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Titolo

Neutronic analyses of the ALFRED LEADER core with deterministic (ECCO./ ERANOS) and Monte Carlo (Serpent) codes: comparison between macroscopicgroup constants, shutdown systems worth and spatial-angular flux distributions

Descrittori

Tipologia del documento: Collocazione contrattuale: Argomenti trattati:

Rapporto Tecnico **FALCON** International Consortium Generation IV reactors, Neutronica

Sommario

Questo rapporto tecnico - realizzato in collaborazione con il Politecnico di Torino (PoliTO) - rappresenta il primo passo di un ambizioso programma di lavoro finalizzato alla produzione delle sezioni d'urto per il codice neutronico deterministico ERANOS - solitamente create con il codice di cella ECCO - mediante il codice Monte Carlo Serpent. La motivazione di questo sforzo è duplice. Da un lato, grazie a Serpent è possile modellizzare geometrie di cella complesse non riproducibili con ECCO. Dall'altro, Serpent permette di utilizzare in modo semplice librerie di dati nucleari sempre aggiornate, cosa possibile non con la medesima semplicità col sistema ECCO-ERANOS, di cui il CEA (Francia) ha cessato lo sviluppo ed il conseguente mantenimento. Le ultime versioni delle librerie valutate utilizzabili in ECCO fornite dal CEA sono la JEFF-3.1 (utilizzata in questo rapporto) e la ENDF/B-VI.8, ormai datate.

Il sistema ECCO/ERANOS è stato utilizzato diffusamente in ENEA per il progetto di nocciolo dei reattori veloci e, in particolare negli ultimi anni, per il reattore-dimostratore refrigerato a piombo di quarta generazione ALFRED, inizialmente concepito nel progetto EURATOM FP7 LEADER (2010-2014) ed attualmente sviluppato dal consorzio internazionale FALCON. Utilizzando la configurazione di riferimento definita nel progetto LEADER, è stato condotto un accurato confronto tra le sezioni d'urto macroscopiche - rappresentative delle regioni del nocciolo più significative - prodotte mediante ECCO e Serpent in strutture energetiche a 33 e 80 gruppi utilizzando diverse metodologie ed opzioni di calcolo. Dal confronto risulta evidente un generale accordo tra i due codici, con l'eccezione delle discrepanze a basse energie dove i risultati Serpent sono affetti da un'elevata incertezza statistica. Nelle parti assorbitrici (in B₄C) delle barre di controllo e sicurezza, differenze significative si sono invece riscontrate in un ampio intervallo spettrale. A livello di nocciolo ciò si riflette nella stima del'anti-reattività fornita dall'inserzione di entrambi i sistemi che differisce del ~10%, in linea con l'usuale sovrastima dei codici deterministici rispetto a quelli stocastici per i reattori a spettro veloce, come ampiamente documentato dall'esperienza ENEA. Il presente rapporto investiga anche tale aspetto e ne individua le cause principali nelle differenti sezioni d'urto di cattura degli stessi assorbitori, che danno origine a distribuzioni spaziali e angolari di flusso nel nocciolo significativamente diverse quando gli stessi sono inseriti.

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List of Abbreviations

ACE	A Compact ENDF
ALFRED	Advanced Lead-cooled Fast Reactor European Demonstrator
BoL	Beginning of Life
CEA	Commissariat à l'énergie atomique et aux énergies alternatives (France)
CR(s)	Control Rod(s)
CSG	Constructive Solid Geometry
ECCO	European Cell Code
EDL	Ensemble de Données LU
ERANOS	European Reactor ANalysis Optimised System
FA(s)	Fuel Assembly(ies)
FALCON	FOstering ALfred CONstruction
FC	Full-Core
FMS	Ferritic Martensitic Steel
FP	Framework Program
GIF	Generation IV International Forum
НН	Heterogeneous Homogenised
LEADER	Lead-cooled European Advanced Demonstration Reactor
LFR	Lead Fast Reactor
LU	Langage utilisateur
MC	Monte Carlo
MOX	Mixed Oxide
pcm	per cent mille
PoliTO	Politecnico di Torino
RSD	Relative Standard Deviation
SR(s)	Safety Rod(s)
SS	Stainless Steel
XS(s)	Macroscopic cross-section(s)
YSZ	Yttria-stabilised Zirconia

Symbols

k _{eff}	Multiplication factor, k-effective
k _{inf}	k-infinite
Δk_{eff} (pcm)	k-effective variation in per cent mille



1 Introduction

1.1 Aim and purposes

This technical report, produced in collaboration with Politecnico di Torino (PoliTO), represents the first step of an ambitious work program whose final purpose is the production of the homogenised and condensed multi-group cross-sections for the deterministic neutronic code ERANOS [1] - usually produced with the ECCO cell code - through the Monte Carlo (MC) code Serpent [2].

The motivation of this effort is twofold. In fact, with Serpent it is possible to model complex cell geometries not reproducible by ECCO. Furthermore, the Commissariat à l'énergie atomique et aux énergies alternatives (CEA, France) decided to interrupt the ERANOS development and, consequently, the updating process of the nuclear data evaluated in multi-group energy structures suitable for the ECCO cell code [3]. The latest evaluated data available in ECCO provided by the CEA are the JEFF-3.1 [4] and ENDF/B-VI.8 [5] libraries, actually rather dated.

The ECCO/ERANOS system has been widely used in ENEA for the core design and neutronic analyses of fast reactors (*e.g.*, Sodium Fast Reactors). In the last years, it has been adopted for the design of the ALFRED (Advanced Lead Fast Reactor European Demonstrator) core, initially conceived in the EURATOM FP7 LEADER (Lead-cooled European Advanced Demonstration Reactor) project [6] and currently carried on within the FALCON (Fostering ALfred CONstruction) international consortium [7]. The Lead-cooled Fast Reactor (LFR) concept - selected by the Generation IV International Forum (GIF) [8] as one of the most promising nuclear systems for the future - is nowadays widely investigated because it could effectively represent a viable technology for safer, cleaner, cheaper and proliferation-resistant nuclear energy systems.

The ALFRED core design is challenging for the several technological constraints of the LFR systems along with the target performances aimed for this demonstrator, such as [6]: the maximum Pu enrichment (< 30%) in the Mixed OXide (MOX) fuel and the achievement of a peak burn-up of 100 GWd/t, the narrow temperature range (400/480 °C as core inlet/outlet) and the limiting temperature for the steel cladding in nominal conditions (550 °C¹), the respect of the system integrity even in extreme conditions, etc. Therefore, the design process requires many scoping analyses, for which, relatively to neutronics, ERANOS is the main tool used in ENEA for its flexibility and reduced computational times, especially in comparison with MC codes.

The ALFRED design defined in LEADER was used as reference for the present study, carried out by adopting the JEFF-3.1 nuclear data library with both ECCO/ERANOS and Serpent codes. The core models were accurately compared and their congruence verified in detail. The comparison was limited to the Beginning of Life (BoL) conditions at full power (300 MW), with fresh fuel and the shutdown systems completely withdrawn and inserted. The reference state is represented by both shutdown systems withdrawn, which defines an over-critical core condition at BoL: at the same time, this condition represents the easiest core configuration for a code benchmark, since it does not involve the effects due the fuel burn-up and absorbers depletion.

A very detailed comparison between the deterministic and MC analyses was performed by verifying (first of all) the full consistency between the two core models. This work summarises the main outcomes of the study carried out in steady state, focusing on:

• the macroscopic cross-sections produced by the ECCO and Serpent codes, whose behaviour with respect to the incident neutron energy was accurately compared in all regions of the core models. In general, a good agreement between the two codes was found, with some noticeable exceptions (*e.g.*, the absorbing bundles of the control and safety rods);

¹ These temperature range and limit refer to the ALFRED LEADER version.



- the different calculation options available in ECCO and Serpent, with the analyses of their impact on the macroscopic-group constant values. In ECCO, the "reference" data were obtained with 2D cell geometry models of the main core regions, an energy refinement at 33 groups (ECCO-33 grid) and the P₁ consistent approximation for the solution of the multi-group transport equations. Additionally, the cross-sections were evaluated also with homogeneous cell models, 80 energy groups and different calculation options (P₁ inconsistent, B₁ consistent and inconsistent and so on; see Appendix A). In Serpent all the condensed and homogenised cross-sections were scored on the ECCO-33 grid using a 3D Full-Core (FC) model (named MC1), a 2D radially-infinite model (named MC2) and, finally, a 3D axially-limited and radially-infinite model (named MC3) for the most important core regions (*e.g.*, fissile and absorbing parts of shutdown systems). The B₁ approximation was used in order to provide leakage-corrected constants for the MC2 and MC3 cases;
- the reactivity worth of the shutdown systems that differs by ~10%, that is the usual overestimation introduced by deterministic codes (with respect to stochastic ones) for fast spectrum reactors as widely documented by the ENEA experience (*e.g.*, [9]);
- the impact of the shutdown systems insertion on the radial and axial spatial flux distribution within the core. Besides the ~10% reactivity worth difference, the flux spatial distributions result sensibly different: both effects mainly derive from the different macroscopic-group constants created by ECCO and Serpent for their absorbing regions. Additionally, the different spatial distributions are necessarily related also with the different methods adopted by deterministic and MC codes for the treatment of the flux angular dependency.

1.2 Organisation of the work

This report summarises part of the work carried out in collaboration between ENEA and PoliTO in the last year dealing with the ALFRED core neutronic analyses with ECCO/ERANOS and Serpent. It is structured as follows.

- Chapter 2 describes briefly:
 - the main features of the ALFRED core (in the LEADER version, §2.1);
 - the core conditions examined (§2.2);
 - the ERANOS model of the ALFRED core (§2.3).
- Chapter 3 describes briefly:
 - the ECCO/ERANOS system code (§3.1);
 - the procedure ("route") adopted in ECCO to produce the reference data (*i.e.*, multi-group homogenised cross-sections representative of the core zones, §2.3), together with an overview of the calculation options available whose theoretical background is described in Appendix A; furthermore, their impact on the multi-group constant values evaluated at the P₁ (and B₁) order was accurately verified (§A.8).
- Chapter 4 describes briefly:
 - the Serpent MC code and the calculation options adopted to create the multi-group homogenised cross-sections (§4.1);
 - the Serpent model of the ALFRED core (§4.2).
- Chapter 5 reports the most significant results of the cross-sections analyses and comparison. While the full data set of the Serpent-ERANOS relative differences is reported in Appendix B, in §5 are summarised:
 - the most significant ECCO (§5.1) and Serpent (§5.2) cross-section results, together with the impact of the different calculation options on their values;



- some significant comparisons between the ECCO and Serpent multi-group constants for both fissile and non-multiplying media (§5.3 and §5.4, respectively);
- \circ the main conclusions that can be drawn from the ECCO-Serpent comparison (§5.5).
- Chapter 6 reports the most significant results of the ERANOS and Serpent full-core analyses at BoL for what concerns the core reactivity, the shutdown systems performances and the spatial distribution of the total flux within the core (with the control and safety rods completely withdrawn and inserted). In particular:
 - §6.1 reports the ERANOS values for the core reactivity and the shutdown systems worth. The impact of the different ECCO calculation options was verified at the core level, as well as the difference between the P₃ (reference) and P₁ flux order expansion in the ERANOS spatial calculations;
 - §6.2 reports the Serpent values for the core reactivity and the shutdown systems worth, while §6.3 summarises some significant comparisons between the results of the two codes;
 - §6.4 reports the comparison between the radial and axial flux distributions within the core obtained by ERANOS and Serpent with the shutdown systems fully withdrawn and inserted. A couple of significant radial directions (passing through the core positions hosting control and safety rods) were considered and their radial flux profiles compared, as well as the axial ones for each assembly intercepted by these radial traverses. The full data set of the axial flux traverses is reported in Appendix C.

Besides the most significant concluding remarks and future perspective of the present work (§7), for the sake of completeness the report includes other two appendixes:

- the ECCO/ERANOS input decks of the reference case, together with the indications of the instructions to be modified to reproduce the different calculation options (Appendix D);
- the Serpent code input decks used for the "reference" cross-sections generation and the fullcore analysis (Appendix E). Even in this case, the instructions to be modified and used to explore the different calculation options are briefly provided. For more details about the code calculation options, the reader is referred to the Serpent 2 code Wiki [10].



2 The ALFRED core design and conditions examined

2.1 Brief description of the ALFRED Leader core

Fig. 2.1 shows the main features of the MOX fuel pin (60 cm fissile length) and the wrapped hexagonal Fuel Assembly (FA) made of 127 pins arranged in six rows of a triangular lattice. Fig. 2.2 shows a quarter of the core layout having a 90° symmetry, while Fig. 2.3 sketches the main features of the shutdown systems design. The core layout is essentially made of [6]:

- 57 inner FAs and 114 outer FAs, having the same architecture but a different Pu enrichment in the fuel pellet (21.7 and 27.8 at%, respectively) to flatten the core radial power distribution. The fuel clad is made of 15-15/Ti austenitic Stainless Steel (SS) and the FA wrap is made of T91 Ferritic Martensitic Steel (FMS);
- 12 Control Rods (CRs) located in the fuel outer zone, used for both normal control of the reactor (*i.e.*, start-up, reactivity control during the fuel cycle, power tuning and shutdown) and for scram in case of emergency. In control mode, they partially enter the active region from the bottom during irradiation (to compensate the initial over-criticality) and are progressively withdrawn as far as the refuelling condition is reached (with an irradiation scheme made of 5 cycles of 1 year). The absorbing pin bundle is made of 19 pins embedding Boron Carbide (B₄C) pellets enriched at 90 at.% in ¹⁰B. Inversely to the FA, the CR clads are made of T91 FMS and the surrounding tube is made of 15-15/Ti SS;
- 4 Safety Rods (SRs) located in the fuel inner zone, which stay still atop the active zone during normal operation and, in emergency cases, enter the core by gravity for the reactor shutdown. The SR bundle is made of 12 pins: as for the CRs, the absorber material is B₄C (with 90 at.% ¹⁰B), the clad is in T91 FMS and the surrounding tube in 15-15/Ti SS;
- the surrounding dummies, having the same structure of the FAs but with pins filled by Yttriastabilised Zirconia (YSZ) pellets (used also as axial thermal insulators in the fuel pin, see Fig. 2.1), acting as reflector for both neutron economy and shielding of the inner vessel.



Figure 2.1 Alfred fuel pin and FA main dimensions [mm] [6].









Figure 2.3 ALFRED CR (left) and SR (right) design.

Both shutdown systems were similarly conceived (B_4C pin bundles cooled by the primary lead, see Fig. 2.3). The main difference (for the diversity requirement in case of scram) arises from their mechanism of insertion relying on different physical phenomena.

- The CRs' fully withdrawn position is below the core: they are actuated by motors during reactor operation, while for emergency shutdown they are provided with an electromagnetic connection whose release allows for a rapid insertion into the core by buoyancy.
- The SRs stay still atop the core in reactor operation and their actuation occurs only for scram through the unlocking of an electromagnet. By the unlocking, the resistance to a pneumatic system is simultaneously lost and the SRs are passively pushed rapidly into the core. To face the failure of the pneumatic system, a tungsten ballast is added atop the SRs providing a sufficient weight to counteract the buoyancy and ensuring their insertion into the core, even if at a reduced speed.



2.2 Core conditions examined

The "reference" core models developed with ECCO/ERANOS (§3) and Serpent (§4) refer to the full power (300 MW) conditions at BoL (*i.e.*, fresh fuel everywhere) with the CRs completely withdrawn 4 cm below the fissile zone and the SRs completely withdrawn 12 cm above it. Therefore, the core examined is over-critical (*i.e.*, the layout of 57 + 114 FA of Fig. 2.2 was defined for the criticality at the equilibrium of the 5-year fuel cycle [6] and not at BoL when a lower number of fresh FA will be loaded), but this over-critical condition does not represent a limitation for the current study since the fundamental requirement for the neutronic codes benchmark is the full consistency between the ERANOS and Serpent models, and the simplicity of the model is preferred to avoid any influence of burnup modules on the actual benchmark.

In both codes, a cold geometry model (*i.e.*, 20 °C) was considered while the nuclear data were evaluated at the average working temperatures at full power reported in Table 2.1 for the fuel, absorbers, structures and coolant. Differently from the solid materials, the coolant density was correctly reproduced at its working temperature. As a main consequence, the fuel Doppler effect is taken into account whereas the thermal dilatation of solid materials (*e.g.*, fuel axial expansion) is neglected. The main reason for this choice is due to the fact that Serpent is not endowed with an *ad hoc* routine for the thermal dilatation as ECCO is, instead.

Besides the over-critical core model (*i.e.* full power BoL conditions with CRs and SRs completely withdrawn, representing the simplest configuration to be simulated), the calculations with both codes were extended to include the case of complete insertion of the shutdown systems, in order to compare their reactivity worth values. The complete withdrawn and fully inserted positions are sketched in Fig. 2.4 for both systems, where "CROD" and "SROD" are the absorbing bundles of the CRs and SRs, respectively (see also Fig. 2.5).

Material	T [°C]	Zone	T [°C]
Fuel	900	Inlet	400
Clad	460	Core	440
CR & SR pins	450	Outlet	480

 Table 2.1
 Average working temperatures of the core materials/zones in the ECCO model.



Figure 2.4 ALFRED CRs' and SRs' absorbing bundle positions when fully withdrawn (left) and inserted (right; figure not in scale, dimensions in cm).



2.3 The ALFRED core model with ECCO/ERANOS

Fig. 2.5 depicts the ERANOS axial model of the core assemblies (FA, CR, SR and dummy, §2.1). All the axial zones (*i.e.*, hexagonal slices of a certain thickness) of these elements were characterised with the ECCO cell code to obtain the corresponding (homogeneous equivalent) macroscopic cross-sections. A list of all the zones - together with their brief description and acronyms used in Fig. 2.5 - is provided in the following.

- In the FA (see also Fig. 2.1): the bottom reflector (BREF), the bottom plug of the fuel pins (BPLG), the plenum (PLEN, *i.e.*, voided pin clads containing a thin cylindrical tube in 15-15/Ti SS as support for the fuel pellets), the bottom thermal insulator (BINS, *i.e.*, pin clads filled with YSZ pellets), the fissile zone (FINN and FOUT for the inner and outer FA, respectively), the top insulator (TINS), the spring (SPRN, *i.e.*, plena with a 15-15/Ti SS spring), the top plug (TPLG) and the top reflector (TREF).
- In the dummy: the reflector region (DUMM) that is identical to the BINS and TINS ones. It is however necessary to evaluate different cross-sections to take into account their different temperatures in operating conditions (see Table 2.1). The other zones (below and above the DUMM region) are identical to the FA ones.
- In the CR: the absorbing part (CROD, made of B₄C pellets in T91 FMS clads) and its follower (FROD, *i.e.*, clads with YSZ pellets). For the sake of simplicity, the other zones were assumed identical to the FA ones in order to have a unique data set of cross-sections². Nevertheless, such approximation is acceptable since it does not introduce significant biases in the resulting cross-sections, as well as in the full-core features here examined (*i.e.*, core reactivity, flux distributions, CRs and SRs reactivity worth).
- In the SR: the absorbing part (SROD) made of B₄C pellets in T91 FMS clads as the CR but with different dimensions (resulting in a lower B₄C volume fraction; see Fig. 2.3). As for the CR, the other zones were assumed identical to the FA ones to simplify the core modelling without penalising the calculations accuracy.

All the core regions shown Fig. 2.5 were modelled with ECCO by adopting a 2D heterogeneous geometry, with the exception of the axial reflectors (BREF and TREF), the external lead in the down-comer (Ext Pb), the inner vessel and the surrounding lead, which were described with homogeneous models. Table 2.2 reports the materials volume fractions in them with the density values representing the materials mix. The densities of the solid ones were considered at room temperature, while the lead density values were obtained from an extrapolation of its linear behaviour with temperature in the liquid phase [11] down to 20 °C. The inner vessel (or barrel made of 316L SS) was modelled with 72 assemblies, which represent a homogeneous mix of steel and lead to simulate it and the surrounding coolant in a hexagonal position of the core lattice. Other rings of "virtual" assemblies made by lead only were introduced in the ERANOS 3D hexagonal core model to simulate the down-comer outside the inner vessel.

Due to the ECCO cell code limitations, the CR and SR bundles (Fig. 2.3) were modelled as the FA, with the pins arranged in triangular lattices (by preserving the materials volume fractions) and the surrounding SS tube described with a hexagonal wrap having an equivalent volume.

Table 2.3 reports the materials density (at 20°C), their volume fraction in the FA, CR, SR and dummy clads, and the corresponding filling densities. The MOX density is computed from the theoretical one by assuming a 5% porosity. The filling density represents the "effective" density of the materials (MOX, YSZ, B₄C and 15-15/Ti SS) diluted in the corresponding clads. This dilution is usually adopted in deterministic codes because of their difficulty in simulating regions with "voids" or with materials having a very low density, such as the gap between fuel pellets and clads filled by He gas [6].

² As an example, the material/geometrical features of the SPRN zone of the FA were assumed also for the SPRN regions of the CR and SR.



	FA	h [cm]		CR IN Compl. In	h [cm]		CR Out Compl. Out	h [cm]		SR IN Compl. In	h [cm]		SR Out Compl. Out	h [cm]		Dummy	h [cm]
240		_	240	TDEE	0	240			240			240		22	240		
340			340	IKEF	8	340			340			340	TREF	33	340		
307			001					-				307	SPRN	10			
297	TREF	122		SPRN	60		TREF	76		TREF	117	297	TINS	1		TREF	122
296												296					
272			272			264											
223						204			223				SROD	84			
218	TPLG	5								SPRN	10		SHOL	•••	218	TPLG	5
010				FROD	68		SPRN	60		TTD 10							
213									213	TINS	1	212			213		
-12	SPRN	12							-12				BPLG	5.0		SPRN	12
207												207					
204	TTT	_	204			204									201		
201	TINS	1													201		
200																	
	FUEL	60		CROD	68		FROD	68		SROD	84						
																DIMM	117
140	BINS	1														DUMM	117
139																	
136			136	BINS	1	136							BREF	207			
135			135	BPLG	5												
130			130						129								
120									128	BPLG	5						
123	PLEN	55							123								
							CROD	68									
				BREF	130												
84	BPLG	5								BREF	123				84	BPLG	5
79															79		
							DING										
67	RDFF	70				68 67	BINS	1 5								RDFF	70
62	DREF	""				62	DILG	3								DREF	19
							BREF	62									

Figure 2.5 The ERANOS axial model of the ALFRED core assemblies (not in scale).



Table 2.2	ECCO models of homogeneous core zones: materials volume fraction and
	density (at 20°C).

Zone	15-15/Ti SS [vol. %]	Pb [vol. %]	Density** [g cm ⁻³]
BREF	12.0	88.0	10.649
TREF	20.0	80.0	10.404
Barrel*	33.8	66.2	9.980
Ext Pb		100.0	11.017

* actually, the ECCO cell for the barrel is made of 316L SS (instead of 15-15/Ti) and surrounding coolant ** of the materials mix

Table 2.3Materials density (at 20°C) and their corresponding filling density in the FA, CR,
SR and dummy clads.

Motorial	Density	70NE	Fraction in	Filling density			
	[g cm ⁻³]	- ZONE	clad [vol. %]	in clad [g cm ⁻³]			
MOX (FINN)	10.494	FINN	89.028	9.3426			
MOX (FOUT)	10.513	FOUT	89.028	9.3595			
Ve7	6.0	BINS, TINS, DUMM	93.652	5.6191			
132	0.0	FROD	94.703	5.6822			
46 46/Ti 66	7.05	PLEN	7.559**	0.6009**			
15-15/11 55	7.95	SPRN	7.594	0.6037			
B ₄ C	2.2	CROD, SROD	94.703	2.0835			
FMS T91	7.736	FA wrap, CR and SR tubes*					
Pb	11.017	Everywhere					

* modelled as equivalent hexagonal layers

** these values represent the filling density of the thin cylindrical tube supporting the pellets



Centro Ricerche Saluggia

3 The ECCO/ERANOS system code

3.1 Brief description of the ECCO/ERANOS system code

The European Reactor ANalysis Optimised System (ERANOS) was developed by CEA for the core design of Sodium Fast Reactors [1]. It is a modular system and consists of data libraries, deterministic codes and calculation procedures: the different modules perform several functions to analyse the core reactivity, flux distributions, burn-up and reaction rates, etc. of a nuclear system that can be modelled by 1D, 2D and 3D geometries. The cross-sections of the core regions are usually produced in a 1968 energy-group structure and condensed to the standard one at few groups (*e.g.*, 33) by the European Cell COde (ECCO) [3].

The ERANOS system code has been widely used by ENEA in the last 20 years for the core design of the LFR and Accelerator Driven Systems, *e.g.* [9], [12] and [13]. As mentioned in §1, the nuclear data suitable for ECCO in different energy structures are based on evaluated data: specifically, the JEFF-3.1 library [4] was adopted in this study. The multi-group macroscopic cross-sections (or macroscopic-group constants) obtained by ECCO are then used for the ERANOS full-core calculations. In the 3D hexagonal geometry model of the ALFRED core, they were carried out with the TGV module [14] adopting the variational-nodal method [15, 16].

Since the ECCO cell code was developed for the analysis of fast reactors, it considers correctly the peculiarities of this kind of systems like the neutron slowing down, the self-shielding effect, the inelastic and/or non-isotropic scattering events, etc. In the "reference" cell calculation option, a 2D heterogeneous geometry model was adopted to reproduce the spatial self-shielding effect (§2.3) and approached with the collision probability method for the flux solution [3] to take into account the cells heterogeneity. Successively, the cross-sections were homogenised (with the flux times volume weighting method) to obtain homogeneous equivalent values to consider (at some extent) the heterogeneity of the cell.

3.2 The ECCO calculation reference route

The ECCO model of the ALFRED core assemblies (Fig. 2.5) relies on an accurate 2D geometry description of them [17], while the axial leakages were taken into account by tuning opportunely the buckling value (identical for each energy group). More specifically [3]:

- in the fissile zone of the FA, the bucking value is calculated by ECCO in order to yield a unitary multiplication factor (k_{eff}) so as to reproduce the critical core condition;
- in the non-fissile zones the ECCO calculation procedures foresee the introduction of an external source, having the (flux and current) spectrum of the (nearest) fissile region and uniformly distributed in space within the zone. The bucking value is fixed by a semi-empirical relation depending on the (radial or axial) thickness of the zone examined (see Appendix A).

The method recommended by the ECCO developers - called *reference route* [3] - was used to create the macroscopic cross-sections of the core regions. Fig. 3.1 summarises this route, which foresees at least four steps in which the calculations:

- start with a homogeneous geometry description of the cell and a broad energy structure, usually at 172 or 33 groups (172 were chosen as reference);
- introduce the heterogeneous geometry description of the cell by maintaining the broad energy structure;
- refine the energy grid at 1968 groups for the nuclides included in the evaluated library (the most important ones for ALFRED are available) by maintaining the heterogeneous model;
- end with the spatial homogenisation of the cell and the energy collapsing in a broad energy structure at 33 groups. For the codes benchmark, the same energy grid was adopted to create the cross-sections with Serpent (§4).





Figure 3.1 Reference route for the ECCO calculations [3].

As a net result, the macroscopic cross-section "x" (x=total, fission, capture, elastic, inelastic, etc.) was evaluated at the P_1 order of the transport equation in a broad energy-group-structure:

$$\Sigma_{x,g} = \frac{\int_{V} \int_{Eg}^{Eg+1} \phi(\mathbf{r}, E) \Sigma_{x}(\mathbf{r}, E) dE}{\int_{V} \int_{Eg}^{Eg+1} \phi(\mathbf{r}, E) dE}$$
(3.1)

where:

- "g" (1-33) is the energy (E) group considered;
- the neutron flux "φ(r, E)" is used as weighting function in the integrals, in order to keep the reaction rates constant *e.g.*, during the condensation process from 1968 down to 33 groups;
- "r" is the position within the cell and, trivially, the final homogeneous equivalent values of the macroscopic cross-sections obtained by integrating over the volume "V" do not vary with r.

The multi-group constants of the non-fissile zones modelled by a heterogeneous geometry in ECCO (see §2.3) were obtained with the four-step calculation procedure of Fig. 3.1 and are usually named Heterogeneous Homogenised (HH) cross-sections (Σ_{HH}). For the fissile zones, the last step was divided in two by treating the energy collapsing and the spatial homogenisation separately. An additional sixth step can be added by imposing the buckling at zero, in order to make the leakage term vanish and to evaluate the k-infinite (k_{inf}) parameter of the fuel cells.

The mathematical basis of the ECCO cell analyses - producing the macroscopic cross-sections (vectors and matrices) for ERANOS - is described in detail in Appendix A, together with the different calculation methodologies adopted. The cross-section behaviours with energy produced by the different ECCO methods were compared, as well as their impact on the main ERANOS full-core quantities. The ECCO calculation options examined in this work deal with:

- the initial energy refinement, *i.e.*, by starting with 33 energy groups (instead of 172) for both fissile and non-fissile zones;
- the final energy refinement, *i.e.*, by a final collapsing in a structure at 80 groups (instead of 33) for both fissile and non-fissile zones;



- the homogeneous geometry models of the ECCO cells describing the fissile zone of the FA and the absorbing regions of shutdown systems, which are the most important zones for neutronics;
- the adoption of the (flux and current) fuel spectrum generated by Serpent (at 33 energy groups) as weighting function in Eq. (3.1) to obtain the HH cross-sections for the nonmultiplying media. The Serpent fuel spectrum was introduced as an "external source" in ECCO and, to verify the congruence of this calculation option, the same method was used also by inserting "externally" the "internal" spectrum evaluated by ECCO itself.

The macroscopic cross-sections were created with a 33-group structure (the reference one, see Table 3.1 reporting its upper energy limits) and the more refined one at 80 groups (see Table 3.2). The latter reports in the last column also the upper energy limits in correspondence with the structure at 1968 groups (to be used in the ECCO CONDENSE instruction; see Appendix D).

Table 3.1The 33-energy-group structure (Group / Energy [MeV]).

1	1.9640E+01
2	1.0000E+01
3	6.0653E+00
4	3.6788E+00
5	2.2313E+00
6	1.3534E+00
7	8.2085E-01
8	4.9787E-01
9	3.0197E-01
10	1.8316E-01
11	1.1109E-01
12	6.7380E-02
13	4.0868E-02
14	2.4788E-02
15	1.5034E-02
16	9.1188E-03
17	5.5308E-03
18	3.3546E-03
19	2.0347E-03
20	1.2341E-03
21	7.4852E-04
22	4.5400E-04
23	3.0433E-04
24	1.4863E-04
25	9.1661E-05
26	6.7904E-05
27	4.0169E-05
28	2.2603E-05
29	1.3710E-05
30	8.3153E-06
31	4.0000E-06
32	5.4000E-07
33	1.0000E-07



Table 3.2	The 80-energy-group	structure (Grou	ıp / Energy [MeV] / Group i	n 1968 grid).
	1	1.9640E+07	1	
	2	1.6905E+07	19	
	3	1.4918E+07	34	
	4	1.3499E+07	46	
	5	1.1912E+07	61	
	6	1.0000E+07	82	
	7	7.7880E+06	112	
	8	6.0653E+06	142	
	9	4.7237E+06	172	
	10	3.6788E+06	202	
	11	2.8650E+06	232	
	12	2.2313E+06	262	
	13	1.7377E+06	292	
	14	1.3534E+06	322	
	15	1.1943E+06	337	
	16	1.0540E+06	352	
	17	9.3014E+05	367	
	18	8.2085E+05	382	
	19	7.2440E+05	397	
	20	6.3928E+05	412	
	21	5.6416E+05	427	
	22	4.9787E+05	442	
	23	4.3937E+05	457	
	24	3.8774E+05	472	
	25	3.0197E+05	502	
	26	2.3518E+05	534	
	27	1.8316E+05	564	
	28	1.4264E+05	594	
	29	1.1109E+05	624	
	30	8.6517E+04	654	
	31	6.7379E+04	686	
	32	5.2475E+04	716	
	33	4.0868E+04	746	
	34	3.1828E+04	776	
	35	2.8088E+04	792	
	30	2.6058E+04	802	
	37	2.4788E+04	808	
	38	2.1875E+04	823	
	39	1.9305E+04	000	
	40	1.7U30E+U4	000	
	41	1 22605+04	000	
	42	1.3200E+U4	000 909	
	43	1.1709E+04	090 013	
	44 15	0 1100E+04	910 028	
	45 76	3.1100E+03	920	
	40 17	7 1017F±03	958	
	T/	1.101/1.00		

973

6.2673E+03

48



49	5.5308E+03	988
50	4.8810E+03	1003
51	4.3074E+03	1018
52	3.8013E+03	1033
53	3.3546E+03	1048
54	2.9604E+03	1063
55	2.6126E+03	1078
56	2.3056E+03	1093
57	2.0347E+03	1108
58	1.7956E+03	1123
59	1.5846E+03	1138
60	1.3984E+03	1153
61	1.2341E+03	1168
62	1.0891E+03	1183
63	9.6112E+02	1198
64	7.4852E+02	1228
65	5.8295E+02	1258
66	4.5400E+02	1288
67	3.5358E+02	1318
68	2.7536E+02	1348
69	1.6702E+02	1408
70	1.0130E+02	1468
71	6.1442E+01	1528
72	3.7267E+01	1588
73	2.2603E+01	1648
74	1.3710E+01	1708
75	8.3153E+00	1768
76	5.0435E+00	1828
77	3.0590E+00	1848
78	1.1230E+00	1892
79	4.1399E-01	1927
80	1.5303E-01	1947



4 The SERPENT code and its ALFRED core model

4.1 Brief description of the SERPENT code

Serpent ([2], [10], and [18]) is a MC code written in C language and developed at VTT Technical Research Centre of Finland. Its original purpose was to fill the gap left by MCNP (developed by LANL [19]) for the multi-group cross-section energy collapsing and spatial homogenisation.

Since 2004, both the code capabilities and its user community have steadily grown, and nowadays Serpent is a reference tool for fission reactor physics research and development. With the latest code version (2.1.31), the users can now perform: cross-section homogenisation at the assembly level, burn-up calculations, coupled neutron-photon transport calculations, uncertainty evaluation and multi-physics simulations in coupling with the OpenFOAM toolbox [20].

The spatial homogenisation of the multi-group constants can be carried out in many ways. Thanks to the code flexibility, the user can decide to collapse the constants over arbitrary energy grids and to compute them for different reactor regions without too much effort.

Serpent 2 employs a 3D Constructive Solid Geometry (CSG) routine which enables the user to easily nest different universes (*i.e.*, sets of surfaces and cells for a detailed representation of each reactor spatial scale, from the fuel pin up to the FA/core level). This routine can thus be used to generate both 3D objects and 2D systems, like the traditional cells defined for lattice calculations. According to the geometrical model adopted, the stochastic transport of neutrons inside the core may require very different computational times as well as it can provide different levels of statistical accuracy.

Once the system is geometrically defined, the code reads the continuous-energy data (crosssections, angular distributions, fission emission spectra, and so on) from the selected nuclear data library and evaluates them over a unionized energy grid, in order to reduce the memory consumption. After these preliminary steps, the code performs a bunch of "inactive" cycles in order to initialise the fission source³. At the end of the inactive cycles, the statistical scoring begins.

The effective HH cross-section for a certain reaction "x" over a group "g" is usually evaluate preserving the associated reaction rate:

$$\Sigma_{x,g} = \frac{\langle \Sigma_x(\mathbf{r}, E) | \phi(\mathbf{r}, E) \rangle_{V,g}}{\langle \phi(\mathbf{r}, E) \rangle_{V,g}}$$
(4.1)

where the bracket notation indicates an integration over the volume "V" for each energy group "g", while the other variables have the usual meaning (see §3.2).

While deterministic codes usually rely on application data libraries evaluated on a limited number of groups (*e.g.*, 33, 172, 175 and 1968 in ECCO), MC codes allow reading the continuousenergy data, avoiding any data pre-processing. Thanks to this energy management, Serpent 2 implicitly takes into account all the self-shielding effects, without any approximation. In addition, also the unresolved resonance region is treated more accurately, as the user can force the code to sample the data from the probability tables (the so-called p-table) in the A Compact ENDF (ACE) format specification files [21]. This option (available also in ECCO in a multi-energy-group form; §3.1) is particularly important for fast systems, where the flux in the unresolved resonance region assumes relevant values.

Another significant difference with respect to the ECCO cell code is the number of steps employed to evaluate equation (4.1) (identical to (3.1)). If the reference calculation route is

³ In each cycle, a certain number of neutron histories is simulated: once the initial position, energy and flying direction of a particle are sampled, the particle starts moving and colliding with the medium, and its history ends when the particle leaks from the domain or it is absorbed.



employed, ECCO computes the integral in 4-5 steps (§3.2) while Serpent 2 firstly evaluates the effective cross-section on an intermediate group structure called *fine grid* (the WIMS-69 grid is the default choice, but the user can change it) and then it condenses the Σ_x over the *few-group grid* required by the user (33 in this study; see Table 3.1). If the number of energy groups required is larger than 69 (as for the 80 groups case, see Table 3.2), the *fine grid* coincides with the *few-group grid*.

The reason for this two-steps calculation is simplifying the implementation of the spatial homogenisation, which can be carried out by the code in two ways: the infinite-lattice procedure, which is always performed, and the leakage-corrected calculation, that has to be switched on by the user. The first routine does not introduce any correction to the code output, which thus strongly depends on the flux distribution in the geometry considered, while the leakage-corrected mode, known as B₁ calculation, applies a correction that takes into account the fact that the cells defined are usually sub- or super-critical. The main hypotheses made in Serpent 2 are that the flux can be factorised in angle, space and energy, so that an eigenvalue problem for the material buckling can be retrieved. This problem is solved iteratively until a spatial buckling providing a critical system is reached. The fundamental eigenfunction found to solve this problem is then employed to collapse the effective constants over the few-group structure instead of the noncorrected flux. Since the homogenisation is performed in two steps, the B₁ calculation mode does not take full advantage of the continuous-energy MC capabilities, as the leakage-corrected flux is evaluated over the few-group grid. Thanks to the options available in the code, however, the user can make the few-group and the fine-group structures overlap, to minimise the condensation errors.

The other, straightforward face of the medal is that Serpent, as an MC code, is affected by the statistical noise of its results, which – although subject to due management by the experienced user, to the price of increasing the computational burden – is inherent to its stochastic nature.

4.2 The Serpent models of the ALFRED core and calculation options adopted

The Serpent core model is based on the ERANOS one described in §2.2 (see Figs. 2.3 and 2.5) and it is shown in Figs 4.1 and 4.2.

As mentioned in §4.1, the quality of the (leakage) non-corrected calculation, which is the default one, improves with the reactor geometrical model: therefore, the most accurate set of multigroup constants would be evaluated scoring them over each assembly family with a 3D FC model, since the flux used to weight the cross-sections would be the most representative of a certain core region. However, the computational time of a full-core calculation would be too much for design calculation purposes. On the other hand, cell calculations, that are radially and axially infinite thanks to the reflective boundary conditions, are suitable for design but the results quality suffers from the geometrical simplification. This issue can be tackled for multiplying regions employing a B_1 calculation, but an alternative treatment for inactive regions like CRs, SRs or dummy reflector assemblies is needed.

