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Feasibility of Burning First and Second Generation Plutonium in Pebble Bed HTRs

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Feasibility of Burning First and Second Generation Plutonium in Pebble Bed HTRs

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SUMMARY

The core physics investigations at NRG, as part of the activities within the 'HTR-N' project of the European Fifth Framework Program, are focussed on the incineration of pure first and second generation Pu fuel in the reference pebble bed HTR ('HTR–MODUL') with a continuous reload ('MEDUL' – German: 'MEhrfach DUrchLauf', multi pass) fuelling strategy, in which the spherical fuel elements, or pebbles, pass through the core a number of times before being permanently discharged. For pebbles fuelled with different loadings on plutonium the feasibility of a sustained fuel cycle under nominal reactor conditions were investigated by means of the reactivity and temperature coefficients of the reactor. The HTR–MODUL was found to be a very effective reactor to reduce the stockpile of first generation plutonium. It reduces the amount of plutonium to about one sixth of the original, and also reduces the risk of proliferation by denaturing the plutonium vector. For second generation plutonium the incineration is less favourable, as the amount of plutonium is only halved.

1. INTRODUCTION

In the 'HTR-N' project of the European Fifth Framework Program [1] investigations are being made concerning the feasibility of burning plutonium in High Temperature Gas-Cooled Reactors (HTR). The capability to reach ultra high burnup (up to 800 MWd/kgHM) with (TRISO/BISO) coated particles containing actinides, which has already been demonstrated in the early seventies, opens the way to burn e.g. military or civil plutonium in a way that no intermediate or further reprocessing is required. In addition the HTR coated particle fuel may already be well suited for final disposal due to the ceramic coating retaining the fission products from the biosphere.

A substantial part of the 'HTR-N' project is devoted to investigation and intercomparison of the plutonium and actinide burning capabilities of a number of HTR concepts and associated fuel cycles. This with emphasis on the use of civil plutonium from spent LWR uranium fuel (first generation Pu) and from spent LWR MOX fuel (second generation Pu). Two main types of HTR's under investigation are the hexagonal block type reactor with batch-wise reloading and the continuously loaded pebble bed reactor. In conjunction with the reactor types also a number of different fuel types (e.g. Pu-based and Pu/Th-based) and associated fuel cycles are under investigation. Furthermore a study is being conducted on the possibilities of optimisation of a park of symbiotic LWR's and HTR's to obtain a stable or even a decreasing plutonium stockpile.

For a meaningful assessment and intercomparison of HTR concepts a common basis has been defined and agreed upon by the partners in the 'HTR-N' project. This common basis includes the definition of a reference pebble bed reactor ('flat bottom' 'HTR-MODUL') with continuous re-loading ('MEDUL') of fuel elements, the definition of a reference hexagonal block type reactor ('GT-MHR'), the definition of a reference TRISO coated particle (kernel diameter, composition and thickness of coatings), the definition of reference first and second generation Pu composition and the definition of a set of transmutation (plutonium and minor actinide reduction) and safety related common output parameters to be calculated for each of the concepts and cases under study by the partners.

2. REFERENCE REACTOR MODEL

As indicated above, the results of the NRG studies on Pu incineration are to be inter-compared with those of other partners in the 'HTR-N' project. Therefore the reference pebble bed HTR was employed in this activity. This reference reactor is a simplified version of the 'HTR-MODUL' design[3]. E.g. the conical shaped defuelling chute is not modelled and consequently a uniform vertical flow velocity distribution of the pebbles over the entire radius of the core is assumed (see Section 3.5). As in the original HTR-MODUL design, in our analyses the 'MEDUL' (German: 'MEhrfach DUrchLauf' – multi-pass) fuelling strategy was assumed as well.

Main parameters on the reference pebble bed reactor are presented in Figure 1 and Table 1. General information on the fuel pebbles containing coated particles is presented in Table 2. More specific – case-dependent – data on the fuel, such as the isotopic composition of the Pu, is given in Section 4.

Table 1 General parameters of the Pu-burning HTR-MODUL[2].

Nominal power	200 MWth
Power density in the core	3.0 MW/m^3
Circulation rate	3.0 kg initial Pu per day
Core height	9.43 m
Core diameter	3.0 m
Number of pebbles per m^3	5394 per m^3
He core inlet temperature	250 degr. C
He core outlet temperature	700 degr. C
System pressure	60 bar
He mass flow rate	85.55 kg/s
Basic graphite density (in reflectors)	1.80 g/cm^3

Table 2 General parameters of the pebbles containing coated particle fuel[2].

Pebble diameter	6.0 cm
Diameter of fuel zone (matrix/coated particles)	5.0 cm
Graphite density (matrix and outer shell)	1.75 g/cm^3
Kernel diameter of coated particle	0.240 mm
Kernel material (fuel)	PuO_2
Density of kernel material	10.4 g/cm^3
Coating materials (inner to outer)	C / C / SiC / C
Coating thickness (inner to outer)	0.095 / 0.040 / 0.035 / 0.040 mm
Density of coating material (inner to outer)	1.05 / 1.90 / 3.18 / 1.90 g/cm^3

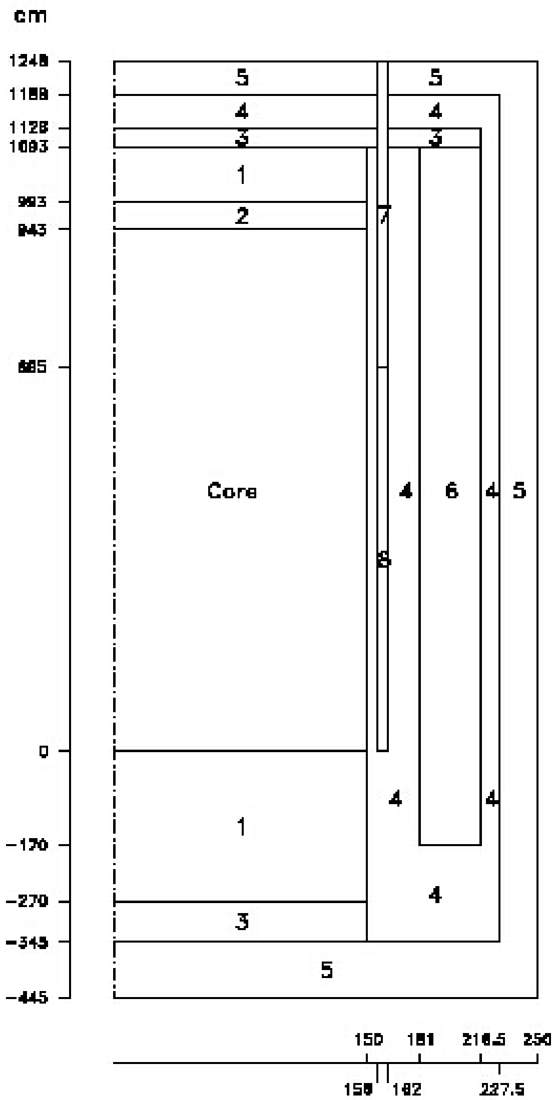

Fig. 1 Main dimensions and material regions in the PANTHERMIX calculational model of the HTR-MODUL. Dimensions are in cm. The core is a random stacking of the well-known 6 cm fuel balls (‘pebbles’). The conical defuelling chute below the core is not modelled. Other (more or less homogenised) material regions in the model are: (1) reflector (graphite), (2) void (so He gas), (3) homogenised void and graphite, (4) reflector (graphite), (5) carbon bricks, (6) reflector with coolant channels, (7) reflector with control rod channels, (8) reflector (graphite).

3. CALCULATIONAL METHODOLOGY

The analyses on the Pu-loaded HTR-MODUL presented in this report were performed by means of the WIMS/PANTHERMIX code system. Since a number of years NRG is developing the HTR reactor physics code system WIMS/PANTHERMIX[4–6], based on the well-known lattice code WIMS (versions 7 and 8)[7], the 3-D steady-state and transient core physics code PANTHER[8] and the 2-D R-Z HTR thermal hydraulics code THERMIX-DIREKT[9]. At NRG the PANTHER code has been interfaced with THERMIX-DIREKT to enable core follow and transient analyses on both pebble bed and block type HTR systems.

Several benchmark exercises have been carried out, together with FZ Jülich, on the PAP20 pebble-bed HTR with a Peu-à-Peu ('PAP') loading scheme[10]. The results of PANTHERMIX were compared with those of the FZ Jülich HTR code package VSOP[11], demonstrating the feasibility of the PANTHERMIX code combination for pebble-bed HTR applications. Extensive static and dynamic calculations on HTR pebble type cores with PANTHERMIX have been reported elsewhere[4,10,12–17].

3.1 Pebble bed HTR modelling in PANTHERMIX

Within the PANTHERMIX code system the PANTHER code calculates the 3-dimensional neutron flux and power distribution for a given temperature distribution whereas the THERMIX-DIREKT code, calculates (in steady state or transient mode) the temperature and flow distribution for a given power distribution. THERMIX-DIREKT is an improved version of the THERMIX-KONVEK module of the VSOP code. The combined code system is controlled from the PANTHER code, which calls THERMIX-DIREKT from within an iteration (steady state) or time step (transient) calculation loop.

PANTHER approximates the 2-D R-Z geometrical structure employed in THERMIX-DIREKT by a 3-D Hex-Z model with small stacked hexagons or, alternatively, an X-Y-Z model of pillars of small rectangular blocks. This is done as follows. A radial mesh (or 'ring') in the THERMIX-DIREKT geometry specification can be associated with a set of radial hexagons (blocks) in the PANTHER geometry, of which the total area is equal to the area of the THERMIX-DIREKT radial mesh. The validity of this approach has been confirmed by intercomparison of calculations in the framework of an MHTGR benchmark exercise[12]. For radial meshes and hexagon (block) sets associated in this way the power distribution and temperature distribution information is transferred between the codes.

In the PANTHER part of the model of the HTR-MODUL the 3-D X-Y-Z mode was employed with 1417 hexagonal radial meshes (channels) of 6.32 cm flat-to-flat and 93 axial intervals of varying height but over the core height all 16.55 cm high. The full model comprises 511 core channels, 60 core layers, 19 bottom reflector layers and 14 top reflector layers. The size of the hexagonal mesh has been chosen such that concentric 'rings' can be composed from these meshes in a manner that those rings fit snugly with the main radial dimensions of the reactor structures.

For the mapping of the 3-D power profile on the 2-D grid of THERMIX the power in the hexagons which form a 'ring' in PANTHER are radially averaged and transferred to the mesh in THERMIX. For the temperature profile from THERMIX the values for an R-Z set are unfolded to a PANTHER ring. In the model of the HTR-MODUL there are 23 radial rings composed in the PANTHER model and 27 radial meshes in the THERMIX model of which the extra meshes do form the boundary conditions. The THERMIX part of the code solves the (time-dependent) equations for the conductive and radiative heat transfer whereas DIREKT solves the (time-dependent) equations for the heat transfer from solid material to the gaseous coolant and the continuity equation of the gas flow. Contrary to the thermal hydraulic options in PANTHER itself, THERMIX allows for cross channel flows necessary to simulate natural convection under loss of flow conditions (i.e. active coolant pumping). The complex heat transfer and heat conductivity in the pebble bed is chosen as modelled in THERMIX according to the Zehner-Schlünder method[18]. Thermal data like heat conductivity and heat capacity of the different materials are calculated as function of temperature and pressure according build-in equations. For the graphite the properties of un-irradiated A3 grade have been used.

3.2 PANTHERMIX database generation I – Double heterogeneous cell calculations

PANTHER, and therefore PANTHERMIX, requires a nuclear database containing - presently - 2-group nuclear data (macroscopic cross sections) for all reactor materials, depending on irradiation, fuel temperature, Xenon density, etc., in which a multi-dimensional interpolation can be performed, according to the local condition of the materials in the reactor. The WIMS code (version 8) was selected to generate these databases, in view of the presence of the special WPROCOL module and also because of the possibility to perform burn-up calculations in a convenient way within the WIMS code system.

The WIMS8 calculations were performed on the basis of an adapted version of the standard 172 groups 1997 WIMS library based on JEF-2.2. Adaptations have been made for Pu, Am and Cm isotopes to extend the range of temperatures and of the potential scattering cross-section to improve the resonance treatment[14].

The standard WPROCOL module in WIMS was especially designed to calculate neutron transport in infinite cylinders containing coated particle fuel. In order to implement a model of a spherical pebble containing coated particle fuel, a simple but sufficiently accurate transformation was applied by modelling the pebble as a cylindrical cell with an equivalent radius. The spherical pebble is transformed into an infinite long cylinder with a radius equal the mean chord length of the sphere. The mean chord length of a convex body is given by the simple relation: 4 times the ratio of volume over surface. So the fuelled part of the pebble (radius 2.5 cm) is translated into a cylinder of 1.667 cm radius and contains the fuel kernels, coatings and matrix graphite. This cylinder is surrounded by an annulus of radius 2.191 cm to accommodate the unfuelled graphite shell of 0.5 cm, based on conservation of volume ratio. Finally the outer cylinder may contain admixed moderator pebbles and the helium filled void between the pebbles. This method has been proved adequate in the HTR-PROTEUS benchmark[12]. These dimensions, packing fractions and densities are fed into the WIMS module WPROCOL to produce collision probabilities for use in the subgroup resonance treatment, for Pu-239, -240, -241 and -242 in WRES after an approximate resonance treatment in WHEAD for all other resonant isotopes not treated explicitly in WPROCOL/WRES. The approximate resonance treatment in WHEAD is based on equivalence theory with calculated potential scatter cross section applied on slabs with thickness according to mean chord lengths of the fuel kernel, coatings and matrix graphite belonging to the kernel. In this approximation a Dancoff factor has been used which is derived analytically to account for the double heterogeneity of kernels and pebbles[19].

It should be noted that a uniform distribution of the temperature over the pebble was assumed in the WIMS cell calculations.

3.3 PANTHERMIX database generation II – Pseudo reactor calculations

As only 2-group nuclear constants are presently employed in PANTHERMIX, the fine spectrum effects must be accounted for in the generation of the nuclear database. The double heterogeneous cell calculations mentioned above yield 16-group cross sections for homogenised fuel. In order to get sufficiently accurate 2-group nuclear constants for all reactor material to be used in PANTHERMIX, one-dimensional radial and axial 'pseudo-reactor' calculations for the (pebble bed) HTR under study are performed in 16 energy groups prior to the collapse to 2 groups. In the calculations presented in this report the energy boundary between the fast and the thermal energy group is at 2.1 eV.

The WIMS code system also provides the 6-group delayed neutron data (yields β_i), required for transient calculations by PANTHERMIX. However, in the analyses in this report the transient calculation capabilities of PANTHERMIX were not required. In the near future the multi-group (up to 12 neutron energy groups) capabilities of the present version of PANTHER will be tested for HTR applications.

3.4 Modelling of gas spaces

The neutronics calculation in the PANTHER(MIX) code are based upon diffusion theory. For a correct effective treatment of the gas space above the pebble bed, the Gerwin-Scherer method[20] was applied to calculate effective anisotropic diffusion coefficients to be used in the PANTHERMIX calculations.

PANTHERMIX features a special capability for the modelling of pebble bed HTR's with a continuously variable pebble bed height, e.g. an HTR with Peu-à-Peu ('PAP') fuel loading strategy[10]. The PANTHER control rod model is employed for all core channel positions to implement a 'gas' control rod bank, comprising all core channels in the PANTHER model. This bank in the 'unrodded' state returns the nuclear data of the fuel in the unrodded axial meshes of the core, in the 'rodded' state it returns the nuclear data of the helium void on top of the pebble bed in the rodded axial intervals. By moving in and out this 'gas' rod bank one can simulate the level of the pebble bed height in the core. In the analyses presented in this report this feature was not required.

3.5 Modelling of pebble flow and reload

In order to model pebble bed HTR's with continuous reload fuelling strategies, the capabilities of PANTHERMIX have been extended with the possibility to simulate the flow of pebbles through the core cavity and the (re-) loading of pebbles on top of the core[21–23]. One of the consequences of the continuous reload operation mode is the fact that each (homogenised PANTHERMIX calculational mesh) region in the core contains a mixture of fuel pebbles at different degrees of burnup. The extended PANTHERMIX keeps track of the local composition of such a mixture of fuel pebbles in terms of a distribution over a number of burnup classes. This distribution can change by either a burnup time step, which may cause pebbles to 'move up' – fractionally – to the next higher burnup class, or by a – downward or radial – shift of the pebble bed, by which a certain fraction of the pebbles in the volume under consideration is replaced by pebbles, distributed over the burnup classes, coming from another volume. In the analyses in this report 7 or 8 burnup classes were employed, distributed over the burnup range from 0 to the case-dependent threshold burnup, in these calculations as 735 MWd/kgHM for the first generation and 420 MWd/kg for the second generation Pu. An extra burnup class contains the pebbles with a burnup higher than the threshold. These are to be discharged permanently after unloading from the bottom of the core.

Besides a considerable extension to the modelling in PANTHER this also requires an extension of the procedure for the generation of the nuclear database. Now these cross sections must not only be dependent upon the local burnup (irradiation) and the local temperature but also, in case of the mixed pebbles in the core cavity, upon the local enrichment and the local heavy metal mass per unit height, the latter being representative of the local mixture of moderator and fuel pebbles. For each combination of enrichment and heavy metal mass per unit height, a burn-up sequence calculation with xenon- and temperature branchings is performed by means of the WIMS code. The resulting databases are combined into a single nuclear database with enrichment and heavy metal mass per unit height as extra dependencies, ready to be used in the PANTHERMIX calculations. In the present analyses this database contains 2-group nuclear data for all reactor materials dependent on temperatures from 27 (300 K) to 1600 °C and on burnup up to 760 MWd/kg. It should be noted that, while the extended PANTHERMIX keeps track of the distribution of burnup of a mixture of pebbles, the interpolation in the nuclear data, as generated by the WIMS code, is performed on the basis of the (weighted) average burnup of the mixture.

The extended PANTHERMIX is capable of modelling the combined axial/radial pebble flow associated with the conical shaped defuelling chute in the 'real' HTR-MODUL design[3]. However, as the investigations focus on the Pu-incineration capabilities, it was decided to implement a uniform vertical flow velocity distribution over the entire radius of the core, with pebbles 'appearing' uniformly distributed at the top of the core and 'disappearing' at the bottom. Pebbles unloaded from the bottom of the core are re-loaded at the top, unless they are in the highest burnup class. In this case they are permanently discharged and replaced – at the top – by fresh fuel.

4. INVESTIGATION OF FUELLING STRATEGIES

In order to investigate in the influence of the (re-) loading strategy on the Pu incineration capabilities and the safety related parameters, 2-group macroscopic cross section data sets were generated for fuel pebbles containing 1.0 and 2.0 gram of first generation plutonium, respectively, and another set for a mixture consisting of 50% pebbles with 2.0 gram and 50% moderator balls of just graphite. Two types of first generation plutonium have been investigated. Pebbles containing second generation Pu were treated analogously except for extra data sets for 0.75, 3.0 gram and 3.0 gram with an additional moderator ball. The reference first and second-generation plutonium vectors, as agreed upon in the project[24], are listed in Table 3.

Table 3 Plutonium vectors[2].

Nuclide	Composition of 1st generation Pu [weight %]		Composition of 2nd generation Pu [weight %]
^{238}Pu	1.0	2.59	4.90
^{239}Pu	62.0	53.85	26.90
^{240}Pu	24.0	23.66	34.30
^{241}Pu	8.0	13.13	15.30
^{242}Pu	5.0	6.78	18.6
Pu_{fiss}/Pu_{tot}	70%	67 %	42.2 %

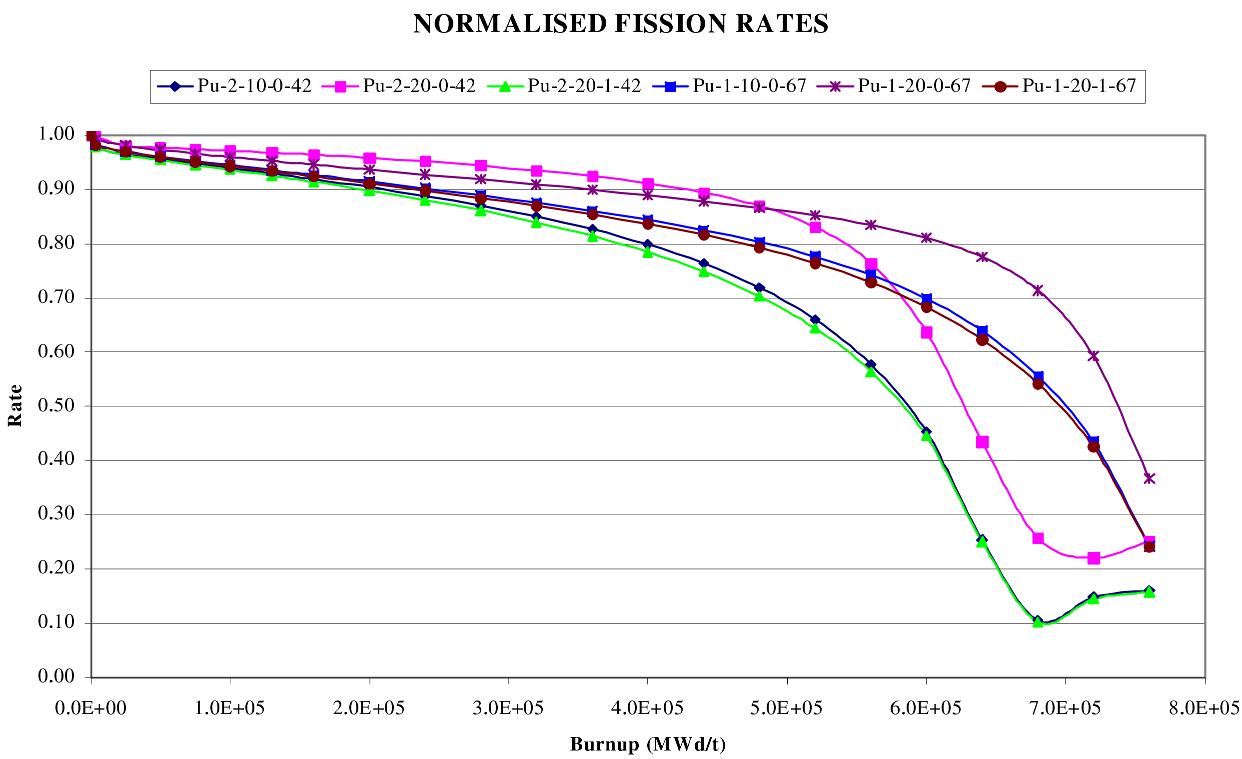

Fig.2 Normalized fission rate versus pebble burnup

From the results of the nuclear database generator the behaviour of the reactivity of these fuels, as expressed by the normalised (to fresh fuel) fission rate in a constant flux as a function of the depletion of a pebble can be seen in Fig. 2 for some first and second generation Pu-fuels (coding as in table 4).

