.68%	14.71%
U235	7.83%	7.85%	7.92%	7.99%	8.28%
U236	4.14%	4.10%	3.79%	3.53%	3.08%
U238	0.17%	0.17%	0.17%	0.17%	0.17%
Np236	45.39%	45.38%	45.38%	45.38%	45.36%
Np237	11.75%	11.56%	9.50%	8.81%	8.32%
Pu236	48.36%	48.93%	54.74%	52.52%	53.40%
Pu238	18.52%	14.69%	14.70%	14.72%	14.82%
Pu239	13.42%	13.18%	13.17%	13.17%	13.14%
Pu240	4.20%	4.22%	4.31%	4.33%	4.33%
Pu241	7.74%	7.74%	7.81%	7.95%	23.90%
Pu242	5.66%	5.66%	5.66%	5.66%	5.66%
Pu243	14.65%	32.72%	32.72%	244.95%	32.73%
Pu244	40.44%	40.44%	40.44%	40.44%	40.44%
Am241	16.38%	9.07%	8.06%	8.04%	8.04%
Am242m	31.78%	31.78%	31.78%	31.80%	31.79%
Am243	6.26%	6.26%	6.25%	6.26%	6.26%
Cm242	3.18%	4.36%	31.62%	31.62%	31.67%
Cm243	5.64%	5.56%	5.27%	6.16%	14.97%
Cm244	8.14%	8.18%	8.14%	8.15%	8.32%
Cm245	24.47%	24.47%	24.48%	24.47%	24.46%
Cm246	18.17%	18.17%	18.17%	18.17%	18.17%
Cm247	33.28%	33.28%	33.28%	33.28%	33.28%
Cm248	38.26%	38.29%	38.27%	38.27%	38.26%
Ra226	8.00%	13.97%	14.80%	14.71%	14.71%
Ra228	5.71%	6.41%	14.13%	16.30%	16.15%
Ac227	22.20%	17.40%	13.16%	11.60%	10.93%
Th229	83.36%	88.08%	72.12%	37.81%	9.76%
Th230	8.36%	15.61%	14.74%	14.69%	14.70%
Th232	3.62%	3.99%	3.95%	3.79%	3.34%
Cf252	49.57%	49.56%	49.46%	244.93%	223.60%

Table A.7. Results for fission products in assembly calculation at discharge (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Se79	4.857E+00	4.337E+00	4.627E+00	5.120E+00	4.781E+00	4.506E+00	4.705E+00	2.764E-01	5.88%
Kr85	1.696E+01	1.664E+01	1.563E+01	1.757E+01	1.546E+01	1.591E+01	1.636E+01	8.303E-01	5.07%
Rb85	6.438E+01	6.384E+01	6.356E+01	6.734E+01	6.090E+01	6.152E+01	6.359E+01	2.292E+00	3.60%
Rb87	1.461E+02	1.431E+02	1.478E+02	1.608E+02	1.493E+02	1.476E+02	1.491E+02	6.095E+00	4.09%
Sr88	1.985E+02	1.959E+02	1.971E+02	2.146E+02	2.038E+02	1.974E+02	2.012E+02	7.113E+00	3.53%
Sr90	2.958E+02	2.999E+02	3.038E+02	3.365E+02	3.011E+02	3.086E+02	3.076E+02	1.477E+01	4.80%
Nb93m	3.292E-04	3.072E-04	3.201E-04	2.499E-02	3.400E-01	4.598E-02	6.865E-02	1.342E-01	195.48%
Mo95	5.712E+02	5.624E+02	5.662E+02	6.665E+02	6.118E+02	6.147E+02	5.988E+02	4.038E+01	6.74%
Mo97	8.043E+02	8.095E+02	8.255E+02	9.613E+02	8.683E+02	8.672E+02	8.560E+02	5.853E+01	6.84%
Tc99	8.449E+02	8.544E+02	8.619E+02	9.896E+02	8.898E+02	8.757E+02	8.860E+02	5.315E+01	6.00%
Ru101	9.407E+02	9.444E+02	9.432E+02	1.051E+03	9.108E+02	9.454E+02	9.559E+02	4.840E+01	5.06%
Ru106	3.582E+02	3.609E+02	3.692E+02	4.376E+02	3.734E+02	3.719E+02	3.785E+02	2.957E+01	7.81%
Rh103	6.773E+02	6.810E+02	6.792E+02	8.572E+02	6.331E+02	6.793E+02	7.012E+02	7.864E+01	11.21%
Pd107	5.731E+02	5.447E+02	5.603E+02	6.403E+02	5.777E+02	5.723E+02	5.781E+02	3.274E+01	5.66%
Ag108m	1.043E-03	4.888E-06	7.215E-06	2.126E-06	8.101E-06	2.188E-06	1.779E-04	4.238E-04	238.20%
Ag109	1.950E+02	1.304E+02	2.075E+02	2.297E+02	1.995E+02	1.960E+02	1.930E+02	3.327E+01	17.24%
Ag110m	3.010E+00	4.475E+00	2.812E+00	2.214E+00	3.568E+00	2.348E+00	3.071E+00	8.422E-01	27.42%
I127	8.110E+01	8.046E+01	8.238E+01	8.552E+01	7.283E+01	7.448E+01	7.946E+01	4.852E+00	6.11%
I129	2.511E+02	2.586E+02	2.393E+02	2.699E+02	2.456E+02	2.357E+02	2.500E+02	1.273E+01	5.09%
Xe130	1.162E+01	1.170E+01	9.876E+00	9.332E+00	1.158E+01	1.133E+01	1.091E+01	1.031E+00	9.45%
Xe131	4.911E+02	4.193E+02	4.950E+02	6.161E+02	4.689E+02	4.874E+02	4.963E+02	6.503E+01	13.10%
Xe132	1.299E+03	1.388E+03	1.320E+03	1.455E+03	1.349E+03	1.372E+03	1.364E+03	5.535E+01	4.06%
Xe134	1.526E+03	1.650E+03	1.685E+03	1.869E+03	1.648E+03	1.692E+03	1.678E+03	1.109E+02	6.61%
Xe136	2.680E+03	2.622E+03	2.760E+03	2.768E+03	2.698E+03	2.758E+03	2.714E+03	5.791E+01	2.13%
Cs133	1.217E+03	1.244E+03	1.235E+03	1.408E+03	1.208E+03	1.253E+03	1.261E+03	7.400E+01	5.87%
Cs134	1.651E+02	1.490E+02	1.738E+02	1.670E+02	1.812E+02	1.528E+02	1.648E+02	1.223E+01	7.42%
Cs135	4.098E+02	4.514E+02	4.238E+02	7.502E+02	4.348E+02	4.298E+02	4.833E+02	1.315E+02	27.20%
Cs137	1.380E+03	1.376E+03	1.415E+03	1.572E+03	1.393E+03	1.416E+03	1.425E+03	7.377E+01	5.18%
Ba136	2.802E+01	3.366E+01	2.788E+01	5.763E+01	3.103E+01	4.727E+01	3.758E+01	1.216E+01	32.36%
Ba138	1.373E+03	1.387E+03	1.394E+03	1.539E+03	1.388E+03	1.394E+03	1.412E+03	6.249E+01	4.42%
La139	1.315E+03	1.221E+03	1.290E+03	1.431E+03	1.267E+03	1.292E+03	1.303E+03	7.053E+01	5.41%
Ce140	1.226E+03	1.233E+03	1.246E+03	1.354E+03	1.279E+03	1.240E+03	1.263E+03	4.823E+01	3.82%
Ce144	3.696E+02	3.696E+02	3.727E+02	4.424E+02	3.780E+02	3.744E+02	3.844E+02	2.857E+01	7.43%
Nd142	2.026E+01	1.877E+01	2.115E+01	1.635E+01	2.015E+01	2.084E+01	1.959E+01	1.785E+00	9.11%
Nd143	7.313E+02	7.773E+02	7.520E+02	9.395E+02	7.579E+02	7.475E+02	7.843E+02	7.751E+01	9.88%
Nd144	8.295E+02	7.972E+02	8.296E+02	7.563E+02	8.184E+02	8.285E+02	8.099E+02	2.907E+01	3.59%
Nd145	6.475E+02	6.613E+02	6.556E+02	7.328E+02	6.478E+02	6.510E+02	6.660E+02	3.314E+01	4.98%
Nd146	7.119E+02	7.144E+02	7.115E+02	7.680E+02	7.208E+02	7.168E+02	7.239E+02	2.187E+01	3.02%
Nd148	4.246E+02	4.327E+02	4.248E+02	4.655E+02	4.229E+02	4.201E+02	4.318E+02	1.705E+01	3.95%
Nd150	2.471E+02	2.495E+02	2.504E+02	2.767E+02	2.508E+02	2.508E+02	2.542E+02	1.110E+01	4.37%

Table A.7. Results for fission products in assembly calculation at discharge (g/tHMI) (continued)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Pm147	1.894E+02	1.529E+02	1.756E+02	2.317E+02	1.770E+02	1.770E+02	1.839E+02	2.623E+01	14.26%
Sm146	8.269E-03	5.283E-08	9.040E-07	2.911E-03	9.873E-03	6.040E-03	4.516E-03	4.206E-03	93.15%
Sm147	6.414E+01	5.639E+01	6.237E+01	7.239E+01	6.054E+01	6.167E+01	6.292E+01	5.316E+00	8.45%
Sm148	1.489E+02	1.629E+02	1.556E+02	1.603E+02	1.404E+02	1.346E+02	1.505E+02	1.125E+01	7.48%
Sm149	2.442E+00	3.342E+00	1.698E+00	5.444E+00	2.903E+00	2.905E+00	3.122E+00	1.267E+00	40.58%
Sm150	3.591E+02	3.496E+02	2.704E+02	3.838E+02	3.586E+02	3.622E+02	3.473E+02	3.935E+01	11.33%
Sm151	1.463E+01	2.259E+01	1.329E+01	2.766E+01	1.872E+01	1.984E+01	1.945E+01	5.274E+00	27.11%
Sm152	1.427E+02	1.958E+02	1.379E+02	1.696E+02	1.737E+02	1.726E+02	1.654E+02	2.161E+01	13.06%
Sm154	7.298E+01	7.543E+01	6.940E+01	7.828E+01	7.333E+01	7.098E+01	7.340E+01	3.161E+00	4.31%
Eu153	1.805E+02	1.887E+02	1.825E+02	1.990E+02	1.862E+02	1.813E+02	1.864E+02	6.928E+00	3.72%
Eu154	4.270E+01	6.630E+01	3.783E+01	5.468E+01	3.919E+01	4.156E+01	4.704E+01	1.118E+01	23.76%
Eu155	1.333E+01	1.606E+01	1.382E+01	1.497E+01	1.536E+01	9.320E+00	1.381E+01	2.417E+00	17.50%
Gd154	3.053E+00	4.134E+00	2.785E+00	3.298E+00	2.714E+00	2.912E+00	3.149E+00	5.254E-01	16.68%
Gd155	8.180E-02	1.176E-01	8.498E-02	1.530E-01	9.457E-02	6.395E-02	9.932E-02	3.163E-02	31.85%
Gd156	1.451E+02	1.377E+02	1.564E+02	1.214E+02	1.497E+02	1.472E+02	1.429E+02	1.218E+01	8.52%
Ho166m	2.116E-02	3.224E-02	9.017E-04	5.073E-04	1.871E-03	7.292E-04	9.569E-03	1.373E-02	143.53%

Table A.8. Results for fission products in assembly calculation at 5 years (g/HMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Se79	4.857E+00	4.337E+00	4.627E+00	5.120E+00	4.781E+00	4.506E+00	4.705E+00	2.764E-01	5.88%
Kr85	1.229E+01	1.205E+01	1.131E+01	1.272E+01	1.121E+01	1.151E+01	1.185E+01	6.009E-01	5.07%
Rb85	6.907E+01	6.846E+01	6.790E+01	7.223E+01	6.517E+01	6.594E+01	6.813E+01	2.506E+00	3.68%
Rb87	1.461E+02	1.431E+02	1.478E+02	1.608E+02	1.493E+02	1.476E+02	1.491E+02	6.093E+00	4.09%
Sr88	1.985E+02	1.959E+02	1.971E+02	2.146E+02	2.038E+02	1.975E+02	2.012E+02	7.096E+00	3.53%
Sr90	2.622E+02	2.663E+02	2.686E+02	2.975E+02	2.668E+02	2.729E+02	2.724E+02	1.279E+01	4.69%
Nb93m	1.410E-03	1.430E-03	1.397E-03	2.147E-02	2.648E-01	3.828E-02	5.480E-02	1.040E-01	189.71%
Mo95	6.916E+02	6.854E+02	6.838E+02	8.222E+02	7.330E+02	7.344E+02	7.251E+02	5.288E+01	7.29%
Mo97	8.053E+02	8.106E+02	8.266E+02	9.628E+02	8.694E+02	8.682E+02	8.571E+02	5.870E+01	6.85%
Tc99	8.499E+02	8.594E+02	8.668E+02	9.960E+02	8.950E+02	8.806E+02	8.913E+02	5.370E+01	6.03%
Ru101	9.407E+02	9.444E+02	9.432E+02	1.052E+03	9.108E+02	9.454E+02	9.561E+02	4.879E+01	5.10%
Ru106	1.199E+01	1.159E+01	1.223E+01	1.449E+01	1.264E+01	1.232E+01	1.254E+01	1.016E+00	8.10%
Rh103	7.526E+02	7.568E+02	7.544E+02	9.588E+02	7.046E+02	7.567E+02	7.806E+02	8.960E+01	11.48%
Pd107	5.732E+02	5.447E+02	5.603E+02	6.404E+02	5.777E+02	5.723E+02	5.781E+02	3.277E+01	5.67%
Ag108m	1.034E-03	4.848E-06	7.022E-06	2.069E-06	7.883E-06	2.129E-06	1.763E-04	4.202E-04	238.30%
Ag109	1.954E+02	1.308E+02	2.079E+02	2.301E+02	1.999E+02	1.964E+02	1.934E+02	3.328E+01	17.21%
Ag110m	1.895E-02	2.823E-02	1.771E-02	1.394E-02	2.260E-02	1.478E-02	1.937E-02	5.337E-03	27.56%
I127	8.451E+01	8.412E+01	8.573E+01	8.953E+01	7.567E+01	7.751E+01	8.285E+01	5.241E+00	6.33%
I129	2.564E+02	2.613E+02	2.417E+02	2.733E+02	2.482E+02	2.383E+02	2.532E+02	1.311E+01	5.18%
Xe130	1.165E+01	1.172E+01	9.895E+00	9.350E+00	1.160E+01	1.135E+01	1.093E+01	1.034E+00	9.46%
Xe131	5.018E+02	4.306E+02	5.056E+02	6.307E+02	4.796E+02	4.985E+02	5.078E+02	6.631E+01	13.06%
Xe132	1.305E+03	1.394E+03	1.326E+03	1.463E+03	1.354E+03	1.378E+03	1.370E+03	5.606E+01	4.09%
Xe134	1.526E+03	1.650E+03	1.685E+03	1.870E+03	1.648E+03	1.692E+03	1.678E+03	1.113E+02	6.63%
Xe136	2.680E+03	2.622E+03	2.760E+03	2.768E+03	2.698E+03	2.758E+03	2.714E+03	5.791E+01	2.13%
Cs133	1.233E+03	1.260E+03	1.250E+03	1.429E+03	1.223E+03	1.268E+03	1.277E+03	7.623E+01	5.97%
Cs134	3.082E+01	2.775E+01	3.236E+01	3.107E+01	3.378E+01	2.845E+01	3.070E+01	2.288E+00	7.45%
Cs135	4.107E+02	4.523E+02	4.245E+02	7.515E+02	4.357E+02	4.308E+02	4.842E+02	1.316E+02	27.18%
Cs137	1.230E+03	1.226E+03	1.260E+03	1.401E+03	1.242E+03	1.261E+03	1.270E+03	6.581E+01	5.18%
Ba136	2.894E+01	3.495E+01	2.865E+01	5.923E+01	3.219E+01	4.839E+01	3.872E+01	1.239E+01	32.01%
Ba138	1.373E+03	1.387E+03	1.394E+03	1.539E+03	1.388E+03	1.394E+03	1.412E+03	6.248E+01	4.42%
La139	1.315E+03	1.221E+03	1.290E+03	1.431E+03	1.267E+03	1.292E+03	1.303E+03	7.050E+01	5.41%
Ce140	1.257E+03	1.269E+03	1.280E+03	1.396E+03	1.312E+03	1.272E+03	1.298E+03	5.164E+01	3.98%
Ce144	4.353E+00	4.344E+00	4.390E+00	5.202E+00	4.451E+00	4.402E+00	4.524E+00	3.345E-01	7.39%
Nd142	2.033E+01	1.883E+01	2.122E+01	1.642E+01	2.022E+01	2.091E+01	1.966E+01	1.785E+00	9.08%
Nd143	7.581E+02	8.047E+02	7.781E+02	9.752E+02	7.850E+02	7.749E+02	8.127E+02	8.105E+01	9.97%
Nd144	1.195E+03	1.163E+03	1.198E+03	1.194E+03	1.192E+03	1.199E+03	1.190E+03	1.376E+01	1.16%
Nd145	6.479E+02	6.616E+02	6.562E+02	7.332E+02	6.481E+02	6.512E+02	6.664E+02	3.316E+01	4.98%
Nd146	7.119E+02	7.145E+02	7.115E+02	7.680E+02	7.208E+02	7.168E+02	7.239E+02	2.187E+01	3.02%
Nd148	4.246E+02	4.327E+02	4.248E+02	4.655E+02	4.229E+02	4.201E+02	4.318E+02	1.705E+01	3.95%
Nd150	2.471E+02	2.495E+02	2.504E+02	2.767E+02	2.508E+02	2.508E+02	2.542E+02	1.110E+01	4.37%

Table A.8. Results for fission products in assembly calculation at 5 years (g/tHMI) (continued)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Pm147	5.314E+01	4.344E+01	4.935E+01	6.524E+01	4.989E+01	4.985E+01	5.182E+01	7.291E+00	14.07%
Sm146	9.351E-03	1.898E-07	9.040E-07	3.172E-03	1.010E-02	6.192E-03	4.803E-03	4.460E-03	92.87%
Sm147	2.100E+02	1.758E+02	1.979E+02	2.515E+02	1.975E+02	1.986E+02	2.052E+02	2.525E+01	12.30%
Sm148	1.524E+02	1.667E+02	1.593E+02	1.657E+02	1.438E+02	1.380E+02	1.543E+02	1.173E+01	7.60%
Sm149	4.350E+00	5.473E+00	2.915E+00	7.747E+00	4.975E+00	4.995E+00	5.076E+00	1.582E+00	31.16%
Sm150	3.591E+02	3.496E+02	2.704E+02	3.838E+02	3.586E+02	3.622E+02	3.473E+02	3.935E+01	11.33%
Sm151	1.447E+01	2.212E+01	1.317E+01	2.713E+01	1.844E+01	1.948E+01	1.913E+01	5.114E+00	26.73%
Sm152	1.427E+02	1.958E+02	1.379E+02	1.696E+02	1.737E+02	1.726E+02	1.654E+02	2.161E+01	13.07%
Sm154	7.298E+01	7.544E+01	6.940E+01	7.828E+01	7.333E+01	7.098E+01	7.340E+01	3.162E+00	4.31%
Eu153	1.822E+02	1.906E+02	1.841E+02	2.010E+02	1.880E+02	1.831E+02	1.882E+02	7.048E+00	3.75%
Eu154	2.853E+01	4.431E+01	2.527E+01	3.653E+01	2.644E+01	2.776E+01	3.147E+01	7.438E+00	23.63%
Eu155	6.428E+00	7.982E+00	6.591E+00	7.135E+00	7.422E+00	4.444E+00	6.667E+00	1.227E+00	18.40%
Gd154	1.722E+01	2.612E+01	1.534E+01	2.144E+01	1.546E+01	1.670E+01	1.871E+01	4.256E+00	22.74%
Gd155	6.982E+00	8.198E+00	7.314E+00	7.982E+00	8.035E+00	4.941E+00	7.242E+00	1.221E+00	16.86%
Gd156	1.539E+02	1.454E+02	1.654E+02	1.295E+02	1.587E+02	1.560E+02	1.515E+02	1.259E+01	8.31%
Ho166m	2.110E-02	3.215E-02	8.992E-04	5.059E-04	1.866E-03	7.272E-04	9.542E-03	1.369E-02	143.53%