The most intuitive option would be to simulate a mini-core made of one or more non-fissile assemblies in the centre (for which the homogenised and collapsed data are desired) surrounded by some rings of FA. This solution, however, would require a criticality calculation for each different inactive region, making the computational time comparable with the one of a FC calculation but much less accurate. Moreover, sensitivity studies would be required to assess the impact of the number of assemblies for both the active and inactive regions on the overall leakage effect.

To preserve the cell calculation main features (*i.e.*, a good compromise between computational speed and accuracy) also for non-fissile assemblies and, at the same time, to properly consider the leakage effects, the following strategy has been devised. The inactive region is studied



considering an isotropic source of particles with the same energy spectrum of the fuel and spatially distributed across a radially infinite cell with finite height, equal to the active height of the fuel rods. Since this approach can induce strong modifications in the flux energy spectrum due to the absence of the axial reflectors, the cell was surrounded by a top and a bottom layer of lead. This precaution allows obtaining a flux which is closer to the physical one and, at the same time, to increase the statistics of the groups at the lowest energies.

To sum up, the following models have been employed by Serpent (used as a cell code; §3) to carry out the spatial homogenisation and the energy collapsing.

- 1. The 3D FC heterogeneous model (see Fig. 4.1) with homogeneous core assemblies (FA, CR, SR, dummy) and barrel (SS and lead homogenised over a hexagonal area; see §2.3). Outside an external lead layer surrounding the barrel, void boundary conditions are imposed.
- 2. The most accurate 3D FC heterogeneous model with heterogeneous core assemblies (only the barrel and external lead were assumed homogeneous; see Fig. 4.2). Outside the external lead layer, void boundary conditions are imposed.
- 3. The 3D axially and radially infinite cells with heterogeneous core assemblies (see Fig. 4.3), with the B₁ calculation mode for FA and the source calculation one for non-fissile regions. The "cell" is built with a limited number of assemblies, but the imposition of reflective boundary conditions forces the particles to move in the system as if it were infinite.
- 4. The 3D radially infinite but axially finite cells with homogeneous core assemblies (see Fig. 4.4), with the B₁ calculation mode for FA and the source calculation one for non-fissile regions. The void boundary conditions are imposed axially, while reflective conditions are set radially.
- The 3D radially infinite but axially finite cell with heterogeneous core assemblies (see Fig. 4.5), with the B₁ calculation mode for FA and the source calculation one for non-fissile zones. As before, void and reflective boundary conditions were settled axially and radially, respectively.



Figure 4.1 The 3D FC model with homogeneous core and barrel.





Figure 4.2 The 3D FC model with heterogeneous core assemblies (reference).



Figure 4.3 Axially and radially infinite model with heterogeneous assembly geometries.



Figure 4.4 Axially finite and radially infinite model with homogeneous assembly geometries.



Figure 4.5 Axially finite and radially infinite cell model with heterogeneous assembly geometries.



The first model, in which the core assemblies are assumed to be spatially homogeneous (see Fig. 4.1), is an approximation of the second one (see Fig. 4.2), which can be assumed as a reference since it accurately represents the whole ALFRED core geometry. The other three models are the closest to the ECCO ones, since they represent a single region within a cell. However, there are some intrinsic differences between the stochastic and the deterministic approaches for cell calculations, in addition to the ones already mentioned.

The first difference is due to the neutron spectrum. In a fast reactor, the particles mean free path is longer than in moderated systems: therefore, in principle the cell dimensions can have a detrimental effect on the cross-sections accuracy, as the reflective boundary conditions would force the particles to collide within the cell itself, increasing artificially the reaction rate inside the region. However, since the ALFRED core composition can be roughly divided into three rings characterised by the same kind of assemblies (inner fuel, outer fuel and dummy elements), the error induced by considering an infinite cell is negligible, as shown in the results section (§5.2).

The second difference between deterministic and stochastic cell calculations is related to statistics. Since the presence of thermal particles inside the FA cell of a fast reactor is a rare event, the statistical error on the effective cross-sections can be significantly high at low energies. In principle there are many ways to reduce the statistical noise, like simulating a huge number of particles or employing some variance reduction techniques. However, the first approach could increase too much the computational time for design-oriented calculations, while the second is currently not possible in Serpent 2, as there are no variance reduction techniques available in the cross-sections generation based on flux-engeinvalue calculations. An alternative strategy could be "helping" the thermal population to increase, surrounding the cells axially with a layer of lead, so that more particles are slowed down and reflected back into the cell. This approach (*i.e.*, simulating an axially limited cell) would change the cell spectrum making it closer to the one of the FC (where the presence of the axial reflectors and of the other components, like pin insulators and plugs, softens the flux spectrum) by enhancing the calculation accuracy of its thermal component.



5 Comparison between ECCO and SERPENT cross-sections data

5.1 The most significant ECCO multi-group cross-section results

The macroscopic cross-section vectors (3.1) representing the most significant core zones are reported in the following graphs. They were obtained by ECCO at 33 energy groups by adopting the reference route described in §3.2 (and explained in more detail in §A.8). Fig. 5.1 shows the main cross-section results for the fuel inner (top) and outer (bottom) zones. It is evident that the elastic, capture and fission values are dominant over the whole spectrum, with the exception of the inelastic and (n,xn) threshold reactions above 0.1 and 2 MeV, respectively. Fig. 5.2 shows the CR (top) and SR (bottom) absorbing bundle (B_4C) cross-sections: the elastic and capture values are dominant over the whole spectrum, with the inelastic and (n,xn) threshold reactions above 0.1 and 2 MeV, respectively. Fig. 5.2 shows the CR (top) and SR (bottom) absorbing bundle (B_4C) cross-sections: the elastic and capture values are dominant over the whole spectrum, with the inelastic and (n,xn) threshold reactions above 0.1 and 2 MeV.



Figure 5.1 Fuel inner (top) and outer (bottom) macroscopic cross-sections (ECCO results: P₁ order, heterogeneous geometry, 33 energy groups).





Figure 5.2 CR (top) and SR (bottom) absorbing bundles macroscopic cross-sections (ECCO results: P₁ order, heterogeneous geometry, 33 energy groups).

Fig. 5.3 shows the FA plena (left) and the pure lead (external to the barrel; right) cross-sections: it is evident that the elastic values are dominant over the whole spectrum, with the exception of the inelastic and (n,xn) threshold reactions at high energies.



Figure 5.3 FA plena (left) and pure lead (right) macroscopic cross-sections (ECCO results: P₁ order, 33 energy groups).



5.2 Impact of different SERPENT models on multi-group cross-sections

This section reports some comparisons between the ECCO "reference" multi-group constants at 33 energy groups (§3.2) and the Serpent ones in the same energy grid obtained with different geometrical models and calculation options (§4.2). The results here reported are the most interesting and relevant ones obtained in this study. The analysis concerned mainly the transport cross-section (which is directly linked to the diffusion coefficient), the capture and the fission cross-sections. The scattering matrix comparison has been left for future evaluations.

While the multi-group constants reported in Figs. 5.1-5.3 are depicted in their "correct" histogram form, for easiness in the following graphs they are reported in a "punctual form" (with the multigroup cross-section values in correspondence of the upper energy limits) as they come out from the codes output. The complete set of the relative differences between the ECCO and Serpent cross-section results at 33 groups is reported in Appendix B.

5.2.1 Main comparisons for multi-group constants of fissile zones

Figs. 5.4, 5.5 and 5.6 show the transport, capture and fission cross-sections, respectively, scored on the ECCO-33 energy grid, for the inner fuel region. In all the three graphs, the lowest energy point in the green curve (Serpent B_1 option with a heterogeneous 3D cell axially infinite) is missing because of poor statistics.

An inspection of the data represented in these plots suggests that the Serpent models that provide the closest results to the ECCO "reference" HH cross-sections (light blue curve, §3.2) are the 3D FC and the axially limited infinite cell models (brown and purple curves, respectively), where both the inner and outer fuel regions are considered as spatially homogeneous.

The multi-group constants evaluated with Serpent usually come out with a Relative Standard Deviation (RSD) less than 1%, by the exception of the spectrum tails (first thermal and last fast groups, respectively), where it can reach values up to 30%.

For energies above 100 eV there is a good general agreement between the two codes with a relative error approximately below 10%, while at lower energies significant discrepancies (that can reach even 100% in the thermal region) appear. These larger differences are mainly due to Serpent statistical noise at low energies. Similar trends can be found also for the outer fuel region: they were omitted for the sake of conciseness.



Figure 5.4 Transport macroscopic cross-sections at 33 energy groups of the inner fuel with the ECCO "reference" and different Serpent models.





Figure 5.5 Capture macroscopic cross-sections at 33 energy groups of the inner fuel with the ECCO "reference" and different Serpent models.



Figure 5.6 Fission macroscopic cross-sections at 33 energy groups of the inner fuel with the ECCO "reference" and different Serpent models different models.

Continuing to refer to the inner fuel zone, Fig. 5.7 shows the comparison between the transport, fission and capture multi-group constants on the more refined energy grid at 80 groups computed with the most accurate geometry models in ECCO (2D reference) and Serpent (3D FC with heterogeneous core assemblies, §4.2). As expected, the resonances region results to be described more accurately by both codes with respect to the 33-group results. Except for the first thermal and the last fast groups, the agreement between the codes for the fuel cross-sections results to be very good ($0.1 \div 2\%$) and, in the light of the previous observations on Figs. 5.4-5.6, it is expected to improve if the Serpent 3D FC homogeneous model would be employed.





Figure 5.7 Inner fuel assembly multi-group constants (transport, capture and fission) scored on 80 energy groups with the ECCO (2D) and Serpent (3D FC) heterogeneous models.

5.2.2 Main comparisons for multi-group constants of non-fissile zones

Figs. 5.8 and 5.9 show the 33-group transport and capture cross-sections, respectively, for the SR absorbing region obtained with different Serpent models (§4.2) and the ECCO 2D reference one (§3.2). The lowest energy point in the Serpent brown curves (3D cell axially infinite) is missing because of poor statistics.

It can be observed that, for the transport cross-section (Fig. 5.8), the Serpent results with the 3D FC and the axially finite cell models are very similar among them and to the ECCO results. Differently, for the capture cross-sections (Fig. 5.9), the Serpent models axially finite and infinite differ significantly from the ECCO and the Serpent FC ones from thermal energies up to 10 eV. The behaviour of the latter two (that are the references for the code comparison analyses) is very similar, even if the ECCO values are greater than the Serpent FC ones over a large part of the spectrum. These discrepancies (that reach 40-50% in some energy groups, see Table 5.1 in $\S5.3$) could be explained by the fact that Serpent samples the neutron flying directions without introducing any approximation in the transport process, while ECCO uses the P₁ approach. The P₁ model is a good transport approximation for scattering-dominated systems, while it may distort the physics in strong absorbing media as the SR absorbing bundles [22]. The discrepancies are less evident for higher energies above 10-100 keV, where the interaction between neutrons and the medium is weaker.

Fig. 5.10 shows the results for the transport and capture cross-sections at 80 groups obtained by the most accurate geometry models in ECCO (2D reference) and Serpent (3D FC with heterogeneous core assemblies, §4.2): also in this case there is a very good agreement for the transport values, whereas ECCO overestimates Serpent from thermal energies up to 10-100 keV for the capture ones (as in the 33-group case with 40-50% differences in some energy groups). Similar trends were found also for the CR absorbing region: they were omitted for the sake of conciseness.

It can be finally noticed that, with respect to ECCO that assumes an empirical value for the bucking factor (§3.2), Serpent does not allow to use the B_1 model for the non-fissile zones since they are non-multiplying media. As mentioned above, the axially limited cells with an active zone 60 cm thick were surrounded by top and bottom layers of lead to increase the statistics in the thermal region.





Figure 5.8 SR absorbing bundles transport cross-sections calculated at 33 energy groups with ECCO (2D) and different Serpent models.



Figure 5.9 SR absorbing bundles capture cross-sections calculated at 33 energy groups with ECCO (2D) and different Serpent models.



Figure 5.10 SR absorbing bundles macroscopic cross-sections (transport and capture) calculated at 80 groups with ECCO (2D) and Serpent (3D FC) heterogeneous models.



5.3 Discussion

An assessment of the different calculation options in Serpent for the multi-group constants generation has been reported previously (§5.2): a similar study was carried out also with ECCO and is reported in Appendix A, together with the description of the background mathematical theory. However, some general conclusions can be here drawn for the code benchmark in the cross-sections generation.

- 1. The poor statistics in the lowest energy groups is the major responsible for the discrepancies between ECCO and Serpent in the thermal region. This issue for fast systems has already been observed in [18] for the B₁ calculation mode, where it is suggested to merge the lowest energy groups in order to enhance the statistics.
- 2. The discrepancies between ECCO and Serpent tend to increase when the incident neutron energy decreases. Since at low energies the absorptions are more likely, the effect of the different angular approximations (P₁vs. continuous directions) could explain such difference.
- 3. The highest discrepancies between ECCO and Serpent occur in the CR and SR absorbing regions. As shown in Fig. 5.11 the Serpent capture cross-sections are significantly lower than the ECCO ones in the 1 eV ÷ 10 keV range for both 33 and 80 energy-group-structure, thereby impacting on the reactivity worth evaluation by the two codes as reported in §6.
- 4. Generally, the agreement between the data computed with the different Serpent (and ECCO, §A.8) models is quite good but deserves more investigations (*e.g.*, a sensitivity analysis in order to quantify the impact of the multi-group constants computed with the different calculation modes on the main neutronics and thermal-hydraulics output parameters).



Figure 5.11 CR (left) and SR (right) absorbing bundles capture cross-sections at 33 and 80 energy groups calculated with ECCO (2D) and Serpent (3D FC) heterogeneous models.

The complete comparison between the "reference" cross-section results obtained by the two codes is reported in Appendix B, through the relative error between the 33-group values evaluated with Serpent (3D FC heterogeneous) and ECCO (2D heterogeneous) models. Table 5.1 summarises the results for the fuel inner, CR and SR absorbing bundle regions. As mentioned in §5.2.2, the fuel cross-sections differ significantly only at low energies (where the Serpent statistics is poor) while for the CR and SR absorbing bundles:

- the highest relative difference for the total cross-sections reaches 27% for the SR at 20 keV (group 14) and 23% for the CR at 0.5 keV (group 22);
- the highest relative difference for the capture cross-sections for the SR / CR reaches 47 / 50%, respectively, around 0.5 keV.



Table 5.1 Relative error [%] between the 33-group cross-sections evaluated with Serpent (3D FC heterogeneous model) and ECCO (2D reference model) for the fuel inner, CR and SR absorbing bundle regions (data ordered from the upper to the lower energy boundary).

	Inner fuel			Safety rod B ₄ C			Control rod B ₄ C			
Energy group	Total	Transport	Capture	Fission	Total	Transport	Capture	Total	Transport	Capture
1	0.11%	2.21%	1.28%	1.65%	1.87%	- 1.52%	- 6.26%	0.11%	- 0.97%	-4.48%
2	0.11%	0.04%	0.57%	- 0.21%	-0.24%	- 0.65%	- 11.70%	0.28%	0.01%	- 4.24%
3	0.05%	0.32%	0.39%	0.00%	0.24%	0.21%	- 9.25%	0.82%	0.78%	- 4.49%
4	- 0.07%	- 0.13%	0.22%	- 0.19%	- 1.26%	- 1.30%	- 8.62%	-0.57%	- 0.68%	- 5.94%
5	0.11%	0.54%	0.27%	-0.12%	- 2.44%	- 1.46%	- 10.16%	- 1.12%	- 0.82%	- 7.56%
6	- 0.68%	1.27%	0.25%	-0.33%	- 4.49%	- 3.46%	- 8.04%	- 2.62%	-1.30%	- 6.21%
7	- 1.43%	0.09%	0.08%	-0.57%	- 6.46%	- 3.48%	- 7.53%	- 4.85%	- 1.87%	- 6.69%
8	- 0.15%	4.17%	-0.02%	- 0.65%	- 7.20%	-0.52%	- 15.01%	- 5.79%	0.44%	-11.65%
9	- 0.11%	1.91%	0.11%	-0.50%	- 6.98%	- 2.06%	- 13.76%	- 4.89%	- 0.75%	- 11.19%
10	-0.10%	2.18%	0.05%	-0.55%	- 7.09%	- 2.38%	- 13.79%	- 4.92%	- 1.97%	- 12.35%
11	0.08%	3.25%	0.09%	-0.55%	- 6.76%	-3.05%	- 15.63%	- 3.90%	-1.27%	- 12.82%
12	0.17%	1.46%	0.25%	-0.62%	- 5.78%	- 4.08%	-1 7.50%	- 3.86%	- 2.27%	- 15.52%
13	0.11%	8.53%	0.32%	- 0.11%	- 4.61%	5.31%	- 20.45%	-4.41%	0.71%	-1 7.30 %
14	0.18%	3.76%	0.55%	- 1.34%	- 27.10%	- 22.66%	- 30.54%	- 14.08%	-11.52%	- 25.90%
15	0.11%	1.60%	0.52%	0.55%	- 20.36%	- 16.96%	- 20.86%	- 10.64%	- 8.68%	- 22.6 4%
16	0.07%	4.88%	0.57%	- 1.26%	- 2.52%	8.24%	- 29.76%	- 5.74%	-1.77%	- 28.96%
17	0.12%	2.50%	- 0.07%	- 4.86%	- 18.31%	- 12.50%	- 35.87%	-14.44%	- 10.95%	-35.43%
18	0.23%	3.87%	-0.03%	- 4.69%	- 18.24%	- 12.14%	-37.82%	- 17.42%	- 11.81%	- 39.69%
19	0.09%	4.26%	- 1.04%	- 0.65%	- 12.59%	- 9.21%	- 37.26%	- 17.46%	- 9.89%	- 41.23%
20	0.00%	4.98%	-1.54%	- 2.40%	-11.95%	- 5.98%	-40.43%	-19.66%	- 8.25%	-44.77%
21	0.24%	3.86%	0.18%	0.69%	- 10.47%	- 5.14%	- 41.80%	- 20.6 1%	- 6.75%	-47.45%
22	0.73%	8.16%	- 0.47%	0.52%	- 16.48%	-0.08%	- 46.57%	-22.72%	- 5.8 4%	-49.69%
23	- 0.46%	5.79%	-1.53%	-3.03%	- 10.54%	-4.48%	- 36.5 1%	- 20.77%	- 4.67 %	-47.27%
24	1.40%	9.31%	4.86%	- 0.29%	- 10.07%	- 2.77%	- 40.67%	- 19.61%	- 3.84%	- 46.47%
25	- 0.62%	5.35%	- 5.87%	- 4.96%	- 6.81%	-0.48%	- 36.69%	- 10.15%	-1.88%	- 29.70%
26	- 3.47%	11.17%	- 11.80%	- 14.81%	- 6.37 %	0.29%	- 27.2 1%	-17.14%	5.99%	-42.34%
27	- 6.10%	9.28%	- 27.83%	8.34%	- 6.73 %	-0.83%	-32.24%	-15.70%	-0.02%	- 40.64%
28	-4.95%	1 2.50%	-18.65%	1.94%	- 6.43 %	- 1.19%	- 29.38%	- 8.72 %	0.46%	- 26.3 1%
29	0.21%	4.87%	-3.83%	1.52%	- 5.30 %	-0.40%	- 33.8 1%	-8.51%	1.52%	- 26.91%
30	6.03%	13.69%	24.15%	1 0.92%	- 7.44%	- 0.69%	-44.82%	- 18.67%	0.96%	-45.17%
31	- 15.97%	- 7.72%	- 54.29%	-55.52%	- 6.43 %	- 2.58%	- 16.67%	0.55%	4.75%	6.90%
32	- 7.07%	12.54%	- 7.75%	- 19.90%	- 6.7 1%	- 2.86 %	- 15.63%	4.17%	5.90%	19.82%
33	117.3%	- 100.0%	1 70.5%	197.6%	- 7.12%	2.91%	- 21.78%	5.02%	10.04%	16.87%

(Serpent – ECCO) / ECCO



6 Comparison between ERANOS and SERPENT full-core analyses

6.1 ERANOS k_{eff} and reactivity worth value of shutdown systems

The ERANOS full-core calculations were carried out with the variational nodal method by adopting the multi-group constants evaluated by ECCO at the P₁ order. In the reference case:

- the macroscopic cross-sections were calculated with the P₁ consistent option, by adopting a 33 energy-group structure (starting from 172 groups and collapsing at 33 after the step through 1968 groups) and a 2D heterogeneous geometry model for almost all zones with few exceptions (see Table 2.2 and Fig. 2.5);
- the ERANOS calculations were performed with the P₁ order cross-sections and the P₃ order for the angular flux (in the TGV module, §3.1) at 33 energy groups.

Besides the reference case, the ECCO/ERANOS analyses were carried out also by adopting:

- a more refined 80 energy-group structure;
- a homogeneous description of the ECCO cells representing the fuel and the absorbing bundles of the shutdown systems;
- the P₁ order of the flux in ERANOS (instead of P₃).

Table 6.1 reports the values of the k_{inf} parameter for the fuel inner and outer regions evaluated by ECCO at 33 and 80 energy groups with homogeneous and heterogeneous cell geometry models. It appears evident that:

- the less accurate homogeneous model of the fuel cells yields a reactivity ~0.6-0.7% lower than the heterogeneous case for both energy structures;
- the more accurate energy refinement at 80 groups yields fuel cells reactivity ~0.3% lower than the 33-group case for both geometry models.

The ERANOS spatial calculations were performed at BoL with the CRs and SRs completely withdrawn and inserted. Table 6.2 reports the k_{eff} values with different ECCO cell calculation options in which the reference one is marked by a red box. As mentioned in §3, among the ECCO calculation options the cross-sections were generated by 2D heterogeneous geometry models of the cells starting from 172 groups (reference) and from 33 groups. Additionally, the flux and current spectra of the fuel calculated by Serpent (and condensed down to 33 groups) were used as weighting functions by ECCO in (3.1) to compute the cross-section constants of non-multiplying media. Even whether the Serpent fuel spectra are significantly different from the ECCO ones (see Figs A.1 and A.2 in §A.8), the cross-section values are not significantly different (see §A.8) and, as shown in Table 6.2, the impact on k_{eff} is almost negligible.

	k	ECC	0 P ₁	Hom -Het (ncm)	Hom - Het (%)
Energy groups	nit	Het	Hom		
22	Fuel Inn	1.34464	1.33483	-981	-0.73
33	Fuel Out	1.53358	1.52465	-893	-0.58
	Fuel Inn	1.34146	1.33163	-983	-0.73
80	Fuel Out	1.52815	1.51923	-892	-0.58
90. 22 (ncm)	Fuel Inn	-318	-320		
80-33 (pcm)	Fuel Out	-543	-542	_	
80 -33 (%)	Fuel Inn	-0.24	-0.24	_	
	Fuel Out	-0.35	-0.36		

Table 6.1ECCO k_{inf} values for the fuel inner and outer zones evaluated at 33 and 80energy groups with homogeneous and heterogeneous cell geometry models.



Table 6.2	ERANOS k _{eff} values (P ₃ flux moment, 33 energy groups) with different ECCO cell
	calculation options (and related P ₁ cross-sections used in ERANOS).

k _{eff}	CR position	SR position	ERANOS P ₃ 3	3 eg , ECCO P ₁ X	∆k _{eff} (pcm)		
	chiposition		172 eg*	33 eg**	Serpent 33 eg***	ERANOS 33 - 172	Serpent 33 - 172
CR & SR Out	Out	Out	1.07746	1.0771	1.07648	-36	-98
CR Inserted	In	Out	0.98148	0.98149	0.98115	1	-33
SR Inserted	Out	In	1.03763	1.03741	1.03682	-22	-81
CR & SR Ins	In	In	0.90121	0.90155	0.90126	34	5

* REFERENCE: all macroscopic cross-sections (XS) calculations in ECCO start with 172 energy groups (eg)

** All XS calculations in ECCO start with 33 eg

*** XS calculations of non-fissile zones start with flux & current spectra of fissile zone calculated by Serpent at 33 eg

Table 6.3 reports the k_{eff} values obtained with the P_1 order flux development in ERANOS. The comparison with the P_3 reference case (of Table 6.2) indicates that the P_1 order yields k_{eff} levels ~400-1000 per cent mille (pcm) lower in dependence of the CRs and SRs positions. The discrepancies between the P_N approximations increase when the CRs and SRs are fully inserted: this reasonably means that, when the system becomes less diffusive, the difference between the P_1 and P_3 flux orders increases.

Table 6.4 reports the ERANOS reference results (P_1 cross-sections, P_3 flux moment, 33 energy groups) for the CRs and SRs reactivity worth, together with the ERANOS P_1 (flux moment) ones obtained with the same ECCO heterogeneous geometry model and calculation options. Tables 6.3 and 6.4 show clearly that, in comparison with the reference P_3 results, the ERANOS P_1 approximation underestimates the k_{eff} level (from 400 up to 995 pcm) and overestimates the shutdown system anti-reactivity worth (from 172 up to 595 pcm).

Ŀ	CB position	SP position	ECCO P ₁ XS Het, ERANOS flux		∆k _{eff} (pcm)
ĸ _{eff}	CK position	Six position	P ₃	P ₁	P ₁ - P ₃
CR & SR Out	Out	Out	1.07746	1.07346	-400
CR Inserted	In	Out	0.98148	0.97576	-572
SR Inserted	Out	In	1.03763	1.03212	-551
CR & SR In	In	In	0.90121	0.89126	-995

Table 6.3 ERANOS k_{eff} values with P_1 (and P_3) flux moments at 33 energy groups.

Table 6.4	ERANOS CRs and SRs reactivity worth results (P ₃ and P ₁ flux moments, 33
	energy groups).

CR & SR worth CR position		SR position	ECCO P ₁ XS Het, ERANOS P ₃ 33 eg		ECCO P_1 XS Het, ERANOS P_1 33 eg		P ₁ - P ₃
			k _{eff}	∆k _{eff} (pcm)	k _{eff}	∆k _{eff} (pcm)	$\Delta(\Delta k_{eff})$ (pcm)
CR & SR Out	Out	Out	1.07746		1.07346		
CR Inserted	In	Out	0.98148	-9598	0.97576	-9770	-172
SR Inserted	Out	In	1.03763	-3983	1.03212	-4134	-151
CR & SR Ins	In	In	0.90121	-17625	0.89126	-18220	-595

Table 6.5 reports the ERANOS k_{eff} values obtained with the ECCO cells representing the fuel and the CR and SR absorbing bundle described with a homogeneous geometry. The results indicate that the spatial self-shielding effect (taken into account, to some extent, in the reference ECCO heterogeneous geometry models) for the fuel weights 743 pcm on the core reactivity. This effect for the CR and SR absorbing bundles is limited to 102 pcm since the calculations were carried out with both shutdown systems completely withdrawn.



Table 6.5 ERANOS k_{eff} values (P_3 flux moment, 33 energy groups) obtained with the fuel and absorbing bundle cells described with ECCO heterogeneous and homogeneous geometry models.

CR & SR Out	ECCO P ₁ XS Het, ERANOS P ₃ 33 eg							
Fuel model	Het	Hom	Het	Hom				
CR & SR model	Het	Het	Hom	Hom				
k _{eff}	1.07746	1.07003	1.07644	1.06903				
$\Delta { t k}_{ ext{eff}}$ (pcm)		-743	-102	-843				
Hom - Het		∆fuel	∆CR&SR	∆fuel,CR&SR				

Table 6.6 reports the ERANOS k_{eff} values and the reactivity worth of CR and SR: differently from Table 6.4, the macroscopic cross-sections of the absorbing bundles were created with the ECCO homogeneous cell geometry models. The comparison with the reference case (in which the CR and SR bundles are described in ECCO with 2D heterogeneous models) indicates that the CR and SR ECCO homogeneous models (not describing spatial self-shielding effects) yield:

- a decrease of ~100-660 pcm for the k_{eff} values;
- an increase of ~160-560 pcm for the shutdown systems performances;

in dependence of the CR and SR position. As shown in §A.8, the higher anti-reactivity obtained with ECCO homogeneous models of the CR and SR absorbing bundles is due to the higher values of the capture cross-sections at low energies: the difference steadily increases with decreasing energy up to the last thermal group, where the homogeneous results are two order of magnitudes greater than the heterogeneous ones (see Fig. A.13).

CR & SR worth CR position			ERANOS P ₃ 33	eg, ECCO P ₁ XS		Δ (CR&SR) worth
		SR position	All Het	CR & SR Hom	Hon	n - Het
			k	eff	$\Delta k_{ m eff}$ (pcm)	$\Delta(\Delta k_{eff})$ (pcm)
CR & SR Out	Out	Out	1.07746	1.07644	-102	
CR Inserted	In	Out	0.98148	0.97884	-264	-162
SR Inserted	Out	In	1.03763	1.03256	-507	-405
CR & SR Ins	In	In	0.90121	0.89461	-660	-558

Table 6.6 ERANOS results (P_3 flux moment, 33 energy groups) for the reactivity worth of CR and SR (with ECCO homogeneous and heterogeneous cell models of absorbing bundles).

Table 6.7 reports the ERANOS k_{eff} values obtained with 80 energy groups. The comparison with the reference ones at 33 groups indicates that the impact of the energy refinement on the core reactivity is almost negligible (< 100 pcm) for each position of the CRs and SRs.

Table 6.7 ERANOS k_{eff} values (P₃ flux moment) obtained with 80 energy groups.

k	CR position	SR position	ECCO P ₁ XS Het	$\Delta {f k}_{ m eff}$ (pcm)	
N eff	en position	Shiposhion	33 eg	80 eg	80 - 33
CR & SR Out	Out	Out	1.07746	1.07801	55
CR Inserted	In	Out	0.98148	0.98172	24
SR Inserted	Out	In	1.03763	1.03852	89
CR & SR In	In	In	0.90121	0.90163	42



Table 6.8 compares the ERANOS k_{eff} values obtained with the P₁ and P₃ flux moments at 80 energy groups. As in the 33 groups case (see Table 6.3), the P₁ values are ~400-1000 pcm lower than the P₃ ones in dependence of the CRs and SRs positions, meaning that the energy and the angular effects are loosely coupled.

k _{eff}	CP position	SP position	ECCO P ₁ XS Het	$\Delta k_{ m eff}$ (pcm)	
	CK position	SK POSICION	P ₃	P ₁ - P ₃	
CR & SR Out	Out	Out	1.07801	1.07399	-402
CR Inserted	In	Out	0.98172	0.97602	-570
SR Inserted	Out	In	1.03852	1.03301	-551
CR & SR In	In	In	0.90163	0.89171	-992

Table 6.8	ERANOS keff values obtained with P	$_{1}$ (and P ₃) flux moments at 80 energy groups.

Table 6.9 reports the ERANOS k_{eff} values obtained with 80 energy groups by the ECCO cells of the fuel and absorbing bundles described with homogeneous geometries. As in the 33 groups case (see Table 6.5), the spatial self-shielding effect of the fuel weights ~740 pcm on the core reactivity and is limited to ~100 pcm for the CRs and SRs (in completely withdrawn position). The same impact is obtained with the P₁ flux moment used in ERANOS, shown in Table 6.10.

Table 6.11 reports the ERANOS results for the k_{eff} and reactivity worth values of CRs and SRs in which the cross-sections of the absorbing bundles were generated with the ECCO homogeneous geometry models. As in the 33 groups case (see Table 6.6), the k_{eff} values decreases by ~100-660 pcm and the shutdown systems performances increase by ~150-550 pcm (due to the spatial self-shielding not taken into account by the homogeneous models). The same effect is obtained with the P₁ flux development in ERANOS, as shown in Table 6.12.

Table 6.9 ERANOS k_{eff} values (P₃ flux moment, 80 energy groups) obtained with the fuel and absorbing bundle cells described by ECCO heterogeneous and homogeneous geometry models.

CR & SR Out	ECCO P ₁ XS Het, ERANOS P ₃ 80 eg					
Fuel model	Het Hom Het Hom					
CR & SR model	Het	Het	Hom	Hom		
k _{eff}	1.07801	1.07055	1.07695	1.06951		
∆k _{eff} (pcm)		-746	-106	-850		
Hom - Het		∆fuel	∆CR&SR	∆fuel,CR&SR		

Table 6.10	ERANOS k _{eff} values (P ₁ flux moment, 80 energy groups) obtained with the fuel
and absorbing	bundle cells described by an ECCO heterogeneous and homogeneous geometry
	models.

CR & SR Out	ECCO P ₁ XS Het, ERANOS P ₁ 80 eg					
Fuel model	Het	Hom	Het	Hom		
CR & SR model	Het	Het	Hom	Hom		
k_{eff}	1.07399	1.06659	1.07289	1.06551		
$\Delta { t k}_{ ext{eff}}$ (pcm)		-740	-110	-848		
Hom - Het		∆fuel	∆CR&SR	Δ fuel,CR&SR		



Table 6.11	ERANOS results (P ₃ flux moment, 80 energy groups) for the reactivity worth of
CR and SR (with ECCO homogeneous and heterogeneous cell models of absorbing bundles).

		_	ERANOS P_3 80 eg , ECCO P_1 XS			Δ (CR&SR) worth
CR & SR worth	CR position	SR position	All Het	CR & SR Hom	Hor	n - Het
				k _{eff}	$\Delta {f k}_{ m eff}$ (pcm)	$\Delta(\Delta k_{ m eff})$ (pcm)
CR & SR Out	Out	Out	1.07801	1.07695	-106	
CR Inserted	In	Out	0.98172	0.979	-272	-166
SR Inserted	Out	In	1.03852	1.03611	-241	-135
CR & SR Ins	In	In	0.90163	0.89493	-670	-564

Table 6.12 ERANOS results (P_1 flux moment, 80 energy groups) for the reactivity worth of CR and SR (with ECCO homogeneous and heterogeneous cell models of absorbing bundles).

			ERANOS P ₁ 80 eg , ECCO P ₁ XS			Δ (CR&SR) worth
CR & SR worth	CR position	SR position	All Het	CR & SR Hom	Hor	n - Het
			k _{eff}		$\Delta k_{ m eff}$ (pcm)	$\Delta(\Delta k_{eff})$ (pcm)
CR & SR Out	Out	Out	1.07399	1.07289	-110	
CR Inserted	In	Out	0.97602	0.97326	-276	-166
SR Inserted	Out	In	1.03301	1.03052	-249	-139
CR & SR Ins	In	In	0.89171	0.88478	-693	-583


6.2 Serpent k_{eff} and reactivity worth values of shutdown systems

Tables 6.13 and 6.14 report the k_{eff} and the shutdown systems reactivity worth values, respectively, obtained with two different Serpent FC models (§4.2): the reference (in which each core assembly is described with a heterogeneous geometry) and a simplified one where the fuel regions (both inner and outer) were approximated as spatially homogeneous. The homogeneous description of the fuel has an important impact over the k_{eff} value, leading to an underestimation of about 750-800 pcm (as in ECCO/ERANOS, §6.1). On the contrary, the influence of the fuel homogeneous model is quite limited on the estimation of the CRs and SRs worth.

Table 6.13	Serpent keff results with the 3D FC models with heterogeneous and homogeneous
	descriptions of the fuel region.

k _{eff}	CR position	SR position	All Het.	Fuel Hom.	Δk_{eff} (pcm)
CR & SR Out	Out	Out	1.07534	1.06746	-788
CR Inserted	In	Out	0.9866	0.97936	-724
SR Inserted	Out	In	1.04008	1.03204	-804
CR & SR In	In	In	0.91859	0.9112	-739

Table 6.14Serpent results (3D FC heterogeneous model vs. 3D FC with homogeneous
description of the fuel region) for the CR and SR reactivity worth.

∆k _{eff} (pcm)	CR position	SR position	All Het.	Fuel Hom.	$\Delta\Delta k_{eff}$ (pcm)
CR & SR Out	Out	Out			
CR Inserted	In	Out	-8874	-8810	64
SR Inserted	Out	In	-3526	-3542	-16
CR & SR In	In	In	-15675	-15626	49

6.3 Significant comparisons between ERANOS and Serpent reactivity results

Tables 6.15-6.18 show the comparison between the k_{eff} , CRs and SRs reactivity worth values obtained with:

- the Serpent 3D FC heterogeneous model;
- the ERANOS code by adopting different ECCO calculation options using a heterogeneous geometry description of the cells (that takes into account the self-shielding effect; §6.1).

Tables 6.19-6.22 show the same comparison (k_{eff} , CRs and SRs worth values) between the Serpent 3D FC heterogeneous model with a homogeneous geometry description of the fuel and the different ECCO/ERANOS calculation options. In Tables 6.20 and 6.22 the differences refer to the Serpent 3D FC model with homogeneous fuel (assumed as reference in them).

Tables 6.18 and 6.22 highlight a significant discrepancy (~400-1900 pcm) between the Serpent and ERANOS results for the CRs and SRs reactivity worth, with the deterministic values higher than the MC ones and the highest difference occurs with both CRs and SRs inserted. A further inspection indicates that, as expected (and similarly to the ECCO / ERANOS results; §6.1), the homogeneous fuel model in Serpent underscores the k_{eff} eigenvalue for each CRs and SRs position in comparison with the heterogeneous fuel model.



Table 6.15	keff values computed with the Serpent FC heterogeneous model and ERANOS
with differe	nt ECCO calculation options (see Table 6.2 for the meaning of the asterisks).

k _{eff}						
CR position	SR position	SERDENT	ECCO P ₁ XS Het, ERANOS P ₃ flux			
	Sitposition		from 172 eg* from 33 eg*	from 33 eg**	from Serpent 33 eg***	
Out	Out	1.07534	1.07746	1.0771	1.07648	
In	Out	0.986603	0.98148	0.98149	0.98115	
Out	In	1.04008	1.03763	1.03741	1.03682	
In	In	0.91859	0.90121	0.90155	0.90126	

Table 6.16Differences between the k_{eff} values computed with the Serpent FC heterogeneous
model (assumed as reference) and ERANOS with different ECCO calculation options.

Δk _{eff} (pcm)						
CR position	SR position	SERPENT	ECCO P ₁ XS Het, ERANOS P ₃ flux			
chiposition			from 172 eg*	from 33 eg**	from Serpent 33 eg***	
Out	Out	REF	212	176	114	
In	Out		-512	-511	-545	
Out	In		-245	-267	-326	
In	In		-1738	-1704	-1733	

Table 6.17	CRs and SRs read	ctivity worth compu	ted with the Serpe	ent FC heterogeneous
model (a	assumed as reference)) and ERANOS wit	h different ECCO	calculation options.

CR & SR worth (pcm)						
CR position	SR position	SERDENT	ECCO	ECCO P ₁ XS Het, ERANOS P ₃ flux		
CK position SK position		JERFENT	from 172 eg*	from 33 eg**	from Serpent 33 eg***	
Out	Out			REF		
In	Out	-8874	-9598	-9561	-9533	
Out	In	-3526	-3983	-3969	-3966	
In	In	-15675	-17625	-17555	-17522	
CR+SR	worth	-12400	-13581	-13530	-13499	

Table 6.18Difference between the CRs and SRs worth computed with the Serpent FCheterogeneous model (assumed as reference) and ERANOS with different ECCO options.

