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Document Title

Feasability of Burning First and Second Generation Plutonium in Prismatic Blocks HTRs

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0	23-07-2004	First proposal by F. Damian, CEA
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1. INTRODUCTION

The objective of the present report is to provide necessary information for estimating the capability of **plutonium transmutation and incineration in a prismatic block type HTGR**. This will constitute therefore a preliminary evaluation that could be compared to the PBR plutonium burning capacities.

However, it should be stressed that the European calculational methods used in PBR and bloc type HTGR are not at the same level of maturity. If the 3D core burn-up calculations are available for the PBR and largely and commonly used to evaluate the core performances assuming different pebble shuffling modes, those concerning the HTGR block-type appears a little bit immature. They are not so widely used and remain to be validated and qualified. Through the past few years, an important effort has been devoted in France to these validation steps especially as far as the **uranium fuel** is concerned. These validations are essentially based on Monte Carlo comparisons at each level of the calculation scheme (particles, compact, fuel element, 2D and 3D core calculations). A qualification step of this calculation scheme has also been done through the WP1 activities of the present HTR-N contract and this is also true for the others HTR-N partners. Even though core burn-up calculations are being validated on the base of *reference 2D core transport calculations*, this first validation stage for **uranium fuel** has not been carried out for all other sort of fuels containing **plutonium and minor actinides**.

The huge effort associated with these validation and qualification steps could not be planed in the present HTR-N contract. Just as the allocated effort to this WP3 could not allow using such new 3D core calculation scheme for block-type reactors. Indeed, it is noteworthy that to give information such as, cycle length, mass balance, peak power, core flux distribution … for a specific block-type HTGR loaded with plutonium and minor actinides fuels suppose an important optimisation stage of the core: use burnable poison or not, flattening the flux distribution in the annular zone (different filling fraction in the compact close to the reflector, different enrichment, burnable poison in the reflector, …), number of the control rod,… Moreover, this optimisation stage must be based on an equilibrium fuel cycle assuming a specific fuel-reshuffling scheme.

For all these above reasons, simplest methods than 3D core burn-up calculations have been employed for the present study. 2D transport detailed calculations allowed to compute the fuel depletion. Nevertheless, in order to get the fuel element discharged burn-up, the core reactivity was calculated during fuel depletion using a simplified 2D annular core configuration on which also transport calculations have been done. It is important to note that all these calculations have been performed without taking into account temperature feedback. The same 2D annular core configuration was used for the temperature coefficient estimations.

After a brief description of the block-type HTGR used for this plutonium cycle study, the methods are described in detail. Then, some trends and physical analyses are given with respect to the use of burnable poison, both plutonium isotopic compositions and the obtained temperature coefficients.

Finally, all the results corresponding the previously defined common output [xx] have been provided in the present report as far as it was possible. Of course, it turns out that for example it was difficult to give indication on 3D core peak power from such employed methods. Moreover, one must keep in mind that 3D core parameters would have a sense only if core optimisations (conceptual design study) have been done before. That was not the case. Therefore, some indicated results must rather be considered as trends indicator and precaution must be taken in the direct use of these results for HTGR concept comparisons of the plutonium burning capabilities.

2. REFERENCE REACTOR MODEL

The main features of the GT-MHR core [1] are indicated in Table 1 and Figure 1, 2 and 3. The core of the GT-MHR consists of 102 columns of fuel comprising 72 standard element columns and 30 control element columns. The reflector and fuel columns consist of stacks of prismatic blocks with a height of 80 cm and 36.0 cm across opposite sides. The core of the GT-MHR also includes a reflector at the top and the bottom with a height of 130 cm.

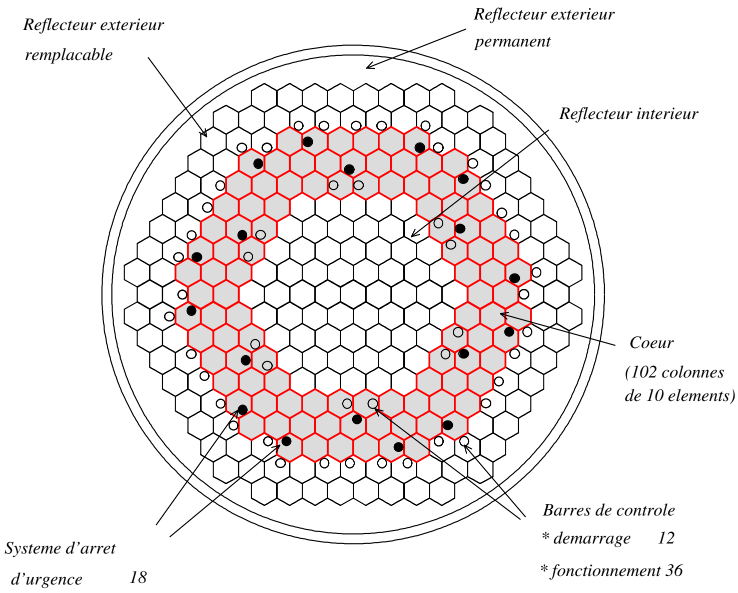

Figure 1: Geometry of the 600 MWth GT-MHR core

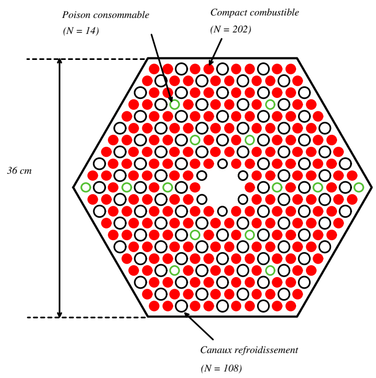

Figure 2: Geometry of a standard fuel element

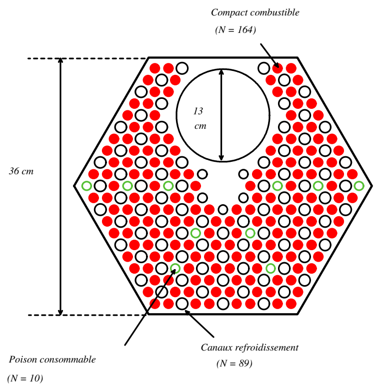

Figure 3: Geometry of a control fuel element

Power	600 MWth
Power density in active zone	6.6 MW/m^3
Inlet/outlet temperature	490 / 850 °C
Height of active zone	8 m
Equivalent diameter of active zone	2.96 / 4.84 m
Height of axial reflectors	1.3 m
Number of columns in the annular core	102
Standard fuel elements	720 (10 per column)
Control fuel elements	300 (10 per column)
Control rods in core	12 (start-up) and 18 (shutdown)
Control rods in reflector	36 (core operation)
Type of fuel loaded into core	PuO_x
Fuel composition	Only one type of particle

Table I - Features of the GT-MHR core

The standard fuel element is *36.0 cm across opposite sides* and has *a total height of 80.0 cm*. The graphite matrix of the element can receive *216 rods* corresponding to the position of the fuel rods or the burnable poison rods.

A fuel rod (or a burnable poison rod) consists of a vertical stack of 15 compacts with a unit height of 4.928 cm. The "active" length of a fuel rod (i.e. that occupied by fuel or burnable poison) is 73.92 cm. The remaining space (i.e. a length of some 6.0 cm divided between the top and the bottom of the element) is occupied by graphite caps. There is therefore no fissile matter in the upper and lower parts.

Furthermore, the number of compacts vertically stacked in the rods is considered to be identical, whatever the radial position of the rod in the fuel element (whether or not the rod is located below an element positioning hole).

Distance between opposite sides [cm]	36
Height of fuel element [cm]	80
Thickness of the helium gap between elements [mm]	1.0
Number of fuel rods	202
Number of burnable poison rods	14
Number of cooling holes	108
Number of compacts stacked in a rod (fuel or burnable poison)	15
Number of fuel compacts per element	3150
Radius of fuel compacts [cm]	0.6225
Radius of burnable poison compacts [cm]	0.6225
Radius of cooling holes [cm]	0.794 (102) 0.635 (6)
Height of a compact [cm]	4.928 cm
Number of burnable poison compacts per element	210
Density of the graphite matrix of the element	1.74
Density of the graphite matrix of a compact	1.74

Table II – Technological data adopted for the standard fuel element modelling

	Material	Density	Outside radius [μm]
Central zone (kernel)	PuO_x	10.0	100
Buffer	Graphite	1.0	200
Pyrocarbon	Graphite	1.8	235
Silicon carbide	SiC	3.2	270
Pyrocarbon	Graphite	1.8	315

Table III - Dimensions and composition of a fuel particle

3. CATEGORIES OF FUEL INVESTIGATED

In this study, two types of plutonium have been analysed. The first one (Pu1) corresponds to a first generation plutonium coming from LWR UOx Fuel [2]. As far as the second generation plutonium is concerned, the composition has been previously defined in [3].

	1st generation	2nd generation
Pu^{238}	2,7	4,90
Pu^{239}	54,5	26,90
Pu^{240}	22,9	34,30
Pu^{241}	11,7	15,30
Pu^{242}	7,0	18,60
Am^{241}	1,20	***
Pu_{fiss}/Pu_{tot}	***66,2***	***42,2***

Table IV – Plutonium vectors

4. CODE AND CALCULATION METHODS

The investigation of fuel cycle studies for block type HTR cores has been performed for *1st generation* and *2nd generation* plutonium based fuel cycles. The core neutronics analysis presented here is essentially based on a specific calculation process employing the **APOLLO2** [4] transport code which is a part of the code system SAPHYR.

The formalism used to solve the multigroup Boltzmann transport equation is either the Integral-Equation (P_{ij}: collision probability 1D and 2D) or Integral-Differential-Equation (S_n: discrete ordinates and nodal methods in 2D). The standard **172-group cross section library** issued mainly from JEF 2.2 is used in the present study. The standard depletion chain consists of **24 heavy nuclei (till Cm^{248}) and 77 fission products.**

Seven of the principal heavy nuclides (Pu^{238} to Pu^{242}, Am^{241} and Am^{243}) are **self shielded** during the fuel evolution. An example of the standard fuel element described with a hexahedral multicell geometry is given in Figure 4.

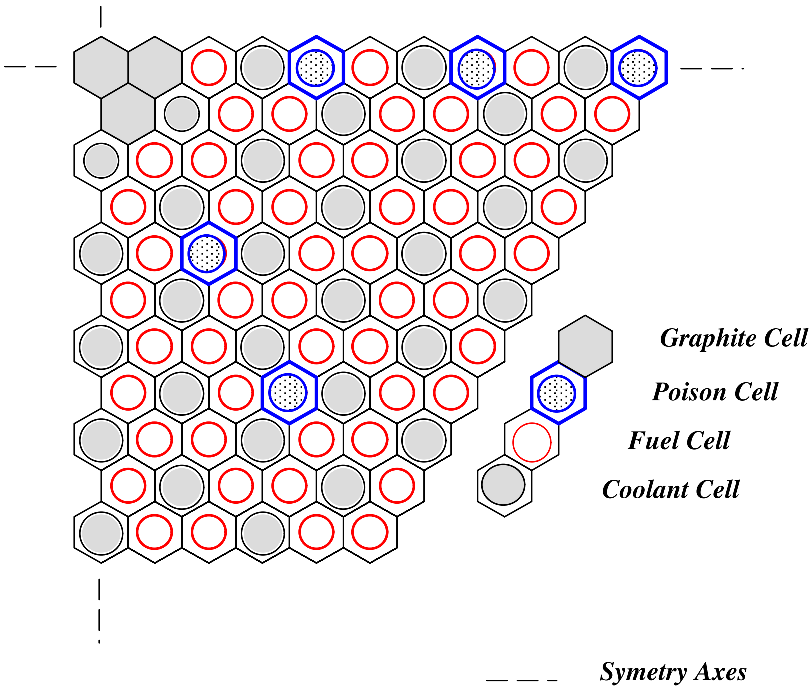

Figure 4: Fuel element modeling in APOLLO2

<u>The calculations have been performed in fundamental mode (critical buckling),</u> considering a linear anisotropic collision hypothesis for the calculation of the graphite diffusion coefficient.

In order to evaluate the fuel element discharged burnup, the core keffective needs to be calculated. The core reactivity during fuel depletion is calculated using a simplified 2D core configuration (Figure 5). Although the calculations are performed using a simplified modelling, it allows to make an accurate calculation of the radial leakage during core depletion. After all, the core volumic leakage (3D leakage) are evaluated using the radial leakage issued from the simplified core calculation and considering a constant axial leakage value (1500 pcm in any cases). For the different fuel types feeding the reactor, the discharged burnup was determined in order to achieve a reactivity margin of 2000 pcm at the end of cycle (k_{eff} = 1.02) embracing the possible uncertainties.

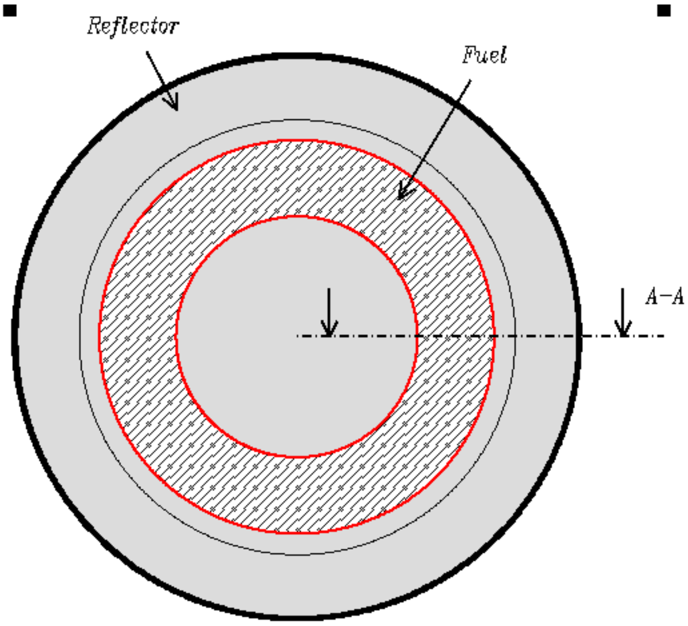

Figure 5: Simplified core geometry used for the core leakage calculation

5. RESULTS AND COMMENTS

5.1. Introduction

As it was said in the previous section, the major part of the results presented hereafter are issued from the fuel element calculation in infinite medium (parameters such as the heavy nuclides concentrations). However, some calculations have been also performed on a simplified 2D core configuration in order to evaluate some physical parameters such as the neutron leakage. From theses calculations, we have also extracted some informations such as the radial flux in the core, the Doppler and moderator temperature coefficient… All these results are presented in Appendix 1&2.