Table A.9. Results for fission products in assembly calculation at 50 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Se79	4.857E+00	4.335E+00	4.627E+00	5.119E+00	4.781E+00	4.504E+00	4.704E+00	2.770E-01	5.89%
Kr85	6.755E-01	6.563E-01	6.165E-01	6.931E-01	6.185E-01	6.274E-01	6.479E-01	3.208E-02	4.95%
Rb85	8.069E+01	7.985E+01	7.859E+01	8.426E+01	7.576E+01	7.682E+01	7.933E+01	3.034E+00	3.82%
Rb87	1.461E+02	1.431E+02	1.478E+02	1.608E+02	1.493E+02	1.476E+02	1.491E+02	6.093E+00	4.09%
Sr88	1.985E+02	1.959E+02	1.971E+02	2.146E+02	2.038E+02	1.975E+02	2.012E+02	7.096E+00	3.53%
Sr90	8.874E+01	9.123E+01	8.872E+01	9.824E+01	8.985E+01	9.010E+01	9.115E+01	3.599E+00	3.95%
Nb93m	5.268E-03	5.488E-03	5.242E-03	8.928E-03	3.166E-02	1.082E-02	1.123E-02	1.027E-02	91.41%
Mo95	6.916E+02	6.854E+02	6.838E+02	8.222E+02	7.330E+02	7.344E+02	7.251E+02	5.288E+01	7.29%
Mo97	8.053E+02	8.106E+02	8.266E+02	9.628E+02	8.694E+02	8.682E+02	8.571E+02	5.870E+01	6.85%
Tc99	8.497E+02	8.593E+02	8.668E+02	9.960E+02	8.949E+02	8.806E+02	8.912E+02	5.375E+01	6.03%
Ru101	9.407E+02	9.444E+02	9.432E+02	1.052E+03	9.108E+02	9.454E+02	9.561E+02	4.879E+01	5.10%
Ru106	1.769E-07	4.220E-13	5.853E-13	6.931E-13	7.363E-13	5.891E-13	2.948E-08	7.222E-08	244.94%
Rh103	7.526E+02	7.568E+02	7.544E+02	9.588E+02	7.046E+02	7.567E+02	7.806E+02	8.960E+01	11.48%
Pd107	5.732E+02	5.447E+02	5.603E+02	6.404E+02	5.777E+02	5.723E+02	5.781E+02	3.277E+01	5.67%
Ag108m	9.597E-04	4.499E-06	5.493E-06	1.619E-06	6.167E-06	1.665E-06	1.632E-04	3.902E-04	239.11%
Ag109	1.954E+02	1.308E+02	2.079E+02	2.301E+02	1.999E+02	1.964E+02	1.934E+02	3.328E+01	17.21%
Ag110m	5.018E-12	4.467E-22	2.760E-22	2.173E-22	3.701E-22	2.304E-22	8.363E-13	2.049E-12	244.95%
I127	8.451E+01	8.412E+01	8.573E+01	8.953E+01	7.567E+01	7.751E+01	8.285E+01	5.241E+00	6.33%
I129	2.564E+02	2.613E+02	2.417E+02	2.733E+02	2.482E+02	2.383E+02	2.532E+02	1.311E+01	5.18%
Xe130	1.165E+01	1.172E+01	9.895E+00	9.350E+00	1.160E+01	1.135E+01	1.093E+01	1.034E+00	9.46%
Xe131	5.018E+02	4.306E+02	5.056E+02	6.307E+02	4.796E+02	4.985E+02	5.078E+02	6.631E+01	13.06%
Xe132	1.305E+03	1.394E+03	1.326E+03	1.463E+03	1.354E+03	1.378E+03	1.370E+03	5.606E+01	4.09%
Xe134	1.526E+03	1.650E+03	1.685E+03	1.870E+03	1.648E+03	1.692E+03	1.678E+03	1.113E+02	6.63%
Xe136	2.680E+03	2.622E+03	2.760E+03	2.768E+03	2.698E+03	2.758E+03	2.714E+03	5.791E+01	2.13%
Cs133	1.233E+03	1.260E+03	1.250E+03	1.429E+03	1.223E+03	1.268E+03	1.277E+03	7.623E+01	5.97%
Cs134	8.496E-06	7.468E-06	8.723E-06	8.366E-06	9.195E-06	7.664E-06	8.319E-06	6.508E-07	7.82%
Cs135	4.107E+02	4.523E+02	4.245E+02	7.515E+02	4.357E+02	4.308E+02	4.842E+02	1.316E+02	27.18%
Cs137	4.353E+02	4.335E+02	4.455E+02	4.953E+02	4.419E+02	4.459E+02	4.496E+02	2.299E+01	5.11%
Ba136	2.894E+01	3.495E+01	2.865E+01	5.923E+01	3.219E+01	4.839E+01	3.872E+01	1.239E+01	32.01%
Ba138	1.373E+03	1.387E+03	1.394E+03	1.539E+03	1.388E+03	1.394E+03	1.412E+03	6.248E+01	4.42%
La139	1.315E+03	1.221E+03	1.290E+03	1.431E+03	1.267E+03	1.292E+03	1.303E+03	7.050E+01	5.41%
Ce140	1.257E+03	41.269E+03	1.280E+03	1.396E+03	1.312E+03	1.272E+03	1.298E+03	5.164E+01	3.98%
Ce144	9.567E-08	1.860E-17	1.912E-17	2.235E-17	1.938E-17	1.891E-17	1.595E-08	3.906E-08	244.95%
Nd142	2.033E+01	1.883E+01	2.122E+01	1.642E+01	2.022E+01	2.091E+01	1.966E+01	1.785E+00	9.08%
Nd143	7.581E+02	8.047E+02	7.781E+02	9.752E+02	7.850E+02	7.749E+02	8.127E+02	8.105E+01	9.97%
Nd144	1.199E+03	1.167E+03	1.202E+03	1.199E+03	1.196E+03	1.203E+03	1.194E+03	1.370E+01	1.15%
Nd145	6.479E+02	6.616E+02	6.562E+02	7.332E+02	6.481E+02	6.512E+02	6.664E+02	3.316E+01	4.98%
Nd146	7.119E+02	7.145E+02	7.115E+02	7.680E+02	7.208E+02	7.168E+02	7.239E+02	2.187E+01	3.02%
Nd148	4.246E+02	4.327E+02	4.248E+02	4.655E+02	4.229E+02	4.201E+02	4.318E+02	1.705E+01	3.95%
Nd150	2.471E+02	2.495E+02	2.504E+02	2.767E+02	2.508E+02	2.508E+02	2.542E+02	1.110E+01	4.37%

Table A.9. Results for fission products in assembly calculation at 50 years (g/tHMI) (continued)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Pm147	3.647E-04	2.972E-04	3.379E-04	4.467E-04	3.443E-04	3.414E-04	3.554E-04	4.987E-05	14.03%
Sm146	1.059E-02	3.464E-07	9.040E-07	3.471E-03	1.036E-02	6.363E-03	5.131E-03	4.776E-03	93.09%
Sm147	2.632E+02	2.192E+02	2.472E+02	3.168E+02	2.474E+02	2.485E+02	2.571E+02	3.256E+01	12.67%
Sm148	1.524E+02	1.667E+02	1.593E+02	1.657E+02	1.438E+02	1.380E+02	1.543E+02	1.173E+01	7.60%
Sm149	4.350E+00	5.473E+00	2.915E+00	7.747E+00	4.975E+00	4.995E+00	5.076E+00	1.582E+00	31.16%
Sm150	3.591E+02	3.496E+02	2.704E+02	3.838E+02	3.586E+02	3.622E+02	3.473E+02	3.935E+01	11.33%
Sm151	1.023E+01	1.556E+01	9.315E+00	1.918E+01	1.319E+01	1.378E+01	1.354E+01	3.602E+00	26.60%
Sm152	1.427E+02	1.958E+02	1.379E+02	1.697E+02	1.737E+02	1.726E+02	1.654E+02	2.162E+01	13.07%
Sm154	7.299E+01	7.544E+01	6.943E+01	7.829E+01	7.334E+01	7.098E+01	7.341E+01	3.158E+00	4.30%
Eu153	1.822E+02	1.906E+02	1.841E+02	2.010E+02	1.880E+02	1.831E+02	1.882E+02	7.048E+00	3.75%
Eu154	7.566E-01	1.178E+00	6.691E-01	9.682E-01	7.654E-01	7.356E-01	8.455E-01	1.914E-01	22.64%
Eu155	9.079E-03	1.476E-02	8.402E-03	9.096E-03	1.062E-02	5.666E-03	9.603E-03	3.002E-03	31.26%
Gd154	4.499E+01	6.925E+01	3.994E+01	5.700E+01	4.113E+01	4.372E+01	4.934E+01	1.150E+01	23.31%
Gd155	1.340E+01	1.617E+01	1.390E+01	1.510E+01	1.545E+01	9.380E+00	1.390E+01	2.435E+00	17.52%
Gd156	1.539E+02	1.454E+02	1.654E+02	1.295E+02	1.587E+02	1.560E+02	1.515E+02	1.259E+01	8.31%
Ho166m	2.056E-02	3.133E-02	8.761E-04	4.928E-04	1.818E-03	7.083E-04	9.297E-03	1.334E-02	143.53%

Table A.10. Results for fission products in assembly calculation at 100 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Se79	4.856E+00	4.333E+00	4.625E+00	5.119E+00	4.781E+00	4.504E+00	4.703E+00	2.776E-01	5.90%
Kr85	2.690E-02	2.588E-02	2.432E-02	2.733E-02	2.474E-02	2.475E-02	2.565E-02	1.253E-03	4.88%
Rb85	8.133E+01	8.048E+01	7.918E+01	8.492E+01	7.635E+01	7.741E+01	7.994E+01	3.062E+00	3.83%
Rb87	1.461E+02	1.431E+02	1.478E+02	1.608E+02	1.493E+02	1.476E+02	1.491E+02	6.093E+00	4.09%
Sr88	1.985E+02	1.959E+02	1.971E+02	2.146E+02	2.038E+02	1.975E+02	2.012E+02	7.096E+00	3.53%
Sr90	2.663E+01	2.775E+01	2.590E+01	2.868E+01	2.681E+01	2.629E+01	2.701E+01	1.026E+00	3.80%
Nb93m	5.844E-03	6.112E-03	5.816E-03	7.053E-03	7.498E-03	6.718E-03	6.507E-03	6.925E-04	10.64%
Mo95	6.916E+02	6.854E+02	6.838E+02	8.222E+02	7.330E+02	7.344E+02	7.251E+02	5.288E+01	7.29%
Mo97	8.053E+02	8.106E+02	8.266E+02	9.628E+02	8.694E+02	8.682E+02	8.571E+02	5.870E+01	6.85%
Tc99	8.496E+02	8.592E+02	8.666E+02	9.960E+02	8.947E+02	8.804E+02	8.911E+02	5.380E+01	6.04%
Ru101	9.407E+02	9.444E+02	9.432E+02	1.052E+03	9.108E+02	9.454E+02	9.561E+02	4.879E+01	5.10%
Ru106	2.581E-08	4.935E-28	9.279E-28	1.099E-27		1.864E-05	3.733E-06	8.333E-06	223.22%
Rh103	7.526E+02	7.568E+02	7.544E+02	9.588E+02	7.046E+02	7.567E+02	7.806E+02	8.960E+01	11.48%
Pd107	5.732E+02	5.447E+02	5.603E+02	6.404E+02	5.777E+02	5.723E+02	5.781E+02	3.277E+01	5.67%
Ag108m	8.833E-04	4.141E-06	4.180E-06	1.232E-06	4.695E-06	1.267E-06	1.498E-04	3.593E-04	239.88%
Ag109	1.954E+02	1.308E+02	2.079E+02	2.301E+02	1.999E+02	1.964E+02	1.934E+02	3.328E+01	17.21%
Ag110m	7.344E-13	0.000E+00	0.000E+00	0.000E+00		3.722E-07	7.444E-08	1.665E-07	223.61%
I127	8.451E+01	8.412E+01	8.573E+01	8.953E+01	7.567E+01	7.751E+01	8.285E+01	5.241E+00	6.33%
I129	2.564E+02	2.613E+02	2.417E+02	2.733E+02	2.482E+02	2.383E+02	2.532E+02	1.311E+01	5.18%
Xe130	1.165E+01	1.172E+01	9.895E+00	9.350E+00	1.160E+01	1.135E+01	1.093E+01	1.034E+00	9.46%
Xe131	5.018E+02	4.306E+02	5.056E+02	6.307E+02	4.796E+02	4.985E+02	5.078E+02	6.631E+01	13.06%
Xe132	1.305E+03	1.394E+03	1.326E+03	1.463E+03	1.354E+03	1.378E+03	1.370E+03	5.606E+01	4.09%
Xe134	1.526E+03	1.650E+03	1.685E+03	1.870E+03	1.648E+03	1.692E+03	1.678E+03	1.113E+02	6.63%
Xe136	2.680E+03	2.622E+03	2.760E+03	2.768E+03	2.698E+03	2.758E+03	2.714E+03	5.791E+01	2.13%
Cs133	1.233E+03	1.260E+03	1.250E+03	1.429E+03	1.223E+03	1.268E+03	1.277E+03	7.623E+01	5.97%
Cs134	2.613E-11	3.743E-13	4.378E-13	4.311E-13	4.666E-13	1.611E-05	2.685E-06	6.577E-06	244.95%
Cs135	4.107E+02	4.523E+02	4.245E+02	7.515E+02	4.357E+02	4.308E+02	4.842E+02	1.316E+02	27.18%
Cs137	1.373E+02	1.365E+02	1.404E+02	1.560E+02	1.402E+02	1.405E+02	1.418E+02	7.155E+00	5.05%
Ba136	2.894E+01	3.495E+01	2.865E+01	5.923E+01	3.219E+01	4.839E+01	3.872E+01	1.239E+01	32.01%
Ba138	1.373E+03	1.387E+03	1.394E+03	1.539E+03	1.388E+03	1.394E+03	1.412E+03	6.248E+01	4.42%
La139	1.315E+03	1.221E+03	1.290E+03	1.431E+03	1.267E+03	1.292E+03	1.303E+03	7.050E+01	5.41%
Ce140	1.257E+03	1.269E+03	1.280E+03	1.396E+03	1.312E+03	1.272E+03	1.298E+03	5.164E+01	3.98%
Ce144	1.396E-08	9.361E-37	9.867E-37	0.000E+00		2.464E-05	4.931E-06	1.102E-05	223.45%
Nd142	2.033E+01	1.883E+01	2.122E+01	1.642E+01	2.022E+01	2.091E+01	1.966E+01	1.785E+00	9.08%
Nd143	7.581E+02	8.047E+02	7.781E+02	9.752E+02	7.850E+02	7.749E+02	8.127E+02	8.105E+01	9.97%
Nd144	1.199E+03	1.167E+03	1.202E+03	1.199E+03	1.196E+03	1.203E+03	1.194E+03	1.370E+01	1.15%
Nd145	6.479E+02	6.616E+02	6.562E+02	7.332E+02	6.481E+02	6.512E+02	6.664E+02	3.316E+01	4.98%
Nd146	7.119E+02	7.145E+02	7.115E+02	7.680E+02	7.208E+02	7.168E+02	7.239E+02	2.187E+01	3.02%
Nd148	4.246E+02	4.327E+02	4.248E+02	4.655E+02	4.229E+02	4.201E+02	4.318E+02	1.705E+01	3.95%
Nd150	2.471E+02	2.495E+02	2.504E+02	2.767E+02	2.508E+02	2.508E+02	2.542E+02	1.110E+01	4.37%

**Table A.10. Results for fission products in assembly calculation at 100 years (g/tHMI)
(continued)**

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Pm147	2.436E-08	5.424E-10	6.174E-10	8.158E-10	6.346E-10	3.545E-08	1.040E-08	1.551E-08	149.07%
Sm146	1.059E-02	3.470E-07	9.040E-07	3.472E-03	1.036E-02	6.366E-03	5.132E-03	4.776E-03	93.08%
Sm147	2.632E+02	2.192E+02	2.472E+02	3.168E+02	2.474E+02	2.485E+02	2.571E+02	3.256E+01	12.67%
Sm148	1.524E+02	1.667E+02	1.593E+02	1.657E+02	1.438E+02	1.380E+02	1.543E+02	1.173E+01	7.60%
Sm149	4.350E+00	5.473E+00	2.915E+00	7.747E+00	4.975E+00	4.995E+00	5.076E+00	1.582E+00	31.16%
Sm150	3.591E+02	3.496E+02	2.704E+02	3.838E+02	3.586E+02	3.622E+02	3.473E+02	3.935E+01	11.33%
Sm151	6.962E+00	1.053E+01	6.339E+00	1.305E+01	9.088E+00	9.375E+00	9.224E+00	2.442E+00	26.48%
Sm152	1.427E+02	1.958E+02	1.379E+02	1.697E+02	1.737E+02	1.726E+02	1.654E+02	2.162E+01	13.07%
Sm154	7.299E+01	7.544E+01	6.943E+01	7.829E+01	7.334E+01	7.101E+01	7.342E+01	3.154E+00	4.30%
Eu153	1.822E+02	1.906E+02	1.841E+02	2.010E+02	1.880E+02	1.831E+02	1.882E+02	7.048E+00	3.75%
Eu154	1.340E-02	2.094E-02	1.184E-02	1.714E-02	1.495E-02	1.304E-02	1.522E-02	3.345E-03	21.98%
Eu155	6.192E-06	1.356E-05	5.108E-06	5.529E-06	7.357E-06	4.422E-06	7.027E-06	3.351E-06	47.68%
Gd154	4.573E+01	7.041E+01	4.058E+01	5.795E+01	4.188E+01	4.444E+01	5.016E+01	1.169E+01	23.30%
Gd155	1.341E+01	1.618E+01	1.391E+01	1.511E+01	1.546E+01	9.385E+00	1.391E+01	2.438E+00	17.53%
Gd156	1.539E+02	1.454E+02	1.654E+02	1.295E+02	1.587E+02	1.560E+02	1.515E+02	1.259E+01	8.31%
Ho166m	1.997E-02	3.043E-02	8.511E-04	4.788E-04	1.766E-03	6.882E-04	9.031E-03	1.296E-02	143.53%

Table A.11. Results for fission products in assembly calculation at 300 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Se79	4.855E+00	4.324E+00	4.624E+00	5.116E+00	4.779E+00	4.501E+00	4.700E+00	2.794E-01	5.95%
Kr85	6.765E-08	6.256E-08	5.883E-08	6.612E-08	6.335E-08	5.986E-08	6.306E-08	3.432E-09	5.44%
Rb85	8.136E+01	8.050E+01	7.922E+01	8.495E+01	7.638E+01	7.744E+01	7.998E+01	3.062E+00	3.83%
Rb87	1.461E+02	1.431E+02	1.478E+02	1.608E+02	1.493E+02	1.476E+02	1.491E+02	6.093E+00	4.09%
Sr88	1.985E+02	1.959E+02	1.971E+02	2.146E+02	2.038E+02	1.975E+02	2.012E+02	7.096E+00	3.53%
Sr90	2.158E-01	2.374E-01	1.882E-01	2.084E-01	2.126E-01	1.911E-01	2.089E-01	1.800E-02	8.62%
Nb93m	5.919E-03	6.198E-03	5.891E-03	6.796E-03	5.434E-03	6.167E-03	6.067E-03	4.499E-04	7.42%
Mo95	6.916E+02	6.854E+02	6.838E+02	8.222E+02	7.330E+02	7.344E+02	7.251E+02	5.288E+01	7.29%
Mo97	8.053E+02	8.106E+02	8.266E+02	9.628E+02	8.694E+02	8.682E+02	8.571E+02	5.870E+01	6.85%
Tc99	8.490E+02	8.586E+02	8.660E+02	9.950E+02	8.941E+02	8.799E+02	8.904E+02	5.364E+01	6.02%
Ru101	9.407E+02	9.444E+02	9.432E+02	1.052E+03	9.108E+02	9.454E+02	9.561E+02	4.879E+01	5.10%
Ru106	2.017E-11	-	0.000E+00	0.000E+00		0.000E+00	5.043E-12	1.009E-11	200.00%
Rh103	7.526E+02	7.568E+02	7.544E+02	9.588E+02	7.046E+02	7.567E+02	7.806E+02	8.960E+01	11.48%
Pd107	5.731E+02	5.447E+02	5.603E+02	6.404E+02	5.777E+02	5.723E+02	5.781E+02	3.278E+01	5.67%
Ag108m	6.340E-04	2.972E-06	1.403E-06	4.135E-07	1.577E-06	4.255E-07	1.068E-04	2.583E-04	241.84%
Ag109	1.954E+02	1.308E+02	2.079E+02	2.301E+02	1.999E+02	1.964E+02	1.934E+02	3.328E+01	17.21%
Ag110m	1.598E-15	-	0.000E+00	0.000E+00		0.000E+00	3.995E-16	7.990E-16	200.00%
I127	8.451E+01	8.412E+01	8.573E+01	8.953E+01	7.567E+01	7.751E+01	8.285E+01	5.241E+00	6.33%
I129	2.564E+02	2.613E+02	2.417E+02	2.733E+02	2.482E+02	2.383E+02	2.532E+02	1.311E+01	5.18%
Xe130	1.165E+01	1.172E+01	9.895E+00	9.350E+00	1.160E+01	1.135E+01	1.093E+01	1.034E+00	9.46%
Xe131	5.018E+02	4.306E+02	5.056E+02	6.307E+02	4.796E+02	4.985E+02	5.078E+02	6.631E+01	13.06%
Xe132	1.305E+03	1.394E+03	1.326E+03	1.463E+03	1.354E+03	1.378E+03	1.370E+03	5.606E+01	4.09%
Xe134	1.526E+03	1.650E+03	1.685E+03	1.870E+03	1.648E+03	1.692E+03	1.678E+03	1.113E+02	6.63%
Xe136	2.680E+03	2.622E+03	2.760E+03	2.768E+03	2.698E+03	2.758E+03	2.714E+03	5.791E+01	2.13%
Cs133	1.233E+03	1.260E+03	1.250E+03	1.429E+03	1.223E+03	1.268E+03	1.277E+03	7.623E+01	5.97%
Cs134	1.095E-13	2.441E-42	0.000E+00	3.008E-42		1.082E-34	2.190E-14	4.897E-14	223.61%
Cs135	4.106E+02	4.523E+02	4.245E+02	7.514E+02	4.356E+02	4.308E+02	4.842E+02	1.316E+02	27.18%
Cs137	1.360E+00	1.343E+00	1.381E+00	1.535E+00	1.421E+00	1.383E+00	1.404E+00	6.934E-02	4.94%
Ba136	2.894E+01	3.495E+01	2.865E+01	5.923E+01	3.219E+01	4.839E+01	3.872E+01	1.239E+01	32.01%
Ba138	1.373E+03	1.387E+03	1.394E+03	1.539E+03	1.388E+03	1.394E+03	1.412E+03	6.248E+01	4.42%
La139	1.315E+03	1.221E+03	1.290E+03	1.431E+03	1.267E+03	1.292E+03	1.303E+03	7.050E+01	5.41%
Ce140	1.257E+03	1.269E+03	1.280E+03	1.396E+03	1.312E+03	1.272E+03	1.298E+03	5.164E+01	3.98%
Ce144	1.034E-11	-	0.000E+00	0.000E+00		0.000E+00	2.585E-12	5.170E-12	200.00%
Nd142	2.033E+01	1.883E+01	2.122E+01	1.642E+01	2.022E+01	2.091E+01	1.966E+01	1.785E+00	9.08%
Nd143	7.581E+02	8.047E+02	7.781E+02	9.752E+02	7.850E+02	7.749E+02	8.127E+02	8.105E+01	9.97%
Nd144	1.199E+03	1.167E+03	1.202E+03	1.199E+03	1.196E+03	1.203E+03	1.194E+03	1.370E+01	1.15%
Nd145	6.479E+02	6.616E+02	6.562E+02	7.332E+02	6.481E+02	6.512E+02	6.664E+02	3.316E+01	4.98%
Nd146	7.119E+02	7.145E+02	7.115E+02	7.680E+02	7.208E+02	7.168E+02	7.239E+02	2.187E+01	3.02%
Nd148	4.246E+02	4.327E+02	4.248E+02	4.655E+02	4.229E+02	4.201E+02	4.318E+02	1.705E+01	3.95%
Nd150	2.471E+02	2.495E+02	2.504E+02	2.767E+02	2.508E+02	2.508E+02	2.542E+02	1.110E+01	4.37%