ΔWorth (pcm)						
CP nosition	SP position		ECCO	ECCO P ₁ XS Het, ERANOS P ₃ flux		
CR position SR position		SERPENT	from 172 eg*	from 33 eg**	from Serpent 33 eg***	
Out	Out			REF		
In	Out		-724	-687	-659	
Out	In	DEE	-457	-443	-440	
In	In	KEF	-1950	-1880	-1847	
CR+SR	worth		-1181	-1130	-1099	



Table 6.19k_{eff} values computed with the Serpent 3D FC model with homogeneous fuel and
ERANOS with different ECCO calculation options.

k _{eff}						
CR position	SR position	SERDENIT	ECCO P ₁ XS Het, ERANOS P ₃ flux		RANOS P ₃ flux	
Ch position	Sitposition		from 172 eg* from 33 eg**	from Serpent 33 eg***		
Out	Out	1.06746	1.07746	1.0771	1.07648	
In	Out	0.979361	0.98148	0.98149	0.98115	
Out	In	1.03204	1.03763	1.03741	1.03682	
In	In	0.91120	0.90121	0.90155	0.90126	

Table 6.20Differences between k_{eff} values computed with the Serpent 3D FC model with
homogeneous fuel (assumed as reference) and ERANOS with different ECCO options.

Δk _{eff} [pcm]						
CR nosition	osition SP position S		ECCO P ₁ XS Het, ERANOS P ₃ flux			
chiposition	Sitposition		from 172 eg*	from 33 eg**	from Serpent 33 eg***	
Out	Out		1000	964	902	
In	Out	REF	212	213	179	
Out	In		559	537	478	
In	In		-999	-965	-994	

Table 6.21CRs and SRs reactivity worth computed with the Serpent 3D FC model with
homogeneous fuel and ERANOS with different ECCO calculation options.

CR & SR worth (pcm)							
CR position	SR nosition	ECCO P ₁ X		P ₁ XS Het, E	XS Het, ERANOS P ₃ flux		
CK position SK position		JENF LINT	from 172 eg*	from 33 eg**	from Serpent 33 eg***		
Out	Out			REF			
In	Out	-8810	-9598	-9561	-9533		
Out	In	-3542	-3983	-3969	-3966		
In	In	-15626	-17625	-17555	-17522		
CR+SR worth -12352			-13581	-13530	-13499		

Table 6.22	Difference between the CRs and SRs worth computed with the Serpent FC with
homogene	ous fuel (assumed as reference) and ERANOS with different ECCO options.

ΔWorth (pcm)					
CR position	SR position	SERPENT	ECCO P ₁ XS Het, ERANOS P ₃ flux		
Ch position			from 172 eg*	from 33 eg**	from Serpent 33 eg***
Out	Out			REF	
In	Out	055	-788	-751	-723
Out	In		-441	-427	-424
In	In	REF	-1999	-1929	-1896
CR+SR worth			-1229	-1178	-1147

The observed discrepancy between the worth of the absorbers as estimated by the two codes is mainly due to the differences in the capture cross-section values (§5.3), with ECCO/ERANOS overscoring Serpent even up to 40-50% (see Table 5.1 in §5.3).



6.4 Radial and axial flux traverses (ERANOS vs Serpent)

As shown in §6.3 (Tables 6.18 and 6.22), a significant discrepancy between the ERANOS and Serpent results was found for the CRs and SRs reactivity worth, which is credited as a direct consequence of the difference between the macroscopic cross-section values of their absorbing regions generated by the two codes (§5.3).

Additionally, the energy-integrated flux distributions within the core were compared along the couple of directions shown in Fig. 6.1 with both shutdown systems fully withdrawn and inserted. The flux is calculated/sampled by ERANOS/Serpent over all the length of the FA, CR, SR, dummy and barrel (homogenised with lead) assemblies lying along the directions named "Cut 1" and "Cut 2". In the following graphs the two radial traverses at the core mid-plane are shown together with some significant axial traverses in the assemblies along them: the complete set of the axial traverses is reported in Appendix C.



Figure 6.1 Radial directions ("Cut 1" and "Cut 2") investigated in the ALFRED core (fuel inner/outer: orange/red; CR/SR: red/white; dummy/pure lead: blue/yellow; barrel homogenised with lead: grey).

Fig. 6.2 shows the ERANOS and Serpent radial flux traverses calculated at core mid-plane along the Cut 1 (top) and Cut 2 (bottom) directions with both CRs and SRs completely withdrawn. Fig. 6.3 reports the flux traverses in the same directions (Cut 1 on the left, Cut 2 on the right) with the CRs completely inserted and the SRs withdrawn. In Fig. 6.4 the flux traverses refer to the SRs completely inserted and the CRs withdrawn, while in Fig. 6.5 both shutdown systems are completely inserted. In these radial flux profiles (Figs. 6.2-6.5), the black vertical lines represent the boundary between the different kind of assemblies (inner and outer FA, CR, SR, dummy, barrel and external lead). It appears evident that, especially in the latter case with both shutdown systems inserted, the depression of the flux computed with ERANOS is decisively more pronounced than the Serpent one, thus reflecting the \cong 10% higher anti-reactivity calculated for the shutdown systems insertion.





Figure 6.2 ERANOS and Serpent radial flux traverses at core mid-plane along Cut 1 (top) and Cut 2 (bottom) with both CRs and SRs completely withdrawn.



Figure 6.3 ERANOS and Serpent radial flux traverses at core mid-plane along Cut 1 (left) and Cut 2 (right) with CRs completely inserted and SRs completely withdrawn.



Figure 6.4 ERANOS and Serpent radial flux traverses at core mid-plane along Cut 1 (left) and Cut 2 (right) with SRs completely inserted and CRs completely withdrawn.





Figure 6.5 ERANOS and Serpent radial flux traverses at core mid-plane along Cut 1 (left) and Cut 2 (right) with both CRs and SRs completely inserted.

As shown in Figs. 6.6 (for the core configuration with the SRs inserted and the CRs withdrawn) and 6.7-6.8 (for both CRs and SRs inserted), the difference between the ERANOS and Serpent flux shapes is even more evident by considering the axial traverses. The graph in Fig. 6.6 refers to the flux traverses calculated/sampled by ERANOS/Serpent in the fuel inner and SR assemblies along Cut 1. Figs. 6.7 and 6.8 refer to the values in the fuel, CR and SR assemblies along Cut 1 and Cut 2, respectively.



Figure 6.6 ERANOS and Serpent axial flux traverses in fuel inner and SR positions along Cut 1 with the SRs inserted and the CRs withdrawn (black vertical lines represent the fissile length boundaries).





Figure 6.7 ERANOS and Serpent axial flux traverses in fuel inner and SR positions along Cut 1 with both CRs and SRs completely inserted (black vertical lines represent the fissile length boundaries).



Figure 6.8 ERANOS and Serpent axial flux traverses in fuel outer and CR positions along Cut 2 with both CRs and SRs completely inserted (black vertical lines represent the fissile length boundaries).



7 Concluding remarks

An extensive and accurate comparison between the deterministic ECCO/ERANOS code and the Serpent MC code was performed through the neutronic analyses of the ALFRED (LEADER version) core. The core models were accurately compared, and their consistency verified in detail. The comparison was limited to the full power (300 MW) BoL (fresh fuel) conditions with the shutdown systems completely withdrawn (*i.e.*, over-critical core) and inserted.

By adopting the JEFF-3.1 nuclear data library, some fundamental physical quantities produced by deterministic and MC methods were compared:

- the macroscopic cross-sections produced by the ECCO cell code in the ERANOS system and by Serpent used as a "cell code" - representative of every core region;
- the core reactivity, by obtaining only ~100 pcm difference between the two codes when both shutdown systems are completely withdrawn;
- the reactivity worth of the shutdown systems and the impact of their insertion on the spatial flux distribution within the core.

The energy behaviour of the ECCO and Serpent macroscopic cross-sections was evaluated referring to different models and calculation options, the most significant of which dealing with:

- the energy refinement of the homogenised cross-section values (at 33 and 80 groups);
- the homogeneous and heterogeneous cell geometry models of the most important core regions, as the fuel and the absorbing bundles of the CRs and SRs;
- other simplified geometry models available in Serpent used as a "cell code". The evaluation
 of the multi-group constants was performed with radially infinite and both axially infinite or
 finite geometries, besides the reference (and more accurate) values obtained with a 3D FC
 heterogeneous model.

An overall agreement between the two codes was found for the most part of the 33-group results in both fissile and non-fissile zones, with the exception of the first fast group and the ones at low energies, where the Serpent RSD is quite large. The largest discrepancies appear in:

- the fuel spectra (used in ECCO as weighting function to evaluate multi-group constants of non-fissile regions) at epithermal and thermal energies;
- the capture cross-section values of CR and SR absorbers (B₄C pin bundles) below 10 keV;
- even in a smaller amount, relevant differences were found also in the fuel pins plugs, the axial reflectors and the core barrel (made of SS and the surrounding lead in the ERANOS and Serpent 3D hexagonal models). A significant contribution to this discrepancy could be due to the spectrum "softening" occurring in these regions (far from the active zone) that is correctly reproduced by the Serpent 3D FC model and not by the 2D ECCO ones.

The difference between the fuel spectra evaluated by the two codes has a negligible impact on the main features investigated here at the core level (k_{eff} , CRs and SRs worth). In fact, the fuel spectra calculated by Serpent were also loaded in ECCO as weighting functions to evaluate the cross-sections of non-multiplying media, but their impact on the results was found negligible.

The poor statistics of Serpent cross-section results in the lowest energy groups should be the major responsible of the high discrepancies with ECCO in the thermal and epithermal regions. In spite of the limited Serpent RSD values, a systematic difference between the two codes was found for the CR and SR capture cross-sections in a large part of the spectrum below 10 keV. This could find a reasonable explanation in the increasing effect of captures at these energies, which enhances the impact of the approximation order for the direction of flight that is requested in deterministic codes (P_1 in ECCO vs. Serpent continuous directions).

The difference between the CR and SR capture cross-sections (that reaches up to ~50% in the energy group around 0.5 KeV) represents the primary cause for the \cong 10% discrepancy between



the reactivity worth performances evaluated by the two codes. It is worth mentioning that this discrepancy turns out to be in line with the usual overestimation introduced by deterministic codes with respect to stochastic ones in fast reactors analyses.

To confirm this assertion, the focus of the study was shifted to the full-core scale. Besides the calculation of the k_{eff} , CRs and SRs reactivity worth values, the spatial distributions of the total flux within the core were evaluated and compared in a couple of radial directions (passing through CR and SR positions). Actually, when the absorbers are inserted, the comparison between the (radial and axial) flux traverses shows a more pronounced flux depression predicted by the deterministic code, which supports the differences in absorbers' capture cross-sections as the main cause of the discrepancy.

The absorbers worth and flux depression overscoring obtained with deterministic methods can be explained also by the different angular treatment adopted, *i.e.*, continuous sampling in Serpent vs. P₁ in ECCO/ERANOS. Even though at full-core level a P₃ order of the flux was used in ERANOS, it inherited the physical information generated by ECCO, where cross-sections were calculated at the P₁ order. It is in fact well known that the P₁ approximation is acceptable for scattering-dominated (*i.e.*, non-absorbing) media, which is not the case for the absorbers or the other structures at the core boundary mentioned before. The ERANOS calculations were performed also at the P₁ order of the flux: the discrepancy with the reference P₃ flux order increases when the CR and/or SR are inserted, confirming that the angular treatment becomes fundamental when the system is less diffusive.

An intra-comparison among the ECCO cross-sections of the CR and SR absorbing bundles was performed calculating them with both 2D heterogeneous (reference) and homogeneous cell geometry models. The significant differences appearing at low energies demonstrated that the heterogeneous description is fundamental to properly take into account the spatial self-shielding effects. In the ALFRED fast spectrum core this discrepancy yields and increase of the shutdown systems performances of ~0.15÷0.55 % only in dependence of the CR and SR position.

The impact on the cross-sections of the energy treatment employed by MC and deterministic codes (continuous vs. multi-group) resulted to be very limited. However, it can be noticed that:

- the cross-sections values at 80 groups are surely more accurate for the description of the unresolved resonance region (in comparison with the 33-group ones);
- due to the continuous energy treatment, actually there are no significant differences between the Serpent results at 33 and 80 groups outside the unresolved resonance region;
- the ECCO cross-sections at 80 groups are slightly closer to the Serpent ones (than the 33group values) *e.g.*, for the fuel fission cross-sections at low energies;
- the energy and the angular effects are loosely coupled;
- the impact of the ECCO and Serpent geometry models (heterogeneous vs. homogeneous) in the less diffusive regions is decisively higher than the one due to energy refinement⁴.

It can be finally noticed that, in spite of significant differences in the computational burden associated to the two codes (about 12 hours for a fuel cell calculation and 1-2 hours for a non-fissile one in Serpent vs. less than 1 hour in ECCO for both), Serpent can be profitably employed as "cell code" for producing multi-group constants, provided that enough computational power is available. In addition to the higher model accuracy with respect to ECCO, Serpent also allows an easy and independent update of the nuclear data libraries, which can be produced converting the ENDF-6 format into the ACE one without too much effort.

⁴ In the fuel, the cross-sections at 80 groups yield a cell reactivity ~0.3% lower than the 33-group case, but the k_{eff} values are almost identical. Otherwise, a fuel cell homogeneous model yield k_{eff} value ~0.7% lower.



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Appendix A: Theoretical background for determistic analyses

A.1 Aim and rationale

This appendix describes the theoretical basis (from [23] and [24]) for the steady-state neutronic analyses carried out with deterministic methods. The major part of the mathematical equations discussed is focused on the calculation methods adopted for the creation of the macroscopic cross-sections representing every fissile and non-fissile core region. Afterwards, the exact relationship between these multi-group constants – here created by the ECCO cell code (\S 3) – and the ones used by ERANOS in full-core spatial calculations is examined in detail.

Several approximated methods have been developed to solve the Boltzmann transport equation, notably to what concerns the direction of neutron motion. The most popular and practical approach is represented by the S_N discrete ordinate method where the angular flux is discretised for the angle variable according to a finite number of directions. An alternative approach is the P_N method, which exploits a Legendre moments expansion for the angular flux. In both cases, the space and energy dependencies of the neutron flux are managed by discrete meshes.

In the ERANOS system, the multi-group constants at the P_N order are calculated with ECCO by solving the neutron transport equation for each cell with iterative methods, starting from the nuclear data evaluated in multi-group energy structures (*e.g.*, JEFF-3.1 library in this work) such as: the microscopic cross-sections, the scattering function (§A.2) and their variations with energy for all the isotopes and neutron reactions of interest. Then, the energy dependence of the neutron flux (and its angular Legendre components) can be calculated in order to evaluate the energy condensed and spatially homogenised macroscopic cross-sections.

In the following subsections, the calculation methodologies adopted by deterministic codes are described starting from the time-independent neutron transport equation in its P_N representation, where the neutron flux " $\phi(\mathbf{r}, \mathbf{\Omega}, E)$ " has to be evaluated (§A.2). Then, the multi-energy-group transport equation is introduced (§A.3) – based on the multi-group flux " $\phi_g(\mathbf{r}, \mathbf{\Omega})$ " – that is successively limited to the P₁ approximation adopted in this work (§A.4). The multi-group P₁ transport equations are described in detail for both fissile and non-fissile zones, together with their diffusion approximation and a brief recall of the one-group theory for homogeneous media.

As mentioned before, the analysis is focused on the mathematical basis adopted by cell codes to evaluate the multi-group constants of every core region (§A.5), in which the main goal is an accurate modelling of the cell geometry heterogeneity (" \mathbf{r} ") and of its energy ("E") representation (1968 groups for most of the nuclides in ECCO). As described in §3.2, the cross-sections are then homogenised in space and collapsed to 33 (or 80) energy groups before being used by ERANOS for the full-core analyses, here carried out with the variational nodal method [14-16].

For easiness, even if the "reference" cross-sections were calculated with heterogeneous geometry models for the most important core regions, the solution in fundamental mode of the multi-group diffusion equation is shown, together with the buckling definition for both fissile and non-fissile zones (§A.6). The adoption of the homogeneous geometry model allows an easier description of the ECCO equations at the first order, that can be solved with P_N and B_N calculation methodologies using consistent and inconsistent approximations (§A.7). The impact of the different methods on the cross-section values was examined and resulted to be almost negligible. Differently, the multi-group constants evaluated in the non-scattering-dominated media (e.g., CR and SR absorbing bundles) at low and intermediate energies with the "reference" heterogeneous cell geometry models differ significantly from the ones calculated with homogeneous models (§A.8). This result points out the importance of the correct simulation of the self-shielding effects that are not taken into account by homogeneous cell models, as well as the significant role of the angular flux distribution in less-diffusive media.



Finally, after a brief description of the P_N equations solved by ERANOS in the full-core analyses⁵ (§A.9), the relationship between the multi-group constants – calculated with ECCO and used by ERANOS – is examined in detail (§A.10). While the vectors and matrices are produced by ECCO at the P_1 order, the ERANOS cross-sections are retrieved in the P_0 transport (P_0), P_0 consistent (P_0 total) and P_1 approximations. In the "reference" full-core calculations, the P_1 order was used for the cross-sections and the P_3 moments for the energy-spatial distribution of the flux (see §6.1).

A.2 The time-independent transport equation

A.2.1 The P_N approximation

The time-independent transport equation in its integro-differential form for a one-dimensional (x) slab geometry can be written as:

$$\mu \frac{\mathrm{d}\phi(x,\mu,E)}{\mathrm{d}x} + \Sigma(x,E)\phi(x,\mu,E) =$$

= $\int \Sigma(x,E')f(x;E' \to E,\mu \quad ' \to \mu)\phi(x,\mu \quad ',E')\mathrm{d}E'\mathrm{d}\mu' \quad + Q(x,\mu,E)$
(A.1)

where:

- $(dx,d\mu,dE)$ is the infinitesimal control volume centred around (x,μ,E) ;
- " $\phi(x, \mu, E)$ " is the energy-dependent angular flux in position "x";
- the first term represents the neutron leakage;
- the last term "*Q*" is the source, that can be internal in fissile zones (*i.e.*, fissions) or external for not multiplying media;
- " μ " and " μ '" are the incoming and exiting directions (actually in a more general 2D or 3D geometry) of the neutrons (with energy "E'" and "E", respectively) whose interactions with the nuclei is represented by the scattering function "f";
- the total macroscopic cross-section " $\Sigma(x, E)$ " can be calculated from the microscopic ones " $\sigma^i(T(x), E)$ " (in units of barn) depending on the temperature "*T*" of each nuclide "*i*" as:

$$\Sigma(x, E) = \sum_{i} N_i \sigma^i(T(x), E) \qquad [cm^{-1}] \quad (A.2)$$

where " N_i " is the atomic density of the nuclides in the medium (in units of barn⁻¹ cm⁻¹).

By assuming that the angular variation of the scattering function depends only on the scattering angle (*i.e.*, isotropic medium with azimuthal symmetry in more general 2D and 3D geometries), " Σf " in (A.1) can expanded in a set of Legendre polynomials⁶ "P_n" depending only on the cosine of the scattering angle " μ ". In a 1D slab geometry it can be written as:

$$\Sigma(x, E')f(x; E' \to E, \mu) = \sum_{n=0}^{\infty} \frac{2n+1}{2} \Sigma_{sn}(x, E' \to E) P_n(\mu)$$
(A.3.a)

where the expansion coefficients " Σ_{sn} " (with n = 0, 1, 2...) are:

⁵ In which the main objective is the accurate description of the spatial "r" and angular " Ω " distribution of the flux within the core by adopting a broad energy structure (33 or 80 groups).

⁶ Spherical harmonics symmetrical around the rotation axis.



$$\Sigma_{sn}(x, E' \to E) = \int_{-1}^{1} \Sigma(x, E') f(x; E' \to E, \mu) P_n(\mu) d\mu.$$
(A.3.b)

The first term " Σ_{s0} " in (A.3.a) represents the isotropic events (as the inelastic scattering from heavy nuclides), while from the second one " Σ_{s1} " the angular dependence of the interaction events is taken into account (*e.g.*, elastic scattering).

The angular distribution of the neutron flux " ϕ " and source "Q" can also be expressed as an expansion on Legendre polynomials:

$$\phi(x,\mu,E) = \sum_{n=0}^{\infty} \frac{2n+1}{2} \phi_n(x,E) P_n(\mu) = \frac{1}{2} \phi_0 + \frac{3}{2} \mu \phi_1(x,E) + \cdots$$
 (A.3.c)

$$Q(x,\mu,E) = \sum_{n=0}^{\infty} \frac{2n+1}{2} Q_n(x,E) P_n(\mu) = \frac{1}{2} Q_0 + \frac{3}{2} \mu Q_1(x,E) + \cdots$$
(A.3.d)

where the nth moment of the flux and source are given by:

$$\phi_n(x, E) = \int_{-1}^{1} \phi(x, \mu, E) P_n(\mu) d\mu$$
 (A.3.e)

$$Q_n(x,E) = \int_{-1}^{1} Q(x,\mu,E) P_n(\mu) d\mu.$$
 (A.3.f)

By using the property of orthogonality of Legendre polynomials, the energy-dependent transport equation at the Nth order can be expressed by set of N+1 differential equations (for n = 0, 1, 2..., N) that is still equivalent to (A.1):

$$(n+1)\frac{\mathrm{d}\phi_{n+1}(x,E)}{\mathrm{d}x} + n\frac{\mathrm{d}\phi_{n-1}(x,E)}{\mathrm{d}x} + (2n+1)\Sigma(x,E)\phi_n(x,E) =$$

= $(2n+1)\int \Sigma_{sn}(x;E'\to E)\phi_n(x,E')\mathrm{d}E' + (2n+1)Q_n(x,E)$ (A.4)

where the terms with n>0 in the integral (for neutrons entering in collisions with energy E' and exiting with energy E) act as anisotropic terms (as the source terms $Q_1, Q_2 \dots$).

A.2.2 The P₁ approximation

The P_1 order approximation is obtained by considering n = 0 and 1 in (A.4) by imposing:

$$\phi_2(x, E) = 0 \tag{A.5.a}$$

Therefore, the system (A.4) is limited to a couple of equations:

$$\frac{d\phi_1(x,E)}{dx} + \Sigma(x,E)\phi_0(x,E) = \int \Sigma_{s0}(x,E' \to E) \phi_0(x,E') dE' + Q_0(x,E)$$
(A.5.b)

$$\frac{\mathrm{d}\phi_0(x,E)}{\mathrm{d}x} + 3\Sigma(x,E)\phi_1(x,E) = 3\int \Sigma_{s1}(x,E'\to E)\phi_1(x,E')\mathrm{d}E' + 3Q_1(x,E) \quad (A.5.c)$$

The P_1 approximation is valid for large systems (>> neutron mean free path) in which the angular flux is not significantly anisotropic and can be represented by the first two terms of Legendre polynomials.



A.2.3 The energy-dependent diffusion approximation

The P₁ order equations (A.5) can be approximated in a form leading to the energy-dependent diffusion theory⁷ by expressing the neutron current " ϕ_1 " through the Fick's law involving the diffusion coefficient "*D*" and the spatial gradient of the flux " ϕ_0 ":

$$\phi_1(x,E) = -D(x,E) \frac{\mathrm{d}\phi_0(x,E)}{\mathrm{d}x}$$
(A.6.a)

The equation (A.6.a) is equivalent to (A.5.c), assuming an energy-dependent diffusion coefficient defined as:

$$D(x, E) = \frac{1}{3 \Sigma_{tr}(x, E)} = \frac{1}{3 \left[\Sigma(x, E) - \frac{\int \Sigma_{S1}(x; E' \to E) \phi_1(x, E') dE'}{\phi_1(x, E)} \right]}$$
(A.6.b)

whose denominator in square brackets represents the energy-dependent transport cross-section " $\Sigma_{tr}(x, E)$ ", that is the total cross-section " Σ " with the so-called transport correction in which the scattering term of the first order is subtracted. Afterwards, the P₀ equation (A.5.b) can be written as:

$$-\frac{\mathrm{d}}{\mathrm{d}x} \left[D(x,E) \frac{\mathrm{d}\phi_0(x,E)}{\mathrm{d}x} \right] + \Sigma(x,E)\phi_0(x,E) =$$

= $\int \Sigma_{s0}(x,E' \to E) \phi_0(x,E') \mathrm{d}E' + Q_0(x,E)$ (A.6.c)

For the sake of easiness, the first moment of the source " Q_1 " has been neglected. Similar but a little more intricate equations can be retrieved by adding the term " $\frac{Q_1(x,E)}{\Sigma_{tr}(x,E)}$ " on the right side of the Fick's law approximation (A.6.a). In this case, the equation (A.6.c) could be written at the P₁ order through an energy-dependent diffusion coefficient involving the first moment of the source.

A.3 The multi-group transport equation

The energy-dependent equations in the linear system (A.4) can be expressed in a multi-group form – with "G" energy groups – without implying any restrictions on the energy-dependent cross-sections. For each energy group g ($E_g < E < E_{g-1}$), the macroscopic constants are represented by multi-group vectors (*e.g.*, $\Sigma_{c,g}(x)$ for capture events) and matrices for the differential cross-sections (*i.e.*; $E_{g'} \rightarrow E_g$ in scattering events). By replacing the integral over E' with a sum over all the energy groups g', the system (A.4) can be written at Nth order thorough the G(N+1) multi-group equations:

$$(n+1)\frac{\mathrm{d}\phi_{n+1,g}(x)}{\mathrm{d}x} + n\frac{\mathrm{d}\phi_{n-1,g}(x)}{\mathrm{d}x} + (2n+1)\Sigma_{n,g}(x)\phi_{n,g}(x) =$$

= $(2n+1)\Sigma_{g'=1}^{G}\Sigma_{sn,g'\to g}(x)\phi_{n,g'}(x) + (2n+1)Q_{n,g}(x)$ (A.7.a)

⁷ The diffusion theory is equivalent to the P₁ approximation only for time-independent problems with isotropic sources (fissions or external neutrons) and scattering events (*i.e.*, $Q_n = \Sigma_{sn} = 0$ for n>0).



where the nth moments of the neutron flux " $\phi_{n,g}$ " and of the source " $Q_{n,g}$ " are given by the expansion coefficients (A.3.c) and (A.3.d), respectively, integrated in each energy group g:

$$\phi_{n,g}(x) = \int_g \phi_n(x, E) dE$$
(A.7.b)

$$Q_{n,g}(x) = \int_g Q(x, E) dE.$$
 (A.7.c)

The system (A.7a) is still exact (from a theoretical point of view) and equivalent to the system (A.4) and to the transport equation (A.1). For each order "n", the moments of the multi-group cross-sections (vectors of G elements) are defined as:

$$\Sigma_{n,g}(x) = \frac{\int_g \Sigma(x,E)\phi_n(x,E)dE}{\phi_{n,g}(x)}$$
(A.7.d)

for the total cross-section (and similarly for the other reactions " Σ_{χ} "). Otherwise, the moments of the differential cross-sections (matrices of G x G elements) are defined as:

$$\Sigma_{sn,g' \to g}(x) = \frac{\int_{g'} \phi_n(x,E') \int_g \Sigma_{sn}(x,E' \to E) dE dE'}{\phi_{n,g}(x)}.$$
 (A.7.e)

where " $\Sigma_{sn,g' \to g}$ " are the nth order terms of the flux-averaged transfer cross-sections between group g' and g including the diagonal terms g' = g.

A.4 The multi-group P₁ approximation

In the multi-group form, the system of P_N equations (A.7.a) at the first order (P_1) becomes a system of 2G equations:

$$\frac{\mathrm{d}\phi_{1,g}(x)}{\mathrm{d}x} + \Sigma_{0,g}(x)\phi_{0,g}(x) = \sum_{g'=1}^{G} \Sigma_{s0,g'\to g}(x)\phi_{0,g'}(x) + Q_{0,g}(x)$$
(A.8.a)

$$\frac{\mathrm{d}\phi_{0,g}(x)}{\mathrm{d}x} + 3\Sigma_{1,g}(x)\phi_{1,g}(x) = 3\Sigma_{g'=1}^G \Sigma_{s1,g'\to g}(x)\phi_{1,g'}(x) + 3Q_{1,g}(x) \tag{A.8.b}$$

A.4.1 The multi-group P₁ approximation for fissile zones

In case of <u>fissile zones</u>, the source term "Q" due to fission neutrons can be assumed isotropic and included it in the 0th order term of the transfer cross-section (A.7.e) by defining:

$$\Sigma_{s0,g' \to g}(x) = \Sigma_{s0,g' \to g}(x) + \upsilon \Sigma_{f,g' \to g}(x)$$
(A.9.a)

where " $v\Sigma_{f,g' \to g}(x)$ " is the rate at which fission neutrons appear in group g as a result of fissions brought by neutrons of the group g'. The cross-section " $\Sigma_{s0,g' \to g}(x)$ " accounts for all other transfers from group g' to group g, in which the subscript "s" suggests scattering but it includes also the (n, xn) reactions.

By adopting the definition (A.9.a), the multi-group P₁ equations (A.8) for fissile media become:

$$\frac{\mathrm{d}\phi_{1,g}(x)}{\mathrm{d}x} + \Sigma_{0,g}(x)\phi_{0,g}(x) = \sum_{g'=1}^{G} \Sigma_{s0,g'\to g}(x)\phi_{0,g'}(x) + \frac{1}{k} \sum_{g'=1}^{G} \nu \Sigma_{f,g'\to g}(x)\phi_{0,g'}$$
(A.9.b)



$$\frac{\mathrm{d}\phi_{0,g}(x)}{\mathrm{d}x} + 3\Sigma_{1,g}(x)\phi_{1,g}(x) = 3\sum_{g'=1}^{G}\Sigma_{s1,g'\to g}(x)\phi_{1,g'}(x) \tag{A.9.c}$$

where:

- as usual, an auxiliary reactivity eigenvalue "k" is introduced (*i.e.*, " ν/k " instead of " ν ");
- the scattering term at the first order " $\Sigma_{s1,g' \to g}(x)$ " remains identical (as well as for n>1), that is by assuming an isotropic angular distribution of fission neutrons.

A.4.2 The multi-group P₁ approximation for non-fissile zones

In case of <u>non-multiplying media</u>, the " $\Sigma_{sn,g' \to g}(x)$ " terms maintain their original meaning for every "n", that are the moments of the differential cross-section accounting for all transfers from g' to g (*i.e.*, elastic / inelastic scattering and (n, xn) reactions). The multi-group P₁ equations in presence of an external source "Q" (the nearest fissile region in ECCO calculations [3]) remain formally identical to (A.8):

$$\frac{\mathrm{d}\phi_{1,g}(x)}{\mathrm{d}x} + \Sigma_{0,g}(x)\phi_{0,g}(x) = \sum_{g'=1}^{G} \Sigma_{s0,g'\to g}(x)\phi_{0,g'}(x) + Q_{0,g}(x) \tag{A.10.a}$$

$$\frac{\mathrm{d}\phi_{0,g}(x)}{\mathrm{d}x} + 3\Sigma_{1,g}(x)\phi_{1,g}(x) = 3\sum_{g'=1}^{G}\Sigma_{s1,g'\to g}(x)\phi_{1,g'}(x) + Q_{1,g}(x).$$
(A.10.b)

A.4.3 The multi-group diffusion approximation

Similarly to §A.2, the multi-group-energy P₁ equations can be approximated in a form leading to a multi-group diffusion theory. In this case, the multi-group neutron current " $\phi_{1,g}$ " is expressed in the form of a Fick's law through a multi-group diffusion coefficient " D_a ":

$$\phi_{1,g}(x) = -D_g(x) \frac{\mathrm{d}\phi_{0,g}(x)}{\mathrm{d}x}.$$
 (A.11.a)

Equation (A.11.a) is still equivalent to (A.9.c) and (A.10.b) P_1 equations for the fissile and non-fissile zones, respectively, by defining a multi-group diffusion coefficient:

$$D_g(x) = \frac{1}{3\left[\sum_{1,g(x)} - \frac{\sum_{g'=1}^{G} \sum_{s1,g' \to g(x)} \phi_{1,g'(x)}}{\phi_{1,g(x)}}\right]}.$$
 (A.11.b)

It must be noticed that:

- for easiness, as in §A.2 the external source in non-multiplying media is assumed isotropic (Q_{1,q} = 0);
- the terms " $\Sigma_{s1,q' \rightarrow q}(x)$ " are identical for both fissile and non-fissile zones;
- the multi-group transport cross section is defined as:

$$\Sigma_{tr,g}(x) = \Sigma_{1,g}(x) - \frac{\Sigma_{g'=1}^G \Sigma_{s1,g' \to g}(x) \phi_{1,g'}(x)}{\phi_{1,g}(x)}.$$
(A.11.c)



By substituting the Fick's law approximation (A.11.a) in the P_0 equation (A.9.b), the multi-group diffusion equation for the <u>fissile zones</u> can be written as:

$$-\frac{\mathrm{d}}{\mathrm{d}x} \left[D_g(x) \frac{\mathrm{d}\phi_{0,g}(x)}{\mathrm{d}x} \right] + \Sigma_{0,g}(x)\phi_0(x) =$$

= $\sum_{g'=1}^G \Sigma_{s0,g'\to g}(x) \phi_{0,g'}(x) + \frac{1}{k} \sum_{g'=1}^G \nu \Sigma_{f,g'\to g}(x) \phi_{0,g'}(x)$ (A.11.d)

Similarly, by substituting it in the P_0 equation (A.10.a), the multi-group diffusion equation for the <u>non-fissile zones</u> with an isotropic external source becomes:

$$-\frac{\mathrm{d}}{\mathrm{d}x} \left[D_g(x) \frac{\mathrm{d}\phi_{0,g}(x)}{\mathrm{d}x} \right] + \Sigma_{0,g}(x)\phi_0(x) = \sum_{g'=1}^G \Sigma_{s0,g'\to g}(x)\phi_{0,g'}(x) + Q_{0,g}(x) \quad (A.11.e)$$

A.4.4 The one-group diffusion approximation in homogeneous fissile media

By assuming a one-group approximation (*i.e.*, cross-sections behaviour constant with energy), the multi-group diffusion equations (A.11.d) in a <u>homogeneous fissile medium</u> reduce to:

$$-D\frac{d^{2}\phi_{0}}{dx^{2}} + \Sigma_{0}\phi_{0} = \Sigma_{s0}\phi_{0} + \frac{1}{k}\upsilon\Sigma_{f}\phi_{0}$$
(A.12.a)

where the diffusion coefficient does not vary with "x" (*i.e.*, homogeneous). Adopting the definition of the absorption cross-section, that is the total minus the scattering one at the 0th order:

$$\Sigma_a = \Sigma_0 - \Sigma_{s0} \tag{A.12.b}$$

equation (A.12.a) becomes:

$$D\frac{\mathrm{d}^2\phi_0}{\mathrm{d}x} - \Sigma_a\phi_0 + \frac{1}{k}\upsilon\Sigma_f\phi_0 = 0 \tag{A.12.c}$$

With the definition of the material bucking " B^2 ":

$$B^{2} = \frac{1}{D} \left(\frac{v}{k} \Sigma_{f} - \Sigma_{a} \right)$$
(A.12.d)

equation (A.12.c) can be rewritten as an eigenvalue problem:

$$\nabla^2 \phi = -B^2 \phi \tag{A.12.e}$$

where the buckling represents the eigenvalue of the wave equation with the boundary condition of zero flux at the extrapolated boundary of the system. This equation can be solved for the constant "k" (*i.e.*, multiplication coefficient) yielding:

$$k = \frac{\upsilon \Sigma_f}{DB^2 + \Sigma_a} \tag{A.12.f}$$

where " $D B^2$ " is the leakage term. The equation (A.12.e) is solved by ECCO iterating on the " B^2 " buckling value expressed by (A.12.d) (equal for all energy groups in the multi-group case) in order to obtain the criticality condition *(i.e., k = 1 expressing the equivalence between the geometrical and material buckling*). From (A.12.f) it can be clearly seen that the criticality represents the equilibrium between the neutrons production (numerator) and their disappearance by absorption and leakage (denominator). Consequently, the macroscopic cross-sections representing the fuel cell are calculated not in an infinite lattice (as described by the ECCO 2D heterogeneous geometry models), but in a condition simulating a critical reactor.



A.5 Evaluation of the P_N multi-group cross-sections by cell codes

A.5.1 Cross-sections evaluation in the multi-group P_N approximation

The main problem for the treatment of realistic, energy-dependent situations by means of multigroup methods is represented by the consistent determination of the multi-group constants, as done by the ECCO cell code [3]. It has become a common practice to adopt the spherical harmonics method by introducing the expansion of the scattering cross-sections in Legendre polynomials. Once this has been done, the group constants are similar to those used in the multi-group treatment described in §A.3-4.

Starting from the general transport equation (A.1) and replacing both the cross-section and flux values with their expansion coefficients (A.3.a) and (A.3.c) only in the right side, the energy-dependent transport equation in plane geometry becomes:

$$\mu \frac{\mathrm{d}\phi(x,\mu,E)}{\mathrm{d}x} + \Sigma(x,E)\phi(x,\mu,E) =$$

= $\sum_{n} \frac{2n+1}{2} P_n(\mu) \int \phi_n(x,E') \Sigma_{sn}(x,E' \to E) \mathrm{d}E' + Q(x,\mu,E)$ (A.13.a)

By expanding the angular flux in the second term on the left side of (A.13.a) as a sum of Legendre polynomials (A.3.c) and by integrating them in each energy group g (with $E_{g-1} < E < E_g$), equation (A.13.a) for each group becomes:

$$\mu \frac{\mathrm{d}\phi_{g}(x,\mu)}{\mathrm{d}x} + \sum_{n} \frac{2n+1}{2} P_{n}(\mu)\phi_{n,g}(x)\Sigma_{n,g}(x) = \sum_{n} \frac{2n+1}{2} P_{n}(\mu)\sum_{g'=1}^{G} \Sigma_{sn,g'\to g}(x)\phi_{n,g'}(x) + Q_{g}(x,\mu)$$
(A.13.b)

where:

- " $\Sigma_{n,g}(x)$ " and " $\Sigma_{sn,g' \to g}(x)$ " are the moments of flux-averaged total and differential crosssections defined in (A.7.d) and (A.7.e), respectively;
- the multi-group angular flux in each group:

$$\phi_g(x,\mu) = \int_g \phi(x,\mu,E) dE$$
 (A.13.c)

was also expanded in a series of Legendre polynomials with coefficients " $\phi_{n,g}(x)$ ":

$$\phi_g(x) = \sum_{n=0}^{\infty} \frac{2n+1}{2} \phi_{n,g}(x,\mu) P_n(\mu)$$
(A.13.d)

by the exception of the leakage term (*i.e.*, the first one on the left side of (A.13.b) with the spatial derivate of the multi-group flux).

Now, by moving on the right side the second term of the left one, the multi-group transport equation (A.13.b) becomes:

$$\mu \frac{\mathrm{d}\phi_g(x,\mu)}{\mathrm{d}x} = \sum_n \frac{2n+1}{2} P_n(\mu) \sum_{g'} \phi_{n,g'}(x) \left[\sum_{n,g' \to g} (x) - \sum_{n,g} (x) \delta_{g,g'} \right] + Q_g(x,\mu) (A.14)$$

where " $\delta_{q,q'}$ " is the Kronecker delta.

Then, if the product " $\Sigma_g(x) \phi_g(x,\mu)$ " is added to both sides of (A.14) with " $\phi_g(x,\mu)$ " expanded as a sum of Legendre polynomials (A.13.d) only on the right side, the latter equation becomes:



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$$\mu \frac{\mathrm{d}\phi_{g}(x,\mu)}{\mathrm{d}x} + \Sigma_{g}(x)\phi_{g}(x,\mu) = \sum_{n} \frac{2n+1}{2} P_{n}(\mu) \sum_{g'} \phi_{n,g'}(x) \{\Sigma_{sn,g' \to g}(x) + [\Sigma_{g}(x) - \Sigma_{n,g}(x)]\delta_{g,g'}\} + Q_{g}(x,\mu)$$
(A.15)

Provided that estimates of " $\phi_{n,g}(x)$ " are available, and using them to evaluate " $\Sigma_{n,g}(x)$ " and " $\Sigma_{sn,g' \to g}(x)$ " with (A.7.d) and (A.7.e), all the terms in equation (A.15) become known, by the exception of the multi-group total cross-section " $\Sigma_g(x)$ " which is still undetermined (and for this reason here written in red).