The pebbles were fed into the reactor at a rate of 3000 gram initial Pu per day. So by average they were circulated about 12 times before being permanently discharged from the reactor. Flow of the pebbles is straight from top to bottom with an overall constant speed. The reactor is supposed to be brought from 'Beginning Of Life' ('BOL'; i.e. all fresh fuel and cold reactor) into the equilibrium state in an artificial way by just circulating pebbles through the core, adding each time step almost the amount of fresh fuel needed for this time step and withdrawing the same number of partially burned pebbles at the bottom of the core before reloading to the top. This until the oscillations in k_{eff} are damped out. In the equilibrium state no change in the isotopic content of the reloaded fuel occurs anymore and the artificial history of the burn-in process in the core is 'forgotten'. The number of fresh fuel pebbles per day becomes equal to the number of completely burned pebbles, which are permanently discharged from the reactor.

An example of the power density and temperature distribution of the MEDUL reactor at equilibrium and fuelled with 2.0 gram second generation Pu per pebble is shown in Figs. 3 and 4. White lines indicate the core location, the dashed line indicates the pebble bed surface. From these figures one can notice the "up-swing" in power and the resulting temperature increase for the core region adjecent to the reflectors, because of the usual thermal fluence rate peaking in the reflectors. This peaking is caused by the slowing down process of the neutrons in a low absorptive medium.

4.1 Results

The following relation should evaluate the temperature coefficients for a fully loaded core from the effective multiplication factors, where the temperature distribution over the pebble itself is assumed uniform:

$$\alpha_n = \left[(1/k_n) - (1/k_{n+1}) \right] / \left[T_{n+1} - T_n \right]$$

With:

α_n Temperature coefficient between T_n and T_{n+1} ($\Delta k/k/K$)
T_n Core temperature at n^{th} case (K)
T_{n+1} Core temperature at $n+1^{th}$ case (K)
k_n Effective multiplication factor at T_n
k_{n+1} Effective multiplication factor at T_{n+1}.

At BOL the temperature coefficient has been obtained by raising the temperature of the reactor in a uniform way from 300 K to 350 K, and at equilibrium with full power all local reactor temperatures were increased by 50 K as well.

It was found that, with all fuel types containing first generation Pu, the reactor could be made critical at BOL with a negative temperature coefficient (see Table 4). However, for the reactor at equilibrium the temperature coefficient remains sufficiently negative only with the fuel type containing 2.0 gram Pu.

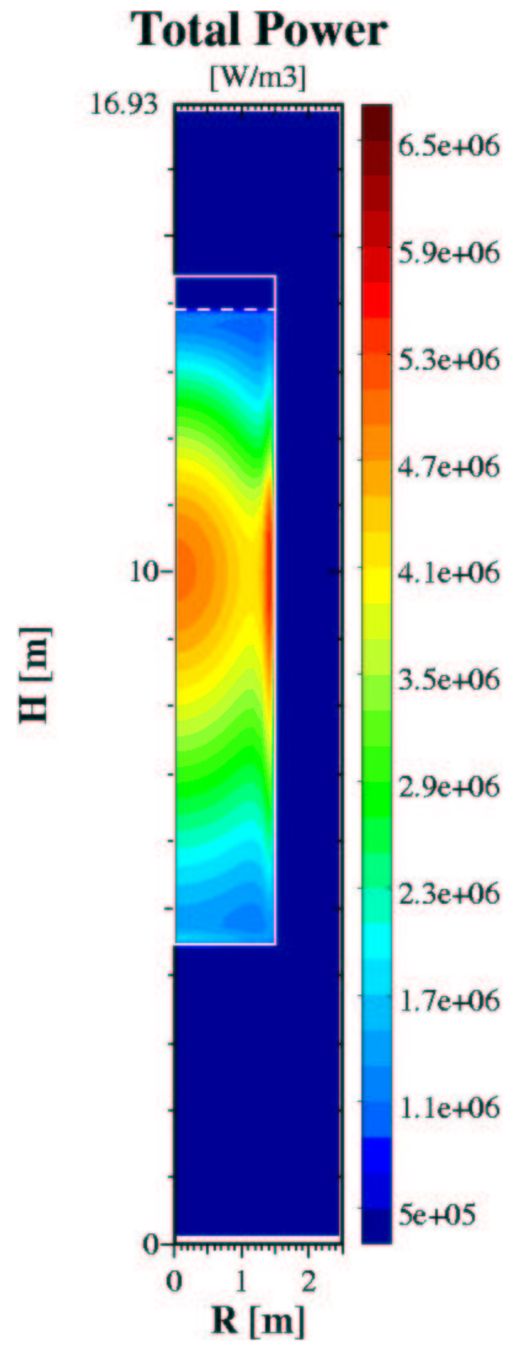

Fig. 3 Power density.

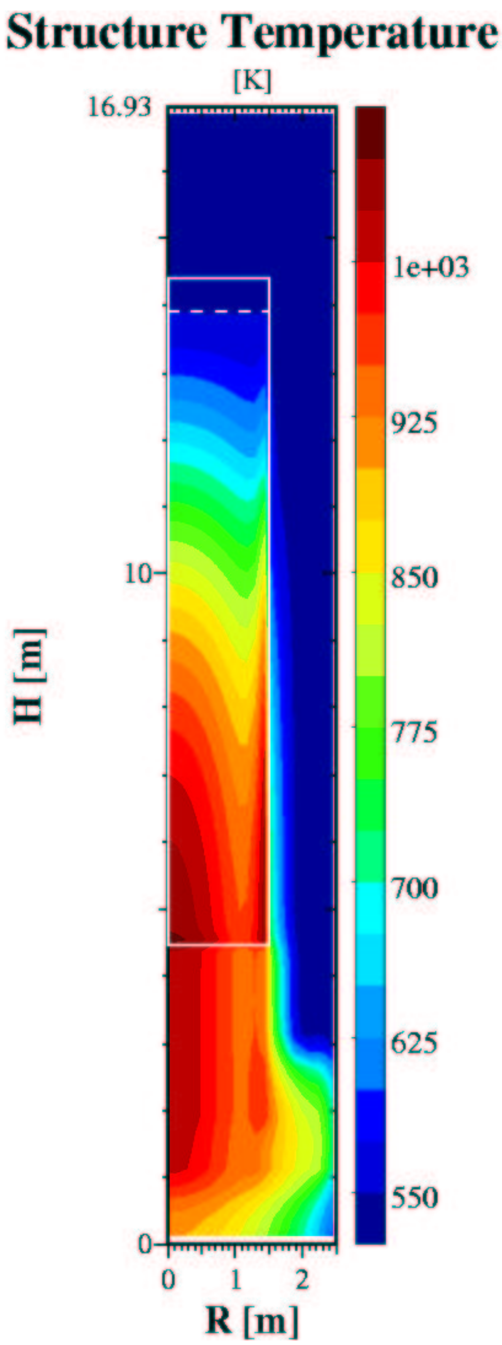

Fig. 4 Reactor temperature.

The average burnup for these disposed pebbles is about 750 MWd/kg. An appreciable reduction of about 85 % of the original plutonium can be achieved, leaving about 8.5 % of the initial HM weight as minor actinides like Cm and Am, due to the transmutation of the plutonium. The main difference between the cases with 1-gram pebbles and those with 2-gram pebbles with an extra moderator ball is a worse (i.e. less negative or even positive) temperature coefficient for the latter.

The results for the different cases are summarised in Table 4.

For the reactor fuelled with second generation Pu, the reactor remains critical, with negative temperature coefficients at BOL and equilibrium, only for the pebbles with 1.5 gram Pu. This also requires a reduction of the discharge burnup maximum to 440 MWd/kg. The original Pu will be reduced by about half at discharge from the reactor and about 10 % of the initial HM will be transmuted into minor actinides. Cases with an additional moderator ball result in worse temperature coefficients as well, but also in a slightly increased reactivity. Results for the second generation Pu are also summarised in Table 4.

For the 1.5 g pebble the temperature coefficient is rather small at 'cold equilibrium'. As the temperature coefficient becomes more negative with the initial Pu-loading, 2-gram pebbles result in a dynamically more stable reactor. In this case a further reduction of the discharge burnup (to about 350 MWd/kg) is required for sufficient reactivity, causing a further loss in Pu destruction. Ultimately, transient calculations are required to determine whether these fuels stay within the design criteria for temperature during their entire lifetime.

Table 4 Results.

Case	Pu-fiss	Pu feed	BU cycl	BU disc	k_{eff}	k_{eff}	$\alpha(T)$	$\alpha(T)$	rem. HM	rem. Pu
	%	g/d	MWd/kg	MWd/kg	BOL	equi	BOL	equi	%	%
Pu-1-1.00-0	70.0	255.8	373	781.8	1.2825	1.0717	-3.25E-05	-4.01E-06	23.4	18.0
Pu-1-2.00-1	70.0	255.8	373	781.8	1.2931	1.0705	-2.95E-05	8.73E-07	23.4	18.1
Pu-1-2.00-0	70.0	254.1	361	787.0	1.1892	1.0353	-5.41E-05	-4.60E-05	23.3	15.9
Pu-1-1.00-0	67.0	266.3	384	751.1	1.2961	1.0706	-1.94E-05	1.64E-05	23.4	16.7
Pu-1-2.00-1	67.0	266.3	384	751.1	1.3044	1.0686	-1.72E-05	2.08E-05	23.5	16.8
Pu-1-2.00-0	67.0	270.1	366	740.4	1.2111	1.0575	-4.17E-05	-3.28E-05	23.4	14.8
Pu-2-0.75-0	42.2	256.0	376	781.4	1.1647	0.8411	2.58E-05	9.80E-05		
Pu-2-1.00-0	42.2	256.2	363	780.7	1.1436	0.8991	6.10E-07	5.43E-05	22.6	6.6
Pu-2-2.00-1	42.2	266.3	383	751.1	1.1509	0.8789	9.66E-06	7.54E-05	22.6	6.7
Pu-2-1.50-0	42.2	256.3	377	780.4	1.0964	0.9192	-2.40E-05	7.10E-06	22.6	6.8
Pu-2-3.00-1	42.2	268.2	382	745.8	1.1124	0.9156	-1.71E-05	2.07E-05	22.6	6.9
Pu-2-2.00-0	42.2	271.0	379	738.0	1.0560	0.9250	-4.64E-05	-2.32E-05	22.7	6.9
Pu-2-3.00-0	42.2	282.9	358	706.9	1.0013	0.9210	-7.35E-05	-4.87E-05	22.7	7.5
Pu-2-1.50-0	42.2	456.6	195	438.1	1.0964	1.0068	-2.40E-05	-2.39E-05	54.8	46.5
Pu-2-2.00-0	42.2	444.6	197	449.8	1.0560	0.9831	-4.64E-05	-4.17E-05	55.1	44.9

In Table 4 the columns are coded as follows:

- Pu-generation-Pu mass per pebble-admixed moderator ball ‘0/1’ (= no/yes).
- The plutonium fissile fraction (‘Pu-fiss’) determines the Pu vector as in Table 3.
- ‘Pu feed’ denotes the daily feed of fresh Pu in grams.
- ‘BU’ is the average BurnUp of the fuel when unloaded from the reactor (‘cycl’) and when being discarded (‘disc’) as spent fuel.
- k_{eff} and $\alpha(T)$ are the multiplication factors and the temperature coefficients for a fresh core (‘BOL’) and for the equilibrium core (‘equi’).
- ‘Remaining HM’ and Pu are the remaining fractions of actinides and plutonium in the discarded fuel compared to the original mass.

4.2 Results for some Pu-fuels

For the candidate fuels; Pu-1-2.00-70, Pu-1-2.00-70 and Pu-2-2.00-42 (coding as in table 4) some more detailed results are available. In the annexes 1 and 2 graph’s of the nuclear densities for the actinides, the fuel temperature effect and the fission fractions for the different actinides as function of the depletion are given.
From these graph’s it can be seen that at higher depletion and at lower fuel temperatures the temperature coefficients of the fuels do become positive. Also remarkable is the rapid rise of the fission fraction by Cm 245 with burnup.
A summary of the temperature coefficients for the case Cold Zero Power (CZP) with the reactor uniform at 300 K and no Xenon and for the case Hot Zero Power (HZP) with the reactor uniform at the nominal inlet temperature of 523 K and no Xenon, is given in table 5.

Table 5 Uniform temperature coefficients.

Fuel type	CZP (300 K)	HZP (523 K)
Pu-1-2.00-0-70	-5.30 E-5	-5.62 E-5
Pu-1-2.00-0-67	-4.10 E-5	-4.33 E-5
Pu-2-2.00-0-42	-4.57 E-5	-4.59 E-5

5. CONCLUSIONS

As can be seen from the results an HTR–MODUL is a very effective reactor to reduce the stockpile of 1st generation plutonium. It reduces the amount of plutonium to about one sixth of the original, and also reduces the risk of proliferation by denaturing the plutonium vector. For 2nd generation plutonium the incineration is less favourable, as the amount of plutonium is only halved. Calculations on the dynamic behaviour of the reactor will be required to prove save operation under all circumstances.

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APPENDIX 1

First generation Plutonium

Pu-1-2.00-0-70
Pu-mass: 2.0 gram/pebble
No moderator balls.
Pu-vector at BOL: 1.0, 62.0, 24.0, 8.0, 5.0 (70% fissile).

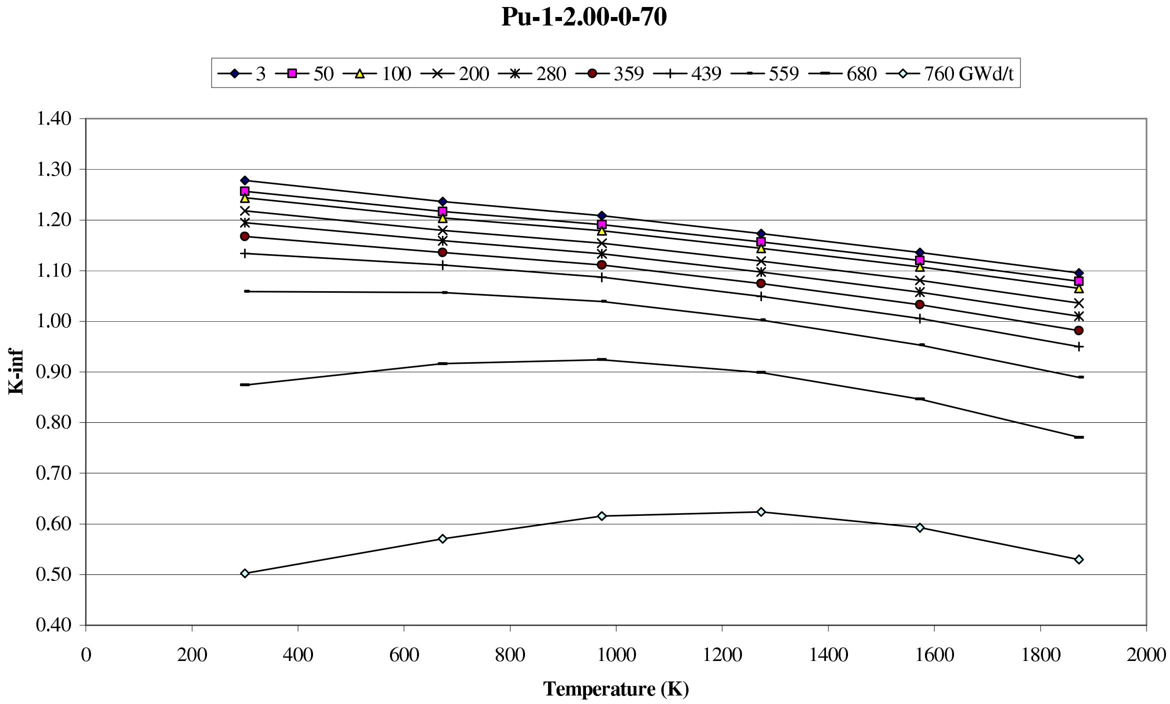

Fig. A.1a.1 Reactivity of the fuel as function of temperature and burnup.

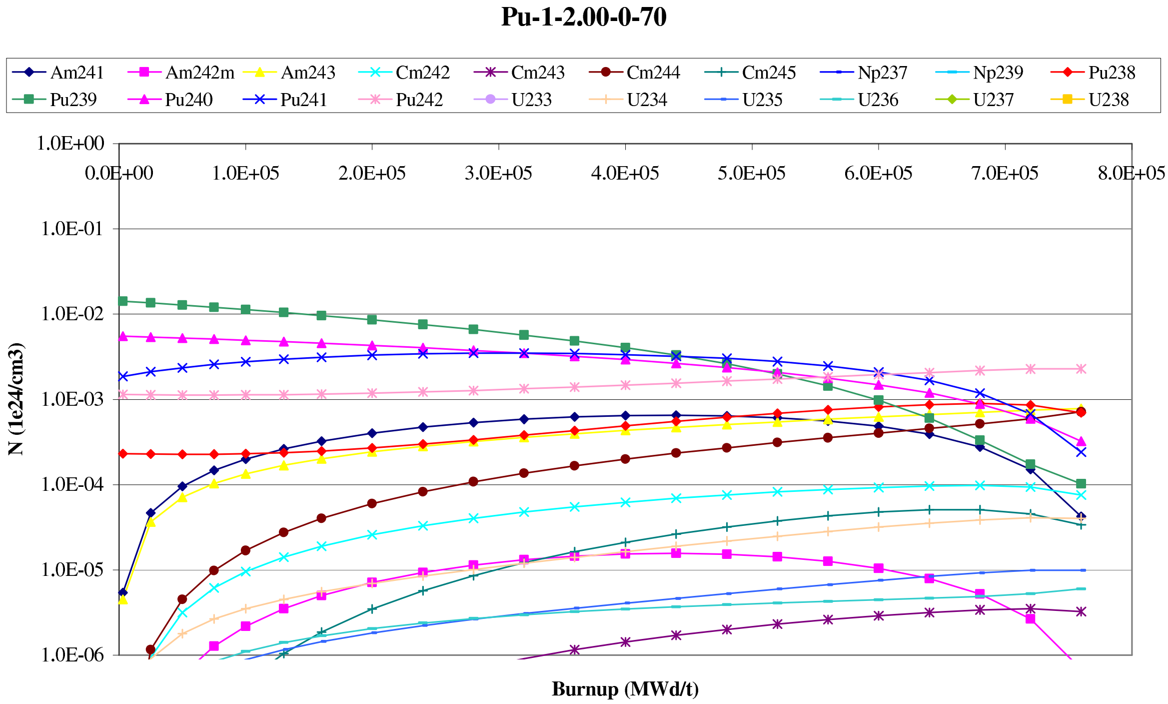

Fig. A.1a.2 Nuclide densities in the kernel as function of the burnup

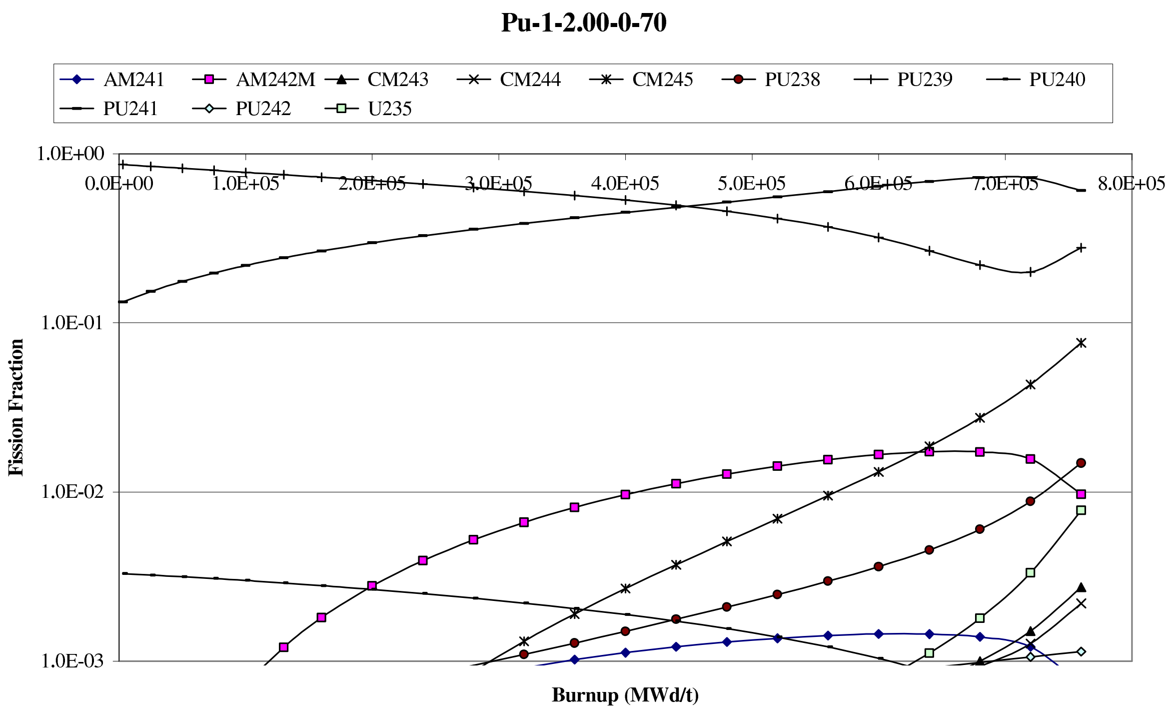

Fig. A.1a.3 Fission fraction in the fuel as function of the burnup.

First generation Plutonium

Pu-1-2.00-0-67
Pu-mass: 2.0 gram/pebble
No moderator balls.
Pu-vector at BOL: 2.59, 53.85, 23.66, 13.13, 6.78 (67% fissile).

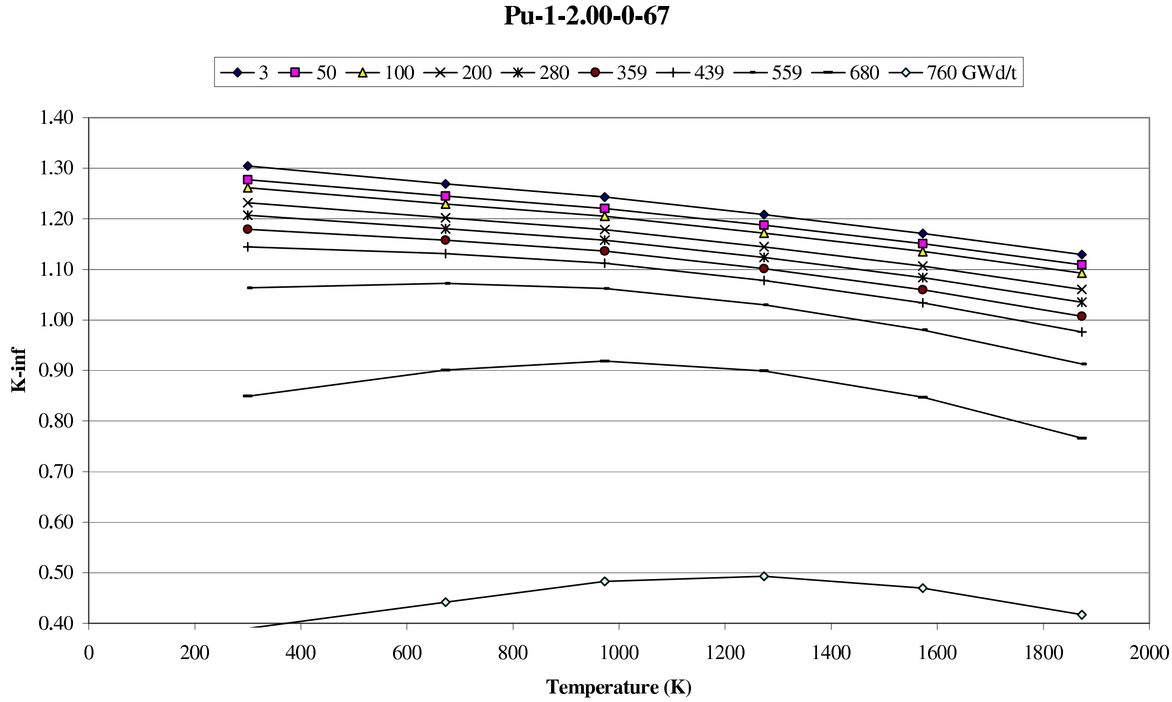

Fig. A.1b.1 Reactivity of the fuel as function of temperature and burnup.