5.2. Some characteristics with regards to the burnable poison impact

It should be stressed that compared to a similar fuel depletion without erbium (1st generation plutonium Pu1 in Figure 6), the fuel with poison presents an initial negative reactivity of around 9000 pcm which strongly decreases towards 600 GWd/t, corresponding to the loss of 90 % of ^{167}Er. The cycle lengths are however comparable. This important feature of the burnable poison equivalent to that observed with ^{10}B allows to adjust the initial reactivity of the different fuel cycle without changing the cycle lengths. The optimum load of fixed burnable poison has not been estimated in the present study and therefore the different fuel cycles analyzed do not exhibit the same initial reactivity. One should note that the presence of Pu^{240} in all the fuel analysed play a important role in the reactivity margin control as it is shown in Figure 7.

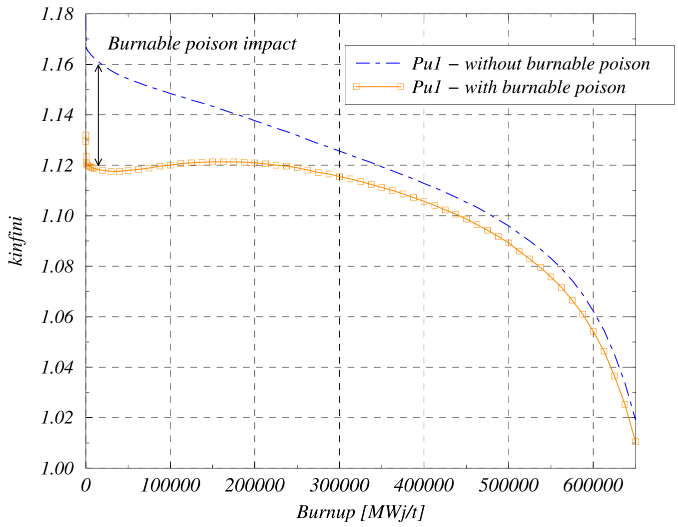

Figure 6: Impact of burnable poison on fuel element $k_{infinity}$

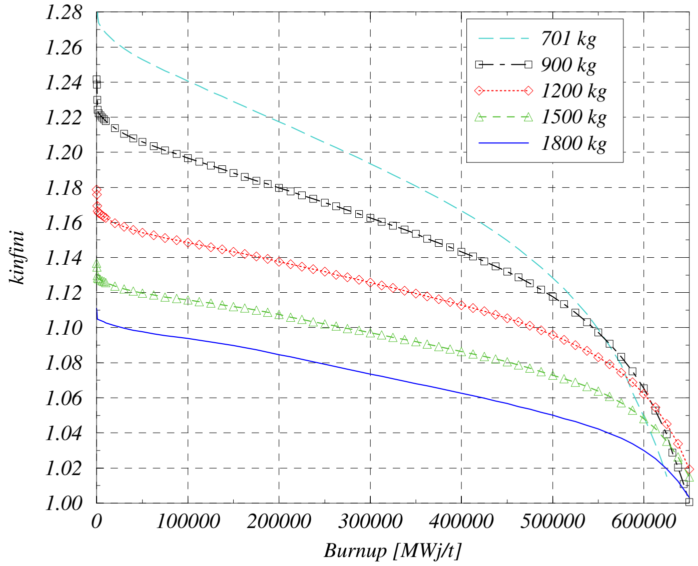

Figure 7: Impact of fuel loading on fuel element depletion

5.3. Plutonium consumption and minor actinides production

Preliminary investigations showed that, whatever the composition of the plutonium is:

► *there is an optimum for the fuel fed into the core with respect to the discharge burnup which allows to use at best the plutonium (Figure 8 and Figure 9).*

► *the fuel cycle length increases linearly with the mass of plutonium loaded into the core (Figure 10)*

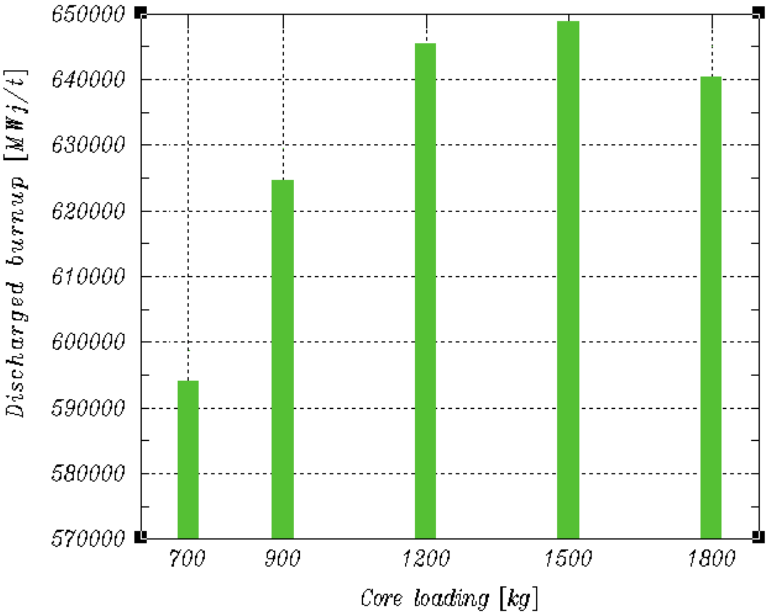

Figure 8: Impact of core loading on discharged burnup
First generation plutonium

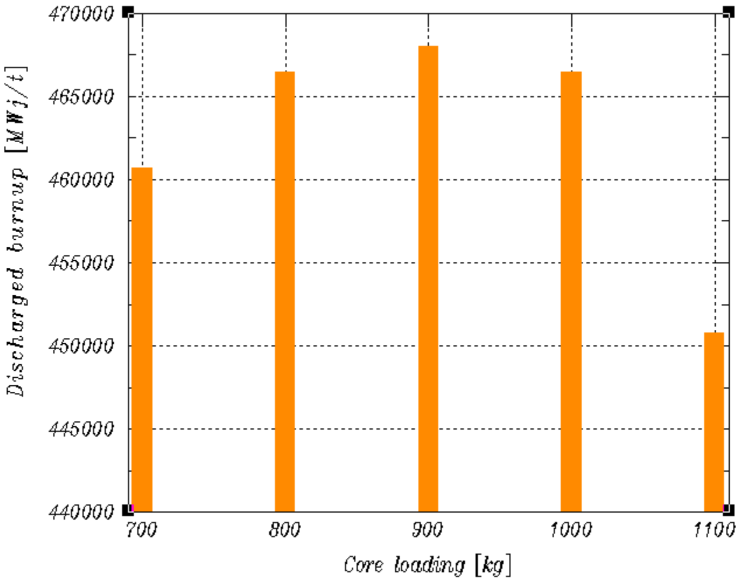

Figure 9: Impact of core loading on discharged burnup
Second generation plutonium

Indeed, an increase of the total mass fed into the core have been analysed for both types of plutonium fuel. All the results are gathered in Table V and Table VI. Whatever the plutonium isotopic content is, the fuel cycle length is proportional to the total mass loaded into the core. The higher the plutonium loaded into the core, the longer the fuel cycle length. Nevertheless, an increase of the plutonium loaded into the core will be limited by technological and physical criteria. For example, the particles volume fraction in the compact represents a technological limit to the plutonium loading capacity.

Besides, the reactivity margin at the beginning of cycle appears as a physical limit to the use of highly degraded plutonium or important fuel loading. In fact, higher plutonium loading imply an increase of great absorbers like ^{240}Pu in a similar core geometry and reduce the reactivity margin although the fissile isotopes content increases. By increasing the loaded fuel mass, the neutron spectrum becomes harder and favours the neutron absorption in the fertile isotopes.

Type of fuel	1st generation plutonium (66,2 %)				
Mass of fuel loaded into the core [kg]	**701**	**900**	**1200**	**1500**	**1800**
Plutonium balance					
[%]	– 67,4	– 71,3	– 74,4	– 75,4	– 75,1
Pu_f / Pu_{total} at EOL [%]	28,3	28,6	30,0	32,7	36,7
Minor actinides balance					
In % of metal burnt	8,3	9,2	10,2	11,1	12,0

Table V - Plutonium and minor actinides balance for 1st generation plutonium fuel

Type of fuel	2nd generation plutonium (42,2 %)		
Mass of fuel loaded into the core [kg]	**700**	**900**	**1100**
Equilibrium cycle length	180	234	275
Average discharged BU	460,7	468,0	450,7
Plutonium balance			
[%]	– 56,1	– 58,2	– 57,6
[kg/TWhe]	– 107,4	– 110,3	– 113,5
Pu_f / Pu_{total} at EOL [%]	19,35	22,4	27,0
Minor actinides balance			
Americium [kg/TWhe]	+ 13,57	+ 14,88	+ 16,93
Curium [kg/TWhe]	+ 3,90	+ 5,29	+ 6,43
Total [kg/TWhe]	+ 17,47	+ 20,17	+ 23,36
In % of metal burnt	**16,3**	**18,3**	**20,5**

Table VI - Plutonium and minor actinides balance for 2nd generation plutonium fuel

It should be noted that if the plutonium balance reaches an optimum with respect to the plutonium loaded into the core, it is not the case with the minor actinide balance, which increases linearly with the mass of plutonium. One could have thought that **maximise the burn-up should minimise both discharged masses of Pu and minor actinides**. In fact, as shown in Table V&Table VI and in Figure 10 below, the production of minor actinides raises continuously with the Pu-loading.

Consequently, the optimum burn-up obtained from the critical calculations, which leads to an optimum of the plutonium consumption with respect to the fuel loading, can be explained as follow:

► despite a smaller initial reactivity, the increasing of the Pu-loading leads to a neutron spectrum hardening that will enhance the Pu conversion and thus increase the cycle length (then the burn-up)

► at a certain level of Pu-loadings, a too hard neutron spectrum (deteriorating the fission rate) and the important amount of minor actinides in the fuel will limit again the cycle length and thus the burn-up

Therefore, it exists for each isotopic Pu-composition, an optimum Pu-loading that maximises the burn-up and then minimises the Pu-discharge despite a constant MA-discharge mass increasing.

In Appendix 1&2, we have summarized all the characteristics of the GT-MHR core loaded with either Pu1 or Pu2. The reference cases that have been chosen in this report correspond to the optimum evaluated in each case (1200 kf of Pu1 and 900 kg of Pu2).

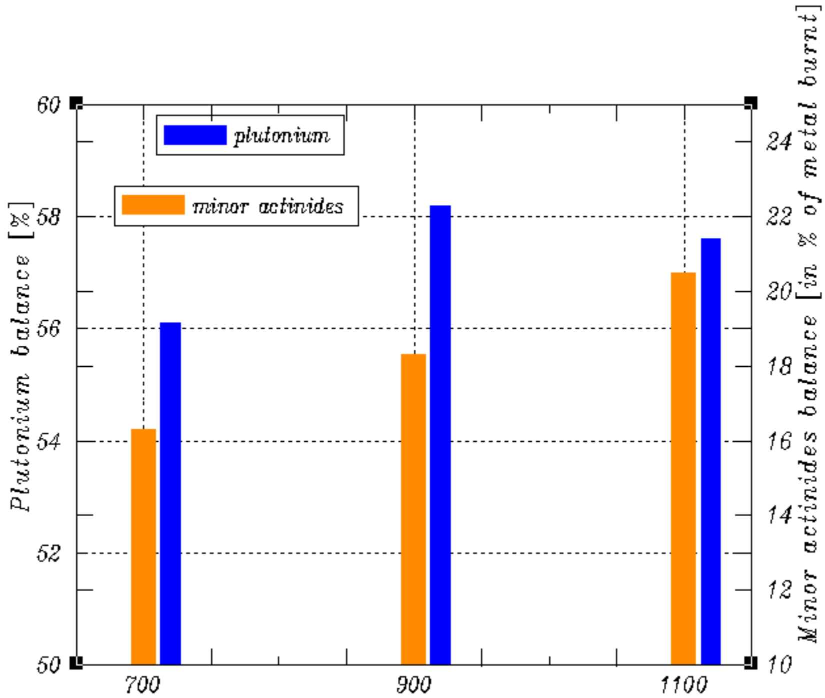

Figure 10: Impact of the core loading on plutonium consumtion and minor actinides production

5.4. Fuel element temperature coefficient

As far as the 1st generation plutonium is concerned (Pu1), the temperature effect (Doppler and moderator) has also been evaluated on the fuel element geometry (Table 4.3.3). The Doppler coefficient given in the table is an average value between 20 and 900 °C. As far as the moderator temperature coefficient is concerned, the calculated value is an average between 20 and 500 °C.

Despite the strong decrease of the moderator temperature coefficient during fuel irradiation, the results have shown that the global core temperature effect is negative and therefore self-stabilizing, with a fuel management by 1/3rd where the average core burnup ranges roughly from 200 and 400 GWd/t between the beginning and the end of cycle.