**Table A.11. Results for fission products in assembly calculation at 300 years (g/tHMI)
(continued)**

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Pm147	1.570E-11	6.019E-33	6.876E-33	0.000E+00		1.561E-28	3.140E-12	7.021E-12	223.61%
Sm146	1.059E-02	3.470E-07	9.040E-07	3.472E-03	1.036E-02	6.366E-03	5.132E-03	4.776E-03	93.08%
Sm147	2.632E+02	2.192E+02	2.472E+02	3.168E+02	2.474E+02	2.485E+02	2.571E+02	3.256E+01	12.67%
Sm148	1.524E+02	1.667E+02	1.593E+02	1.657E+02	1.438E+02	1.380E+02	1.543E+02	1.173E+01	7.60%
Sm149	4.350E+00	5.473E+00	2.915E+00	7.747E+00	4.975E+00	4.995E+00	5.076E+00	1.582E+00	31.16%
Sm150	3.591E+02	3.496E+02	2.704E+02	3.838E+02	3.586E+02	3.622E+02	3.473E+02	3.935E+01	11.33%
Sm151	1.492E+00	2.207E+00	1.358E+00	2.797E+00	2.049E+00	2.009E+00	1.985E+00	5.195E-01	26.17%
Sm152	1.427E+02	1.958E+02	1.379E+02	1.697E+02	1.737E+02	1.726E+02	1.654E+02	2.162E+01	13.07%
Sm154	7.299E+01	7.544E+01	6.943E+01	7.829E+01	7.334E+01	7.101E+01	7.342E+01	3.154E+00	4.30%
Eu153	1.822E+02	1.906E+02	1.841E+02	2.010E+02	1.880E+02	1.831E+02	1.882E+02	7.048E+00	3.75%
Eu154	1.321E-09	2.088E-09	1.160E-09	1.686E-09	2.176E-09	1.282E-09	1.619E-09	4.353E-10	26.89%
Eu155	5.519E-12	9.653E-18	6.979E-19	7.548E-19	1.696E-18	6.405E-19	9.198E-13	2.253E-12	244.95%
Gd154	4.575E+01	7.043E+01	4.061E+01	5.796E+01	4.189E+01	4.447E+01	5.018E+01	1.169E+01	23.29%
Gd155	1.341E+01	1.618E+01	1.391E+01	1.511E+01	1.546E+01	9.385E+00	1.391E+01	2.438E+00	17.53%
Gd156	1.539E+02	1.454E+02	1.654E+02	1.295E+02	1.587E+02	1.560E+02	1.515E+02	1.259E+01	8.31%
Ho166m	1.779E-02	2.711E-02	7.584E-04	4.266E-04	1.573E-03	6.132E-04	8.046E-03	1.155E-02	143.53%

Table A.12. Trends of relative standard deviation versus cooling time for fission products in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
Se79	5.77%	5.77%	5.78%	5.80%	5.84%
Kr85	5.05%	5.05%	4.94%	4.87%	5.46%
Rb85	3.60%	3.67%	3.82%	3.82%	3.82%
Rb87	4.16%	4.16%	4.16%	4.16%	4.16%
Sr88	3.59%	3.59%	3.59%	3.59%	3.59%
Sr90	4.85%	4.74%	3.95%	3.74%	8.48%
Nb93m	195.47%	189.65%	90.75%	10.19%	7.90%
Mo95	5.98%	6.71%	6.71%	6.71%	6.71%
Mo97	6.35%	6.37%	6.37%	6.37%	6.37%
Tc99	5.97%	5.99%	6.00%	6.01%	5.99%
Ru101	5.06%	5.10%	5.10%	5.10%	5.10%
Ru106	7.75%	8.01%	244.94%	223.22%	223.61%
Rh103	11.26%	11.52%	11.52%	11.52%	11.52%
Pd107	5.51%	5.51%	5.51%	5.51%	5.51%
Ag108m	238.20%	238.30%	239.11%	239.88%	241.83%
Ag109	16.56%	16.55%	16.55%	16.55%	16.55%
Ag110m	27.59%	27.73%	244.95%	223.61%	223.61%
I127	6.15%	6.37%	6.37%	6.37%	6.37%
I129	5.11%	5.20%	5.20%	5.20%	5.20%
Xe130	10.74%	10.76%	10.76%	10.76%	10.76%
Xe131	12.87%	12.84%	12.84%	12.84%	12.84%
Xe132	4.03%	4.06%	4.06%	4.06%	4.06%
Xe134	6.61%	6.63%	6.63%	6.63%	6.63%
Xe136	1.76%	1.76%	1.76%	1.76%	1.76%
Cs133	5.86%	5.96%	5.96%	5.96%	5.96%
Cs134	7.89%	7.92%	8.29%	244.95%	223.61%
Cs135	27.93%	27.91%	27.91%	27.91%	27.91%
Cs137	5.18%	5.18%	5.11%	5.05%	4.94%
Ba136	32.92%	32.55%	32.55%	32.55%	32.55%
Ba138	4.42%	4.42%	4.42%	4.42%	4.42%
La139	5.45%	5.45%	5.45%	5.45%	5.45%
Ce140	3.81%	3.97%	3.97%	3.97%	3.97%
Ce144	7.43%	7.40%	244.95%	223.45%	223.61%
Nd142	8.81%	8.78%	8.78%	8.78%	8.78%
Nd143	10.02%	10.11%	10.11%	10.11%	10.11%
Nd144	3.50%	0.54%	0.55%	0.55%	0.55%
Nd145	4.98%	4.98%	4.98%	4.98%	4.98%
Nd146	3.06%	3.05%	3.05%	3.05%	3.05%
Nd148	3.95%	3.95%	3.95%	3.95%	3.95%
Nd150	4.38%	4.38%	4.38%	4.38%	4.38%

Table A.12. Trends of relative standard deviation versus cooling time for fission products in assembly calculation (continued)

	Discharge	5 years	50 years	100 years	300 years
Pm147	14.07%	13.89%	13.85%	149.05%	223.61%
Sm146	94.30%	109.61%	122.73%	122.79%	122.79%
Sm147	7.93%	12.01%	12.40%	12.40%	12.40%
Sm148	7.02%	7.15%	7.15%	7.15%	7.15%
Sm149	41.27%	31.30%	31.30%	31.30%	31.30%
Sm150	11.33%	11.33%	11.33%	11.33%	11.33%
Sm151	26.65%	26.28%	26.21%	26.15%	26.08%
Sm152	13.41%	13.41%	13.42%	13.42%	13.42%
Sm154	4.33%	4.33%	4.33%	4.32%	4.32%
Eu153	3.74%	3.77%	3.77%	3.77%	3.77%
Eu154	22.98%	22.85%	21.87%	21.23%	26.50%
Eu155	16.46%	17.06%	28.08%	43.31%	244.95%
Gd154	15.16%	21.85%	22.49%	22.48%	22.47%
Gd155	31.58%	16.10%	16.47%	16.48%	16.48%
Gd156	8.38%	8.15%	8.15%	8.15%	8.15%
Ho166m	144.06%	144.05%	144.05%	144.06%	144.06%

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

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Cl36	1.682E+00	1.598E+00	1.680E+00	1.565E+00	1.551E+00		1.615E+00	6.245E-02	3.87%
Ca41	2.759E-01	2.451E-01	7.950E-01	2.642E-01	2.554E-01		3.671E-01	2.395E-01	65.23%
Mn53	3.382E-05	1.785E-05		N/A	4.455E-08		1.724E-05	1.690E-05	98.02%
Mn54	1.060E-02	1.705E-02	1.243E-02	1.543E-02	1.433E-02		1.397E-02	2.524E-03	18.07%
Fe55	1.164E-01	1.465E-01	1.470E-01	1.276E-01	1.331E-01		1.341E-01	1.301E-02	9.70%
Fe60	1.353E-05	1.209E-04		N/A	1.316E-05		4.920E-05	6.210E-05	126.22%
Co60	1.411E+00	1.314E+00	1.437E+00	1.605E+00	1.385E+00		1.430E+00	1.078E-01	7.54%
Ni59	1.819E+00	1.780E+00	2.417E+00	1.737E+00	1.686E+00		1.888E+00	2.999E-01	15.89%
Ni63	3.603E-01	3.238E-01	3.522E-01	3.378E-01	3.288E-01		3.406E-01	1.543E-02	4.53%
Mo93	7.058E-02	7.557E-02	7.147E-02	0.000E+00	6.784E-02		5.709E-02	3.204E-02	56.11%

Table A.14. Results for activation products in assembly calculation at 5 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Cl36	1.682E+00	1.598E+00	1.680E+00	1.565E+00	1.551E+00		1.615E+00	6.245E-02	3.87%
Ca41	2.758E-01	2.451E-01	7.950E-01	2.642E-01	2.554E-01		3.671E-01	2.395E-01	65.23%
Mn53	3.382E-05	1.785E-05		N/A	4.455E-08		1.724E-05	1.690E-05	98.02%
Mn54	1.836E-04	2.968E-04	2.153E-04	2.676E-04	2.492E-04		2.425E-04	4.425E-05	18.25%
Fe55	3.277E-02	4.059E-02	4.131E-02	3.583E-02	3.743E-02		3.759E-02	3.507E-03	9.33%
Fe60	1.353E-05	1.209E-04		N/A	1.316E-05		4.920E-05	6.210E-05	126.22%
Co60	7.312E-01	6.802E-01	7.442E-01	8.315E-01	7.182E-01		7.411E-01	5.593E-02	7.55%
Ni59	1.819E+00	1.780E+00	2.417E+00	1.737E+00	1.686E+00		1.888E+00	2.999E-01	15.89%
Ni63	3.481E-01	3.128E-01	3.402E-01	3.263E-01	3.176E-01		3.290E-01	1.492E-02	4.53%
Mo93	7.052E-02	7.549E-02	7.140E-02	0.000E+00	6.777E-02		5.704E-02	3.200E-02	56.11%

Table A.15. Results for activation products in assembly calculation at 50 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Cl36	1.681E+00	1.598E+00	1.679E+00	1.565E+00	1.551E+00		1.615E+00	6.192E-02	3.83%
Ca41	2.758E-01	2.450E-01	7.950E-01	2.641E-01	2.554E-01		3.671E-01	2.395E-01	65.25%
Mn53	3.382E-05	1.785E-05		N/A	4.455E-08		1.724E-05	1.690E-05	98.02%
Mn54	2.585E-20	4.348E-20	3.016E-20	3.774E-20	3.623E-20		3.469E-20	6.848E-21	19.74%
Fe55	3.652E-07	3.899E-07	4.507E-07	3.908E-07	4.116E-07		4.016E-07	3.197E-08	7.96%
Fe60	1.353E-05	1.209E-04		N/A	1.316E-05		4.920E-05	6.210E-05	126.22%
Co60	1.968E-03	1.823E-03	2.003E-03	2.235E-03	1.943E-03		1.994E-03	1.506E-04	7.55%
Ni59	1.818E+00	1.779E+00	2.416E+00	1.736E+00	1.685E+00		1.887E+00	2.999E-01	15.90%
Ni63	2.553E-01	2.290E-01	2.491E-01	2.389E-01	2.325E-01		2.410E-01	1.108E-02	4.60%
Mo93	6.997E-02	7.482E-02	7.075E-02	0.000E+00	6.717E-02		5.654E-02	3.173E-02	56.11%

Table A.16. Results for activation products in assembly calculation at 100 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Cl36	1.681E+00	1.598E+00	1.679E+00	1.565E+00	1.551E+00		1.615E+00	6.192E-02	3.83%
Ca41	2.757E-01	2.450E-01	7.943E-01	2.640E-01	2.553E-01		3.669E-01	2.392E-01	65.21%
Mn53	3.382E-05	1.785E-05		N/A	4.455E-08		1.724E-05	1.690E-05	98.02%
Mn54	6.305E-38	1.109E-37	7.116E-38	0.000E+00	0.000E+00		4.902E-38	4.828E-38	98.48%
Fe55	1.146E-12	1.037E-12	1.382E-12	1.198E-12	1.273E-12		1.207E-12	1.301E-13	10.78%
Fe60	1.353E-05	1.209E-04		N/A	1.316E-05		4.920E-05	6.210E-05	126.22%
Co60	2.745E-06	2.530E-06	2.794E-06	3.112E-06	2.725E-06		2.781E-06	2.105E-07	7.57%
Ni59	1.818E+00	1.778E+00	2.415E+00	1.736E+00	1.684E+00		1.886E+00	2.998E-01	15.89%
Ni63	1.809E-01	1.619E-01	1.762E-01	1.691E-01	1.645E-01		1.705E-01	7.946E-03	4.66%
Mo93	6.937E-02	7.409E-02	7.007E-02	0.000E+00	6.651E-02		5.601E-02	3.143E-02	56.11%

Table A.17. Results for activation products in assembly calculation at 300 years (g/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Cl36	1.680E+00	1.597E+00	1.679E+00	1.564E+00	1.550E+00		1.614E+00	6.218E-02	3.85%
Ca41	2.753E-01	2.446E-01	7.935E-01	2.636E-01	2.549E-01		3.664E-01	2.390E-01	65.24%
Mn53	3.381E-05	1.784E-05		N/A	4.455E-08		1.723E-05	1.689E-05	98.02%
Mn54	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		-	-	-
Fe55	1.112E-34	5.196E-35	1.222E-34	0.000E+00	0.000E+00		5.707E-35	5.855E-35	102.59%
Fe60	1.353E-05	1.209E-04		N/A	1.316E-05		4.920E-05	6.210E-05	126.22%
Co60	4.742E-11	8.483E-11	1.057E-17	1.170E-17	4.625E-11		3.570E-11	3.610E-11	101.11%
Ni59	1.814E+00	1.775E+00	2.410E+00	1.732E+00	1.681E+00		1.882E+00	2.991E-01	15.89%
Ni63	4.559E-02	4.049E-02	4.410E-02	4.231E-02	4.115E-02		4.273E-02	2.106E-03	4.93%
Mo93	6.701E-02	7.121E-02	6.734E-02	0.000E+00	6.393E-02		5.390E-02	3.024E-02	56.11%

Table A.18. Trends of relative standard deviation versus cooling time for activation products in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
Cl36	3.87%	3.87%	3.83%	3.83%	3.85%
Ca41	65.23%	65.23%	65.25%	65.21%	65.24%
Mn53	98.02%	98.02%	98.02%	98.02%	98.02%
Mn54	18.07%	18.25%	19.74%	98.48%	-
Fe55	9.70%	9.33%	7.96%	10.78%	102.59%
Fe60	126.22%	126.22%	126.22%	126.22%	126.22%
Co60	7.54%	7.55%	7.55%	7.57%	101.11%
Ni59	15.89%	15.89%	15.90%	15.89%	15.89%
Ni63	4.53%	4.53%	4.60%	4.66%	4.93%
Mo93	56.11%	56.11%	56.11%	56.11%	56.11%

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

		CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
H3	FP	6.217E-02	6.350E-02	1.415E-01	7.441E-02			8.540E-02	3.780E-02	44.27%
	AP	7.249E-02	8.894E-08	4.375E-10	8.361E-07			1.812E-02	3.624E-02	200.00%
	FP + AP	1.347E-01	6.350E-02	1.415E-01	7.441E-02	7.303E-02	7.577E-02	9.382E-02	3.464E-02	36.92%
Be10	FP	1.106E-02	1.132E-02	1.613E-02	1.137E-02			1.247E-02	2.444E-03	19.60%
	AP	1.127E-02	2.799E-08	1.814E-06	1.061E-04			2.844E-03	5.617E-03	197.48%
	FP + AP	2.234E-02	1.132E-02	1.613E-02	1.148E-02	1.652E-04	1.140E-02	1.214E-02	7.280E-03	59.97%
C14	FP	4.441E-03	4.485E-03	8.210E-02	4.836E-02			3.485E-02	3.769E-02	108.16%
	AP	1.075E-01	8.678E-02	1.203E-01	9.084E-02			1.014E-01	1.549E-02	15.28%
	FP + AP	1.119E-01	9.127E-02	2.024E-01	1.392E-01	1.154E-01	4.856E-02	1.181E-01	5.129E-02	43.42%
Zr93	FP	5.757E+02	5.778E+02	5.585E+02	5.612E+02			5.683E+02	9.857E+00	1.73%
	AP	5.796E+02	2.338E-02	2.340E-02	0.000E+00			1.449E+02	2.898E+02	199.98%
	FP + AP	1.155E+03	5.778E+02	5.585E+02	5.612E+02	5.829E+02	5.606E+02	6.660E+02	2.398E+02	36.00%
Nb94	FP	2.293E-03	9.417E-04	1.135E-03	1.685E+00			4.223E-01	8.418E-01	199.31%
	AP	1.383E+00	1.351E+00	1.492E+00	0.000E+00			1.057E+00	7.069E-01	66.91%
	FP + AP	1.385E+00	1.352E+00	1.493E+00	1.685E+00	1.302E+00	1.325E+00	1.424E+00	1.444E-01	10.14%
Sn119m	FP	1.183E+00	1.061E-02	1.451E-01	1.699E+01			4.582E+00	8.288E+00	180.88%
	AP	1.057E+00	6.102E-03	8.971E-02	0.000E+00			2.882E-01	5.142E-01	178.40%
	FP + AP	2.240E+00	1.671E-02	2.348E-01	1.699E+01	4.662E-02	1.625E-01	3.282E+00	6.770E+00	206.28%
Sn121m	FP	9.537E-01	9.222E-01	6.031E-02	1.168E-02			4.870E-01	5.213E-01	107.05%
	AP	9.197E-01	4.405E-04	4.652E-04	0.000E+00			2.302E-01	4.597E-01	199.74%
	FP + AP	1.873E+00	9.226E-01	6.077E-02	1.168E-02	1.119E-02	4.300E-01	5.515E-01	7.380E-01	133.80%

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

		CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Sn126	FP	5.222E+01	6.030E+01	3.849E+01	3.168E+01			4.567E+01	1.296E+01	28.39%
	AP	5.257E+01	5.173E-06	1.441E-05	N/A			1.752E+01	3.035E+01	173.20%
	FP + AP	1.048E+02	6.030E+01	3.849E+01	3.168E+01	4.029E+01	3.160E+01	5.119E+01	2.829E+01	55.26%
Sb125	FP	2.014E+01	2.985E+01	1.331E+01	1.307E+01			1.909E+01	7.885E+00	41.30%
	AP	1.955E+01	2.622E-02	3.959E-02	0.000E+00			4.904E+00	9.764E+00	199.11%
	FP + AP	3.969E+01	2.988E+01	1.335E+01	1.307E+01	1.275E+01	1.297E+01	2.029E+01	1.165E+01	57.45%

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

		CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
H3	FP	4.694E-02	4.794E-02	1.068E-01	5.618E-02			6.447E-02	2.853E-02	44.25%
	AP	5.473E-02	6.714E-08	3.304E-10	6.312E-07			1.368E-02	2.736E-02	200.00%
	FP + AP	1.017E-01	4.794E-02	1.068E-01	5.618E-02	5.514E-02	5.720E-02	7.083E-02	2.614E-02	36.91%
Be10	FP	1.106E-02	1.132E-02	1.613E-02	1.137E-02			1.247E-02	2.444E-03	19.60%
	AP	1.127E-02	2.799E-08	1.814E-06	1.061E-04			2.844E-03	5.617E-03	197.48%
	FP + AP	2.234E-02	1.132E-02	1.613E-02	1.148E-02	1.652E-04	1.140E-02	1.214E-02	7.280E-03	59.97%
C14	FP	4.439E-03	4.482E-03	8.205E-02	4.833E-02			3.483E-02	3.767E-02	108.16%
	AP	1.074E-01	8.672E-02	1.202E-01	9.079E-02			1.013E-01	1.546E-02	15.27%
	FP + AP	1.118E-01	9.120E-02	2.023E-01	1.391E-01	1.153E-01	4.851E-02	1.180E-01	5.127E-02	43.44%
Zr93	FP	5.761E+02	5.783E+02	5.589E+02	5.615E+02			5.687E+02	9.913E+00	1.74%
	AP	5.799E+02	2.338E-02	2.340E-02	0.000E+00			1.450E+02	2.899E+02	199.98%
	FP + AP	1.156E+03	5.783E+02	5.589E+02	5.615E+02	5.834E+02	5.611E+02	6.665E+02	2.400E+02	36.01%
Nb94	FP	2.292E-03	9.415E-04	1.135E-03	1.685E+00			4.223E-01	8.418E-01	199.31%
	AP	1.382E+00	1.351E+00	1.491E+00	0.000E+00			1.056E+00	7.066E-01	66.91%
	FP + AP	1.385E+00	1.352E+00	1.493E+00	1.685E+00	1.302E+00	1.325E+00	1.424E+00	1.444E-01	10.14%
Sn119m	FP	1.573E-02	1.411E-04	1.932E-03	1.714E+01			4.289E+00	8.567E+00	199.72%
	AP	1.406E-02	8.110E-05	1.194E-03	0.000E+00			3.834E-03	6.839E-03	178.39%
	FP + AP	2.978E-02	2.222E-04	3.126E-03	1.714E+01	6.216E-04	2.160E-03	2.863E+00	6.994E+00	244.33%
Sn121m	FP	8.954E-01	8.604E-01	5.662E-02	1.770E-05			4.531E-01	4.913E-01	108.42%
	AP	8.635E-01	4.110E-04	4.367E-04	0.000E+00			2.161E-01	4.316E-01	199.74%
	FP + AP	1.759E+00	8.608E-01	5.706E-02	1.770E-05	1.051E-02	4.039E-01	5.152E-01	6.941E-01	134.72%
Sn126	FP	5.221E+01	6.029E+01	3.849E+01	3.168E+01			4.567E+01	1.296E+01	28.38%
	AP	5.257E+01	5.173E-06	1.441E-05	N/A			1.752E+01	3.035E+01	173.20%
	FP + AP	1.048E+02	6.029E+01	3.849E+01	3.168E+01	4.029E+01	3.160E+01	5.119E+01	2.829E+01	55.26%
Sb125	FP	5.790E+00	8.521E+00	3.790E+00	3.710E+00			5.453E+00	2.261E+00	41.46%
	AP	5.607E+00	7.462E-03	1.140E-02	0.000E+00			1.406E+00	2.800E+00	199.11%
	FP + AP	1.140E+01	8.528E+00	3.801E+00	3.710E+00	3.695E+00	3.682E+00	5.803E+00	3.349E+00	57.72%