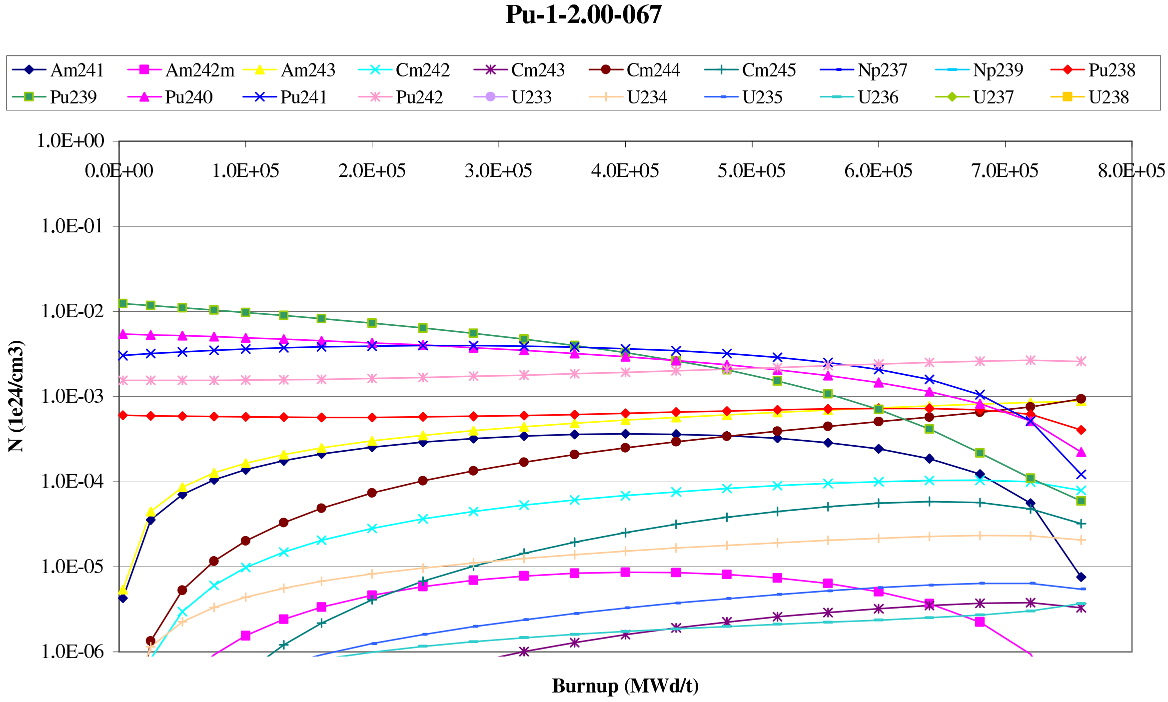

Fig. A.1b.2 Nuclide densities in the kernel as function of the burnup.

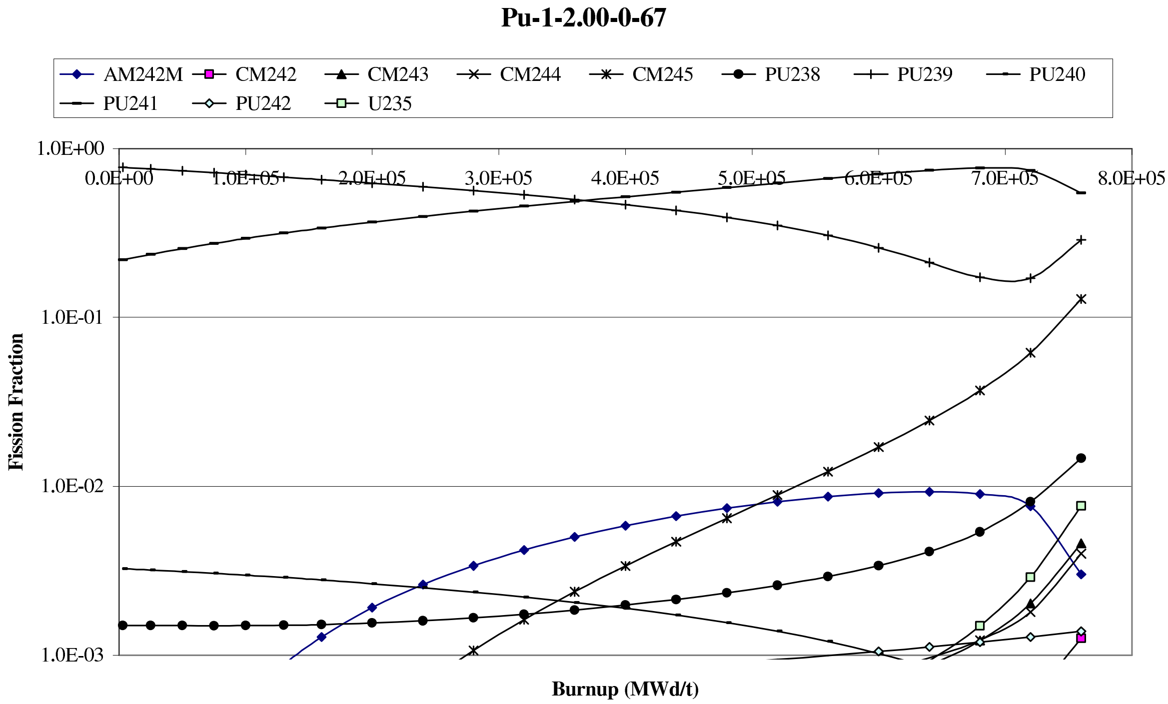

Fig. A.1b.3 Fission fraction in the fuel as function of the burnup.

APPENDIX 2

Second generation Plutonium

Pu-2-2.00-0-42
Pu-mass: 2.0 gram/pebble
No moderator balls.
Pu-vector at BOL: 4.9, 26.9, 34.3, 15.3, 18.6 (42.2% fissile).

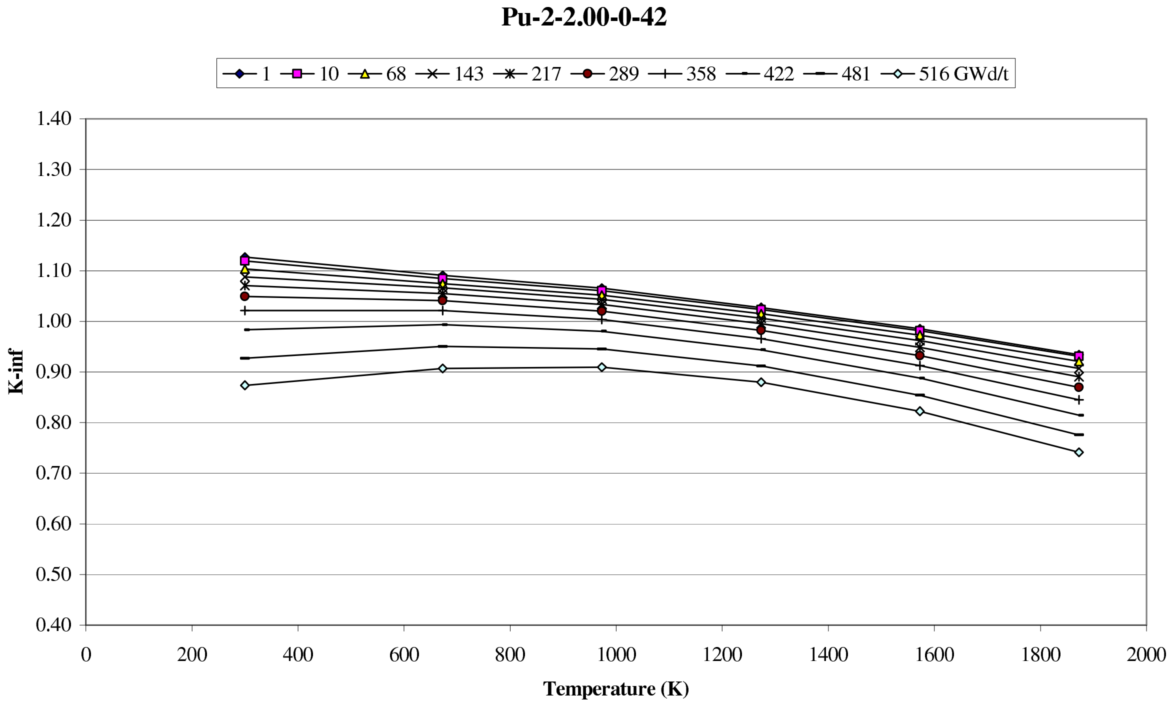

Fig. A.2.1 Reactivity of the fuel as function of temperature and burnup.

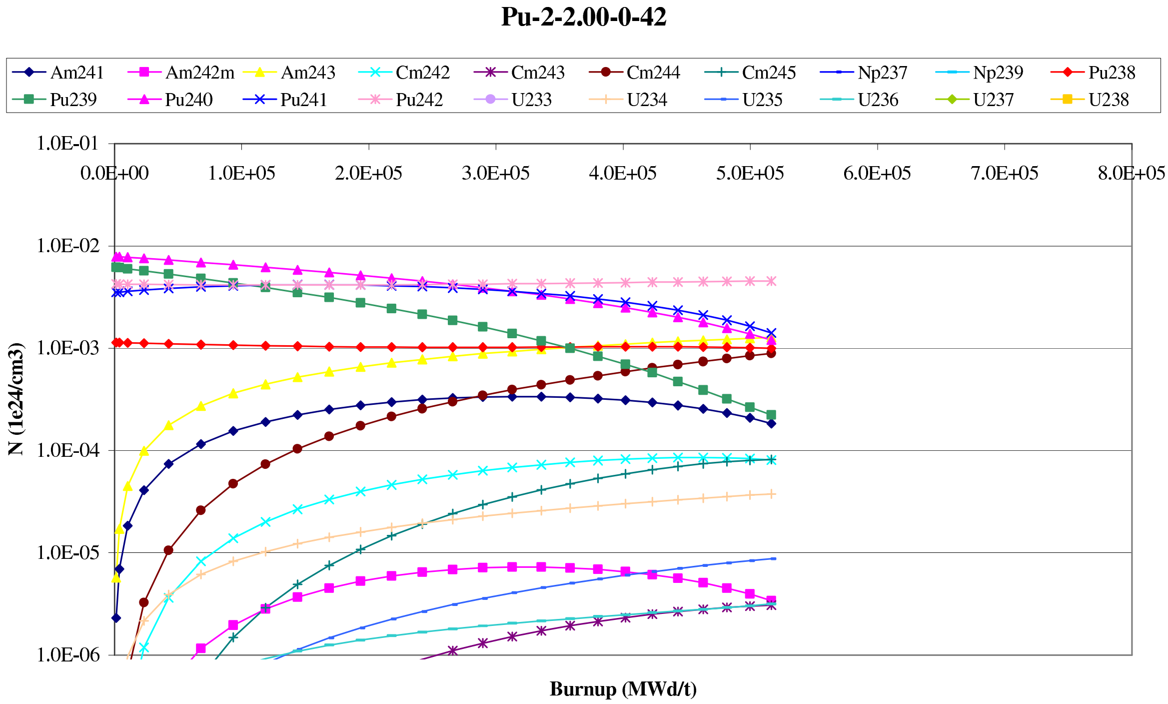

Fig. A.2.2 Nuclide densities in the kernel as function of the burnup.

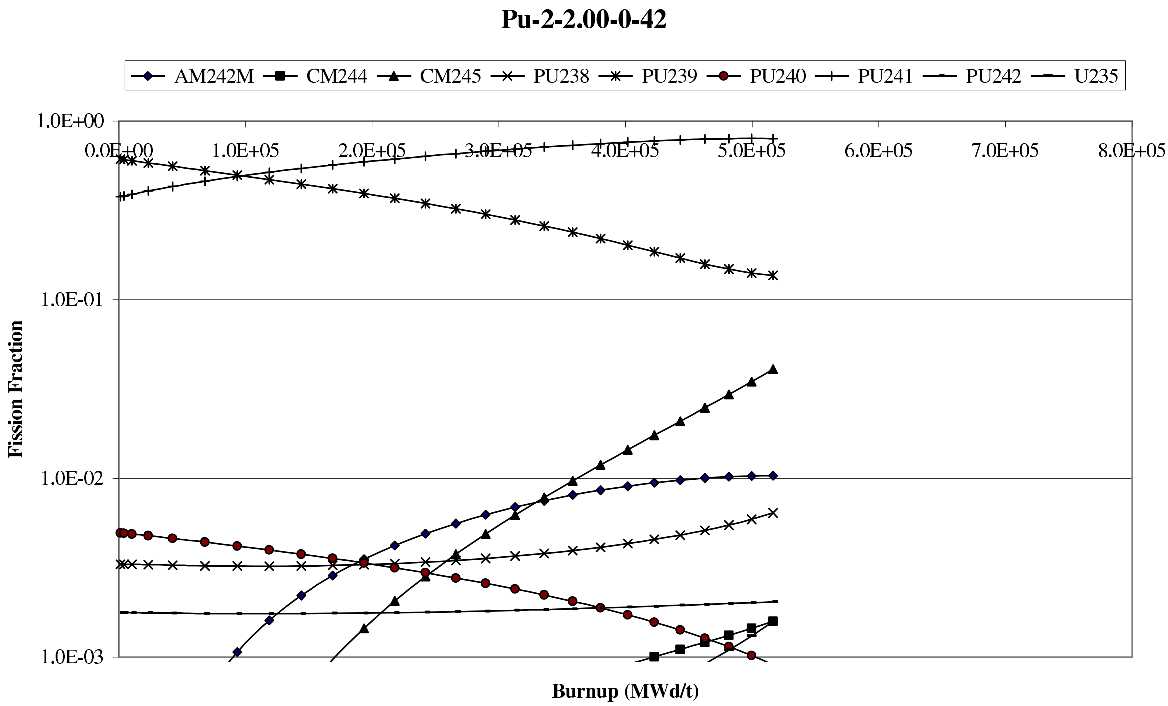

Fig. A.2.3 Fission fraction in the fuel as function of the burnup.

APPENDIX 3

Pu-1-2.00-0-70

```
## 0. Case identification and description.
##
#0.1# J.B.M. de Haas
## Origin
#0.2# NRG
## Organisation
#0.3# Pu-1-2.00-0-70
## Case number
#0.4# 20 Sept 2003
## Date
#0.5# PANTHERMIX
## Applied code system
#0.6# HTR-N-03/11-D-3.2.1
## References (arbitrary number of text lines)
##
## 1. General fuel/reactor/system specifications. This section is intended
##    as a complete description of the fuel, the reactor (system) and the applied
##    fuel loading and discharge scheme.
##
#1.1# MEDUL reactor 200 MWth with reload
#1.1# first generation Pu with 70% fissile isotopes and 2.0 gr HM per pebble
## System (part) under consideration (reactor, supercell, etc.)
## (arbitrary number of text lines)
#1.2# reactor
#1.2# core diameter                 3.0 m
#1.2# core/pebblebed height         9.93/9.43 m
#1.2# botom reflector height        4.45 m
#1.2# top reflector height          2.05 m
## Main system dimensions (i.e. core diameter, core height, reflector dimensions, etc.)
## (arbitrary number of text lines)
#1.3# PuO2 particle:    kernel              0.120 mm radius
#1.3# PuO2 particle:    low dens. carbon    0.215
#1.3# PuO2 particle:    high dens.carbon    0.255
#1.3# PuO2 particle:    silicon carbide     0.290
#1.3# PuO2 particle:    high dens.carbon    0.330
#1.3# PuO2 particle:
## Coated particle dimensions (kernel and coatings) (per coated particle type)
## (arbitrary number of text lines)
#1.4# PuO2 kernel:          Pu238     2.3211e-4
#1.4# PuO2 kernel:          Pu239     1.4331e-2
#1.4# PuO2 kernel:          Pu240     5.5242e-3
#1.4# PuO2 kernel:          Pu241     1.8337e-3
#1.4# PuO2 kernel:          Pu242     1.1413e-3
#1.4# PuO2 kernel:          O16       4.6123e-2
#1.4# low dens. carbon:     C12       5.2645e-2
#1.4# high dens. Carbon:    C12       9.5263e-2
```

#1.4# silicon carbide : C12 4.7761e-2
#1.4# silicon carbide : Si28 4.7761e-2
#1.4# high dens. Carbon C12 9.5263e-2
Initial coated particle composition per nuclide per material zone (units: (barn cm)^-1)
(arbitrary number of text lines; one line per nuclide per coated particle type; see
Table 2; add extra nuclide names for impurities)
#1.5# pebble 30 mm radius, fuelled 25 mm radius
Compact/pebble dimensions (arbitrary number of lines)
#1.6# Bnat 1.2672e-7
#1.6# C12 8.7742e-2
pebble matrix composition per nuclide (outside coated particles; including impurities)
(units: (barn cm)^-1) (arbitrary number of lines; one line per nuclide)
#1.7# Bnat 9.7481e-8
#1.7# C12 8.7742e-2
pebble shell composition per nuclide (outside coated particles; including impurities)
(units: (barn cm)^-1) (arbitrary number of lines; one line per nuclide)
#1.8# Type_2.0-70 30114
Number of coated particles per pebble/compact (of each coated particle type)
(arbitrary number of lines; one line per particle type)
#1.9# 365
Operating cycle length (units: full power days)
#1.10# 0
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)
#1.11# 200.0
Nominal reactor power (units: MW)
#1.12# 1.0
Capacity factor (units: -)
#1.13# N.A.
Number of fuel batches (batch wise reload only) (units: -)
#1.14# 523.15
Nominal coolant inlet temperature (units: K)
#1.15# 6000000.0
Nominal coolant inlet pressure (units: Pa)
#1.16# 972.15
Nominal coolant outlet temperature at nominal (Hot Full Power, HFP) conditions (units: K)
#1.17# 6070930.0
Nominal coolant outlet pressure at nominal (Hot Full Power, HFP) conditions (units: Pa)
#1.18# 85.55
Nominal coolant mass flow (unit: kg/s)
#1.19# continues reload
#1.19# 1500 balls per day (3000 gr Pu per day)
#1.19# no moderator balls
#1.19# 5394.6 balls per cubic meter
Description of fuel cycle strategy and other relevant information on the specific case
(arbitrary number of text lines).
##
2. Rating and power density
##
2.1. Power produced per coated particle (per coated partcile type) (units: W):

#2.1.1# 41.9e-3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.1.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power (units: W)) (arbitrary number of lines)
2.2. Power produced per compact/pebble (units: W)
#2.2.1# 1261.
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.2.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power (units: W)) (arbitrary number of lines)
2.3. Power produced per unit heavy metal mass (units: W/kg)
#2.3.1# 630.3e+3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.3.2# N.A.
Maximum value anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power per unit heavy metal mass (units: W/kg))
(arbitrary number of lines)
2.4. Power density in the core (units: W/m^3)
#2.4.1# 6.80 MW/m**3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.4.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power density (units: W/m^3)) (arbitrary number of lines)
##
3. Core inventory
##
3.1. Amount of each of the heavy metal isotopes present in the core (units: kg)

#3.1.2#	AM241	2.004E+01
#3.1.2#	AM242M	4.760E-01
#3.1.2#	AM243	1.351E+01
#3.1.2#	CM242	1.927E+00
#3.1.2#	CM243	4.414E-02
#3.1.2#	CM244	6.190E+00
#3.1.2#	CM245	6.550E-01
#3.1.2#	NP237	1.003E-02
#3.1.2#	NP239	4.008E-08
#3.1.2#	PU238	1.493E+01
#3.1.2#	PU239	1.294E+02
#3.1.2#	PU240	9.273E+01
#3.1.2#	PU241	1.054E+02
#3.1.2#	PU242	4.607E+01
#3.1.2#	U233	3.820E-07
#3.1.2#	U234	4.899E-01
#3.1.2#	U235	1.281E-01
#3.1.2#	U236	1.062E-01
#3.1.2#	U237	7.520E-05
#3.1.2#	U238	1.920E-04
#3.1.2#	CS135FP	1.023E+01
#3.1.2#	EU154FP	3.403E-01

#3.1.2# I129FP 2.128E+00
#3.1.2# PD107FP 4.660E+00
#3.1.2# SM147FP 1.344E+00
#3.1.2# SM151FP 4.219E-01
#3.1.2# ZR93FP 3.988E+00
At equilibrium (arbitrary number of lines; see Table 2)
#3.1.3# N.A.
At EOL (arbitrary number of lines; see Table 2)
3.2. Fissile Pu fraction, i.e. amount of (239Pu and 241Pu) divided by the total
amount of Pu (units: -) (this can be derived from 3.1)
#3.2.1# 0.700
At BOL
#3.2.2# 0.604
At equilibrium
#3.2.3# 0.094
At discharge

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 3 (Table 1 and Table 2).
#4.1# PU238 0.928
#4.1# PU239 57.542
#4.1# PU240 22.274
#4.1# PU241 7.424
#4.1# PU242 4.640
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)
(arbitrary number of lines; one line per nuclide)
#4.2#Am241 0.1716
#4.2#Am242m 0.0028
#4.2#Am243 3.2111
#4.2#Cm242 0.3087
#4.2#Cm243 0.0133
#4.2#Cm244 2.9397
#4.2#Cm245 0.1398
#4.2#Np237 0.0028
#4.2#Np239 0.0000
#4.2#Pu238 2.8008
#4.2#Pu239 0.4113
#4.2#Pu240 1.3061
#4.2#Pu241 0.9786
#4.2#Pu242 9.3146
#4.2#U233 0.0000
#4.2#U234 0.1593
#4.2#U235 0.0392
#4.2#U236 0.0238
#4.2#U237 0.0000
#4.2#U238 0.0000
#4.2#Cs135fp 2.0918
#4.2#Eu154fp 0.1308