It results evident that the form of equation (A.15) is identical to (A.14): therefore, the group constants can be chosen so that the corresponding terms in the two equations are equal. The transfer cross-sections " $\Sigma_{sn,g' \to g}(x)$ " result to be equal for g' \neq g, while for g' = g the only necessary constraint is that the diagonal elements of the transfer matrix become:

$$\Sigma_{sn,g\to g}^*(x) = \Sigma_{sn,g\to g}(x) + \Sigma_g(x) - \Sigma_{n,g}(x)$$
(A.16)

that are the transport-corrected self-scattering cross-sections. As mentioned before, by solving equation (A.15) the terms " $\Sigma_{sn,g\to g}(x)$ " and " $\Sigma_{n,g}(x)$ " are known, but the multi-group total cross-section " $\Sigma_g(x)$ " is still unknown. Nevertheless, a univocal solution can be obtained provided the latter is chosen to satisfy equation (A.16).

A.5.2 The consistent P_N approximation

Actually, the sum over "n" in equation (A.15) will be terminated after some finite number, *i.e.*, N+1 in the P_N approximation. Consequently, there are only G(N+1) equations for determining the G(N+1) values of the transfer cross-section " $\Sigma_{sn,g' \to g}(x)$ " and the G values of the total cross-section " $\Sigma_{a}(x)$ ". Therefore, G extra conditions must be imposed.

The default option in the ECCO cell code developed for fast reactor analyses is the <u>consistent</u> $\underline{P}_{\underline{N}}$ <u>approximation</u> in which it is imposed that the unknown " $\Sigma_g(x)$ " coincides with the flux-averaged total cross-section given by (A.7.d) at the 0th order:

$$\Sigma_{g}(x) = \Sigma_{0,g}(x) = \frac{\int_{g} \Sigma(x,E)\phi_{0}(x,E)dE}{\phi_{0,g}(x)}$$
(A.17)

The name consistent P_N approximation is used since, by the choice expressed in (A.17), the integral in equation (A.15) over all angles (through their Legendre polynomials series) results identical to the first term of the multi-group P_N equations. Therefore, the definition (A.17) for " Σ_g " is consistent with the P_N equations and for this reason is called the consistent P_N approximation. To determine the cross-section constants from the multi-group transport equations, the values of " $\Sigma_{n,g}$ " and " $\Sigma_{sn,g' \to g}(x)$ " are obtained from equations (A.7.d) and (A.7.e). Consequently, the P_N consistent approximation applied to equation (A.15) for cell calculations yields:

$$\mu \frac{\mathrm{d}\phi_g(x,\mu)}{\mathrm{d}x} + \Sigma_{0,g}(x)\phi_g(x,\mu) = \sum_n \frac{2n+1}{2} P_n(\mu) \sum_{g'} \phi_{n,g'}(x) \{ \Sigma_{sn,g' \to g}(x) + [\Sigma_{0,g}(x) - \Sigma_{n,g}(x)] \delta_{g,g'} \} + Q_g(x,\mu)$$
(A.18)

in which the G(N+1) unknown " $\Sigma_{sn,g' \rightarrow g}(x)$ " of equation (A.16) can be derived from the system (A.18) of G(N+1) equations.



A.5.3 The consistent P1 approximation

By expanding in (A.18) also the flux " $\phi_g(x,\mu)$ " on the left side and the source " $Q_g(x,\mu)$ " on the right one as sum of Legendre polynomials function of " μ ", the system of equations (A.18) at the P₁ order becomes:

$$\frac{d\phi_1(g)}{dx} + \Sigma_0(g)\phi_0(g) = \sum_{g'=1}^G \Sigma_{s0}(g' \to g) \phi_0(g') + Q_0(g)$$
(A.19.a)

$$\frac{d\phi_0(g)}{dx} + 3\Sigma_0(g)\phi_1(g) = 3\sum_{g'=1}^G \phi_1(g') \left\{ \Sigma_{s1}(g' \to g) + [\Sigma_0(g) - \Sigma_1(g)]\delta_{g,g'} \right\} + 3Q_1(g)$$
(A.19.b)

where the dependence from the spatial coordinate "x" was assumed implicit, while the dependence from the energy group was made explicit putting it in round brackets.

A.5.4 The consistent P₁ approximation for fissile zones

By adopting the definition used in A.4, the P₁ transport equations as solved by cell codes for fissile zones (*i.e.*, isotropic fissions) become:

$$\frac{\mathrm{d}\phi_1(g)}{\mathrm{d}x} + \Sigma_0(g)\phi_0(g) = \sum_{g'=1}^G \left[\Sigma_{s0}(g' \to g) + \frac{v}{k} \Sigma_f(g' \to g) \right] \phi_0(g') \tag{A.20.a}$$

$$\frac{\mathrm{d}\phi_0(g)}{\mathrm{d}x} + 3\Sigma_0(g)\phi_1(g) = 3\sum_{g'=1}^G \phi_1(g') \left\{ \Sigma_{s1}(g' \to g) + [\Sigma_0(g) - \Sigma_1(g)]\delta_{g,g'} \right\}$$
(A.20.b)

where an eingenvalue search for k equal to 1 is usually adopted to simulate the fuel cell in a reactor.

A.5.5 The consistent P₁ approximation for non-fissile zones

Otherwise, the P₁ transport equations solved by ECCO for non-multiplying media with an anisotropic external source (*i.e.*, $Q_1 \neq 0$) become:

$$\frac{\mathrm{d}\phi_1(g)}{\mathrm{d}x} + \Sigma_0(g)\phi_0(g) = \sum_{g'=1}^G \Sigma_{g0}(g' \to g)\phi_0(g) + Q_0(g)$$
(A.21.a)

$$\frac{\mathrm{d}\phi_0(g)}{\mathrm{d}x} + 3\Sigma_0(g)\phi_1(g) = 3\sum_{g'=1}^G \phi_1(g') \left\{ \Sigma_{s1}(g' \to g) + [\Sigma_0(g) - \Sigma_1(g)]\delta_{g,g'} \right\} + 3Q_1(g)$$
(A.21.b)

In both fissile (A.20) and non-fissile (A.21) equations, the 0th and 1st terms " $\Sigma_{s0}(g' \rightarrow g)$ " and " $\Sigma_{s1}(g' \rightarrow g)$ " represent the isotropic and anisotropic components of the transfer matrix, respectively, that takes into account the (elastic and inelastic) scattering and (n,xn) reactions.

A.6 The fundamental mode in the multi-group diffusion equation

For calculations aimed to describe physical phenomena with a fine group energy spectrum, a spatial trend for the flux of exponential type (for non-multiplying media) or sinusoidal one (for multiplying media) may roughly represent the effect of leakages in <u>homogeneous media</u>. In both cases it can be assumed that the angular flux (and hence the multi-group flux moments) can be described in fundamental mode by:

$$\phi_n(x,g) = \operatorname{Re}[\phi_n(g)e^{-iBx}]$$
(A.23.a)

where "Re" means the real part, the term "B" is the square root of the geometrical bucking " B^2 " and it was assumed that the spatial variation of the flux moments is independent from energy (and hence from the group "g").



To easily understand the " B^2 " physical meaning, it is useful to recall the multi-group diffusion equations (A.11.d) and (A.11.e) (for fissile and non-fissile zones, respectively) which contain the first order flux term (describing the leakage). In fundamental mode the latter can be written as:

$$-\frac{d}{dx}\left[D(g)\frac{d\phi_0(g)}{dx}\right] = -\frac{dD(g)}{dx}\frac{d\phi_0(g)}{dx} - D(g)\frac{d^2\phi_0(g)}{dx^2} = D(g)B^2\phi_0(g)e^{-iBx}$$
(A.23.b)

where:

- as in §A.5, and differently from (A.11.d) and (A.11.e), the flux "φ₀" dependence from the spatial coordinate "x" was assumed implicit (and it was assumed explicit in brackets the dependence from the energy group);
- for the <u>fissile zones</u>: the buckling " B^2 " is positive, its square root is real and the exponent in (A.23.b) is imaginary yielding a flux sinusoidal behaviour with x;
- for the <u>non-fissile zones</u>: the buckling " B^2 " is negative, its square root is imaginary and the exponent in (A.23.b) is negative yielding a flux exponential behaviour with x.

By assuming the fundamental mode (A.23.a) and dividing each term by " e^{-iBx} " the multi-group diffusion equation (A.11.d) for <u>fissile zones</u> becomes:

$$D(g)B^{2}\phi_{0}(g) + \Sigma_{0}(g)\phi_{0}(g) =$$

= $\sum_{g'=1}^{G} \Sigma_{s0}(g' \to g)\phi_{0}(g) + \frac{1}{k} \sum_{g'=1}^{G} v\Sigma_{f}(g' \to g)\phi_{0}(g)$ (A.24.a)

In case of <u>non-multiplying media</u>, the multi-group diffusion equation (A.11.e) in fundamental mode becomes:

$$D(g)B^{2}\phi_{0}(g) + \Sigma_{0}(g)\phi_{0}(g) = \sum_{g'=1}^{G} \Sigma_{s0}(g' \to g)\phi_{0}(g) + Q_{0}(g)$$
(A.24.b)

Differently from the fissile zones (see §A.4.4), the bucking is imposed by the ECCO code through a semi-empirical formula [3]:

$$B^{2} = \frac{5}{8} \left(\frac{\pi}{h}\right)^{2}$$
(A.24.c)

where "h" is the typical dimension of the cell considered (*i.e.*, the height, for axial regions above and below the fuel, and the thickness for the radial zones). By assuming the fundamental mode (A.23.a) for the flux and by extending the previous concepts to the ECCO P₁ multi-group approximation, equations (A.20) and (A.21) correspond to a system of 2G equations in which:

- for the <u>fissile zones</u>, in (A.20) there is a buckling " B^2 " search in order to obtain k = 1 (for a critical reactor, or lower for an Acceleration Driven System);
- for the <u>non-fissile zones</u>, in (A.21) the buckling " B^2 " is imposed through the geometrical dimension of the cell by equation (A.24.c).

For the fuel cell zones, the <u>average fission spectrum</u> in its multi-group form " $\chi(g)$ " (*i.e.*, fraction of fission neutrons in the group g) is obtained from the one " $\chi(g)_i$ " of each fissionable nuclide "i" with the following relation:

$$\chi(g) = \frac{\sum_{i} \chi(g)_{i} \sum_{g'=1}^{G} \nu \sigma_{f,i}(g') N_{i} \phi_{0}(g')}{\sum_{g'=1}^{G} \nu \Sigma_{f}(g') \phi_{0}(g')}$$
(A.25)

where " $\phi_0(g)$ " is the multi-group flux of the cell calculations (A.24.a) stored for every medium, " N_i " is the atomic density of the nuclide "i", " $\sigma_{f,i}(g')$ " its mult-group microscopic fission crosssection and " $\nu(g)$ " the number of neutrons with energy E_g emitted by fission. The macroscopic fission term " Σ_f " in denominator is derived from the microscopic one through the relation (A.2).



A.7 The ECCO P_N solutions for homogeneous media

A.7.1 The P_N consistent solution

By adopting the fundamental mode for the multi-group flux:

$$\phi_g(x,\mu) = \operatorname{Re}[\phi_g(\mu)e^{-iBx}]$$
(A.26.a)

the transport equation (A.1) to be solved in 1D geometries for each energy group g can be written as:

$$[\Sigma - iB\mu]\phi_g(\mu) = \int \Sigma_{s,g' \to g}(\mu' \to \mu)\phi_g(\mu')d\mu' + Q_g(\mu)$$
(A.26.b)

By expanding the angular flux " $\phi_g(\mu)$ " and the scattering functions in series of Legendre polynomials, and projecting the resulting equations on each polynomial, the orthogonality rule leads to an infinite system of algebraic equations. By the <u>P₁ consistent</u> approximation it reduces to a couple of equations for each group g:

$$\Sigma_{0,g}\phi_{0,g} - iB\phi_{1,g} = \sum_{g'=1}^{G} \Sigma_{s0,g' \to g}\phi_{0,g'} + Q_{0,g}$$
(A.27.a)

$$\Sigma_{1,g}\phi_{1,g} - \frac{\iota_B}{3}\phi_{0,g} = \sum_{g'=1}^G \Sigma_{s1,g'\to g}\phi_{1,g'} + Q_{1,g}$$
(A.27.b)

It has to be remarked that:

- in the <u>non-fissile zones</u>, the two source terms "Q_{1-2,g}" are obtained from the flux and current spectra coming from the nearest fissile zone (loaded with the "SUBCRITICAL FLUXB" instruction in ECCO; §D.2);
- in <u>fissile zones</u>, the source term " Q_0 " is included in the scattering one (as done in (A.9.a)) and then both the " Q_0 " and " Q_1 " terms vanish (*i.e.*, isotropic fissions).

It can be further noticed that at higher orders in fissile zones, the flux moments are obtained with the recurrence relation:

$$\phi_{n,g} = -\frac{n}{2n+1} i \frac{B}{A_{n,g}} \phi_{n-1,g} \qquad \text{(for n >1)} \tag{A.27.c}$$

in which the transport-like cross-sections " A_n " are given by the continued fraction:

$$A_{n,g} = b_{n-1,g} + \frac{a_n}{b_{n,g} + \frac{a_{n+1}}{b_{n+1,g} + \dots}}$$
(A.27.d)

and the coefficients "a" and "b" are:

$$a_n = \frac{(n+1)^2 B^2}{(2n+1)(2n+3)} \tag{A.27.e}$$

$$b_{0,g} = \Sigma_{1,g} \tag{A.27.f}$$

$$b_{n,g} = \Sigma_{1,g} - \Sigma_{s*,n+1,g}$$
(A.27.g)

being " $\Sigma_{s*,n+1}$ " the transport-corrected self-scattering cross-section as in (A.16):

$$\Sigma_{sn,g\to g}^* = \Sigma_{sn,g\to g} + \Sigma_{1,g} - \Sigma_{n,g}$$
(A.27.h)

where the " $\Sigma_{sn,g\to g}$ " terms are the within group scattering terms at nth order, " Σ_1 " is the currentweighed total cross-section (*i.e.*, first order) and " Σ_n " is the nth flux moment " ϕ_n " weighed one.



A.7.2 The P_N inconsistent solution

The faster inconsistent solution is obtained with the further assumption of extended transport approximation:

$$\sum_{g'=1}^{G} \sum_{sn,g' \to g} \phi_{n,g'} = \sum_{sn,g} \phi_{n,g}$$
(A.28.a)

that simplifies the system of equations (A.27.a-b) yielding the P_1 inconsistent solving method.

In <u>fissile zones</u> the terms with n>1 are identical to the continued fractions (A.27.d) by the exception of the coefficient " b_0 " containing a scattering diagonal term for the current weighted total cross-section:

$$b_{0,g} = \Sigma_1 - \Sigma_{s0,g \to g}^* + 1 \tag{A.28.b}$$

with " $\Sigma_{s0,a \rightarrow a}^*$ " expressed through equation (A.27.h).

A.7.3 The B_N method

The B_N method is quite similar to the P_N one. It consists again in an expansion in Legendre polynomials, but the general equation (A.26.b) is first divided by the term " $\Sigma - iB\mu$ " before being projected. By performing the scalar product on " $P_n(\mu)$ " and dividing both sides by " $\Sigma - iB\mu$ ", (A.26.b) can be rewritten as:

$$\phi(E,\mu) = \frac{1}{\Sigma(E) - iB\mu} \sum_{n} \frac{2n+1}{4\pi} P_n(\mu) \int \Sigma_{sn}(E' \to E) \phi_n(E') dE' + \frac{1}{4\pi} \frac{Q_0(E)}{\Sigma(E) - iB\mu}$$
(A.29.a)

By introducing the coefficients " $A_{l,n}(z)$ " (that are new functions to be calculated depending on the Legendre polynomials):

$$A_{l,n}(z) = \frac{1}{2} \int_{-1}^{1} \frac{P_l(\mu) P_n(\mu)}{1 - iz\mu} d\mu$$
(A.29.b)

after some passages the previous equations (A.29.a) become:

$$\Sigma(E)\phi_l(E) = \sum_{n=0}^{\infty} (2n+1)A_{l,n}\left(\frac{B}{\Sigma(E)}\right) \int \Sigma_{sn}(E' \to E)\phi_n(E')dE' + A_{l,0}\left(\frac{B}{\Sigma(E)}\right) Q_0(E) \quad (A.29.c)$$

The functions " $A_{l,n}$ " satisfy the recurrence condition:

$$\frac{1}{iz}(2n+1)A_{l,n}(z) - (n+1)A_{l,n+1}(z) - lA_{l,n-1}(z) = \frac{\delta_{l,n}}{iz}$$
(A.29.d)

and it is:

$$A_{l,n}(z) = A_{n,l}(z)$$
 $A_{0,0}(z) = \frac{1}{z} \operatorname{arctg}(z)$ (A.29.e)

$$A_{0,1}(z) = A_{1,0}(z) = \frac{1}{iz} \left[A_{0,0}(z) - 1 \right] \qquad A_{1,1}(z) = \frac{1}{iz} A_{1,0}(z) \quad (A.29.f)$$

The B_N method approximation consists in truncating the system of equations at the Nth order (and beyond) by imposing the scattering source vanishes. The resulting <u>consistent B₁</u> system is quite similar to (A.27.a) and (A.27.b). In the latter, the current-weighted total cross-section " Σ_1 " for each energy group g is replaced by " $\gamma \Sigma_1$ ", where:



$$\gamma = \frac{\frac{B}{\Sigma_{1}} \operatorname{arctg}\left(\frac{B}{\Sigma_{1}}\right)}{3\left[1 - \frac{\Sigma_{1}}{B} \operatorname{arctg}\left(\frac{\Sigma_{1}}{B}\right)\right]}$$
(A.29.h)

In <u>fissile zones</u>, the coefficients " b_n " at the Nth order of equations (A.27.f-g) are now defined as:

$$b_n = \Sigma_1 - \frac{2}{3} |B| \operatorname{Rleg}(\Sigma_1, B^2, N)$$
 (n=0 and N=1) (A.29.i)

$$b_n = \Sigma_1 - \Sigma_{s*,n+1}$$
 (n < N-1) (A.29.1)

$$b_n = \Sigma_1 - \Sigma_{s*,n+1} - \frac{N+1}{2N+1} \operatorname{Rleg}(\Sigma_1, B^2, N)$$
 (n= N-1) (A.29.m)

where "Rleg" are the ratios of the Legendre functions of the second kind. Similarly to the P_N case, by applying the extended transport approximation (A.28.a) the simplified and faster inconsistent B_N solution is obtained.

As in the P_N case, the B_N (consistent and inconsistent) approximations consist again in truncating at "n = N" the system of infinite equations thus obtained. It can be noted that:

- this occurs putting $\Sigma_{sn}(E' \rightarrow E) = 0$ for n > N;
- the B_N equations converge more rapidly than the corresponding P_N ones. For instance, in the case of isotropic scattering, an "exact" expression is obtained for "φ₀" and also the higher order coefficients can be obtained exactly;
- it is foreseeable that also for anisotropic scattering the process converges more rapidly.



A.8 Impact of the different ECCO calculation options in the ALFRED case

The ECCO calculation route briefly described in §3.2 was adopted to produce the "reference" macroscopic cross-sections. The homogenised multi-group constants are derived as shown in the previous sections of this appendix, by generalising the equation of homogeneous media for the ECCO 2D heterogeneous geometry models with weighted averages on the different volumes of the cell regions. The main features of the ECCO calculation methodology (whose input decks are reported in Appendix D) can be summarised as follows.

- For fissile zones, there is a buckling "B²" search in order to obtain a unitary k value (see (A.12.f)) for the cell (ECCO instruction "BSEARCH 1.0", so to simulate a critical reactor).
- For both fissile and non-fissile zones:
 - it starts with a 172 energy-group structure and proceeds with the calculation scheme indicated in Fig. 3.1 by collapsing the computed cross-sections in a 33 energy-group one after the passage through 1968 groups for most of the nuclides;
 - it computes the cross-sections at the first order of the Legendre polynomials for the scattering angle (*i.e.*, isotropic media) with the P₁ consistent calculation option.
- For the non-fissile zones:
 - it calculates the cross-sections starting with the flux and current spectra of the nearest fissile region and spatial-uniformly distributed within the zone;
 - it simulates accurately the spatial self-shielding effect by introducing an additional term to the computed cross-sections to consider the neutrons coming from fuel and not shielded in the region examined. The so-called self-shielding "DB²" term is added, where "D" is the diffusion coefficient and "B²" the value of the geometrical buckling driving the leakage, estimated by the semi-empirical formula (A.24.c) involving a representative dimension of the zone examined. As reported in Appendix D, this calculation method is indicated by the "SELF SHIELDING DBBSH" instruction in ECCO.

One of the goals of this work was also to verify whether different ECCO calculation options could produce significant differences in the values of the cross-sections created. For this purpose:

- in all zones (fissile and non-fissile):
 - an alternative route to the one indicated in Fig. 3.1 was explored, by starting with 33 energy groups (instead of 172) and then, as in the reference case, the cross-sections are collapsed at 33 groups after the passage through 1968 groups;
 - another alternative route was implemented starting from the usual 172 energy-group structure and collapsing the computed cross-sections in an 80 energy-group structure after the passage through 1968 groups;
 - the B₁ calculation option was adopted, with the reference 172-1968-33 energy groups treatment (as described in §A.7, while in the P_N method the *n*+1 moment of the flux ϕ_n is imposed equal to zero, in the B_N method all the scattering sources are assumed to be zero above the nth moment, leading to a simplified relationship between ϕ_n and ϕ_{n+1} through a Legendre function of the second kind).
- in the non-fissile zones (see §D.2):
 - the additional spatial self-shielding term was not added to the computed cross-sections (*i.e.*, SELF SHIELDING NODBBSH instruction in ECCO);
 - instead of the utilisation of the (flux and current) spectrum evaluated by ECCO in the (nearest) fissile region, the fuel spectrum evaluated by Serpent at 33 energy groups in the same zone was introduced "externally";



in the fuel and the absorbing parts of CR and SR bundles (*i.e.*, B₄C pins), a homogeneous cell description was adopted in order to verify the impact of self-shielding effects (that should be reproduced by the ECCO 2D heterogeneous geometry model of the cells).

Here in the following it is shown an intra-comparison among the ECCO cross-sections obtained with different calculation methods (anyway, most of them led to very similar values) and, in some cases, their confrontation with the Serpent results obtained with the most accurate 3D FC heterogeneous model. Differently from Figs 5.1-5.3 where the values were reported in their "correct" histogram form, for easiness the following graphs are reported in a "punctual form" - with the multigroup cross-section values in correspondence of the upper energy limits - as they come from the codes output.

Figs. A.1 and A.2 show the normalised flux and current spectra evaluated by ECCO in the inner (FINN) and outer (FOUT) fuel cells, respectively, compared with the corresponding Serpent ones obtained with the 3D FC heterogeneous model (see §4.2). The ECCO values were evaluated with a 2D heterogeneous geometry in three different ways: two at 33 energy groups, obtained starting from 172 groups (reference) and 33 groups (and then collapsing to 33 after the passage through 1968 groups) and one at 80 groups (starting from 172, and then collapsing to 80 after the passage through 1968 groups). It results evident that the three ECCO options lead almost to the same fuel spectra (with an improved resonance description with the 80-group grid), while the Serpent 33-group spectra appear significantly higher below 1 keV energy, especially for the flux.



Figure A.1 Normalised flux (top) and current (bottom) spectra at 33 energy groups evaluated by ECCO (with different calculation options) and Serpent (3D FC model) in the fuel inner zone.







The flux and current in the fuel zones are used by ECCO (as external source Q, see §A.3-7) to evaluate the cross-sections of non-multiplying media. Because of the significant difference between the fuel spectra computed by the two codes (Figs. A.1-2), the flux and current terms coming out from Serpent at 33 groups were introduced "externally" in ECCO (SUBCRITICAL SOURCE instruction; see §D.2). To verify the congruence of this calculation option, the same instruction was used also by inserting "externally" the "internal" ECCO source. Figs. A.3 and A.4 show the results obtained in the CR and SR absorbing bundle regions, respectively, for the total (left) and capture (right) cross-sections. It appears evident that all the ECCO options (a, b, d, e) yield very similar results for both cross-sections. Furthermore, the congruence of the external source calculation option is respected since the b) and e) behaviours are practically equivalent.



Figure A.3 CR total (left) and capture (right) cross-sections at 33 energy groups evaluated by ECCO (with different options) and Serpent (3D FC model).



Figure A.4 SR total (left) and capture (right) cross-sections evaluated at 33 energy groups by ECCO (with different options) and Serpent (3D FC model).



The 33-group ECCO calculations were carried out also by adopting (see §A.7 and Appendix D):

- the P₁ inconsistent, the B₁ consistent and inconsistent options (to be compared with the reference P_1 consistent):
- without the additional self-shielding term for not multiplying media (NODBBSH instruction, to be compared with the DBBSH reference one).

The impact of these calculation options on the cross-section values resulted to be negligible. As examples:

- Fig. A.5 reports the total cross-sections of the inner (FINN) and outer (FOUT) fuel zones, where the consistent P_1 (reference) and B_1 methods were compared. The graph shows also that the fuel inner and outer cross-sections differ significantly only at low energies;
- Fig. A.6 reports the total cross-sections of the CR absorbing bundle, where the NODBBSH and DBBSH (reference) calculation options, combined with the P1 and B1 consistent methods, were compared.





Fuel inner and outer total cross-sections evaluated by ECCO with P₁ (reference) and B₁ consistent calculation options at 33 energy groups.



Figure A.6 CR absorbing bundle total cross-section evaluated by ECCO with NODBBSH and DBBSH (reference) calculation options at 33 energy groups.

Besides the "reference" ECCO calculations at 33 energy groups adopting 2D heterogeneous geometry models, the cross-sections were evaluated also at 80 groups. Furthermore, the most important regions for core neutronics (*i.e.*, fuel and shutdown systems absorbing bundles) were described with homogeneous cell geometries in both energy-group structures.

Figs. A.7 and A.8 show the results obtained for the total and capture cross-sections with these four different calculation options in the fuel inner and outer zones, respectively. In the same



graphs they are also compared with the 33-group values of the Serpent 3D FC heterogeneous model. Fig. A.9 shows the inner (left) and outer (right) fuel elastic cross-sections, evaluated by ECCO with the four above mentioned options. It appears evident that:

- the 33 and 80 energy group structures yield very similar results, for both the ECCO intracomparison and the confrontation with the Serpent values (Figs. A.7 and A.8);
- the increased energy refinement at 80 groups yields a better description of the resonances (that is evident in Fig. A.9 for the elastic cross-section).



Figure A.7 Fuel Inner total (left) and capture (right) cross-sections evaluated by ECCO with 33 and 80 groups (heterogeneous and homogeneous geometry models) and by Serpent (3D FC model) at 33 groups.



Figure A.8 Fuel outer total (left) and capture (right) cross-sections evaluated by ECCO with 33 and 80 groups (heterogeneous and homogeneous geometry models) and by Serpent (3D FC model) at 33 groups.



Figure A.9 Fuel inner (left) and outer (right) elastic cross-sections evaluated by ECCO at 33 and 80 groups with heterogeneous and homogeneous geometry models.



Fig. A.10 compares the fission cross-sections obtained with the four abovementioned ECCO options together with the Serpent (3D FC model) results at 33 groups. It appears evident that there is a good and general agreement above 10 eV (besides the better description of the resonances by the 80-group structure). At lower energies, the ECCO results at 80 groups are the closest to the Serpent values at 33 (and 80, here not shown) energy groups.



Figure A.10 Fuel fission cross-section evaluated by ECCO at 33 and 80 energy groups (heterogeneous and homogeneous geometries) and Serpent (3D FC model) at 80 groups.

Figs. A.11 and A.12 show the ECCO and Serpent multi-group constants of the CR and SR absorbing zones, respectively, for the total (left) and transport (right) cross-sections calculated at 33 and 80 groups. The ECCO results refer to the heterogeneous cell geometry models and the Serpent ones refer to the 3D FC heterogeneous model. It appears evident that, especially for the CR having a high B_4C volume fraction and in spite of the energy structure adopted, the ECCO total cross-sections are higher than the Serpent ones, while the difference is less evident for the transport cross-sections. As discussed in §5.3 (see Fig. 5.11), the main contribution to the difference between the total cross-sections is due to the capture constants over a large part of the spectrum.

Fig. A.13 shows the ECCO and Serpent capture cross-section values calculated at 33 and 80 groups by heterogeneous models (as in Fig. 5.11) compared with the ECCO ones obtained by homogeneous cell geometries (at 33 groups). It appears evident that at low energies the latter homogeneous values are significantly higher than the heterogeneous ones, reaching two order of magnitude difference in the thermal groups. It can be therefore deduced that in absorbing regions the self-shielding effect (treated by ECCO with 2D heterogeneous geometry models) has a large impact on the cross-section values. Nevertheless, since the larger differences appear only below 1 keV, the impact on the corresponding shutdown systems worth in the ALFRED fast spectrum core resulted to be limited (~150-560 pcm anti-reactivity in dependence of the CR and SR position; see §6.1).













Figure A.13 CR (left) and SR (right) capture cross-sections at 33 and 80 groups evaluated by ECCO (heterogeneous and homogeneous cell geometries) and Serpent (3D FC model).

For the other core regions, the impact of the self-shielding effects and the energy refinement on the cross-section values results to be decisively lower or negligible. As examples:

- Fig. A.14 shows the total cross-sections for the dummy (*i.e.*, YSZ bundle) and pure lead regions obtained with heterogeneous and homogeneous geometry cell models, respectively, treated at 33 and 80 energy groups;
- Fig. A.15. shows the total, elastic and capture cross-sections of the FA plenum obtained with a heterogeneous geometry model at 33 and 80 energy groups;
- Fig. A.16 and A.17 show the FA plenum and dummy total cross-sections, respectively, obtained with heterogeneous and homogeneous geometry models at 33 and 80 groups. Differently from the previous graphs, the values are not reported in a logarithmic scale to make evident the improvement obtained by the 80 group-structure in the resonances region.

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Figure A.14 Dummy (heterogeneous model, left) and pure lead (homogeneous model, right) total cross-sections evaluated with ECCO at 33 and 80 energy groups.















A.9 Cross-sections for ERANOS full-core calculations

The ERANOS full-core calculations can be carried out by adopting either the S_N discrete ordinate method or the variational nodal one (§A.1). The latter was used since by this option it is possible to reproduce a realistic 3D hexagonal geometry model of the ALFRED core. In any case, the code solves the following equations for both the discrete ordinates and variational nodal methods:

$$\mu \frac{\partial}{\partial x} \phi_g(x,\mu) + \Sigma_g^*(x) \phi_g(x,\mu) = \sum_{n=0}^N \frac{2n+1}{2} P_n(\mu) \sum_{g'=1}^G \Sigma_{sn,g'\to g}^*(x) \phi_{ng}(x) \, \mathrm{d}E' + Q_g(x,\mu)$$
(A.30)

where the " $\Sigma_{g,x}^*(x)$, $\Sigma_{sn,g' \to g}^*$ " cross-sections for the "x" reaction have to be evaluated starting from the corresponding ECCO ones " $\Sigma_{g,x}(x)$, $\Sigma_{sn,g' \to g}$ " (see §A.5). In some cases they are identical (e.g., for fission $\Sigma_{g,f}^* = \Sigma_{g,f}$), but for the most part of vectors and matrices their values differ in dependence of the different P_N order chosen for the ERANOS cross-sections.

By comparing equations (A.30) with the ECCO ones (A.15), it can be seen that the expressions are equivalent by imposing that:

$$\Sigma_{sn,g' \to g}^*(x) = \Sigma_{n,g' \to g}(x) \qquad (g' \neq g) \qquad (A.31.a)$$

$$\Sigma_{sn,g\to g}^*(x) = \Sigma_{n,g\to g} + \Sigma_g^* - \Sigma_{n,g} \qquad (g' = g) \qquad (A.31.b)$$

Note that " Σ_g^* " in (A.30) is not determined and can be chosen to improve the convergence of the ERANOS calculation. Each choice of " Σ_g^* " gives rise to a given transport approximation, and, as shown in the following, the correspondence between the ECCO and ERANOS cross-sections varies according to the approximation chosen.

The easiest approximations used for the ERANOS cross-sections are essentially three: \underline{P}_0 transport, \underline{P}_0 total and \underline{P}_1 . On the other hand, the \underline{P}_3 approximation was used to describe the anisotropy of the flux within the core.

A.9.1 The transport approximation (P₀)

With this approximation, the ERANOS total cross-section results identical to the transport one calculated by ECCO:

$$\Sigma_{g}^{*}(x) = \Sigma_{P0,g}^{*}(x) = \Sigma_{tr,g}(x).$$
 (A.32.a)

As it is clearly indicated in (A.11.c), the transport cross-section takes into account the anisotropy through the scattering term at the first order " Σ_{s1} ".

A.9.2 The consistent P₀ approximation (P₀ total)

With this approximation, the ERANOS total cross-section is identical to the ECCO one calculated at the 0^{th} order:

$$\Sigma_{g}^{*}(x) = \Sigma_{P0tot,g}^{*}(x) = \Sigma_{0,g}(x)$$
 (A.32.b)

With (A.32.b), the equations solved by ERANOS consist in a "pure" P_0 system since all the scattering events (as well as fissions or the external source terms) are assumed isotropic.



A.9.3 The consistent P₁ approximation (P₁)

With this approximation, the ERANOS total cross-section results identical to the total one calculated by ECCO at the first order:

$$\Sigma_{q}^{*}(x) = \Sigma_{P1,q}^{*}(x) = \Sigma_{1,q}(x)$$
(A.32.c)

Actually, the ECCO code does not provide in output these multi-group values, since the total cross-section is represented by the 0th term " $\Sigma_{0,g}$ " for both consistent (§A.7.2) and inconsistent (§A.7.3) solutions. Nevertheless, as shown in §A.10, it can be retrieved from the ECCO output through the transport cross-section and the scattering matrices at the first order " Σ_{s1} ".

A.10 Correspondence between ECCO and ERANOS cross-sections

A.10.1 The ECCO cross-sections

Table A.1 summarises the macroscopic cross-sections (vectors Σ) and GxG matrices (M) given in output by the ECCO cell code at the P₁ order. The dependence from the spatial coordinate (x) is assumed implicit while in brackets the energy group g (and g' for the scattering and (n,xn) matrices) is specified. As mentioned in §A.9.3, despite the P₁ approximation the ECCO total cross-section is identical to the term at the 0th order " $\Sigma_0(g)$ ".

Cross-sections / Matrices	Notat	ion
TOTAL	Σ ₀ (g)	
TRANSPORT	$\Sigma_{tr}(g)$	
CAPTURE	$\Sigma_{c}(g)$	
FISSION	$\Sigma_{f}(g)$	
PRODUCTION	$v \Sigma_{f}(g)$	
N,XN	$\Sigma_{n,xn}(g)$	
ELASTIC SCATTERING	$\Sigma_{el}(g)$	
INELASTIC SCATTERING	$\Sigma_{in}(g)$	
ELASTIC SCATTERING MATRIX	$\mathbf{M}_{el,0}(g, g')$	$\mathbf{M}_{el,1}(g,g')$
INELASTIC SCATTERING MATRIX	$\mathbf{M}_{in,0}(g, g')$	$\overline{\mathbf{M}_{in,1}(g, g')}$
n,xn MATRIX	$\mathbf{M}_{n,xn,0}(g, g')$	$\mathbf{M}_{n,xn,1}(g, g')$

Table A.1	ECCO cross-sections and matrices (P ₁ approximation).
-----------	--

The total cross-section (at the 0th order) can be retrieved also by applying the relation between the cross-section vectors:

$$\begin{split} \Sigma_{\mathbf{0}}(g) &= \Sigma_{\mathbf{c}}(g) + \Sigma_{\mathbf{f}}(g) + \Sigma_{\mathbf{s}, \mathbf{0}}(g) = \\ &= \Sigma_{\mathbf{c}}(g) + \Sigma_{\mathbf{f}}(g) + \Sigma_{\mathbf{el}}(g) + \Sigma_{\mathbf{in}}(g) + \Sigma_{\mathbf{n},\mathbf{xn}}(g) \end{split}$$
(A.33)



The transfer (or total scattering) cross-sections " Σ_s " at the P₀ and P₁ orders result from the sum of elements of the corresponding matrices (M_{el}, M_{in} and M_{n,xn}; see Table A.1) that can be included in unique transfer matrices "TM*" (as done in ERANOS; see §A.10.2) summing the elastic, inelastic and n,xn ones at different orders. That is:

$$\begin{split} \boldsymbol{\Sigma}_{s0}(g) &= \boldsymbol{\Sigma}_{n,xn}(g) + \boldsymbol{\Sigma}_{el}(g) + \boldsymbol{\Sigma}_{in}(g) = \sum_{j} \mathbf{TM}_{0}^{*}(g,j) = \\ &= \sum_{j} \mathbf{M}_{el,0}(g,j) + \sum_{j} \mathbf{M}_{in,0}(g,j) + \sum_{j} \mathbf{M}_{n,xn,0}(g,j) \quad (A.34.a) \\ &\mathbf{3} \boldsymbol{\Sigma}_{s1}(g) = \mathbf{3} \sum_{j} \mathbf{TM}_{1}^{*}(g,j) = \end{split}$$

$$= 3\sum_{j} \mathbf{M}_{el,1}(g,j) + 3\sum_{j} \mathbf{M}_{in,1}(g,j) + 3\sum_{j} \mathbf{M}_{n,xn,1}(g,j)$$
(A.34.b)

where:

$$\Sigma_{el}(g) = \sum_{j} \mathbf{M}_{el,0}(g,j)$$
(A.34.c)

$$\Sigma_{in}(g) = \sum_{j} \mathbf{M}_{in,0}(g,j)$$
(A.34.d)

The absorption term " Σ_a " and the total cross-section at the first order " Σ_1 " are not listed in the ECCO output but they can be retrieved by the following relations:

$$\Sigma_{\mathbf{a}}(g) = \Sigma_{\mathbf{0}}(g) - \Sigma_{\mathbf{s}\mathbf{0}}(g) = \Sigma_{\mathbf{0}}(g) - \Sigma_{\mathbf{e}\mathbf{I}}(g) - \Sigma_{\mathbf{i}\mathbf{n}}(g) - \Sigma_{\mathbf{n},\mathbf{x}\mathbf{n}}(g) = \Sigma_{\mathbf{c}}(g) + \Sigma_{\mathbf{f}}(g) \quad (A.35.a)$$

$$\Sigma_{1}(g) = \Sigma_{tr}(g) + \Sigma_{S1}(g) = \Sigma_{tr}(g) + \frac{1}{3}\sum_{j} TM_{1}^{*}(g, j)$$
 (A.35.b)

A.10.2 The ERANOS cross-sections

Table A.2 summarises the macroscopic cross-section vectors " Σ ^{*}" and GxG transfer matrices "TM^{*}" (A.34) used by ERANOS in the P₀ transport, P₀ total and P₁ approximations (§A.9.1-A.9.3). The ERANOS vectors identical to the ECCO ones are written in red (as in Table A.1) while, besides the asterisk, the other ERANOS cross-sections are reported in blue in order to distinguish even more easily them from the ECCO ones. As mentioned in §A.10.1, the ERANOS P₁ total cross-section " $\Sigma_{P1}^{*}(g)$ " values can be derived from the ECCO P₁ results through the relation (A.35.b) as they are not present explicitly in the ECCO output.