Doppler Coefficient [pcm/ºC]					
Burnup [GWd/t]	**701 kg**	**900 kg**	**1200 kg**	**1500 kg**	**1800 kg**
	without erbium				
0	– 2,76	– 3,13	– 3,49	– 3,67	– 3,70
Variable	– 0,98 625 GWd/t	– 1,00 650 GWd/t	– 0,92 650 GWd/t	– 1,04 650 GWd/t	– 1,14 650 GWd/t
Graphite temperature coefficient [pcm/ºC]					
Burnup [GWd/t]	701 kg	900 kg	1200 kg	1500 kg	1800 kg
	without erbium				
0	– 2,29	– 2,14	– 1,91	– 1,69	– 1,46
Variable	+ 8,15 625 GWd/t	+ 6,33 650 GWd/t	+ 4,47 650 GWd/t	+ 2,86 650 GWd/t	+ 1,74 650 GWd/t

Table VII - Doppler and Moderator temperature coefficient for the 1st generation Pu

6. CONCLUSION

It is now well known that HTGR have attractive characteristics concerning the use of plutonium. It has especially a flexible core that can fulfil a wide range of diverse fuel cycles. The use of a wide spectrum of plutonium isotopic compositions prove HTGR potentials to use at best the plutonium as fuel without generating large amounts of minor actinides.

Plutonium cycles in block-type reactor have been studied in the present report. However, this has been done without really taking into account the common fuel particle performance limits (burnup, fast fluence, temperature). It is obvious that such long cycles and associated high level of Pu-destruction will be possible only if burnups as high as 700 GWd/t and fluences in the order of 12 n/kb (a factor 2 with the common requirements) sustained by the fuel particles will be technologically feasible. The use of high-burnup plutonium particles cannot be regarded as proven technology today and important fuel characterisation program including irradiation will be required to demonstrate that a burnup equal about 80 % “fissions per initial metal atom” (FIMA) can be achieved for the Pu-particles without an inadmissible failure rate of the fuel coating.

It should be stressed that precaution must be taken with regard to the preliminary results given in this report. Indeed, the indicated mass balances have not been estimated from 3D full core calculations and remain to be confirmed. Nevertheless, such a 3D core calculation is inferred that a core optimisation approach close to conceptual design studies is needed for a block-type reactor fully loaded with plutonium fuel. This has not been carried out in the present study.

Moreover, it is noticeable that further detailed core physic analyses will be required in the future in order to assess the dynamic features of such a reactor. Additional studies concerning also, the reactivity control aspects, the temperature coefficients, the decay heat associated with plutonium fuel, the appropriate fuel management and the associated power distributions related issues (especially important in the case of the plutonium use) should allow to precise that pure plutonium cycles will respect the current high level of safety of the HTGR.

7. REFERENCES

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8. APPENDIX 1

0. Case identification and description.

0.1. Origin
F. Damian
0.2. Organisation
CEA
0.3. Case number
Pu1
0.4.. Date
July 2004
0.5. Applied code system
SAPHYR (APOLLO2 - CRONOS2)

1. General fuel/reactor/system specifications. This section is intended as a compl ete description of the fuel, the reactor (system) and the applied fuel loading and discharge scheme

1.1. System (part) under consideration (reactor)
GT-MHR 600 MWth
1.2. Main system dimensions

Height of active zone	8 m
Equivalent diameter of active zone	2.96 / 4.84 m
Height of axial reflectors	1.3 m

1.3. Coated particle dimensions (kernel and coatings) (per coated particle type)

Particle composition	**Material**	**Density**	**External radius**
Central zone (kernel)	PuOx	10.0	100
Buffer	Graphite	1.0	200
Pyrocarbon	Graphite	1.8	235
Silicon carbide	SiC	3.2	270
Pyrocarbon	Graphite	1.8	315

1.4. Initial coated particle composition per nuclide per material zone (units: $(\text{barn cm})^{-1}$) (per coated particle type; including impurities)

Central zone (kernel)	
O16	4.4327E-02
PU238	6.0262E-04
PU239	1.2113E-02
PU240	5.0684E-03
PU241	2.5788E-03
PU242	1.5365E-03
AM241	2.6449E-04
Buffer	
GRAPH	*5.0138E-02*
Pyrocarbon	
GRAPH	*9.0248E-02*
Silicon Carbide	
SINAT	4.8061E-02

CNAT 4.8061E-02

Pyrocarbon

GRAPH 9.0248E-02

1.5. Compact dimensions

Radius : 0,6225 cm – Height : 4,978 cm

1.6. Compact/pebble composition per nuclide (outside coated particles; including impurities) (units: (barn cm)$^{-1}$)

Graphite Matrix

GRAPH	8.7240E-02
B10	1.9193E-08
B11	7.6771E-08

1.7. Block composition per nuclide (outside coated particles; including impurities) (units: (barn cm)$^{-1}$)

Graphite Matrix

GRAPH	8.7240E-02
B10	1.9193E-08
B11	7.6771E-08

1.8. Number of coated particles per compact (of each coated particle type)

10527 coated fuel particles

1.9. Operating cycle length (units: full power days)

3 × 430 EFPD

1.10. Reload stop duration (units: days) (may be 0 in case of continuous reload, in which case EOL coincides with the end of the Operating cycle)

Loading factor : 0,85

1.11. Nominal reactor power (units: MW)

600 MWth

1.12. Capacity factor (units : -)

Not Evaluated

1.13. Number of fuel batches (batch wise reload only)

3

1.14. Nominal coolant inlet temperature (units: K)

763 K

1.15. Nominal coolant inlet pressure (units: Pa)

7 MPa

1.16. Nominal coolant outlet temperature at nominal (Hot Full Power, HFP) conditions (units: K)

1123 K

1.17. Nominal coolant outlet pressure at nominal (Hot Full Power, HFP) conditions (units: Pa)

Not Evaluated

1.18. Nominal coolant mass flow (unit: kg/s)

320 kg/s

1.19. Description of the fuel cycle strategy and other relevant information on the specified case.

Three batches loading scheme

720 standard fuel elements

300 control fuel elements

2. Rating and power density

2.1. Power produced per coated particle (per coated particle type) (units: W):

18,29 10^{-3} W

2.1.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.1.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

2.2. Power produced per compact (units: W)

192,5 W

2.2.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.2.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

2.3. Power produced per unit heavy metal mass (units: W/kg)

0,5 W/kg

2.3.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.3.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

2.4. Power density in the core (units: W/cm^3)

6,6 W/cm^3

2.4.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.4.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

3. Core inventory

3.1. Amount of each of the heavy metal isotopes present in the fuel element (units: kg)

1200 kg of HM in the core

1,247 kg of HM in the standard fuel element

1,005 kg of HM in the control fuel element

3.1.1. At BOL *(kg, normalised to the total core inventory)*

Burnup 0 MWd/t

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00		
3.240026E+01	6.540052E+02	2.748022E+02	1.404011E+02
8.400066E+01			
1.440011E+01	0.000000E+00	0.000000E+00	
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	

3.1.2. At MOL *(kg, normalised to the total core inventory)*

Burnup 320 MWd/t

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

3.733879E-01	7.818113E-02	3.870285E-02	2.857302E-04
3.569752E-02	2.249799E-05		
3.391433E+01	2.392100E+02	1.568165E+02	2.265969E+02
9.203210E+01			
1.524021E+01	5.323632E-01	2.587004E+01	
4.340732E+00	1.219131E-01	1.142715E+01	1.094417E+00
3.286775E-02	3.286097E-04	1.253340E-05	

3.1.3. At EOL *(kg, normalised to the total core inventory)*

Burnup 640 MWd/t

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

6.486107E-01	2.033239E-01	6.626170E-02	6.800545E-04
4.977107E-02	3.780971E-05		
3.642939E+01	2.123334E+01	3.859227E+01	9.437663E+01
1.288352E+02			
6.771695E+00	1.816209E-01	4.277332E+01	
6.409743E+00	2.541135E-01	3.631593E+01	4.388395E+00
6.409865E-01	1.065707E-02	1.112524E-03	

3.2. Fissile Pu fraction, i.e. amount of (^{239}Pu and ^{241}Pu) divided by the total amount of Pu (units: %) (this can be derived from 3.1)

3.2.1.AtBOL

Burnup 0 MWd/t

67,0 % in Fissile Pu

3.2.2. At MOL

Burnup 320 MWd/t

62,2 % in Fissile Pu

3.2.3. At EOL

Burnup 640 MWd/t

36,2 % in Fissile Pu

4. Fuel (actinide) consumption, actinide and fission product production and discharge burnup at nominal conditions. A list of nuclides under consideration is presented in section 4.

4.1. Amount and composition of fresh fuel loaded into the system for one operating cycle (per heavy metal nuclide) divided by the operating cycle length (units:kg/year) ***(normalised to the total core inventory)***

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

0,0	0,0	0,0	0,0
0,0	0,0		
7,79	157,3	66,1	33,76
20,2			
3,46	0,0	0,0	
0,0	0,0	0,0	0,0
0,0	0,0	0,0	

4.2. Amount and composition of fuel discharged from (and not reloaded into) the System for one operating cycle (per heavy metal and fission product nuclide) divided by the operating cycle length (units: kg/year) ***(normalised to the total core inventory)***

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

0,15	***	***	***
***	***		
8,8	5,1	9,3	22,7
32,0			
1,63	***	10,3	
1,54	***	8.73	1,05
***	***	***	

4.3. Balance of heavy metal and fission products, i.e. the difference between corresponding items 4.1 and 4.2, divided by nominal thermal power times capacity factor (units: kg/MWd)

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

+ 8,06 10^{-7}	***	***	***
***	***		
– 5,4 10^{-6}	– 8,2$10^{-4}$	– 3,05 10^{-4}	– 5,9 10^{-5}
+ 6,3 10^{-5}			
– 9,8 10^{-6}	***	+ 5,5 10^{-5}	
+ 8,3 10^{-6}	***	+ 4,7 10^{-5}	+ 5,6$10^{-6}$
***	***	***	

4.4. Attained discharged burnup of the fuel (units: MWd/kg)

640 MWd/kg HM

4.4.1. Minimum value

Not Evaluated

4.4.2. Average value

Not Evaluated

4.4.3. Maximum value

Not Evaluated

5. Reaction rates at nominal conditions

5.1. Neutron induced fission rate per heavy metal nuclide in the entire System (units: $s^{-1}.cm^{-3}$ of core)

5.1.1.AtBOL

Burnup 0 MWd/t

PU238	7.0887E+09
PU239	4.5940E+12
PU240	1.2545E+10
PU241	1.0559E+12
PU242	2.4749E+09
AM241	1.5104E+09

5.1.2. At MOL

Burnup 320 MWd/t

U234	1.2228E+07
U235	2.8737E+08
U236	1.2485E+06
U237	2.6147E+04

U238	1.4518E+03
NP237	1.0558E+06
NP238	1.0348E+06
NP239	7.8687E+02
PU236	4.0189E+01
PU238	7.7220E+09
PU239	2.6021E+12
PU240	6.9222E+09
PU241	2.3332E+12
PU242	2.5502E+09
AM241	1.9346E+09
AM242M	2.5971E+10
AM243	6.9589E+08
CM242	3.6660E+08
CM243	1.2563E+09
CM244	1.0833E+09
CM245	1.0435E+10
CM246	1.5097E+06
CM247	1.1269E+06
CM248	8.7909E+02

5.1.3.AtEOL

Burnup 640 MWd/t

U234	2.3348E+07
U235	2.0601E+09
U236	2.0889E+06
U237	5.2875E+04
U238	3.3051E+03
NP237	1.3929E+06
NP238	7.6653E+06
NP239	1.2398E+03
PU236	1.9651E+02
PU238	1.3294E+10
PU239	7.7488E+11
PU240	1.7400E+09
PU241	2.9890E+12
PU242	3.3654E+09
AM241	1.9250E+09
AM242M	3.0108E+10
AM243	1.1226E+09
CM242	9.6577E+08
CM243	4.0364E+09
CM244	3.6932E+09
CM245	1.1759E+11
CM246	2.8830E+07
CM247	5.7777E+07
CM248	7.5958E+04

5.2. Neutron **absorption rate for all (heavy metal, fission product and possibly burnable poison) nuclides present in the kernels** of all coated particles **(units: $s^{-1}.cm^{-3}$ of core)** (per nuclide)

5.2.1.AtBOL

Burnup 0 MWd/t

PU238	6.3552E+10
PU239	7.3817E+12
PU240	3.2575E+12
PU241	1.4071E+12
PU242	3.8040E+11
AM241	1.6160E+11
O16	4.0193E+08

5.2.2. At MOL

Burnup 320 MWd/t

U234	1.3242E+09
U235	3.7192E+08
U236	6.6112E+07
U237	7.2544E+05
U238	4.0413E+05
NP237	1.8473E+08
NP238	1.1422E+06
NP239	5.4935E+04
PU236	7.9250E+01
PU238	8.4304E+10
PU239	4.1929E+12
PU240	2.4237E+12
PU241	3.1344E+12
PU242	3.8713E+11
AM241	2.2038E+11
AM242M	3.1685E+10
AM243	2.1849E+11
CM242	3.2540E+09
CM243	1.4696E+09
CM244	3.5070E+10
CM245	1.2033E+10
CM246	1.7558E+07
CM247	1.8675E+06
CM248	1.6024E+04
ZR95PF	8.6181E+07
ZR96PF	6.0162E+08
NB95PF	5.2493E+08
MO95PF	8.7870E+09
MO96PF	4.3072E+07
MO97PF	2.1225E+09
MO98PF	9.1806E+08
MO99PF	2.3176E+07
MO100PF	6.2306E+08