#4.2#I129fp 0.4889
#4.2#Pd107fp 1.2045
#4.2#Sm147fp 0.2677
#4.2#Sm151fp 0.0104
#4.2#Tc99fp 1.3916
#4.2#Zr93fp 0.9261
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) (arbitrary number of lines; one line per nuclide)
#4.3#Am241 2.349E-06
#4.3#Am242m 3.793E-08
#4.3#Am243 4.396E-05
#4.3#Cm242 4.225E-06
#4.3#Cm243 1.819E-07
#4.3#Cm244 4.024E-05
#4.3#Cm245 1.913E-06
#4.3#Np237 3.847E-08
#4.3#Np239 1.651E-13
#4.3#Pu238 2.562E-05
#4.3#Pu239 -7.792E-04
#4.3#Pu240 -2.871E-04
#4.3#Pu241 -9.044E-05
#4.3#Pu242 6.388E-05
#4.3#U233 1.673E-12
#4.3#U234 2.174E-06
#4.3#U235 5.344E-07
#4.3#U236 3.234E-07
#4.3#U237 4.764E-10
#4.3#U238 1.828E-10
#4.3#Cs135fp 2.864E-05
#4.3#Eu154fp 1.790E-06
#4.3#I129fp 6.693E-06
#4.3#Pd107fp 1.649E-05
#4.3#Sm147fp 3.664E-06
#4.3#Sm151fp 1.423E-07
#4.3#Tc99fp 1.905E-05
#4.3#Zr93fp 1.268E-05
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)
(same number of lines as for item 4.2; one line per nuclide)
##
4.4 Attained discharge burnup of the fuel (units: MWd/kg) (for each fuel type)
#4.4.1# Fuel_type_1 N.A.
Minimum value (arbitrary number of lines; one line per fuel type;
indicate fuel type by a single word, which may contain underscores)
#4.4.2# Fuel_type_1 787.0
Average value (one line per fuel type)
#4.4.3# Fuel_type_1 N.A.
Maximum value (one line per fuel type)

5. Reaction rates at nominal conditions
##
5.1 Neutron induced fission fraction per heavy metal nuclide in the entire system
#5.1.2# AM241 6.02E+15
#5.1.2# AM242M 4.79E+16
#5.1.2# AM243 9.52E+14
#5.1.2# CM242 3.71E+14
#5.1.2# CM243 9.57E+14
#5.1.2# CM244 1.34E+15
#5.1.2# CM245 1.12E+16
#5.1.2# NP237 7.19E+11
#5.1.2# NP239 3.87E+06
#5.1.2# PU238 7.55E+15
#5.1.2# PU239 3.34E+18
#5.1.2# PU240 1.21E+16
#5.1.2# PU241 2.47E+18
#5.1.2# PU242 3.46E+15
#5.1.2# U233 4.62E+09
#5.1.2# U234 3.83E+13
#5.1.2# U235 9.55E+14
#5.1.2# U236 8.74E+12
#5.1.2# U237 9.99E+09
#5.1.2# U238 2.76E+09
At equi (same number of lines as for item 5.1.1; one line per heavy metal nuclide, see Table 2)
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) (per nuclide)
#5.2.1#
At BOL (arbitrary number of lines: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard lists in Table 1 and Table 2)
#5.2.2#
At MOL (same number of lines as for item 5.2.1)
#5.2.3#
At EOL (same number of lines as for item 5.2.1)
##
5.3 Neutron absorption rate in all other material in the core cavity (units: s^-1)
(per nuclide, including impurities and/or burnable poison if present)
#5.3.1#
At BOL (arbitrary number of lines: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard list)
#5.3.2#
At MOL (same number of lines as for item 5.3.1: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard list)
#5.3.3#
At EOL (same number of lines as for item 5.3.1: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard list)
##
5.4 Net neutron leakage rate from the core cavity (units: s^-1) (integrated over all neutron energies)
#5.4.1# 1.6981 E+18
At BOL

#5.4.2# 1.6981 E+18
At equi
#5.4.3# 1.6981 E+18
At EOL

6. Fast and thermal neutron flux (fluence rate) and fluence measures at nominal conditions
##
6.1 Thermal flux below 1.86 eV (units: m^-2s^-1). The items listed below should be calculated at BOL,
MOL and EOL.
#6.1.1# 1.544 E+17 1.544 E+17 1.544 E+17
Average value in the core (one line containing BOL, MOL and EOL values)
#6.1.2# 7.869 E+17 7.869 E+17 7.869 E+17
Peak value in the core (one line containing BOL, MOL and EOL values)
#6.1.3# 9.9999E99 9.9999E99 9.9999E99
Average value in the reflector (one line containing BOL, MOL and EOL values)
#6.1.4# 9.9999E99 9.9999E99 9.9999E99
Peak value in the reflector (one line containing BOL, MOL and EOL values)
#6.1.5# -4.3250e+00 9.6552e+00 9.6552e+00 9.6552e+00
#6.1.5# -4.0750e+00 4.2582e+04 4.2582e+04 4.2582e+04
#6.1.5# -3.8250e+00 2.5546e+08 2.5546e+08 2.5546e+08
#6.1.5# -3.5750e+00 1.4945e+12 1.4945e+12 1.4945e+12
#6.1.5# -3.3250e+00 4.2637e+15 4.2637e+15 4.2637e+15
#6.1.5# -3.0750e+00 4.3317e+15 4.3317e+15 4.3317e+15
#6.1.5# -2.8250e+00 4.4285e+15 4.4285e+15 4.4285e+15
#6.1.5# -2.5750e+00 6.9733e+15 6.9733e+15 6.9733e+15
#6.1.5# -2.3250e+00 1.2866e+16 1.2866e+16 1.2866e+16
#6.1.5# -2.0750e+00 2.0721e+16 2.0721e+16 2.0721e+16
#6.1.5# -1.8250e+00 3.1865e+16 3.1865e+16 3.1865e+16
#6.1.5# -1.5750e+00 4.8147e+16 4.8147e+16 4.8147e+16
#6.1.5# -1.3250e+00 7.2219e+16 7.2219e+16 7.2219e+16
#6.1.5# -1.0750e+00 1.0788e+17 1.0788e+17 1.0788e+17
#6.1.5# -8.2500e-01 1.6021e+17 1.6021e+17 1.6021e+17
#6.1.5# -6.1250e-01 2.2307e+17 2.2307e+17 2.2307e+17
#6.1.5# -4.3750e-01 2.8293e+17 2.8293e+17 2.8293e+17
#6.1.5# -2.6250e-01 3.3372e+17 3.3372e+17 3.3372e+17
#6.1.5# -8.7500e-02 3.0540e+17 3.0540e+17 3.0540e+17
#6.1.5# 8.2750e-02 1.1414e+17 1.1414e+17 1.1414e+17
#6.1.5# 2.4825e-01 8.8908e+16 8.8908e+16 8.8908e+16
#6.1.5# 4.1375e-01 8.7484e+16 8.7484e+16 8.7484e+16
#6.1.5# 5.7925e-01 9.1780e+16 9.1780e+16 9.1780e+16
#6.1.5# 7.4475e-01 9.7556e+16 9.7556e+16 9.7556e+16
#6.1.5# 9.1025e-01 1.0379e+17 1.0379e+17 1.0379e+17
#6.1.5# 1.0757e+00 1.1023e+17 1.1023e+17 1.1023e+17
#6.1.5# 1.2412e+00 1.1680e+17 1.1680e+17 1.1680e+17
#6.1.5# 1.4067e+00 1.2347e+17 1.2347e+17 1.2347e+17
#6.1.5# 1.5722e+00 1.3023e+17 1.3023e+17 1.3023e+17
#6.1.5# 1.7377e+00 1.3708e+17 1.3708e+17 1.3708e+17
#6.1.5# 1.9033e+00 1.4399e+17 1.4399e+17 1.4399e+17
#6.1.5# 2.0688e+00 1.5096e+17 1.5096e+17 1.5096e+17

#6.1.5# 2.2342e+00 1.5798e+17 1.5798e+17 1.5798e+17
#6.1.5# 2.3998e+00 1.6504e+17 1.6504e+17 1.6504e+17
#6.1.5# 2.5652e+00 1.7212e+17 1.7212e+17 1.7212e+17
#6.1.5# 2.7308e+00 1.7921e+17 1.7921e+17 1.7921e+17
#6.1.5# 2.8963e+00 1.8632e+17 1.8632e+17 1.8632e+17
#6.1.5# 3.0617e+00 1.9340e+17 1.9340e+17 1.9340e+17
#6.1.5# 3.2273e+00 2.0043e+17 2.0043e+17 2.0043e+17
#6.1.5# 3.3927e+00 2.0738e+17 2.0738e+17 2.0738e+17
#6.1.5# 3.5583e+00 2.1420e+17 2.1420e+17 2.1420e+17
#6.1.5# 3.7237e+00 2.2085e+17 2.2085e+17 2.2085e+17
#6.1.5# 3.8893e+00 2.2729e+17 2.2729e+17 2.2729e+17
#6.1.5# 4.0548e+00 2.3348e+17 2.3348e+17 2.3348e+17
#6.1.5# 4.2203e+00 2.3933e+17 2.3933e+17 2.3933e+17
#6.1.5# 4.3857e+00 2.4482e+17 2.4482e+17 2.4482e+17
#6.1.5# 4.5512e+00 2.4985e+17 2.4985e+17 2.4985e+17
#6.1.5# 4.7168e+00 2.5439e+17 2.5439e+17 2.5439e+17
#6.1.5# 4.8822e+00 2.5836e+17 2.5836e+17 2.5836e+17
#6.1.5# 5.0477e+00 2.6169e+17 2.6169e+17 2.6169e+17
#6.1.5# 5.2133e+00 2.6425e+17 2.6425e+17 2.6425e+17
#6.1.5# 5.3788e+00 2.6601e+17 2.6601e+17 2.6601e+17
#6.1.5# 5.5442e+00 2.6685e+17 2.6685e+17 2.6685e+17
#6.1.5# 5.7097e+00 2.6675e+17 2.6675e+17 2.6675e+17
#6.1.5# 5.8753e+00 2.6559e+17 2.6559e+17 2.6559e+17
#6.1.5# 6.0408e+00 2.6339e+17 2.6339e+17 2.6339e+17
#6.1.5# 6.2062e+00 2.6005e+17 2.6005e+17 2.6005e+17
#6.1.5# 6.3717e+00 2.5564e+17 2.5564e+17 2.5564e+17
#6.1.5# 6.5373e+00 2.5011e+17 2.5011e+17 2.5011e+17
#6.1.5# 6.7027e+00 2.4359e+17 2.4359e+17 2.4359e+17
#6.1.5# 6.8682e+00 2.3608e+17 2.3608e+17 2.3608e+17
#6.1.5# 7.0338e+00 2.2776e+17 2.2776e+17 2.2776e+17
#6.1.5# 7.1993e+00 2.1865e+17 2.1865e+17 2.1865e+17
#6.1.5# 7.3647e+00 2.0894e+17 2.0894e+17 2.0894e+17
#6.1.5# 7.5302e+00 1.9860e+17 1.9860e+17 1.9860e+17
#6.1.5# 7.6958e+00 1.8772e+17 1.8772e+17 1.8772e+17
#6.1.5# 7.8612e+00 1.7626e+17 1.7626e+17 1.7626e+17
#6.1.5# 8.0267e+00 1.6439e+17 1.6439e+17 1.6439e+17
#6.1.5# 8.1922e+00 1.5199e+17 1.5199e+17 1.5199e+17
#6.1.5# 8.3577e+00 1.3912e+17 1.3912e+17 1.3912e+17
#6.1.5# 8.5232e+00 1.2563e+17 1.2563e+17 1.2563e+17
#6.1.5# 8.6887e+00 1.1159e+17 1.1159e+17 1.1159e+17
#6.1.5# 8.8542e+00 9.6925e+16 9.6925e+16 9.6925e+16
#6.1.5# 9.0197e+00 8.2227e+16 8.2227e+16 8.2227e+16
#6.1.5# 9.1852e+00 6.9832e+16 6.9832e+16 6.9832e+16
#6.1.5# 9.3507e+00 7.0970e+16 7.0970e+16 7.0970e+16
#6.1.5# 9.5162e+00 1.1212e+17 1.1212e+17 1.1212e+17
#6.1.5# 9.6817e+00 1.1438e+17 1.1438e+17 1.1438e+17
#6.1.5# 9.8472e+00 1.1659e+17 1.1659e+17 1.1659e+17
#6.1.5# 1.0013e+01 1.7225e+17 1.7225e+17 1.7225e+17
#6.1.5# 1.0180e+01 1.8020e+17 1.8020e+17 1.8020e+17
#6.1.5# 1.0347e+01 1.4733e+17 1.4733e+17 1.4733e+17

#6.1.5# 1.0513e+01 1.0873e+17 1.0873e+17 1.0873e+17
#6.1.5# 1.0680e+01 7.3223e+16 7.3223e+16 7.3223e+16
#6.1.5# 1.0847e+01 4.1762e+16 4.1762e+16 4.1762e+16
#6.1.5# 1.1018e+01 2.6988e+16 2.6988e+16 2.6988e+16
#6.1.5# 1.1193e+01 2.6491e+16 2.6491e+16 2.6491e+16
#6.1.5# 1.1380e+01 2.1518e+16 2.1518e+16 2.1518e+16
#6.1.5# 1.1580e+01 1.4846e+16 1.4846e+16 1.4846e+16
#6.1.5# 1.1780e+01 1.0402e+16 1.0402e+16 1.0402e+16
#6.1.5# 1.1980e+01 2.4556e+12 2.4556e+12 2.4556e+12
#6.1.5# 1.2180e+01 3.3507e+08 3.3507e+08 3.3507e+08
#6.1.5# 1.2380e+01 1.0507e+05 1.0507e+05 1.0507e+05
Axial distribution of the thermal flux (2.1 eV cut off) along the centre axis
(arbitrary number of lines; one line per axial position; each line contains
the axial position above core bottom (units: m), BOL, MOL and EOL values)
#6.1.6# 0.0000e+00 2.5439e+17 2.5439e+17 2.5439e+17
#6.1.6# 1.2639e-01 2.5372e+17 2.5372e+17 2.5372e+17
#6.1.6# 2.3584e-01 2.5204e+17 2.5204e+17 2.5204e+17
#6.1.6# 3.4931e-01 2.4924e+17 2.4924e+17 2.4924e+17
#6.1.6# 4.6368e-01 2.4534e+17 2.4534e+17 2.4534e+17
#6.1.6# 5.7841e-01 2.4036e+17 2.4036e+17 2.4036e+17
#6.1.6# 6.9332e-01 2.3439e+17 2.3439e+17 2.3439e+17
#6.1.6# 8.0704e-01 2.2767e+17 2.2767e+17 2.2767e+17
#6.1.6# 9.2883e-01 2.2011e+17 2.2011e+17 2.2011e+17
#6.1.6# 1.0544e+00 2.1357e+17 2.1357e+17 2.1357e+17
#6.1.6# 1.1783e+00 2.1322e+17 2.1322e+17 2.1322e+17
#6.1.6# 1.3008e+00 2.3298e+17 2.3298e+17 2.3298e+17
#6.1.6# 1.4313e+00 3.2080e+17 3.2080e+17 3.2080e+17
#6.1.6# 1.5315e+00 5.9291e+17 5.9291e+17 5.9291e+17
#6.1.6# 1.5822e+00 6.3634e+17 6.3634e+17 6.3634e+17
#6.1.6# 1.6703e+00 7.3980e+17 7.3980e+17 7.3980e+17
#6.1.6# 1.7663e+00 6.9855e+17 6.9855e+17 6.9855e+17
#6.1.6# 1.8716e+00 6.0687e+17 6.0687e+17 6.0687e+17
#6.1.6# 1.9917e+00 5.0016e+17 5.0016e+17 5.0016e+17
#6.1.6# 2.1112e+00 3.9742e+17 3.9742e+17 3.9742e+17
#6.1.6# 2.2242e+00 2.9684e+17 2.9684e+17 2.9684e+17
#6.1.6# 2.3372e+00 2.8175e+14 2.8175e+14 2.8175e+14
#6.1.6# 2.4452e+00 1.9584e+11 1.9584e+11 1.9584e+11
Radial distribution of the thermal flux (2.1 eV cut off) at half core height
(arbitrary number of lines; one line per radial position; each line contains
the distance to centre line (units: m), BOL, MOL and EOL values)
6.2 59Co(n,gamma) reaction rate of a 10^-10 (barn cm)^-1 trace of 59Co 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 and presented in the same way as for item set 6.1.
#6.2.1# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the core (units: s-1)
#6.2.2# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the reflector (units: s-1)

#6.2.3# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the core (units: s-1m-3)
#6.2.4# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the reflector (units: s-1m-3)
#6.2.5# 0.0 9.9999E99 9.9999E99 9.9999E99
Axial distribution of the reaction rate density along the centre axis (units: s-1m-3)
#6.2.6# 0.0 9.9999E99 9.9999E99 9.9999E99
Radial distribution of the reaction rate density at half core height (units: s-1m-3)
6.3 Fast flux (fluence rate) above 0.1 MeV (units: m-2s-1). The items listed below should be
calculated at BOL, MOL and EOL and presented in the same way as for item set 6.1.
#6.3.1# 2.492 E+17 2.492 E+17 2.492 E+17
Average value in the core (one line containing BOL, MOL and EOL values)
#6.3.2# 4.914 E+17 4.914 E+17 4.914 E+17
Peak value in the core (one line containing BOL, MOL and EOL values)
#6.3.3# 9.9999E99 9.9999E99 9.9999E99
Average value in the reflector (one line containing BOL, MOL and EOL values)
#6.3.4# 9.9999E99 9.9999E99 9.9999E99
Peak value in the reflector (one line containing BOL, MOL and EOL values)
#6.3.5# -4.3250e+00 1.4927e+03 1.4927e+03 1.4927e+03
#6.3.5# -4.0750e+00 5.7492e+04 5.7492e+04 5.7492e+04
#6.3.5# -3.8250e+00 2.1722e+06 2.1722e+06 2.1722e+06
#6.3.5# -3.5750e+00 8.2181e+07 8.2181e+07 8.2181e+07
#6.3.5# -3.3250e+00 1.6338e+09 1.6338e+09 1.6338e+09
#6.3.5# -3.0750e+00 1.7659e+09 1.7659e+09 1.7659e+09
#6.3.5# -2.8250e+00 1.9697e+09 1.9697e+09 1.9697e+09
#6.3.5# -2.5750e+00 6.3540e+09 6.3540e+09 6.3540e+09
#6.3.5# -2.3250e+00 3.7037e+10 3.7037e+10 3.7037e+10
#6.3.5# -2.0750e+00 1.9717e+11 1.9717e+11 1.9717e+11
#6.3.5# -1.8250e+00 1.0459e+12 1.0459e+12 1.0459e+12
#6.3.5# -1.5750e+00 5.5441e+12 5.5441e+12 5.5441e+12
#6.3.5# -1.3250e+00 2.9372e+13 2.9372e+13 2.9372e+13
#6.3.5# -1.0750e+00 1.5553e+14 1.5553e+14 1.5553e+14
#6.3.5# -8.2500e-01 8.2320e+14 8.2320e+14 8.2320e+14
#6.3.5# -6.1250e-01 3.8256e+15 3.8256e+15 3.8256e+15
#6.3.5# -4.3750e-01 1.2818e+16 1.2818e+16 1.2818e+16
#6.3.5# -2.6250e-01 4.3653e+16 4.3653e+16 4.3653e+16
#6.3.5# -8.7500e-02 1.4148e+17 1.4148e+17 1.4148e+17
#6.3.5# 8.2750e-02 3.4733e+17 3.4733e+17 3.4733e+17
#6.3.5# 2.4825e-01 3.9727e+17 3.9727e+17 3.9727e+17
#6.3.5# 4.1375e-01 4.3267e+17 4.3267e+17 4.3267e+17
#6.3.5# 5.7925e-01 4.6502e+17 4.6502e+17 4.6502e+17
#6.3.5# 7.4475e-01 4.9740e+17 4.9740e+17 4.9740e+17
#6.3.5# 9.1025e-01 5.3046e+17 5.3046e+17 5.3046e+17
#6.3.5# 1.0757e+00 5.6428e+17 5.6428e+17 5.6428e+17
#6.3.5# 1.2412e+00 5.9881e+17 5.9881e+17 5.9881e+17
#6.3.5# 1.4067e+00 6.3402e+17 6.3402e+17 6.3402e+17
#6.3.5# 1.5722e+00 6.6985e+17 6.6985e+17 6.6985e+17
#6.3.5# 1.7377e+00 7.0626e+17 7.0626e+17 7.0626e+17
#6.3.5# 1.9033e+00 7.4323e+17 7.4323e+17 7.4323e+17
#6.3.5# 2.0688e+00 7.8072e+17 7.8072e+17 7.8072e+17