Besides the cross-sections, Table A.2 reports also the fission spectrum defined in (A.25) and the diffusion coefficient D that is:

$$\mathbf{D}^{*}(g) = \mathbf{1} / (\mathbf{3} \Sigma_{tr}(g))$$
(A.36.a)

The ERANOS capture cross-section results to be:

$$\Sigma_{c}^{*}(\mathbf{g}) = \Sigma_{c}(\mathbf{g})$$
 (with UP-SCATTERING) (A.36.b)

$$\boldsymbol{\Sigma}_{c}^{*}(\mathbf{g}) = \boldsymbol{\Sigma}_{c}(\mathbf{g}) - \frac{\sum_{j=g+1}^{G} M_{el,0}(g,j)\phi_{j}}{\phi_{g}} \qquad (\text{without UP-SCATTERING}) \quad (A.36.c)$$

In this work the <u>up-scattering option</u> (A.36.b) was adopted: it has to be specified in the ECCO / ERANOS interface in ERANOS (BASIC_EDL_CREATION_STARTING_FROM_ECCO_FILE; see §D.3).



		Notation
Cross-sections / Matrices		Notation
TOTAL	$\Sigma_{PN}^*(\mathbf{g})$	
FISSION SPECTRUM	χ*(g)	
DIFFUSION COEFFICIENT	D*(g)	
CAPTURE	$\Sigma_c^*(\mathbf{g})$	
FISSION	$\Sigma_{f}(g)$	
PRODUCTION	$\nu \Sigma_{f}(g)$	
N,XN	$\Sigma_{n,xn}(g)^{s}$	
DISAPPEARANCE	$\Sigma^*_{dis}(\mathbf{g})$	
ELASTIC G \rightarrow G	$\Sigma^*_{el,g}(\mathbf{g})$	
ELASTIC G \rightarrow G+	$\Sigma^*_{el,g+}(\mathbf{g})$	
INELASTIC G \rightarrow G	$\Sigma_{in,g}^*(\mathbf{g})$	
ELASTIC SCATTERING	$\Sigma_{el}(g)$	
INELASTIC SCATTERING	$\Sigma_{in}(g)$	
TRANSFER MATRIX	TM ₀ *(g,g')	TM [*] ₁ (g,g')

Table A.2	ERANOS cross-sections and matrices at the P _N order
	$(P_N = P_0 \text{ transport}, P_0 \text{ total and } P_1).$

The ERANOS in-scattering inelastic cross-section (INELASTIC G \rightarrow G) is actually related with the diagonal terms of the ECCO scattering matrices by the following relation including the (n,xn) reactions:

$$\Sigma_{in,g}^{*}(\mathbf{g}) = \mathbf{M}_{in,0}(g,g) + \mathbf{M}_{n,xn,0}(g,g)$$
(A.37)

while the in-scattering elastic cross-sections (ELASTIC G \rightarrow G) relation with the ECCO values depends on the approximation (A.32.a-c) chosen:

$$\Sigma_{el,g}^{*}(g) = M_{el,0}(g,g) + \Sigma_{PN}^{*}(g) - \Sigma_{0}(g) + \Sigma_{c}^{*}(g) - \Sigma_{c}(g) \quad (A.38.a)$$

With the up-scattering option (A.36.b) (here used), the ERANOS in-scattering elastic cross-section in the P_0 transport, P_0 total and P_1 approximations result:

⁸ In the package identifier record, there is an integer IDUM1 which is described as an unused variable. If IDUM1 value is zero (not our case), the (n,xn) cross-section does not exist in the ECCO output file and is included in the corresponding inelastic values for vectors (as for matrices): $\Sigma_{in}^*(g) = \Sigma_{in}(g) + \Sigma_{n,xn}(g)$.


$$\mathbf{P}_{0} \text{ transport} \qquad \mathbf{\Sigma}_{el,g}^{*}(\mathbf{g}) = \mathbf{M}_{el,0}(\mathbf{g},\mathbf{g}) + \mathbf{\Sigma}_{tr}(\mathbf{g}) - \mathbf{\Sigma}_{0}(\mathbf{g}) \qquad (A.38.b)$$

P₀ total)
$$\Sigma_{el,q}^{*}(g) = M_{el,0}(g,g)$$
 (A.38.c)

P₁)
$$\Sigma_{el,g}^{*}(g) = M_{el,0}(g,g) + \Sigma_{P1}^{*}(g) - \Sigma_{0}(g)$$
 (A.38.d)

By using relation (A.35.b), the in-scattering elastic cross-section in the P_1 approximation (A.38.d) can be rewritten also as:

$$\mathbf{P}_{1} \qquad \Sigma_{el,g}^{*}(\mathbf{g}) = \mathbf{M}_{el,0}(\mathbf{g},\mathbf{g}) + \Sigma_{tr} + \Sigma_{S1} - \Sigma_{0} = \mathbf{M}_{el,0}(\mathbf{g},\mathbf{g}) + \Sigma_{tr}(\mathbf{g}) + \frac{1}{3}\sum_{j} \mathbf{T}\mathbf{M}_{1}^{*}(\mathbf{g},j) - \Sigma_{0}(\mathbf{g}) \quad (A.38.e)$$

The ERANOS transfer (or total scattering) cross-section matrices are related with the elastic, inelastic and (n,xn) ones generated by ECCO as indicated in (A.34.a) and (A.34.b). Only the diagonal elements at the 0th order depend on the approximation (A.32.a-c) chosen:

$$\mathbf{TM}_{0}^{*}(g, j) = \mathbf{M}_{el,0}(g, j) + \mathbf{M}_{in,0}(g, j) + \mathbf{M}_{n,xn,0}(g, j) \qquad \text{(with } j \neq g) \qquad (A.39.a)$$

$$\mathbf{TM}_{0}^{*}(g,g) = \mathbf{M}_{el,0}(g,g) + \mathbf{M}_{in,0}(g,g) + \mathbf{M}_{n,xn,0}(g,g) + \Sigma_{PN}^{*}(g) - \Sigma_{0}(g) + \Sigma_{c}^{*}(g) - \Sigma_{c}(g)$$

With the up-scattering option (A.36.b) the three approximations yield for the P₀ diagonal terms:

$$P_{0} \text{ transport) } TM_{0}^{*}(g,g) = M_{el,0}(g,g) + M_{in,0}(g,g) + M_{n,xn,0}(g,g) + \Sigma_{tr}(g) - \Sigma_{0}(g) \text{ (A.39.c)}$$

$$P_{0} \text{ total}) \qquad TM_{0}^{*}(g,g) = M_{el,0}(g,g) + M_{in,0}(g,g) + M_{n,xn,0}(g,g)$$
(A.39.d)

$$P_{1} TM_{0}^{*}(g,g) = M_{el,0}(g,g) + M_{in,0}(g,g) + M_{n,xn,0}(g,g) + \Sigma_{P1}^{*}(g) - \Sigma_{0}(g)$$
(A.39.e)

Using equation (A.35.b), the diagonal elements in the P_1 approximation (A.39.e) can be expressed similarly to (A.38.e).

The relation between the transfer matrix at the first order (used only in P_0 transport and P_1 approximations) can be easily deduced from (A.35.b):

$$TM_{1}^{*}(g, j) = 3 \left(M_{el,1}(g, j) + M_{in,1}(g, j) + M_{n,xn,1}(g, j) \right)$$
(A.40)

for each value of j.

The ERANOS down-scattering elastic cross-section (ELASTIC G \rightarrow G+, which actually involves all the groups j > G) is related with the ECCO scattering matrices by the relation:

$$\boldsymbol{\Sigma}_{el,g+}^{*}(\mathbf{g}) = \sum_{j=g+1}^{G} \mathbf{M}_{el,0}(\mathbf{g},\mathbf{j})$$
(A.41)

for each ERANOS approximation (*i.e.*, down-scattering because the energy intervals of groups j are below the energy limits of group g).

The disappearance cross-section (from the group g) " $\Sigma_{dis}^*(g)$ " is defined in ERANOS as:

$$\Sigma_{dis}^{*}(g) = \Sigma_{c}^{*}(g) + \Sigma_{f}(g) + \Sigma_{el}(g) + \Sigma_{in}(g) + \Sigma_{n,xn}(g) - M_{el,0}(g,g) - M_{in,0}(g,g) - M_{n,xn,0}(g,g)$$
(A.42.a)

that, with the up-scattering option (A.36.b), becomes (for every ERANOS approximation):



 $\Sigma_{dis}^{*}(g) = \Sigma_{c}(g) + \Sigma_{f}(g) + \Sigma_{el}(g) + \Sigma_{in}(g) + \Sigma_{n,xn}(g) - M_{el,0}(g,g) - M_{in,0}(g,g) - M_{n,xn,0}(g,g)$ (A.42.b)

By comparing (A.42.b) with the total cross-section at the 0^{th} order (A.33), the disappearance cross-section can be written as:

$$\Sigma_{0}(g) = \Sigma_{dis}^{*}(g) + M_{el,0}(g,g) + M_{in,0}(g,g) + M_{n,xn,0}(g,g)$$
(A.43)

that makes clear the meaning of disappearance from the group g.

Table A.3 summarises the whole cross-sections set used by ERANOS in full-core calculations. The ECCO P_1 input cross-sections can be used in ERANOS with the P_0 (transport), P_0 total and P_1 approximation orders, as they were retrieved with previous formulae. It can be again pointed out that, in this work, the reference full-core calculations exploit the P_3 order for the flux moments even if the ECCO cross-sections and matrices were evaluated (and used in ERANOS) in the P_1 order approximation.

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Table A.3Relation between the ERANOS cross-sections - at the P_0 transport (P_0 tra), P_0 total (P_0 tot) and P_1 orders - and the ECCO cross-
sections and matrices (calculated at the P_1 order).

Macroscopic cross-section	P _N	ERANOS	Equation	ECCO
	P₀ tra	$\Sigma_{P0}^*(\mathbf{g})$	(A.32.a)	$\Sigma_{tr}(g)$
Total	P ₀ tot	$\Sigma_{P0tot}^*(\mathbf{g})$	(A.32.b)	Σ ₀ (g)
	P ₁	$\Sigma_{P1}^*(\mathbf{g})$	(A.32.c) (A.35.b)	$\Sigma_{tr}(g) + \Sigma_{S1}(g) = \Sigma_{tr}(g) + \frac{1}{3}\sum_{j} TM_{1}^{*}(g,g)$
Diffusion coeff.	All	$\mathbf{D}^{*}(g)$	(A.36.a)	$1 / (3 \Sigma_{tr}(g))$
		$\Sigma_c^*(\mathbf{g})$	(A.36.b)	$\Sigma_{c}(g)$ (with up scattering)
Capture	All		(A.36.c)	$\Sigma_{c}(g) - \frac{\sum_{j=g+1}^{G} M_{el,0}(g,j) \Phi_{j}}{\phi_{g}}$ (without up scattering)
Fission	All	$\Sigma_f^*(\mathbf{g})$		$\Sigma_{f}(g)$
Production	All	$\nu \Sigma_f^*(\mathbf{g})$		$\nu \Sigma_{f}(g)$
n,xn	All	$\Sigma_{n,xn}^*(\mathbf{g})$		$\Sigma_{n,xn}(g)$ (with IDUM1 $\neq 0^{b}$)
Inelastic g→g	All	$\Sigma_{in,g}^*(\mathbf{g})$	(A.37)	$\mathbf{M}_{in,0}(g,g) + \mathbf{M}_{n,xn,0}(g)$
	P ₀ tra		(A.38.b)	$\mathbf{M}_{el,0}(g,g) + \Sigma_{tr}(g) - \Sigma_{0}(g)$
	P ₀ tot	$\mathbf{\Sigma}^*$	(A.38.c)	M _{el,0} (g,g)
Elastic g→g	P ₁	$\Sigma_{el,g}(\mathbf{g})$	(A.38.d) (A.38.e)	$\begin{split} \mathbf{M}_{\text{el},0}(g,g) + &\Sigma_{\text{P1}}(g) - \Sigma_{0}(g) = \mathbf{M}_{\text{el},0}(g,g) + \Sigma_{\text{tr}}(g) + \Sigma_{\text{S1}}(g) - \Sigma_{0}(g) = \\ &= \mathbf{M}_{\text{el},0}(g,g) + \Sigma_{\text{tr}}(g) + \frac{1}{3}\sum_{j} \mathbf{T}\mathbf{M}_{0}^{*}(g,j) - \Sigma_{0}(g) \end{split}$

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Elastic g → g+ (down-scatt.)	All	$\Sigma^*_{el,g+}(\mathbf{g})$	(A.41)	$\sum_{j=g+1}^{G} \mathbf{M}_{el,0}(\mathbf{g},\mathbf{j})$
Elastic	All	$\Sigma_{el}^{*}(\mathbf{g})$	(A.34.a)	$\Sigma_{el}(g) = \sum_j M_{el,0}(g,j)$
Inelastic	All	$\Sigma_{in}^*(\mathbf{g})$	(A.34.a)	$\Sigma_{in}(g) = \sum_j M_{in,0}(g,j)$
	All		(A.39.a)	$\mathbf{M}_{el,0}(g,j) + \mathbf{M}_{in,0}(g,j) + \mathbf{M}_{n,xn,0}(g,j) \text{(with } j \neq g\text{)}$
Transfer Matrix	P₀ tra		(A.39.c)	$\mathbf{M}_{el,0}(\mathbf{g},\mathbf{g}) + \mathbf{M}_{in,0}(\mathbf{g},\mathbf{g}) + \mathbf{M}_{n,xn,0}(\mathbf{g},\mathbf{g}) + \boldsymbol{\Sigma}_{tr}(\mathbf{g}) - \boldsymbol{\Sigma}_{0}(\mathbf{g})$
at 0 th order	P ₀ tot	I M0(8,8)	(A.39.d)	$\mathbf{M}_{el,0}(g,g) + \mathbf{M}_{in,0}(g,g) + \mathbf{M}_{n,xn,0}(g,g)$
	P ₁		(A.39.e)	$M_{el,0}(g,g) + M_{in,0}(g,g) + M_{n,xn,0}(g,g) + \Sigma_{P1}^{*}(g) - \Sigma_{0}(g)$
Transfer Matrix at 1 th order	P₀ traª, P₁	TM [*] ₁ (g, g)	(A.40)	3 ($M_{el,1}(g,j) + M_{in,1}(g,j) + M_{n,xn,1}(g,j)$) (for each j)
Disappearance	All	$\Sigma_{dis}^{*}(\mathbf{g})$	(A.42.a)	$\Sigma_c^*(\mathbf{g}) + \Sigma_{f}(\mathbf{g}) + \Sigma_{el}(\mathbf{g}) + \Sigma_{in}(\mathbf{g}) + \Sigma_{n,xn}(\mathbf{g}) - \mathbf{M}_{el,0}(\mathbf{g},\mathbf{g}) - \mathbf{M}_{in,0}(\mathbf{g},\mathbf{g}) - \mathbf{M}_{n,xn,0}(\mathbf{g},\mathbf{g})$

^a The P₀ transport approximation adopts the transfer matrix at the first order through the transport cross-section

^b Differently, with IDUM1 = 0 the (n,xn) ECCO cross-sections and matrices are included in the inelastic cross-sections



Appendix B: Comparison between multi-group constants (full data set of Serpent-ERANOS relative differences)

The following tables report the values of:

• the relative difference [%] between the Serpent (3D FC heterogeneous model) macroscopic cross-sections at 33 energy groups and the ECCO "reference" ones:

(Serpent – ECCO) / ECCO

• the Relative Standard Deviation (RSD) of the Serpent results.

In both cases, the results were coloured according to their values: green if they are lower than 1%, orange if they are within the interval 1-10%, red if they are above 10%. The data are ordered from the upper to the lower energy groups (see Table 3.1 for the energy grid values).

It results evident the overall agreement between ECCO and Serpent for the great majority of the groups in the fissile (see Table B.1 in §B.1) and non-fissile (see Tables B.3, B.5, B.7 and B.9 in §B.2) zones, by the exception of the first (fastest) group and the thermal region of the spectrum where the Serpent RSD is also quite high for the MC Statistics (see Tables B.2, B.4, B.6, B.8 and B.10).

It can be then deduced that the poor statistics in the lowest energy groups is the major responsible of the code discrepancies in the thermal region. Furthermore, at lower energies the neutron absorptions are more likely and the effect of the different angular approximations (P_1 vs. continuous directions) will increase. Such effect should explain the relative difference between Serpent and ECCO capture cross-sections of the CR and SR absorbing bundle zones, which reaches up to ~50% around 0.5 keV (Table B.7), in spite of limited Serpent RSD (Table B.8), because of their "less diffusive" behaviour.

Significant differences (even if smaller than for CRs and SRs) were found also in the fuel pins plug (top and bottom) and axial reflector (top and bottom), as well as in the core barrel. All these zones (made of SS and lead only) are relatively far from the fissile region: therefore, also the spectrum "softening" in them (correctly reproduced by the Serpent 3D FC model and not by the 2D ECCO ones) could contribute to these discrepancies.



B.1 Fissile zones

Table B.1Relative difference [%] between Serpent and ECCO macroscopic cross-sections
at 33 energy groups for the fuel inner and outer zones.

Inner fuel				
Total	Transport	Capture	Fission	
0.1%	2.2%	1.3%	1.6%	
0.1%	0.0%	0.6%	-0.2%	
0.1%	0.3%	0.4%	0.0%	
-0.1%	-0.1%	0.2%	-0.2%	
0.1%	0.5%	0.3%	- 0.1%	
-0.7%	1.3%	0.2%	-0.3%	
-1.4%	0.1%	0.1%	-0.6%	
- 0.1%	4.2%	0.0%	- 0.7%	
-0.1%	1.9%	0.1%	-0.5%	
- 0.1%	2.2%	0.0%	-0.5%	
0.1%	3.3%	0.1%	- 0.6%	
0.2%	1.5%	0.3%	- 0.6%	
0.1%	8.5%	0.3%	- 0.1%	
0.2%	3.8%	0.6%	- 1.3%	
0.1%	1.6%	0.5%	0.6%	
0.1%	4.9%	0.6%	- 1.3%	
0.1%	2.5%	- 0.1%	- 4.9%	
0.2%	3.9%	0.0%	- 4.7%	
0.1%	4.3%	- 1.0%	- 0.7%	
0.0%	5.0%	-1.5%	- 2.4%	
0.2%	3.9%	0.2%	0.7%	
0.7%	8.2%	- 0.5 %	0.5%	
-0.5%	5.8%	- 1.5%	- 3.0%	
1.4%	9.3%	4.9%	- 0.3%	
- 0.6%	5.4%	- 5.9%	- 5.0%	
- 3.5%	11.2%	- 11.8%	- 14.8%	
-6.1%	9.3%	- 27.8%	8.3 %	
-5.0%	12.5%	-18.6%	1.9%	
0.2%	4.9%	- 3.8 %	1.5%	
6.0%	13.7%	24.2%	10.9%	
- 16.0%	-7.7%	-54.3%	-55.5%	
-7.1%	12.5%	- 7.8%	-19.9%	
117.3%	- 100.0%	170.5%	197.6%	

(Serpent - ECCO) / ECCO



Table B.2	RSD of the Serpent macroscopic cross-sections at 33 energy groups for the fuel
	inner and outer zones.

Inner fuel					
Total	Transport	Capture	Fission		
0.14%	0.92%	0.90%	1.27%		
0.05%	0.22%	0.28%	0.45%		
0.02%	0.11%	0.16%	0.12%		
0.01%	0.06%	0.09%	0.10%		
0.01%	0.03%	0.06%	0.08%		
0.02%	0.03%	0.06%	0.06%		
0.01%	0.02%	0.04%	0.04%		
0.02%	0.02%	0.03%	0.04%		
0.01%	0.02%	0.04%	0.04%		
0.01%	0.02%	0.02%	0.03%		
0.01%	0.02%	0.04%	0.05%		
0.01%	0.02%	0.04%	0.04%		
0.02%	0.02%	0.04%	0.04%		
0.02%	0.02%	0.05%	0.05%		
0.01%	0.02%	0.04%	0.05%		
0.02%	0.04%	0.08%	0.08%		
0.02%	0.04%	0.07%	0.07%		
0.02%	0.04%	0.09%	0.08%		
0.02%	0.05%	0.17%	0.15%		
0.04%	0.07%	0.23%	0.19%		
0.05%	0.09%	0.24%	0.28%		
0.11%	0.16%	0.35%	0.30%		
0.12%	0.15%	0.46%	0.48%		
0.21%	0.26%	0.85%	0.68%		
0.38%	0.49%	1.59%	1.58%		
0.39%	0.52%	1.54%	1.46%		
0.43%	0.57%	1.74%	1.91%		
0.64%	0.81%	2.25%	3.04%		
0.49%	0.82%	2.31%	2.24%		
0.87%	1.01%	3.31%	3.31%		
0.65%	0.91%	3.11%	1.88%		
10.78%	11.09%	16.82%	18.97%		
9.60%	0.00%	8.52%	12.14%		



B.2 Non-fissile zones

Table B.3Relative difference [%] between Serpent and ECCO macroscopic cross-sections
at 33 energy groups for the fuel pin insulators, spring and top plug zones.

			(DC									
Тс	op insulat	or	Bot	tom insul	ator		Spring			Top plug		
Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture	
0.03%	3.62%	-8.32%	1.91%	18.51%	21.61%	11.04%	10.43%	21.71%	6.15%	-1 3.36 %	-12.47%	
-1.31%	2.02%	- 3.18%	-0.52%	7.24%	0.77%	0.94%	2.72%	-8.42%	1.01%	16.13%	-27.44%	
-0.52%	0.30%	- 3.29%	-0.82%	0.11%	-1.71%	0.46%	1.93%	-13.57%	0.64%	2.71%	-44.22%	
-1.71%	-0.02%	- 1.08%	-1.74%	-0.05%	- 2.20%	-0.53%	1.87%	-13.39%	-0.49%	1.27%	- 47.86 %	
- 1.46%	- 0.95%	- 1.48%	-1.11%	-0.13%	-1.51%	-2.06%	1.19%	-10.13%	-2.44%	-0.37%	- 36.15%	
- 5.04%	0.19%	- 0.91%	-5.68%	-1.15%	- 2.66%	-3.71%	- 0.35%	-3.60%	-5.67%	-5.27%	-16.59%	
- 5.09%	- 2.43%	-4.88%	-5.14%	- 2.39%	-4.55%	-6.17%	- 1.12%	-4.00%	-8.89%	- 5.64%	-14.08%	
- 7.18%	0.19%	- 3.90%	-7.16%	0.02%	-3.52%	-4.77%	2.76%	-3.84%	-8.45%	-3.35%	-13.13%	
- 4.51%	-0.77%	- 6.06 %	-4.53%	- 0.91%	- 5.94%	-3.91%	2.15%	- 6.21%	-10.59%	-5.45%	- 20.64%	
-5.73%	- 2.31%	- 8.09%	-5.72%	-2.31%	-8.99%	- 3.61 %	3.60%	- 6.92%	-12.24%	-4.61%	-23.01%	
- 7.8 1%	- 2.77%	-5.55%	-7.75%	-2.90%	-6.02%	- 2.97 %	6.23%	-3.05%	- 9.87%	- 2.84%	-12.84%	
-3.91%	0.06%	-17.31%	-3.83%	0.04%	-16.45%	-1.06%	4.27%	-5.30%	-5.04%	- 2.85 %	-22.82%	
-10.36%	2.13%	-11.60%	-10.32%	2.21%	-10.77%	- 1.66 %	16.05%	-4.57%	- 8.18 %	12.70%	-15.23%	
-9.65%	-1.54%	-11.20%	- 9.48 %	-1.52%	-11.51%	- 6.99 %	- 0.66%	-3.07%	-34.08%	-25.14%	- 20 .11%	
- 2.6 1%	0.33%	-11.14%	-2.76%	0.19%	-10.05%	-3.18%	0.31%	-7.78%	-18.86%	-15.57%	-35.88%	
-7.22%	1.92%	-14.28%	-6.82%	1.98%	-14.05%	-0.88%	9.46%	-3.38%	-1.10%	5.53%	-10.68%	
-4.22%	1.34%	-17.82%	-4.31%	0.80%	-20.69%	-2.72%	2.41%	0.86%	-13.57%	-10.09%	-15.40%	
-7.30%	0.30%	-22.10%	-7.36%	0.05%	-21.97%	-2.25%	3.45%	- 5.26%	-12.84%	-8.46%	-22.06%	
-3.04%	-0.05%	-19.35%	-3.28%	-0.74%	-18.43%	-1.54%	3.64%	-4.95%	-5.71%	-3.96%	-17.64%	
-3.23%	-0.05%	-47.67%	-2.83%	0.06%	-46.67%	-1.38%	5.47%	-9.52%	-4.13%	- 0.57%	-8.07%	
-3.23%	0.20%	-46.00%	-3.05%	0.01%	-48.75%	-1.08%	5.14%	-0.96%	-1.69%	0.15%	-14.25%	
- 6.17%	2.82%	-14.61%	-6.16%	3.43%	-15.66%	-1.81%	11.39%	-4.88%	-9.94%	4.07%	-25.44%	
- 7.32%	0.09%	-49.70%	-6.82%	0.48%	- 50.98%	-2.18%	4.66%	- 9.57%	-3.80%	-0.73%	-25.94%	
- 2.8 8%	-0.23%	-15.39%	-2.27%	1.36%	-16.10%	-0.97%	6.17%	-13.85%	-1.86%	1.17%	-33.80%	
- 2.56%	1.93%	-5.23%	-1.72%	2.81%	0.73%	-1.42%	6.05%	-0.20%	0.22%	3.32%	- 8.47%	
-1.25%	1.94%	19.47%	-1.25%	1.72%	19.54%	-1.55%	6.52%	32.18%	0.51%	3.43%	32.07%	
-1.31%	1.38%	-1.48%	-2.44%	1.84%	-7.15%	-1.70%	5.63%	-3.99%	0.37%	2.71%	-15.40%	
-1.12%	3.03%	-3.53%	-3.18%	0.92%	-8.68%	- 2.96 %	4.60%	- 8.14%	-0.64%	3.13%	-22.65%	
- 1.83 %	3.87%	- 5.31%	-1.84%	0.58%	-6.34%	-1.24%	6.63 %	-2.82%	-0.19%	2.73%	-10.58%	
-2.52%	1.29%	-19.58%	-3.13%	1.08%	-20.52%	0.53%	7.53%	- 9.21%	0.28%	1.61%	- 26.70%	
-5.03%	1.08%	-23.94%	-2.61%	-0.32%	-18.99%	0.50%	6.71%	-31.75%	-1.77%	- 0.4 1%	-42.43%	
-7.41%	- 6.76%	-40.51%	-0.29%	19.10%	-28.07%	2.57%	11.13%	-11.77%	-1.35%	5.32%	-18.10%	
-100.0%	-100.0%	-100.0%	3.7%	106.3%	6.7%	93.75%	168.4%	125.6%	2.87%	23.76%	-0.93%	

(Serpent - ECCO) / ECCO



Т	op insulat	or	Bot	tom insul	ator		Spring			Top plug			
Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture		
1.79%	13.96%	12.26%	1.94%	15. 3 4%	11.63%	6.45%	11.95%	13.29%	3.79%	17.86%	15.87%		
0.68%	3.00%	2.76%	0.66%	3.49%	3.62%	1.55%	2.40%	3.17%	0.91%	4.54%	4.19%		
0.25%	1.23%	1.91%	0.20%	1.57%	1.79%	0.79%	1.30%	1.34%	0.23%	1.72%	2.25%		
0.17%	0.67%	1.03%	0.13%	0.52%	0.91%	0.41%	0.46%	0.71%	0.14%	0.77%	1.03%		
0.11%	0.48%	0.51%	0.12%	0.55%	0.57%	0.24%	0.28%	0.36%	0.14%	0.39%	0.47%		
0.22%	0.32%	0.44%	0.20%	0.30%	0.30%	0.16%	0.24%	0.21%	0.10%	0.28%	0.27%		
0.10%	0.20%	0.36%	0.12%	0.28%	0.57%	0.10%	0.14%	0.32%	0.07%	0.16%	0.33%		
0.18%	0.23%	0.64%	0.13%	0.23%	0.72%	0.09%	0.11%	0.39%	0.11%	0.12%	0.45%		
0.07%	0.14%	0.58%	0.08%	0.18%	0.53%	0.10%	0.13%	0.31%	0.05%	0.10%	0.41%		
0.07%	0.15%	0.51%	0.09%	0.16%	0.62%	0.11%	0.11%	0.33%	0.06%	0.10%	0.41%		
0.07%	0.14%	0.66%	0.08%	0.14%	0.97%	0.13%	0.14%	0.42%	0.08%	0.10%	0.75%		
0.05%	0.15%	0.87%	0.05%	0.13%	0.90%	0.08%	0.09%	0.38%	0.03%	0.08%	0.69%		
0.17%	0.22%	1.14%	0.14%	0.21%	0.91%	0.14%	0.15%	0.49%	0.09%	0.13%	0.83%		
0.15%	0.19%	1.15%	0.12%	0.18%	1.30%	0.13%	0.14%	0.60%	0.06%	0.12%	1.19%		
0.09%	0.22%	0.92%	0.08%	0.17%	1.09%	0.15%	0.17%	0.42%	0.05%	0.11%	0.62%		
0.18%	0.24%	0.95%	0.18%	0.21%	1.07%	0.14%	0.15%	0.25%	0.13%	0.14%	0.22%		
0.19%	0.27%	1.90%	0.14%	0.23%	1.57%	0.14%	0.16%	0.84%	0.07%	0.11%	0.73%		
0.23%	0.28%	1.66%	0.16%	0.30%	1.39%	0.18%	0.19%	0.87%	0.07%	0.13%	0.95%		
0.13%	0.24%	2.20%	0.13%	0.27%	1.69%	0.18%	0.18%	0.72%	0.07%	0.13%	0.91%		
0.18%	0.26%	4.45%	0.14%	0.34%	4.13%	0.22%	0.24%	1.18%	0.09%	0.15%	1.32%		
0.23%	0.45%	3.12%	0.23%	0.54%	2.55%	0.25%	0.26%	0.59%	0.09%	0.15%	0.38%		
0.54%	0.76%	2.19%	0.50%	0.64%	1.83%	0.38%	0.39%	0.59%	0.23%	0.23%	0.52%		
0.36%	0.39%	4.49%	0.26%	0.46%	3.28%	0.31%	0.31%	0.42%	0.12%	0.18%	0.30%		
0.45%	0.72%	4.56%	0.32%	0.75%	2.41%	0.36%	0.37%	0.93%	0.18%	0.23%	0.69%		
0.74%	1.31%	3.59%	0.51%	1.13%	2.93%	0.70%	0.78%	0.94%	0.23%	0.36%	0.68%		
0.68%	1.24%	8.57%	0.60%	1.15%	5.67%	0.57%	0.59%	1.16%	0.19%	0.32%	1.19%		
0.81%	1.49%	3.47%	0.58%	1.40%	2.58%	0.60%	0.64%	0.72%	0.17%	0.31%	0.46%		
1.03%	1.78%	4.29%	0.65%	1.30%	3.33%	0.70%	0.73%	1.08%	0.24%	0.40%	0.70%		
1.41%	1.91%	5.73%	1.21%	1.77%	5.21%	0.91%	1.12%	1.10%	0.26%	0.49%	0.76%		
1.50%	2.36%	6.84%	0.71%	1.60%	3.84%	0.90%	1.09%	1.20%	0.30%	0.53%	0.87%		
1.27%	1.93%	6.23%	1.09%	1.41%	4.85%	1.09%	1.13%	1.29%	0.30%	0.53%	1.04%		
10.79%	1 3.0 4%	43.44%	3.44%	6.48%	11.80%	4.10%	6.37%	5.70%	1.71%	3.67%	4.72%		
0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	16.59%	20.37%	34.12%	11.49%	19.88%	30.13%		

Table B.4	RSD of the Serpent macroscopic cross-sections at 33 energy groups for the fuel
	pin insulators, spring and top plug zones.



Table B.5Relative difference [%] between Serpent and ECCO macroscopic cross-sections
at 33 energy groups for the FA axial reflectors, plenum and bottom plug zones.

(Serpent - ECCO) / ECCO

Bottom plug			Plenum		Тор	reflect	or	Bottom reflector			
Total	Transport	Capture	Total	Transport	Capture	Total 1	Transport	Capture	Total	Transport	Capture
5.42%	1 3.0 4%	3.44%	14.58%	16.05%	1.69%	4.79%	2.64%	-8.55%	-100.0%	-100.0%	-100.0%
0.22%	2.03%	- 34.0 6%	-1.02%	- 0.66%	- 2.57%	4.50%	12.83%	- 29.61%	4.10%	- 3.8 6%	- 30.52%
0.20%	1.84%	-49.94%	0.80%	1.38%	- 2.16%	3.49%	4.10%	- 56.50%	1.15%	21.96%	- 50.63%
- 0.83%	-1.08%	-49.25%	-0.75%	1.36%	- 3.81%	2.40%	2.65%	-54.39%	0.94%	18.11%	-53.75%
- 3.09%	- 1.56%	-38.72%	-0.23%	2.68%	- 2.12%	2.19%	3.33%	- 36.12%	0.46%	2.90%	-31.01%
- 6.26%	- 4.86%	-18.86%	-1.96%	1.85%	- 0.62%	-0.61%	-0.07%	- 6.19%	- 1.05%	0.42%	1.93%
- 9.41%	- 5.94%	-15.13%	-3.14%	2.03%	- 0.49%	-1.73%	0.48%	-3.83%	- 2.69 %	- 0.17%	0.44%
- 9.11%	-3.93%	-14.93%	-0.86%	7.67%	-0.45%	1.15%	6.10%	- 2.56%	2.45%	8.17%	-1.47%
-11.10%	-5.55%	-22.25%	-0.49%	5.92%	0.07%	-1.51%	0.28%	-5.57%	-0.47%	-0.92%	-0.83%
-12.45%	-4.36%	-24.33%	-0.58%	6.48%	-0.98%	- 2.71%	0.11%	-10.63%	- 1.28%	-0.83%	- 6.0 6%
-10.11%	-3.10%	-15.24%	-0.21%	9.14%	-0.44%	-1.60%	2.68%	2.09%	-0.08%	3.87%	5.70%
-5.45%	- 2.91%	-24.85%	0.05%	6.15%	-0.42%	-1.34%	0.10%	-9.32%	-0.47%	- 0.96%	-4.43%
-9.38%	11.47%	-18.73%	0.17%	18.24%	-0.65%	4.18%	11.52%	- 2.67%	4.46%	9.01%	0.77%
-34.82%	-25.37%	- 20.54%	-0.40%	5.83%	0.14%	-21.07%	-18.46%	- 18.63%	- 13.59%	- 12.05%	- 13.91%
- 20.12 %	- 16.53%	-37.20%	-0.65%	4.08%	- 1.37%	-12.65%	- 12.26%	-33.01%	- 8.03 %	- 7.83 %	- 24.87%
- 3.0 6%	3.81%	- 13.67%	0.07%	13.03%	- 0.63%	8.06%	9.08%	2.20%	6.56%	6.89%	3.51%
-15.22%	-11.58%	-16.77%	-0.60%	6.13%	0.10%	-7.07%	-6.89%	-8.17%	-4.38%	- 4.26%	-3.01%
- 14.36 %	- 9.73%	-22.28%	-0.45%	6.88%	-0.34%	-6.53%	-5.52%	-14.98%	-4.02%	- 3.46%	-11.15%
- 7.0 4%	-5.11%	-18.58%	-0.10%	6.30%	-0.91%	0.72%	0.84%	- 8.89 %	0.81%	-0.88%	-7.51%
- 5.50%	- 1.65%	-11.55%	-0.20%	7.82%	- 1.01%	2.63%	3.40%	29.88%	2.09%	2.64%	31.90%
- 3.12%	-1.18%	-17.50%	-0.16%	7.33%	- 0.95%	4.20%	4.19%	- 9.55%	3.26%	3.28%	- 6.18%
-11.73%	2.60%	- 27.86 %	-0.37%	14.79%	-1.17%	-2.55%	3.03%	- 22.14%	-1.57%	1.64%	- 21.28%
-5.35%	- 2.40 %	- 28.57%	-0.16%	7.75%	-1.18%	5.25%	5.11%	- 10.79%	3.97%	3.91%	- 8.75 %
-3.43%	- 0.17%	-35.71%	-0.29%	7.99%	-4.39%	5.11%	5.18%	- 28.95%	3.92%	4.04%	- 27.66%
-1.32%	1.96%	-12.25%	0.58%	8.98%	0.03%	6.94%	7.09%	- 2.39%	5.13%	5.07%	0.37%
-1.07%	2.39%	25.93%	-0.16%	8.78%	-0.20%	6.90%	7.39%	- 3.76%	5.15%	5.30%	- 0.95 %
-1.19%	0.84%	-18.05%	0.14%	8.57%	- 0.58%	7.17%	7.14%	- 5.02%	5.30%	5.32%	- 2.60 %
- 2.22%	0.85%	- 27.02%	0.01%	8.52%	- 1.07%	6.57%	6.49%	- 18.30%	4.91%	4.94%	-15.77%
-1.73%	0.73%	-15.47%	-0.25%	8.42%	- 0.71%	7.30%	7.19%	0.80%	5.40%	5.34%	2.93%
-1.25%	0.67%	-29.52%	0.01%	8.66%	-0.44%	7.23%	7.29%	- 7.19%	5.36%	5.18%	- 4.63 %
- 3.46%	- 0.39%	-43.32%	-0.37%	7.75%	1.70%	7.40%	6.42%	7.03%	5.51%	4.87%	10.33%
- 3.0 6%	0.61%	- 24.51%	0.15%	8.94%	- 0.51%	7.37%	7.07%	5.78%	5.51%	4.55%	7.30%
0.99%	4.47%	-16.75%	25.30%	23.17%	24.80%	7.18%	5.98%	3.68%	5.53%	4.67%	5.92%



Table B.6	RSD of the Serpent macroscopic cross-sections at 33 energy groups for the FA
	axial reflectors, plenum and bottom plug zones.