TC99PF	3.3058E+10
RU101PF	1.3979E+10
RU102PF	6.1081E+08
RU103PF	7.6671E+09
RU104PF	8.9573E+08
RU105PF	4.2866E+05
RU106PF	1.4662E+08
RH103PF	9.6595E+10
RH105PF	6.7210E+09
PD105PF	1.2786E+10
PD106PF	3.4033E+08
PD107PF	8.5248E+09
PD108PF	9.9604E+09
AG109PF	4.0916E+10
I131PF	1.2085E+07
I135PF	2.5100E+03
XE131PF	5.1760E+10
XE132PF	2.4951E+08
XE133PF	8.1033E+08
XE135PF	1.6361E+11
XE136PF	4.5769E+07
CS133PF	5.1189E+10
CS134PF	2.1671E+09
CS135PF	7.6285E+09
CS136PF	6.2720E+06
CS137PF	1.0608E+08
TE127MPF	2.2903E+07
I127PF	1.4416E+09
TE129MPF	2.6230E+06
I129PF	1.6150E+09
CE141PF	1.4432E+09
PR141PF	2.6622E+09
CE144PF	1.5912E+08
PR143PF	7.1645E+08
ND143PF	3.0781E+10
ND144PF	3.2392E+08
ND145PF	1.4745E+10
ND146PF	2.3661E+08
ND147PF	1.0001E+09
ND148PF	8.4542E+08
ND150PF	3.7950E+08
PM147PF	4.4192E+10
PM148PF	4.6306E+09
PM148MPF	1.7843E+10
PM149PF	3.4747E+08
PM151PF	1.0516E+08

SM147PF	4.3827E+09
SM148PF	3.2576E+08
SM149PF	1.1762E+11
SM150PF	1.1465E+10
SM151PF	5.5196E+10
SM152PF	4.1081E+10
SM153PF	3.9831E+08
SM154PF	2.8138E+08
EU153PF	2.2836E+10
EU154PF	9.1840E+09
EU155PF	2.3923E+10
EU156PF	7.4525E+08
EU157PF	7.1340E+06
GD154PF	5.0712E+07
GD155PF	1.8353E+09
GD156PF	8.1834E+08
GD157PF	1.4361E+10
KR83PF	1.7015E+09
ZR93PF	2.6515E+09
CD113PF	7.3130E+09
IN115PF	1.8944E+09
LA139PF	2.0801E+09
O16	3.9240E+08

5.2.3.AtEOL

Burnup 640 MWd/t

U234	2.9742E+09
U235	2.5106E+09
U236	1.1365E+08
U237	2.2914E+06
U238	9.5482E+05
NP237	4.3744E+08
NP238	8.4435E+06
NP239	1.0612E+05
PU236	3.9012E+02
PU238	2.5592E+11
PU239	1.2465E+12
PU240	1.2441E+12
PU241	4.0505E+12
PU242	5.2008E+11
AM241	2.4765E+11
AM242M	3.6961E+10
AM243	3.9823E+11
CM242	6.2239E+09
CM243	4.7602E+09
CM244	1.1324E+11
CM245	1.3520E+11

CM246	3.4533E+08
CM247	9.6110E+07
CM248	1.4145E+06
ZR95PF	7.9377E+07
ZR96PF	1.1089E+09
NB95PF	4.8147E+08
MO95PF	2.2678E+10
MO96PF	2.1501E+08
MO97PF	4.8809E+09
MO98PF	1.7606E+09
MO99PF	2.3274E+07
MO100PF	1.2523E+09
TC99PF	6.6897E+10
RU101PF	2.7447E+10
RU102PF	2.0043E+09
RU103PF	9.0737E+09
RU104PF	1.8817E+09
RU105PF	4.1250E+05
RU106PF	2.1870E+08
RH103PF	2.2611E+11
RH105PF	1.2805E+10
PD105PF	3.4038E+10
PD106PF	1.1114E+09
PD107PF	1.7318E+10
PD108PF	2.2518E+10
AG109PF	7.8394E+10
I131PF	1.1906E+07
I135PF	6.2801E+03
XE131PF	9.1351E+10
XE132PF	7.6201E+08
XE133PF	1.4060E+09
XE135PF	2.2696E+11
XE136PF	2.4237E+08
CS133PF	1.0083E+11
CS134PF	1.8853E+10
CS135PF	1.5451E+10
CS136PF	1.1957E+07
CS137PF	2.7433E+08
TE127MPF	3.2981E+07
I127PF	3.0130E+09
TE129MPF	3.2897E+06
I129PF	7.1702E+09
CE141PF	1.8321E+09
PR141PF	1.0256E+10
CE144PF	3.0946E+08
PR143PF	1.1936E+09

ND143PF	1.5071E+11
ND144PF	2.2534E+09
ND145PF	3.6887E+10
ND146PF	8.7972E+08
ND147PF	1.9976E+09
ND148PF	2.0164E+09
ND150PF	8.4045E+08
PM147PF	5.8337E+10
PM148PF	8.9625E+09
PM148MPF	3.0789E+10
PM149PF	1.2347E+09
PM151PF	1.7578E+08
SM147PF	1.1259E+10
SM148PF	1.1199E+09
SM149PF	1.0631E+11
SM150PF	3.7993E+10
SM151PF	9.1572E+10
SM152PF	8.2017E+10
SM153PF	9.3673E+08
SM154PF	8.3164E+08
EU153PF	7.0386E+10
EU154PF	5.4037E+10
EU155PF	8.1268E+10
EU156PF	3.9745E+09
EU157PF	1.6650E+07
GD154PF	5.8023E+08
GD155PF	2.1218E+09
GD156PF	3.1975E+09
GD157PF	1.9129E+10
KR83PF	6.3271E+09
ZR93PF	5.2705E+09
CD113PF	5.8753E+09
IN115PF	2.6545E+09
LA139PF	8.1842E+09
O16	3.9790E+08

5.3. Neutron absorption rate in all other material in the core cavity (units: s^{-1}) (per nuclide, including burnable poison if present)

5.3.1.AtBOL

Not Evaluated

5.3.2. At MOL

Not Evaluated

5.3.3. AtEOL

Not Evaluated

5.4. Net neutron leakage rate from the core cavity (units: s"1)

5.2.1.At BOL

Burnup 0 MWd/t

9100 pcm (2D radial leakage)

5.2.2. At MOL

Burnup 320 MWd/t

9300 pcm (2D radial leakage)

5.2.3.AtEOL

Burnup 640 MWd/t

11180 pcm (2D radial leakage)

6. Fast and thermal neutron flux (fluence rate) and fluence measures at nominal conditions

6.1. Thermal flux below **1.84 eV** (units: **cm**$^{-2}$.**s**$^{-1}$). The items listed below should be calculated at BOL, MOL and EOL.

6.1.1. Average value in the core

5,43.10^{14} cm^{-2}.s^{-1} (MOL 320 GWd/t)

6.1.2. Peak value in the core

1,13.10^{15} cm^{-2}.s^{-1} (MOL 320 GWd/t)

6.1.3. Average value in the reflector

1,48.10^{15} cm^{-2}.s^{-1} (MOL 320 GWd/t)

6.1.4. Peak value in the reflector

3,11.10^{15} cm^{-2}.s^{-1} (MOL 320 GWd/t)

6.1.5. Axial distribution of the thermal flux along the centre axis

Not Evaluated

6.1.6. Radial distribution of the thermal flux at half core height

At BOL

Burnup 0 MWd/t

.295200E+01	1.6745E+15
.885600E+01	1.6835E+15
.147600E+02	1.7014E+15
.206640E+02	1.7284E+15
.265680E+02	1.7646E+15
.324720E+02	1.8102E+15
.383760E+02	1.8652E+15
.442800E+02	1.9301E+15
.501840E+02	2.0049E+15
.560880E+02	2.0901E+15
.619920E+02	2.1857E+15
.678960E+02	2.2919E+15
.738000E+02	2.4086E+15
.797040E+02	2.5355E+15
.856080E+02	2.6712E+15
.915120E+02	2.8134E+15
.974160E+02	2.9576E+15
.103320E+03	3.0958E+15
.109224E+03	3.2152E+15

.115128E+03	3.2956E+15
.121032E+03	3.3077E+15
.126936E+03	3.2113E+15
.132840E+03	2.9559E+15
.138744E+03	2.4838E+15
.144648E+03	1.7350E+15
.149474E+03	9.9184E+14
.153222E+03	6.7982E+14
.156970E+03	5.2446E+14
.160718E+03	4.4620E+14
.164466E+03	4.0755E+14
.168214E+03	3.8901E+14
.171962E+03	3.8031E+14
.175710E+03	3.7610E+14
.179458E+03	3.7363E+14
.183206E+03	3.7156E+14
.186954E+03	3.6927E+14
.190702E+03	3.6653E+14
.194450E+03	3.6323E+14
.198198E+03	3.5939E+14
.201946E+03	3.5504E+14
.205694E+03	3.5029E+14
.209442E+03	3.4540E+14
.213190E+03	3.4093E+14
.216938E+03	3.3803E+14
.220686E+03	3.3899E+14
.224434E+03	3.4809E+14
.228182E+03	3.7334E+14
.231930E+03	4.2952E+14
.235678E+03	5.4442E+14
.239426E+03	7.7615E+14
.243830E+03	1.2735E+15
.248890E+03	1.7310E+15
.253950E+03	2.0034E+15
.259010E+03	2.1322E+15
.264070E+03	2.1537E+15
.270370E+03	2.0749E+15
.277910E+03	1.8982E+15
.285450E+03	1.6752E+15
.292990E+03	1.4382E+15
.300530E+03	1.2038E+15
.308070E+03	9.7905E+14
.315610E+03	7.6602E+14
.323150E+03	5.6430E+14
.330690E+03	3.7237E+14
.338230E+03	1.8782E+14

.343375E+03	4.6416E+13
.346125E+03	8.3001E+12

At MOL

Burnup 320 MWd/t

.295200E+01	1.4751E+15
.885600E+01	1.4838E+15
.147600E+02	1.5013E+15
.206640E+02	1.5275E+15
.265680E+02	1.5628E+15
.324720E+02	1.6071E+15
.383760E+02	1.6607E+15
.442800E+02	1.7238E+15
.501840E+02	1.7966E+15
.560880E+02	1.8794E+15
.619920E+02	1.9724E+15
.678960E+02	2.0758E+15
.738000E+02	2.1895E+15
.797040E+02	2.3131E+15
.856080E+02	2.4457E+15
.915120E+02	2.5852E+15
.974160E+02	2.7277E+15
.103320E+03	2.8663E+15
.109224E+03	2.9897E+15
.115128E+03	3.0801E+15
.121032E+03	3.1112E+15
.126936E+03	3.0471E+15
.132840E+03	2.8415E+15
.138744E+03	2.4410E+15
.144648E+03	1.7890E+15
.149474E+03	1.1333E+15
.153222E+03	8.3481E+14
.156970E+03	6.6953E+14
.160718E+03	5.7735E+14
.164466E+03	5.2679E+14
.168214E+03	4.9965E+14
.171962E+03	4.8535E+14
.175710E+03	4.7772E+14
.179458E+03	4.7327E+14
.183206E+03	4.7007E+14
.186954E+03	4.6707E+14
.190702E+03	4.6375E+14
.194450E+03	4.5990E+14
.198198E+03	4.5545E+14
.201946E+03	4.5049E+14
.205694E+03	4.4526E+14
.209442E+03	4.4027E+14

.213190E+03	4.3646E+14
.216938E+03	4.3551E+14
.220686E+03	4.4033E+14
.224434E+03	4.5591E+14
.228182E+03	4.9059E+14
.231930E+03	5.5831E+14
.235678E+03	6.8264E+14
.239426E+03	9.0792E+14
.243830E+03	1.3544E+15
.248890E+03	1.7597E+15
.253950E+03	1.9943E+15
.259010E+03	2.0974E+15
.264070E+03	2.1030E+15
.270370E+03	2.0151E+15
.277910E+03	1.8367E+15
.285450E+03	1.6182E+15
.292990E+03	1.3885E+15
.300530E+03	1.1621E+15
.308070E+03	9.4542E+14
.315610E+03	7.3998E+14
.323150E+03	5.4531E+14
.330690E+03	3.5995E+14
.338230E+03	1.8159E+14
.343375E+03	4.4881E+13
.346125E+03	8.0261E+12

AtEOL

Burnup 640 MWd/t

.295200E+01	1.5311E+15
.885600E+01	1.5400E+15
.147600E+02	1.5579E+15
.206640E+02	1.5849E+15
.265680E+02	1.6212E+15
.324720E+02	1.6669E+15
.383760E+02	1.7223E+15
.442800E+02	1.7877E+15
.501840E+02	1.8635E+15
.560880E+02	1.9500E+15
.619920E+02	2.0475E+15
.678960E+02	2.1564E+15
.738000E+02	2.2767E+15
.797040E+02	2.4086E+15
.856080E+02	2.5513E+15
.915120E+02	2.7035E+15
.974160E+02	2.8625E+15
.103320E+03	3.0232E+15
.109224E+03	3.1767E+15

.115128E+03	3.3094E+15
.121032E+03	3.4001E+15
.126936E+03	3.4193E+15
.132840E+03	3.3280E+15
.138744E+03	3.0787E+15
.144648E+03	2.6176E+15
.149474E+03	2.1248E+15
.153222E+03	1.8580E+15
.156970E+03	1.6761E+15
.160718E+03	1.5515E+15
.164466E+03	1.4668E+15
.168214E+03	1.4097E+15
.171962E+03	1.3711E+15
.175710E+03	1.3446E+15
.179458E+03	1.3257E+15
.183206E+03	1.3113E+15
.186954E+03	1.2992E+15
.190702E+03	1.2882E+15
.194450E+03	1.2774E+15
.198198E+03	1.2666E+15
.201946E+03	1.2562E+15
.205694E+03	1.2467E+15
.209442E+03	1.2394E+15
.213190E+03	1.2361E+15
.216938E+03	1.2394E+15
.220686E+03	1.2530E+15
.224434E+03	1.2820E+15
.228182E+03	1.3330E+15
.231930E+03	1.4152E+15
.235678E+03	1.5410E+15
.239426E+03	1.7298E+15
.243830E+03	2.0479E+15
.248890E+03	2.3111E+15
.253950E+03	2.4313E+15
.259010E+03	2.4447E+15
.264070E+03	2.3818E+15
.270370E+03	2.2322E+15
.277910E+03	2.0022E+15
.285450E+03	1.7484E+15
.292990E+03	1.4928E+15
.300530E+03	1.2462E+15
.308070E+03	1.0124E+15
.315610E+03	7.9181E+14
.323150E+03	5.8329E+14
.330690E+03	3.8493E+14
.338230E+03	1.9417E+14

.343375E+03	4.7985E+13
.346125E+03	8.5797E+12

6.2. ^{59}Co(n,y) reaction rate of a 10"'° (barn cm)"^{1} trace of ^{59}Co in all materials in the core and reflector. This is a measure of the thermal flux below ~1 eV, which is independent of the energy group structure employed in the calculations. The items listed below should be calculated at BOL, MOL and EOL.