**Table A.21. Results for activation-fission products
in assembly calculation at 50 years (g/tHMI)**

		CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
H3	FP	3.740E-03	3.819E-03	8.514E-03	4.476E-03			5.137E-03	2.275E-03	44.29%
	AP	4.361E-03	5.349E-09	2.632E-11	5.030E-08			1.090E-03	2.180E-03	200.00%
	FP + AP	8.101E-03	3.819E-03	8.514E-03	4.476E-03	4.392E-03	4.558E-03	5.643E-03	2.084E-03	36.93%
Be10	FP	1.106E-02	1.132E-02	1.613E-02	1.137E-02			1.247E-02	2.444E-03	19.60%
	AP	1.127E-02	2.799E-08	1.814E-06	1.061E-04			2.844E-03	5.617E-03	197.48%
	FP + AP	2.234E-02	1.132E-02	1.613E-02	1.148E-02	1.652E-04	1.140E-02	1.214E-02	7.280E-03	59.97%
C14	FP	4.414E-03	4.458E-03	8.160E-02	4.807E-02			3.464E-02	3.746E-02	108.16%
	AP	1.068E-01	8.625E-02	1.196E-01	9.029E-02			1.007E-01	1.540E-02	15.29%
	FP + AP	1.112E-01	9.071E-02	2.012E-01	1.384E-01	1.147E-01	4.826E-02	1.174E-01	5.099E-02	43.43%
Zr93	FP	5.761E+02	5.783E+02	5.589E+02	5.615E+02			5.687E+02	9.913E+00	1.74%
	AP	5.799E+02	2.337E-02	2.340E-02	0.000E+00			1.450E+02	2.899E+02	199.98%
	FP + AP	1.156E+03	5.783E+02	5.589E+02	5.615E+02	5.833E+02	5.611E+02	6.665E+02	2.400E+02	36.01%
Nb94	FP	2.289E-03	9.401E-04	1.133E-03	1.683E+00			4.218E-01	8.408E-01	199.31%
	AP	1.380E+00	1.349E+00	1.489E+00	0.000E+00			1.055E+00	7.056E-01	66.91%
	FP + AP	1.382E+00	1.350E+00	1.490E+00	1.683E+00	1.300E+00	1.323E+00	1.421E+00	1.444E-01	10.16%
Sn119m	FP	3.663E-10	1.825E-21	2.540E-20	1.714E+01			4.285E+00	8.570E+00	200.00%
	AP	1.826E-19	1.049E-21	1.570E-20	0.000E+00			4.984E-20	8.880E-20	178.18%
	FP + AP	3.663E-10	2.874E-21	4.110E-20	1.714E+01	8.284E-21	2.803E-20	2.857E+00	6.997E+00	244.95%
Sn121m	FP	5.079E-01	4.611E-01	3.211E-02	1.004E-05			2.503E-01	2.714E-01	108.46%
	AP	4.898E-01	2.203E-04	2.478E-04	0.000E+00			1.226E-01	2.448E-01	199.75%
	FP + AP	9.976E-01	4.613E-01	3.236E-02	1.004E-05	5.961E-03	2.290E-01	2.877E-01	3.911E-01	135.95%
Sn126	FP	5.221E+01	6.027E+01	3.846E+01	3.167E+01			4.565E+01	1.296E+01	28.39%
	AP	5.256E+01	5.171E-06	1.440E-05	N/A			1.752E+01	3.035E+01	173.20%
	FP + AP	1.048E+02	6.027E+01	3.846E+01	3.167E+01	4.028E+01	3.158E+01	5.118E+01	2.830E+01	55.29%
Sb125	FP	7.114E-05	9.219E-05	4.135E-05	4.049E-05			6.129E-05	2.505E-05	40.86%
	AP	6.887E-05	8.073E-08	1.245E-07	0.000E+00			1.727E-05	3.440E-05	199.21%
	FP + AP	1.400E-04	9.227E-05	4.148E-05	4.049E-05	4.792E-05	4.017E-05	6.706E-05	4.100E-05	61.15%

**Table A.22. Results for activation-fission products
in assembly calculation at 100 years (g/tHMI)**

		CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
H3	FP	2.250E-04	2.297E-04	5.121E-04	2.693E-04			3.090E-04	1.368E-04	44.28%
	AP	2.624E-04	3.217E-10	1.583E-12	3.026E-09			6.560E-05	1.312E-04	200.00%
	FP + AP	4.874E-04	2.297E-04	5.121E-04	2.693E-04	2.641E-04	2.741E-04	3.395E-04	1.254E-04	36.94%
Be10	FP	1.106E-02	1.132E-02	1.613E-02	1.137E-02			1.247E-02	2.444E-03	19.60%
	AP	1.127E-02	2.799E-08	1.814E-06	1.061E-04			2.844E-03	5.617E-03	197.48%
	FP + AP	2.234E-02	1.132E-02	1.613E-02	1.148E-02	1.652E-04	1.140E-02	1.214E-02	7.280E-03	59.97%
C14	FP	4.388E-03	4.431E-03	8.110E-02	4.778E-02			3.442E-02	3.723E-02	108.16%
	AP	1.062E-01	8.573E-02	1.189E-01	8.974E-02			1.001E-01	1.532E-02	15.30%
	FP + AP	1.106E-01	9.016E-02	2.000E-01	1.375E-01	1.140E-01	4.797E-02	1.167E-01	5.068E-02	43.43%
Zr93	FP	5.761E+02	5.782E+02	5.589E+02	5.615E+02			5.687E+02	9.881E+00	1.74%
	AP	5.799E+02	2.337E-02	2.340E-02	0.000E+00			1.450E+02	2.899E+02	199.98%
	FP + AP	1.156E+03	5.782E+02	5.589E+02	5.615E+02	5.833E+02	5.611E+02	6.665E+02	2.400E+02	36.01%
Nb94	FP	2.285E-03	9.385E-04	1.131E-03	1.680E+00			4.211E-01	8.393E-01	199.31%
	AP	1.378E+00	1.347E+00	1.487E+00	0.000E+00			1.053E+00	7.046E-01	66.91%
	FP + AP	1.380E+00	1.348E+00	1.488E+00	1.680E+00	1.298E+00	1.321E+00	1.419E+00	1.440E-01	10.15%
Sn119m	FP	5.348E-11	3.138E-40	0.000E+00	1.714E+01			4.285E+00	8.570E+00	200.00%
	AP	3.154E-38	1.804E-40	0.000E+00	0.000E+00			7.930E-39	1.574E-38	198.49%
	FP + AP	5.348E-11	4.942E-40	0.000E+00	1.714E+01		1.665E-08	3.428E+00	7.665E+00	223.61%
Sn121m	FP	2.705E-01	2.305E-01	1.710E-02	5.346E-06			1.295E-01	1.408E-01	108.71%
	AP	2.608E-01	1.101E-04	1.320E-04	0.000E+00			6.526E-02	1.304E-01	199.75%
	FP + AP	5.313E-01	2.306E-01	1.723E-02	5.346E-06	3.176E-03	1.220E-01	1.507E-01	2.071E-01	137.38%
Sn126	FP	5.220E+01	6.025E+01	3.846E+01	3.165E+01			4.564E+01	1.296E+01	28.39%
	AP	5.256E+01	5.169E-06	1.440E-05	N/A			1.752E+01	3.035E+01	173.20%
	FP + AP	1.048E+02	6.025E+01	3.846E+01	3.165E+01	4.028E+01	3.158E+01	5.117E+01	2.830E+01	55.30%
Sb125	FP	1.410E-09	2.800E-10	1.268E-10	1.241E-10			4.852E-10	6.208E-10	127.94%
	AP	2.409E-10	2.452E-13	3.816E-13	0.000E+00			6.038E-11	1.203E-10	199.31%
	FP + AP	1.651E-09	2.802E-10	1.272E-10	1.241E-10	1.780E-10	2.617E-07	4.401E-08	1.066E-07	242.33%

**Table A.23. Results for activation-fission products
in assembly calculation at 300 years (g/tHMI)**

		CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
H3	FP	2.947E-09	3.006E-09	6.703E-09	3.524E-09			4.045E-09	1.791E-09	44.27%
	AP	3.436E-09	4.209E-15	2.073E-17	3.961E-14			8.590E-10	1.718E-09	200.00%
	FP + AP	6.383E-09	3.006E-09	6.703E-09	3.524E-09	3.452E-09	3.590E-09	4.443E-09	1.643E-09	36.97%
Be10	FP	1.106E-02	1.131E-02	1.613E-02	1.137E-02			1.247E-02	2.445E-03	19.61%
	AP	1.127E-02	2.799E-08	1.814E-06	1.061E-04			2.844E-03	5.617E-03	197.48%
	FP + AP	2.233E-02	1.131E-02	1.613E-02	1.148E-02	1.652E-04	1.140E-02	1.214E-02	7.278E-03	59.97%
C14	FP	4.282E-03	4.325E-03	7.918E-02	4.664E-02			3.361E-02	3.635E-02	108.17%
	AP	1.036E-01	8.368E-02	1.160E-01	8.760E-02			9.772E-02	1.493E-02	15.27%
	FP + AP	1.079E-01	8.801E-02	1.952E-01	1.342E-01	1.113E-01	4.682E-02	1.139E-01	4.947E-02	43.43%
Zr93	FP	5.760E+02	5.782E+02	5.589E+02	5.615E+02			5.687E+02	9.856E+00	1.73%
	AP	5.798E+02	2.337E-02	2.340E-02	0.000E+00			1.450E+02	2.899E+02	199.98%
	FP + AP	1.156E+03	5.782E+02	5.589E+02	5.615E+02	5.833E+02	5.611E+02	6.665E+02	2.400E+02	36.01%
Nb94	FP	2.269E-03	9.321E-04	1.123E-03	1.668E+00			4.181E-01	8.333E-01	199.31%
	AP	1.368E+00	1.338E+00	1.476E+00	0.000E+00			1.046E+00	6.995E-01	66.91%
	FP + AP	1.371E+00	1.339E+00	1.478E+00	1.668E+00	1.289E+00	1.312E+00	1.410E+00	1.428E-01	10.13%
Sn119m	FP	5.213E-14	-	0.000E+00	1.714E+01			5.713E+00	9.896E+00	173.21%
	AP	0.000E+00	-	0.000E+00	0.000E+00			0.000E+00	0.000E+00	-
	FP + AP	5.213E-14	-	0.000E+00	1.714E+01		0.000E+00	4.285E+00	8.570E+00	200.00%
Sn121m	FP	2.175E-02	1.440E-02	1.376E-03	4.299E-07			9.382E-03	1.049E-02	111.84%
	AP	2.097E-02	6.881E-06	1.061E-05	0.000E+00			5.247E-03	1.048E-02	199.78%
	FP + AP	4.272E-02	1.441E-02	1.387E-03	4.299E-07	2.558E-04	9.807E-03	1.143E-02	1.641E-02	143.60%
Sn126	FP	5.217E+01	6.017E+01	3.842E+01	3.161E+01			4.559E+01	1.295E+01	28.39%
	AP	5.252E+01	5.162E-06	1.438E-05	N/A			1.751E+01	3.032E+01	173.20%
	FP + AP	1.047E+02	6.017E+01	3.842E+01	3.161E+01	4.025E+01	3.153E+01	5.111E+01	2.827E+01	55.31%
Sb125	FP	1.098E-12	2.381E-32	1.121E-32	0.000E+00			2.745E-13	5.490E-13	200.00%
	AP	3.602E-32	2.085E-35	3.374E-35	0.000E+00			9.019E-33	1.800E-32	199.60%
	FP + AP	1.098E-12	2.383E-32	1.125E-32	0.000E+00		4.874E-29	2.196E-13	4.910E-13	223.61%

Table A.24. Trends of relative standard deviation versus cooling time for activation-fission products in assembly calculation

		Discharge	5 years	50 years	100 years	300 years
H3	FP + AP	36.92%	36.91%	36.93%	36.94%	36.97%
Be10	FP + AP	59.97%	59.97%	59.97%	59.97%	59.97%
C14	FP + AP	43.42%	43.44%	43.43%	43.43%	43.43%
Zr93	FP + AP	36.00%	36.01%	36.01%	36.01%	36.01%
Nb94	FP + AP	10.14%	10.14%	10.16%	10.15%	10.13%
Sn119m	FP + AP	206.28%	244.33%	244.95%	223.61%	200.00%
Sn121m	FP + AP	133.80%	134.72%	135.95%	137.38%	143.60%
Sn126	FP + AP	55.26%	55.26%	55.29%	55.30%	55.31%
Sb125	FP + AP	57.45%	57.72%	61.15%	242.33%	223.61%

Table A.25. Results for decay heat in assembly calculation at discharge (W/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Alpha Decay	1.493E+04	3.986E+04	1.460E+04	N/A	2.362E+04		2.326E+04	1.185E+04	50.95%
Beta Decay	1.504E+06	1.466E+06	1.374E+06	N/A	1.718E+06		1.517E+06	1.452E+05	9.57%
Gamma Decay	1.255E+06	1.313E+06	1.338E+06	1.755E+06	1.451E+06		1.4223E+06	1.991E+05	14.00%
Total Decay Heat	2.774E+06	2.818E+06	2.726E+06	3.624E+06	3.383E+06		3.065E+06	4.103E+05	13.38%

Table A.26. Results for decay heat in assembly calculation at 5 years (W/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Alpha Decay	1.517E+03	1.334E+03	1.476E+03	N/A	1.732E+03		1.515E+03	1.647E+02	10.87%
Beta Decay	9.275E+02	9.284E+02	9.543E+02	N/A	9.547E+02		9.412E+02	1.533E+01	1.63%
Gamma Decay	8.545E+02	8.598E+02	8.848E+02	8.984E+02	9.685E+02		8.932E+02	4.577E+01	5.12%
Total Decay Heat	3.299E+03	3.122E+03	3.315E+03	3.593E+03	4.111E+03		3.488E+03	3.869E+02	11.09%

Table A.27. Results for decay heat in assembly calculation at 50 years (W/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Alpha Decay	8.006E+02	7.677E+02	7.946E+02	N/A	1.201E+03		8.910E+02	2.072E+02	23.25%
Beta Decay	1.409E+02	1.436E+02	1.427E+02	N/A	1.289E+02		1.390E+02	6.843E+00	4.92%
Gamma Decay	1.304E+02	1.307E+02	1.335E+02	1.346E+02	1.499E+02		1.358E+02	8.073E+00	5.94%
Total Decay Heat	1.072E+03	1.042E+03	1.071E+03	1.256E+03	1.758E+03		1.240E+03	3.019E+02	24.35%

Table A.28. Results for decay heat in assembly calculation at 100 years (W/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Alpha Decay	5.777E+02	5.718E+02	5.764E+02	N/A	9.518E+02		6.694E+02	1.883E+02	28.12%
Beta Decay	4.489E+01	4.598E+01	4.285E+01	N/A	3.906E+01		4.320E+01	3.047E+00	7.05%
Gamma Decay	4.206E+01	4.191E+01	4.309E+01	4.359E+01	4.982E+01		4.409E+01	3.277E+00	7.43%
Total Decay Heat	6.646E+02	6.597E+02	6.624E+02	8.047E+02	1.255E+03		8.093E+02	2.567E+02	31.72%

Table A.29. Result for decay heat in assembly calculation at 300 years (W/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
Alpha Decay	3.496E+02	3.485E+02	3.492E+02	N/A	5.928E+02		4.100E+02	1.219E+02	29.72%
Beta Decay	2.650E+00	2.659E+00	6.091E-01	N/A	6.544E-01		1.643E+00	1.168E+00	71.08%
Gamma Decay	1.928E+00	1.952E+00	1.990E+00	2.297E+00	3.555E+00		2.344E+00	6.930E-01	29.56%
Total Decay Heat	3.542E+02	3.531E+02	3.518E+02	4.300E+02	7.247E+02		4.428E+02	1.611E+02	36.38%

Table A.30. Trends of relative standard deviation versus cooling time for decay heat in assembly calculation

	Discharge	5 years	50 years	100 years	300 years
Alpha decay	50.95%	10.87%	23.25%	28.12%	29.72%
Beta decay	9.57%	1.63%	4.92%	7.05%	71.08%
Gamma decay	14.00%	5.12%	5.94%	7.43%	29.56%
Total decay heat	13.38%	11.09%	24.35%	31.72%	36.38%

Table A.31. Results for neutron emission rate in assembly calculation at discharge (n/s/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
(α ,n) emission rate	5.034E+08	4.800E+08	4.843E+08	4.83E+08	9.906E+08		5.8815E+08	2.252E+08	38.28%
Spontaneous fission rate	7.221E+09	6.340E+09	7.223E+09	7.65E+09	1.001E+10		7.6889E+09	1.382E+09	17.98%
Total emission rate	7.724E+09	6.820E+09	7.708E+09	8.13E+09	1.100E+10		8.2770E+09	1.596E+09	19.28%

Table A.32. Results for neutron emission rate in assembly calculation at 5 years (n/s/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
(α ,n) emission rate	4.425E+07	3.567E+07	4.264E+07	4.720E+07	5.793E+07		4.554E+07	8.120E+06	17.83%
Spontaneous fission rate	4.248E+09	3.444E+09	4.141E+09	4.558E+09	4.379E+09		4.154E+09	4.263E+08	10.26%
Total emission rate	4.292E+09	3.480E+09	4.184E+09	4.562E+09	4.437E+09		4.191E+09	4.225E+08	10.29%

Table A.33. Results for neutron emission rate in assembly calculation at 50 years (n/s/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
(α ,n) emission rate	2.177E+07	1.908E+07	2.123E+07	2.454E+07	3.828E+07		2.498E+07	7.685E+06	30.77%
Spontaneous fission rate	7.972E+08	6.548E+08	7.841E+08	8.714E+08	8.230E+08		7.861E+08	8.063E+07	10.26%
Total emission rate	8.190E+08	6.739E+08	8.053E+08	8.96E+08	8.612E+08		8.1106E+08	8.460E+07	10.43%

Table A.34. Results for neutron emission rate in assembly calculation at 100 years (n/s/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
(α ,n) emission rate	1.522E+07	1.379E+07	1.487E+07	1.742E+07	2.983E+07		1.823E+07	6.620E+06	36.32%
Spontaneous fission rate	1.651E+08	1.385E+08	1.643E+08	1.929E+08	1.633E+08		1.648E+08	1.926E+07	11.69%
Total emission rate	1.804E+08	1.523E+08	1.792E+08	2.10E+08	1.931E+08		1.8305E+08	2.129E+07	11.63%

Table A.35. Results for neutron emission rate in assembly calculation at 300 years (n/s/tHMI)

	CEA	NNL	KURCHATOV	UNIPI	GRS (KENOREST)	GRS (TRITON)	AVERAGE	SD	RSD
(α ,n) emission rate	9.0459E+06	8.258E+06	8.832E+06	1.01E+07	1.829E+07		1.0913E+07	4.180E+06	38.30%
Spontaneous fission rate	5.5432E+07	4.770E+07	5.540E+07	7.33E+07	4.707E+07		5.5778E+07	1.058E+07	18.97%
Total emission rate	6.4478E+07	5.596E+07	6.423E+07	8.34E+07	6.535E+07		6.6690E+07	1.010E+07	15.15%

Table A.36. Trends of relative standard deviation versus cooling time for neutron emission rate

	Discharge	5 years	50 years	100 years	300 years
(α ,n) emission rate	38.28%	17.83%	30.77%	36.32%	38.30%
Spontaneous fission rate	17.98%	10.26%	10.26%	11.69%	18.97%
Total emission rate	19.28%	10.29%	10.43%	11.63%	15.15%

Appendix B: Tables providing detailed results of L14 fuel

Table B.1. Results for actinides in assembly calculation (g/tHMI)

CEA					
MASSES OF ACTINIDES (g/tHM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
U232	8.7215E-05	3.7136E-04	3.2138E-04	1.9561E-04	2.6854E-05
U233	4.0334E-04	6.1867E-04	4.7445E-03	1.6314E-02	1.3424E-01
U234	2.1956E+01	5.7566E+01	3.2924E+02	5.3748E+02	8.8140E+02
U235	1.1033E+03	1.1055E+03	1.1254E+03	1.1475E+03	1.2356E+03
U236	2.5427E+02	2.6101E+02	3.2238E+02	3.9087E+02	6.6169E+02
U238	9.1878E+05	9.1878E+05	9.1878E+05	9.1878E+05	9.1878E+05
Np236	1.8974E-04	1.8974E-04	1.8970E-04	1.8965E-04	1.8948E-04
Np237	1.2928E+02	1.4139E+02	4.8207E+02	9.7342E+02	2.6459E+03
Pu236	4.2776E-04	1.2789E-04	2.7497E-09	4.2081E-10	4.2041E-10
Pu238	7.7264E+02	9.2207E+02	6.4796E+02	4.3799E+02	9.2034E+01
Pu239	1.5559E+04	1.5649E+04	1.5636E+04	1.5619E+04	1.5545E+04
Pu240	1.2944E+04	1.3003E+04	1.3194E+04	1.3171E+04	1.2903E+04
Pu241	6.5693E+03	5.1581E+03	5.8509E+02	5.2154E+01	5.4874E-02
Pu242	3.2395E+03	3.2397E+03	3.2399E+03	3.2400E+03	3.2397E+03
Pu243	6.3596E-01	1.2127E-12	1.2127E-12	1.2127E-12	1.2127E-12
Pu244	2.6444E-01	2.6446E-01	2.6446E-01	2.6446E-01	2.6446E-01
Am241	4.9701E+02	1.8984E+03	6.1250E+03	6.1584E+03	4.5101E+03
Am242m	1.3543E+01	1.3214E+01	1.0592E+01	8.2838E+00	3.0992E+00
Am243	8.2068E+02	8.2093E+02	8.1747E+02	8.1364E+02	7.9847E+02
Cm242	1.8739E+02	1.1427E-01	2.7839E-02	2.1773E-02	8.1457E-03
Cm243	6.9310E+00	6.1749E+00	2.1832E+00	6.8768E-01	6.7696E-03
Cm244	3.7934E+02	3.1297E+02	5.5327E+01	8.0679E+00	3.6480E-03
Cm245	3.1831E+01	3.1818E+01	3.1701E+01	3.1572E+01	3.1062E+01
Cm246	2.3437E+00	2.3419E+00	2.3266E+00	2.3096E+00	2.2429E+00
Cm247	3.4886E-02	3.4886E-02	3.4886E-02	3.4886E-02	3.4886E-02
Cm248	1.8301E-03	1.8305E-03	1.8305E-03	1.8303E-03	1.8295E-03
Ra226	1.3391E-09	1.6890E-08	4.2208E-06	2.8253E-05	5.1564E-04
Ra228	5.1808E-16	6.0366E-15	1.4140E-13	3.4096E-13	1.5331E-12
Ac227	4.0729E-10	3.3966E-09	3.2700E-08	6.7628E-08	2.1582E-07
Th229	8.8425E-08	9.9280E-08	5.3375E-07	2.6394E-06	5.9039E-05
Th230	1.1222E-04	6.6030E-04	2.5782E-02	8.6777E-02	5.0357E-01
Th232	1.1313E-05	4.8348E-05	4.2564E-04	9.3829E-04	3.9671E-03
Cf252	6.0473E-07	1.6313E-07	1.2335E-12	2.5159E-18	4.3545E-41