B	Bottom plug			Plenum			Top reflector			Bottom reflector		
Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture	
3.79%	20.13%	15.64%	-14.58%	-16.05%	-1.69%	0.17%	19.81%	1.73%	0.00%	0.00%	0.00%	
0.91%	4.36%	4.07%	1.02%	0.66%	2.57%	0.40%	4.56%	1.88%	1.93%	30.42%	7.93%	
0.23%	1.73%	1.41%	-0.80%	- 1.38%	2.16%	0.09%	2.12%	0.97%	1.22%	14.02%	8.74%	
0.14%	0.74%	1.05%	0.75%	- 1.36%	3.81%	0.10%	0.76%	0.43%	0.56%	5.26%	2.95%	
0.14%	0.40%	0.44%	0.23%	- 2.68%	2.12%	0.07%	0.38%	0.05%	0.28%	1.40%	0.19%	
0.10%	0.28%	0.30%	1.96%	-1.85%	0.62%	0.04%	0.18%	0.16%	0.12%	0.56%	0.57%	
0.07%	0.17%	0.36%	3.14%	- 2.03%	0.49%	0.03%	0.06%	0.15%	0.08%	0.23%	0.57%	
0.11%	0.15%	0.43%	0.86%	-7.67%	0.45%	0.03%	0.05%	0.20%	0.05%	0.13%	0.36%	
0.05%	0.11%	0.45%	0.49%	-5.92%	-0.07%	0.02%	0.06%	0.18%	0.03%	0.07%	0.20%	
0.06%	0.09%	0.44%	0.58%	- 6.48%	0.98%	0.01%	0.04%	0.21%	0.02%	0.07%	0.35%	
0.08%	0.12%	0.73%	0.21%	- 9.14%	0.44%	0.02%	0.03%	0.30%	0.03%	0.06%	0.35%	
0.03%	0.09%	0.60%	-0.05%	-6.15%	0.42%	0.02%	0.04%	0.27%	0.03%	0.07%	0.52%	
0.09%	0.13%	0.61%	-0.17%	-18.24%	0.65%	0.03%	0.05%	0.28%	0.05%	0.08%	0.57%	
0.06%	0.11%	1.12%	0.40%	-5.83%	-0.14%	0.01%	0.04%	0.36%	0.01%	0.06%	0.48%	
0.05%	0.09%	0.60%	0.65%	-4.08%	1.37%	0.01%	0.04%	0.35%	0.02%	0.06%	0.47%	
0.13%	0.15%	0.27%	-0.07%	- 13.03 %	0.63%	0.02%	0.06%	0.07%	0.03%	0.06%	0.15%	
0.07%	0.13%	0.89%	0.60%	- 6.13%	-0.10%	0.00%	0.05%	0.52%	0.01%	0.04%	0.80%	
0.07%	0.10%	0.89%	0.45%	- 6.88 %	0.34%	0.01%	0.05%	0.61%	0.01%	0.05%	0.67%	
0.07%	0.10%	0.86%	0.10%	- 6.30 %	0.91%	0.00%	0.04%	0.32%	0.01%	0.06%	0.50%	
0.09%	0.14%	1.11%	0.20%	- 7.82%	1.01%	0.01%	0.05%	0.53%	0.01%	0.07%	0.65%	
0.09%	0.17%	0.50%	0.16%	-7.33%	0.95%	0.00%	0.06%	0.14%	0.00%	0.08%	0.17%	
0.23%	0.25%	0.57%	0.37%	-14.79%	1.17%	0.02%	0.07%	0.15%	0.03%	0.07%	0.20%	
0.12%	0.20%	0.33%	0.16%	-7.75%	1.18%	0.00%	0.06%	0.04%	0.00%	0.06%	0.05%	
0.18%	0.27%	0.53%	0.29%	-7.99%	4.39%	0.00%	0.06%	0.24%	0.00%	0.07%	0.24%	
0.23%	0.29%	0.69%	-0.58%	-8.98%	-0.03%	0.00%	0.09%	0.14%	0.00%	0.10%	0.13%	
0.19%	0.21%	1.32%	0.16%	-8.78%	0.20%	0.01%	0.07%	0.37%	0.01%	0.06%	0.52%	
0.17%	0.32%	0.36%	-0.14%	-8.57%	0.58%	0.00%	0.09%	0.02%	0.00%	0.09%	0.02%	
0.24%	0.39%	0.61%	-0.01%	-8.52%	1.07%	0.00%	0.10%	0.02%	0.00%	0.09%	0.02%	
0.26%	0.43%	0.57%	0.25%	- 8.42%	0.71%	0.00%	0.11%	0.02%	0.00%	0.08%	0.02%	
0.30%	0.57%	0.66%	-0.01%	-8.66%	0.44%	0.00%	0.10%	0.05%	0.00%	0.11%	0.03%	
0.30%	0.42%	0.97%	0.37%	-7.75%	-1.70%	0.00%	0.10%	0.18%	0.00%	0.08%	0.15%	
1.71%	2.09%	3.75%	-0.15%	-8.94%	0.51%	0.02%	0.32%	0.54%	0.01%	0.23%	0.33%	
11.49%	15.25%	24.77%	-25.30%	- 23.17%	-24.80%	0.21%	2.83%	2.42%	0.10%	1.15%	1.49%	



Table B.7Relative difference [%] between Serpent and ECCO macroscopic cross-sections
at 33 energy groups for the CR and SR absorbing bundles, the CR follower and dummy zones.(Serpent - ECCO) / ECCO

Co	ntrol rod	B₄C	Cont	rol rod fol	lower	Safe	ety rod I	B₄C	-	Dummy		
Total	Transport	Capture	Total	Transport	Capture	Total	Transport	Capture	-	Total	Transport	Capture
0.11%	-0.97%	-4.48%	-0.62%	0.23%	-8.03%	1.87%	-1.52%	-6.26%	-	0.66%	0.67%	-0.45%
0.28%	0.01%	-4.24%	0.87%	0.09%	-13.16%	-0.24%	-0.65%	-11.70%		1.51%	1.07%	- 2.68%
0.82%	0.78%	-4.49%	0.89%	0.55%	- 16.90%	0.24%	0.21%	-9.25%		1.10%	1.25%	-4.44%
-0.57%	-0.68%	-5.94%	0.15%	0.52%	- 29.0 4%	-1.26%	-1.30%	-8.62%		0.08%	0.51%	-1.05%
-1.12%	-0.82%	-7.56%	-0.85%	-0.31%	-12.29%	- 2.44 %	-1.46%	-10.16%		0.32%	0.81%	- 0.21%
- 2.62%	-1.30%	- 6.21%	- 2.6 4%	1.85%	- 6.06%	-4.49%	-3.46%	-8.04%		-1.02%	1.35%	0.68%
-4.85%	-1.87%	-6.69%	-2.26%	-0.02%	-3.15%	-6.46%	-3.48%	-7.53%		-1.15%	0.34%	0.57%
-5.79%	0.44%	-11.65%	-2.03%	6.43%	-3.49%	-7.20%	-0.52%	-15.01%		-0.31%	4.72%	0.47%
-4.89%	-0.75%	-11.19%	-1.55%	1.38%	-4.98%	- 6.98 %	- 2.0 6%	-13.76%		0.02%	2.38%	0.46%
-4.92%	-1.97%	-12.35%	-1.44%	0.95%	-4.92%	- 7.09 %	-2.38%	-13.79%		-0.16%	2.49%	0.08%
- 3.90 %	-1.27%	-12.82%	-0.96%	2.03%	- 2.5 1%	- 6.76 %	-3.05%	-15.63%		0.34%	4.02%	0.79%
- 3.8 6%	-2.27%	-15.52%	-0.98%	2.56%	-4.88%	-5.78%	-4.08%	-17.50%		0.59%	3.41%	0.49%
-4.41%	0.71%	-17.30%	-0.76%	4.97%	-5.65%	-4.61%	5.31%	-20.45%		0.39%	9.71%	-0.15%
-14.08%	-11.52%	-25.90%	-6.66%	-1.59%	-4.31%	-27.10%	-22.66%	-30.54%		0.52%	5.77%	2.74%
-10.64%	-8.68%	-22.64%	-5.71%	- 2.8 4%	- 9.11%	-20.36%	-16.96%	- 20.86%		0.32%	2.13%	0.07%
-5.74%	-1.77%	-28.96%	-1.52%	4.51%	-1.18%	-2.52%	8.24%	-29.76%		- 0.11%	5.83%	0.28%
-14.44%	-10.95%	-35.43%	-5.16%	-0.55%	-3.65%	-18.31%	-12.50%	-35.87%		0.21%	3.28%	0.33%
-17.42%	-11.81%	-39.69%	-4.63%	1.53%	-0.13%	-18.24%	-12.14%	-37.82%		0.51%	4.48%	1.55%
-17.46%	-9.89%	-41.23%	-2.43%	-0.21%	-6.43%	-12.59%	- 9.21%	-37.26%		0.16%	1.75%	-4.53%
-19.66%	-8.25%	-44.77%	-2.34%	-1.17%	-2.65%	-11.95%	-5.98%	-40.43%		0.13%	1.70%	-8.05%
- 20.6 1%	-6.75%	-47.45%	-1.92%	-0.37%	-5.57%	-10.47%	-5.14%	-41.80%		0.15%	1.78%	-5.14%
-22.72%	-5.84%	-49.69%	-6.10%	-1.35%	- 23.81%	-16.48%	-0.08%	-46.57%		0.67%	7.16%	1.86%
- 20.77 %	-4.67%	-47.27%	- 2.15 %	1.33%	4.53%	-10.54%	-4.48%	- 36.51%		-0.59%	2.64%	-13.31%
-19.61%	-3.84%	-46.47%	-2.34%	-1.14%	-36.52%	-10.07%	- 2.77%	-40.67%		0.05%	1.74%	-4.18%
-10.15%	-1.88%	-29.70%	-1.89%	-0.91%	-23.29%	-6.81%	-0.48%	-36.69%		0.10%	1.70%	0.83%
-17.14%	5.99%	-42.34%	-2.08%	-0.93%	-25.96%	-6.37%	0.29%	-27.21%		0.19%	2.08%	7.15%
-15.70%	-0.02%	-40.64%	-1.81%	-0.82%	-23.37%	- 6.73 %	-0.83%	-32.24%		0.07%	1.72%	0.08%
- 8.72 %	0.46%	- 26.31%	-2.04%	-0.98%	- 30.51%	-6.43%	-1.19%	-29.38%		0.05%	1.73%	-0.60%
-8.51%	1.52%	- 26.91%	-1.80%	-0.73%	- 20.56%	-5.30%	-0.40%	-33.81%		0.07%	1.76%	-0.16%
-18.67%	0.96%	-45.17%	-1.80%	- 0.81%	- 23.47%	-7.44%	- 0.69%	-44.82%		0.08%	1.78%	1.78%
0.55%	4.75%	6.90%	-1.73%	- 2.36 %	-17.24%	-6.43%	- 2.58%	-16.67%		0.14%	0.55%	9.70%
4.17%	5.90%	19.82%	-2.31%	- 2.95 %	- 22.08%	-6.71%	- 2.86 %	-15.63%		-0.03%	0.51%	2.06%
5.02%	10.04%	16.87%	-1.44%	0.37%	- 16.93 %	-7.12%	2.91%	-21.78%		-0.56%	0.71%	-4.08%



Table B.8	RSD of the Serpent macroscopic cross-sections at 33 energy groups for the CR
	and SR absorbing bundles, the CR follower and dummy zones.

Со	Control rod B ₄ C			Control rod follower			Safety rod				Dummy rod		
Total	Transport	Capture	Total	Transport	Capture		Total	Transport	Capture	Tot	al	Transport	Capture
0.20%	2.21%	1.81%	0.07%	0.63%	0.39%		1.38%	5.24%	5.45%	0.06	5%	0.33%	0.41%
0.11%	0.49%	0.50%	0.02%	0.10%	0.10%		0.31%	1.44%	2.08%	0.02	%	0.07%	0.09%
0.04%	0.23%	0.22%	0.01%	0.05%	0.07%		0.16%	0.66%	1.09%	0.01	%	0.05%	0.06%
0.01%	0.09%	0.15%	0.01%	0.02%	0.03%		0.04%	0.33%	0.68%	0.00)%	0.02%	0.03%
0.02%	0.07%	0.08%	0.00%	0.02%	0.01%		0.04%	0.12%	0.28%	0.00)%	0.01%	0.02%
0.02%	0.03%	0.05%	0.01%	0.01%	0.01%		0.03%	0.07%	0.18%	0.01	%	0.01%	0.01%
0.02%	0.02%	0.05%	0.00%	0.01%	0.01%		0.02%	0.05%	0.08%	0.00)%	0.01%	0.01%
0.02%	0.02%	0.04%	0.01%	0.01%	0.02%		0.03%	0.04%	0.10%	0.00)%	0.01%	0.02%
0.01%	0.02%	0.04%	0.00%	0.00%	0.01%		0.03%	0.03%	0.08%	0.00)%	0.00%	0.01%
0.01%	0.02%	0.03%	0.00%	0.01%	0.02%		0.02%	0.03%	0.07%	0.00)%	0.00%	0.01%
0.01%	0.02%	0.04%	0.00%	0.01%	0.02%		0.02%	0.03%	0.08%	0.00)%	0.00%	0.02%
0.01%	0.02%	0.03%	0.00%	0.00%	0.03%		0.01%	0.03%	0.08%	0.00)%	0.00%	0.01%
0.02%	0.02%	0.05%	0.01%	0.01%	0.03%		0.04%	0.04%	0.12%	0.00)%	0.00%	0.02%
0.02%	0.02%	0.05%	0.00%	0.01%	0.04%		0.02%	0.03%	0.08%	0.00)%	0.00%	0.02%
0.03%	0.03%	0.09%	0.00%	0.01%	0.04%		0.02%	0.04%	0.13%	0.00)%	0.00%	0.02%
0.04%	0.05%	0.09%	0.01%	0.01%	0.04%		0.06%	0.08%	0.17%	0.00)%	0.00%	0.02%
0.03%	0.05%	0.09%	0.00%	0.01%	0.05%		0.03%	0.04%	0.16%	0.00)%	0.00%	0.03%
0.04%	0.04%	0.14%	0.00%	0.01%	0.06%		0.04%	0.06%	0.22%	0.00)%	0.00%	0.02%
0.04%	0.05%	0.13%	0.00%	0.01%	0.10%		0.04%	0.06%	0.22%	0.00)%	0.00%	0.03%
0.05%	0.06%	0.14%	0.00%	0.01%	0.23%		0.05%	0.06%	0.24%	0.00)%	0.01%	0.05%
0.09%	0.10%	0.22%	0.01%	0.01%	0.09%		0.05%	0.06%	0.20%	0.00)%	0.00%	0.03%
0.08%	0.09%	0.20%	0.01%	0.02%	0.07%		0.09%	0.09%	0.35%	0.00)%	0.01%	0.01%
0.05%	0.07%	0.18%	0.01%	0.02%	0.11%		0.08%	0.08%	0.27%	0.00)%	0.00%	0.03%
0.10%	0.10%	0.27%	0.01%	0.03%	0.22%		0.07%	0.08%	0.30%	0.00)%	0.00%	0.02%
0.13%	0.13%	0.37%	0.02%	0.05%	0.14%		0.10%	0.11%	0.38%	0.00)%	0.01%	0.03%
0.10%	0.12%	0.27%	0.02%	0.05%	0.33%		0.08%	0.10%	0.32%	0.00)%	0.01%	0.04%
0.12%	0.12%	0.33%	0.02%	0.06%	0.16%		0.09%	0.13%	0.34%	0.00)%	0.01%	0.02%
0.14%	0.17%	0.39%	0.03%	0.07%	0.16%		0.10%	0.13%	0.40%	0.00)%	0.01%	0.02%
0.12%	0.14%	0.38%	0.04%	0.08%	0.29%		0.13%	0.10%	0.51%	0.01	%	0.01%	0.02%
0.18%	0.22%	0.47%	0.04%	0.07%	0.24%		0.11%	0.14%	0.52%	0.00)%	0.01%	0.02%
0.13%	0.13%	0.31%	0.05%	0.06%	0.35%		0.09%	0.12%	0.37%	0.00)%	0.01%	0.01%
0.69%	0.67%	1.61%	0.13%	0.24%	0.85%		0.36%	0.46%	1.33%	0.01	%	0.01%	0.03%
4.49%	4.07%	10.15%	0.83%	1.10%	4.57%	;	2.58%	2.83%	10.88%	0.04	%	0.06%	0.15%



Table B.9Relative difference [%] between Serpent and ECCO macroscopic cross-sections
at 33 energy groups for the barrel (SS and Pb mix) and external lead regions.

(Serpent - ECCO) / ECCO

	Barrel		E	External lead				
Total	Transport	Capture	Total	Transport	Capture			
5.23%	1 3.8 1%	-8.53%	-0.15%	0.97%	-4.58%			
6.02%	4.07%	- 35.45%	0.46%	0.39%	- 2.03 %			
3.91%	4.17%	- 58.59%	-0.09%	0.07%	- 0.44%			
1.55%	4.28%	- 61.62%	0.73%	- 0.37%	0.18%			
1.86%	3.23%	- 42.66 %	1.58%	2.28%	-0.03%			
- 1.06%	- 0.72%	- 12.90%	-1.41%	0.33%	5.09%			
- 2.85%	- 0.58%	- 8.39%	-1.88%	2.38%	5.63%			
-1.38%	3.50%	- 7.4 4%	3.15%	10.80%	2.21%			
- 3.60 %	- 0.36%	- 12.54%	-0.48%	0.60%	4.57%			
- 5.85%	- 1.26%	- 17.57%	0.23%	2.19%	6.17%			
- 5.23%	-0.35%	-4.03%	3.45%	7.24%	1 7.83%			
- 2.54%	- 0.89%	- 18.47%	0.93%	2.87%	8.72%			
2.38%	14.57%	- 9.58%	0.97%	1.93%	27.37%			
- 31.69%	- 27.26 %	- 26.43%	0.06%	0.45%	3.50%			
- 19.35%	- 18.52%	- 40.90%	0.03%	0.13%	5.34%			
7.15%	8.88%	-1.73%	0.05%	0.17%	2.86%			
- 12.08%	- 11.80 %	- 12.77%	0.12%	0.26%	40.85%			
- 10.92%	- 9.44%	- 23.16%	0.08%	0.35%	7.79%			
- 1.33%	- 1.16%	- 16.04%	0.06%	0.37%	7.22%			
1.27%	2.70%	10.20%	0.01%	-0.01%	0.54%			
3.72%	3.74%	- 11.89%	0.01%	0.03%	5.99%			
- 4.80 %	3.95%	- 22.92%	0.00%	0.00%	0.10%			
4.66%	4.71%	-15.76%	0.02%	0.02%	1.87%			
4.59%	4.79%	-33.87%	0.00%	0.00%	0.81%			
7.27%	7.20%	- 5.7 1%	0.00%	0.01%	0.40%			
7.31%	7.83%	-1.19%	0.00%	0.01%	0.75%			
7.55%	7.48%	- 9.31%	0.00%	0.01%	1.22%			
6.64%	6.63%	- 22.70%	0.00%	-0.01%	0.79%			
7.70%	7.63%	- 3.5 1%	0.00%	0.02%	0.75%			
7.61%	7.54%	- 9.48%	0.00%	0.00%	0.97%			
7.96%	6.97%	11.42%	0.01%	-0.32%	4.88%			
7.71%	6.75%	3.94%	-0.03%	- 0.34%	- 4.71%			
6.34%	5.54%	-5.55%	-0.08%	-0.60%	- 4.50 %			



	Barrel		External lead				
Total	Transport	Capture	Total	Transport	Capture		
0.10%	3.22%	0.56%	0.02%	0.51%	0.47%		
0.08%	0.66%	0.40%	0.01%	0.15%	0.03%		
0.03%	0.43%	0.23%	0.00%	0.07%	0.01%		
0.02%	0.13%	0.12%	0.00%	0.03%	0.00%		
0.02%	0.07%	0.02%	0.00%	0.02%	0.00%		
0.01%	0.05%	0.03%	0.00%	0.02%	0.03%		
0.01%	0.02%	0.04%	0.00%	0.01%	0.04%		
0.00%	0.01%	0.04%	0.00%	0.01%	0.04%		
0.00%	0.01%	0.04%	0.00%	0.01%	0.03%		
0.00%	0.01%	0.04%	0.00%	0.01%	0.04%		
0.00%	0.01%	0.05%	0.00%	0.00%	0.05%		
0.00%	0.01%	0.04%	0.00%	0.00%	0.06%		
0.01%	0.01%	0.04%	0.00%	0.01%	0.05%		
0.00%	0.01%	0.06%	0.00%	0.00%	0.10%		
0.00%	0.01%	0.03%	0.00%	0.01%	0.08%		
0.00%	0.00%	0.01%	0.00%	0.01%	0.05%		
0.00%	0.00%	0.04%	0.00%	0.01%	0.16%		
0.00%	0.01%	0.05%	0.00%	0.01%	0.10%		
0.00%	0.00%	0.04%	0.00%	0.01%	0.06%		
0.00%	0.00%	0.05%	0.00%	0.01%	0.00%		
0.00%	0.00%	0.01%	0.00%	0.01%	0.08%		
0.00%	0.01%	0.01%	0.00%	0.01%	0.00%		
0.00%	0.00%	0.00%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.02%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.01%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.02%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.00%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.00%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.00%	0.00%	0.01%	0.00%		
0.00%	0.01%	0.00%	0.00%	0.01%	0.01%		
0.00%	0.01%	0.01%	0.00%	0.01%	0.03%		
0.00%	0.02%	0.02%	0.00%	0.02%	0.05%		
0.01%	0.08%	0.08%	0.01%	0.12%	0.30%		

Table B.10RSD of the Serpent macroscopic cross-sections at 33 energy groups for the
barrel (SS and Pb mix) and external lead regions.



Appendix C: Axial flux distributions within core (full data set)

The following graphs (Figs. C.1-C.8) report the axial flux traverses calculated by ERANOS and Serpent along the directions Cut 1 and Cut 2 (see Fig. 6.1) with the CRs and SRs completely inserted and withdrawn. The black lines represent the boundary of the 60 cm fissile length.



Figure C.1 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 1 with both CR and SR completely withdrawn.



Figure C.2 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 2 with both CR and SR completely withdrawn.





Figure C.3 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 1 with the CR completely inserted and SR completely withdrawn.



Figure C.4 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 2 with the CR completely inserted and SR completely withdrawn.





Figure C.5 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 1 with the SR completely inserted and CR completely withdrawn.



Figure C.6 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 2 with the SR completely inserted and CR completely withdrawn.

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EVEV	Centro Ricerche Saluggia	SICNUC – P000 – 037	0	R	91	200



Figure C.7 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 1 with both CR and SR completely inserted.



Figure C.8 ERANOS and Serpent axial flux traverses in the assembly positions along Cut 2 with both CR and SR completely inserted.

As remarked in §6.4, the depression of the flux caused by the CR and/or SR insertion results decisively higher with ERANOS, reflecting the effect of the ~10% higher calculated anti-reactivity worth of the shutdown systems in comparison with the Serpent results.



Appendix D: The ECCO / ERANOS input files

D.1 ECCO input files for fissile zones

In the following it is reported the ECCO input – written in the "Langage Utilisateur" (LU) adopted in the ERANOS system - used to create the "reference" macroscopic cross-sections of the fuel inner cell at 33 energy groups with a 2D heterogeneous geometry model. The input for the fuel outer is identical, by the exception of the lines written in red.

PROCEDURE ->ECCO_FUEL; !----- Arricchimenti in Pu, B10 e AM ------->AM_SU_PU 0.013; 0.2110565 ; !ENRICHISS INIZIALE in Pu vol.% ->ENR_INN ->ENR OUT 0.2709639 ; !ENRICHISS INIZIALE in Pu vol.% ! !----- Geometrie varie di uso pratico ------->R_HOLL 0.100; ->R FUEL 0.450 ; 0.015; ->S_GAP ->R_GAP (R_FUEL+S_GAP); ->S_CLAD 0.060; ->R_CLAD (R_GAP+S_CLAD); ! !----- Densita' e porosita' per uso pratico ------->PRACT_DENS 0.95; ! Densita' pratica del combustibile ->FIL_DENS ((R_FUEL**2-R_HOLL**2)/(R_GAP**2)); ! Densità nel gap **CREATION MILIEU ->MIL 20** REFERENCE_UNIT 'JECCOLIB_JEFF_31.REF' **TEMPERATURE INITIALE 20.0** 1 MATERIAUX !_____ MATERIAU_SIMPLE 'PIOMBO' CALOPORTEUR POURCENTAGE_EN_POIDS 11.017 !g/cm^3 CORPS 'Pb204' 1.42 'Pb206' 24.10 'Pb207' 22.10 'Pb208' 52.38 MATERIAU_SIMPLE 'T91' STRUCTURE POURCENTAGE_EN_POIDS 7.7359 !g/cm^3 CORPS 'C0' 0.1 'Si28' (0.5*0.9187) 'Si29' (0.5*0.0483) 'Si30' (0.5*0.033) 'V0' 0.2 'Cr52' (9.0*0.837) 'Cr50' (9.0*0.0418) 'Cr53' (9.0*0.0967) 'Cr54' (9.0*0.0245) 'Mn55' 0.6 'Fe54' (88.3*0.0565) 'Fe56' (88.3*0.919) 'Fe57' (88.3*0.0216) 'Fe58' (88.3*0.0029) 'Ni58' (0.2*0.672) 'Ni60' (0.2*0.2678) 'Ni61' (0.2*0.0118) 'Ni62' (0.2*0.0383) 'Ni64' (0.2*0.0101) 'Nb93' 0.1 'Mo92' (1.0*0.1484) 'Mo94' (1.0*0.0925) 'Mo95' (1.0*0.1592) 'Mo96' (1.0*0.1668) 'Mo97' (1.0*0.0955) 'Mo98' (1.0*0.2413) 'Mo100' (1.0*0.0963)



```
MATERIAU_SIMPLE '1515TI' STRUCTURE
 POURCENTAGE_EN_POIDS 7.95 !g/cm^3
  CORPS
   'C0' 0.09 'Si28' (0.85*0.9187) 'Si29' (0.85*0.0483) 'Si30' (0.85*0.033)
         0.03 'Cr52' (14.5*0.837) 'Cr50' (14.5*0.0418) 'Cr53' (14.5*0.0967)
   'V0'
   'Cr54' (14.5*0.0245) 'Mn55' 1.5 'Fe54' (65.354*0.0565) 'Fe56' (65.354*0.919)
   'Fe57' (65.354*0.0216) 'Fe58' (65.354*0.0029) 'Ni58' (15.5*0.672) 'Ni60' (15.5*0.2678)
   'Ni61' (15.5*0.0118) 'Ni62' (15.5*0.0383) 'Ni64' (15.5*0.0101) 'Nb93' 0.015
   'Mo92' (1.5*0.1484) 'Mo94' (1.5*0.0925) 'Mo95' (1.5*0.1592)
   'Mo96' (1.5*0.1668) 'Mo97' (1.5*0.0955) 'Mo98' (1.5*0.2413) 'Mo100' (1.5*0.0963)
   'Ti46' (0.4*0.0825) 'Ti47' (0.4*0.0744) 'Ti48' (0.4*0.7372) 'Ti49' (0.4*0.0541)
   'Ti50' (0.4*0.0518) 'B10' (0.006*0.199) 'B11' (0.006*0.801) 'P31' 0.045
   'N14' (0.015*0.99632) 'N15' (0.015*0.00368) 'S32' (0.015*0.9493)
   'S33' (0.015*0.0076) 'S34' (0.015*0.0429) 'S36' (0.015*0.0002) 'Al27' 0.015
   'Zr90' (0.03*0.5145) 'Zr91' (0.03*0.1122) 'Zr92' (0.03*0.1715)
   'Zr94' (0.03*0.1738) 'Zr96' (0.03*0.0280)! 'W180' (0.03*0.0012)
   'W182' (0.03*0.26532) 'W183' (0.03*0.14327) 'W184' (0.03*0.30677)
   'W186' (0.03*0.28464) 'Ta181' 0.015 'Cu63' (0.03*0.6917) 'Cu65' (0.03*0.3083)
   'Co59' 0.03 'Ca40' (0.03*0.96945) 'Ca42' (0.03*0.00647)
                                                                'Ca43' (0.03*0.00135)
   'Ca44' (0.03*0.02086)! 'Ca46' (0.03*0.00004) 'Ca48' (0.03*0.00187)
MATERIAU_SIMPLE 'COMB_INN' COMBUSTIBLE
 FORMULE_MOLECULAIRE 10.494
  ELEMENT CIP 0.78299087
   'U234' 0.003000194904
   'U235' 0.404162518132
   'U236' 0.010002296764
   'U238' 99.582834990200
  ELEMENT CIP 0.21700913
   'Pu238' 2.301581154003
   'Pu239' 56.136812325802
   'Pu240' 26.650590345084
   'Pu241' 6.026944416127
   'Pu242' 7.593331097559
   'Am241' 1.290740661425
  ELEMENT CIA 1.97
   'O16' 100.0
MATERIAU_SIMPLE 'COMB_OUT' COMBUSTIBLE
 FORMULE MOLECULAIRE 10.513
   ELEMENT CIP 0.72203820
   'U234' 0.002999447021
   'U235' 0.403941574675
   'U236' 0.009996781937
   'U238' 99.583062196367
   ELEMENT CIP 0.27796180
   'Pu238' 2.301764074405
   'Pu239' 56.139989750890
   'Pu240' 26.646602344285
   'Pu241' 6.026447182106
   'Pu242' 7.594582799311
   'Am241' 1.290613849003
  ELEMENT CIA 1.97
   'O16' 100.0
```



!_____ L MILIEUX

!-----

!=== Combustibile Inner ================== !==== diluito nel Gap (FIL_DENS) ========== MILIEU 'M_FUEINN' 'COMB_INN' (100.0*(FIL_DENS))

MILIEU 'M_FUEOUT' 'COMB_OUT' (100.0*(FIL_DENS))

MILIEU 'M_PIOMB1' 'PIOMBO' 100.0 MILIEU 'M_CALO_1' 'PIOMBO' 100.0 MILIEU 'M_CALO_2' 'PIOMBO' 100.0 MILIEU 'M_CLAD_1' '1515TI' 100.0 MILIEU 'M_WRAP_1'

!_____

```
1
     CELLULE
```

```
'T91' 100.0
```

```
!-----
```

```
!===== CELLULE ETEROGENEE =======
```

```
!==== FUEL INNER
CELLULE 'FINN'
RANGEMENT_COMPOSITION
 'M_FUEINN' 'M_CLAD_1' 'M_WRAP_1' 'M_CALO_1' 'M_PIOMB1' 'M_CALO_2'
GEOMETRY DATA
 HEXAGON 3
  15.80
   HEXAGONAL LATTICE
    7 1.386
    1
     CYL 2
      0.465 REGION 1 'COMB_INN' COMP 1 293.16
      0.525 REGION 2 'CLADDING' COMP 2 293.16
      IN REGION 3 'PB_AR_CL' COMP 4 293.16
    1111111
   IN
          REGION 4 'BB_LEADA' COMP 6 293.16
  16.60
         REGION 5 'SWRAPPER' COMP 3 293.16
  17.10
         REGION 6 'PB_FALIK' COMP 5 293.16
 REFLECT
END OF GEOMETRY DATA
```



```
!==== FUEL OUTER
CELLULE 'FOUT'
RANGEMENT_COMPOSITION
 'M_FUEOUT' 'M_CLAD_1' 'M_WRAP_1' 'M_CALO_1' 'M_PIOMB1' 'M_CALO_2'
GEOMETRY DATA
 HEXAGON 3
  15.80
   HEXAGONAL LATTICE
   7 1.386
   1
    CYL 2
     0.465 REGION 1 'COMB_OUT' COMP 1 293.16
     0.525 REGION 2 'CLADDING' COMP 2 293.16
     IN REGION 3 'PB_AR_CL' COMP 4 293.16
   1111111
   IN
        REGION 4 'BB_LEADA' COMP 6 293.16
  16.60
        REGION 5 'SWRAPPER' COMP 3 293.16
  17.10
        REGION 6 'PB_FALIK' COMP 5 293.16
 REFLECT
END OF GEOMETRY DATA ;
!EDITION_MILIEU (MIL_20);
->T_CLAD (460.0+273.16);
->T_HOT (450.0+273.16);
->T_MEDIA (440.0+273.16);
->T_OUT (480.0+273.16);
->T_FUEL (900.0+273.16);
->T_IN (400.0+273.16);
!______
!
     DEBUT DES CALCULS CELLULES ECCO
ECCO
MILIEU (MIL_20)
REFERENCE_UNIT 'JECCOLIB_JEFF_31.REF'
! CELLULE FINN /FOUT HET
CELLULE 'FINN' / 'FOUT'
 EDITION MOYENNE
 'FUEL INNER HET' / 'FUEL OUTER HET'
 TEMPERATURE
  1 (T_FUEL)
  2 (T_CLAD)
```

```
3 (T_MEDIA)
4 (T_MEDIA)
5 (T_MEDIA)
```

6 (T_MEDIA)



STEPS 6 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 **BSEARCH 1.0** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING NODBBSH OUTPUT LIBRARY 'FINN_172G_HOM_JEFF31'/ OUTPUT LIBRARY 'FOUT_172G_HOM_JEFF31' CROSS SECTIONS FLUXES STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB JEFF 31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING NODBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **FI EMENTS 81** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'O16' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Zr93' 'Tc99' 'I129' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' Pb204' 'Pb206' 'Pb207' 'Pb208' 'U234' 'U235' 'U236' 'U238' 'Pu238' 'Pu239' 'Pu240' 'Pu241' 'Pu242' 'Am241' 'U233' 'Np237' 'Np239' 'Am243' 'Am242m' 'Cm242' 'Cm243' 'Cm244' 'Cm245' 'Cm246' 'Cm247' 'Cm248' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 **BFROM 1** SELF SHIELDING NODBBSH LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP GEOMETRY ORIGINAL



```
GROUP STRUCTURE OTHER 33
 FLUX SOLUTION CP P1 CONSISTENT ORDER 1
 BSEARCH 1.0
 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN
 SELE SHIELDING NODBBSH
 PROFILE COLLISION PROBABILITIES ROTH 6
STEP
 HOMOGENISE
 GEOMETRY HOMOGENEOUS
 GROUP STRUCTURE OTHER 33
 FLUX SOLUTION FM P1 CONSISTENT ORDER 1
 BFROM 4
 OUTPUT LIBRARY 'FINN_HH_33G_JEFF31' / OUTPUT LIBRARY 'FOUT_HH_33G_JEFF31'
  CROSS SECTIONS FLUXES
 PRINT DATA FLUXES
  CROSS SECTIONS MACROSCOPIC VECTORS
STEP
 GEOMETRY HOMOGENEOUS
 GROUP STRUCTURE OTHER 33
 FLUX SOLUTION FM P1 CONSISTENT ORDER 1
 BUCKLING 0.0
ENDSTEPS;
```

FINPROC ;

Besides the reference input reported before, other ECCO calculation options were adopted for the fuel inner and outer cells (see §3.2 and §A.8). For the calculations with the P₁ inconsistent and B₁ consistent/inconsistent options, the instruction "FLUX SOLUTION FM/CP P1 CONSISTENT ORDER 1" for homogeneous/heterogeneous cell geometries, respectively (FM = Fundamental Mode; CP = Collision Probabilities) was replaced by;

- FLUX SOLUTION FM/CP P1 INCONSISTENT ORDER 1
- FLUX SOLUTION FM/CP B1 CONSISTENT/INCONSITENT ORDER 1

The reference macroscopic cross-sections were created with a 33 energy-group-structure (see Table 3.1), but also with the more refined structure at 80 groups (see Table 3.2). In the latter case the group numbers reported in the last column of Table 3.2 have to be replaced in the "CONDENSE" instructions of the previous ECCO input.

D.2 ECCO input files for non-fissile zones

In the following it is reported the "reference" ECCO input for the cells representing the non-fissile zones. As weighting function, the fuel inner and outer spectra at 172 groups (evaluated by a homogeneous geometry model in the first step of the ECCO routine; see §D.1) were adopted. The lines written in red abbreviate the MILIEU definitions for the media having the same materials compositions that have to be used with a different name in the different cells for the ECCO/ERANOS code programming rules.