Not Evaluated

6.2.1. Total reaction rate in the core (units: s"^{1})

Not Evaluated

6.2.2. Total reaction rate in the reflector (units: s"^{1})

Not Evaluated

6.2.3. Peak value of the reaction rate density in the core (units: s^m"^{3})

Not Evaluated

6.2.4. Peak value of the reaction rate density in the reflector (units: s'W^{3})

Not Evaluated

6.2.5. Axial distribution of the reaction rate density along the centre axis (units: s'W^{3})

Not Evaluated

6.2.6. Radial distribution of the reaction rate density at half core height (units: s'W^{3})

Not Evaluated

6.3. Fast flux (fluence rate) above **0.11 MeV** (units: **$cm^{-2}.s^{-1}$**). The items listed below should be calculated at BOL, MOL and EOL.

6.3.1. Average value in the core

$8{,}72.10^{14}$ $cm^{-2}.s^{-1}$ (MOL 320 GWd/t)

6.3.2. Peak value in the core

$1{,}02.10^{15}$ $cm^{-2}.s^{-1}$ (MOL 320 GWd/t)

6.3.3. Average value in the reflector

$6{,}06.10^{13}$ $cm^{-2}.s^{-1}$ (MOL 320 GWd/t)

6.3.4. Peak value in the reflector

$5{,}94.10^{14}$ $cm^{-2}.s^{-1}$ (MOL 320 GWd/t)

6.3.5. Axial distribution of the fast flux along the centre axis

Not Evaluated

6.3.6. Radial distribution of the fast flux at half core height

At BOL

Burnup 0 MWd/t

.295200E+01	5.3304E+09
.885600E+01	6.1732E+09
.147600E+02	7.9070E+09
.206640E+02	1.0906E+10
.265680E+02	1.5824E+10
.324720E+02	2.3761E+10
.383760E+02	3.6556E+10
.442800E+02	5.7290E+10
.501840E+02	9.1159E+10
.560880E+02	1.4702E+11
.619920E+02	2.4018E+11
.678960E+02	3.9736E+11

.738000E+02	6.6584E+11
.797040E+02	1.1303E+12
.856080E+02	1.9438E+12
.915120E+02	3.3859E+12
.974160E+02	5.9697E+12
.103320E+03	1.0641E+13
.109224E+03	1.9143E+13
.115128E+03	3.4672E+13
.121032E+03	6.3044E+13
.126936E+03	1.1469E+14
.132840E+03	2.0794E+14
.138744E+03	3.7452E+14
.144648E+03	6.7783E+14
.149474E+03	1.0393E+15
.153222E+03	1.1201E+15
.156970E+03	1.1132E+15
.160718E+03	1.0813E+15
.164466E+03	1.0445E+15
.168214E+03	1.0106E+15
.171962E+03	9.8196E+14
.175710E+03	9.5859E+14
.179458E+03	9.3973E+14
.183206E+03	9.2442E+14
.186954E+03	9.1181E+14
.190702E+03	9.0125E+14
.194450E+03	8.9237E+14
.198198E+03	8.8500E+14
.201946E+03	8.7920E+14
.205694E+03	8.7527E+14
.209442E+03	8.7366E+14
.213190E+03	8.7503E+14
.216938E+03	8.8003E+14
.220686E+03	8.8913E+14
.224434E+03	9.0199E+14
.228182E+03	9.1636E+14
.231930E+03	9.2572E+14
.235678E+03	9.1392E+14
.239426E+03	8.3219E+14
.243830E+03	5.5163E+14
.248890E+03	3.2170E+14
.253950E+03	1.8925E+14
.259010E+03	1.1067E+14
.264070E+03	6.4424E+13
.270370E+03	3.3388E+13
.277910E+03	1.4790E+13
.285450E+03	6.5997E+12

.292990E+03	2.9815E+12
.300530E+03	1.3682E+12
.308070E+03	6.3880E+11
.315610E+03	3.0335E+11
.323150E+03	1.4620E+11
.330690E+03	7.1179E+10
.338230E+03	3.4770E+10
.343375E+03	2.0234E+10
.346125E+03	1.1869E+10

At MOL

Burnup 320 MWd/t

.295200E+01	4.7752E+09
.885600E+01	5.5283E+09
.147600E+02	7.0766E+09
.206640E+02	9.7532E+09
.265680E+02	1.4138E+10
.324720E+02	2.1209E+10
.383760E+02	3.2594E+10
.442800E+02	5.1017E+10
.501840E+02	8.1066E+10
.560880E+02	1.3055E+11
.619920E+02	2.1291E+11
.678960E+02	3.5159E+11
.738000E+02	5.8797E+11
.797040E+02	9.9602E+11
.856080E+02	1.7093E+12
.915120E+02	2.9712E+12
.974160E+02	5.2285E+12
.103320E+03	9.3038E+12
.109224E+03	1.6714E+13
.115128E+03	3.0244E+13
.121032E+03	5.4975E+13
.126936E+03	1.0005E+14
.132840E+03	1.8164E+14
.138744E+03	3.2788E+14
.144648E+03	5.9477E+14
.149474E+03	9.1555E+14
.153222E+03	1.0070E+15
.156970E+03	1.0198E+15
.160718E+03	1.0043E+15
.164466E+03	9.7934E+14
.168214E+03	9.5327E+14
.171962E+03	9.2963E+14
.175710E+03	9.0943E+14
.179458E+03	8.9261E+14
.183206E+03	8.7866E+14

.186954E+03	8.6701E+14
.190702E+03	8.5717E+14
.194450E+03	8.4882E+14
.198198E+03	8.4183E+14
.201946E+03	8.3624E+14
.205694E+03	8.3228E+14
.209442E+03	8.3030E+14
.213190E+03	8.3070E+14
.216938E+03	8.3377E+14
.220686E+03	8.3940E+14
.224434E+03	8.4653E+14
.228182E+03	8.5205E+14
.231930E+03	8.4903E+14
.235678E+03	8.2269E+14
.239426E+03	7.3413E+14
.243830E+03	4.8472E+14
.248890E+03	2.8222E+14
.253950E+03	1.6567E+14
.259010E+03	9.6738E+13
.264070E+03	5.6272E+13
.270370E+03	2.9161E+13
.277910E+03	1.2929E+13
.285450E+03	5.7787E+12
.292990E+03	2.6165E+12
.300530E+03	1.2039E+12
.308070E+03	5.6363E+11
.315610E+03	2.6838E+11
.323150E+03	1.2967E+11
.330690E+03	6.3271E+10
.338230E+03	3.0964E+10
.343375E+03	1.8035E+10
.346125E+03	1.0582E+10

AtEOL

Burnup 640 MWd/t

.295200E+01	3.7774E+09
.885600E+01	4.3712E+09
.147600E+02	5.5908E+09
.206640E+02	7.6973E+09
.265680E+02	1.1144E+10
.324720E+02	1.6692E+10
.383760E+02	2.5610E+10
.442800E+02	4.0008E+10
.501840E+02	6.3431E+10
.560880E+02	1.0189E+11
.619920E+02	1.6569E+11
.678960E+02	2.7272E+11

.738000E+02	4.5445E+11
.797040E+02	7.6687E+11
.856080E+02	1.3108E+12
.915120E+02	2.2692E+12
.974160E+02	3.9775E+12
.103320E+03	7.0523E+12
.109224E+03	1.2630E+13
.115128E+03	2.2803E+13
.121032E+03	4.1394E+13
.126936E+03	7.5324E+13
.132840E+03	1.3693E+14
.138744E+03	2.4788E+14
.144648E+03	4.5046E+14
.149474E+03	6.9697E+14
.153222E+03	8.0302E+14
.156970E+03	8.5494E+14
.160718E+03	8.7889E+14
.164466E+03	8.8689E+14
.168214E+03	8.8610E+14
.171962E+03	8.8076E+14
.175710E+03	8.7336E+14
.179458E+03	8.6525E+14
.183206E+03	8.5712E+14
.186954E+03	8.4927E+14
.190702E+03	8.4181E+14
.194450E+03	8.3477E+14
.198198E+03	8.2813E+14
.201946E+03	8.2189E+14
.205694E+03	8.1598E+14
.209442E+03	8.1027E+14
.213190E+03	8.0445E+14
.216938E+03	7.9788E+14
.220686E+03	7.8936E+14
.224434E+03	7.7679E+14
.228182E+03	7.5668E+14
.231930E+03	7.2338E+14
.235678E+03	6.6761E+14
.239426E+03	5.6935E+14
.243830E+03	3.7396E+14
.248890E+03	2.1755E+14
.253950E+03	1.2736E+14
.259010E+03	7.4247E+13
.264070E+03	4.3166E+13
.270370E+03	2.2383E+13
.277910E+03	9.9466E+12
.285450E+03	4.4623E+12

.292990E+03	2.0299E+12
.300530E+03	9.3875E+11
.308070E+03	4.4178E+11
.315610E+03	2.1140E+11
.323150E+03	1.0260E+11
.330690E+03	5.0253E+10
.338230E+03	2.4669E+10
.343375E+03	1.4388E+10
.346125E+03	8.4461E+09

6.4. ^{58}Ni(n,p) reaction rate of a 10~^{10} (barn cm)"^{1} trace of ^{5S}Ni in all materials in the core and reflector. This is a measure of the fast flux above ~2 MeV, which is independent of the energy group structure employed in the calculations. The items listed below should be calculated at BOL, MOL and EOL.

Not Evaluated

6.4.1. Total reaction rate in the core (units: s"^{1})

Not Evaluated

6.4.2. Total reaction rate in the reflector (units: s"^{1})

Not Evaluated

6.4.3. Peak value of the reaction rate density in the core (units: s'W^{3})

Not Evaluated

6.4.4. Peak value of the reaction rate density in the reflector (units: s"'m"^{3})

Not Evaluated

6.4.5. Axial distribution of the reaction rate density along the centre axis (units: s'W^{3})

Not Evaluated

6.4.6. Radial distribution of the reaction rate density at half core height (units: s"'m"^{3})

Not Evaluated

6.5. Fast fluence above 0.1 MeV of discharged fuel (kernel, coatings, matrix) (units: m"^{2})

6.5.1. Minimum value

Not Evaluated

6.5.2. Average value

5,76 10^{21} cm^{-2} = 5,76 n/kbarn

6.5.3. Maximum value

~ 14 10^{21} cm^{-2} ~14 n/kbarn (taking into account à 3D peaking factor of 2.5)

7. Temperatures at nominal conditions

7.1. Coated particle temperature (units: K)

1130 K

7.1.1. Maximum value occurring anywhere in the core at BOL

Not Evaluated

7.1.2. Maximum value occurring anywhere in the core at EOL

Not Evaluated

7.1.3. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

7.2. Compact and fuel element matrix temperature (units: K)

1080 K

7.2.1. Maximum value occurring anywhere in the core at BOL

Not Evaluated

7.2.2. Maximum value occurring anywhere in the core at EOL

Not Evaluated

7.2.3. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

8. Temperature reactivity coefficients. The perturbed state has "frozen" thermal hydraulics and the same nuclide concentrations as the reference state anywhere in the System. The local temperature of the System part (fuel, moderator, reflector) for which the temperature reactivity coefficient is to be calculated is increased by AT= 50 K *(k_{Mta})*, while the temperature of the remainder of the System is at the same temperature as in the reference state. The temperature reactivity coefficient *(a)* is subsequently calculated as:

$$a = (1/k_1 - 1/k_2)/(T_2 - T_1) \text{ (units: pcm/K)}$$

The following items should be calculated as function of time over the operating cycle, at least at BOL, MOL and EOL. The exact part of the System for which the coefficient is calculated should be indicated.