#6.3.5#	2.2342e+00	8.1867e+17	8.1867e+17	8.1867e+17
#6.3.5#	2.3998e+00	8.5705e+17	8.5705e+17	8.5705e+17
#6.3.5#	2.5652e+00	8.9577e+17	8.9577e+17	8.9577e+17
#6.3.5#	2.7308e+00	9.3475e+17	9.3475e+17	9.3475e+17
#6.3.5#	2.8963e+00	9.7388e+17	9.7388e+17	9.7388e+17
#6.3.5#	3.0617e+00	1.0130e+18	1.0130e+18	1.0130e+18
#6.3.5#	3.2273e+00	1.0521e+18	1.0521e+18	1.0521e+18
#6.3.5#	3.3927e+00	1.0910e+18	1.0910e+18	1.0910e+18
#6.3.5#	3.5583e+00	1.1295e+18	1.1295e+18	1.1295e+18
#6.3.5#	3.7237e+00	1.1673e+18	1.1673e+18	1.1673e+18
#6.3.5#	3.8893e+00	1.2043e+18	1.2043e+18	1.2043e+18
#6.3.5#	4.0548e+00	1.2401e+18	1.2401e+18	1.2401e+18
#6.3.5#	4.2203e+00	1.2745e+18	1.2745e+18	1.2745e+18
#6.3.5#	4.3857e+00	1.3071e+18	1.3071e+18	1.3071e+18
#6.3.5#	4.5512e+00	1.3375e+18	1.3375e+18	1.3375e+18
#6.3.5#	4.7168e+00	1.3653e+18	1.3653e+18	1.3653e+18
#6.3.5#	4.8822e+00	1.3900e+18	1.3900e+18	1.3900e+18
#6.3.5#	5.0477e+00	1.4113e+18	1.4113e+18	1.4113e+18
#6.3.5#	5.2133e+00	1.4287e+18	1.4287e+18	1.4287e+18
#6.3.5#	5.3788e+00	1.4417e+18	1.4417e+18	1.4417e+18
#6.3.5#	5.5442e+00	1.4500e+18	1.4500e+18	1.4500e+18
#6.3.5#	5.7097e+00	1.4529e+18	1.4529e+18	1.4529e+18
#6.3.5#	5.8753e+00	1.4502e+18	1.4502e+18	1.4502e+18
#6.3.5#	6.0408e+00	1.4415e+18	1.4415e+18	1.4415e+18
#6.3.5#	6.2062e+00	1.4267e+18	1.4267e+18	1.4267e+18
#6.3.5#	6.3717e+00	1.4056e+18	1.4056e+18	1.4056e+18
#6.3.5#	6.5373e+00	1.3784e+18	1.3784e+18	1.3784e+18
#6.3.5#	6.7027e+00	1.3453e+18	1.3453e+18	1.3453e+18
#6.3.5#	6.8682e+00	1.3067e+18	1.3067e+18	1.3067e+18
#6.3.5#	7.0338e+00	1.2630e+18	1.2630e+18	1.2630e+18
#6.3.5#	7.1993e+00	1.2150e+18	1.2150e+18	1.2150e+18
#6.3.5#	7.3647e+00	1.1630e+18	1.1630e+18	1.1630e+18
#6.3.5#	7.5302e+00	1.1077e+18	1.1077e+18	1.1077e+18
#6.3.5#	7.6958e+00	1.0492e+18	1.0492e+18	1.0492e+18
#6.3.5#	7.8612e+00	9.8785e+17	9.8785e+17	9.8785e+17
#6.3.5#	8.0267e+00	9.2341e+17	9.2341e+17	9.2341e+17
#6.3.5#	8.1922e+00	8.5591e+17	8.5591e+17	8.5591e+17
#6.3.5#	8.3577e+00	7.8499e+17	7.8499e+17	7.8499e+17
#6.3.5#	8.5232e+00	7.1046e+17	7.1046e+17	7.1046e+17
#6.3.5#	8.6887e+00	6.3177e+17	6.3177e+17	6.3177e+17
#6.3.5#	8.8542e+00	5.4846e+17	5.4846e+17	5.4846e+17
#6.3.5#	9.0197e+00	4.5945e+17	4.5945e+17	4.5945e+17
#6.3.5#	9.1852e+00	3.6232e+17	3.6232e+17	3.6232e+17
#6.3.5#	9.3507e+00	2.5315e+17	2.5315e+17	2.5315e+17
#6.3.5#	9.5162e+00	1.5262e+17	1.5262e+17	1.5262e+17
#6.3.5#	9.6817e+00	1.4565e+17	1.4565e+17	1.4565e+17
#6.3.5#	9.8472e+00	1.4017e+17	1.4017e+17	1.4017e+17
#6.3.5#	1.0013e+01	7.6979e+16	7.6979e+16	7.6979e+16
#6.3.5#	1.0180e+01	2.4922e+16	2.4922e+16	2.4922e+16
#6.3.5#	1.0347e+01	7.7180e+15	7.7180e+15	7.7180e+15

#6.3.5# 1.0513e+01 2.3885e+15 2.3885e+15 2.3885e+15
#6.3.5# 1.0680e+01 7.3394e+14 7.3394e+14 7.3394e+14
#6.3.5# 1.0847e+01 2.0878e+14 2.0878e+14 2.0878e+14
#6.3.5# 1.1018e+01 1.0354e+14 1.0354e+14 1.0354e+14
#6.3.5# 1.1193e+01 9.8646e+13 9.8646e+13 9.8646e+13
#6.3.5# 1.1380e+01 2.4374e+13 2.4374e+13 2.4374e+13
#6.3.5# 1.1580e+01 3.4962e+12 3.4962e+12 3.4962e+12
#6.3.5# 1.1780e+01 4.9653e+11 4.9653e+11 4.9653e+11
#6.3.5# 1.1980e+01 2.6095e+10 2.6095e+10 2.6095e+10
#6.3.5# 1.2180e+01 1.3449e+09 1.3449e+09 1.3449e+09
#6.3.5# 1.2380e+01 6.6873e+07 6.6873e+07 6.6873e+07
Axial distribution of the fast flux (2.1 eV cut off) along the centre axis
(arbitrary number of lines; one line per axial position; each line contains
the axial position above core bottom (units: m), BOL, MOL and EOL values)
#6.3.6# 0.0000e+00 1.3653e+18 1.3653e+18 1.3653e+18
#6.3.6# 1.2639e-01 1.3618e+18 1.3618e+18 1.3618e+18
#6.3.6# 2.3584e-01 1.3533e+18 1.3533e+18 1.3533e+18
#6.3.6# 3.4931e-01 1.3390e+18 1.3390e+18 1.3390e+18
#6.3.6# 4.6368e-01 1.3190e+18 1.3190e+18 1.3190e+18
#6.3.6# 5.7841e-01 1.2933e+18 1.2933e+18 1.2933e+18
#6.3.6# 6.9332e-01 1.2619e+18 1.2619e+18 1.2619e+18
#6.3.6# 8.0704e-01 1.2250e+18 1.2250e+18 1.2250e+18
#6.3.6# 9.2883e-01 1.1789e+18 1.1789e+18 1.1789e+18
#6.3.6# 1.0544e+00 1.1231e+18 1.1231e+18 1.1231e+18
#6.3.6# 1.1783e+00 1.0562e+18 1.0562e+18 1.0562e+18
#6.3.6# 1.3008e+00 9.6778e+17 9.6778e+17 9.6778e+17
#6.3.6# 1.4313e+00 8.1324e+17 8.1324e+17 8.1324e+17
#6.3.6# 1.5315e+00 4.8564e+17 4.8564e+17 4.8564e+17
#6.3.6# 1.5822e+00 3.9397e+17 3.9397e+17 3.9397e+17
#6.3.6# 1.6703e+00 1.9002e+17 1.9002e+17 1.9002e+17
#6.3.6# 1.7663e+00 8.6057e+16 8.6057e+16 8.6057e+16
#6.3.6# 1.8716e+00 3.8835e+16 3.8835e+16 3.8835e+16
#6.3.6# 1.9917e+00 1.5743e+16 1.5743e+16 1.5743e+16
#6.3.6# 2.1112e+00 6.4383e+15 6.4383e+15 6.4383e+15
#6.3.6# 2.2242e+00 2.2349e+15 2.2349e+15 2.2349e+15
#6.3.6# 2.3372e+00 3.9798e+14 3.9798e+14 3.9798e+14
#6.3.6# 2.4452e+00 6.2103e+13 6.2103e+13 6.2103e+13
Radial distribution of the fast flux (2.1 eV cut off) at half core height
(arbitrary number of lines; one line per radial position; each line contains
the distance to centre line (units: m), BOL, MOL and EOL values)
##
6.4 58Ni(n,p) reaction rate of a 10^-10 (barn cm)^-1 trace of 58Ni 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 and presented in the same way as for item set 6.1.
#6.4.1# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the core (units: s-1)
#6.4.2# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the reflector (units: s-1)
#6.4.3# 9.9999E99 9.9999E99 9.9999E99

Peak value of the reaction rate density in the core (units: s-1m-3)
#6.4.4# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the reflector (units: s-1m-3)
#6.4.5# 0.0 9.9999E99 9.9999E99 9.9999E99
Axial distribution of the reaction rate density along the centre axis (units: s-1m-3)
#6.4.6# 0.0 9.9999E99 9.9999E99 9.9999E99
Radial distribution of the reaction rate density at half core height (units: s-1m-3)
##
6.5 Fast fluence above 0.1 MeV of discharged fuel (kernel, coatings, matrix) (units: m-2)
#6.5.1# 9.9999E99
Minimum value
#6.5.2# 9.9999E99
Average value
#6.5.3# 9.9999E99
Maximum value

7. Temperatures at nominal conditions
##
7.1 Coated particle temperature (units: K)
#7.1.1# 999.9
Maximum value occurring anywhere in the core at BOL
#7.1.2# 999.9
Maximum value occurring anywhere in the core at EOL
#7.1.3# 999.9
Maximum value occurring anywhere in the core at any time during the operating cycle
##
##7.2. Pebble surface temperature (units: K)
#7.2.1# 1098.5
Maximum value occurring anywhere in the core at BOL
#7.2.2# 1098.5
Maximum value occurring anywhere in the core at EOL
#7.2.3# 1098.5
Maximum value occurring anywhere in the core at any time during the operating cycle

8. Temperature reactivity coefficients. 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 in additional comment lines (so starting with '##').
##
8.1 Temperature reactivity coefficients at Cold Zero Power (CZP, zero xenon) conditions (units:
pcm/K). The reference state for this calculation is an isothermal reactor at 300 K (kref). The
temperature reactivity coefficients should be calculated for:
#8.1.1#
Fuel compacts/pebbles
#8.1.2#
Moderator in the core cavity (e.g. central reflector)
#8.1.3# -5.30
Reactor
##
8.2 Temperature reactivity coefficients at Hot Zero Power (HZP, zero xenon) conditions (unit:

pcm/K). The reference state for this calculation is an isothermal reactor at nominal coolant inlet
temperature (kref) (see item 1.14). The temperature reactivity coefficients should be calculated
for:
#8.2.1#
Fuel compacts/pebbles
#8.2.2#
Moderator in the core cavity
#8.2.3# -5.62
Reactor
##
8.3 Temperature reactivity coefficients at Hot Full Power (HFP or nominal, equilibrium xenon)
conditions (units: pcm/K). The reference state for this calculation is the temperature distribution
at nominal conditions (kref). The temperature reactivity coefficients should be calculated for:
#8.3.1# Type_1 999.9
Coated particles (arbitrary number of lines; one line per coated particle type;
line contains particle type and temperature reactivity coefficient;
indicate particle type by a single word, which may contain underscores)
#8.3.2# 999.9
Fuel compacts/pebbles
#8.3.3# 999.9
Moderator in the core cavity (central reflector)
#8.3.4# -4.60
Reactor
##
8.4 Differences in reactivity (units: pcm) between:
#8.4.1# -1684
CZP (zero xenon) state and HZP (zero xenon) state
#8.4.2# -16368
CZP (zero xenon) state and HFP (equilibrium xenon) state

APPENDIX 4

Pu-1-2.00-0-67

```
## 0. Case identification and description.
##
#0.1# J.B.M. de Haas
## Origin
#0.2# NRG
## Organisation
#0.3# Pu-1-2.00-0-67
## Case number
#0.4# 20 Sept 2003
## Date
#0.5# PANTHERMIX
## Applied code system
#0.6# HTR-N-03/11-D-3.2.1
## References (arbitrary number of text lines)
##
## 1. General fuel/reactor/system specifications. This section is intended
##    as a complete description of the fuel, the reactor (system) and the applied
##    fuel loading and discharge scheme.
##
#1.1# MEDUL reactor 200 MWth with reload
#1.1# first generation Pu with 67% fissile isotopes and 2.0 gr HM per pebble
## System (part) under consideration (reactor, supercell, etc.)
## (arbitrary number of text lines)
#1.2# reactor
#1.2# core diameter                              3.0 m
#1.2# core/pebblebed height                      9.93/9.43 m
#1.2# botom reflector height                     4.45 m
#1.2# top reflector height                       2.05 m
## Main system dimensions (i.e. core diameter, core height, reflector dimensions, etc.)
## (arbitrary number of text lines)
#1.3# PuO2 particle:    kernel                   0.145 mm radius
#1.3# PuO2 particle:    low dens. carbon         0.240
#1.3# PuO2 particle:    high dens.carbon         0.280
#1.3# PuO2 particle:    silicon carbide          0.315
#1.3# PuO2 particle:    high dens.carbon         0.355
#1.3# PuO2 particle:
## Coated particle dimensions (kernel and coatings) (per coated particle type)
## (arbitrary number of text lines)
#1.4# PuO2 kernel:           Pu238      6.0122e-4
#1.4# PuO2 kernel:           Pu239      1.2448e-2
#1.4# PuO2 kernel:           Pu240      5.4464e-3
#1.4# PuO2 kernel:           Pu241      3.0099e-3
#1.4# PuO2 kernel:           Pu242      1.5478e-3
#1.4# PuO2 kernel:           O16        4.6096e-2
#1.4# low dens. carbon:      C12        5.2645e-2
#1.4# high dens. Carbon  :   C12        9.5263e-2
```

#1.4# silicon carbide : C12 4.7761e-2
#1.4# silicon carbide : Si28 4.7761e-2
#1.4# high dens. Carbon C12 9.5263e-2
Initial coated particle composition per nuclide per material zone (units: (barn cm)^-1)
(arbitrary number of text lines; one line per nuclide per coated particle type; see
Table 2; add extra nuclide names for impurities)
#1.5# pebble 30 mm radius, fuelled 25 mm radius
Compact/pebble dimensions (arbitrary number of lines)
#1.6# Bnat 1.2672e-7
#1.6# C12 8.7742e-2
pebble matrix composition per nuclide (outside coated particles; including impurities)
(units: (barn cm)^-1) (arbitrary number of lines; one line per nuclide)
#1.7# Bnat 9.7481e-8
#1.7# C12 8.7742e-2
pebble shell composition per nuclide (outside coated particles; including impurities)
(units: (barn cm)^-1) (arbitrary number of lines; one line per nuclide)
#1.8# Type_2.0-67 17068
Number of coated particles per pebble/compact (of each coated particle type)
(arbitrary number of lines; one line per particle type)
#1.9# 365
Operating cycle length (units: full power days)
#1.10# 0
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)
#1.11# 200.0
Nominal reactor power (units: MW)
#1.12# 1.0
Capacity factor (units: -)
#1.13# N.A.
Number of fuel batches (batch wise reload only) (units: -)
#1.14# 523.15
Nominal coolant inlet temperature (units: K)
#1.15# 6000000.0
Nominal coolant inlet pressure (units: Pa)
#1.16# 972.15
Nominal coolant outlet temperature at nominal (Hot Full Power, HFP) conditions (units: K)
#1.17# 6070930.0
Nominal coolant outlet pressure at nominal (Hot Full Power, HFP) conditions (units: Pa)
#1.18# 85.55
Nominal coolant mass flow (unit: kg/s)
#1.19# continues reload
#1.19# 1500 balls per day (3000 gr Pu per day)
#1.19# no moderator balls
#1.19# 5394.6 balls per cubic meter
Description of fuel cycle strategy and other relevant information on the specific case
(arbitrary number of text lines).
##
2. Rating and power density
##
2.1. Power produced per coated particle (per coated partcile type) (units: W):

#2.1.1# 73.85e-3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.1.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power (units: W)) (arbitrary number of lines)
2.2. Power produced per compact/pebble (units: W)
#2.2.1# 1261.0
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.2.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power (units: W)) (arbitrary number of lines)
2.3. Power produced per unit heavy metal mass (units: W/kg)
#2.3.1# 630.3e+3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.3.2# N.A.
Maximum value anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power per unit heavy metal mass (units: W/kg))
(arbitrary number of lines)
2.4. Power density in the core (units: W/m^3)
#2.4.1# 6.80e+6
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.4.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power density (units: W/m^3)) (arbitrary number of lines)
##
3. Core inventory
##
3.1. Amount of each of the heavy metal isotopes present in the core (units: kg)
#3.1.2# AM241 1.13E+01
#3.1.2# AM242M 2.69E-01
#3.1.2# AM243 1.66E+01
#3.1.2# CM242 2.15E+00
#3.1.2# CM243 5.00E-02
#3.1.2# CM244 7.88E+00
#3.1.2# CM245 7.99E-01
#3.1.2# NP237 4.85E-03
#3.1.2# NP239 8.83E-08
#3.1.2# PU238 1.96E+01
#3.1.2# PU239 1.03E+02
#3.1.2# PU240 9.21E+01
#3.1.2# PU241 1.14E+02
#3.1.2# PU242 6.06E+01
#3.1.2# U233 4.26E-07
#3.1.2# U234 4.61E-01
#3.1.2# U235 1.05E-01
#3.1.2# U236 5.39E-02
#3.1.2# U237 7.59E-05
#3.1.2# U238 2.11E-04
#3.1.2# CS135FP 9.05E+00
#3.1.2# EU154FP 3.72E-01

#3.1.2# I129FP 2.14E+00
#3.1.2# PD107FP 4.87E+00
#3.1.2# SM147FP 8.43E-01
#3.1.2# SM151FP 4.13E-01
#3.1.2# ZR93FP 3.94E+00
At equilibrium (arbitrary number of lines; see Table 2)
#3.1.3# N.A.
At EOL (arbitrary number of lines; see Table 2)
3.2. Fissile Pu fraction, i.e. amount of (239Pu and 241Pu) divided by the total
amount of Pu (units: -) (this can be derived from 3.1)
#3.2.1# 0.670
At BOL
#3.2.2# 0.558
At equilibrium
#3.2.3# 0.053
At discharge

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 3 (Table 1 and Table 2).
#4.1# PU238 2.555
#4.1# PU239 53.125
#4.1# PU240 23.342
#4.1# PU241 12.953
#4.1# PU242 6.689
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)
(arbitrary number of lines; one line per nuclide)
#4.2#Am241 3.254E-02
#4.2#Am242m 5.095E-04
#4.2#Am243 3.827E+00
#4.2#Cm242 3.438E-01
#4.2#Cm243 1.435E-02
#4.2#Cm244 4.089E+00
#4.2#Cm245 1.402E-01
#4.2#Np237 1.446E-03
#4.2#Np239 6.882E-08
#4.2#Pu238 1.729E+00
#4.2#Pu239 2.542E-01
#4.2#Pu240 9.563E-01
#4.2#Pu241 5.249E-01
#4.2#Pu242 1.123E+01
#4.2#U233 6.841E-08
#4.2#U234 8.635E-02
#4.2#U235 2.297E-02
#4.2#U236 1.562E-02
#4.2#U237 5.816E-05
#4.2#U238 6.193E-05
#4.2#Cs135fp 1.851E+00
#4.2#Eu154fp 1.432E-01

#4.2#I129fp 5.073E-01
#4.2#Pd107fp 1.313E+00
#4.2#Sm147fp 1.796E-01
#4.2#Sm151fp 1.014E-02
#4.2#Tc99fp 1.447E+00
#4.2#Zr93fp 9.633E-01
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) (arbitrary number of lines; one line per nuclide)
#4.3#Am241 1.922E-07
#4.3#Am242m 6.870E-09
#4.3#Am243 5.207E-05
#4.3#Cm242 4.706E-06
#4.3#Cm243 1.964E-07
#4.3#Cm244 5.597E-05
#4.3#Cm245 1.920E-06
#4.3#Np237 1.980E-08
#4.3#Np239 7.869E-13
#4.3#Pu238 -1.136E-05
#4.3#Pu239 -7.209E-04
#4.3#Pu240 -3.065E-04
#4.3#Pu241 -1.720E-04
#4.3#Pu242 6.195E-05
#4.3#U233 9.364E-13
#4.3#U234 1.174E-06
#4.3#U235 3.129E-07
#4.3#U236 2.128E-07
#4.3#U237 7.956E-10
#4.3#U238 4.080E-10
#4.3#Cs135fp 2.534E-05
#4.3#Eu154fp 1.960E-06
#4.3#I129fp 6.945E-06
#4.3#Pd107fp 1.798E-05
#4.3#Sm147fp 2.459E-06
#4.3#Sm151fp 1.388E-07
#4.3#Tc99fp 1.981E-05
#4.3#Zr93fp 1.319E-05

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)
(same number of lines as for item 4.2; one line per nuclide)
##
4.4 Attained discharge burnup of the fuel (units: MWd/kg) (for each fuel type)
#4.4.1# Fuel_type_1 N.A.
Minimum value (arbitrary number of lines; one line per fuel type;
indicate fuel type by a single word, which may contain underscores)
#4.4.2# Fuel_type_2 740.4
Average value (one line per fuel type)
#4.4.3# Fuel_type_2 N.A.
Maximum value (one line per fuel type)

```
## 5. Reaction rates at nominal conditions
##
## 5.1 Neutron induced fission fraction per heavy metal nuclide in the entire system
#5.1.2#     AM241       3.57e+15
#5.1.2#     AM242M      2.96e+16
#5.1.2#     AM243       1.18e+15
#5.1.2#     CM242       4.19e+14
#5.1.2#     CM243       1.05e+15
#5.1.2#     CM244       1.67e+15
#5.1.2#     CM245       1.40e+16
#5.1.2#     NP237       3.46e+11
#5.1.2#     NP239       8.46e+06
#5.1.2#     PU238       1.09e+16
#5.1.2#     PU239       2.95e+18
#5.1.2#     PU240       1.21e+15
#5.1.2#     PU241       2.87e+18
#5.1.2#     PU242       4.60e+15
#5.1.2#     U233        5.34e+09
#5.1.2#     U234        3.83e+15
#5.1.2#     U235        8.02e+14
#5.1.2#     U236        4.34e+12
#5.1.2#     U237        1.00e+10
#5.1.2#     U238        3.10e+09
## At equi (same number of lines as for item 5.1.1; one line per heavy metal nuclide, see Table 2)
## 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) (per nuclide)
#5.2.1#
## At BOL (arbitrary number of lines: one line per nuclide; add extra lines to describe
## e.g. burnable poison nuclides not present in the standard lists in Table 1 and Table 2)
#5.2.2#
## At MOL (same number of lines as for item 5.2.1)
#5.2.3#
## At EOL (same number of lines as for item 5.2.1)
##
## 5.3 Neutron absorption rate in all other material in the core cavity (units: s^-1)
##    (per nuclide, including impurities and/or burnable poison if present)
#5.3.1#
## At BOL (arbitrary number of lines: one line per nuclide; add extra lines to describe
## e.g. burnable poison nuclides not present in the standard list)
#5.3.2#
## At MOL (same number of lines as for item 5.3.1: one line per nuclide; add extra lines to describe
## e.g. burnable poison nuclides not present in the standard list)
#5.3.3#
## At EOL (same number of lines as for item 5.3.1: one line per nuclide; add extra lines to describe
## e.g. burnable poison nuclides not present in the standard list)
##
## 5.4 Net neutron leakage rate from the core cavity (units: s^-1) (integrated over all neutron energies)
#5.4.1#          1.676 E+18
```