Table B.2. Results for actinides in assembly calculation (g/tHMI)

NNL					
MASSES OF ACTINIDES (g/tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
U232	4.762E-04	1.460E-03	1.235E-03	7.514E-04	1.031E-04
U233	7.474E-03	7.682E-03	1.180E-02	2.353E-02	1.438E-01
U234	1.431E+01	5.024E+01	3.252E+02	5.357E+02	8.823E+02
U235	1.036E+03	1.038E+03	1.056E+03	1.076E+03	1.157E+03
U236	2.848E+02	2.911E+02	3.485E+02	4.125E+02	6.660E+02
U238	9.166E+05	9.166E+05	9.166E+05	9.166E+05	9.166E+05
Np236	3.383E-04	3.383E-04	3.382E-04	3.382E-04	3.379E-04
Np237	1.242E+02	1.369E+02	4.844E+02	9.873E+02	2.701E+03
Pu236	1.512E-03	4.580E-04	1.052E-08	7.614E-10	7.606E-10
Pu238	7.568E+02	9.335E+02	6.553E+02	4.424E+02	9.232E+01
Pu239	1.423E+04	1.435E+04	1.434E+04	1.432E+04	1.425E+04
Pu240	1.205E+04	1.212E+04	1.234E+04	1.233E+04	1.208E+04
Pu241	6.759E+03	5.313E+03	6.089E+02	5.492E+01	6.604E-02
Pu242	3.386E+03	3.386E+03	3.386E+03	3.386E+03	3.385E+03
Pu243	8.120E-01	1.361E-12	1.361E-12	1.361E-12	1.361E-12
Pu244	3.394E-01	3.394E-01	3.394E-01	3.394E-01	3.394E-01
Am241	4.754E+02	1.911E+03	6.262E+03	6.305E+03	4.618E+03
Am242m	9.123E+00	8.901E+00	7.135E+00	5.580E+00	2.087E+00
Am243	8.665E+02	8.669E+02	8.632E+02	8.592E+02	8.431E+02
Cm242	2.152E+02	1.146E-01	1.864E-02	1.458E-02	5.437E-03
Cm243	8.153E+00	7.263E+00	2.568E+00	8.087E-01	7.958E-03
Cm244	4.177E+02	3.450E+02	6.156E+01	9.072E+00	4.277E-03
Cm245	3.832E+01	3.831E+01	3.816E+01	3.801E+01	3.739E+01
Cm246	3.336E+00	3.333E+00	3.311E+00	3.287E+00	3.192E+00
Cm247	3.915E-02	3.915E-02	3.915E-02	3.915E-02	3.915E-02
Cm248	2.110E-03	2.111E-03	2.111E-03	2.111E-03	2.110E-03
Ra226	1.216E-09	1.369E-08	4.016E-06	2.760E-05	5.129E-04
Ra228	4.650E-16	6.647E-15	1.574E-13	3.738E-13	1.613E-12
Ac227	2.313E-10	2.510E-09	2.769E-08	5.989E-08	1.987E-07
Th229	8.527E-07	1.014E-06	2.800E-06	6.415E-06	6.969E-05
Th230	9.675E-05	5.404E-04	2.497E-02	8.558E-02	5.025E-01
Th232	1.214E-05	5.404E-05	4.727E-04	1.026E-03	4.168E-03
Cf252	1.303E-06	3.516E-07	2.655E-12	5.409E-18	9.323E-41

Table B.3. Results for actinides in assembly calculation (g/tHMI)

GRS KENOREST					
MASSES OF ACTINIDES (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
U232	9.1920E-05	4.3530E-04	3.7770E-04	2.2850E-04	3.0600E-05
U233	3.4670E-04	5.5960E-04	4.7840E-03	1.6870E-02	1.4120E-01
U234	2.0040E+01	5.7760E+01	3.3820E+02	5.5310E+02	9.0740E+02
U235	9.4730E+02	9.4940E+02	9.6830E+02	9.8930E+02	1.0730E+03
U236	2.4660E+02	2.5290E+02	3.1030E+02	3.7460E+02	6.2920E+02
U238	9.1550E+05	9.1550E+05	9.1550E+05	9.1550E+05	9.1550E+05
Np236	2.0650E-04	2.0650E-04	2.0640E-04	2.0640E-04	2.0620E-04
Np237	1.2750E+02	1.4030E+02	5.0070E+02	1.0220E+03	2.8000E+03
Pu236	5.1630E-04	1.5450E-04	3.1710E-09	3.3710E-10	3.3680E-10
Pu238	7.6950E+02	9.5300E+02	6.6940E+02	4.5230E+02	9.4660E+01
Pu239	1.4770E+04	1.4890E+04	1.4880E+04	1.4860E+04	1.4790E+04
Pu240	1.2050E+04	1.2130E+04	1.2390E+04	1.2380E+04	1.2130E+04
Pu241	7.0190E+03	5.5140E+03	6.2830E+02	5.6290E+01	7.0750E-02
Pu242	3.4460E+03	3.4470E+03	3.4470E+03	3.4470E+03	3.4460E+03
Pu243	8.4020E-01	2.0000E-12	2.0000E-12	2.0000E-12	2.0000E-12
Pu244	3.4840E-01	3.4840E-01	3.4840E-01	3.4840E-01	3.4840E-01
Am241	4.7740E+02	1.9720E+03	6.4920E+03	6.5340E+03	4.7850E+03
Am242m	1.0230E+01	9.9800E+00	8.0000E+00	6.2580E+00	2.3430E+00
Am243	8.9210E+02	8.9250E+02	8.8870E+02	8.8460E+02	8.6810E+02
Cm242	2.2290E+02	1.2100E-01	2.0840E-02	1.6310E-02	6.1040E-03
Cm243	9.4200E+00	8.3630E+00	2.8650E+00	8.7150E-01	7.4600E-03
Cm244	4.8070E+02	3.9710E+02	7.0950E+01	1.0470E+01	4.9640E-03
Cm245	4.1360E+01	4.1340E+01	4.1190E+01	4.1020E+01	4.0360E+01
Cm246	3.5250E+00	3.5220E+00	3.4990E+00	3.4730E+00	3.3730E+00
Cm247	5.6100E-02	5.6100E-02	5.6100E-02	5.6100E-02	5.6100E-02
Cm248	2.6670E-03	2.6680E-03	2.6680E-03	2.6680E-03	2.6670E-03
Ra226	1.2030E-09	1.6100E-08	4.2990E-06	2.8950E-05	5.3030E-04
Ra228	4.8230E-16	5.8310E-15	1.3800E-13	3.3200E-13	1.5420E-12
Ac227	3.9230E-10	3.5120E-09	3.1110E-08	6.1750E-08	1.8990E-07
Th229	1.1050E-07	1.2020E-07	5.4870E-07	2.7110E-06	6.1880E-05
Th230	1.0340E-04	6.4470E-04	2.6390E-02	8.9150E-02	5.1850E-01
Th232	1.0700E-05	4.7010E-05	4.1530E-04	9.1320E-04	3.8340E-03
Cf252	2.0120E-06	5.4320E-07	4.1390E-12	8.5140E-18	

Table B.4. Results for actinides in assembly calculation (g/tHMI)

GRS TRITON					
MASSES OF ACTINIDES (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
U232	1.0446E-04	4.1770E-04	3.6209E-04	2.2033E-04	3.0250E-05
U233	3.0064E-04	5.3388E-04	4.7604E-03	1.6385E-02	1.3369E-01
U234	1.9960E+01	5.3686E+01	3.1181E+02	5.0980E+02	8.3663E+02
U235	9.8323E+02	9.8522E+02	1.0033E+03	1.0233E+03	1.1033E+03
U236	2.5633E+02	2.6278E+02	3.2100E+02	3.8629E+02	6.4448E+02
U238	9.1608E+05	9.1608E+05	9.1608E+05	9.1608E+05	9.1608E+05
Np236	9.9763E-05	9.9763E-05	9.9738E-05	9.9713E-05	9.9589E-05
Np237	1.3679E+02	1.4945E+02	4.8609E+02	9.7231E+02	2.6278E+03
Pu236	4.7641E-04	1.4474E-04	3.3118E-09	2.2393E-10	2.2356E-10
Pu238	7.1126E+02	8.7636E+02	6.1581E+02	4.1633E+02	8.7449E+01
Pu239	1.4076E+04	1.4188E+04	1.4188E+04	1.4176E+04	1.4114E+04
Pu240	1.2232E+04	1.2306E+04	1.2562E+04	1.2550E+04	1.2299E+04
Pu241	6.5131E+03	5.1154E+03	5.8180E+02	5.2023E+01	5.5002E-02
Pu242	3.6134E+03	3.6134E+03	3.6134E+03	3.6134E+03	3.6134E+03
Pu243	9.3842E-01	1.7217E-12	5.4567E-06	1.7217E-12	1.7217E-12
Pu244	1.4722E-01	1.4722E-01	1.4722E-01	1.4722E-01	1.4722E-01
Am241	4.7579E+02	1.8632E+03	6.0550E+03	6.0910E+03	4.4600E+03
Am242m	1.2674E+01	1.2363E+01	9.9105E+00	7.7507E+00	2.8997E+00
Am243	1.0089E+03	1.0094E+03	1.0052E+03	1.0005E+03	9.8187E+02
Cm242	2.0121E+02	1.1781E-01	2.5819E-02	2.0196E-02	7.5545E-03
Cm243	9.0404E+00	8.0064E+00	2.6800E+00	7.9431E-01	6.1308E-03
Cm244	4.6834E+02	3.8753E+02	6.9165E+01	1.0194E+01	4.8088E-03
Cm245	3.1852E+01	3.1839E+01	3.1715E+01	3.1591E+01	3.1082E+01
Cm246	2.9158E+00	2.9146E+00	2.8947E+00	2.8736E+00	2.7904E+00
Cm247	4.9515E-02	4.9515E-02	4.9515E-02	4.9515E-02	4.9515E-02
Cm248	3.1976E-03	3.1988E-03	3.1988E-03	3.1988E-03	3.1976E-03
Ra226	1.3356E-09	1.5640E-08	3.9796E-06	2.6725E-05	4.8907E-04
Ra228	4.5084E-16	5.9247E-15	1.4300E-13	3.4347E-13	1.5864E-12
Ac227	3.1976E-10	3.5799E-09	3.2336E-08	6.4138E-08	1.9650E-07
Th229	1.5566E-07	1.6460E-07	5.9458E-07	2.7147E-06	5.9086E-05
Th230	1.0309E-04	6.0997E-04	2.4354E-02	8.2186E-02	4.7777E-01
Th232	1.0501E-05	4.8262E-05	4.3023E-04	9.4475E-04	3.9461E-03
Cf252	2.8376E-06	7.6526E-07	5.8788E-12	1.1987E-17	1.7105E-36

Table B.5. Results for actinides in assembly calculation (g/tHMI)

KURCHATOV INSTITUT					
MASSES OF ACTINIDES (g/ tHM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
U232	1.3557E-04	1.3815E-04	1.6000E-04	1.8347E-04	2.6962E-04
U233	2.3196E-04	2.3253E-04	2.3775E-04	2.4375E-04	2.6806E-04
U234	2.0859E+01	2.0938E+01	2.1695E+01	2.2566E+01	2.6310E+01
U235	1.0043E+03	1.0043E+03	1.0043E+03	1.0043E+03	1.0043E+03
U236	2.6149E+02	2.6149E+02	2.6166E+02	2.6184E+02	2.6255E+02
U238	9.1600E+05	9.1600E+05	9.1600E+05	9.1600E+05	9.1600E+05
Np236	2.6774E-04	2.6774E-04	2.6774E-04	2.6774E-04	2.6774E-04
Np237	1.3644E+02	1.3765E+02	1.3952E+02	1.3965E+02	1.4019E+02
Pu236	7.6010E-04	7.6099E-04	7.3880E-04	7.1484E-04	6.2565E-04
Pu238	7.6385E+02	7.6878E+02	8.0413E+02	8.3590E+02	9.1152E+02
Pu239	1.4335E+04	1.4420E+04	1.4447E+04	1.4447E+04	1.4447E+04
Pu240	1.2536E+04	1.2536E+04	1.2536E+04	1.2540E+04	1.2549E+04
Pu241	6.5114E+03	6.5069E+03	6.4706E+03	6.4253E+03	6.2576E+03
Pu242	3.6268E+03	3.6268E+03	3.6268E+03	3.6268E+03	3.6268E+03
Pu243	8.2376E-01	4.2353E-08	1.7910E-12	1.7910E-12	1.7910E-12
Pu244	1.2859E-01	1.2859E-01	1.2859E-01	1.2859E-01	1.2859E-01
Am241	4.3165E+02	4.3595E+02	4.7442E+02	5.1747E+02	6.8512E+02
Am242m	9.3549E+00	9.3549E+00	9.3503E+00	9.3412E+00	9.3185E+00
Am243	9.2565E+02	9.2610E+02	9.2610E+02	9.2610E+02	9.2610E+02
Cm242	2.1408E+02	2.1044E+02	1.7377E+02	1.4046E+02	5.9970E+01
Cm243	8.5757E+00	8.5712E+00	8.5483E+00	8.5163E+00	8.4067E+00
Cm244	4.4743E+02	4.4812E+02	4.4601E+02	4.4367E+02	4.3450E+02
Cm245	3.9625E+01	3.9625E+01	3.9625E+01	3.9620E+01	3.9620E+01
Cm246	3.5064E+00	3.5064E+00	3.5064E+00	3.5064E+00	3.5059E+00
Cm247	5.0249E-02	5.0249E-02	5.0249E-02	5.0249E-02	5.0249E-02
Cm248	4.6218E-03	4.6218E-03	4.6223E-03	4.6223E-03	4.6228E-03
Ra226	1.2930E-09	1.3062E-09	1.4282E-09	1.5735E-09	2.2653E-09
Ra228	4.9513E-16	5.0113E-16	5.6029E-16	6.3102E-16	9.6282E-16
Ac227	3.8229E-10	3.9069E-10	4.6607E-10	5.5015E-10	8.8561E-10
Th229	1.2973E-07	1.2973E-07	1.2986E-07	1.2999E-07	1.3059E-07
Th230	1.0534E-04	1.0612E-04	1.1343E-04	1.2182E-04	1.5888E-04
Th232	1.1346E-05	1.1446E-05	1.2384E-05	1.3426E-05	1.7605E-05
Cf252	4.5694E-06	4.5533E-06	4.4088E-06	4.2534E-06	3.6848E-06

Table B.6. Results for actinides in assembly calculation (g/tHMI)

UNIPI					
MASSES OF ACTINIDES (grams/THM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
U232	2.2340E-04	1.0080E-03	8.8230E-04	5.3710E-04	7.3730E-05
U233	5.3870E-04	8.0630E-04	5.4530E-03	1.7930E-02	1.4280E-01
U234	2.0540E+01	5.5000E+01	3.1860E+02	5.2080E+02	8.5470E+02
U235	1.0150E+03	1.0170E+03	1.0370E+03	1.0590E+03	1.1450E+03
U236	2.7280E+02	2.7940E+02	3.3880E+02	4.0530E+02	6.6860E+02
U238	9.1470E+05	9.1470E+05	9.1470E+05	9.1470E+05	9.1470E+05
Np236	3.2000E-04	3.2000E-04	3.1990E-04	3.1980E-04	3.1940E-04
Np237	1.5730E+02	1.7090E+02	5.2670E+02	1.0410E+03	2.7910E+03
Pu236	1.1900E-03	3.6190E-04	8.4360E-09	7.1790E-10	7.1700E-10
Pu238	7.2960E+02	8.9490E+02	6.2900E+02	4.2520E+02	8.9410E+01
Pu239	1.5210E+04	1.5340E+04	1.5330E+04	1.5310E+04	1.5240E+04
Pu240	1.2450E+04	1.2530E+04	1.2810E+04	1.2800E+04	1.2540E+04
Pu241	6.8970E+03	5.4170E+03	6.1610E+02	5.5110E+01	8.5860E-02
Pu242	3.3460E+03	3.3460E+03	3.3460E+03	3.3460E+03	3.3460E+03
Pu243	9.4010E-01	2.7710E-12	2.7710E-12	2.7710E-12	2.7710E-12
Pu244	1.5130E-01	1.5130E-01	1.5130E-01	1.5130E-01	1.5130E-01
Am241	4.9310E+02	1.9630E+03	6.4020E+03	6.4410E+03	4.7160E+03
Am242m	1.3570E+01	1.3240E+01	1.0620E+01	8.3040E+00	3.1060E+00
Am243	9.6170E+02	9.6220E+02	9.5810E+02	9.5360E+02	9.3590E+02
Cm242	2.0210E+02	1.2050E-01	2.7660E-02	2.1630E-02	8.0940E-03
Cm243	7.7220E+00	6.8380E+00	2.2890E+00	6.7840E-01	5.2360E-03
Cm244	4.9900E+02	4.1290E+02	7.3690E+01	1.0870E+01	5.1240E-03
Cm245	5.0740E+01	5.0710E+01	5.0530E+01	5.0320E+01	4.9500E+01
Cm246	4.4400E+00	4.4360E+00	4.4070E+00	4.3750E+00	4.2490E+00
Cm247	7.9710E-02	7.9710E-02	7.9710E-02	7.9710E-02	7.9710E-02
Cm248	5.3250E-03	5.3280E-03	5.3290E-03	5.3280E-03	5.3260E-03
Ra226	1.3390E-09	1.5900E-08	4.0680E-06	2.7310E-05	4.9960E-04
Ra228	5.2520E-16	6.4330E-15	1.5170E-13	4.0120E-13	1.6590E-12
Ac227	3.3610E-10	3.7610E-09	3.3710E-08	6.6630E-08	2.0370E-07
Th229	3.1350E-07	3.2790E-07	8.4490E-07	3.1950E-06	6.3640E-05
Th230	1.0290E-04	6.2290E-04	2.4900E-02	8.3970E-02	4.8810E-01
Th232	1.1740E-05	5.1910E-05	4.5640E-04	9.9800E-04	4.1240E-03
Cf252	4.7350E-06	1.2780E-06	9.6550E-12	1.9690E-17	0.0000E+00

Table B.7. Trends of relative standard deviation versus cooling time for actinides masses

Nuclide	RSD				
	Discharge	5 years	50 years	100 years	300 years
U232	81%	77%	74%	67%	105%
U233	187%	168%	70%	51%	49%
U234	14%	29%	45%	47%	47%
U235	5%	5%	5%	6%	7%
U236	5%	5%	10%	15%	27%
U238	0%	0%	0%	0%	0%
Np236	38%	38%	38%	38%	38%
Np237	9%	9%	34%	41%	46%
Pu236	54%	74%	245%	245%	245%
Pu238	3%	7%	10%	33%	147%
Pu239	4%	4%	4%	4%	4%
Pu240	3%	3%	3%	2%	2%
Pu241	3%	9%	151%	233%	245%
Pu242	4%	4%	4%	4%	4%
Pu243	13%	245%	245%	31%	31%
Pu244	44%	44%	44%	44%	44%
Am241	5%	36%	45%	44%	41%
Am242m	18%	18%	15%	19%	72%
Am243	7%	7%	7%	7%	8%
Cm242	6%	244%	245%	245%	245%
Cm243	11%	12%	70%	154%	244%
Cm244	10%	13%	120%	216%	245%
Cm245	18%	18%	18%	18%	18%
Cm246	21%	21%	21%	21%	21%
Cm247	31%	31%	31%	31%	31%
Cm248	43%	43%	43%	43%	43%
Ra226	5%	45%	49%	49%	49%
Ra228	6%	45%	49%	50%	49%
Ac227	19%	45%	49%	49%	49%
Th229	107%	115%	105%	68%	49%
Th230	5%	40%	49%	49%	49%
Th232	5%	37%	48%	48%	49%
Cf252	64%	129%	245%	245%	224%

Table B.8. Results for fission products in assembly calculation (g/tHMI)