8.1. Temperature reactivity coefficients at Cold Zero Power **(CZP, zero xenon)** conditions (units: pcm/K). **The calculations are performed on the simplified 2D core configuration (2D radial).** The reference state for this calculation is an isothermal reactor at 300 K *(k_{ref})*. The temperature reactivity coefficients should be calculated for:

8.1.1. Fuel particles

0 MWJ/t	-2,669
320 MWJ/t	-2,725
640 MWJ/t	-1,850

8.1.2. Moderator in the core cavity (fuel element matrix & compact matrix)

0 MWJ/t	-1,997
320 MWJ/t	-0,204
640 MWJ/t	+8,275

8.1.3. Reflectors

0 MWJ/t	+3,732
320 MWJ/t	+5,019
640 MWJ/t	+8,419

8.2. Temperature reactivity coefficients at Hot Zero Power **(HZP, zero xenon)** conditions (unit: pcm/K). **The calculations are performed on the simplified 2D core configuration (2D radial).** The reference state for this calculation is an isothermal reactor at nominal temperature:

- *Tparticles = 1130 K*
- *Tmoderator in the core cavity = 1080 K*
- *Treflector = 900 K*

The temperature reactivity coefficients should be calculated for:

8.2.1. Fuel particles

0 MWJ/t	-2,000

320 MWJ/t -1,984
640 MWJ/t -1,725

8.2.2. Moderator in the core cavity (fuel element matrix & compact matrix)
0 MWJ/t -4,383
320 MWJ/t -2,899
640 MWJ/t -3,097

8.2.3. Reflectors
0 MWJ/t 0,780
320 MWJ/t 1,368
640 MWJ/t 2,672

8.3. Temperature reactivity coefficients at Hot Full Power (HFP or nominal, equilibrium xenon) conditions (units: pcm/K). The calculations are performed on the simplified 2D core configuration (2D radial). The reference state for this calculation is an isothermal reactor at nominal temperature:

- *Tparticles = 1130 K*
- *Tmoderator in the core cavity = 1080 K*
- *Treflector = 900 K*

8.3.1. Coated particles (per coated particle type)

8.3.1. Fuel particles
0 MWJ/t -1,984
320 MWJ/t -2,042
640 MWJ/t -2,216

8.3.2. Moderator in the core cavity (fuel element matrix & compact matrix)
0 MWJ/t -4,378
320 MWJ/t -3,602
640 MWJ/t -1,922

8.3.3. Reflectors
0 MWJ/t +1,501
320 MWJ/t +1,699
640 MWJ/t +2,118

8.4. Differences in reactivity (units: pcm) between:
8.4.1. CZP (zero xenon) state and HZP (zero xenon) state
Not Evaluated
8.4.2. CZP (zero xenon) state and HFP (equilibrium xenon) state
Not Evaluated

9. APPENDIX 2

0. Case identification and description.

0.1. Origin
F. Damian
0.2. Organisation
CEA
0.3. Case number
Pu2
0.4.. Date
July 2004
0.5. Applied code system
SAPHYR (APOLLO2 – CRONOS2)

1. General fuel/reactor/system specifications. This section is intended as a compl ete description of the fuel, the reactor (system) and the applied fuel loading and discharge scheme

1.1. System (part) under consideration (reactor)
GT-MHR 600 MWth
1.2. Main system dimensions

Height of active zone	8 m
Equivalent diameter of active zone	2.96 / 4.84 m
Height of axial reflectors	1.3 m

1.3. Coated particle dimensions (kernel and coatings) (per coated particle type)

Particle composition	Material	Density	External radius
Central zone (kernel)	PuOx	10.0	100
Buffer	Graphite	1.0	200
Pyrocarbon	Graphite	1.8	235
Silicon carbide	SiC	3.2	270
Pyrocarbon	Graphite	1.8	315

1.4. Initial coated particle composition per nuclide per material zone (units: $(\text{barn cm})^{-1}$) (per coated particle type; including impurities)

Central zone (kernel)

O16	*4.4248E-02*
PU238	*1.0939E-03*
PU239	*5.9801E-03*
PU240	*7.5934E-03*
PU241	*3.3730E-03*
PU242	*4.0836E-03*

Buffer

GRAPH	*5.0138E-02*

Pyrocarbon

GRAPH	*9.0248E-02*

Silicon Carbide

SINAT	4.8061E-02

CNAT 4.8061E-02

Pyrocarbon

GRAPH 9.0248E-02

1.5. Compact dimensions

Radius : 0,6225 cm – Height : 4,978 cm

1.6. Compact/pebble composition per nuclide (outside coated particles; including impurities) (units: (barn cm)"1)

Graphite Matrix

GRAPH 8.7240E-02

B10 1.9193E-08

B11 7.6771E-08

1.7. Block composition per nuclide (outside coated particles; including impurities) (units: $(\text{barn cm})^{-1}$)

Graphite Matrix

GRAPH 8.7240E-02

B10 1.9193E-08

B11 7.6771E-08

1.8. Number of coated particles per compact (of each coated particle type)

7895 coated fuel particles

1.9. Operating cycle length (units: full power days)

3 × 235 EFPD

1.10. Reload stop duration (units: days) (may be 0 in case of continuous reload, in which case EOL coincides with the end of the Operating cycle)

Loading factor : 0,85

1.11. Nominal reactor power (units: MW)

600 MWth

1.12. Capacity factor (units : -)

Not Evaluated

1.13. Number of fuel batches (batch wise reload only)

3

1.14. Nominal coolant inlet temperature (units: K)

763 K

1.15. Nominal coolant inlet pressure (units: Pa)

7 MPa

1.16. Nominal coolant outlet temperature at nominal (Hot Full Power, HFP) conditions (units: K)

1123 K

1.17. Nominal coolant outlet pressure at nominal (Hot Full Power, HFP) conditions (units: Pa)

Not Evaluated

1.18. Nominal coolant mass flow (unit: kg/s)

320 kg/s

1.19. Description of the fuel cycle strategy and other relevant information on the specified case.

Three batches loading scheme

720 standard fuel elements

300 control fuel elements

2. Rating and power density

2.1. Power produced per coated particle (per coated particle type) (units: W):

$18{,}29\ 10^{-3}$ W

2.1.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.1.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

2.2. Power produced per compact (units: W)

192,5 W

2.2.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.2.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

2.3. Power produced per unit heavy metal mass (units: W/kg)

0,5 W/kg

2.3.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.3.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

2.4. Power density in the core (units: W/cm^3)

6,6 W/cm^3

2.4.1. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

2.4.2. Maximum value anywhere in the core as function of time over the operating cycle

Not Evaluated

3. Core inventory

3.1. Amount of each of the heavy metal isotopes present in the fuel element (units: kg)

900 kg of HM in the core

0,935 kg of HM in the standard fuel element

0,753 kg of HM in the control fuel element

3.1.1. At BOL ***(kg, normalised to the total core inventory)***

Burnup 0 MWd/t

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00		
4.410036E+01	2.421019E+02	3.087024E+02	1.377011E+02
1.674013E+02			
0.000000E+00	0.000000E+00	0.000000E+00	
0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0.000000E+00	0.000000E+00	0.000000E+00	

3.1.2. At MOL *(kg, normalised to the total core inventory)*

Burnup 235 MWd/t

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

2.747091E-01	3.399320E-02	2.418981E-02	2.948779E-04
4.995061E-03	2.521078E-05		
3.830948E+01	7.969750E+01	1.841840E+02	1.712267E+02
1.677586E+02			
4.869320E+00	1.131421E-01	2.914241E+01	
1.314193E+00	1.716119E-02	8.358744E+00	4.998321E-01
1.376637E-02	8.644501E-05	2.253955E-06	

3.1.3. At EOL *(kg, normalised to the total core inventory)*

Burnup 470 MWd/t

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

4.440980E-01	9.793222E-02	3.958552E-02	6.170115E-04
1.203000E-02	4.149065E-05		
3.214434E+01	1.180531E+01	6.684204E+01	9.060186E+01
1.851818E+02			
3.745216E+00	9.089502E-02	4.747539E+01	
3.278407E+00	8.308110E-02	2.753794E+01	2.301991E+00
2.486774E-01	2.788196E-03	1.876736E-04	

3.2. Fissile Pu fraction, i.e. amount of (^{239}Pu and ^{241}Pu) divided by the total amount of Pu (units: %) (this can be derived from 3.1)

3.2.1.AtBOL

Burnup 0 MWd/t

42,2 % in Fissile Pu

3.2.2. At MOL

Burnup 235 MWd/t

39,1 % in Fissile Pu

3.2.3. At EOL

Burnup 470 MWd/t

26,5 % in Fissile Pu

4. Fuel (actinide) consumption, actinide and fission product production and discharge burnup at nominal conditions. A list of nuclides under consideration is presented in section 4.

4.1. Amount and composition of fresh fuel loaded into the system for one operating cycle (per heavy metal nuclide) divided by the operating cycle length (units:kg/year) ***(normalised to the total core inventory)***

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	**Pu^{239}**	**Pu^{240}**	**Pu^{241}**
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

0,0	0,0	0,0	0,0
0,0	0,0		
19,40	**106,54**	**135,8**	**60,6**
73,6			
0,0	0,0	0,0	
0,0	0,0	0,0	0,0
0,0	0,0	0,0	

4.2. Amount and composition of fuel discharged from (and not reloaded into) the System for one operating cycle (per heavy metal and fission product nuclide) divided by the operating cycle length (units: kg/year) ***(normalised to the total core inventory)***

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	**Pu^{239}**	**Pu^{240}**	**Pu^{241}**
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

0,19	***	***	***
***	***		
14,14	**5,19**	**29,41**	**39,87**
81,50			
1,64	***	20,9	
1,44	***	12,1	1,01
0,11	***	***	

4.3. Balance of heavy metal and fission products, i.e. the difference between corresponding items 4.1 and 4.2, divided by nominal thermal power times capacity factor (units: kg/MWd)

U^{234}	U^{235}	U^{236}	U^{238}
Np^{237}	Np^{239}		
Pu^{238}	Pu^{239}	Pu^{240}	Pu^{241}
Pu^{242}			
Am^{241}	Am^{242M}	Am^{243}	
Cm^{242}	Cm^{243}	Cm^{244}	Cm^{245}
Cm^{246}	Cm^{247}	Cm^{248}	

+ 10,04 10^{-7}	***	***	***
***	***		
– 2,8 10^{-5}	– 5,4 10^{-4}	– 6,2 10^{-4}	– 1,1 10^{-4}
+ 4,2 10^{-5}			
– 8,8 10^{-6}	***	+ 1,1 10^{-4}	
+ 7,7 10^{-6}	***	+ 6,5 10^{-5}	+ 5,4$10^{-6}$
***	***	***	

4.4. Attained discharged burnup of the fuel (units: MWd/kg)

470 MWd/kg HM

4.4.1. Minimum value

Not Evaluated

4.4.2. Average value

Not Evaluated

4.4.3. Maximum value

Not Evaluated

5. Reaction rates at nominal conditions

5.1. Neutron induced fission rate per heavy metal nuclide in the entire System (units: $s^{-1}.cm^{-3}$ of core)

5.1.1.AtBOL

Burnup 0 MWd/t

PU238	5.6892E+13
PU239	1.6547E+16
PU240	7.1510E+13
PU241	9.0146E+15
PU242	2.4714E+13

5.1.2. At MOL

Burnup 235 MWd/t

U234	5.3398E+10
U235	1.0977E+12
U236	4.5319E+09
U237	1.0557E+08
U238	8.5689E+06

NP237	8.3757E+08
NP238	1.6698E+09
NP239	4.9800E+06
PU236	1.9891E+04
PU238	5.8953E+13
PU239	8.6069E+15
PU240	4.5728E+13
PU241	1.6573E+16
PU242	2.5909E+13
AM241	4.9241E+12
AM242M	5.4916E+13
AM243	4.5020E+12
CM242	7.8846E+11
CM243	1.1883E+12
CM244	4.7197E+12
CM245	4.2442E+13
CM246	3.6592E+09
CM247	1.9463E+09
CM248	9.0534E+05

5.1.3.AtEOL

Burnup 470 MWd/t

U234	1.0837E+11
U235	7.2134E+12
U236	8.3407E+09
U237	2.1918E+08
U238	1.9962E+07
NP237	2.2385E+09
NP238	1.4580E+10
NP239	9.0160E+06
PU236	1.8516E+05
PU238	8.2375E+13
PU239	3.1500E+15
PU240	1.9486E+13
PU241	2.1310E+16
PU242	3.1638E+13
AM241	7.6131E+12
AM242M	1.1117E+14
AM243	8.2982E+12
CM242	3.4914E+12
CM243	9.1732E+12
CM244	1.8898E+13
CM245	4.5085E+14
CM246	7.4559E+10
CM247	1.0145E+11
CM248	8.4679E+07

5.2. Neutron **absorption rate for all (heavy metal, fission product and possibly burnable poison) nuclides present in the kernels** of all coated particles **(units: $s^{-1}.cm^{-3}$ of core)** (per nuclide)

5.2.1.AtBOL

Burnup 0 MWd/t

PU238	6.9094E+14
PU239	2.6600E+16
PU240	1.8824E+16
PU241	1.2116E+16
PU242	3.2310E+15
O16	1.6042E+12

5.2.2. At MOL

Burnup 235 MWd/t

U234	6.2438E+12
U235	1.3760E+12
U236	2.4381E+11
U237	3.4469E+09
U238	2.4053E+09
NP237	1.8111E+11
NP238	1.8410E+09
NP239	3.7187E+08
PU236	3.9343E+04
PU238	8.4782E+14
PU239	1.3859E+16
PU240	1.5946E+16
PU241	2.2377E+16
PU242	3.4191E+15
AM241	5.9613E+14
AM242M	6.7249E+13
AM243	1.4744E+15
CM242	6.1471E+12
CM243	1.3952E+12
CM244	1.5267E+14
CM245	4.8861E+13
CM246	4.3074E+10
CM247	3.2305E+09
CM248	1.6632E+07
ZR95PF	4.6346E+11
ZR96PF	1.8023E+12
NB95PF	2.7621E+12
MO95PF	2.2385E+13
MO96PF	6.3618E+10
MO97PF	6.8483E+12
MO98PF	2.7724E+12
MO99PF	1.3177E+11
MO100PF	1.9032E+12
TC99PF	1.1094E+14

RU101PF	4.4482E+13
RU102PF	2.2348E+12
RU103PF	4.6998E+13
RU104PF	2.8750E+12
RU105PF	2.4193E+09
RU106PF	6.2014E+11
RH103PF	3.4036E+14
RH105PF	4.9191E+13
PD105PF	4.4922E+13
PD106PF	7.7263E+11
PD107PF	2.9033E+13
PD108PF	3.5545E+13
AG109PF	1.6634E+14
I131PF	6.7504E+10
I135PF	2.1376E+07
XE131PF	1.7884E+14
XE132PF	7.9945E+11
XE133PF	5.7505E+12
XE135PF	1.1900E+15
XE136PF	2.4113E+11
CS133PF	1.7448E+14
CS134PF	7.1217E+12
CS135PF	1.8061E+13
CS136PF	1.7488E+10
CS137PF	3.6342E+11
TE127MPF	1.3579E+11
I127PF	4.6772E+12
TE129MPF	1.6240E+10
I129PF	6.9376E+12
CE141PF	8.9664E+12
PR141PF	9.8010E+12
CE144PF	7.8726E+11
PR143PF	4.9866E+12
ND143PF	1.4783E+14
ND144PF	9.5683E+11
ND145PF	5.3091E+13
ND146PF	8.8460E+11
ND147PF	7.5854E+12
ND148PF	2.8429E+12
ND150PF	1.2498E+12
PM147PF	1.8862E+14
PM148PF	2.2874E+13
PM148MPF	8.9752E+13
PM149PF	3.0367E+12
PM151PF	7.3815E+11
SM147PF	9.6228E+12