At BOL
#5.4.2# 1.676 E+18
At equi
#5.4.3# 1.676 E+18
At EOL

6. Fast and thermal neutron flux (fluence rate) and fluence measures at nominal conditions
##
6.1 Thermal flux below 1.86 eV (units: m^-2s^-1). The items listed below should be calculated at BOL,
MOL and EOL.
#6.1.1# 1.658 E+17 1.658 E+17 1.658 E+17
Average value in the core (one line containing BOL, MOL and EOL values)
#6.1.2# 7.753 E+17 7.753 E+17 7.753 E+17
Peak value in the core (one line containing BOL, MOL and EOL values)
#6.1.3# 9.9999E99 9.9999E99 9.9999E99
Average value in the reflector (one line containing BOL, MOL and EOL values)
#6.1.4# 9.9999E99 9.9999E99 9.9999E99
Peak value in the reflector (one line containing BOL, MOL and EOL values)
#6.1.5# -4.3250e+00 1.0418e+01 1.0418e+01 1.0418e+01
#6.1.5# -4.0750e+00 4.5795e+04 4.5795e+04 4.5795e+04
#6.1.5# -3.8250e+00 2.7393e+08 2.7393e+08 2.7393e+08
#6.1.5# -3.5750e+00 1.5963e+12 1.5963e+12 1.5963e+12
#6.1.5# -3.3250e+00 4.5307e+15 4.5307e+15 4.5307e+15
#6.1.5# -3.0750e+00 4.6032e+15 4.6032e+15 4.6032e+15
#6.1.5# -2.8250e+00 4.7065e+15 4.7065e+15 4.7065e+15
#6.1.5# -2.5750e+00 7.4253e+15 7.4253e+15 7.4253e+15
#6.1.5# -2.3250e+00 1.3717e+16 1.3717e+16 1.3717e+16
#6.1.5# -2.0750e+00 2.2102e+16 2.2102e+16 2.2102e+16
#6.1.5# -1.8250e+00 3.3997e+16 3.3997e+16 3.3997e+16
#6.1.5# -1.5750e+00 5.1378e+16 5.1378e+16 5.1378e+16
#6.1.5# -1.3250e+00 7.7078e+16 7.7078e+16 7.7078e+16
#6.1.5# -1.0750e+00 1.1516e+17 1.1516e+17 1.1516e+17
#6.1.5# -8.2500e-01 1.7107e+17 1.7107e+17 1.7107e+17
#6.1.5# -6.1250e-01 2.3828e+17 2.3828e+17 2.3828e+17
#6.1.5# -4.3750e-01 3.0244e+17 3.0244e+17 3.0244e+17
#6.1.5# -2.6250e-01 3.5745e+17 3.5745e+17 3.5745e+17
#6.1.5# -8.7500e-02 3.2986e+17 3.2986e+17 3.2986e+17
#6.1.5# 8.2750e-02 1.3137e+17 1.3137e+17 1.3137e+17
#6.1.5# 2.4825e-01 1.0360e+17 1.0360e+17 1.0360e+17
#6.1.5# 4.1375e-01 1.0214e+17 1.0214e+17 1.0214e+17
#6.1.5# 5.7925e-01 1.0728e+17 1.0728e+17 1.0728e+17
#6.1.5# 7.4475e-01 1.1416e+17 1.1416e+17 1.1416e+17
#6.1.5# 9.1025e-01 1.2154e+17 1.2154e+17 1.2154e+17
#6.1.5# 1.0757e+00 1.2909e+17 1.2909e+17 1.2909e+17
#6.1.5# 1.2412e+00 1.3671e+17 1.3671e+17 1.3671e+17
#6.1.5# 1.4067e+00 1.4438e+17 1.4438e+17 1.4438e+17
#6.1.5# 1.5722e+00 1.5207e+17 1.5207e+17 1.5207e+17
#6.1.5# 1.7377e+00 1.5977e+17 1.5977e+17 1.5977e+17
#6.1.5# 1.9033e+00 1.6747e+17 1.6747e+17 1.6747e+17

#6.1.5# 2.0688e+00 1.7515e+17 1.7515e+17 1.7515e+17
#6.1.5# 2.2342e+00 1.8280e+17 1.8280e+17 1.8280e+17
#6.1.5# 2.3998e+00 1.9041e+17 1.9041e+17 1.9041e+17
#6.1.5# 2.5652e+00 1.9795e+17 1.9795e+17 1.9795e+17
#6.1.5# 2.7308e+00 2.0542e+17 2.0542e+17 2.0542e+17
#6.1.5# 2.8963e+00 2.1279e+17 2.1279e+17 2.1279e+17
#6.1.5# 3.0617e+00 2.2006e+17 2.2006e+17 2.2006e+17
#6.1.5# 3.2273e+00 2.2718e+17 2.2718e+17 2.2718e+17
#6.1.5# 3.3927e+00 2.3410e+17 2.3410e+17 2.3410e+17
#6.1.5# 3.5583e+00 2.4080e+17 2.4080e+17 2.4080e+17
#6.1.5# 3.7237e+00 2.4722e+17 2.4722e+17 2.4722e+17
#6.1.5# 3.8893e+00 2.5331e+17 2.5331e+17 2.5331e+17
#6.1.5# 4.0548e+00 2.5903e+17 2.5903e+17 2.5903e+17
#6.1.5# 4.2203e+00 2.6431e+17 2.6431e+17 2.6431e+17
#6.1.5# 4.3857e+00 2.6911e+17 2.6911e+17 2.6911e+17
#6.1.5# 4.5512e+00 2.7334e+17 2.7334e+17 2.7334e+17
#6.1.5# 4.7168e+00 2.7696e+17 2.7696e+17 2.7696e+17
#6.1.5# 4.8822e+00 2.7987e+17 2.7987e+17 2.7987e+17
#6.1.5# 5.0477e+00 2.8206e+17 2.8206e+17 2.8206e+17
#6.1.5# 5.2133e+00 2.8343e+17 2.8343e+17 2.8343e+17
#6.1.5# 5.3788e+00 2.8391e+17 2.8391e+17 2.8391e+17
#6.1.5# 5.5442e+00 2.8341e+17 2.8341e+17 2.8341e+17
#6.1.5# 5.7097e+00 2.8189e+17 2.8189e+17 2.8189e+17
#6.1.5# 5.8753e+00 2.7928e+17 2.7928e+17 2.7928e+17
#6.1.5# 6.0408e+00 2.7558e+17 2.7558e+17 2.7558e+17
#6.1.5# 6.2062e+00 2.7074e+17 2.7074e+17 2.7074e+17
#6.1.5# 6.3717e+00 2.6482e+17 2.6482e+17 2.6482e+17
#6.1.5# 6.5373e+00 2.5780e+17 2.5780e+17 2.5780e+17
#6.1.5# 6.7027e+00 2.4981e+17 2.4981e+17 2.4981e+17
#6.1.5# 6.8682e+00 2.4090e+17 2.4090e+17 2.4090e+17
#6.1.5# 7.0338e+00 2.3124e+17 2.3124e+17 2.3124e+17
#6.1.5# 7.1993e+00 2.2088e+17 2.2088e+17 2.2088e+17
#6.1.5# 7.3647e+00 2.1000e+17 2.1000e+17 2.1000e+17
#6.1.5# 7.5302e+00 1.9858e+17 1.9858e+17 1.9858e+17
#6.1.5# 7.6958e+00 1.8678e+17 1.8678e+17 1.8678e+17
#6.1.5# 7.8612e+00 1.7459e+17 1.7459e+17 1.7459e+17
#6.1.5# 8.0267e+00 1.6214e+17 1.6214e+17 1.6214e+17
#6.1.5# 8.1922e+00 1.4933e+17 1.4933e+17 1.4933e+17
#6.1.5# 8.3577e+00 1.3621e+17 1.3621e+17 1.3621e+17
#6.1.5# 8.5232e+00 1.2264e+17 1.2264e+17 1.2264e+17
#6.1.5# 8.6887e+00 1.0867e+17 1.0867e+17 1.0867e+17
#6.1.5# 8.8542e+00 9.4269e+16 9.4269e+16 9.4269e+16
#6.1.5# 9.0197e+00 8.0013e+16 8.0013e+16 8.0013e+16
#6.1.5# 9.1852e+00 6.8230e+16 6.8230e+16 6.8230e+16
#6.1.5# 9.3507e+00 6.9506e+16 6.9506e+16 6.9506e+16
#6.1.5# 9.5162e+00 1.0679e+17 1.0679e+17 1.0679e+17
#6.1.5# 9.6817e+00 1.0881e+17 1.0881e+17 1.0881e+17
#6.1.5# 9.8472e+00 1.1078e+17 1.1078e+17 1.1078e+17
#6.1.5# 1.0013e+01 1.6011e+17 1.6011e+17 1.6011e+17
#6.1.5# 1.0180e+01 1.6599e+17 1.6599e+17 1.6599e+17

#6.1.5# 1.0347e+01 1.3539e+17 1.3539e+17 1.3539e+17
#6.1.5# 1.0513e+01 9.9834e+16 9.9834e+16 9.9834e+16
#6.1.5# 1.0680e+01 6.7211e+16 6.7211e+16 6.7211e+16
#6.1.5# 1.0847e+01 3.8325e+16 3.8325e+16 3.8325e+16
#6.1.5# 1.1018e+01 2.4764e+16 2.4764e+16 2.4764e+16
#6.1.5# 1.1193e+01 2.4308e+16 2.4308e+16 2.4308e+16
#6.1.5# 1.1380e+01 1.9744e+16 1.9744e+16 1.9744e+16
#6.1.5# 1.1580e+01 1.3622e+16 1.3622e+16 1.3622e+16
#6.1.5# 1.1780e+01 9.5436e+15 9.5436e+15 9.5436e+15
#6.1.5# 1.1980e+01 2.2530e+12 2.2530e+12 2.2530e+12
#6.1.5# 1.2180e+01 3.0739e+08 3.0739e+08 3.0739e+08
#6.1.5# 1.2380e+01 9.8729e+04 9.8729e+04 9.8729e+04
Axial distribution of the thermal flux (2.1 eV cut off) along the centre axis
(arbitrary number of lines; one line per axial position; each line contains
the axial position above core bottom (units: m), BOL, MOL and EOL values)
#6.1.6# 0.0000e+00 2.7696e+17 2.7696e+17 2.7696e+17
#6.1.6# 1.2639e-01 2.7617e+17 2.7617e+17 2.7617e+17
#6.1.6# 2.3584e-01 2.7424e+17 2.7424e+17 2.7424e+17
#6.1.6# 3.4931e-01 2.7103e+17 2.7103e+17 2.7103e+17
#6.1.6# 4.6368e-01 2.6657e+17 2.6657e+17 2.6657e+17
#6.1.6# 5.7841e-01 2.6090e+17 2.6090e+17 2.6090e+17
#6.1.6# 6.9332e-01 2.5413e+17 2.5413e+17 2.5413e+17
#6.1.6# 8.0704e-01 2.4657e+17 2.4657e+17 2.4657e+17
#6.1.6# 9.2883e-01 2.3815e+17 2.3815e+17 2.3815e+17
#6.1.6# 1.0544e+00 2.3096e+17 2.3096e+17 2.3096e+17
#6.1.6# 1.1783e+00 2.3059e+17 2.3059e+17 2.3059e+17
#6.1.6# 1.3008e+00 2.5133e+17 2.5133e+17 2.5133e+17
#6.1.6# 1.4313e+00 3.4031e+17 3.4031e+17 3.4031e+17
#6.1.6# 1.5315e+00 6.0479e+17 6.0479e+17 6.0479e+17
#6.1.6# 1.5822e+00 6.4618e+17 6.4618e+17 6.4618e+17
#6.1.6# 1.6703e+00 7.4441e+17 7.4441e+17 7.4441e+17
#6.1.6# 1.7663e+00 7.0045e+17 7.0045e+17 7.0045e+17
#6.1.6# 1.8716e+00 6.0756e+17 6.0756e+17 6.0756e+17
#6.1.6# 1.9917e+00 5.0035e+17 5.0035e+17 5.0035e+17
#6.1.6# 2.1112e+00 3.9744e+17 3.9744e+17 3.9744e+17
#6.1.6# 2.2242e+00 2.9685e+17 2.9685e+17 2.9685e+17
#6.1.6# 2.3372e+00 2.8132e+14 2.8132e+14 2.8132e+14
#6.1.6# 2.4452e+00 1.9489e+11 1.9489e+11 1.9489e+11
Radial distribution of the thermal flux (2.1 eV cut off) at half core height
(arbitrary number of lines; one line per radial position; each line contains
the distance to centre line (units: m), BOL, MOL and EOL values)
6.2 59Co(n,gamma) reaction rate of a 10^-10 (barn cm)^-1 trace of 59Co 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 and presented in the same way as for item set 6.1.
#6.2.1# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the core (units: s-1)
#6.2.2# 9.9999E99 9.9999E99 9.9999E99

Total reaction rate in the reflector (units: s-1)
#6.2.3# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the core (units: s-1m-3)
#6.2.4# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the reflector (units: s-1m-3)
#6.2.5# 0.0 9.9999E99 9.9999E99 9.9999E99
Axial distribution of the reaction rate density along the centre axis (units: s-1m-3)
#6.2.6# 0.0 9.9999E99 9.9999E99 9.9999E99
Radial distribution of the reaction rate density at half core height (units: s-1m-3)
6.3 Fast flux (fluence rate) above 0.1 MeV (units: m-2s-1). The items listed below should be
calculated at BOL, MOL and EOL and presented in the same way as for item set 6.1.
#6.3.1# 2.474 E+17 2.474 E+17 2.474 E+17
Average value in the core (one line containing BOL, MOL and EOL values)
#6.3.2# 4.914 E+17 4.914 E+17 4.914 E+17
Peak value in the core (one line containing BOL, MOL and EOL values)
#6.3.3# 9.9999E99 9.9999E99 9.9999E99
Average value in the reflector (one line containing BOL, MOL and EOL values)
#6.3.4# 9.9999E99 9.9999E99 9.9999E99
Peak value in the reflector (one line containing BOL, MOL and EOL values)
#6.3.5# -4.3250e+00 1.6207e+03 1.6207e+03 1.6207e+03
#6.3.5# -4.0750e+00 6.2070e+04 6.2070e+04 6.2070e+04
#6.3.5# -3.8250e+00 2.3318e+06 2.3318e+06 2.3318e+06
#6.3.5# -3.5750e+00 8.7718e+07 8.7718e+07 8.7718e+07
#6.3.5# -3.3250e+00 1.7344e+09 1.7344e+09 1.7344e+09
#6.3.5# -3.0750e+00 1.8750e+09 1.8750e+09 1.8750e+09
#6.3.5# -2.8250e+00 2.0922e+09 2.0922e+09 2.0922e+09
#6.3.5# -2.5750e+00 6.7707e+09 6.7707e+09 6.7707e+09
#6.3.5# -2.3250e+00 3.9434e+10 3.9434e+10 3.9434e+10
#6.3.5# -2.0750e+00 2.0967e+11 2.0967e+11 2.0967e+11
#6.3.5# -1.8250e+00 1.1108e+12 1.1108e+12 1.1108e+12
#6.3.5# -1.5750e+00 5.8804e+12 5.8804e+12 5.8804e+12
#6.3.5# -1.3250e+00 3.1114e+13 3.1114e+13 3.1114e+13
#6.3.5# -1.0750e+00 1.6454e+14 1.6454e+14 1.6454e+14
#6.3.5# -8.2500e-01 8.6978e+14 8.6978e+14 8.6978e+14
#6.3.5# -6.1250e-01 4.0370e+15 4.0370e+15 4.0370e+15
#6.3.5# -4.3750e-01 1.3513e+16 1.3513e+16 1.3513e+16
#6.3.5# -2.6250e-01 4.5969e+16 4.5969e+16 4.5969e+16
#6.3.5# -8.7500e-02 1.4890e+17 1.4890e+17 1.4890e+17
#6.3.5# 8.2750e-02 3.6561e+17 3.6561e+17 3.6561e+17
#6.3.5# 2.4825e-01 4.2299e+17 4.2299e+17 4.2299e+17
#6.3.5# 4.1375e-01 4.6355e+17 4.6355e+17 4.6355e+17
#6.3.5# 5.7925e-01 4.9996e+17 4.9996e+17 4.9996e+17
#6.3.5# 7.4475e-01 5.3586e+17 5.3586e+17 5.3586e+17
#6.3.5# 9.1025e-01 5.7207e+17 5.7207e+17 5.7207e+17
#6.3.5# 1.0757e+00 6.0872e+17 6.0872e+17 6.0872e+17
#6.3.5# 1.2412e+00 6.4578e+17 6.4578e+17 6.4578e+17
#6.3.5# 1.4067e+00 6.8319e+17 6.8319e+17 6.8319e+17
#6.3.5# 1.5722e+00 7.2092e+17 7.2092e+17 7.2092e+17
#6.3.5# 1.7377e+00 7.5891e+17 7.5891e+17 7.5891e+17
#6.3.5# 1.9033e+00 7.9712e+17 7.9712e+17 7.9712e+17