PROCEDURE -> ECCO_SUB ;

->ENR_B4C 0.900 ; !ARRICCHIMENTO DEL BORO IN B10 at.% !------ Geometrie varie di uso pratico ------->R_HOLL 0.100 ; ->R_FUEL 0.450 ;



->S_GAP 0.015; ->R_GAP (R_FUEL+S_GAP); ->S_CLAD 0.060; ->R CLAD (R_GAP+S_CLAD); ! !----- Densita' e porosita' per uso pratico ------->PRACT_DENS 0.95; ! Densita' pratica del combustibile ->FIL_DENS ((R_FUEL**2-R_HOLL**2)/(R_GAP**2)); ! Densità nel gap ->THI_DENS 0.9365245 ; ! Filling density isolante nel clad della fuel pin ->SPR_DENS 0.07594 ; ! Filling density molla nel plenum della fuel pin ->PLE_DENS 0.07559; ! Filling density tubo nel plenum della fuel pin ->ABS_DENS 0.94703; ! Filling density assorbitore nel gap ->THA_DENS 0.94703 ; ! Filling density isolante nel clad della abs pin !====== DEFINIZIONI DELLE CELLE ======= CREATION_MILIEU ->MIL_20 REFERENCE_UNIT 'JECCOLIB_JEFF_31.REF' **TEMPERATURE_INITIALE 20.0** 1_____ 1 MATERIAUX !_____ MATERIAU_SIMPLE 'PIOMBO' CALOPORTEUR POURCENTAGE_EN_POIDS 11.017 !g/cm^3 CORPS 'Pb204' 1.42 'Pb206' 24.10 'Pb207' 22.10 'Pb208' 52.38 MATERIAU_SIMPLE 'T91' STRUCTURE (see ECCO for fuel) MATERIAU_SIMPLE '1515TI' STRUCTURE (see ECCO for fuel) MATERIAU_SIMPLE 'B4C_ARR' ABSORBANT FORMULE_MOLECULAIRE 2.2 **ELEMENT CIA 4** 'B10' (100.0*(ENR_B4C)) 'B11' (100.0*(1-(ENR_B4C))) **ELEMENT CIA 1** 'C0' 100.0 MATERIAU_SIMPLE 'REFL' STRUCTURE POURCENTAGE_EN_POIDS 6.0 CORPS 'O16' 25.7226 'Y89' 4.0162 'Zr90' 35.6267 'Zr91' 7.8558 'Zr96' 2.0683 'Zr92' 12.1398 'Zr94' 12.5705 MATERIAU_SIMPLE 'VOID' CALOPORTEUR NOMBRE_D_ATOMES CORPS



'Pb208' 1.0E-15 !PART/CM BARN

!
! MILIEUX
!======================================
MILIEU 'M_TTHINS' 'REFL' (100.0*(THI_DENS))
MILIEU 'M_BTHINS' 'REFL' (100.0*(THI_DENS))
MILIEU 'M_SPRING' '1515TI' (100.0*(SPR_DENS))
MILIEU 'M_PLENUM' '1515TI' (100.0*(PLE_DENS))
MILIEU 'M_TOPLUG' '1515TI' 85.00 'PIOMBO' 15.00
MILIEU 'M_BOPLUG' '1515TI' 90.00 'PIOMBO' 10.00
MILIEU 'M_B4C' 'B4C_ARR' (100.0*(ABS_DENS))
MILIEU 'M_FOLLOW' 'REFL' (100.0*(THA_DENS))
MILIEU 'M_REFL' 'REFL' (100.0*(THI_DENS))
MILIEU 'M_TOPREF' '1515TI' 20.00 'PIOMBO' 80.00
MILIEU 'M_BOTREF' '1515TI' 12.00 'PIOMBO' 88.00
MILIEU 'M_BARREL' '1515TI' 33.80 'PIOMBO' 66.20
MILIEU 'M_ZEXT' 'PIOMBO' 100.0
MILIEU 'M_PIOMBO' 'PIOMBO' 100.0

MILIEU 'M_PIOMB1' / 'M_PIOMB2 - M-PIOM26'



'PIOMBO' 100.0
MILIEU 'M_CLAD' '1515TI' 100.0
MILIEU 'M_CLAD1'/ 'M_CLAD2 – M_CLAD11' '1515TI' 100.0
MILIEU 'M_WRAP' 'T91' 100.0
MILIEU 'M_WRAP1' / 'M_WRAP2 – M_WRAP11' 'T91' 100.0
MILIEU 'M_VOID'/ 'M_VOID1' 'VOID' 100.0
!=====================================
!==== BOTTOM THERMAL INSULATOR CELLULE 'BTHINS' RANGEMENT_COMPOSITION 'M_BTHINS' M_CLAD2' 'M_WRAP2' 'M_PIOMB6' 'M_PIOMB7' GEOMETRY DATA HEXAGON 3 15.80 HEXAGONAL LATTICE 7 1.386 1 CYL 2 0.465 REGION 1 'BTHINS' COMP 1 293.16 0.525 REGION 2 'CLAD' COMP 2 293.16 IN REGION 3 'CALO1' COMP 4 293.16 1111111 IN REGION 4 'CALO2' COMP 4 293.16 16.60 REGION 5 'WRAPPER' COMP 3 293.16 17.10 REGION 6 'PB_IA' COMP 5 293.16 REFLECT END OF GEOMETRY DATA
!==== TOP THERMAL INSULATOR CELLULE 'TTHINS' RANGEMENT_COMPOSITION 'M_TTHINS' 'M_CLAD3' 'M_WRAP3' 'M_PIOMB8' 'M_PIOMB9' GEOMETRY DATA HEXAGON 3 15.80 HEXAGONAL LATTICE 7 1.386



1

CYL 2 0.465 REGION 1 'TTHINS' COMP 1 293.16 0.525 REGION 2 'CLAD' COMP 2 293.16 IN REGION 3 'CALO1' COMP 4 293.16 1111111 IN REGION 4 'CALO2' COMP 4 293.16 16.60 REGION 5 'WRAPPER' COMP 3 293.16 17.10 REGION 6 'PB_IA' COMP 5 293.16 REFLECT END OF GEOMETRY DATA !==== SPRING CELLULE 'SPRING' RANGEMENT_COMPOSITION 'M_SPRING' 'M_CLAD4' 'M_WRAP4' 'M_PIOM10' 'M_PIOM11' GEOMETRY DATA **HEXAGON 3** 15.80 HEXAGONAL LATTICE 7 1.386 1 CYL 2 0.465 REGION 1 'SPRING' COMP 1 293.16 0.525 REGION 2 'CLAD' COMP 2 293.16 IN REGION 3 'CALO1' COMP 4 293.16 1111111 IN REGION 4 'CALO2' COMP 4 293.16 16.60 REGION 5 'WRAPPER' COMP 3 293.16 17.10 REGION 6 'PB_IA' COMP 5 293.16 REFLECT END OF GEOMETRY DATA !==== PLENUM CELLULE 'PLENUM' RANGEMENT_COMPOSITION 'M_VOID' 'M_PLENUM' 'M_CLAD5' 'M_WRAP5' 'M_PIOM12' 'M_PIOM13' GEOMETRY DATA HEXAGON 3 15.80 HEXAGONAL LATTICE 7 1.386 1 CYL 3 0.4 REGION 1 'VOID' COMP 1 293.16 0.465 REGION 2 'PLENUM' COMP 2 293.16 0.525 REGION 3 'CLAD' COMP 3 293.16 IN REGION 4 'CALO1' COMP 5 293.16 1111111 IN REGION 5 'CALO2' COMP 5 293.16



16.60

```
REGION 6 'WRAPPER' COMP 4 293.16
  17.10
         REGION 7 'PB IA' COMP 6 293.16
 REFLECT
END OF GEOMETRY DATA
!==== TOP PLUG
CELLULE 'TPLG'
RANGEMENT_COMPOSITION
 'M_TOPLUG' 'M_CLAD6' 'M_WRAP6' 'M_PIOM14' 'M_PIOM15'
GEOMETRY DATA
 HEXAGON 3
  15.80
   HEXAGONAL LATTICE
    7 1.386
    1
     CYL 2
      0.465 REGION 1 'TPLUG' COMP 1 293.16
      0.525 REGION 2 'CLAD'
                             COMP 2 293.16
     IN REGION 3 'CALO1'
                             COMP 4 293.16
    1111111
   IN
          REGION 4 'CALO2' COMP 4 293.16
  16.60
         REGION 5 'WRAPPER' COMP 3 293.16
  17.10
         REGION 6 'PB_IA' COMP 5 293.16
 REFLECT
END OF GEOMETRY DATA
!==== BOTTOM PLUG
CELLULE 'BPLG'
RANGEMENT_COMPOSITION
 'M_BOPLUG' 'M_CLAD7' 'M_WRAP7' 'M_PIOM16' 'M_PIOM17'
GEOMETRY DATA
 HEXAGON 3
  15.80
   HEXAGONAL LATTICE
    7 1.386
    1
     CYL 2
      0.465 REGION 1 'BPLUG' COMP 1 293.16
      0.525 REGION 2 'CLAD'
                             COMP 2 293.16
     IN REGION 3 'CALO1'
                             COMP 4 293.16
    1111111
   IN
          REGION 4 'CALO2'
                             COMP 4 293.16
  16.60
         REGION 5 'WRAPPER' COMP 3 293.16
  17.10
         REGION 6 'PB_IA' COMP 5 293.16
 REFLECT
END OF GEOMETRY DATA
```

!=== CONTROL ROD B-10 90%



CELLULE 'C_ROD'

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RANGEMENT_COMPOSITION
 'M_B4C' 'M_CLAD8' 'M_WRAP8' 'M_PIOM18' 'M_PIOM19'
GEOMETRY DATA
 HEXAGON 3
  16.04
   HEXAGONAL LATTICE
    3 3.3
    1
     CYL 2
      1.49 REGION 1 'B4C90' COMP 1 293.16
      1.55 REGION 2 'CLAD'
                              COMP 3 293.16
      IN REGION 3 'CALO5' COMP 4 293.16
    111
   IN
          REGION 4 'CALO6'
                              COMP 4 293.16
  16.60
         REGION 5 'WRAPPER' COMP 2 293.16
  17.10
         REGION 6 'PB_IA' COMP 5 293.16
 REFLECT
END OF GEOMETRY DATA
!=== CONTROL ROD FOLLOWER
CELLULE 'F_ROD'
RANGEMENT_COMPOSITION
 'M_FOLLOW' 'M_CLAD9' 'M_WRAP9' 'M_PIOM20' 'M_PIOM21'
GEOMETRY DATA
 HEXAGON 3
  16.04
   HEXAGONAL LATTICE
    3 3.3
    1
     CYL 2
      1.49 REGION 1 'FOLLOW' COMP 1 293.16
      1.55 REGION 2 'CLAD' COMP 3 293.16
      IN REGION 3 'CALO5' COMP 4 293.16
    111
   IN
          REGION 4 'CALO6' COMP 4 293.16
  16.60
         REGION 5 'WRAPPER' COMP 2 293.16
  17.10
         REGION 6 'PB_IA' COMP 5 293.16
 REFLECT
END OF GEOMETRY DATA
!==== SECURITY ROD B-10 90%
CELLULE 'S ROD'
RANGEMENT_COMPOSITION
 'M_B4C' 'M_CLAD10' 'M_WRAP10' 'M_PIOM22' 'M_PIOM23' 'M_PIOM24'
GEOMETRY DATA
 HEXAGON 3
  14.78
   HEXAGONAL LATTICE
    2 5.25
```



2

CYL 2 2.58 REGION 1 'B4C90I' COMP 1 293.16 2.64 REGION 2 'CLADI' COMP 3 293.16 IN REGION 3 'CALO5' COMP 4 293.16 CYL 2 1.83 REGION 4 'B4C90E' COMP 1 293.16 1.89 REGION 5 'CLADE' COMP 3 293.16 IN REGION 6 'CALO5' COMP 4 293.16 12 IN REGION 7 'CALO6' COMP 5 293.16 16.60 REGION 8 'WRAPP' COMP 2 293.16 17.10 REGION 9 'PB IA' COMP 6 293.16 REFLECT END OF GEOMETRY DATA !==== DUMMY ELEMENT CELLULE 'DUMMY' RANGEMENT COMPOSITION 'M_REFL' 'M_CLAD11' 'M_WRAP11' 'M_PIOM25' 'M_PIOM26' GEOMETRY DATA **HEXAGON 3** 15.80 HEXAGONAL LATTICE 7 1.386 1 CYL 2 0.465 REGION 1 'THIS' COMP 1 293.16 0.525 REGION 2 'CLAD' COMP 2 293.16 IN REGION 3 'CALO1' COMP 4 293.16 1111111 IN REGION 4 'CALO2' COMP 4 293.16 16.60 REGION 5 'WRAPPER' COMP 3 293.16 17.10 REGION 6 'PB_IA' COMP 5 293.16 REFLECT END OF GEOMETRY DATA CELLULE 'C_TOPREF' RANGEMENT_COMPOSITION 'M TOPREF' GEOMETRY DATA HOMOGENEOUS REGION 1 'TOP_FA' COMP 1 293.16 END OF GEOMETRY DATA CELLULE 'C_BOTREF' RANGEMENT_COMPOSITION 'M_BOTREF' GEOMETRY DATA HOMOGENEOUS REGION 1 'BOT_FA' COMP 1 293.16 END OF GEOMETRY DATA



CELLULE 'C_BARREL' RANGEMENT_COMPOSITION 'M BARREL' GEOMETRY DATA HOMOGENEOUS REGION 1 'H_BARREL' COMP 1 293.16 END OF GEOMETRY DATA CELLULE 'C_ZEXT' RANGEMENT_COMPOSITION 'M_ZEXT' GEOMETRY DATA HOMOGENEOUS REGION 1 'OUTER_PB' COMP 1 293.16 END OF GEOMETRY DATA; !EDITION_MILIEU (MIL_20); ->T_HOT (450.0+273.16); ->T_MEDIA (440.0+273.16); ->T_OUT (480.0+273.16); ->T FUEL (900.0+273.16); ->T_IN (400.0+273.16); 1_____ DEBUT DES CALCULS CELLULES ECCO 1 !______ ECCO MILIEU (MIL_20) REFERENCE UNIT 'JECCOLIB JEFF 31.REF' ! CELLULE TINS CELLULE 'TTHINS' EDITION MOYENNE 'TOP INSULATOR HET' TEMPERATURE 1 (T_OUT) 2 (T_OUT) 3 (T_OUT) 4 (T_OUT) 5 (T_OUT) 6 (T_OUT) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/1.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL



FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 COLLISION PROBABILITIES ROTH 6 STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 56** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'O16' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'TINS_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS

! CELLULE SPRN

!_____

CELLULE 'SPRING'



EDITION MOYENNE 'SPRING HET' TEMPERATURE 1 (T OUT) 2 (T_OUT) 3 (T_OUT) 4 (T_OUT) 5 (T_OUT) 6 (T_OUT) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/12.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB JEFF 31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952



STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'SPRN_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS ! CELLULE TPLG CELLULE 'TPLG' EDITION MOYENNE 'TOP PLUG HET' TEMPERATURE 1 (T_OUT) 2 (T_OUT) 3 (T_OUT) 4 (T_OUT) 5 (T_OUT) 6 (T_OUT) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/5.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97'


'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'TPLG_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS !-----! CELLULE BINS !-----CELLULE 'BTHINS' **FDITION MOYENNE** 'BOTTOM INSULATOR HET' TEMPERATURE 1 (T_IN) 2 (T_IN) 3 (T_IN) 4 (T_IN) 5 (T_IN) 6 (T_IN) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB JEFF 31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/1.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL



GROUP STRUCTURE OTHER 172 INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 56** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'O16' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6** CONDENSE 33 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'BINS_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS **ENDSTEPS**



!_____ ! CELLULE PLENUM CELLULE 'PLENUM' EDITION MOYENNE 'PLENUM HET' TEMPERATURE 2 (T_IN) 3 (T_IN) 4 (T_IN) 5 (T_IN) 1 (T_IN) 6 (T_IN) 7 (T_IN) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT 172G HOM JEFF31' BUCKLING ((5/8)*((3.14159/55.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33**



1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'PLEN_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS **ENDSTEPS** !-----! CELLULE BPLG l_____ CELLULE 'BPLG' EDITION MOYENNE 'BOTTOM PLUG HET' TEMPERATURE 1 (T_IN) 2 (T_IN) 3 (T_IN) 4 (T_IN) 5 (T_IN) 6 (T_IN) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/5.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 55**



'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'BPLG_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS !_____ ! CELLULE CONTROL ROD CELLULE 'C_ROD' EDITION MOYENNE 'B4C CONTROL ROD HET' TEMPERATURE 1 (T_HOT) 2 (T_HOT) 3 (T_HOT) 4 (T_HOT) 5 (T_HOT) 6 (T_HOT) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/17.1)**2))



LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL **GROUP STRUCTURE FINE** INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'CROD_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA



CROSS SECTIONS MACROSCOPIC VECTORS FLUXES ENDSTEPS !_____ ! CELLULE CR FOLLOWER l_____ CELLULE 'F_ROD' EDITION MOYENNE 'FOLLOWER CONTROL ROD' TEMPERATURE 1 (T_OUT) 2 (T_OUT) 3 (T_OUT) 4 (T_OUT) 5 (T_OUT) 6 (T_OUT) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/17.1)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FI EMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 56** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'O16' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1**



LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'FROD_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS !_____ ! CELLULE SAFETY ROD CELLULE 'S_ROD' EDITION MOYENNE 'B4C SAFETY ROD' TEMPERATURE 1 (T_HOT) 2 (T_HOT) 3 (T_HOT) 4 (T_HOT) 5 (T_HOT) 6 (T_HOT) 9 (T_HOT) 7 (T_HOT) 8 (T_HOT) STEPS 4 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FINN_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/17.1)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 COLLISION PROBABILITIES ROTH 6



STEPS 4 STEP

GEOMETRY HOMOGENEOUS

6 (T_MEDIA)

STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB JEFF 31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'SROD_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS ! CELLULE DUMMY !-----CELLULE 'DUMMY' EDITION MOYENNE 'DUMMY ELEMENT HET' TEMPERATURE 1 (T_MEDIA) 2 (T_MEDIA) 3 (T_MEDIA) 4 (T_MEDIA) 5 (T_MEDIA)



GROUP STRUCTURE OTHER 172 INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT 172G HOM JEFF31' BUCKLING ((5/8)*((3.14159/17.1)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY ORIGINAL **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' ELEMENTS ALL FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH PROFILE OUTER ITERATIONS BROAD MAXIMUM NUMBER 70 **COLLISION PROBABILITIES ROTH 6** STEP GEOMETRY ORIGINAL GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 56** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'O16' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION CP P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP BFROM 1 LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **PROFILE COLLISION PROBABILITIES ROTH 6 CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 STEP HOMOGENISE GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 33** FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1**



LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH OUTPUT LIBRARY 'DUMM_HH_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS

! CELLULE C_TOPREF !-----CELLULE 'C_TOPREF' EDITION MOYENNE 'TOP REFLECTOR HOM' TEMPERATURE 1 (T_OUT) STEPS 2 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB JEFF 31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/50.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY HOMOGENEOUS GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB JEFF 31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 OUTPUT LIBRARY 'TREF_HOM_33G_JEFF31'



CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS !-----! CELLULE C_BOTREF CELLULE 'C_BOTREF' EDITION MOYENNE 'BOTTOM REFLECTOR HOM' TEMPERATURE 1 (T_IN) STEPS 2 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/50.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY HOMOGENEOUS GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 OUTPUT LIBRARY 'BREF_HOM_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS



ENDSTEPS

_____ ! CELLULE C BARREL !_____ CELLULE 'C_BARREL' EDITION MOYENNE 'BARREL HOM' TEMPERATURE 1 (T_MEDIA) STEPS 2 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB JEFF 31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT_172G_HOM_JEFF31' BUCKLING ((5/8)*((3.14159/22.56)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY HOMOGENEOUS GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 55** 'Fe54' 'Fe56' 'Fe57' 'Fe58' 'Cr50' 'Cr52' 'Cr53' 'Cr54' 'Ni58' 'Ni60' 'Ni61' 'Ni62' 'Ni64' 'Mo92' 'Mo94' 'Mo95' 'Mo96' 'Mo97' 'Mo98' 'Mo100' 'Nb93' 'Al27' 'Mn55' 'N14' 'N15' 'C0' 'Si28' 'Si29' 'Si30' 'V0' 'Ti46' 'Ti47' 'Ti48' 'Ti49' 'Ti50' 'Ca40' 'Ca42' 'Ca43' 'Ca44' 'Ca48' 'W182' 'W183' 'W184' 'W186' 'Zr90' 'Zr91' 'Zr92' 'Zr94' 'Zr96' 'B10' 'B11' 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 OUTPUT LIBRARY 'BARL_HOM_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS **ENDSTEPS**



!_____ ! CELLULE C_ZEXT CELLULE 'C ZEXT' EDITION MOYENNE 'DOWNCOMER HOM' TEMPERATURE 1 (T_IN) STEPS 2 STEP GEOMETRY HOMOGENEOUS **GROUP STRUCTURE OTHER 172** INPUT LIBRARY 'JECCOLIB_JEFF_31.172' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FLUXB 'FOUT 172G HOM JEFF31' BUCKLING ((5/8)*((3.14159/50.0)**2)) LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH STEP GEOMETRY HOMOGENEOUS GROUP STRUCTURE FINE INPUT LIBRARY 'JECCOLIB_JEFF_31.1968' **ELEMENTS 4** 'Pb204' 'Pb206' 'Pb207' 'Pb208' FLUX SOLUTION FM P1 CONSISTENT ORDER 1 SUBCRITICAL FROM PREVIOUS STEP **BFROM 1** LEAKAGE NLFACT CELL BENOIST FLUXWT MEAN SELF SHIELDING DBBSH **CONDENSE 33** 1 82 142 202 262 322 382 442 502 564 624 686 746 808 868 928 988 1048 1108 1168 1228 1288 1336 1422 1480 1516 1579 1648 1708 1768 1837 1919 1952 OUTPUT LIBRARY 'ZEXT_HOM_33G_JEFF31' CROSS SECTIONS FLUXES PRINT DATA FLUXES CROSS SECTIONS MACROSCOPIC VECTORS ENDSTEPS: FINPROC ;

As for the fuel cells (see §D.1), the P_1 inconsistent, the B_1 consistent and inconsistent options (to be compared with the reference P_1 consistent one) were adopted. Furthermore, the additional spatial self-shielding term was not added to the computed cross-sections (with the "SELF SHIELDING NODBBSH" instruction, instead of "SELF SHIELDING DBBSH") as alternative calculation option.

Finally, instead of the utilisation of the (flux and current) spectra evaluated by ECCO in the (nearest) fissile region at 172 (reference) and 33 groups as weighting functions in the first step of ECCO calculations, the fuel spectrum evaluated by Serpent at 33 energy groups in the fuel was introduced "externally" by means of the instruction:

"SUBCRITICAL SOURCE 64/65"

replacing: "SUBCRITICAL FLUXB 'FINN/FOUT_172G_HOM_JEFF31'"



in the first step of the ECCO procedure. The "64/65" refers to the external files "FILE64/65" containing the flux and current values of the fuel inner/outer Serpent spectra, which are reported in the following.

FILE 64 (fuel inner flux and current spectra)

3.3712E-055.3378E-042.4524E-037.4709E-031.3076E-021.9744E-024.8238E-024.8393E-025.9309E-026.1251E-025.1598E-024.8097E-023.5070E-024.7342E-023.0919E-021.7508E-022.0162E-021.7471E-021.5804E-021.1001E-029.1066E-035.1208E-039.4158E-035.4854E-033.1178E-034.7889E-034.2103E-033.1686E-032.7013E-033.1228E-034.0035E-033.8704E-049.7733E-065.4272E-052.4400E-046.9636E-041.1071E-031.4854E-033.2925E-032.7424E-033.4888E-033.4731E-032.8934E-032.5505E-031.8578E-031.8916E-031.3209E-037.7561E-047.1121E-045.0728E-043.6886E-041.9634E-041.0728E-044.0935E-054.1626E-051.4357E-055.2066E-066.2378E-065.8950E-062.7653E-062.3688E-062.3179E-063.4112E-067.1697E-081.6602E-099999999999

FILE 65 (fuel outer flux and current spectra)

2.8880E-054.5636E-042.0901E-036.3585E-031.1093E-021.6597E-023.9869E-023.9617E-024.8201E-024.9326E-024.1135E-023.7962E-022.7365E-023.6839E-022.3730E-021.3264E-021.5273E-021.3189E-021.1893E-028.2782E-036.8999E-033.9066E-037.2451E-034.2469E-032.4205E-033.7235E-033.2764E-032.4678E-032.1033E-032.4324E-033.1183E-033.0179E-047.6140E-067.9182E-041.2558E-031.6666E-033.6234E-032.9813E-033.7605E-033.6997E-033.0409E-032.6375E-031.8926E-031.8936E-031.2960E-037.4570E-046.6946E-044.6339E-043.2399E-041.6497E-048.6612E-053.2249E-053.2430E-051.1769E-054.3722E-065.4149E-065.4243E-062.5301E-062.0713E-062.1253E-063.0363E-066.8588E-081.4429E-099

D.3 ERANOS input files (fresh fuel with CRs and SRs fully withdrawn)

In the following the ERANOS input for the full-core spatial calculations with the TGV VARIANT module is reported (see "AVNM" instruction at the end). The multi-group macroscopic cross-sections created by ECCO (at 33 and 80 groups) are loaded as external library in a binary format (see "BASIC_EDL_CREATION_STARTING_FROM_ECCO_FILE" instruction). These data are then used to create the Ensemble de Donnè LU (EDL) describing the different cells (EDL_MILIEU, EDL_MICRO and EDL_MACRO). For briefness and since the fuel depletion calculations were not performed in this work, the instruction for the creation of the evolution chain of the isotopes and the list of fission products (in any case necessary to *e.g.*, obtain the core mass balance) were not reported entirely (see lines of red dots). The calculation refers to the configuration with CRs and SRs fully withdrawn, but in the EDL "COEUR" the assemblies corresponding to their fully inserted positions are also defined (and have to be replaced in the EDL "GEOMETRIE" to simulate the other configurations).

PROCEDURE ->TRASPORTO ;

! -----

! -----

->PN PN_MOMENT 1 ;! Order of ECCO XS ->PTH 3.0E+8 ;! Power

^{!--} Calcolo in trasporto con configurazione di riferimento



->DILRAD 1.00 ; ->DILAX 1.00 ;

->WEIGHT 0 1 0 ;

BASIC_EDL_CREATION_STARTING_FROM_ECCO_FILE

MILIEU ->EDL_MILIEU MICRO ->EDL_MICRO MACRO ->EDL_MACRO

EXPANSION (DILRAD) (DILAX) TEMPERATURE (20+273.15) **UP_SCATTERING YES** REACTION_LIST STANDARD ! DIRECTIONAL_DIFFUSION_COEFFICIENT NO

CONSTANT_FISSION_SPECTRUM 'FINN'

REFERENCE_UNIT 'JECCOLIB_JEFF_31.REF'

UNIT 'FUEL_INN'	(PN) MEDIUM 'FINN' FUEL
UNIT 'FUEL_OUT'	(PN) MEDIUM 'FOUT' FUEL
UNIT 'IN_VESSL'	(PN) MEDIUM 'BARL' STRUCTURE
UNIT 'BOTTHINS'	(PN) MEDIUM 'BINS' STRUCTURE
UNIT 'BOT_PLUG'	(PN) MEDIUM 'BPLG' STRUCTURE
UNIT 'BOT_REFL'	(PN) MEDIUM 'BREF' STRUCTURE
UNIT 'CR_ABSRB'	(PN) MEDIUM 'CROD' ABSORBER
UNIT 'DUMMY_EL'	(PN) MEDIUM 'DUMM' STRUCTURE
UNIT 'CR_FOLLW'	(PN) MEDIUM 'FROD' STRUCTURE
UNIT 'GAS_PLEN'	(PN) MEDIUM 'PLEN' STRUCTURE
UNIT 'GAS_SPRN'	(PN) MEDIUM 'SPRN' STRUCTURE
UNIT 'SR_ABSRB'	(PN) MEDIUM 'SROD' ABSORBER
UNIT 'TOPTHINS'	(PN) MEDIUM 'TINS' STRUCTURE
UNIT 'TOP_PLUG'	(PN) MEDIUM 'TPLG' STRUCTURE
UNIT 'TOP_REFL'	(PN) MEDIUM 'TREF' STRUCTURE
UNIT 'OUTER_PB'	(PN) MEDIUM 'ZEXT' STRUCTURE

SANS_EDITION ;

CONTROLE_COHERENCE_LISTES_DE_CORPS MILIEU (EDL_MILIEU) MICRO (EDL_MICRO) ;

EDITION_MACRO (EDL_MACRO) ;

!_____ !

DECAY CHAIN CREATION

= 'TYPE DE TRACE' 0;

ARCHIVE 'ARCHJEFF31' ->YIELD_SET FISSION YIELD LOWER_CASE ;

ARCHIVE 'ARCHERAN' ->FISSION_YIELD_PROC



FISSION_YIELD_PROVISION_FOR_DECAY_CHAIN_CREATION;

!-----

FISSION_YIELD_PROC;

= 'TYPE DE TRACE' 2 ;

CREATION_CHAINE_EVOLUTION ->EDL_CHAINE MILIEU (EDL_MILIEU) NOYAU_LOURD NL 'U233' FIS N2N NGF 'U234' DAF

.....

PRODUIT_FISSION PF 'Br81' NGF PF 'Kr83' NGF 'Kr84' PF 'Kr84' NGF 'Rb85'

(FISSION_YIELD_DIRECTIVE)

ACTIVATION_PRODUCT PA 'B10' NGF 'B11' ;

1

CREATION GEOMETRIE



33 22 3 6

LIGNE 'ZDUMMY' 40 23 5 1 37 33 5 2 27 40 5 3 20 37 5 4 23 27 5 5 33 20 5 6 LIGNE 'ZBRL' 41 22 6 1 38 33 6 2 27 41 6 3 19 38 6 4 22 27 6 5 33 19 6 6 POSITION 'ZPB' 39 21 39 30 30 39 21 39 21 30 30 21 LATTICE_STEP (17.10*(DILRAD)) BASIC_MESH ΟZ 5 (62.00*(DILAX)) 1 (67.00*(DILAX)) 1 (68.00*(DILAX)) 2 (79.00*(DILAX)) 1 (84.00*(DILAX)) 13 (136.00*(DILAX)) 1 (139.00*(DILAX)) 1 (140.00*(DILAX)) 20 (200.00*(DILAX)) 1 (201.00*(DILAX)) 1 (204.00*(DILAX)) 1 (207.00*(DILAX)) 2 (212.00*(DILAX)) 1 (213.00*(DILAX)) 1 (218.00*(DILAX)) 9 (264.00*(DILAX)) 4 (296.00*(DILAX)) 1 (297.00*(DILAX)) 1 (307.00*(DILAX)) 3 (340.00*(DILAX)) SUB_ASSEMBLY 'FUEL_INT' FUEL 127 (0.465*2*(DILRAD)) MEDIUM 'BREF' 0.00 (79.00*(DILAX)) ! == FOOT == 'BPLG' (79.00*(DILAX)) (84.00*(DILAX)) 'PLEN' (84.00*(DILAX)) (139.00*(DILAX)) (139.00*(DILAX)) (140.00*(DILAX)) 'BINS' (140.00*(DILAX)) (200.00*(DILAX)) 'FINN' (200.00*(DILAX)) (201.00*(DILAX)) 'TINS' 'SPRN' (201.00*(DILAX)) (213.00*(DILAX)) (213.00*(DILAX)) (218.00*(DILAX)) 'TPLG' 'TREF' (218.00*(DILAX)) (340.00*(DILAX)) ! == HEAD == ZONE 'ZINT' BURNABLE_ZONE (152.0*(DILAX)) (164.0*(DILAX)) (176.0*(DILAX)) (188.0*(DILAX))

'TREF' ZONE 'ZOUT' BURNABLE_ZONE (152.0*(DILAX)) (164.0*(DILAX)) (176.0*(DILAX)) (188.0*(DILAX)) SUB_ASSEMBLY 'CROD' ABSORBER 1 0.00 MEDIUM 'BREF' 0.00 (62.00*(DILAX)) 'BPLG' (62.00*(DILAX)) (67.00*(DILAX)) 'BINS' (67.00*(DILAX)) (68.00*(DILAX)) 'CROD' (68.00*(DILAX)) (136.00*(DILAX)) 'FROD' (136.00*(DILAX)) (204.00*(DILAX)) (204.00*(DILAX)) (264.00*(DILAX)) 'SPRN' 'TREF' (264.00*(DILAX)) (340.00*(DILAX)) ZONE 'ZCR' SUB_ASSEMBLY 'SROD' ABSORBER 1 0.00 (207.00*(DILAX)) MEDIUM 'BREF' 0.00 'BPLG' (207.00*(DILAX)) (212.00*(DILAX)) 'SROD' (212.00*(DILAX)) (296.00*(DILAX)) 'TINS' (296.00*(DILAX)) (297.00*(DILAX)) 'SPRN' (297.00*(DILAX)) (307.00*(DILAX)) 'TREF' (307.00*(DILAX)) (340.00*(DILAX)) ZONE 'ZSR' SUB_ASSEMBLY 'SRODBIS' ABSORBER 1 0.00 MEDIUM 'BREF' 0.00 (207.00*(DILAX)) 'BPLG' (207.00*(DILAX)) (212.00*(DILAX)) 'SROD' (212.00*(DILAX)) (296.00*(DILAX)) (296.00*(DILAX)) (297.00*(DILAX)) 'TINS' (297.00*(DILAX)) (307.00*(DILAX)) 'SPRN' 'TREF' (307.00*(DILAX)) (340.00*(DILAX)) ZONE 'ZSRBIS' SUB ASSEMBLY 'DUMMY' STRUCTURE 1 0.00 MEDIUM 'BREF' 0.00 (79.00*(DILAX)) ! == FOOT == 'BPLG' (79.00*(DILAX)) (84.00*(DILAX)) 'DUMM' (84.00*(DILAX)) (201.00*(DILAX)) (201.00*(DILAX)) (213.00*(DILAX)) 'SPRN' 'TPLG' (213.00*(DILAX)) (218.00*(DILAX)) 'TREF' (218.00*(DILAX)) (340.00*(DILAX)) ! == HEAD == ZONE 'ZDUMMY' SUB_ASSEMBLY 'BARREL' STRUCTURE 1 0.00 MEDIUM 'BARL' 0.00 (340.00*(DILAX))

```
SUB_ASSEMBLY 'FUEL_OUT' FUEL 127 (0.465*2*(DILRAD))
 MEDIUM 'BREF'
                   0.00
                            (79.00*(DILAX)) ! == FOOT ==
     'BPLG' (79.00*(DILAX)) (84.00*(DILAX))
               (84.00*(DILAX)) (139.00*(DILAX))
     'PLEN'
     'BINS'
              (139.00*(DILAX)) (140.00*(DILAX))
     'FOUT'
              (140.00*(DILAX)) (200.00*(DILAX))
     'TINS'
              (200.00*(DILAX)) (201.00*(DILAX))
     'SPRN'
              (201.00*(DILAX)) (213.00*(DILAX))
              (213.00*(DILAX)) (218.00*(DILAX))
     'TPLG'
              (218.00*(DILAX)) (340.00*(DILAX)) ! == HEAD ==
```



ZONE 'ZBRL'

 SUB_ASSEMBLY 'DOWNCMR'
 STRUCTURE
 1
 0.00

 MEDIUM 'ZEXT'
 0.00
 (340.00*(DILAX))

 ZONE 'ZPB';
 (340.00*(DILAX))

! The directive ZONE indicates where the sub-assembly can be placed

! You can allow many sub-assembly types to be placed in a zone, but

! you choose which sub-assembly you want in this zone when you define the

! geometry (directive CONFIGURATION)

CORE_EDITION (EDL_CORE);

!---> geometry of the core :

! tells where the (sub)-assemblies are actually placed, what are the control ! rod positions and the boundary conditions

GEOMETRY_CREATION ->EDL_GEOMETRIE CORE (EDL_CORE) MEDIUM (EDL_MILIEU) DESCRIPTION H3D CONFIGURATION ZONE 'ZINT' 'FUEL_INT' ZONE 'ZOUT' 'FUEL_OUT' ZONE 'ZCR' 'CROD' ZONE 'ZSR' 'SROD' ZONE 'ZSRBIS' 'SRODBIS' ZONE 'ZDUMMY' 'DUMMY' ZONE 'ZBRL' 'BARREL' ZONE 'ZPB' 'DOWNCMR' BOUNDARY RSUP VACUUM ZINF VACUUM ZSUP VACUUM ;

! GEOMETRY_EDITION (EDL_GEOMETRIE)

! DECOUPAGE MILIEU ;

CREATION_CONCENTRATION_REACTEUR ->CONC GEOMETRIE (EDL_GEOMETRIE) CHAINE (EDL_CHAINE) MILIEU (EDL_MILIEU) 'FINN' 'FOUT' ;

!-----

AVNM ->FLUX_TGV GEOMETRY (EDL_GEOMETRIE) MACRO (EDL_MACRO) DIRECT_CALCULATION TRANSPORT FLUX_EXPANSION_ORDER 3 LEAKAGE_EXPANSION_ORDER 3 WITH_SIMPLIFIED_SPHERICAL_HARMONIC OUTPUT_FILE ON_6 !GEOMETRY CROSS_SECTION



POWER FLUX MAX_NUMBER_OF_OUTER_ITERATIONS 100 REACTOR_POWER (PTH) SPATIAL_APPROXIMATION INTERIOR 4 INTERFACE 1 SOURCE 2 DO_NOT_USE_SYMMETRY_FLAG !OMEGA_TRANSFORMATION_ACCELERATION RADIAL_INNER_ITERATION_FULL_MATRIX FLUX_STORAGE 2 ;

NODAL_FLUX_BUILDING ->FLUX_BUILT NODAL_FLUX (FLUX_TGV) APPROXIMATION_ORDER 2 RADIAL_REFINEMENT 2 AXIAL_REFINEMENT 2 NEGATIVE_FIX_UP YES AVERAGE_FLUX YES ;

(FLUX_TGV) ON_NODAL ON_HEX_FLUX ON_HEX_CONSTANT K_EFFECTIVE ->KEFF_TGV ;

* ('KEFF_INIT = '/CAR(KEFF_TGV)/' ') ; ! ->KEFF_INIT ('= '/CAR(KEFF_TGV)/' ') ;

FINPROC ;



Appendix E: The Serpent 2 input files

In the following, the input files needed to reproduce the Serpent 2 code results presented throughout the report are transcribed.

E.1 Input file for nuclide specification ("eranos_jeff31.ml")

The file "eranos_jeff31.ml" contains the data specifications for all the materials defined in the calculations, that has to be included in the main input file.