SM148PF	6.2875E+11
SM149PF	5.3915E+14
SM150PF	4.3681E+13
SM151PF	2.6704E+14
SM152PF	1.6900E+14
SM153PF	2.1240E+12
SM154PF	1.0543E+12
EU153PF	7.6344E+13
EU154PF	2.3826E+13
EU155PF	1.1171E+14
EU156PF	5.1358E+12
EU157PF	5.4967E+10
GD154PF	7.1785E+10
GD155PF	4.1418E+12
GD156PF	2.7609E+12
GD157PF	7.3504E+13
KR83PF	7.0501E+12
ZR93PF	8.0139E+12
CD113PF	3.7326E+13
IN115PF	8.7381E+12
LA139PF	8.2998E+12
O16	1.7269E+12

5.2.3.AtEOL

Burnup 470 MWd/t

U234	1.4106E+13
U235	8.7628E+12
U236	4.5612E+11
U237	1.0003E+10
U238	5.7262E+09
NP237	7.3796E+11
NP238	1.6058E+10
NP239	7.8678E+08
PU236	3.6777E+05
PU238	1.6509E+15
PU239	5.0644E+15
PU240	1.1877E+16
PU241	2.8884E+16
PU242	4.3239E+15
AM241	9.8489E+14
AM242M	1.3654E+14
AM243	2.9626E+15
CM242	2.1762E+13
CM243	1.0833E+13
CM244	5.7640E+14
CM245	5.1843E+14
CM246	8.9278E+11

CM247	1.6884E+11
CM248	1.5747E+09
ZR95PF	5.2075E+11
ZR96PF	3.9130E+12
NB95PF	3.1497E+12
MO95PF	7.5526E+13
MO96PF	4.1015E+11
MO97PF	1.7850E+13
MO98PF	6.1974E+12
MO99PF	1.5533E+11
MO100PF	4.4504E+12
TC99PF	2.6136E+14
RU101PF	1.0198E+14
RU102PF	7.5507E+12
RU103PF	6.2204E+13
RU104PF	7.0057E+12
RU105PF	2.7433E+09
RU106PF	1.2213E+12
RH103PF	9.6772E+14
RH105PF	9.0209E+13
PD105PF	1.3093E+14
PD106PF	3.1352E+12
PD107PF	6.8690E+13
PD108PF	9.1114E+13
AG109PF	3.7629E+14
I131PF	7.9101E+10
I135PF	4.6386E+07
XE131PF	3.9100E+14
XE132PF	2.5719E+12
XE133PF	1.0020E+13
XE135PF	1.4968E+15
XE136PF	1.0860E+12
CS133PF	4.0604E+14
CS134PF	5.6940E+13
CS135PF	4.0870E+13
CS136PF	3.3632E+10
CS137PF	1.0426E+12
TE127MPF	2.2983E+11
I127PF	1.1579E+13
TE129MPF	2.2808E+10
I129PF	2.8268E+13
CE141PF	1.2637E+13
PR141PF	3.8368E+13
CE144PF	1.8745E+12
PR143PF	8.4837E+12
ND143PF	6.1694E+14

ND144PF	6.8826E+12
ND145PF	1.4719E+14
ND146PF	3.2581E+12
ND147PF	1.4420E+13
ND148PF	7.6665E+12
ND150PF	3.1700E+12
PM147PF	3.3162E+14
PM148PF	5.2152E+13
PM148MPF	1.7308E+14
PM149PF	8.5750E+12
PM151PF	1.2437E+12
SM147PF	3.4802E+13
SM148PF	2.7621E+12
SM149PF	6.2920E+14
SM150PF	1.5509E+14
SM151PF	4.4135E+14
SM152PF	3.9123E+14
SM153PF	5.0419E+12
SM154PF	3.3487E+12
EU153PF	2.7276E+14
EU154PF	1.6585E+14
EU155PF	2.9020E+14
EU156PF	1.7334E+13
EU157PF	1.0785E+11
GD154PF	9.5649E+11
GD155PF	5.1906E+12
GD156PF	9.8446E+12
GD157PF	9.9833E+13
KR83PF	2.4775E+13
ZR93PF	1.8521E+13
CD113PF	3.8479E+13
IN115PF	1.5754E+13
LA139PF	3.1056E+13
O16	2.0051E+12

5.3. Neutron absorption rate in all other material in the core cavity (units: s^{-1}) (per nuclide, including burnable poison if present)

5.3.1.AtBOL

Not Evaluated

5.3.2. At MOL

Not Evaluated

5.3.3. AtEOL

Not Evaluated

5.4. Net neutron leakage rate from the core cavity (units: s"¹)

5.2.1.At BOL

Burnup 0 MWd/t

9600 pcm (2D radial leakage)

5.2.2. At MOL

Burnup 235 MWd/t

9960 pcm (2D radial leakage)

5.2.3.AtEOL

Burnup 470 MWd/t

11590 pcm (2D radial leakage)

6. Fast and thermal neutron flux (fluence rate) and fluence measures at nominal conditions

6.1. Thermal flux below **1.84 eV** (units: $cm^{-2}.s^{-1}$). The items listed below should be calculated at BOL, MOL and EOL.

6.1.1. Average value in the core

$8,42.10^{14}$ $cm^{-2}.s^{-1}$ (MOL 235 GWd/t)

6.1.2. Peak value in the core

$1,54.10^{15}$ $cm^{-2}.s^{-1}$ (MOL 235 GWd/t)

6.1.3. Average value in the reflector

$1,58.10^{15}$ $cm^{-2}.s^{-1}$ (MOL 235 GWd/t)

6.1.4. Peak value in the reflector

$3,3.10^{15}$ $cm^{-2}.s^{-1}$ (MOL 235 GWd/t)

6.1.5. Axial distribution of the thermal flux along the centre axis

Not Evaluated

6.1.6. Radial distribution of the thermal flux at half core height

At BOL

Burnup 0 MWd/t

.295200E+01	1.5775E+15
.885600E+01	1.5868E+15
.147600E+02	1.6054E+15
.206640E+02	1.6335E+15
.265680E+02	1.6711E+15
.324720E+02	1.7184E+15
.383760E+02	1.7756E+15
.442800E+02	1.8430E+15
.501840E+02	1.9208E+15
.560880E+02	2.0093E+15
.619920E+02	2.1088E+15
.678960E+02	2.2193E+15
.738000E+02	2.3410E+15
.797040E+02	2.4734E+15
.856080E+02	2.6156E+15
.915120E+02	2.7655E+15
.974160E+02	2.9191E+15
.103320E+03	3.0692E+15
.109224E+03	3.2044E+15
.115128E+03	3.3063E+15
.121032E+03	3.3480E+15
.126936E+03	3.2920E+15

.132840E+03	3.0905E+15
.138744E+03	2.6874E+15
.144648E+03	2.0214E+15
.149474E+03	1.3446E+15
.153222E+03	1.0227E+15
.156970E+03	8.3450E+14
.160718E+03	7.2368E+14
.164466E+03	6.5916E+14
.168214E+03	6.2208E+14
.171962E+03	6.0090E+14
.175710E+03	5.8860E+14
.179458E+03	5.8097E+14
.183206E+03	5.7554E+14
.186954E+03	5.7094E+14
.190702E+03	5.6640E+14
.194450E+03	5.6157E+14
.198198E+03	5.5637E+14
.201946E+03	5.5091E+14
.205694E+03	5.4553E+14
.209442E+03	5.4094E+14
.213190E+03	5.3836E+14
.216938E+03	5.3991E+14
.220686E+03	5.4907E+14
.224434E+03	5.7146E+14
.228182E+03	6.1610E+14
.231930E+03	6.9733E+14
.235678E+03	8.3821E+14
.239426E+03	1.0801E+15
.243830E+03	1.5391E+15
.248890E+03	1.9503E+15
.253950E+03	2.1830E+15
.259010E+03	2.2792E+15
.264070E+03	2.2751E+15
.270370E+03	2.1727E+15
.277910E+03	1.9757E+15
.285450E+03	1.7384E+15
.292990E+03	1.4906E+15
.300530E+03	1.2471E+15
.308070E+03	1.0144E+15
.315610E+03	7.9384E+14
.323150E+03	5.8497E+14
.330690E+03	3.8611E+14
.338230E+03	1.9479E+14
.343375E+03	4.8141E+13
.346125E+03	8.6088E+12

Burnup 235 MWd/t

.295200E+01	1.5199E+15
.885600E+01	1.5288E+15
.147600E+02	1.5469E+15
.206640E+02	1.5740E+15
.265680E+02	1.6104E+15
.324720E+02	1.6561E+15
.383760E+02	1.7115E+15
.442800E+02	1.7768E+15
.501840E+02	1.8522E+15
.560880E+02	1.9380E+15
.619920E+02	2.0345E+15
.678960E+02	2.1418E+15
.738000E+02	2.2601E+15
.797040E+02	2.3890E+15
.856080E+02	2.5278E+15
.915120E+02	2.6746E+15
.974160E+02	2.8260E+15
.103320E+03	2.9756E+15
.109224E+03	3.1132E+15
.115128E+03	3.2222E+15
.121032E+03	3.2783E+15
.126936E+03	3.2472E+15
.132840E+03	3.0847E+15
.138744E+03	2.7381E+15
.144648E+03	2.1493E+15
.149474E+03	1.5427E+15
.153222E+03	1.2386E+15
.156970E+03	1.0486E+15
.160718E+03	9.2931E+14
.164466E+03	8.5504E+14
.168214E+03	8.0927E+14
.171962E+03	7.8116E+14
.175710E+03	7.6366E+14
.179458E+03	7.5224E+14
.183206E+03	7.4405E+14
.186954E+03	7.3733E+14
.190702E+03	7.3109E+14
.194450E+03	7.2482E+14
.198198E+03	7.1836E+14
.201946E+03	7.1187E+14
.205694E+03	7.0585E+14
.209442E+03	7.0121E+14
.213190E+03	6.9948E+14
.216938E+03	7.0308E+14
.220686E+03	7.1571E+14

.224434E+03	7.4297E+14
.228182E+03	7.9320E+14
.231930E+03	8.7884E+14
.235678E+03	1.0186E+15
.239426E+03	1.2440E+15
.243830E+03	1.6507E+15
.248890E+03	2.0080E+15
.253950E+03	2.2010E+15
.259010E+03	2.2695E+15
.264070E+03	2.2473E+15
.270370E+03	2.1327E+15
.277910E+03	1.9305E+15
.285450E+03	1.6942E+15
.292990E+03	1.4505E+15
.300530E+03	1.2126E+15
.308070E+03	9.8583E+14
.315610E+03	7.7133E+14
.323150E+03	5.6830E+14
.330690E+03	3.7507E+14
.338230E+03	1.8921E+14
.343375E+03	4.6761E+13
.346125E+03	8.3616E+12

AtEOL

Burnup 470 MWd/t

.295200E+01	1.5440E+15
.885600E+01	1.5531E+15
.147600E+02	1.5713E+15
.206640E+02	1.5988E+15
.265680E+02	1.6358E+15
.324720E+02	1.6825E+15
.383760E+02	1.7394E+15
.442800E+02	1.8068E+15
.501840E+02	1.8852E+15
.560880E+02	1.9750E+15
.619920E+02	2.0766E+15
.678960E+02	2.1905E+15
.738000E+02	2.3169E+15
.797040E+02	2.4558E+15
.856080E+02	2.6069E+15
.915120E+02	2.7687E+15
.974160E+02	2.9386E+15
.103320E+03	3.1115E+15
.109224E+03	3.2786E+15
.115128E+03	3.4263E+15
.121032E+03	3.5333E+15
.126936E+03	3.5698E+15

.132840E+03	3.4964E+15
.138744E+03	3.2648E+15
.144648E+03	2.8194E+15
.149474E+03	2.3351E+15
.153222E+03	2.0685E+15
.156970E+03	1.8840E+15
.160718E+03	1.7556E+15
.164466E+03	1.6670E+15
.168214E+03	1.6061E+15
.171962E+03	1.5642E+15
.175710E+03	1.5350E+15
.179458E+03	1.5140E+15
.183206E+03	1.4978E+15
.186954E+03	1.4843E+15
.190702E+03	1.4722E+15
.194450E+03	1.4607E+15
.198198E+03	1.4494E+15
.201946E+03	1.4388E+15
.205694E+03	1.4294E+15
.209442E+03	1.4226E+15
.213190E+03	1.4203E+15
.216938E+03	1.4251E+15
.220686E+03	1.4408E+15
.224434E+03	1.4725E+15
.228182E+03	1.5267E+15
.231930E+03	1.6124E+15
.235678E+03	1.7414E+15
.239426E+03	1.9323E+15
.243830E+03	2.2488E+15
.248890E+03	2.5058E+15
.253950E+03	2.6167E+15
.259010E+03	2.6191E+15
.264070E+03	2.5444E+15
.270370E+03	2.3798E+15
.277910E+03	2.1319E+15
.285450E+03	1.8609E+15
.292990E+03	1.5890E+15
.300530E+03	1.3268E+15
.308070E+03	1.0783E+15
.315610E+03	8.4367E+14
.323150E+03	6.2169E+14
.330690E+03	4.1038E+14
.338230E+03	2.0704E+14
.343375E+03	5.1171E+13
.346125E+03	9.1499E+12

6.2. ^{59}Co(n,y) reaction rate of a 10"'° (barn cm)"1 trace of ^{59}Co in all materials in the core and reflector. This is a measure of the thermal flux below ~1 eV, which is independent of the energy group structure employed in the calculations. The items listed below should be calculated at BOL, MOL and EOL.