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#6.3.5#   2.0688e+00 8.3550e+17 8.3550e+17 8.3550e+17
#6.3.5#   2.2342e+00 8.7400e+17 8.7400e+17 8.7400e+17
#6.3.5#   2.3998e+00 9.1253e+17 9.1253e+17 9.1253e+17
#6.3.5#   2.5652e+00 9.5104e+17 9.5104e+17 9.5104e+17
#6.3.5#   2.7308e+00 9.8939e+17 9.8939e+17 9.8939e+17
#6.3.5#   2.8963e+00 1.0275e+18 1.0275e+18 1.0275e+18
#6.3.5#   3.0617e+00 1.0651e+18 1.0651e+18 1.0651e+18
#6.3.5#   3.2273e+00 1.1023e+18 1.1023e+18 1.1023e+18
#6.3.5#   3.3927e+00 1.1387e+18 1.1387e+18 1.1387e+18
#6.3.5#   3.5583e+00 1.1743e+18 1.1743e+18 1.1743e+18
#6.3.5#   3.7237e+00 1.2089e+18 1.2089e+18 1.2089e+18
#6.3.5#   3.8893e+00 1.2421e+18 1.2421e+18 1.2421e+18
#6.3.5#   4.0548e+00 1.2737e+18 1.2737e+18 1.2737e+18
#6.3.5#   4.2203e+00 1.3034e+18 1.3034e+18 1.3034e+18
#6.3.5#   4.3857e+00 1.3310e+18 1.3310e+18 1.3310e+18
#6.3.5#   4.5512e+00 1.3559e+18 1.3559e+18 1.3559e+18
#6.3.5#   4.7168e+00 1.3780e+18 1.3780e+18 1.3780e+18
#6.3.5#   4.8822e+00 1.3967e+18 1.3967e+18 1.3967e+18
#6.3.5#   5.0477e+00 1.4116e+18 1.4116e+18 1.4116e+18
#6.3.5#   5.2133e+00 1.4224e+18 1.4224e+18 1.4224e+18
#6.3.5#   5.3788e+00 1.4287e+18 1.4287e+18 1.4287e+18
#6.3.5#   5.5442e+00 1.4302e+18 1.4302e+18 1.4302e+18
#6.3.5#   5.7097e+00 1.4264e+18 1.4264e+18 1.4264e+18
#6.3.5#   5.8753e+00 1.4170e+18 1.4170e+18 1.4170e+18
#6.3.5#   6.0408e+00 1.4019e+18 1.4019e+18 1.4019e+18
#6.3.5#   6.2062e+00 1.3809e+18 1.3809e+18 1.3809e+18
#6.3.5#   6.3717e+00 1.3540e+18 1.3540e+18 1.3540e+18
#6.3.5#   6.5373e+00 1.3215e+18 1.3215e+18 1.3215e+18
#6.3.5#   6.7027e+00 1.2835e+18 1.2835e+18 1.2835e+18
#6.3.5#   6.8682e+00 1.2406e+18 1.2406e+18 1.2406e+18
#6.3.5#   7.0338e+00 1.1934e+18 1.1934e+18 1.1934e+18
#6.3.5#   7.1993e+00 1.1425e+18 1.1425e+18 1.1425e+18
#6.3.5#   7.3647e+00 1.0884e+18 1.0884e+18 1.0884e+18
#6.3.5#   7.5302e+00 1.0316e+18 1.0316e+18 1.0316e+18
#6.3.5#   7.6958e+00 9.7258e+17 9.7258e+17 9.7258e+17
#6.3.5#   7.8612e+00 9.1149e+17 9.1149e+17 9.1149e+17
#6.3.5#   8.0267e+00 8.4833e+17 8.4833e+17 8.4833e+17
#6.3.5#   8.1922e+00 7.8313e+17 7.8313e+17 7.8313e+17
#6.3.5#   8.3577e+00 7.1563e+17 7.1563e+17 7.1563e+17
#6.3.5#   8.5232e+00 6.4563e+17 6.4563e+17 6.4563e+17
#6.3.5#   8.6887e+00 5.7263e+17 5.7263e+17 5.7263e+17
#6.3.5#   8.8542e+00 4.9616e+17 4.9616e+17 4.9616e+17
#6.3.5#   9.0197e+00 4.1510e+17 4.1510e+17 4.1510e+17
#6.3.5#   9.1852e+00 3.2695e+17 3.2695e+17 3.2695e+17
#6.3.5#   9.3507e+00 2.2751e+17 2.2751e+17 2.2751e+17
#6.3.5#   9.5162e+00 1.3736e+17 1.3736e+17 1.3736e+17
#6.3.5#   9.6817e+00 1.3117e+17 1.3117e+17 1.3117e+17
#6.3.5#   9.8472e+00 1.2628e+17 1.2628e+17 1.2628e+17
#6.3.5#   1.0013e+01 6.9337e+16 6.9337e+16 6.9337e+16
#6.3.5#   1.0180e+01 2.2453e+16 2.2453e+16 2.2453e+16
```

#6.3.5# 1.0347e+01 6.9578e+15 6.9578e+15 6.9578e+15
#6.3.5# 1.0513e+01 2.1547e+15 2.1547e+15 2.1547e+15
#6.3.5# 1.0680e+01 6.6252e+14 6.6252e+14 6.6252e+14
#6.3.5# 1.0847e+01 1.8858e+14 1.8858e+14 1.8858e+14
#6.3.5# 1.1018e+01 9.3548e+13 9.3548e+13 9.3548e+13
#6.3.5# 1.1193e+01 8.9133e+13 8.9133e+13 8.9133e+13
#6.3.5# 1.1380e+01 2.2081e+13 2.2081e+13 2.2081e+13
#6.3.5# 1.1580e+01 3.1767e+12 3.1767e+12 3.1767e+12
#6.3.5# 1.1780e+01 4.5312e+11 4.5312e+11 4.5312e+11
#6.3.5# 1.1980e+01 2.5260e+10 2.5260e+10 2.5260e+10
#6.3.5# 1.2180e+01 1.3709e+09 1.3709e+09 1.3709e+09
#6.3.5# 1.2380e+01 7.1628e+07 7.1628e+07 7.1628e+07
Axial distribution of the fast flux (2.1 eV cut off) along the centre axis
(arbitrary number of lines; one line per axial position; each line contains
the axial position above core bottom (units: m), BOL, MOL and EOL values)
#6.3.6# 0.0000e+00 1.3780e+18 1.3780e+18 1.3780e+18
#6.3.6# 1.2639e-01 1.3743e+18 1.3743e+18 1.3743e+18
#6.3.6# 2.3584e-01 1.3654e+18 1.3654e+18 1.3654e+18
#6.3.6# 3.4931e-01 1.3504e+18 1.3504e+18 1.3504e+18
#6.3.6# 4.6368e-01 1.3294e+18 1.3294e+18 1.3294e+18
#6.3.6# 5.7841e-01 1.3024e+18 1.3024e+18 1.3024e+18
#6.3.6# 6.9332e-01 1.2695e+18 1.2695e+18 1.2695e+18
#6.3.6# 8.0704e-01 1.2309e+18 1.2309e+18 1.2309e+18
#6.3.6# 9.2883e-01 1.1826e+18 1.1826e+18 1.1826e+18
#6.3.6# 1.0544e+00 1.1241e+18 1.1241e+18 1.1241e+18
#6.3.6# 1.1783e+00 1.0539e+18 1.0539e+18 1.0539e+18
#6.3.6# 1.3008e+00 9.6107e+17 9.6107e+17 9.6107e+17
#6.3.6# 1.4313e+00 8.0103e+17 8.0103e+17 8.0103e+17
#6.3.6# 1.5315e+00 4.7818e+17 4.7818e+17 4.7818e+17
#6.3.6# 1.5822e+00 3.8743e+17 3.8743e+17 3.8743e+17
#6.3.6# 1.6703e+00 1.8702e+17 1.8702e+17 1.8702e+17
#6.3.6# 1.7663e+00 8.4719e+16 8.4719e+16 8.4719e+16
#6.3.6# 1.8716e+00 3.8255e+16 3.8255e+16 3.8255e+16
#6.3.6# 1.9917e+00 1.5525e+16 1.5525e+16 1.5525e+16
#6.3.6# 2.1112e+00 6.3553e+15 6.3553e+15 6.3553e+15
#6.3.6# 2.2242e+00 2.2092e+15 2.2092e+15 2.2092e+15
#6.3.6# 2.3372e+00 3.9452e+14 3.9452e+14 3.9452e+14
#6.3.6# 2.4452e+00 6.1739e+13 6.1739e+13 6.1739e+13

Radial distribution of the fast flux (2.1 eV cut off) at half core height
(arbitrary number of lines; one line per radial position; each line contains
the distance to centre line (units: m), BOL, MOL and EOL values)
##
6.4 58Ni(n,p) reaction rate of a 10^-10 (barn cm)^-1 trace of 58Ni 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 and presented in the same way as for item set 6.1.
#6.4.1# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the core (units: s-1)
#6.4.2# 9.9999E99 9.9999E99 9.9999E99

Total reaction rate in the reflector (units: s-1)
#6.4.3# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the core (units: s-1m-3)
#6.4.4# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the reflector (units: s-1m-3)
#6.4.5# 0.0 9.9999E99 9.9999E99 9.9999E99
#6.4.5# 0.50 9.9999E99 9.9999E99 9.9999E99
Axial distribution of the reaction rate density along the centre axis (units: s-1m-3)
#6.4.6# 0.0 9.9999E99 9.9999E99 9.9999E99
#6.4.6# 0.30 9.9999E99 9.9999E99 9.9999E99
Radial distribution of the reaction rate density at half core height (units: s-1m-3)
##
6.5 Fast fluence above 0.1 MeV of discharged fuel (kernel, coatings, matrix) (units: m-2)
#6.5.1# 9.9999E99
Minimum value
#6.5.2# 9.9999E99
Average value
#6.5.3# 9.9999E99
Maximum value

7. Temperatures at nominal conditions
##
7.1 Coated particle temperature (units: K)
#7.1.1# 999.9
Maximum value occurring anywhere in the core at BOL
#7.1.2# 999.9
Maximum value occurring anywhere in the core at EOL
#7.1.3# 999.9
Maximum value occurring anywhere in the core at any time during the operating cycle
##
##7.2. Pebble surface temperature (units: K)
#7.2.1# 1089
Maximum value occurring anywhere in the core at BOL
#7.2.2# 1089
Maximum value occurring anywhere in the core at equi
#7.2.3# 1089
Maximum value occurring anywhere in the core at any time during the operating cycle

8. Temperature reactivity coefficients. 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 in additional comment lines (so starting with '##').
##
8.1 Temperature reactivity coefficients at Cold Zero Power (CZP, zero xenon) conditions (units:
pcm/K). The reference state for this calculation is an isothermal reactor at 300 K (kref). The
temperature reactivity coefficients should be calculated for:
#8.1.1#
Fuel compacts/pebbles
#8.1.2#
Moderator in the core cavity (e.g. central reflector)

#8.1.3# -4.10
Reactor
##
8.2 Temperature reactivity coefficients at Hot Zero Power (HZP, zero xenon) conditions (unit:
pcm/K). The reference state for this calculation is an isothermal reactor at nominal coolant inlet
temperature (kref) (see item 1.14). The temperature reactivity coefficients should be calculated
for:
#8.2.1#
Fuel compacts/pebbles
#8.2.2#
Moderator in the core cavity
#8.2.3# -4.33
Reactor
##
8.3 Temperature reactivity coefficients at Hot Full Power (HFP or nominal, equilibrium xenon)
conditions (units: pcm/K). The reference state for this calculation is the temperature distribution
at nominal conditions (kref). The temperature reactivity coefficients should be calculated for:
#8.3.1# Type_2
Coated particles (arbitrary number of lines; one line per coated particle type;
line contains particle type and temperature reactivity coefficient;
indicate particle type by a single word, which may contain underscores)
#8.3.2#
Fuel compacts/pebbles
#8.3.3#
Moderator in the core cavity (central reflector)
#8.3.4# -3.28
Reactor
##
8.4 Differences in reactivity (units: pcm) between:
#8.4.1# -1695
CZP (zero xenon) state and HZP (zero xenon) state
#8.4.2# -13796
CZP (zero xenon) state and HFP (equilibrium xenon) state

APPENDIX 5

Pu-2-2.00-0-42

0. Case identification and description.
##
#0.1# J.B.M. de Haas
Origin
#0.2# NRG
Organisation
#0.3# Pu-2-2.00-0-42
Case number
#0.4# 20 Sept 2003
Date
#0.5# PANTHERMIX
Applied code system
#0.6# HTR-N-03/11-D-3.2.1
References (arbitrary number of text lines)
##
1. General fuel/reactor/system specifications. This section is intended
as a complete description of the fuel, the reactor (system) and the applied
fuel loading and discharge scheme.
##
#1.1# MEDUL reactor 200 MWth with reload
#1.1# second generation Pu with 42% fissile isotopes and 2.0 gr HM per pebble
System (part) under consideration (reactor, supercell, etc.)
(arbitrary number of text lines)
#1.2# reactor
#1.2# core diameter 3.0 m
#1.2# core/pebblebed height 9.93/9.43 m
#1.2# botom reflector height 4.45 m
#1.2# top reflector height 2.05 m
Main system dimensions (i.e. core diameter, core height, reflector dimensions, etc.)
(arbitrary number of text lines)
#1.3# PuO2 particle: kernel 0.145 mm radius
#1.3# PuO2 particle: low dens. carbon 0.240
#1.3# PuO2 particle: high dens.carbon 0.280
#1.3# PuO2 particle: silicon carbide 0.315
#1.3# PuO2 particle: high dens.carbon 0.355
#1.3# PuO2 particle:
Coated particle dimensions (kernel and coatings) (per coated particle type)
(arbitrary number of text lines)
#1.4# PuO2 kernel: Pu238 1.1377e-3
#1.4# PuO2 kernel: Pu239 6.2195e-3
#1.4# PuO2 kernel: Pu240 7.8974e-3
#1.4# PuO2 kernel: Pu241 3.5081e-3
#1.4# PuO2 kernel: Pu242 4.2471e-3
#1.4# PuO2 kernel: O16 4.6019e-2
#1.4# low dens. carbon: C12 5.2645e-2
#1.4# high dens. Carbon : C12 9.5263e-2

#1.4# silicon carbide : C12 4.7761e-2
#1.4# silicon carbide : Si28 4.7761e-2
#1.4# high dens. Carbon C12 9.5263e-2
Initial coated particle composition per nuclide per material zone (units: (barn cm)^-1)
(arbitrary number of text lines; one line per nuclide per coated particle type; see
Table 2; add extra nuclide names for impurities)
#1.5# pebble 30 mm radius, fuelled 25 mm radius
Compact/pebble dimensions (arbitrary number of lines)
#1.6# Bnat 1.2672e-7
#1.6# C12 ‘ 8.7742e-2
pebble matrix composition per nuclide (outside coated particles; including impurities)
(units: (barn cm)^-1) (arbitrary number of lines; one line per nuclide)
#1.7# Bnat 9.7481e-8
#1.7# C12 8.7742e-2
pebble shell composition per nuclide (outside coated particles; including impurities)
(units: (barn cm)^-1) (arbitrary number of lines; one line per nuclide)
#1.8# Type_2.0-42 17064
Number of coated particles per pebble/compact (of each coated particle type)
(arbitrary number of lines; one line per particle type)
#1.9# 365
Operating cycle length (units: full power days)
#1.10# 0
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)
#1.11# 200.0
Nominal reactor power (units: MW)
#1.12# 1.0
Capacity factor (units: -)
#1.13# N.A.
Number of fuel batches (batch wise reload only) (units: -)
#1.14# 523.15
Nominal coolant inlet temperature (units: K)
#1.15# 6000000.0
Nominal coolant inlet pressure (units: Pa)
#1.16# 972.15
Nominal coolant outlet temperature at nominal (Hot Full Power, HFP) conditions (units: K)
#1.17# 6070930.0
Nominal coolant outlet pressure at nominal (Hot Full Power, HFP) conditions (units: Pa)
#1.18# 85.55
Nominal coolant mass flow (unit: kg/s)
#1.19# continues reload
#1.19# 1500 balls per day (3000 gr Pu per day)
#1.19# no moderator balls
#1.19# 5394.6 balls per cubic meter
Description of fuel cycle strategy and other relevant information on the specific case
(arbitrary number of text lines).
##
2. Rating and power density
##
2.1. Power produced per coated particle (per coated partcile type) (units: W):

#2.1.1# 74.74e-3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.1.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power (units: W)) (arbitrary number of lines)
2.2. Power produced per compact/pebble (units: W)
#2.2.1# 1275.4
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.2.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power (units: W)) (arbitrary number of lines)
2.3. Power produced per unit heavy metal mass (units: W/kg)
#2.3.1# 637.7e+3
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.3.2# N.A.
Maximum value anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power per unit heavy metal mass (units: W/kg))
(arbitrary number of lines)
2.4. Power density in the core (units: W/m^3)
#2.4.1# 6.88e+6
Maximum value occurring anywhere in the core at any time during the operating cycle
#2.4.2# N.A.
Maximum value occurring anywhere in the core as function of time over the operating cycle
(pairs of numbers: time (units: days), power density (units: W/m^3)) (arbitrary number of lines)
##
3. Core inventory
##
3.1. Amount of each of the heavy metal isotopes present in the core (units: kg)
#3.1.2# AM241 9.496E+00
#3.1.2# AM242M 1.928E-01
#3.1.2# AM243 2.359E+01
#3.1.2# CM242 1.535E+00
#3.1.2# CM243 2.577E-02
#3.1.2# CM244 7.434E+00
#3.1.2# CM245 5.403E-01
#3.1.2# NP237 3.066E-03
#3.1.2# NP239 1.495E-07
#3.1.2# PU238 3.176E+01
#3.1.2# PU239 7.223E+01
#3.1.2# PU240 1.471E+02
#3.1.2# PU241 1.267E+02
#3.1.2# PU242 1.318E+02
#3.1.2# U233 3.615E-07
#3.1.2# U234 5.635E-01
#3.1.2# U235 8.090E-02
#3.1.2# U236 4.970E-02
#3.1.2# U237 6.712E-05
#3.1.2# U238 3.758E-04
#3.1.2# CS135FP 4.917E+00
#3.1.2# EU154FP 1.533E-01

#3.1.2#	I129FP	1.232E+00
#3.1.2#	PD107FP	3.024E+00
#3.1.2#	SM147FP	4.076E-01
#3.1.2#	SM151FP	3.142E-01
#3.1.2#	ZR93FP	2.182E+00
At equilibrium (arbitrary number of lines; see Table 2)
#3.1.3#	N.A.
At EOL (arbitrary number of lines; see Table 2)
3.2. Fissile Pu fraction, i.e. amount of (239Pu and 241Pu) divided by the total
##	amount of Pu (units: -) (this can be derived from 3.1)
#3.2.1#	0.422
At BOL
#3.2.2#	0.390
At equilibrium
#3.2.3#	0.274
At discharge

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 3 (Table 1 and Table 2).
#4.1#	PU238	7.960
#4.1#	PU239	43.537
#4.1#	PU240	55.641
#4.1#	PU241	24.962
#4.1#	PU242	30.231
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)
(arbitrary number of lines; one line per nuclide)
#4.2#Am241	1.958E+00
#4.2#Am242m	4.007E-02
#4.2#Am243	8.338E+00
#4.2#Cm242	6.071E-01
#4.2#Cm243	1.908E-02
#4.2#Cm244	4.961E+00
#4.2#Cm245	5.046E-01
#4.2#Np237	2.009E-03
#4.2#Np239	2.975E-08
#4.2#Pu238	7.231E+00
#4.2#Pu239	3.329E+00
#4.2#Pu240	1.421E+01
#4.2#Pu241	1.669E+01
#4.2#Pu242	3.170E+01
#4.2#U233	2.308E-07
#4.2#U234	2.270E-01
#4.2#U235	4.866E-02
#4.2#U236	1.871E-02
#4.2#U237	2.294E-05
#4.2#U238	8.244E-05
#4.2#Cs135fp	1.939E+00
#4.2#Eu154fp	1.241E-01

#4.2#I129fp 5.279E-01
#4.2#Pd107fp 1.360E+00
#4.2#Sm147fp 2.339E-01
#4.2#Sm151fp 5.124E-02
#4.2#Tc99fp 1.569E+00
#4.2#Zr93fp 9.181E-01
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) (arbitrary number of lines; one line per nuclide)
#4.3#Am241 2.658E-05
#4.3#Am242m 5.484E-07
#4.3#Am243 1.136E-04
#4.3#Cm242 8.310E-06
#4.3#Cm243 2.611E-07
#4.3#Cm244 6.791E-05
#4.3#Cm245 6.908E-06
#4.3#Np237 2.750E-08
#4.3#Np239 2.620E-15
#4.3#Pu238 -9.981E-06
#4.3#Pu239 -5.504E-04
#4.3#Pu240 -5.672E-04
#4.3#Pu241 -1.132E-04
#4.3#Pu242 2.005E-05
#4.3#U233 3.160E-12
#4.3#U234 3.095E-06
#4.3#U235 6.650E-07
#4.3#U236 2.550E-07
#4.3#U237 3.136E-10
#4.3#U238 -1.387E-10
#4.3#Cs135fp 2.655E-05
#4.3#Eu154fp 1.699E-06
#4.3#I129fp 7.227E-06
#4.3#Pd107fp 1.862E-05
#4.3#Sm147fp 3.202E-06
#4.3#Sm151fp 7.015E-07
#4.3#Tc99fp 2.148E-05
#4.3#Zr93fp 1.257E-05
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)
(same number of lines as for item 4.2; one line per nuclide)
##
4.4 Attained discharge burnup of the fuel (units: MWd/kg) (for each fuel type)
#4.4.1# Fuel_type_3 N.A.
Minimum value (arbitrary number of lines; one line per fuel type;
indicate fuel type by a single word, which may contain underscores)
#4.4.2# Fuel_type_3 444.6
Average value (one line per fuel type)
#4.4.3# Fuel_type_3 N.A.
Maximum value (one line per fuel type)

5. Reaction rates at nominal conditions
##
5.1 Neutron induced fission fraction per heavy metal nuclide in the entire system
#5.1.2# AM241 3.58e+15
#5.1.2# AM242M 2.89e+16
#5.1.2# AM243 1.95e+15
#5.1.2# CM242 3.97e+14
#5.1.2# CM243 8.15e+14
#5.1.2# CM244 2.19e+15
#5.1.2# CM245 1.67e+16
#5.1.2# NP237 2.93e+11
#5.1.2# NP239 1.51e+07
#5.1.2# PU238 2.00e+16
#5.1.2# PU239 2.04e+18
#5.1.2# PU240 1.75e+16
#5.1.2# PU241 3.75e+18
#5.1.2# PU242 1.05e+16
#5.1.2# U233 6.71e+09
#5.1.2# U234 5.62e+13
#5.1.2# U235 9.21e+14
#5.1.2# U236 4.80e+12
#5.1.2# U237 1.09e+10
#5.1.2# U238 5.63e+09
At equi (same number of lines as for item 5.1.1; one line per heavy metal nuclide, see Table 2)
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) (per nuclide)
#5.2.1#
At BOL (arbitrary number of lines: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard lists in Table 1 and Table 2)
#5.2.2#
At MOL (same number of lines as for item 5.2.1)
#5.2.3#
At EOL (same number of lines as for item 5.2.1)
##
5.3 Neutron absorption rate in all other material in the core cavity (units: s^-1)
(per nuclide, including impurities and/or burnable poison if present)
#5.3.1#
At BOL (arbitrary number of lines: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard list)
#5.3.2#
At MOL (same number of lines as for item 5.3.1: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard list)
#5.3.3#
At EOL (same number of lines as for item 5.3.1: one line per nuclide; add extra lines to describe
e.g. burnable poison nuclides not present in the standard list)
##
5.4 Net neutron leakage rate from the core cavity (units: s^-1) (integrated over all neutron energies)
#5.4.1# 1.777 E+18
At BOL

#5.4.2# 1.777 E+18
At equi
#5.4.3# 1.777 E+18
At EOL

6. Fast and thermal neutron flux (fluence rate) and fluence measures at nominal conditions
##
6.1 Thermal flux below 1.86 eV (units: m^-2s^-1). The items listed below should be calculated at BOL,
MOL and EOL.
#6.1.1# 1.751 E+17 1.751 E+17 1.751 E+17
Average value in the core (one line containing BOL, MOL and EOL values)
#6.1.2# 8.358 E+17 8.358 E+17 8.358 E+17
Peak value in the core (one line containing BOL, MOL and EOL values)
#6.1.3# 9.9999E99 9.9999E99 9.9999E99
Average value in the reflector (one line containing BOL, MOL and EOL values)
#6.1.4# 9.9999E99 9.9999E99 9.9999E99
Peak value in the reflector (one line containing BOLand equi values)
#6.1.5# -4.3250e+00 1.0803e+01 1.0803e+01 1.0803e+01
#6.1.5# -4.0750e+00 5.2549e+04 5.2549e+04 5.2549e+04
#6.1.5# -3.8250e+00 3.1718e+08 3.1718e+08 3.1718e+08
#6.1.5# -3.5750e+00 1.8668e+12 1.8668e+12 1.8668e+12
#6.1.5# -3.3250e+00 5.3618e+15 5.3618e+15 5.3618e+15
#6.1.5# -3.0750e+00 5.4471e+15 5.4471e+15 5.4471e+15
#6.1.5# -2.8250e+00 5.5688e+15 5.5688e+15 5.5688e+15
#6.1.5# -2.5750e+00 8.7679e+15 8.7679e+15 8.7679e+15
#6.1.5# -2.3250e+00 1.6180e+16 1.6180e+16 1.6180e+16
#6.1.5# -2.0750e+00 2.6068e+16 2.6068e+16 2.6068e+16
#6.1.5# -1.8250e+00 4.0106e+16 4.0106e+16 4.0106e+16
#6.1.5# -1.5750e+00 6.0628e+16 6.0628e+16 6.0628e+16
#6.1.5# -1.3250e+00 9.0992e+16 9.0992e+16 9.0992e+16
#6.1.5# -1.0750e+00 1.3601e+17 1.3601e+17 1.3601e+17
#6.1.5# -8.2500e-01 2.0222e+17 2.0222e+17 2.0222e+17
#6.1.5# -6.1250e-01 2.8213e+17 2.8213e+17 2.8213e+17
#6.1.5# -4.3750e-01 3.5897e+17 3.5897e+17 3.5897e+17
#6.1.5# -2.6250e-01 4.2617e+17 4.2617e+17 4.2617e+17
#6.1.5# -8.7500e-02 3.9635e+17 3.9635e+17 3.9635e+17
#6.1.5# 8.2750e-02 1.5721e+17 1.5721e+17 1.5721e+17
#6.1.5# 2.4825e-01 1.2044e+17 1.2044e+17 1.2044e+17
#6.1.5# 4.1375e-01 1.1663e+17 1.1663e+17 1.1663e+17
#6.1.5# 5.7925e-01 1.2107e+17 1.2107e+17 1.2107e+17
#6.1.5# 7.4475e-01 1.2769e+17 1.2769e+17 1.2769e+17
#6.1.5# 9.1025e-01 1.3494e+17 1.3494e+17 1.3494e+17
#6.1.5# 1.0757e+00 1.4244e+17 1.4244e+17 1.4244e+17
#6.1.5# 1.2412e+00 1.5005e+17 1.5005e+17 1.5005e+17
#6.1.5# 1.4067e+00 1.5773e+17 1.5773e+17 1.5773e+17
#6.1.5# 1.5722e+00 1.6544e+17 1.6544e+17 1.6544e+17
#6.1.5# 1.7377e+00 1.7316e+17 1.7316e+17 1.7316e+17
#6.1.5# 1.9033e+00 1.8087e+17 1.8087e+17 1.8087e+17
#6.1.5# 2.0688e+00 1.8856e+17 1.8856e+17 1.8856e+17

#6.1.5# 2.2342e+00 1.9621e+17 1.9621e+17 1.9621e+17
#6.1.5# 2.3998e+00 2.0379e+17 2.0379e+17 2.0379e+17
#6.1.5# 2.5652e+00 2.1131e+17 2.1131e+17 2.1131e+17
#6.1.5# 2.7308e+00 2.1873e+17 2.1873e+17 2.1873e+17
#6.1.5# 2.8963e+00 2.2601e+17 2.2601e+17 2.2601e+17
#6.1.5# 3.0617e+00 2.3313e+17 2.3313e+17 2.3313e+17
#6.1.5# 3.2273e+00 2.4006e+17 2.4006e+17 2.4006e+17
#6.1.5# 3.3927e+00 2.4674e+17 2.4674e+17 2.4674e+17
#6.1.5# 3.5583e+00 2.5315e+17 2.5315e+17 2.5315e+17
#6.1.5# 3.7237e+00 2.5925e+17 2.5925e+17 2.5925e+17
#6.1.5# 3.8893e+00 2.6497e+17 2.6497e+17 2.6497e+17
#6.1.5# 4.0548e+00 2.7027e+17 2.7027e+17 2.7027e+17
#6.1.5# 4.2203e+00 2.7507e+17 2.7507e+17 2.7507e+17
#6.1.5# 4.3857e+00 2.7933e+17 2.7933e+17 2.7933e+17
#6.1.5# 4.5512e+00 2.8296e+17 2.8296e+17 2.8296e+17
#6.1.5# 4.7168e+00 2.8592e+17 2.8592e+17 2.8592e+17
#6.1.5# 4.8822e+00 2.8811e+17 2.8811e+17 2.8811e+17
#6.1.5# 5.0477e+00 2.8949e+17 2.8949e+17 2.8949e+17
#6.1.5# 5.2133e+00 2.8996e+17 2.8996e+17 2.8996e+17
#6.1.5# 5.3788e+00 2.8949e+17 2.8949e+17 2.8949e+17
#6.1.5# 5.5442e+00 2.8799e+17 2.8799e+17 2.8799e+17
#6.1.5# 5.7097e+00 2.8543e+17 2.8543e+17 2.8543e+17
#6.1.5# 5.8753e+00 2.8175e+17 2.8175e+17 2.8175e+17
#6.1.5# 6.0408e+00 2.7696e+17 2.7696e+17 2.7696e+17
#6.1.5# 6.2062e+00 2.7103e+17 2.7103e+17 2.7103e+17
#6.1.5# 6.3717e+00 2.6401e+17 2.6401e+17 2.6401e+17
#6.1.5# 6.5373e+00 2.5592e+17 2.5592e+17 2.5592e+17
#6.1.5# 6.7027e+00 2.4689e+17 2.4689e+17 2.4689e+17
#6.1.5# 6.8682e+00 2.3698e+17 2.3698e+17 2.3698e+17
#6.1.5# 7.0338e+00 2.2638e+17 2.2638e+17 2.2638e+17
#6.1.5# 7.1993e+00 2.1517e+17 2.1517e+17 2.1517e+17
#6.1.5# 7.3647e+00 2.0351e+17 2.0351e+17 2.0351e+17
#6.1.5# 7.5302e+00 1.9148e+17 1.9148e+17 1.9148e+17
#6.1.5# 7.6958e+00 1.7925e+17 1.7925e+17 1.7925e+17
#6.1.5# 7.8612e+00 1.6682e+17 1.6682e+17 1.6682e+17
#6.1.5# 8.0267e+00 1.5429e+17 1.5429e+17 1.5429e+17
#6.1.5# 8.1922e+00 1.4158e+17 1.4158e+17 1.4158e+17
#6.1.5# 8.3577e+00 1.2874e+17 1.2874e+17 1.2874e+17
#6.1.5# 8.5232e+00 1.1564e+17 1.1564e+17 1.1564e+17
#6.1.5# 8.6887e+00 1.0233e+17 1.0233e+17 1.0233e+17
#6.1.5# 8.8542e+00 8.8765e+16 8.8765e+16 8.8765e+16
#6.1.5# 9.0197e+00 7.5504e+16 7.5504e+16 7.5504e+16
#6.1.5# 9.1852e+00 6.4874e+16 6.4874e+16 6.4874e+16
#6.1.5# 9.3507e+00 6.7468e+16 6.7468e+16 6.7468e+16
#6.1.5# 9.5162e+00 1.0326e+17 1.0326e+17 1.0326e+17
#6.1.5# 9.6817e+00 1.0520e+17 1.0520e+17 1.0520e+17
#6.1.5# 9.8472e+00 1.0708e+17 1.0708e+17 1.0708e+17
#6.1.5# 1.0013e+01 1.5420e+17 1.5420e+17 1.5420e+17
#6.1.5# 1.0180e+01 1.5821e+17 1.5821e+17 1.5821e+17
#6.1.5# 1.0347e+01 1.2830e+17 1.2830e+17 1.2830e+17

#6.1.5# 1.0513e+01 9.4264e+16 9.4264e+16 9.4264e+16
#6.1.5# 1.0680e+01 6.3312e+16 6.3312e+16 6.3312e+16
#6.1.5# 1.0847e+01 3.6026e+16 3.6026e+16 3.6026e+16
#6.1.5# 1.1018e+01 2.3243e+16 2.3243e+16 2.3243e+16
#6.1.5# 1.1193e+01 2.2813e+16 2.2813e+16 2.2813e+16
#6.1.5# 1.1380e+01 1.8513e+16 1.8513e+16 1.8513e+16
#6.1.5# 1.1580e+01 1.2765e+16 1.2765e+16 1.2765e+16
#6.1.5# 1.1780e+01 8.9456e+15 8.9456e+15 8.9456e+15
#6.1.5# 1.1980e+01 2.0889e+12 2.0889e+12 2.0889e+12
#6.1.5# 1.2180e+01 2.8148e+08 2.8148e+08 2.8148e+08
#6.1.5# 1.2380e+01 7.6902e+04 7.6902e+04 7.6902e+04
Axial distribution of the thermal flux (2.1 eV cut off) along the centre axis
(arbitrary number of lines; one line per axial position; each line contains
the axial position above core bottom (units: m), BOL and equi values)
#6.1.6# 0.0000e+00 2.8592e+17 2.8592e+17 2.8592e+17
#6.1.6# 1.2639e-01 2.8519e+17 2.8519e+17 2.8519e+17
#6.1.6# 2.3584e-01 2.8337e+17 2.8337e+17 2.8337e+17
#6.1.6# 3.4931e-01 2.8034e+17 2.8034e+17 2.8034e+17
#6.1.6# 4.6368e-01 2.7614e+17 2.7614e+17 2.7614e+17
#6.1.6# 5.7841e-01 2.7079e+17 2.7079e+17 2.7079e+17
#6.1.6# 6.9332e-01 2.6439e+17 2.6439e+17 2.6439e+17
#6.1.6# 8.0704e-01 2.5728e+17 2.5728e+17 2.5728e+17
#6.1.6# 9.2883e-01 2.4947e+17 2.4947e+17 2.4947e+17
#6.1.6# 1.0544e+00 2.4326e+17 2.4326e+17 2.4326e+17
#6.1.6# 1.1783e+00 2.4477e+17 2.4477e+17 2.4477e+17
#6.1.6# 1.3008e+00 2.6996e+17 2.6996e+17 2.6996e+17
#6.1.6# 1.4313e+00 3.7152e+17 3.7152e+17 3.7152e+17
#6.1.6# 1.5315e+00 6.6265e+17 6.6265e+17 6.6265e+17
#6.1.6# 1.5822e+00 7.0747e+17 7.0747e+17 7.0747e+17
#6.1.6# 1.6703e+00 8.1126e+17 8.1126e+17 8.1126e+17
#6.1.6# 1.7663e+00 7.5997e+17 7.5997e+17 7.5997e+17
#6.1.6# 1.8716e+00 6.5727e+17 6.5727e+17 6.5727e+17
#6.1.6# 1.9917e+00 5.4033e+17 5.4033e+17 5.4033e+17
#6.1.6# 2.1112e+00 4.2904e+17 4.2904e+17 4.2904e+17
#6.1.6# 2.2242e+00 3.2080e+17 3.2080e+17 3.2080e+17
#6.1.6# 2.3372e+00 2.9724e+14 2.9724e+14 2.9724e+14
#6.1.6# 2.4452e+00 1.9738e+11 1.9738e+11 1.9738e+11
Radial distribution of the thermal flux (2.1 eV cut off) at half core height
(arbitrary number of lines; one line per radial position; each line contains
the distance to centre line (units: m), BOL, MOL and EOL values)
##
6.2 59Co(n,gamma) reaction rate of a 10^-10 (barn cm)^-1 trace of 59Co 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 and presented in the same way as for item set 6.1.
#6.2.1# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the core (units: s-1)
#6.2.2# 9.9999E99 9.9999E99 9.9999E99

Total reaction rate in the reflector (units: s-1)
#6.2.3# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the core (units: s-1m-3)
#6.2.4# 9.9999E99 9.9999E99 9.9999E99
Peak value of the reaction rate density in the reflector (units: s-1m-3)
#6.2.5# 0.0 9.9999E99 9.9999E99 9.9999E99
Axial distribution of the reaction rate density along the centre axis (units: s-1m-3)
#6.2.6# 0.0 9.9999E99 9.9999E99 9.9999E99
Radial distribution of the reaction rate density at half core height (units: s-1m-3)
6.3 Fast flux (fluence rate) above 0.1 MeV (units: m-2s-1). The items listed below should be
calculated at BOL, MOL and EOL and presented in the same way as for item set 6.1.
#6.3.1# 2.574 E+17 2.574 E+17 2.574 E+17
Average value in the core (one line containing BOL, MOL and EOL values)
#6.3.2# 4.951 E+17 4.951 E+17 4.951 E+17
Peak value in the core (one line containing BOL, MOL and EOL values)
#6.3.3# 9.9999E99 9.9999E99 9.9999E99
Average value in the reflector (one line containing BOL, MOL and EOL values)
#6.3.4# 9.9999E99 9.9999E99 9.9999E99
Peak value in the reflector (one line containing BOL, MOL and EOL values)
#6.3.5# -4.3250e+00 1.2185e+03 1.2185e+03 1.2185e+03
#6.3.5# -4.0750e+00 4.8027e+04 4.8027e+04 4.8027e+04
#6.3.5# -3.8250e+00 1.8578e+06 1.8578e+06 1.8578e+06
#6.3.5# -3.5750e+00 7.1952e+07 7.1952e+07 7.1952e+07
#6.3.5# -3.3250e+00 1.4633e+09 1.4633e+09 1.4633e+09
#6.3.5# -3.0750e+00 1.5818e+09 1.5818e+09 1.5818e+09
#6.3.5# -2.8250e+00 1.7647e+09 1.7647e+09 1.7647e+09
#6.3.5# -2.5750e+00 5.7484e+09 5.7484e+09 5.7484e+09
#6.3.5# -2.3250e+00 3.4424e+10 3.4424e+10 3.4424e+10
#6.3.5# -2.0750e+00 1.8869e+11 1.8869e+11 1.8869e+11
#6.3.5# -1.8250e+00 1.0308e+12 1.0308e+12 1.0308e+12
#6.3.5# -1.5750e+00 5.6279e+12 5.6279e+12 5.6279e+12
#6.3.5# -1.3250e+00 3.0709e+13 3.0709e+13 3.0709e+13
#6.3.5# -1.0750e+00 1.6749e+14 1.6749e+14 1.6749e+14
#6.3.5# -8.2500e-01 9.1307e+14 9.1307e+14 9.1307e+14
#6.3.5# -6.1250e-01 4.3665e+15 4.3665e+15 4.3665e+15
#6.3.5# -4.3750e-01 1.4981e+16 1.4981e+16 1.4981e+16
#6.3.5# -2.6250e-01 5.2249e+16 5.2249e+16 5.2249e+16
#6.3.5# -8.7500e-02 1.7355e+17 1.7355e+17 1.7355e+17
#6.3.5# 8.2750e-02 4.3413e+17 4.3413e+17 4.3413e+17
#6.3.5# 2.4825e-01 4.9656e+17 4.9656e+17 4.9656e+17
#6.3.5# 4.1375e-01 5.3797e+17 5.3797e+17 5.3797e+17
#6.3.5# 5.7925e-01 5.7453e+17 5.7453e+17 5.7453e+17
#6.3.5# 7.4475e-01 6.1071e+17 6.1071e+17 6.1071e+17
#6.3.5# 9.1025e-01 6.4745e+17 6.4745e+17 6.4745e+17
#6.3.5# 1.0757e+00 6.8486e+17 6.8486e+17 6.8486e+17
#6.3.5# 1.2412e+00 7.2285e+17 7.2285e+17 7.2285e+17
#6.3.5# 1.4067e+00 7.6132e+17 7.6132e+17 7.6132e+17
#6.3.5# 1.5722e+00 8.0016e+17 8.0016e+17 8.0016e+17
#6.3.5# 1.7377e+00 8.3929e+17 8.3929e+17 8.3929e+17
#6.3.5# 1.9033e+00 8.7862e+17 8.7862e+17 8.7862e+17

#6.3.5#	2.0688e+00	9.1806e+17	9.1806e+17	9.1806e+17
#6.3.5#	2.2342e+00	9.5751e+17	9.5751e+17	9.5751e+17
#6.3.5#	2.3998e+00	9.9685e+17	9.9685e+17	9.9685e+17
#6.3.5#	2.5652e+00	1.0360e+18	1.0360e+18	1.0360e+18
#6.3.5#	2.7308e+00	1.0747e+18	1.0747e+18	1.0747e+18
#6.3.5#	2.8963e+00	1.1131e+18	1.1131e+18	1.1131e+18
#6.3.5#	3.0617e+00	1.1508e+18	1.1508e+18	1.1508e+18
#6.3.5#	3.2273e+00	1.1878e+18	1.1878e+18	1.1878e+18
#6.3.5#	3.3927e+00	1.2239e+18	1.2239e+18	1.2239e+18
#6.3.5#	3.5583e+00	1.2588e+18	1.2588e+18	1.2588e+18
#6.3.5#	3.7237e+00	1.2922e+18	1.2922e+18	1.2922e+18
#6.3.5#	3.8893e+00	1.3240e+18	1.3240e+18	1.3240e+18
#6.3.5#	4.0548e+00	1.3537e+18	1.3537e+18	1.3537e+18
#6.3.5#	4.2203e+00	1.3812e+18	1.3812e+18	1.3812e+18
#6.3.5#	4.3857e+00	1.4061e+18	1.4061e+18	1.4061e+18
#6.3.5#	4.5512e+00	1.4279e+18	1.4279e+18	1.4279e+18
#6.3.5#	4.7168e+00	1.4464e+18	1.4464e+18	1.4464e+18
#6.3.5#	4.8822e+00	1.4612e+18	1.4612e+18	1.4612e+18
#6.3.5#	5.0477e+00	1.4717e+18	1.4717e+18	1.4717e+18
#6.3.5#	5.2133e+00	1.4778e+18	1.4778e+18	1.4778e+18
#6.3.5#	5.3788e+00	1.4789e+18	1.4789e+18	1.4789e+18
#6.3.5#	5.5442e+00	1.4748e+18	1.4748e+18	1.4748e+18
#6.3.5#	5.7097e+00	1.4650e+18	1.4650e+18	1.4650e+18
#6.3.5#	5.8753e+00	1.4494e+18	1.4494e+18	1.4494e+18
#6.3.5#	6.0408e+00	1.4277e+18	1.4277e+18	1.4277e+18
#6.3.5#	6.2062e+00	1.3999e+18	1.3999e+18	1.3999e+18
#6.3.5#	6.3717e+00	1.3661e+18	1.3661e+18	1.3661e+18
#6.3.5#	6.5373e+00	1.3266e+18	1.3266e+18	1.3266e+18
#6.3.5#	6.7027e+00	1.2818e+18	1.2818e+18	1.2818e+18
#6.3.5#	6.8682e+00	1.2323e+18	1.2323e+18	1.2323e+18
#6.3.5#	7.0338e+00	1.1788e+18	1.1788e+18	1.1788e+18
#6.3.5#	7.1993e+00	1.1220e+18	1.1220e+18	1.1220e+18
#6.3.5#	7.3647e+00	1.0627e+18	1.0627e+18	1.0627e+18
#6.3.5#	7.5302e+00	1.0014e+18	1.0014e+18	1.0014e+18
#6.3.5#	7.6958e+00	9.3863e+17	9.3863e+17	9.3863e+17
#6.3.5#	7.8612e+00	8.7478e+17	8.7478e+17	8.7478e+17
#6.3.5#	8.0267e+00	8.0991e+17	8.0991e+17	8.0991e+17
#6.3.5#	8.1922e+00	7.4408e+17	7.4408e+17	7.4408e+17
#6.3.5#	8.3577e+00	6.7708e+17	6.7708e+17	6.7708e+17
#6.3.5#	8.5232e+00	6.0871e+17	6.0871e+17	6.0871e+17
#6.3.5#	8.6887e+00	5.3851e+17	5.3851e+17	5.3851e+17
#6.3.5#	8.8542e+00	4.6596e+17	4.6596e+17	4.6596e+17
#6.3.5#	9.0197e+00	3.8996e+17	3.8996e+17	3.8996e+17
#6.3.5#	9.1852e+00	3.0795e+17	3.0795e+17	3.0795e+17
#6.3.5#	9.3507e+00	2.1543e+17	2.1543e+17	2.1543e+17
#6.3.5#	9.5162e+00	1.2960e+17	1.2960e+17	1.2960e+17
#6.3.5#	9.6817e+00	1.2374e+17	1.2374e+17	1.2374e+17
#6.3.5#	9.8472e+00	1.1912e+17	1.1912e+17	1.1912e+17
#6.3.5#	1.0013e+01	6.4228e+16	6.4228e+16	6.4228e+16
#6.3.5#	1.0180e+01	2.0262e+16	2.0262e+16	2.0262e+16

#6.3.5# 1.0347e+01 6.1193e+15 6.1193e+15 6.1193e+15
#6.3.5# 1.0513e+01 1.8470e+15 1.8470e+15 1.8470e+15
#6.3.5# 1.0680e+01 5.5382e+14 5.5382e+14 5.5382e+14
#6.3.5# 1.0847e+01 1.5403e+14 1.5403e+14 1.5403e+14
#6.3.5# 1.1018e+01 7.5933e+13 7.5933e+13 7.5933e+13
#6.3.5# 1.1193e+01 7.2327e+13 7.2327e+13 7.2327e+13
#6.3.5# 1.1380e+01 1.7501e+13 1.7501e+13 1.7501e+13
#6.3.5# 1.1580e+01 2.4514e+12 2.4514e+12 2.4514e+12
#6.3.5# 1.1780e+01 3.4023e+11 3.4023e+11 3.4023e+11
#6.3.5# 1.1980e+01 1.7693e+10 1.7693e+10 1.7693e+10
#6.3.5# 1.2180e+01 9.0110e+08 9.0110e+08 9.0110e+08
#6.3.5# 1.2380e+01 4.4278e+07 4.4278e+07 4.4278e+07
Axial distribution of the fast flux (2.1 eV cut off) along the centre axis
(arbitrary number of lines; one line per axial position; each line contains
the axial position above core bottom (units: m), BOL, MOL and EOL values)
#6.3.6# 0.0000e+00 1.4464e+18 1.4464e+18 1.4464e+18
#6.3.6# 1.2639e-01 1.4429e+18 1.4429e+18 1.4429e+18
#6.3.6# 2.3584e-01 1.4341e+18 1.4341e+18 1.4341e+18
#6.3.6# 3.4931e-01 1.4194e+18 1.4194e+18 1.4194e+18
#6.3.6# 4.6368e-01 1.3989e+18 1.3989e+18 1.3989e+18
#6.3.6# 5.7841e-01 1.3725e+18 1.3725e+18 1.3725e+18
#6.3.6# 6.9332e-01 1.3403e+18 1.3403e+18 1.3403e+18
#6.3.6# 8.0704e-01 1.3025e+18 1.3025e+18 1.3025e+18
#6.3.6# 9.2883e-01 1.2551e+18 1.2551e+18 1.2551e+18
#6.3.6# 1.0544e+00 1.1975e+18 1.1975e+18 1.1975e+18
#6.3.6# 1.1783e+00 1.1277e+18 1.1277e+18 1.1277e+18
#6.3.6# 1.3008e+00 1.0333e+18 1.0333e+18 1.0333e+18
#6.3.6# 1.4313e+00 8.6518e+17 8.6518e+17 8.6518e+17
#6.3.6# 1.5315e+00 5.1164e+17 5.1164e+17 5.1164e+17
#6.3.6# 1.5822e+00 4.1359e+17 4.1359e+17 4.1359e+17
#6.3.6# 1.6703e+00 1.9630e+17 1.9630e+17 1.9630e+17
#6.3.6# 1.7663e+00 8.7532e+16 8.7532e+16 8.7532e+16
#6.3.6# 1.8716e+00 3.8982e+16 3.8982e+16 3.8982e+16
#6.3.6# 1.9917e+00 1.5560e+16 1.5560e+16 1.5560e+16
#6.3.6# 2.1112e+00 6.2709e+15 6.2709e+15 6.2709e+15
#6.3.6# 2.2242e+00 2.1454e+15 2.1454e+15 2.1454e+15
#6.3.6# 2.3372e+00 3.7300e+14 3.7300e+14 3.7300e+14
#6.3.6# 2.4452e+00 5.6873e+13 5.6873e+13 5.6873e+13
Radial distribution of the fast flux (2.1 eV cut off)at half core height
(arbitrary number of lines; one line per radial position; each line contains
the distance to centre line (units: m), BOL, MOL and EOL values)
##
6.4 58Ni(n,p) reaction rate of a 10^-10 (barn cm)^-1 trace of 58Ni 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 and presented in the same way as for item set 6.1.
#6.4.1# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the core (units: s-1)
#6.4.2# 9.9999E99 9.9999E99 9.9999E99
Total reaction rate in the reflector (units: s-1)