CEA					
MASSES OF FISSION PRODUCTS (g/tHM)					
Nuclide	discharge	5 years	50 years	100 years	300 years
Se79	5.2580E+00	5.2580E+00	5.2576E+00	5.2571E+00	5.2552E+00
Kr85	1.6953E+01	1.2286E+01	6.7531E-01	2.6892E-02	6.7630E-08
Rb85	6.4108E+01	6.8801E+01	8.0411E+01	8.1059E+01	8.1086E+01
Rb87	1.4425E+02	1.4426E+02	1.4426E+02	1.4426E+02	1.4426E+02
Sr88	1.9567E+02	1.9572E+02	1.9572E+02	1.9572E+02	1.9572E+02
Sr90	2.9236E+02	2.5920E+02	8.7724E+01	2.6322E+01	2.1335E-01
Nb93m	3.3011E-04	1.4171E-03	5.2953E-03	5.8740E-03	5.9499E-03
Mo95	5.8583E+02	7.0800E+02	7.0800E+02	7.0800E+02	7.0800E+02
Mo97	8.1264E+02	8.1370E+02	8.1370E+02	8.1370E+02	8.1370E+02
Tc99	8.7941E+02	8.8442E+02	8.8429E+02	8.8415E+02	8.8357E+02
Ru101	9.6308E+02	9.6312E+02	9.6312E+02	9.6312E+02	9.6312E+02
Ru106	3.6159E+02	1.2100E+01	1.4793E-07	2.1650E-08	4.6032E-11
Rh103	8.0701E+02	8.8342E+02	8.8342E+02	8.8342E+02	8.8342E+02
Pd107	5.8112E+02	5.8114E+02	5.8114E+02	5.8114E+02	5.8113E+02
Ag108m	9.8532E-04	9.7718E-04	9.0692E-04	8.3476E-04	5.9914E-04
Ag109	2.1414E+02	2.1452E+02	2.1452E+02	2.1452E+02	2.1452E+02
Ag110m	2.4065E+00	1.5152E-02	4.2091E-12	6.2554E-13	5.6829E-15
I127	8.4107E+01	8.7599E+01	8.7599E+01	8.7599E+01	8.7599E+01
I129	2.6232E+02	2.6780E+02	2.6780E+02	2.6780E+02	2.6780E+02
Xe130	6.9347E+00	6.9478E+00	6.9478E+00	6.9478E+00	6.9478E+00
Xe131	5.6329E+02	5.7424E+02	5.7424E+02	5.7424E+02	5.7424E+02
Xe132	1.2563E+03	1.2623E+03	1.2623E+03	1.2623E+03	1.2623E+03
Xe134	1.5309E+03	1.5311E+03	1.5311E+03	1.5311E+03	1.5311E+03
Xe136	2.4104E+03	2.4104E+03	2.4104E+03	2.4104E+03	2.4104E+03
Cs133	1.2873E+03	1.3033E+03	1.3033E+03	1.3033E+03	1.3033E+03
Cs134	1.3199E+02	2.4644E+01	6.7926E-06	2.2722E-11	4.2781E-13
Cs135	6.9447E+02	6.9552E+02	6.9551E+02	6.9550E+02	6.9546E+02
Cs137	1.3945E+03	1.2425E+03	4.3991E+02	1.3878E+02	1.3746E+00
Ba136	3.2075E+01	3.3133E+01	3.3133E+01	3.3133E+01	3.3133E+01
Ba138	1.3800E+03	1.3801E+03	1.3801E+03	1.3801E+03	1.3801E+03
La139	1.3311E+03	1.3312E+03	1.3312E+03	1.3312E+03	1.3312E+03
Ce140	1.2211E+03	1.2528E+03	1.2528E+03	1.2528E+03	1.2528E+03
Ce144	3.6916E+02	4.3479E+00	8.0018E-08	1.1706E-08	2.2492E-11
Nd142	1.2548E+01	1.2589E+01	1.2589E+01	1.2589E+01	1.2589E+01
Nd143	8.6303E+02	8.9016E+02	8.9016E+02	8.9016E+02	8.9016E+02
Nd144	6.9918E+02	1.0640E+03	1.0683E+03	1.0683E+03	1.0683E+03

**Table B.8. Results for fission products in assembly calculation (g/tHMI)
(continued)**

CEA					
MASSES OF FISSION PRODUCTS (g/tHM)					
Nuclide	discharge	5 years	50 years	100 years	300 years
Nd145	6.7369E+02	6.7402E+02	6.7402E+02	6.7402E+02	6.7402E+02
Nd146	6.8410E+02	6.8413E+02	6.8413E+02	6.8413E+02	6.8413E+02
Nd148	4.2192E+02	4.2192E+02	4.2192E+02	4.2192E+02	4.2192E+02
Nd150	2.4837E+02	2.4837E+02	2.4837E+02	2.4837E+02	2.4837E+02
Pm147	2.2245E+02	6.1993E+01	4.2542E-04	2.0628E-08	3.0250E-11
Sm146	8.0153E-03	9.0711E-03	1.0279E-02	1.0283E-02	1.0283E-02
Sm147	7.6393E+01	2.4661E+02	3.0860E+02	3.0860E+02	3.0860E+02
Sm148	1.3673E+02	1.4092E+02	1.4092E+02	1.4092E+02	1.4092E+02
Sm149	4.8265E+00	6.5536E+00	6.5536E+00	6.5536E+00	6.5536E+00
Sm150	3.4776E+02	3.4776E+02	3.4776E+02	3.4776E+02	3.4776E+02
Sm151	2.6593E+01	2.5985E+01	1.8375E+01	1.2502E+01	2.6794E+00
Sm152	1.6704E+02	1.6705E+02	1.6707E+02	1.6707E+02	1.6707E+02
Sm154	7.3001E+01	7.3004E+01	7.3010E+01	7.3010E+01	7.3010E+01
Eu153	1.7947E+02	1.8095E+02	1.8095E+02	1.8095E+02	1.8095E+02
Eu154	4.4693E+01	2.9859E+01	7.9182E-01	1.4028E-02	1.3824E-09
Eu155	1.2659E+01	6.1063E+00	8.6240E-03	5.8811E-06	1.1166E-11
Gd154	2.9971E+00	1.7828E+01	4.6889E+01	4.7667E+01	4.7681E+01
Gd155	1.5757E-01	6.7118E+00	1.2809E+01	1.2818E+01	1.2818E+01
Gd156	9.9551E+01	1.0487E+02	1.0487E+02	1.0487E+02	1.0487E+02
Ho166m	9.5900E-03	9.5624E-03	9.3170E-03	9.0518E-03	8.0642E-03

Table B.9. Results for fission products in assembly calculation (g/tHMI)

NNL					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Se79	4.863E+00	4.862E+00	4.860E+00	4.857E+00	4.847E+00
Kr85	1.814E+01	1.313E+01	7.154E-01	2.821E-02	6.819E-08
Rb85	6.884E+01	7.388E+01	8.629E+01	8.698E+01	8.701E+01
Rb87	1.542E+02	1.542E+02	1.542E+02	1.542E+02	1.542E+02
Sr88	2.108E+02	2.108E+02	2.108E+02	2.108E+02	2.108E+02
Sr90	3.224E+02	2.862E+02	9.805E+01	2.982E+01	2.552E-01
Nb93m	3.188E-04	1.552E-03	6.010E-03	6.696E-03	6.790E-03
Mo95	6.068E+02	7.657E+02	7.657E+02	7.657E+02	7.657E+02
Mo97	8.940E+02	8.954E+02	8.954E+02	8.954E+02	8.954E+02
Tc99	9.668E+02	9.735E+02	9.733E+02	9.732E+02	9.725E+02
Ru101	1.055E+03	1.055E+03	1.055E+03	1.055E+03	1.055E+03
Ru106	4.266E+02	1.370E+01	4.989E-13	5.834E-28	-
Rh103	8.471E+02	9.467E+02	9.467E+02	9.467E+02	9.467E+02
Pd107	6.138E+02	6.139E+02	6.139E+02	6.139E+02	6.138E+02
Ag108m	5.702E-06	5.655E-06	5.248E-06	4.831E-06	3.467E-06
Ag109	1.644E+02	1.649E+02	1.649E+02	1.649E+02	1.649E+02
Ag110m	4.863E+00	3.068E-02	4.854E-22	0.000E+00	-
I127	9.123E+01	9.598E+01	9.598E+01	9.598E+01	9.598E+01
I129	2.938E+02	2.973E+02	2.973E+02	2.973E+02	2.973E+02
Xe130	9.271E+00	9.293E+00	9.293E+00	9.293E+00	9.293E+00
Xe131	5.199E+02	5.347E+02	5.347E+02	5.347E+02	5.347E+02
Xe132	1.486E+03	1.494E+03	1.494E+03	1.494E+03	1.494E+03
Xe134	1.819E+03	1.819E+03	1.819E+03	1.819E+03	1.819E+03
Xe136	2.660E+03	2.660E+03	2.660E+03	2.660E+03	2.660E+03
Cs133	1.417E+03	1.438E+03	1.438E+03	1.438E+03	1.438E+03
Cs134	1.411E+02	2.627E+01	7.070E-06	3.543E-13	2.253E-42
Cs135	7.279E+02	7.292E+02	7.292E+02	7.292E+02	7.291E+02
Cs137	1.526E+03	1.360E+03	4.807E+02	1.514E+02	1.490E+00
Ba136	4.274E+01	4.466E+01	4.466E+01	4.466E+01	4.466E+01
Ba138	1.529E+03	1.529E+03	1.529E+03	1.529E+03	1.529E+03
La139	1.353E+03	1.353E+03	1.353E+03	1.353E+03	1.353E+03
Ce140	1.344E+03	1.391E+03	1.391E+03	1.391E+03	1.391E+03
Ce144	4.360E+02	5.125E+00	2.194E-17	1.104E-36	-
Nd142	1.496E+01	1.502E+01	1.502E+01	1.502E+01	1.502E+01
Nd143	9.447E+02	9.803E+02	9.803E+02	9.803E+02	9.803E+02
Nd144	7.470E+02	1.178E+03	1.183E+03	1.183E+03	1.183E+03

**Table B.9. Results for fission products in assembly calculation (g/tHMI)
(continued)**

NNL					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Nd145	7.436E+02	7.440E+02	7.440E+02	7.440E+02	7.440E+02
Nd146	7.603E+02	7.604E+02	7.604E+02	7.604E+02	7.604E+02
Nd148	4.723E+02	4.723E+02	4.723E+02	4.723E+02	4.723E+02
Nd150	2.749E+02	2.749E+02	2.749E+02	2.749E+02	2.749E+02
Pm147	1.977E+02	5.619E+01	3.844E-04	7.017E-10	7.785E-33
Sm146	2.560E-02	3.548E-02	4.679E-02	4.683E-02	4.683E-02
Sm147	6.775E+01	2.222E+02	2.784E+02	2.784E+02	2.784E+02
Sm148	1.744E+02	1.798E+02	1.798E+02	1.798E+02	1.798E+02
Sm149	5.846E+00	8.475E+00	8.475E+00	8.475E+00	8.475E+00
Sm150	3.760E+02	3.760E+02	3.760E+02	3.760E+02	3.760E+02
Sm151	3.595E+01	3.509E+01	2.469E+01	1.671E+01	3.502E+00
Sm152	2.280E+02	2.281E+02	2.281E+02	2.281E+02	2.281E+02
Sm154	8.322E+01	8.322E+01	8.323E+01	8.323E+01	8.323E+01
Eu153	1.993E+02	2.015E+02	2.015E+02	2.015E+02	2.015E+02
Eu154	6.420E+01	4.291E+01	1.141E+00	2.027E-02	2.022E-09
Eu155	1.954E+01	9.713E+00	1.796E-02	1.650E-05	1.175E-17
Gd154	3.489E+00	2.478E+01	6.654E+01	6.766E+01	6.768E+01
Gd155	1.871E-01	1.002E+01	1.972E+01	1.973E+01	1.973E+01
Gd156	1.212E+02	1.285E+02	1.285E+02	1.285E+02	1.285E+02
Ho166m	2.055E-02	2.049E-02	1.996E-02	1.939E-02	1.728E-02

Table B.10. Results for fission products in assembly calculation (g/tHMI)

GRS KENOREST					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Se79	5.4460E+00	5.4460E+00	5.4460E+00	5.4460E+00	5.4440E+00
Kr85	1.7080E+01	1.2390E+01	6.8360E-01	2.7350E-02	7.0030E-08
Rb85	6.6780E+01	7.1510E+01	8.3210E+01	8.3870E+01	8.3890E+01
Rb87	1.6240E+02	1.6250E+02	1.6250E+02	1.6250E+02	1.6250E+02
Sr88	2.2170E+02	2.2170E+02	2.2170E+02	2.2170E+02	2.2170E+02
Sr90	3.2820E+02	2.9080E+02	9.7940E+01	2.9220E+01	2.3170E-01
Nb93m	3.3700E-01	2.6260E-01	3.1920E-02	8.0090E-03	5.9670E-03
Mo95	6.6040E+02	8.1620E+02	8.1620E+02	8.1620E+02	8.1620E+02
Mo97	9.6390E+02	9.6530E+02	9.6530E+02	9.6530E+02	9.6530E+02
Tc99	1.0080E+03	1.0150E+03	1.0150E+03	1.0150E+03	1.0140E+03
Ru101	1.0190E+03	1.0190E+03	1.0190E+03	1.0190E+03	1.0190E+03
Ru106	4.4250E+02	1.4980E+01	8.7260E-13		
Rh103	7.8360E+02	8.7670E+02	8.7670E+02	8.7670E+02	8.7670E+02
Pd107	6.4970E+02	6.4970E+02	6.4970E+02	6.4970E+02	6.4970E+02
Ag108m	9.8570E-06	9.5910E-06	7.5040E-06	5.7130E-06	1.9190E-06
Ag109	2.4160E+02	2.4210E+02	2.4210E+02	2.4210E+02	2.4210E+02
Ag110m	3.8140E+00	2.4150E-02	3.9550E-22		
I127	8.3940E+01	8.7670E+01	8.7670E+01	8.7670E+01	8.7670E+01
I129	2.8270E+02	2.8620E+02	2.8620E+02	2.8620E+02	2.8620E+02
Xe130	8.8030E+00	8.8200E+00	8.8200E+00	8.8200E+00	8.8200E+00
Xe131	5.6410E+02	5.7790E+02	5.7790E+02	5.7790E+02	5.7790E+02
Xe132	1.4700E+03	1.4780E+03	1.4780E+03	1.4780E+03	1.4780E+03
Xe134	1.8290E+03	1.8290E+03	1.8290E+03	1.8290E+03	1.8290E+03
Xe136	2.7040E+03	2.7040E+03	2.7040E+03	2.7040E+03	2.7040E+03
Cs133	1.3830E+03	1.4030E+03	1.4030E+03	1.4030E+03	1.4030E+03
Cs134	1.8250E+02	3.4020E+01	9.2590E-06	4.6980E-13	
Cs135	7.6100E+02	7.6230E+02	7.6230E+02	7.6230E+02	7.6230E+02
Cs137	1.5540E+03	1.3850E+03	4.9300E+02	1.5640E+02	1.5850E+00
Ba136	4.2550E+01	4.4380E+01	4.4380E+01	4.4380E+01	4.4380E+01
Ba138	1.5370E+03	1.5370E+03	1.5370E+03	1.5370E+03	1.5370E+03
La139	1.4090E+03	1.4100E+03	1.4100E+03	1.4100E+03	1.4100E+03
Ce140	1.4040E+03	1.4460E+03	1.4460E+03	1.4460E+03	1.4460E+03
Ce144	4.4840E+02	5.2810E+00	2.2990E-17		
Nd142	1.5860E+01	1.5920E+01	1.5920E+01	1.5920E+01	1.5920E+01
Nd143	9.4790E+02	9.8300E+02	9.8300E+02	9.8300E+02	9.8300E+02
Nd144	7.5330E+02	1.1960E+03	1.2020E+03	1.2020E+03	1.2020E+03

**Table B.10. Results for fission products in assembly calculation (g/tHMI)
(continued)**

GRS KENOREST					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Nd145	7.3210E+02	7.3250E+02	7.3250E+02	7.3250E+02	7.3250E+02
Nd146	7.7410E+02	7.7410E+02	7.7410E+02	7.7410E+02	7.7410E+02
Nd148	4.6460E+02	4.6460E+02	4.6460E+02	4.6460E+02	4.6460E+02
Nd150	2.7780E+02	2.7780E+02	2.7780E+02	2.7780E+02	2.7780E+02
Pm147	2.2340E+02	6.3040E+01	4.3510E-04	8.0180E-10	
Sm146	1.1530E-02	1.2030E-02	1.2590E-02	1.2590E-02	1.2590E-02
Sm147	6.9580E+01	2.4260E+02	3.0560E+02	3.0560E+02	3.0560E+02
Sm148	1.5370E+02	1.5890E+02	1.5890E+02	1.5890E+02	1.5890E+02
Sm149	5.8520E+00	8.3500E+00	8.3500E+00	8.3500E+00	8.3500E+00
Sm150	3.8640E+02	3.8640E+02	3.8640E+02	3.8640E+02	3.8640E+02
Sm151	3.3910E+01	3.3190E+01	2.3740E+01	1.6360E+01	3.6880E+00
Sm152	2.0030E+02	2.0030E+02	2.0040E+02	2.0040E+02	2.0040E+02
Sm154	8.1310E+01	8.1310E+01	8.1320E+01	8.1320E+01	8.1320E+01
Eu153	2.0330E+02	2.0540E+02	2.0540E+02	2.0540E+02	2.0540E+02
Eu154	4.9830E+01	3.3620E+01	9.7320E-01	1.9010E-02	2.7660E-09
Eu155	1.6950E+01	8.1900E+00	1.1760E-02	8.1470E-06	1.8780E-18
Gd154	2.9300E+00	1.9140E+01	5.1780E+01	5.2730E+01	5.2750E+01
Gd155	1.7240E-01	8.9350E+00	1.7110E+01	1.7130E+01	1.7130E+01
Gd156	1.2410E+02	1.3220E+02	1.3220E+02	1.3220E+02	1.3220E+02
Ho166m	1.1830E-03	1.1790E-03	1.1490E-03	1.1160E-03	9.9450E-04

Table B.11. Results for fission products in assembly calculation (g/tHMI)

GRS TRITON					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Se79	5.1017E+00	5.1017E+00	5.1017E+00	5.1005E+00	5.0980E+00
Kr85	1.7552E+01	1.2711E+01	6.9240E-01	2.7309E-02	6.6049E-08
Rb85	6.7303E+01	7.2181E+01	8.4197E+01	8.4867E+01	8.4892E+01
Rb87	1.6050E+02	1.6050E+02	1.6050E+02	1.6050E+02	1.6050E+02
Sr88	2.1437E+02	2.1437E+02	2.1437E+02	2.1437E+02	2.1437E+02
Sr90	3.3602E+02	2.9704E+02	9.8100E+01	2.8637E+01	2.0804E-01
Nb93m	4.4289E-02	3.7028E-02	1.1143E-02	7.2752E-03	6.7551E-03
Mo95	6.6149E+02	8.1677E+02	8.1677E+02	8.1677E+02	8.1677E+02
Mo97	9.5915E+02	9.6052E+02	9.6052E+02	9.6052E+02	9.6052E+02
Tc99	9.8844E+02	9.9502E+02	9.9477E+02	9.9465E+02	9.9403E+02
Ru101	1.0555E+03	1.0556E+03	1.0556E+03	1.0556E+03	1.0556E+03
Ru106	4.4054E+02	1.4585E+01	1.8682E-06	2.9779E-21	0.0000E+00
Rh103	8.4607E+02	9.4723E+02	9.4723E+02	9.4723E+02	9.4723E+02
Pd107	6.4597E+02	6.4597E+02	6.4597E+02	6.4597E+02	6.4597E+02
Ag108m	2.6539E-06	2.5831E-06	2.0196E-06	1.5380E-06	5.1613E-07
Ag109	2.3088E+02	2.3138E+02	2.3138E+02	2.3138E+02	2.3138E+02
Ag110m	2.4789E+00	1.5616E-02	2.9257E-08	2.8724E-30	0.0000E+00
I127	8.5352E+01	8.9336E+01	8.9336E+01	8.9336E+01	8.9336E+01
I129	2.6949E+02	2.7296E+02	2.7296E+02	2.7296E+02	2.7296E+02
Xe130	9.3308E+00	9.3482E+00	9.3482E+00	9.3482E+00	9.3482E+00
Xe131	5.9259E+02	6.0687E+02	6.0687E+02	6.0687E+02	6.0687E+02
Xe132	1.4784E+03	1.4871E+03	1.4871E+03	1.4871E+03	1.4871E+03
Xe134	1.8731E+03	1.8731E+03	1.8731E+03	1.8731E+03	1.8731E+03
Xe136	2.7979E+03	2.7979E+03	2.7979E+03	2.7979E+03	2.7979E+03
Cs133	1.4300E+03	1.4498E+03	1.4498E+03	1.4498E+03	1.4498E+03
Cs134	1.4995E+02	2.7929E+01	8.7425E-06	4.4227E-13	8.7549E-36
Cs135	7.2901E+02	7.3025E+02	7.3025E+02	7.3025E+02	7.3025E+02
Cs137	1.5764E+03	1.4039E+03	4.9652E+02	1.5640E+02	1.5392E+00
Ba136	5.8924E+01	6.0600E+01	6.0600E+01	6.0600E+01	6.0600E+01
Ba138	1.5442E+03	1.5442E+03	1.5442E+03	1.5442E+03	1.5442E+03
La139	1.4349E+03	1.4349E+03	1.4349E+03	1.4349E+03	1.4349E+03
Ce140	1.4287E+03	1.4697E+03	1.4697E+03	1.4697E+03	1.4697E+03
Ce144	4.4327E+02	5.2122E+00	2.3771E-06	1.2100E-25	0.0000E+00
Nd142	1.6311E+01	1.6373E+01	1.6373E+01	1.6373E+01	1.6373E+01
Nd143	9.3631E+02	9.7045E+02	9.7045E+02	9.7045E+02	9.7045E+02
Nd144	7.6675E+02	1.2048E+03	1.2100E+03	1.2100E+03	1.2100E+03