Not Evaluated

6.2.1. Total reaction rate in the core (units: s"1)

Not Evaluated

6.2.2. Total reaction rate in the reflector (units: s"1)

Not Evaluated

6.2.3. Peak value of the reaction rate density in the core (units: s^m"3)

Not Evaluated

6.2.4. Peak value of the reaction rate density in the reflector (units: s'W3)

Not Evaluated

6.2.5. Axial distribution of the reaction rate density along the centre axis (units: s'W3)

Not Evaluated

6.2.6. Radial distribution of the reaction rate density at half core height (units: s'W3)

Not Evaluated

6.3. Fast flux (fluence rate) above **0.11 MeV** (units: **cm^{-2}.s^{-1}**). The items listed below should be calculated at BOL, MOL and EOL.

6.3.1. Average value in the core

8,59.10^{14} cm^{-2}.s^{-1} (MOL 235 GWd/t)

6.3.2. Peak value in the core

9,80.10^{14} cm^{-2}.s^{-1} (MOL 235 GWd/t)

6.3.3. Average value in the reflector

5,53.10^{13} cm^{-2}.s^{-1} (MOL 235 GWd/t)

6.3.4. Peak value in the reflector

5,4.10^{14} cm^{-2}.s^{-1} (MOL 235 GWd/t)

6.3.5. Axial distribution of the fast flux along the centre axis

Not Evaluated

6.3.6. Radial distribution of the fast flux at half core height

At BOL

Burnup 0 MWd/t

.295200E+01	4.8968E+09
.885600E+01	5.6698E+09
.147600E+02	7.2592E+09
.206640E+02	1.0007E+10
.265680E+02	1.4511E+10
.324720E+02	2.1773E+10
.383760E+02	3.3471E+10
.442800E+02	5.2406E+10
.501840E+02	8.3297E+10
.560880E+02	1.3418E+11
.619920E+02	2.1890E+11
.678960E+02	3.6159E+11
.738000E+02	6.0488E+11
.797040E+02	1.0249E+12
.856080E+02	1.7594E+12

.915120E+02	3.0591E+12
.974160E+02	5.3841E+12
.103320E+03	9.5823E+12
.109224E+03	1.7216E+13
.115128E+03	3.1154E+13
.121032E+03	5.6624E+13
.126936E+03	1.0303E+14
.132840E+03	1.8698E+14
.138744E+03	3.3732E+14
.144648E+03	6.1105E+14
.149474E+03	9.4046E+14
.153222E+03	1.0423E+15
.156970E+03	1.0626E+15
.160718E+03	1.0510E+15
.164466E+03	1.0269E+15
.168214E+03	1.0000E+15
.171962E+03	9.7454E+14
.175710E+03	9.5222E+14
.179458E+03	9.3335E+14
.183206E+03	9.1764E+14
.186954E+03	9.0463E+14
.190702E+03	8.9390E+14
.194450E+03	8.8512E+14
.198198E+03	8.7816E+14
.201946E+03	8.7305E+14
.205694E+03	8.6998E+14
.209442E+03	8.6923E+14
.213190E+03	8.7108E+14
.216938E+03	8.7561E+14
.220686E+03	8.8237E+14
.224434E+03	8.8975E+14
.228182E+03	8.9395E+14
.231930E+03	8.8721E+14
.235678E+03	8.5414E+14
.239426E+03	7.5661E+14
.243830E+03	4.9959E+14
.248890E+03	2.9126E+14
.253950E+03	1.7108E+14
.259010E+03	9.9939E+13
.264070E+03	5.8149E+13
.270370E+03	3.0138E+13
.277910E+03	1.3362E+13
.285450E+03	5.9717E+12
.292990E+03	2.7033E+12
.300530E+03	1.2434E+12
.308070E+03	5.8194E+11

.315610E+03	2.7699E+11
.323150E+03	1.3378E+11
.330690E+03	6.5252E+10
.338230E+03	3.1922E+10
.343375E+03	1.8589E+10
.346125E+03	1.0906E+10

At MOL

Burnup 235 MWd/t

.295200E+01	4.4360E+09
.885600E+01	5.1344E+09
.147600E+02	6.5697E+09
.206640E+02	9.0496E+09
.265680E+02	1.3110E+10
.324720E+02	1.9651E+10
.383760E+02	3.0175E+10
.442800E+02	4.7186E+10
.501840E+02	7.4896E+10
.560880E+02	1.2046E+11
.619920E+02	1.9618E+11
.678960E+02	3.2345E+11
.738000E+02	5.3999E+11
.797040E+02	9.1306E+11
.856080E+02	1.5639E+12
.915120E+02	2.7133E+12
.974160E+02	4.7658E+12
.103320E+03	8.4664E+12
.109224E+03	1.5188E+13
.115128E+03	2.7456E+13
.121032E+03	4.9880E+13
.126936E+03	9.0784E+13
.132840E+03	1.6495E+14
.138744E+03	2.9822E+14
.144648E+03	5.4157E+14
.149474E+03	8.3620E+14
.153222E+03	9.4116E+14
.156970E+03	9.7537E+14
.160718E+03	9.7826E+14
.164466E+03	9.6661E+14
.168214E+03	9.4928E+14
.171962E+03	9.3088E+14
.175710E+03	9.1355E+14
.179458E+03	8.9814E+14
.183206E+03	8.8480E+14
.186954E+03	8.7338E+14
.190702E+03	8.6367E+14
.194450E+03	8.5547E+14

.198198E+03	8.4870E+14
.201946E+03	8.4336E+14
.205694E+03	8.3954E+14
.209442E+03	8.3736E+14
.213190E+03	8.3685E+14
.216938E+03	8.3774E+14
.220686E+03	8.3920E+14
.224434E+03	8.3928E+14
.228182E+03	8.3410E+14
.231930E+03	8.1652E+14
.235678E+03	7.7350E+14
.239426E+03	6.7481E+14
.243830E+03	4.4419E+14
.248890E+03	2.5846E+14
.253950E+03	1.5150E+14
.259010E+03	8.8378E+13
.264070E+03	5.1390E+13
.270370E+03	2.6636E+13
.277910E+03	1.1821E+13
.285450E+03	5.2925E+12
.292990E+03	2.4016E+12
.300530E+03	1.1077E+12
.308070E+03	5.1988E+11
.315610E+03	2.4814E+11
.323150E+03	1.2015E+11
.330690E+03	5.8736E+10
.338230E+03	2.8788E+10
.343375E+03	1.6779E+10
.346125E+03	9.8472E+09

AtEOL

Burnup 470 MWd/t

.295200E+01	3.7955E+09
.885600E+01	4.3918E+09
.147600E+02	5.6166E+09
.206640E+02	7.7314E+09
.265680E+02	1.1191E+10
.324720E+02	1.6760E+10
.383760E+02	2.5707E+10
.442800E+02	4.0150E+10
.501840E+02	6.3636E+10
.560880E+02	1.0218E+11
.619920E+02	1.6610E+11
.678960E+02	2.7328E+11
.738000E+02	4.5517E+11
.797040E+02	7.6770E+11
.856080E+02	1.3115E+12

.915120E+02	2.2693E+12
.974160E+02	3.9755E+12
.103320E+03	7.0455E+12
.109224E+03	1.2613E+13
.115128E+03	2.2765E+13
.121032E+03	4.1319E+13
.126936E+03	7.5190E+13
.132840E+03	1.3671E+14
.138744E+03	2.4761E+14
.144648E+03	4.5024E+14
.149474E+03	6.9715E+14
.153222E+03	8.0606E+14
.156970E+03	8.6156E+14
.160718E+03	8.8883E+14
.164466E+03	8.9961E+14
.168214E+03	9.0099E+14
.171962E+03	8.9728E+14
.175710E+03	8.9105E+14
.179458E+03	8.8376E+14
.183206E+03	8.7621E+14
.186954E+03	8.6876E+14
.190702E+03	8.6160E+14
.194450E+03	8.5477E+14
.198198E+03	8.4829E+14
.201946E+03	8.4212E+14
.205694E+03	8.3618E+14
.209442E+03	8.3029E+14
.213190E+03	8.2407E+14
.216938E+03	8.1679E+14
.220686E+03	8.0715E+14
.224434E+03	7.9296E+14
.228182E+03	7.7066E+14
.231930E+03	7.3461E+14
.235678E+03	6.7570E+14
.239426E+03	5.7444E+14
.243830E+03	3.7704E+14
.248890E+03	2.1923E+14
.253950E+03	1.2829E+14
.259010E+03	7.4765E+13
.264070E+03	4.3462E+13
.270370E+03	2.2538E+13
.277910E+03	1.0018E+13
.285450E+03	4.4962E+12
.292990E+03	2.0464E+12
.300530E+03	9.4702E+11
.308070E+03	4.4596E+11

.315610E+03	2.1353E+11
.323150E+03	1.0369E+11
.330690E+03	5.0814E+10
.338230E+03	2.4954E+10
.343375E+03	1.4557E+10
.346125E+03	8.5459E+09

6.4. ^{58}Ni(n,p) reaction rate of a 10~^{10} (barn cm)"^{1} trace of ^{5S}Ni in all materials in the core and reflector. This is a measure of the fast flux above ~2 MeV, which is independent of the energy group structure employed in the calculations. The items listed below should be calculated at BOL, MOL and EOL.

Not Evaluated

6.4.1. Total reaction rate in the core (units: s"^{1})

Not Evaluated

6.4.2. Total reaction rate in the reflector (units: s"^{1})

Not Evaluated

6.4.3. Peak value of the reaction rate density in the core (units: s'W^{3})

Not Evaluated

6.4.4. Peak value of the reaction rate density in the reflector (units: s"'m"^{3})

Not Evaluated

6.4.5. Axial distribution of the reaction rate density along the centre axis (units: s'W^{3})

Not Evaluated

6.4.6. Radial distribution of the reaction rate density at half core height (units: s"'m"^{3})

Not Evaluated

6.5. Fast fluence above 0.1 MeV of discharged fuel (kernel, coatings, matrix) (units: m"^{2})

6.5.1. Minimum value

6.5.2. Average value

3,16 10^{21} cm^{-2} = 3,16 n/kbarn

6.5.3. Maximum value

~ 7,9 10^{21} cm^{-2} ~ 7,9 n/kbarn (taking a 3D peaking factor of 2,5)

7. Temperatures at nominal conditions

7.1. Coated particle temperature (units: K)

1130 K

7.1.1. Maximum value occurring anywhere in the core at BOL

Not Evaluated

7.1.2. Maximum value occurring anywhere in the core at EOL

Not Evaluated

7.1.3. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

7.2. Compact and fuel element matrix temperature (units: K)

1080 K

7.2.1. Maximum value occurring anywhere in the core at BOL

Not Evaluated

7.2.2. Maximum value occurring anywhere in the core at EOL

Not Evaluated

7.2.3. Maximum value occurring anywhere in the core at any time during the operating cycle

Not Evaluated

8. Temperature reactivity coefficients. The perturbed state has "frozen" thermal hydraulics and the same nuclide concentrations as the reference state anywhere in the System. The local temperature of the System part (fuel, moderator, reflector) for which the temperature reactivity coefficient is to be calculated is increased by AT= 50 K *(k_{Mta})*, while the temperature of the remainder of the System is at the same temperature as in the reference state. The temperature reactivity coefficient *(a)* is subsequently calculated as:

$$a = (1/k_1 - 1/k_2) / (T_2 - T_1) \text{ (units: pcm/K)}$$

The following items should be calculated as function of time over the operating cycle, at least at BOL, MOL and EOL. The exact part of the System for which the coefficient is calculated should be indicated.

8.1. Temperature reactivity coefficients at Cold Zero Power (CZP, zero xenon) conditions (units: pcm/K). The calculations are performed on the simplified 2D core configuration (2D radial). The reference state for this calculation is an isothermal reactor at 300 K *(k_{ref})*. The temperature reactivity coefficients should be calculated for:

8.1.1. Fuel particles

0 MWJ/t	-3,240
235 MWJ/t	-3,308
470 MWJ/t	-3,157

8.1.2. Moderator in the core cavity (fuel element matrix & compact matrix)

0 MWJ/t	-0,424
235 MWJ/t	2,858
470 MWJ/t	10,093

8.1.3. Reflectors

0 MWJ/t	5,541
235 MWJ/t	6,615
470 MWJ/t	9,010

8.2. Temperature reactivity coefficients at Hot Zero Power (HZP, zero xenon) conditions (unit: pcm/K). The calculations are performed on the simplified 2D core configuration (2D radial). The reference state for this calculation is an isothermal reactor at nominal temperature:

- *Tparticles = 1130 K*
- *Tmoderator in the core cavity = 1080 K*
- *Treflector = 900 K*

The temperature reactivity coefficients should be calculated for:

8.2.1. Fuel particles

Not Evaluated

8.2.2. Moderator in the core cavity (fuel element matrix & compact matrix)

Not Evaluated

8.2.3. Reflectors

Not Evaluated

8.3. Temperature reactivity coefficients at Hot Full Power (HFP or nominal, equilibrium xenon) conditions (units: pcm/K). **The calculations are performed on the simplified 2D core configuration (2D radial).** The reference state for this calculation is an isothermal reactor at nominal temperature:

- *Tparticles = 1130 K*
- *Tmoderator in the core cavity = 1080 K*
- *Treflector = 900 K*

The temperature reactivity coefficients should be calculated for:

8.2.1. Fuel particles

0 MWJ/t	-2,432
235 MWJ/t	-2,378
470 MWJ/t	-1,427

8.2.2. Moderator in the core cavity (fuel element matrix & compact matrix)

0 MWJ/t	-5,883
235 MWJ/t	-4,686
470 MWJ/t	-4,284

8.2.3. Reflectors

0 MWJ/t	1,528
235 MWJ/t	2,112
470 MWJ/t	2,570

8.4. Differences in reactivity (units: pcm) between:

8.4.1. CZP (zero xenon) state and HZP (zero xenon) state

Not Evaluated

8.4.2. CZP (zero xenon) state and HFP (equilibrium xenon) state

Not Evaluated