```
#6.4.3# 9.9999E99       9.9999E99  9.9999E99
## Peak value of the reaction rate density in the core (units: s-1m-3)
#6.4.4# 9.9999E99       9.9999E99  9.9999E99
## Peak value of the reaction rate density in the reflector (units: s-1m-3)
#6.4.5# 0.0 9.9999E99  9.9999E99  9.9999E99
## Axial distribution of the reaction rate density along the centre axis (units: s-1m-3)
#6.4.6# 0.0 9.9999E99  9.9999E99  9.9999E99
## Radial distribution of the reaction rate density at half core height (units: s-1m-3)
## 6.5 Fast fluence above 0.1 MeV of discharged fuel (kernel, coatings, matrix) (units: m-2)
#6.5.1# 9.9999E99
## Minimum value
#6.5.2# 9.9999E99
## Average value
#6.5.3# 9.9999E99
## Maximum value

## 7. Temperatures at nominal conditions
##
## 7.1 Coated particle temperature (units: K)
#7.1.1# 999.9
## Maximum value occurring anywhere in the core at BOL
#7.1.2# 999.9
## Maximum value occurring anywhere in the core at EOL
#7.1.3# 999.9
## Maximum value occurring anywhere in the core at any time during the operating cycle
##
##7.2. Pebble surface temperature (units: K)
#7.2.1#     1105
## Maximum value occurring anywhere in the core at BOL
#7.2.2#     1105
## Maximum value occurring anywhere in the core at equi
#7.2.3#     1105
## Maximum value occurring anywhere in the core at any time during the operating cycle

## 8. Temperature reactivity coefficients. 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 in additional comment lines (so starting with '##').
##
## 8.1 Temperature reactivity coefficients at Cold Zero Power (CZP, zero xenon) conditions (units:
##     pcm/K). The reference state for this calculation is an isothermal reactor at 300 K (kref). The
##     temperature reactivity coefficients should be calculated for:
#8.1.1#
## Fuel compacts/pebbles
#8.1.2#
## Moderator in the core cavity (e.g. central reflector)
#8.1.3#     -4.57
## Reactor
##
## 8.2 Temperature reactivity coefficients at Hot Zero Power (HZP, zero xenon) conditions (unit:
```

pcm/K). The reference state for this calculation is an isothermal reactor at nominal coolant inlet
temperature (kref) (see item 1.14). The temperature reactivity coefficients should be calculated
for:
#8.2.1#
Fuel compacts/pebbles
#8.2.2#
Moderator in the core cavity
#8.2.3# -4.59
Reactor
##
8.3 Temperature reactivity coefficients at Hot Full Power (HFP or nominal, equilibrium xenon)
conditions (units: pcm/K). The reference state for this calculation is the temperature distribution
at nominal conditions (kref). The temperature reactivity coefficients should be calculated for:
#8.3.1# Type_3
Coated particles (arbitrary number of lines; one line per coated particle type;
line contains particle type and temperature reactivity coefficient;
indicate particle type by a single word, which may contain underscores)
#8.3.2#
Fuel compacts/pebbles
#8.3.3#
Moderator in the core cavity (central reflector)
#8.3.4# -4.17
Reactor
##
8.4 Differences in reactivity (units: pcm) between:
#8.4.1# -1347
CZP (zero xenon) state and HZP (zero xenon) state
#8.4.2# -23516
CZP (zero xenon) state and HFP (equilibrium xenon) state