**Table B.11. Results for fission products in assembly calculation (g/tHMI)
(continued)**

GRS TRITON					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Nd145	7.3559E+02	7.3596E+02	7.3596E+02	7.3596E+02	7.3596E+02
Nd146	7.6762E+02	7.6762E+02	7.6762E+02	7.6762E+02	7.6762E+02
Nd148	4.6362E+02	4.6362E+02	4.6362E+02	4.6362E+02	4.6362E+02
Nd150	2.7755E+02	2.7755E+02	2.7755E+02	2.7755E+02	2.7755E+02
Pm147	2.2319E+02	6.2946E+01	4.3085E-04	7.8946E-10	1.5566E-29
Sm146	7.1735E-03	7.4900E-03	7.8500E-03	7.8512E-03	7.8512E-03
Sm147	7.1834E+01	2.4466E+02	3.0759E+02	3.0759E+02	3.0759E+02
Sm148	1.4486E+02	1.4982E+02	1.4982E+02	1.4982E+02	1.4982E+02
Sm149	5.4381E+00	7.9679E+00	7.9679E+00	7.9679E+00	7.9679E+00
Sm150	3.8964E+02	3.8964E+02	3.8964E+02	3.8964E+02	3.8964E+02
Sm151	3.3366E+01	3.2609E+01	2.3063E+01	1.5690E+01	3.3627E+00
Sm152	2.0270E+02	2.0270E+02	2.0283E+02	2.0283E+02	2.0283E+02
Sm154	7.8574E+01	7.8586E+01	7.8586E+01	7.8586E+01	7.8586E+01
Eu153	1.9426E+02	1.9625E+02	1.9625E+02	1.9625E+02	1.9625E+02
Eu154	4.9515E+01	3.3081E+01	8.7673E-01	1.5529E-02	1.5268E-09
Eu155	1.0339E+01	4.9304E+00	6.2847E-03	3.8207E-06	5.3835E-19
Gd154	2.9977E+00	1.9426E+01	5.1626E+01	5.2482E+01	5.2494E+01
Gd155	1.0453E-01	5.5138E+00	1.0439E+01	1.0446E+01	1.0446E+01
Gd156	1.2438E+02	1.3245E+02	1.3245E+02	1.3245E+02	1.3245E+02
Ho166m	4.9081E-04	4.8932E-04	4.7678E-04	4.6325E-04	4.1273E-04

Table B.12. Results for fission products in assembly calculation (g/tHMI)

KURCHATOV INSTITUT					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Se79	5.2136E+00	5.2136E+00	5.2136E+00	5.2136E+00	5.2136E+00
Kr85	1.7260E+01	1.2466E+01	6.7922E-01	2.6849E-02	6.4725E-08
Rb85	6.9200E+01	7.3995E+01	8.5821E+01	8.6460E+01	8.6460E+01
Rb87	1.6030E+02	1.6030E+02	1.6030E+02	1.6030E+02	1.6030E+02
Sr88	2.1344E+02	2.1344E+02	2.1344E+02	2.1344E+02	2.1344E+02
Sr90	3.2997E+02	2.9105E+02	9.6284E+01	2.8090E+01	2.0475E-01
Nb93m	3.2523E-04	1.5160E-03	5.7528E-03	6.3998E-03	6.4697E-03
Mo95	6.0551E+02	7.6091E+02	7.6091E+02	7.6091E+02	7.6091E+02
Mo97	9.1371E+02	9.1554E+02	9.1554E+02	9.1554E+02	9.1554E+02
Tc99	9.6978E+02	9.7723E+02	9.7723E+02	9.7723E+02	9.7536E+02
Ru101	1.0482E+03	1.0482E+03	1.0482E+03	1.0482E+03	1.0482E+03
Ru106	4.3647E+02	1.4449E+01	6.9157E-13	1.0961E-27	0.0000E+00
Rh103	8.4823E+02	9.4893E+02	9.4893E+02	9.4893E+02	9.4893E+02
Pd107	6.2567E+02	6.2567E+02	6.2567E+02	6.2567E+02	6.2567E+02
Ag108m	8.4473E-06	8.2239E-06	6.4370E-06	4.8937E-06	1.6428E-06
Ag109	2.4798E+02	2.4798E+02	2.4798E+02	2.4798E+02	2.4798E+02
Ag110m	2.9575E+00	1.8552E-02	2.8955E-22	0.0000E+00	0.0000E+00
I127	9.4558E+01	9.9095E+01	9.9095E+01	9.9095E+01	9.9095E+01
I129	2.7165E+02	2.7650E+02	2.7650E+02	2.7650E+02	2.7650E+02
Xe130	7.6260E+00	7.6505E+00	7.6505E+00	7.6505E+00	7.6505E+00
Xe131	5.8867E+02	6.0344E+02	6.0344E+02	6.0344E+02	6.0344E+02
Xe132	1.4246E+03	1.4320E+03	1.4320E+03	1.4320E+03	1.4320E+03
Xe134	1.8568E+03	1.8568E+03	1.8568E+03	1.8568E+03	1.8568E+03
Xe136	2.7616E+03	2.7616E+03	2.7616E+03	2.7616E+03	2.7616E+03
Cs133	1.4079E+03	1.4279E+03	1.4279E+03	1.4279E+03	1.4279E+03
Cs134	1.7283E+02	3.2249E+01	8.6669E-06	4.3586E-13	0.0000E+00
Cs135	7.4624E+02	7.4624E+02	7.4624E+02	7.4624E+02	7.4624E+02
Cs137	1.5687E+03	1.3961E+03	4.9456E+02	1.5558E+02	1.5326E+00
Ba136	3.9123E+01	4.0146E+01	4.0146E+01	4.0146E+01	4.0146E+01
Ba138	1.5360E+03	1.5360E+03	1.5360E+03	1.5360E+03	1.5360E+03
La139	1.4269E+03	1.4269E+03	1.4269E+03	1.4269E+03	1.4269E+03
Ce140	1.3582E+03	1.4030E+03	1.4030E+03	1.4030E+03	1.4030E+03
Ce144	4.4132E+02	5.1983E+00	2.2689E-17	0.0000E+00	0.0000E+00
Nd142	1.6366E+01	1.6420E+01	1.6420E+01	1.6420E+01	1.6420E+01
Nd143	9.4103E+02	9.7598E+02	9.7598E+02	9.7598E+02	9.7598E+02
Nd144	7.5538E+02	1.1913E+03	1.1967E+03	1.1967E+03	1.1967E+03

**Table B.12. Results for fission products in assembly calculation (g/tHMI)
(continued)**

KURCHATOV INSTITUT					
MASSES OF FISSION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Nd-45	7.3609E+02	7.3609E+02	7.3609E+02	7.3609E+02	7.3609E+02
Nd146	7.6038E+02	7.6038E+02	7.6038E+02	7.6038E+02	7.6038E+02
Nd148	4.6471E+02	4.6471E+02	4.6471E+02	4.6471E+02	4.6471E+02
Nd150	2.7582E+02	2.7582E+02	2.7582E+02	2.7582E+02	2.7582E+02
Pm147	2.1890E+02	6.1911E+01	4.2287E-04	7.7388E-10	0.0000E+00
Sm146	1.0486E-06	1.0486E-06	1.0486E-06	1.0486E-06	1.0486E-06
Sm147	7.0202E+01	2.3990E+02	3.0126E+02	3.0126E+02	3.0126E+02
Sm148	1.6696E+02	1.7253E+02	1.7253E+02	1.7253E+02	1.7253E+02
Sm149	3.7540E+00	5.4068E+00	5.4068E+00	5.4068E+00	5.4068E+00
Sm150	3.1305E+02	3.1305E+02	3.1305E+02	3.1305E+02	3.1305E+02
Sm151	2.5921E+01	2.5467E+01	1.8028E+01	1.2265E+01	2.6261E+00
Sm152	1.6919E+02	1.6919E+02	1.6919E+02	1.6919E+02	1.6919E+02
Sm154	7.6730E+01	7.6730E+01	7.6730E+01	7.6730E+01	7.6730E+01
Eu153	1.9907E+02	2.0108E+02	2.0108E+02	2.0108E+02	2.0108E+02
Eu154	4.9513E+01	3.3008E+01	8.7733E-01	1.5520E-02	1.5201E-09
Eu155	1.5387E+01	7.3440E+00	9.3549E-03	5.6829E-06	7.7811E-19
Gd154	3.0403E+00	1.9487E+01	5.1829E+01	5.2698E+01	5.2698E+01
Gd155	1.5242E-01	8.2183E+00	1.5533E+01	1.5533E+01	1.5533E+01
Gd156	1.2759E+02	1.3610E+02	1.3610E+02	1.3610E+02	1.3610E+02
Ho166m	5.7428E-04	5.7428E-04	5.5868E-04	5.4307E-04	4.8377E-04

Table B.13. Results for fission products in assembly calculation (g/tHMI)

UNIPI					
MASSES OF FISSION PRODUCTS (grams/THM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Se79	5.120E+00	5.120E+00	5.119E+00	5.119E+00	5.116E+00
Kr85	1.757E+01	1.272E+01	6.931E-01	2.733E-02	6.612E-08
Rb85	6.734E+01	7.223E+01	8.426E+01	8.492E+01	8.495E+01
Rb87	1.608E+02	1.608E+02	1.608E+02	1.608E+02	1.608E+02
Sr88	2.146E+02	2.146E+02	2.146E+02	2.146E+02	2.146E+02
Sr90	3.365E+02	2.975E+02	9.824E+01	2.868E+01	2.084E-01
Nb93m	2.499E-02	2.147E-02	8.928E-03	7.053E-03	6.796E-03
Mo95	6.665E+02	8.222E+02	8.222E+02	8.222E+02	8.222E+02
Mo97	9.613E+02	9.628E+02	9.628E+02	9.628E+02	9.628E+02
Tc99	9.896E+02	9.960E+02	9.960E+02	9.960E+02	9.950E+02
Ru101	1.051E+03	1.052E+03	1.052E+03	1.052E+03	1.052E+03
Ru106	4.376E+02	1.449E+01	6.931E-13	1.099E-27	0.000E+00
Rh103	8.572E+02	9.588E+02	9.588E+02	9.588E+02	9.588E+02
Pd107	6.403E+02	6.404E+02	6.404E+02	6.404E+02	6.404E+02
Ag108m	2.126E-06	2.069E-06	1.619E-06	1.232E-06	4.135E-07
Ag109	2.297E+02	2.301E+02	2.301E+02	2.301E+02	2.301E+02
Ag110m	2.214E+00	1.394E-02	2.173E-22	0.000E+00	0.000E+00
I127	8.552E+01	8.953E+01	8.953E+01	8.953E+01	8.953E+01
I129	2.699E+02	2.733E+02	2.733E+02	2.733E+02	2.733E+02
Xe130	9.332E+00	9.350E+00	9.350E+00	9.350E+00	9.350E+00
Xe131	6.161E+02	6.307E+02	6.307E+02	6.307E+02	6.307E+02
Xe132	1.455E+03	1.463E+03	1.463E+03	1.463E+03	1.463E+03
Xe134	1.869E+03	1.870E+03	1.870E+03	1.870E+03	1.870E+03
Xe136	2.768E+03	2.768E+03	2.768E+03	2.768E+03	2.768E+03
Cs133	1.408E+03	1.429E+03	1.429E+03	1.429E+03	1.429E+03
Cs134	1.670E+02	3.107E+01	8.366E-06	4.311E-13	3.008E-42
Cs135	7.502E+02	7.515E+02	7.515E+02	7.515E+02	7.514E+02
Cs137	1.572E+03	1.401E+03	4.953E+02	1.560E+02	1.535E+00
Ba136	5.763E+01	5.923E+01	5.923E+01	5.923E+01	5.923E+01
Ba138	1.539E+03	1.539E+03	1.539E+03	1.539E+03	1.539E+03
La139	1.431E+03	1.431E+03	1.431E+03	1.431E+03	1.431E+03
Ce140	1.354E+03	1.396E+03	1.396E+03	1.396E+03	1.396E+03
Ce144	4.424E+02	5.202E+00	2.235E-17	0.000E+00	0.000E+00
Nd142	1.635E+01	1.642E+01	1.642E+01	1.642E+01	1.642E+01
Nd143	9.395E+02	9.752E+02	9.752E+02	9.752E+02	9.752E+02
Nd144	7.563E+02	1.194E+03	1.199E+03	1.199E+03	1.199E+03

**Table B.13. Results for fission products in assembly calculation (g/tHMI)
(continued)**

UNIPI					
MASSES OF FISSION PRODUCTS (grams/THM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Nd145	7.328E+02	7.332E+02	7.332E+02	7.332E+02	7.332E+02
Nd146	7.680E+02	7.680E+02	7.680E+02	7.680E+02	7.680E+02
Nd148	4.655E+02	4.655E+02	4.655E+02	4.655E+02	4.655E+02
Nd150	2.767E+02	2.767E+02	2.767E+02	2.767E+02	2.767E+02
Pm147	2.317E+02	6.524E+01	4.467E-04	8.158E-10	0.000E+00
Sm146	2.911E-03	3.172E-03	3.471E-03	3.472E-03	3.472E-03
Sm147	7.239E+01	2.515E+02	3.168E+02	3.168E+02	3.168E+02
Sm148	1.603E+02	1.657E+02	1.657E+02	1.657E+02	1.657E+02
Sm149	5.444E+00	7.747E+00	7.747E+00	7.747E+00	7.747E+00
Sm150	3.838E+02	3.838E+02	3.838E+02	3.838E+02	3.838E+02
Sm151	2.766E+01	2.713E+01	1.918E+01	1.305E+01	2.797E+00
Sm152	1.696E+02	1.696E+02	1.697E+02	1.697E+02	1.697E+02
Sm154	7.828E+01	7.828E+01	7.829E+01	7.829E+01	7.829E+01
Eu153	1.990E+02	2.010E+02	2.010E+02	2.010E+02	2.010E+02
Eu154	5.468E+01	3.653E+01	9.682E-01	1.714E-02	1.686E-09
Eu155	1.497E+01	7.135E+00	9.096E-03	5.529E-06	7.548E-19
Gd154	3.298E+00	2.144E+01	5.700E+01	5.795E+01	5.796E+01
Gd155	1.530E-01	7.982E+00	1.510E+01	1.511E+01	1.511E+01
Gd156	1.214E+02	1.295E+02	1.295E+02	1.295E+02	1.295E+02
Ho166m	5.073E-04	5.059E-04	4.928E-04	4.788E-04	4.266E-04

Table B.14. Trends of relative standard deviation versus cooling time for FP masses

Nuclide	RSD				
	Discharge	5 years	50 years	100 years	300 years
Se79	4%	4%	4%	4%	4%
Kr85	2%	2%	2%	2%	3%
Rb85	3%	3%	3%	2%	2%
Rb87	4%	4%	4%	4%	4%
Sr88	4%	4%	4%	4%	4%
Sr90	5%	5%	4%	4%	9%
Nb93m	196%	190%	89%	11%	6%
Mo95	6%	6%	6%	6%	6%
Mo97	6%	6%	6%	6%	6%
Tc99	5%	5%	5%	5%	5%
Ru101	4%	4%	4%	4%	4%
Ru106	7%	7%	224%	224%	200%
Rh103	4%	4%	4%	4%	4%
Pd107	4%	4%	4%	4%	4%
Ag108m	237%	237%	238%	239%	241%
Ag109	14%	14%	14%	14%	14%
Ag110m	33%	33%	245%	224%	200%
I127	5%	5%	5%	5%	5%
I129	4%	4%	4%	4%	4%
Xe130	12%	12%	12%	12%	12%
Xe131	6%	6%	6%	6%	6%
Xe132	6%	6%	6%	6%	6%
Xe134	7%	7%	7%	7%	7%
Xe136	5%	5%	5%	5%	5%
Cs133	4%	4%	4%	4%	4%
Cs134	12%	12%	12%	220%	224%
Cs135	3%	3%	3%	3%	3%
Cs137	5%	5%	5%	5%	5%
Ba136	23%	23%	23%	23%	23%
Ba138	4%	4%	4%	4%	4%
La139	3%	3%	3%	3%	3%
Ce140	5%	5%	5%	5%	5%
Ce144	7%	7%	236%	224%	200%
Nd142	10%	10%	10%	10%	10%
Nd143	3%	4%	4%	4%	4%
Nd144	3%	5%	5%	5%	5%
Nd145	4%	4%	4%	4%	4%

Table B.14. Trends of relative standard deviation versus cooling time for FP masses (continued)

RSD					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Nd146	5%	5%	5%	5%	5%
Nd148	4%	4%	4%	4%	4%
Nd150	4%	4%	4%	4%	4%
Pm147	5%	5%	5%	198%	224%
Sm146	98%	113%	125%	126%	126%
Sm147	4%	4%	4%	4%	4%
Sm148	9%	9%	9%	9%	9%
Sm149	15%	16%	16%	16%	16%
Sm150	8%	8%	8%	8%	8%
Sm151	14%	14%	14%	14%	15%
Sm152	13%	13%	13%	13%	13%
Sm154	5%	5%	5%	5%	5%
Eu153	4%	4%	4%	4%	4%
Eu154	13%	13%	13%	14%	28%
Eu155	21%	23%	38%	60%	245%
Gd154	7%	12%	13%	13%	13%
Gd155	18%	20%	21%	21%	21%
Gd156	8%	9%	9%	9%	9%
Ho166m	150%	150%	150%	150%	150%

Table B.15. Results for activation products in assembly calculation (g/tHMI)

CEA					
Masses of Activation Products (g/tHM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Cl36	9.5553E-01	9.5552E-01	9.5542E-01	9.5531E-01	9.5487E-01
Ca41	1.6175E-01	1.6174E-01	1.6169E-01	1.6164E-01	1.6142E-01
Mn53	3.5896E-05	3.5896E-05	3.5896E-05	3.5895E-05	3.5894E-05
Mn54	1.0984E-02	1.9033E-04	2.6795E-20	6.5363E-38	0.0000E+00
Fe55	7.4691E-02	2.1035E-02	2.3441E-07	7.3567E-13	7.1367E-35
Fe60	7.0392E-06	7.0392E-06	7.0391E-06	7.0389E-06	7.0382E-06
Co60	1.0628E+00	5.5068E-01	1.4823E-03	2.0673E-06	2.4671E-11
Ni59	1.0897E+00	1.0896E+00	1.0892E+00	1.0887E+00	1.0867E+00
Ni63	2.1605E-01	2.0873E-01	1.5308E-01	1.0847E-01	2.7343E-02
Mo93	6.6484E-02	6.6427E-02	6.5911E-02	6.5342E-02	6.3116E-02

Table B.16. Results for activation products in assembly calculation (g/tHMI)

NNL					
MASSES OF ACTIVATION PRODUCTS (g/tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
Cl36	8.9076E-01	8.9075E-01	8.9066E-01	8.9055E-01	8.9015E-01
Ca41	1.4355E-01	1.4354E-01	1.4350E-01	1.4345E-01	1.4326E-01
Mn53	1.8336E-05	1.8336E-05	1.8336E-05	1.8336E-05	1.8335E-05
Mn54	1.7805E-02	3.0988E-04	4.5396E-20	1.1574E-37	-
Fe55	1.0240E-01	2.8366E-02	2.7243E-07	7.2477E-13	3.6306E-35
Fe60	7.1911E-05	7.1911E-05	7.1911E-05	7.1910E-05	7.1909E-05
Co60	9.5058E-01	4.9230E-01	1.3193E-03	1.8312E-06	5.0436E-11
Ni59	1.0569E+00	1.0569E+00	1.0565E+00	1.0560E+00	1.0540E+00
Ni63	1.9126E-01	1.8474E-01	1.3525E-01	9.5645E-02	2.3920E-02
Mo93	7.2475E-02	7.2404E-02	7.1761E-02	7.1054E-02	6.8294E-02

Table B.17. Results for activation products in assembly calculation (g/tHMI)

GRS KENOREST					
MASSES OF ACTIVATION PRODUCTS (g/tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
CL 36	8.7120E-01	8.7120E-01	8.7110E-01	8.7100E-01	8.7060E-01
CA 41	1.4950E-01	1.4940E-01	1.4940E-01	1.4930E-01	1.4910E-01
MN 53	4.5760E-08	4.5760E-08	4.5760E-08	4.5760E-08	4.5750E-08
MN 54	1.4940E-02	2.5980E-04	3.7780E-20		
FE 55	8.5680E-02	2.4090E-02	2.6490E-07	8.1930E-13	
FE 60	7.4440E-06	7.4440E-06	7.4440E-06	7.4440E-06	7.4430E-06
CO 60	1.0610E+00	5.4990E-01	1.4870E-03	2.0890E-06	2.6160E-11
NI 59	1.0030E+00	1.0030E+00	1.0020E+00	1.0020E+00	9.9990E-01
NI 63	1.9180E-01	1.8530E-01	1.3570E-01	9.5950E-02	2.4010E-02
MO 93	6.5430E-02	6.5360E-02	6.4780E-02	6.4150E-02	6.1660E-02

Table B.18. Results for activation products in assembly calculation (g/tHMI)

KURCHATOV INSTITUT					
MASSES OF ACTIVATION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Cl36	9.3543E-01	9.3543E-01	9.3543E-01	9.3543E-01	9.3543E-01
Ca41	6.6280E-01	6.6280E-01	6.6280E-01	6.6280E-01	6.6280E-01
Mn53					
Mn54	1.2762E-02	1.2620E-02	1.1422E-02	1.0214E-02	6.5527E-03
Fe55	1.0078E-01	1.0043E-01	9.7340E-02	9.4010E-02	8.1808E-02
Fe60					
Co60	1.0682E+00	1.0663E+00	1.0491E+00	1.0304E+00	9.5889E-01
Ni59	1.4976E+00	1.4976E+00	1.4976E+00	1.4976E+00	1.4976E+00
Ni63	1.9604E-01	1.9604E-01	1.9580E-01	1.9568E-01	1.9485E-01
Mo93	6.7372E-02	6.7372E-02	6.7372E-02	6.7372E-02	6.7355E-02

Table B.19. Results for activation products in assembly calculation (g/tHMI)

UNIPI					
MASSES OF ACTIVATION PRODUCTS (grams/THM)					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Cl36	1.0370E+00	1.0370E+00	1.0370E+00	1.0370E+00	1.0370E+00
Ca41	1.7880E-01	1.7880E-01	1.7870E-01	1.7870E-01	1.7870E-01
Mn53*	N/A	N/A	N/A	N/A	N/A
Mn54	1.5150E-02	2.6260E-04	3.7030E-20	0.0000E+00	0.0000E+00
Fe55	9.4020E-02	2.6420E-02	2.8820E-07	8.8340E-13	0.0000E+00
Fe60*	N/A	N/A	N/A	N/A	N/A
Co60	1.2430E+00	6.4370E-01	1.7300E-03	2.4090E-06	9.0560E-18
Ni59	1.1970E+00	1.1970E+00	1.1970E+00	1.1960E+00	1.1940E+00
Ni63	2.2940E-01	2.2160E-01	1.6230E-01	1.1470E-01	2.8740E-02
Mo93	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Table B.20. Trends of relative standard deviation versus cooling time for AP masses

RSD					
Nuclide	Discharge	5 years	50 years	100 years	300 years
Cl36	8%	8%	8%	8%	8%
Ca41	89%	89%	89%	89%	89%
Mn53	99%	99%	99%	99%	99%
Mn54	21%	173%	185%	167%	146%
Fe55	15%	87%	185%	185%	167%
Fe60	121%	121%	121%	121%	121%
Co60	11%	40%	184%	185%	185%
Ni59	20%	20%	20%	20%	20%
Ni63	10%	9%	18%	39%	121%
Mo93	61%	61%	61%	61%	61%

Table B.21. Results for AP-FP in assembly calculation (g/tHMI)

CEA						
Masses of Fission & Activation Products(g/tHM)						
nuclide		discharge	5 years	50 years	100 years	300 years
H3	FP (fission)	6.3114E-02	4.7650E-02	3.7969E-03	2.2842E-04	2.9919E-09
	AP (activation)	5.3051E-02	4.0052E-02	3.1915E-03	1.9200E-04	2.5148E-09
Be10	FP	1.1738E-02	1.1738E-02	1.1737E-02	1.1737E-02	1.1736E-02
	AP	8.7808E-03	8.7807E-03	8.7806E-03	8.7804E-03	8.7796E-03
C14	FP	4.7089E-03	4.7060E-03	4.6803E-03	4.6520E-03	4.5402E-03
	AP	7.9156E-02	7.9108E-02	7.8676E-02	7.8199E-02	7.6320E-02
Zr93	FP	5.7862E+02	5.7905E+02	5.7904E+02	5.7903E+02	5.7897E+02
	AP	4.4442E+02	4.4472E+02	4.4471E+02	4.4470E+02	4.4466E+02
Nb94	FP	2.5041E-03	2.5037E-03	2.4998E-03	2.4955E-03	2.4782E-03
	AP	1.2223E+00	1.2221E+00	1.2202E+00	1.2181E+00	1.2096E+00
Sn119m	FP	1.2248E+00	1.6285E-02	3.0664E-10	4.4974E-11	1.3956E-13
	AP	9.1721E-01	1.2196E-02	1.5843E-19	2.7365E-38	0.0000E+00
Sn121m	FP	9.6988E-01	9.1065E-01	5.1649E-01	2.7504E-01	2.2119E-02
	AP	6.7348E-01	6.3235E-01	3.5865E-01	1.9099E-01	1.5360E-02
Sn126	FP	5.2870E+01	5.2869E+01	5.2862E+01	5.2854E+01	5.2822E+01
	AP	3.7848E+01	3.7848E+01	3.7843E+01	3.7837E+01	3.7814E+01
Sb125	FP	1.9979E+01	5.7451E+00	7.0579E-05	1.2229E-09	2.8862E-12
	AP	1.4155E+01	4.0668E+00	4.9957E-05	1.7470E-10	2.6129E-32
H3	AP+FP	1.1617E-01	8.7702E-02	6.9884E-03	4.2042E-04	5.5067E-09
Be10	AP+FP	2.0519E-02	2.0519E-02	2.0518E-02	2.0517E-02	2.0516E-02
C14	AP+FP	8.3865E-02	8.3814E-02	8.3356E-02	8.2851E-02	8.0860E-02
Zr93	AP+FP	1.0230E+03	1.0238E+03	1.0238E+03	1.0237E+03	1.0236E+03
Nb94	AP+FP	1.2248E+00	1.2246E+00	1.2227E+00	1.2206E+00	1.2121E+00
Sn119m	AP+FP	2.1420E+00	2.8481E-02	3.0664E-10	4.4974E-11	1.3956E-13
Sn121m	AP+FP	1.6434E+00	1.5430E+00	8.7514E-01	4.6603E-01	3.7479E-02
Sn126	AP+FP	9.0718E+01	9.0717E+01	9.0705E+01	9.0691E+01	9.0636E+01
Sb125	AP+FP	3.4134E+01	9.8119E+00	1.2054E-04	1.3976E-09	2.8862E-12

Table B.22. Results for AP-FP in assembly calculation (g/tHMI)

NNL						
MASSES OF FISSION AND ACTIVATION PRODUCTS (g/ tHM)						
Nuclide		Discharge	5 Years	50 Years	100 Years	300 Years
H3	FP	7.114E-02	5.371E-02	4.279E-03	2.573E-04	3.367E-09
	AP	5.971E-08	4.507E-08	3.591E-09	2.160E-10	2.826E-15
Be10	FP	1.312E-02	1.312E-02	1.312E-02	1.312E-02	1.312E-02
	AP	1.747E-08	1.747E-08	1.747E-08	1.747E-08	1.747E-08
C14	FP	5.223E-03	5.219E-03	5.191E-03	5.160E-03	5.036E-03
	AP	6.927E-02	6.923E-02	6.885E-02	6.844E-02	6.680E-02
Zr93	FP	6.329E+02	6.335E+02	6.335E+02	6.335E+02	6.334E+02
	AP	1.930E-02	1.930E-02	1.930E-02	1.930E-02	1.929E-02
Nb94	FP	1.045E-02	1.045E-02	1.043E-02	1.041E-02	1.034E-02
	AP	1.195E+00	1.194E+00	1.193E+00	1.191E+00	1.182E+00
Sn119m	FP	1.268E-02	1.685E-04	2.180E-21	3.749E-40	-
	AP	5.871E-03	7.803E-05	1.010E-21	1.736E-40	-
Sn121m	FP	1.071E+00	9.991E-01	5.354E-01	2.677E-01	1.673E-02
	AP	4.014E-04	3.746E-04	2.007E-04	1.004E-04	6.271E-06
Sn126	FP	6.784E+01	6.784E+01	6.782E+01	6.780E+01	6.770E+01
	AP	4.400E-06	4.400E-06	4.399E-06	4.397E-06	4.391E-06
Sb125	FP	3.413E+01	9.768E+00	1.057E-04	3.209E-10	2.730E-32
	AP	2.390E-02	6.808E-03	7.365E-08	2.237E-13	1.902E-35
H3	AP+FP	7.114E-02	5.371E-02	4.279E-03	2.573E-04	3.367E-09
Be10	AP+FP	1.312E-02	1.312E-02	1.312E-02	1.312E-02	1.312E-02
C14	AP+FP	7.449E-02	7.445E-02	7.405E-02	7.360E-02	7.184E-02
Zr93	AP+FP	6.330E+02	6.335E+02	6.335E+02	6.335E+02	6.334E+02
Nb94	AP+FP	1.205E+00	1.205E+00	1.203E+00	1.201E+00	1.193E+00
Sn119m	AP+FP	1.855E-02	2.465E-04	3.190E-21	5.485E-40	-
Sn121m	AP+FP	1.071E+00	9.994E-01	5.356E-01	2.678E-01	1.673E-02
Sn126	AP+FP	6.784E+01	6.784E+01	6.782E+01	6.780E+01	6.770E+01
Sb125	AP+FP	3.415E+01	9.775E+00	1.058E-04	3.212E-10	2.731E-32

Table B.23. Results for AP-FP in assembly calculation (g/tHMI)

GRS KENOREST					
MASSES OF FISSION AND ACTIVATION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
H3	0.081	0.06115	0.00487	0.0002929	3.829E-09
Be10	0.0001662	0.0001662	0.0001662	0.0001662	0.0001662
C14	0.09011	0.09006	0.08957	0.08903	0.0869
Zr93	643.8	644.3	644.3	644.3	644.2
Nb94	1.18	1.18	1.178	1.176	1.168
Sn119m	0.05491	0.0007322	9.757E-21	0	0
Sn121m	0.01306	0.01226	0.006956	0.003706	0.0002985
Sn126	46.62	46.61	46.61	46.6	46.57
Sb125	14.95	4.341	0.00005629	2.091E-10	0

Table B.24. Results for AP-FP in assembly calculation (g/tHMI)

GRS TRITON					
MASSES OF FISSION AND ACTIVATION PRODUCTS (g/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
H3	0.08214899	0.06201517	0.0049416	0.00029729	3.8915E-09
Be10	0.01320739	0.01320739	0.01320739	0.01320739	0.01320739
C14	0.0325592	0.03254679	0.0323606	0.0321744	0.0314048
Zr93	618.413837	618.910355	618.910355	618.910355	618.910355
Nb94	1.14944041	1.14931628	1.14757847	1.14559239	1.13777223
Sn119m	0.16136852	0.0021462	1.2202E-09	2.1114E-28	0
Sn121m	0.4976357	0.46722394	0.26501677	0.14113539	0.01134793
Sn126	36.2086142	36.2086142	36.1962013	36.1837883	36.1341365
Sb125	15.1314024	4.30109182	4.6946E-05	1.4399E-10	5.0148E-30

Table B.25. Results for AP-FP in assembly calculation (g/tHMI)

KURCHATOV INSTITUT						
MASSES OF FISSION AND ACTIVATION PRODUCTS (g/ tHM)						
Nuclide		Discharge	5 years	50 years	100 years	300 years
H3	FP	1.4806E-01	1.4795E-01	1.4694E-01	1.4581E-01	1.4141E-01
	AP	1.5951E-10	1.5940E-10	1.5827E-10	1.5709E-10	1.5235E-10
Be10	FP	1.8001E-02	1.8001E-02	1.8001E-02	1.8001E-02	1.8001E-02
	AP	3.1418E-06	3.1418E-06	3.1418E-06	3.1418E-06	3.1418E-06
C14	FP	7.2650E-02	7.2650E-02	7.2650E-02	7.2650E-02	7.2650E-02
	AP	9.2497E-02	9.2497E-02	9.2497E-02	9.2497E-02	9.2471E-02
Zr93	FP	6.1357E+02	6.1410E+02	6.1410E+02	6.1410E+02	6.1410E+02
	AP	1.9094E-02	1.9094E-02	1.9094E-02	1.9094E-02	1.9094E-02
Nb94	FP	1.3326E-03	1.3326E-03	1.3326E-03	1.3326E-03	1.3326E-03
	AP	1.3135E+00	1.3135E+00	1.3135E+00	1.3135E+00	1.3135E+00
Sn119m	FP	1.7054E-01	1.6852E-01	1.5152E-01	1.3463E-01	8.3881E-02
	AP	8.7103E-02	8.6073E-02	7.7392E-02	6.8756E-02	4.2847E-02
Sn121m	FP	7.0617E-02	7.0617E-02	7.0503E-02	7.0389E-02	6.9889E-02
	AP	4.1474E-04	4.1451E-04	4.1405E-04	4.1314E-04	4.1041E-04
Sn126	FP	4.4301E+01	4.4301E+01	4.4301E+01	4.4301E+01	4.4301E+01
	AP	1.2546E-05	1.2546E-05	1.2546E-05	1.2546E-05	1.2546E-05
Sb125	FP	1.5554E+01	1.5570E+01	1.5244E+01	1.4729E+01	1.2818E+01
	AP	3.6499E-02	3.6687E-02	3.6217E-02	3.4995E-02	3.0459E-02
H3	AP+FP	1.4806E-01	1.4795E-01	1.4694E-01	1.4581E-01	1.4141E-01
Be10	AP+FP	1.8004E-02	1.8004E-02	1.8004E-02	1.8004E-02	1.8004E-02
C14	AP+FP	1.6515E-01	1.6515E-01	1.6515E-01	1.6515E-01	1.6512E-01
Zr93	AP+FP	6.1359E+02	6.1412E+02	6.1412E+02	6.1412E+02	6.1412E+02
Nb94	AP+FP	1.3148E+00	1.3148E+00	1.3148E+00	1.3148E+00	1.3148E+00
Sn119m	AP+FP	2.5764E-01	2.5460E-01	2.2891E-01	2.0338E-01	1.2673E-01
Sn121m	AP+FP	7.1031E-02	7.1031E-02	7.0917E-02	7.0802E-02	7.0299E-02
Sn126	AP+FP	4.4301E+01	4.4301E+01	4.4301E+01	4.4301E+01	4.4301E+01
Sb125	AP+FP	1.5590E+01	1.5607E+01	1.5280E+01	1.4764E+01	1.2849E+01

Note: Some of these nuclides, notably ^3H , ^{14}C , $^{121\text{m}}\text{Sn}$ and ^{125}Sb do not show the expected decay behaviour, suggesting that some data in this table have been corrupted. The Kurchatov calculations for rod Q17 show more plausible decay behaviour (see Tables A.19-A.23), suggesting that these anomalies stem from errors in the data processing.

Table B.26. Results for AP-FP in assembly calculation (g/THMI)

UNIPI						
MASSES OF FISSION AND ACTIVATION PRODUCTS (grams/THM)						
nuclide		Discharge	5 years	50 years	100 years	300 years
H3	FP (fission)	8.1790E-02	6.1750E-02	4.9190E-03	2.9590E-04	3.8750E-09
	AP(activation)	7.6310E-07	5.7610E-07	4.5900E-08	2.7610E-09	3.6150E-14
Be10	FP	1.3160E-02	1.3160E-02	1.3160E-02	1.3160E-02	1.3160E-02
	AP	8.6920E-05	8.6920E-05	8.6920E-05	8.6910E-05	8.6910E-05
C14	FP	3.5870E-02	3.5850E-02	3.5650E-02	3.5440E-02	3.4590E-02
	AP	7.6750E-02	7.6700E-02	7.6280E-02	7.5820E-02	7.4010E-02
Zr93	FP	6.1850E+02	6.1900E+02	6.1900E+02	6.1900E+02	6.1900E+02
	AP	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Nb94	FP	1.3900E+00	1.3900E+00	1.3870E+00	1.3850E+00	1.3760E+00
	AP	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sn119m	FP	1.7650E+01	1.7800E+01	1.7800E+01	1.7800E+01	1.7800E+01
	AP	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sn121m	FP	1.6120E-02	2.0390E-05	1.1560E-05	6.1560E-06	4.9500E-07
	AP	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Sn126*	FP	3.6280E+01	3.6280E+01	3.6260E+01	3.6250E+01	3.6200E+01
	AP	N/A	N/A	N/A	N/A	N/A
Sb125	FP	1.5180E+01	4.3150E+00	4.7090E-05	1.4440E-10	0.0000E+00
	AP	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
H3	AP+FP	8.1791E-02	6.1751E-02	4.9190E-03	2.9590E-04	3.8750E-09
Be10	AP+FP	1.3247E-02	1.3247E-02	1.3247E-02	1.3247E-02	1.3247E-02
C14	AP+FP	1.1262E-01	1.1255E-01	1.1193E-01	1.1126E-01	1.0860E-01
Zr93	AP+FP	6.1850E+02	6.1900E+02	6.1900E+02	6.1900E+02	6.1900E+02
Nb94	AP+FP	1.3900E+00	1.3900E+00	1.3870E+00	1.3850E+00	1.3760E+00
Sn119m	AP+FP	1.7650E+01	1.7800E+01	1.7800E+01	1.7800E+01	1.7800E+01
Sn121m	AP+FP	1.6120E-02	2.0390E-05	1.1560E-05	6.1560E-06	4.9500E-07
Sn126	AP+FP	3.6280E+01	3.6280E+01	3.6260E+01	3.6250E+01	3.6200E+01
Sb125	AP+FP	1.5180E+01	4.3150E+00	4.7090E-05	1.4440E-10	0.0000E+00

Table B.27. Trends of relative standard deviation versus cooling time for AP-FP masses

Nuclide		RSD				
		Discharge	5 years	50 years	100 years	300 years
H3	AP+FP	30%	45%	201%	242%	245%
Be10	AP+FP	54%	54%	54%	54%	54%
C14	AP+FP	47%	47%	48%	48%	49%
Zr93	AP+FP	24%	24%	24%	24%	24%
Nb94	AP+FP	7%	7%	7%	7%	7%
Sn119m	AP+FP	208%	240%	241%	242%	222%
Sn121m	AP+FP	122%	123%	120%	114%	119%
Sn126	AP+FP	40%	40%	40%	40%	40%
Sb125	AP+FP	45%	57%	245%	245%	245%

Table B.28. Results for Neutronic emission rate in assembly calculation

CEA DARWIN					
NEUTRON EMISSION RATE (neutrons/s/tHM)					
	discharge	5 years	50 years	100 years	300 years
(alpha, n) emission rate	8.3018E+08	5.0353E+07	3.6079E+07	2.8818E+07	1.7822E+07
Spontaneous Fission emission rate	7.8195E+09	3.5396E+09	6.5972E+08	1.3112E+08	3.9039E+07
Total emission rate	8.6497E+09	3.5900E+09	6.9580E+08	1.5994E+08	5.6860E+07

Table B.29. Results for neutronic emission rate in assembly calculation

NNL					
NEUTRON EMISSION RATE (neutrons/s/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
(α ,n) emission rate	9.075E+08	4.885E+07	3.389E+07	2.678E+07	1.646E+07
Spontaneous Fission emission rate	8.803E+09	3.794E+09	7.174E+08	1.473E+08	4.674E+07
Total emission rate	9.711E+09	3.843E+09	7.513E+08	1.741E+08	6.320E+07

Table B.30. Results for neutronic emission rate in assembly calculation

GRS KENOREST					
NEUTRON EMISSION RATE (neutrons/s/ tHM)					
Nuclide	Discharge	5 Years	50 Years	100 Years	300 Years
(alpha,n)	9.9060E+08	5.7930E+07	3.8280E+07	2.9830E+07	1.8290E+07
spont. Fission (N/s)	1.0010E+10	4.3790E+09	8.2300E+08	1.6330E+08	4.7070E+07
total n emission (N/s)	1.1000E+10	4.4370E+09	8.6120E+08	1.9310E+08	6.5350E+07

Table B.31. Results for neutronic emission rate in assembly calculation

KURCHATOV INSTITUT					
NEUTRON EMISSION RATE (neutrons/ s/ tHM)					
	Discharge	5 years	50 years	100 years	300 years
(α,n) emission rate	9.1803E+08	9.0082E+08	7.5362E+08	6.2002E+08	2.9710E+08
Spontaneous Fission emission rate	9.3628E+09	9.2849E+09	8.5229E+09	7.8265E+09	6.1046E+09
Total emission rate	1.0281E+10	1.0186E+10	9.2765E+09	8.4466E+09	6.4017E+09

Table B.32. Results for neutronic emission rate in assembly calculation

UNIPI					
NEUTRON EMISSION RATE (neutrons/s/THM)					
	Discharge	5 years	50 years	100 years	300 years
(α,n) emission rate	8.5960E+08	5.4800E+07	3.5240E+07	2.7300E+07	1.6840E+07
Spontaneous Fission emission rate	9.6200E+09	4.6630E+09	8.8290E+08	1.8350E+08	6.0300E+07
Total emission rate	9.7060E+09	4.6680E+09	8.8640E+08	1.8620E+08	6.1980E+07

Table B.33. Trends of relative standard deviation versus cooling time for neutronic emission rate

RSD					
	Discharge	5 years	50 years	100 years	300 years
(α,n) emission rate	6%	136%	139%	140%	136%
Spontaneous Fission emission rate	50%	72%	129%	149%	152%
Total emission rate	50%	75%	129%	148%	152%

Table B.34. Results for decay heat in assembly calculation (CEA)

CEA DARWIN					
DECAY HEAT(Watts/tHM)					
	Discharge	5 years	50 years	100 years	300 years
Alpha decay heat	2.45405E+04	1.77916E+03	1.35209E+03	1.09901E+03	6.89135E+02
Beta decay heat	1.45664E+06	9.34590E+02	1.44469E+02	4.77642E+01	4.63714E+00
Gamma decay heat	1.23722E+06	7.88030E+02	1.33582E+02	4.42540E+01	3.20815E+00
Total decay heat	2.71840E+06	3.50178E+03	1.63014E+03	1.19102E+03	6.96981E+02

Table B.35. Results for decay heat in assembly calculation (NNL)

NNL					
DECAY HEAT (Watts/ tHM)					
	Discharge	5 years	50 years	100 years	300 years
Alpha decay heat	5.940E+04	1.866E+03	1.381E+03	1.113E+03	6.943E+02
Beta decay heat	1.844E+06	1.056E+03	1.604E+02	5.300E+01	4.790E+00
Gamma decay heat	1.682E+06	8.969E+02	1.464E+02	4.816E+01	3.394E+00
Total decay heat	3.586E+06	3.819E+03	1.688E+03	1.215E+03	7.025E+02

Table B.36. Results for decay heat in assembly calculation (GRS KENOREST)

GRS KENOREST					
DECAY HEAT (Watts/ tHM)					
	Discharge	5 years	50 years	100 years	300 years
Alpha decay heat (W)	2.2290E+04	1.7870E+03	1.2080E+03	9.4990E+02	5.9030E+02
Beta decay heat (W)	1.5610E+06	9.5960E+02	1.3240E+02	4.0140E+01	6.7090E-01
Gamma decay heat (W)	1.1440E+06	8.9930E+02	1.3250E+02	4.3050E+01	2.0330E+00
Total decay heat (W)	2.6780E+06	3.3430E+03	1.0890E+03	6.8160E+02	3.6380E+02

Table B.37. Results for decay heat in assembly calculation (KURCHATOV)

KURCHATOV INSTITUT					
DECAY HEAT (Watts/ tHM)					
	Discharge	5 years	50 years	100 years	300 years
Alpha decay heat	2.7729E+04	2.7334E+04	2.2916E+04	1.8903E+04	9.2100E+03
Beta decay heat	1.6876E+06	7.2338E+04	2.9722E+04	2.2944E+04	1.3201E+04
Gamma decay heat	1.6735E+06	9.8585E+04	2.5928E+04	1.5195E+04	4.6388E+03
Total decay heat	3.3888E+06	1.9826E+05	7.8567E+04	5.7043E+04	2.7049E+04

Table B.38. Results for decay heat in assembly calculation (UNIP1)

UNIP1					
DECAY HEAT (Watts/THM)					
	Discharge	5 years	50 years	100 years	300 years
Alpha decay heat	N/A	N/A	N/A	N/A	N/A
Beta decay heat	N/A	N/A	N/A	N/A	N/A
Gamma decay heat	1.7550E+06	9.4900E+02	1.5160E+02	5.0010E+01	3.5560E+00
Total decay heat	3.6240E+06	4.1200E+03	1.7490E+03	1.2400E+03	7.2170E+02

Table B.39. Trends of relative standard deviation versus cooling time for decay heat

RSD	Discharge	5 years	50 years	100 years	300 years
Alpha decay heat	48%	113%	115%	104%	9%
Beta decay heat	86%	126%	135%	136%	69%
Gamma decay heat	84%	126%	134%	134%	26%
Total decay heat	84%	122%	128%	125%	33%