```
1. % Material compositions for ALFRED reactor, LEADER version, JEFF-3.1 lib. %
2.
     % -----
                                                                                                   _____}
З.
4. therm gr700 grj3.16t
5. therm gr800 grj3.18t
6.
7. %% -- MATERIAL DEFINITIONS
8.
10. mat fueli -9.3428 tmp 1173 rgb 255 0 0 % Inner fuel (less enriched) Watch Out: a
more precise density is 10.4855 g/cm3
11. 95241.09c -2.473201787523944e-03
12. 92234.09c -2.074190884639327e-05
13. 92235.09c -2.794185837408752e-03
14. 92236.09c -6.915108330357404e-05
15. 92238.09c -6.884679669571728e-01
16. 94238.09c -4.410083910990510e-03
17. 94239.09c -1.075643378560574e-01
18. 94240.09c -5.106547709379653e-02
19. 94241.09c -1.154829172795752e-02
20. 94242.09c -1.454966176010199e-02
21. 0-16.09c -1.170369000768405e-01
% Oxygen
22.
     more precise density is 10.4855 g/cm3
22.
23. mat fuelo -9.3597 tmp 1173 rgb 255 102 102 % Outer fuel (more enriched) Watch Out: a
     more precise density is 10.5128 g/cm3

      24. 95241.09c
      -3.167414950041660e-03

      25. 92234.09c
      -1.912162937122751e-05

                                                                          % Americium
                                                                           % Uranium
25. 92234.09c-1.912162937122751e-0526. 92235.09c-2.575148360510205e-0327. 92236.09c-6.373000015201662e-0528. 92238.09c-6.348471547051961e-0129. 94238.09c-5.648972344726679e-0330. 94239.09c-1.377783470784228e-0131. 94240.09c-6.539589413076820e-0232. 94241.09c-1.479006204294543e-0233. 94242.09c-1.863856886120473e-0234. 0-16.09c-1.170755858966608e-01
                                                                           % Plutonium
                                                                            % Oxygen
35.
36. % ----- Safety rods -----
 37. mat safe -2.083466 tmp 753 rgb 255 255 51 moder gr800 6000 % Safety rod
38. B-10.06c 0.72
39. B-11.06c
40. 6000.06c
                                  0.08
                                 0.20
41.
 42. mat cont -2.083466 tmp 673 rgb 0 153 76 moder gr700 6000 % Control rod
43. B-10.06c 0.72
44. B-11.06c
                                  0.08
                                  0.20
45. 6000.06c
46.
 47. % ------ Structural materials ------
48. mat Ti1515_713 -7.95 tmp 713 rgb 166 166 166 moder gr800 6000 % Dummy rod cladding (15-15
     Ti)
49. % --- Carbon
50. 6000.06c
                                 -0.09
50. 6000.000
51. % --- Chromium
-0.6061

      51. % --- Chicola

      52. 24050.06c
      -0.6001

      53. 24052.06c
      -12.1365

      -1.40215
```



55, 24054,06c	-0.35525
56. % Nickel	
57.28058.06c	-10.416
58. 28060.06c	-4.1509
59.28061.06c	-0.1829
60. 28062.06c	-0.59365
61.28064.06C	-0.15655
63 25055 06c	-1 5
64. %Molvbdenum	1.5
65. 42092.06c	-0.2226
66. 42094.06c	-0.13875
67. 42095.06c	-0.2388
68. 42096.06c	-0.2502
69. 42097.06c	-0.14325
70. 42098.060	-0.36195
71. 42100.00C	-0.14445
73. 22046.06c	-0.033
74. 22047.06c	-0.02976
75. 22048.06c	-0.29488
76. 22049.06c	-0.02164
77. 22050.06c	-0.02072
/8. 8 Silicon	-0.780885
80, 14029,060	-0.041055
81. 14030.06c	-0.028050
82. % Boron	
83. 5010.06c	-0.001194
84. 5011.06c	-0.004806
85. % Phosphorus	0.045
86. 15031.06C	-0.045
88. 7014.06c	-0.0149448
89. 7015.06c	-0.0000552
90. % Sulphur	
91. 16032.06c	-0.0142395
92.16033.06c	-0.000114
93. 16034.06c	-0.0006435
94. 16036.06C	-0.000003
96. 13027.06c	-0.015
97. % Zirconium	
98. 40090.06c	-0.015435
99. 40091.06c	-0.003366
100. 40092.06c	-0.005145
101. 40094.06c	
103. % Vanadium	-0.00004
104. 23000.06c	-0.03
105. % Tungsten	
106. 74182.06c	-0.007959599999999999
107. 74183.06c	-0.0042981
100 74184.06c	-0.009203099999999999
110. % Nichium	-0.0003332
111. 41093.06c	-0.015
112. % Tantalum	
113. 73181.06c	-0.015
114. % Copper	
115. 29063.06c	-0.020751
117 & Coholt	-0.009249
118. 27059.06c	-0.03
119. % Calcium	
120. 20040.06c	-0.0290835
121. 20042.06c	-0.0001941
122. 20043.06c	-0.0000405
123. 20044.06c	-0.0006258
125 & Trop	-19C0000.0-
126. 26054 060	-3.692501
	· · · · · · · · · · · · · · · · · · ·



127.	26056.06c	-60.060326
128.	26057.06c	-1.41164640
129.	26058.06c	-0.1895266
130.		
131.		7 OF two 752 web 100 100 100 medew ew000 0000 % pefety and cladding
132.	15_15 m()	-7.95 tmp /55 rgb 100 100 100 moder group 6000 % Safety rod Cladding
133	* Carbon	
134.	6000.06c	-0.09
135.	% Chromium	
136.	24050.06c	-0.6061
137.	24052.06c	-12.1365
138.	24053.06c	-1.40215
139.	24054.06c	-0.35525
140.	% Nickel	
141.	28058.06c	-10.416
142.	28060.06c	-4.1509
143.	28061.06c	-0.1829
144.	28062.06c	-0.59365
145.	28064.06C	-0.12622
140.	25055 06c	_1 5
1/8	2JUJJ.UUC &Molyhdenum	-1.5
149	42092 06c	-0.2226
150.	42094.06C	-0.13875
151.	42095.06c	-0.2388
152.	42096.06c	-0.2502
153.	42097.06c	-0.14325
154.	42098.06c	-0.36195
155.	42100.06c	-0.14445
156.	🗞 Titanium	
157.	22046.06c	-0.033
158.	22047.06c	-0.02976
159.	22048.06c	-0.2948
160.	22049.06c	
161.	22050.06C	-0.02072
163	3 SIIICON	_0_780895
164	14029.06c	-0.041055
165	14030.06c	-0.028050
166.	% Boron	
167.	5010.06c	-0.001194
168.	5011.06c	-0.004806
169.	% Phosphoru	15
170.	15031.06c	-0.045
171.	% Nitrogen	
172.	7014.06c	-0.0149448
173.	7015.06C	-0.0000552
175	5 Suipnur	-0 01/2305
176	16033 06c	
177.	16034.060	-0.0006435
178.	16036.06c	-0.000003
179.	% Aluminium	
180.	13027.06c	-0.015
181.	% Zirconium	1
182.	40090.06c	-0.015435
183.	40091.06c	-0.003366
184.	40092.06c	-0.005145
185.	40094.06c	-0.005214
186.	40096.06C	-0.00084
100	♂ Vanadium	0.02
180	23000.00C	-0.03
190	74182 06c	-0.00795959999999999
191	74183.060	-0.0042981
192.	74184.06c	-0.009203099999999999
193.	74186.06c	-0.0085392
194.	% Niobium	
195.	41093.06c	-0.015
196.	% Tantalum	
197.	73181.06c	-0.015



198.	% Copper	
199.	29063.06c	-0.020751
200.	29065.06c	-0.009249
201.	% Cobalt	
202.	27059.06c	-0.03
203.	% Calcium	
204.	20040.06c	-0.0290835
205.	20042.06c	-0.0001941
206.	20043.06c	-0.0000405
207.	20044.06c	-0.0006258
208.	20048.06c	-0.0000561
209.	% Iron	
210.	26054.06c	-3.692501
211.	26056.06c	-60.060326
212.	26057.06c	-1.41164640
213.	26058.06c	-0.1895266
214.		
215.		
216.	mat Ti1515 743	-7.95 tmp 743 rgb 166 166 166 moder gr800 6000 % Fuel rod cladding (15-
1	5 Ti)	and group the ign for its model group of a last is creating (is
217.	% Carbon	
218	6000.06c	-0.09
219	<pre>% Chromium</pre>	
220	24050 06c	-0.6061
220.	24050.00C	-12 1365
222	24052.00C	-1 40215
222.	24053.00C	-0.35525
223.	& Nickel	0.33323
225	28058 06c	-10 416
225.	28060 060	-1 1509
220.	28061 06c	-0.1829
228	28062 06c	-0.59365
220.	28064 06c	-0.15655
230	& Manganese	0.10000
231	25055 06c	-1 5
232	<pre>%Molvbdenum</pre>	
233	42092 06c	-0.2226
234	42092.00C	-0 13875
235	42095 06c	-0.2388
236	42096 060	-0.2502
237	42097 06c	-0.14325
238	42098 060	-0.36195
230.	42100 06c	-0.14445
240	% Titanium	0.11110
240.	22046 06c	-0.033
242	22047 06c	-0.02976
243	22047.00C	-0.29488
243.	22040.00C	-0.02164
245	22040.000C	
246	& Silicon	0.02072
247	14028 06c	-0.780895
248	14029 06c	-0.041055
249	14030.060	-0.028050
2.50	% Boron	
251	5010.060	-0.001194
252	5011.06c	-0.004806
253	<pre>% Phosphore</pre>	15
2.54	15031.06c	-0.045
255	8 Nitrogen	
2.56	7014.060	-0.0149448
257.	7015.06c	-0.0000552
258.	% −−− Sulphur	
259	16032.060	-0.0142395
2.60	16033.06c	-0.000114
2.61	16034.06c	-0.0006435
2.62	16036.06c	-0.000003
2.63	& Aluminium	1
2.64	13027.06c	-0.015
265	8 Zirconium	0.0±0
2.66	40090.060	-0.015435
2.67	40091.060	-0.003366
2.68	40092.060	-0.005145



269.	40094.06c	-0.005214
270.	40096.06c	-0.00084
271.	% Vanadium	
272.	23000.06c	-0.03
273.	% Tungsten	
274.	74182.06c	-0.007959599999999999
275.	74183.06c	-0.0042981
276.	74184.06c	-0.009203099999999999
277.	74186.06c	-0.0085392
278.	% Niobium	
279.	41093.06c	-0.015
280.	% Tantalum	
281.	73181.06c	-0.015
282.	% Copper	0.000751
283.	29063.06C	
284.	29065.06C	-0.009249
285.	27059 060	-0.03
200.	27039.00C	-0.03
288	20040 06c	-0.0290835
280	20040.000	-0.0201841
290	20043.06c	-0.0000405
291	20044 060	-0.0006258
292	20048.060	-0.0000561
293	8 Tron	
294.	26054.06c	-3.692501
295.	26056.06c	-60.060326
296.	26057.06c	-1.41164640
297.	26058.06c	-0.1895266
298.		
299.		
300.	mat Ti1515 673	-7.95 tmp 673 rgb 166 166 166 moder gr700 6000 % Cladding (15-15 Ti)
301.	% Carbon	
302.	6000.06c	-0.09
303.	% Chromium	
304.	24050.06c	-0.6061
305.	24052.06c	-12.1365
306.	24053.06c	-1.40215
1.30.7		
507.	24054.06c	-0.35525
308.	24054.06c % Nickel	-0.35525
308. 309.	24054.06c % Nickel 28058.06c	-0.35525
308. 309. 310.	24054.06c % Nickel 28058.06c 28060.06c	-0.35525 -10.416 -4.1509
308. 309. 310. 311.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c	-0.35525 -10.416 -4.1509 -0.1829
308. 309. 310. 311. 312. 313	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c 28064.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655
308. 309. 310. 311. 312. 313.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c 28064.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655
308. 309. 310. 311. 312. 313. 314. 315	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c 28064.06c % Manganese 25055.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5
308. 309. 310. 311. 312. 313. 314. 315. 316.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c 28064.06c % Manganese 25055.06c %Molybdenum	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5
308. 309. 310. 311. 312. 313. 314. 315. 316. 317.	24054.06c % Nickel 28058.06c 28060.06c 28062.06c 28064.06c % Manganese 25055.06c %Molybdenum 42092.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226
308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318.	24054.06c % Nickel 28058.06c 28060.06c 28062.06c 28064.06c % Manganese 25055.06c %Molybdenum 42092.06c 42094.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226 -0.13875
308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28064.06c % Manganese 25055.06c %Molybdenum 42092.06c 42094.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226 -0.13875 -0.2388
307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28064.06c % Manganese 25055.06c %Molybdenum 42092.06c 42094.06c 42095.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226 -0.13875 -0.2388 -0.2502
308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28064.06c % Manganese 25055.06c %Molybdenum 42092.06c 42094.06c 42095.06c 42095.06c 42095.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226 -0.13875 -0.2388 -0.2502 -0.14325
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308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c 28064.06c % Manganese 25055.06c %Molybdenum 42092.06c 42094.06c 42095.06c 42096.06c 42096.06c 42098.06c 42100.06c % Titanium 22046.06c 22047.06c	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226 -0.13875 -0.2388 -0.2502 -0.14325 -0.36195 -0.14445 -0.033 -0.02976 -0.02976
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307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 35. 336. 337.	24054.06c % Nickel 28058.06c 28060.06c 28061.06c 28062.06c 28064.06c % Manganese 25055.06c % Molybdenum 42092.06c 42095.06c 42095.06c 42096.06c 42096.06c 42096.06c 42096.06c 22047.06c 22048.06c 22047.06c 22048.06c 22049.06c 22050.06c % Silicon 14028.06c 14029.06c 14029.06c 14030.06c % Boron 5010.06c % Phosphoru	-0.35525 -10.416 -4.1509 -0.1829 -0.59365 -0.15655 -1.5 -0.2226 -0.13875 -0.2502 -0.14325 -0.36195 -0.14445 -0.02976 -0.29488 -0.02976 -0.29488 -0.02164 -0.02072 -0.780895 -0.028050 -0.028050 -0.001194 -0.004806
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341. 7015.066 -0.042395 343. 16032.066 -0.042395 344. 16033.066 -0.00003 345. 16035.066 -0.00003 347. 10035.066 -0.00003 348. 10037.066 -0.015 349. 1007.066 -0.015 349. 1007.066 -0.015 351. 4009.066 -0.00084 352. 4009.066 -0.00184 353. 8 Tungsten 355. 354. 4009.066 -0.0019595999999999 355. 7018.066 -0.00195959999999999 355. 7018.066 -0.00195959999999999 355. 7018.066 -0.00195 356. 2000.062 -0.00195 357. 8 Tungsten -0.00195 358. 7018.066 -0.00195 359. 7018.066 -0.00195 359.			
342, 8	341.	7015.06c	-0.0000552
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<pre>144. 16033.006</pre>	3/3	16032 069	-0.0142305
 140. 1003.000 - 0.00013 141. \$ 1003.000 142. \$ 1003.000 144. \$ 1007.006 144. \$ 1007.006 144. \$ 1007.006 144. \$ 1007.006 145. \$ 0009.006 146. \$ 0009.006 146. \$ 0009.006 147. \$ 0009.006 148. \$ 1009.006 149. \$ 0009.006 149. \$ 0009.006 149. \$ 0009.006 149. \$ 0009.006 140.006 <	545.	10032.000	
<pre>145. 10034.00c -0.000003 146. 1005.00cminium 147. 1005.00cminium 148. 13027.00c 149. 1</pre>	344.	16033.060	
346. 16036.06c -0.00003 347. 8 Aluminium 348. 13027.06c -0.015 349. 13027.06c -0.01545 351. 0.006.06c -0.005145 352. 40039.06c -0.005145 353. 9 Vanadium 305.8 355.8 9 Vanadium 306.1 356.2 300.06c -0.0053999999999 361.7 74184.06c -0.005392 362.7 9 Vanagten 346.4 363.7 74184.06c -0.005392 364.7 9 Capper -0.015 365.7 9 Capper -0.015 366.8 9 Capper -0.02751 366.8 9 Capper -0.03 377.8 9 Calcium -0.03 377.2 2004.06c -0.0020919 373.7 2004.06c -0.002092 373.7 2004.06c -0.002092 374.2 2003.06c -0.010206 375.2 2044.06c -0.000026 376.2 2048.06c -0.000226	345.	16034.06c	-0.0006435
<pre>347. 8 Aluminum 348. 13027.06C -0.015435 349. 8 Alumonum 350. 40030.06C -0.015435 351. 40081.06C -0.015435 351. 40081.06C -0.015435 353. 40081.06C -0.015435 354. 40081.06C -0.015559999999999 355. 7 Yunadium 355. 23000.06C -0.0154599999999999 357. 14182.06C -0.01042981 360. 74184.06C -0.01042981 361. 74184.06C -0.01042981 362. 74184.06C -0.01085392 362. 8 Nicham 363. 74182.06C -0.01085392 362. 8 Nicham 364. 400-0-C 10m 365. 29065.06C -0.02071 366. 8 Copper 367. 29063.06C -0.02071 368. 29065.06C -0.0290835 371. 8 Calcium 372. 2000.06C -0.0290835 373.20042.06C -0.0000541 373.20042.06C -0.0000541 374.20042.06C -0.0000541 375. 20044.06C -0.018916 375. 20044.06C -0.018926 380. 26057.06C -0.1895266 381. 26057.06C -0.1895266 382. 383. 384. 385.06C -0.1895266 383. 384. 385.06C -0.1895266 384. 385.06C -0.1895266 385. 385.06C -0.1895266 385. 385.06C -0.1895266 387. 388.06C -0.1895266 387. 388.06C -0.1895266 387. 388.06C -0.1895266 387. 388.06C -0.1895266 387. 388.06C -0.1895266 387. 388.06C -0.1895266 387. 398.06C -0.1895266 387. 399.07.06C -0.223 399. 14020.06C -0.223 399. 14020.06C -0.223 399. 14020.06C -0.223 399. 14020.06C -0.223 399. 14020.06C -0.2205 390.22005.06C -0.2205 390.22005.06C -0.223 391. 3405.06C -0.1684 392.23000.06C -0.2205 393. 3405.06C -0.18952 393. 3405.06C -0.18952 394.24050.06C -0.2205 395.250.06C -0.2205 395.250.06C -0.2205 395.250.06C -0.2205 395.250.06C -0.2205 395.250.06C -0.2205 395.250.06C -0.2205 395.250.06C -0.2215 395.250.06C -0.2205 395.250.06C -</pre>	346.	16036.06c	-0.000003
344. 5 0.015 340. 5 - 21rconim 350. 40091.06c -0.013435 351. 40092.06c -0.005214 353. 40094.06c -0.005214 354. 4006.06c -0.00795959999999999 355. 74182.06c -0.00795959999999999 356. 74182.06c -0.0082309999999999 357. 74182.06c -0.0082309999999999 356. 74184.06c -0.0082309999999999 357. 74184.06c -0.0082309999999999 356. 7-10.0114 -0.015 356. * Cologua -0.015 356. * Cologua -0.015 356. * Cologua -0.012 357. 2004.06c -0.020791 358. -0.020791 -0.03 371. 2004.06c -0.020249 372. 20042.06c -0.001941 373. 20042.06c -0.000043 373. 20042.06c -0.000043 373. 20042.06c -0.0189266 384. matfmsts1 713 -7.7359 tmp 71	347.	% Aluminium	n
<pre>149. % zirconim 50. 40090.06c -0.015435 51. 40091.06c -0.03336 53. 40082.06c -0.00514 53. 40084.06c -0.00084 53. % Vanadium 53. 23000.06c -0.03 53. % Tungaten 54. 70182.06c -0.002200e99999999 53. 74154.06c -0.002200e99999999 54. 74154.06c -0.002200e99999999 54. 74154.06c -0.002300e99999999 54. 74154.06c -0.002500e99999999 55. 75. Copper 55. 206c -0.002751 55. 206c -0.002751 55. 206c -0.002751 55. 206c -0.00250 57. 2004.06c -0.00050 57. 2005.06c -0.00250 57. 2004.06c -0.00050 57. 2005.06c -0.109526 58. 59Carbon 58. 6000.06c -0.139266 582. 58. 59. 24052.06c -0.02415 59. 24052.06c -0.0250 59. 24052.06c -0.0250 59. 24052.06c -0.0250 59. 24052.06c -0.0376 59. 24052.</pre>	348.	13027.06c	-0.015
<pre>330 # 0009.06c = -0.013435 531 # 0009.06c = -0.00346 332 # 0009.06c = -0.00344 334 # 0009.06c = -0.03 353 # 0.009.06c = -0.03 354 # 0.009.06c = -0.03 358 # Vanatium 356 # 23000.06c = -0.03 358 # Vanatium 356 # 1402.06c = -0.00555999999999 361 # 1418.06c = -0.0055392 362 # 1403.06c = -0.0055392 363 # 1403.06c = -0.015 364 # 1409.06c = -0.015 365 # Copper 367 # 29063.06c = -0.02949 368 # Copper 367 # 29063.06c = -0.02949 368 # Copper 367 # 29063.06c = -0.02949 368 # Copper 367 # 2008.06c = -0.02949 368 # Copper 367 # 2008.06c = -0.029249 368 # Copper 367 # 2008.06c = -0.000561 373 # 0.000561 373 # 0.000561 374 # 0.000561 375 # 0.000561 376 # 0.000561 377 # 0.000 # MANEK version) 368 # 0.000561 378 # 0.00056 380 # 0.00058 380</pre>	349	% Zirconium	
 131. 0091.0cc -0.003366 132. 0092.0cc -0.005214 133. 0093.0cc -0.005214 135. 40093.0cc -0.00214 135. 1422.0cc -0.00795559999999999 135. 74182.0cc -0.00795559999999999 138. 74182.0cc -0.0023030999999999 131. 74186.0cc -0.0023030999999999 131. 74186.0cc -0.0023030999999999 131. 74186.0cc -0.0023030999999999 131. 74186.0cc -0.0015 135. 14182.0cc -0.0015 136. 1105.0cc -0.0015 137. 20040.0cc -0.0015 136. 20055.0cc -0.00249 137. 20040.0cc -0.000405 137. 20040.0cc -0.0000405 137. 20040.0cc -0.000051 137. 20040.0cc -0.000051 137. 20040.0cc -0.000051 138. 4.000 24050.0cc -0.1895266 238. 1402.0cc -0.1895266 24050.0cc -0.18932 24050.0cc -0.1894 24050.0cc -0.1894 24050.0cc -0.1894 24050.0cc -0.1894 24050.0cc -0.1894 24050.0cc	350	10090 060	-0.015435
<pre>11. 10023.0000.00305 13. 40090.060 -0.00314 13. 40090.060 -0.00314 13. 40090.060 -0.003 13. 23000.060 -0.03 13. 74182.060 -0.0075555999999999 13. 74183.060 -0.004291 13. 74184.060 -0.00220399999999 13. 74183.060 -0.002203999999999 13. 74183.060 -0.002203999999999 13. 74184.060 -0.002203999999999 13. 74184.060 -0.0025 13. 74184.060 -0.015 13. 74184.060 -0.015 13. 74184.060 -0.015 13. 74184.060 -0.015 13. 74184.060 -0.023 13. 74184.060 -0.023 13. 74184.060 -0.023 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 -0.03 13. 74184.060 13. 7200.061 13. 74184.060 13. 7200.061 13. 74184.00 13. 7409.060 -0.020051 13. 7409.060 -0.14184 14.0292.060 -0.02415 13. 7409.060 -0.1 14.118440 14.12022.060 -0.02415 14.124840 15. 8 Carbon 15. 8</pre>	251	40001 060	0.002366
<pre>122. 40032.06c -0.005145 334. 40039.06c -0.005214 334. 40039.06c -0.005214 334. 40039.06c -0.003 335. 4183.06c -0.0075555999999999 335. 74183.06c -0.008332 335. 74183.06c -0.008332 336. 74184.06c -0.008332 336. 74184.06c -0.008332 336. 74184.06c -0.008332 337. 29063.06c -0.005 346. \$ Copper 347. 29063.06c -0.009249 348. * Coplet 349. * Cobalt 349. * Cobalt 349. * Cobalt 349. * Colose 349. * Calcs 349. *</pre>	351.	40091.080	-0.005366
<pre>353. 40094.06c -0.005214 355. % Vanadium 356. 2300.06c -0.0034 357. % Vanadium 357. % Tungsten 358. 74182.06c -0.0075555999999999 359. 74183.06c -0.0085392 359. 74183.06c -0.0085392 361. 74186.06c -0.0085392 362. % Niobium 363. % Carbin 365. % Carbin 365. % Cobalt 370. 27059.06c -0.003 371. % Cobalt 372. 20040.06c -0.009249 373. 20040.06c -0.009249 374. 20040.06c -0.000541 374. 20040.06c -0.000541 374. 20040.06c -0.000541 375. 20040.06c -0.000541 375. 20040.06c -0.000045 375. 20040.06c -0.000045 376. 20040.06c -0.000045 377. % Carbin 378. 20040.06c -0.0000541 379. 20040.06c -0.0000541 379. 20040.06c -0.0000541 379. 20050.06c -0.1895266 380. 26057.06c -0.1895266 382. 384. mat fmat91 713 -7.7399 tmp 713 rpb 115 115 115 moder gr800 6000 % FMS 791 for the varper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1895266 382. 384. 14029.06c -0.02415 393. 8 Chardium 394. 14028.06c -0.02415 394. 14028.06c -0.02415 394. 14028.06c -0.02415 394. 14028.06c -0.02415 394. 14029.06c -0.02415 394. 24050.06c -0.0236 395. 24050.06c -0.02415 395. 24050.06c -0.0235 395. 24050.06c -0.0235 395. 24050.06c -0.0235 395. 24050.06c -0.0235 395. 24050.06c -0.0353 395. 2405</pre>	352.	40092.06c	-0.005145
<pre>354. 40096.06c -0.0084 355. % Vanadium 356. 23000.06c -0.03 357. % Tungsten 358. 74182.06c -0.0075555999999999 358. 74182.06c -0.002030999999999 368. % Nicotum 369. 74184.06c -0.002030999999999 362. 74184.06c -0.008392 364. % Nicotum 364. 100-06c 1000 365. % Copper 365. % Copper 366. % Copper 367. 29063.06c -0.0290835 373. 20042.06c -0.0290835 373. 20042.06c -0.009349 369. % Calcium 372. 20040.06c -0.0009419 374. 2003.06c -0.0009419 375. 20044.06c -0.0009419 376. 20048.06c -0.000941 377. 20040.06c -0.0009419 378. 26054.06c -0.000941 378. 26054.06c -0.000941 379. 20040.06c -0.00000561 379. 20040.06c -0.000941 379. 26054.06c -0.0009561 379. 26054.06c -0.0009561 379. 26054.06c -0.0009561 379. 26054.06c -0.14114440 381. 26058.06c -0.14114440 381. 26058.06c -0.14114440 381. 26058.06c -0.14114440 381. 26058.06c -0.14195266 383. % Carbon 385. %</pre>	353.	40094.06c	-0.005214
355. % Vanadium 357. % Tungsten 358. 74182.06c -0.0079595999999999 358. 74182.06c -0.0042281 360. 74184.06c -0.0042281 361. 74184.06c -0.0042393 362. % Nikobiam -0.015 363. 74185.06c -0.015 364. % Tantalum -0.015 365. 2306.06c -0.02751 366. % Copper -0.03 371. 2006.06c -0.03 373. 2004.06c -0.0370835 373. 2004.06c -0.0320835 373. 2004.06c -0.00270835 373. 2004.06c -0.00270836 374. 2004.06c -0.0000405 377. 2004.06c -0.000051 377. 2004.06c -0.0199266 383. 26058.06c -0.141164640 384. matfmst91_713 -7.7359 tmp 713 rpb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. 385. 9 Carbon	354.	40096.06c	-0.00084
355. 2300.06c -0.03 357. \$ Tungten 358. 74182.06c -0.0029399999999 360. 74184.06c -0.00203999999999 361. 74184.06c -0.00203999999999 362. \$ Ninobium -0.015 363. \$ Ninobium -0.015 364. \$ Copper -0.02029 365. 7318.06c -0.02029 366. \$ Cobalt -0.03 371. \$ Calcium -0.0000405 372. 20040.06c -0.0000405 373. 20040.06c -0.000051 373. 20040.06c -0.000051 377. 20040.06c -0.000051 378. 20040.06c -0.000051 378. 20040.06c -0.000051 378. 20040.06c -0.183266 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. 386. 600.06c -0.1 387. 4 Shifcon 388. 9	355.	% Vanadium	
<pre>357. \$ Tungsten 557. 74183.06c -0.0042981 550. 74184.06c -0.0042981 551. 74184.06c -0.00953999999999 561. 74186.06c -0.0095392 562. \$ Nicbium 563. 41093.06c -0.015 564. \$ Capper 565. \$ Capper 565. \$ Capper 567. 29063.06c -0.109249 568. \$ Capper 577. 29063.06c -0.020751 578. 29063.06c -0.020249 568. \$ Capler 577. 2004.06c -0.020249 578. 2004.06c -0.000249 579. 2004.06c -0.000249 577. 2004.06c -0.000249 577. 2004.06c -0.000249 577. 2004.06c -0.0000405 577. 2004.06c -0.0000405 577. 2004.06c -0.0000405 577. 2004.06c -0.000051 577. 2004.06c -0.000051 577. 2005.06c -0.1895266 582. 583. 584. nat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the vrapper (according to LEADER version) 585. \$ Capton 585. \$ Capper 586. 14028.06c -0.1895266 582. 583. 584. nat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the vrapper (according to LEADER version) 585. \$ Capton 585. \$ Capton 585. 14028.06c -0.1895266 582. 583. 14028.06c -0.165 583. 14028.06c -0.165 583. 14028.06c -0.125 584. 14028.06c -0.2215 585. 14030.06c -0.125 585. 24053.06c -0.2215 585. 24053.06c -0.2215 585. 24053.06c -0.2205 585. 24053.06c -0.1892 585. 24053.06c -0.2205 585. 24053.06c -0.1892 585. 24053.06c -0.1923 585. 24053.06c -0.1934 585. 24053.06c -0.1934 585. 24053.06c -0.1934 585. 24050.06c -0.1934 585. 24050.06c -0.1935 586. 24090.06c -</pre>	356.	23000.06c	-0.03
<pre> 155. 74182.06c -0.007959599999999 156. 74184.06c -0.0042391 156. 74184.06c -0.0045392 156. 74184.06c -0.005392 157. 74184.06c -0.015 158. 74184.06c -0.015 158. 74184.06c -0.015 158. 74181.06c -0.002203 159. 74184.06c -0.022033 159. 74184.06c -0.002203 159. 74184.06c -0.0000405 157. 20040.06c -0.0000405 157. 20040.06c -0.0000405 157. 20040.06c -0.000051 157. 20040.06c -0.185266 1882. 158. 74184.06c -0.185266 1882. 158. 74184.06c -0.185266 1882. 158. 74184.06c -0.185266 1882. 14023.06c -0.185266 1882. 14023.06c -0.18 14024.06c -0.2205 158. 14024.06c -0.2205 158. 14024.06c -0.2205 158. 14024.06c -0.2205 159. 14024.06c -0.18 1402 14002.06c -0.2205 159. 14024.06c -0.2205 159. 14024.</pre>	357	% Tunasten	
<pre>395</pre>	350	74192 062	_0_00795959999999999
<pre>1335. 74184.06c -0.00320309999999999999999999999999999999</pre>	1550.	74102.000	-0.00193939999999
<pre>360. 74184.06c -0.00920309999999999 362. % Nicbium 364. 90.06C -0.015 364. % Tantalum 365. 73181.06C -0.015 366. % Copper 367. 29065.06C -0.020751 368. % Cobalt 370. 27059.06C -0.03 371. % Calcium 372. 20040.06C -0.0290835 373. 20040.06C -0.0000405 373. 20040.06C -0.0000405 375. 20040.06C -0.000051 376. 20040.06C -0.000051 377. % Iron 378. 26054.06C -0.000526 382. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbium 386. 6000.06c -0.1895266 382. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbium 385. % Carbium 386. 6000.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbium 385. % Carbium 386. 6000.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbium 385. % Carbium 386. 14029.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbium 385. % Carb</pre>	359.	74183.060	-0.0042981
<pre>361. 74186.06c -0.008392 362. % Nicbium 363. 41093.06c -0.015 364. % Tantalum 365. 73181.06c -0.020751 366. % Copper 367. 29063.06c -0.020751 368. % Cobalt 370. 27059.06c -0.0290835 373. 20042.06c -0.02090835 373. 20042.06c -0.0000405 375. 20044.06c -0.0000405 375. 20044.06c -0.0000561 376. 2004.06c -0.0000561 377. % Iron 378. 26054.06c -0.1895266 380. 26057.06c -1.41164640 381. 42058.06c -0.1895266 382. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 385. % Carbon 385. % Carbon 386. % Carbon 387. % Silicon 388. % Carbon 389. % Carbon 389. % Chromium 392. 2300.06c -0.2 393. % Chromium 392. 2300.06c -0.2 393. % Chromium 392. 2300.06c -0.2 393. % Chromium 394. 24050.06c -0.2 393. % Chromium 397. 24054.06c -0.184 402.06c -0.2205 398. % Manganese 399. 25055.06c -0.1844 402.4209.06c -0.1346 402.4209.06c -0.1346 402.4209.06c -0.1346 402.4209.06c -0.1346 402.4209.06c -0.1344 402.4209.06c -0.1344 402.4209.06c -0.1344 402.4209.06c -0.2413 400.4209.06c -0.2413 400.4209.06c -0.1344 402.4209.06c -0.1344 402.4209.06c -0.1344 402.4209.06c -0.1344 403.4209.06c -0.1344 403.4209.06c -0.2405 404.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.2413 404.4209.06c -0.2413 404.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.2413 404.4209.06c -0.2413 404.4209.06c -0.2413 404.4209.06c -0.2413 404.4209.06c -0.1344 405.4209.06c -0.1344 405.4209.06c -0.2413 404.4209.06c -0.2413 404.4209.06c -0.2035 404.4209.06c -0.24360 404.4209.06c -0.24346 405.4209.06c -0.2434 405.4209.06c -0</pre>	360.	/4184.06C	-0.0035030333333333
<pre>362. % Nichvim 364. 41093.06c -0.015 364. % Tantalum 365. 71381.06c -0.020751 366. % Copper 366. % Copper 367. 29065.06c -0.0290835 376. 29065.06c -0.0290835 377. % Calcium 372. 20040.06c -0.0000405 373. 20040.06c -0.0000405 375. 20048.06c -0.000051 376. 20048.06c -0.000051 377. % Iron 378. 26054.06c -3.692501 378. 26056.06c -0.1895266 381. 26057.06c -1.41164640 381. 26058.06c -0.1895266 383. 3605.06c -0.1895266 383. 3605.06c -0.1895266 383. 3605.06c -0.1895266 383. 14020.06c -0.1895266 385. 14020.06c -0.165 386. 14020.06c -0.165 387. 23000.06c -0.165 389. 14030.08c -0.2015 389. 14030.08c -0.2015 390. 14030.08c -0.2015 391. 14030.08c -0.2015 392. 24053.06c -0.2753 394. 24050.06c -0.2753 395. 24053.06c -0.2875 395. 24053.06c -0.2875 395. 24053.06c -0.2876 395. 2405.06c -0.</pre>	361.	74186.06c	-0.0085392
<pre>363. 41093.06c -0.015 364. 8 Tantalum 365. 73181.06c -0.015 366. 8 Copper 367. 29063.06c -0.020751 368. 29065.06c -0.00249 369. 8 Cobalt 370. 27059.06c -0.03 371. 2004.06c -0.0209035 372. 20042.06c -0.0001941 373. 20042.06c -0.0000495 374. 2004.06c -0.000051 375. 20042.06c -0.000051 376. 20042.06c -0.000051 377. 8 Iron 378. 26054.06c -0.0000521 378. 26054.06c -0.1095266 388. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADer Version) 385. % Carbon 386. % Sallon 387. % Sallon 388. 14029.06c -0.1195266 391. % Vanadum 392. 2200.06c -0.2 393. % Chronium 392. 2200.06c -0.2 393. % Chronium 394. 24050.06c -0.2 393. % Chronium 395. 24052.06c -0.2 393. % Chronium 394. 24050.06c -0.2 393. % Chronium 395. 24052.06c -0.4 397. 24054.06c -0.2 397. 24054.06c -0.3 397. 24054.06c -0.3 397. 24054.06c -0.2 397. 24054.06c -0.1 397. 24054.06c -0.2 397. 24054.06c -0.3 397.</pre>	362.	% Niobium	
<pre>364. % Tantalum 365. 73181.06c -0.015 366. % Copper 367. 29063.06c -0.009249 368. 29065.06c -0.03 371. % Cobalt 370. 2003.06c -0.0290835 371. 20042.06c -0.0290835 372. 20040.06c -0.0001941 374. 20048.06c -0.0000405 375. 20044.06c -0.0000561 377. % Tron 377. % Tron 377. % Tron 378. 26054.06c -3.692501 379. 26056.06c -60.060326 381. 26058.06c -0.11446400 381. 26058.06c -0.1144640 381. 26058.06c -0.1245 383 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 385. % Carbon 386. % Silicon 387. % Silicon 387. % Silicon 388. 14029.06c -0.1245 391. % Vanadium 392. 2300.06c -0.2 393. % Chronium 394. 24050.06c -0.2205 395. 24052.06c -0.1344 402. 42050.06c -0.1484 402. 42050.06c -0.1484</pre>	363.	41093.06c	-0.015
365. 7181.06c -0.015 366. \$ Copper 366. 2905.06c -0.002249 367. 27059.06c -0.03 371. \$ Calcium 372. 27059.06c -0.0290835 373. 2004.06c -0.0000405 374. 2004.06c -0.0000405 375. 2004.06c -0.000051 377. \$ Iron 378. 26054.06c -6.060326 380. 26057.06c -1.41164640 381. 26056.06c -0.01895266 382. 383. -0.1895266 383. Carbon -0.1 385. Carbon -0.1895266 385. Carbon -0.1 386. 14028.06c -0.1489526 391. ¥ Shiicon -0.1 385. + Shiicon -0.1 386. 14028.06c -0.22015 391. ¥-0 Chronium -0.2205 392. 2305.06c -0.2205 393. * Chronium -0.2205<	364.	% Tantalum	
366. \$ = Copper 367. 2905.06c -0.020751 368. \$ = Cobalt -0.03 371. \$ = Calcium -0.0200835 373. 20042.06c -0.0001941 374. 20043.06c -0.000405 375. 20042.06c -0.0000405 376. 20044.06c -0.0000581 377. \$ = Iron 378. 26054.06c -3.692501 377. \$ = Carbon 380. 26057.06c -1.4116440 381. 26058.06c -0.1895266 382. 384. mat fmst91 713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. 386. \$ Carbon 387. % Stilicon 388. 14029.06c -0.12 391. \$ Vanadium 392. 2300.06c -0.2 393. \$ Chronium 394. 24050.06c -0.2205 395. 24052.06c -0.1484 402. 4004.06c -0	365	73181.060	-0.015
<pre>36. 2003.06c -0.020751 368. 2905.06c -0.009249 368. 2905.06c -0.03 371. \$ Cabalu 370. 27059.06c -0.0290835 371. \$ Calcium 372. 20040.06c -0.0290835 373. 2004.06c -0.0000405 374. 20043.06c -0.0000405 375. 20044.06c -0.0000551 377. \$ Iron 378. 26054.06c -3.692501 379. 26056.06c -0.1895266 380. 26057.06c -1.41164640 381. 26088.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. \$ Carbon 386. 14028.06c -0.045935 389. 14028.06c -0.045935 389. 14028.06c -0.045935 389. 14028.06c -0.02415 390. 14030.06c -0.2415 390. 14030.06c -0.22 393. \$ Chromium 382. 23000.06c -0.2 393. \$ Chromium 394. 24050.06c -0.3762 395. 24052.06c -0.3762 395. 24052.06c -0.18703 397. 24054.06c -0.048703 397. 24054.06c -0.048703 397. 24054.06c -0.048703 397. 24054.06c -0.048703 397. 24054.06c -0.18703 397. 24054.06c -0.048703 397. 24054.06c -0.18703 397. 24054.06c -0.04870 397. 24054.06c -0.0487 397. 24054.06c -0.04703 397. 24054.06c -0.1484 400. 42097.06c -0.0484 400. 42097.06c -0.0484 400.42 4005.06c -0.1484 4005.06c -0.1484 4005.06c -0.048 4008.06c -0.1484 4005.06c -0.04825 403.42080.06c -0.1484 4005.06c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1484 4005.06c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1484 4005.06c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1484 4005.06c -0.1484 4005.06c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1484 4008.05c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1484 40097.06c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1484 40097.06c -0.0483 4008. \$ Margamese 399. 25055.05c -0.1384 410. 25060.05c -0.1384 410. 25060.05c -0.1334 410. 25060.05c -0.03356 410. 25060.05c -0.03356 410. 25060.05 -0.03356 410. 25060.05 -0.03356 410. 25060.05 -0.03356 410</pre>	366	% Conner	
<pre>100. 2000.000</pre>	367	20063 060 000PPCT	-0.020751
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<pre></pre>	308.	29063.06C	-0.009249
370. 27059.06c -0.03 371. % Calcium 372. 20040.06c -0.0001941 374. 20042.06c -0.0000405 375. 20044.06c -0.0000561 377. %	369.	% Cobalt	
<pre>371. % Calcium 372. 20040.06c -0.0290835 373. 20042.06c -0.0001941 374. 20043.06c -0.0000258 376. 20048.06c -0.0000561 377. % Tron 378. 26054.06c -3.692501 379. 26056.06c -6.0.60326 380. 26057.06c -1.41164640 381. 26058.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14022.06c -0.145935 389. 14022.06c -0.02415 390. 14030.06c -0.02415 391. % Vanadium 392. 2300.06c -0.2 393. % Chromium 394. 24050.06c -0.1 395. % Silicon 396. 24053.06c -0.18703 397. 24053.06c -0.18703 398. 8 Manganese 399. 2555.06c -0.6 400. %Manganese 399. 2555.06c -0.1484 402.42094.06c -0.1484 402.42094.06c -0.1484 402.42094.06c -0.1484 402.42094.06c -0.1392 403.42095.06c -0.1484 402.42095.06c -0.1392 403.42095.06c -0.1484 402.42095.06c -0.1392 403.42095.06c -0.1392 403.42095.06c -0.1392 404.42095.06c -0.1392 403.42095.06c -0.1392 404.42095.06c -0.1392 404.42095.06c -0.1392 404.42095.06c -0.1392 404.42095.06c -0.1392 404.42095.06c -0.1392 404.42095.06c -0.1394 405.42097.06c -0.0925 403.42095.06c -0.1344 410.28060.06c -0.05356 411.28060.06c -0.05356 411.28060.06c -0.05356 411.2806.06c -0.05356</pre>	370.	27059.06c	-0.03
372. 20040.06c -0.0001941 373. 20042.06c -0.0001941 374. 20043.06c -0.000561 377. %	371.	% Calcium	
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374. 20043.06c -0.0000405 375. 20043.06c -0.000258 377. * Iron 378. 26054.06c -3.692501 379. 26056.06c -0.108526 380. 26057.06c -1.41164640 381. 26058.06c -0.1895266 382. 383.	373	20042.060	-0.0001941
375. 20044.06c -0.0006258 376. 20048.06c -0.0000561 377. * Iron 378. 26054.06c -3.692501 379. 26056.06c -1.41164640 381. 26058.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. * Carbon 386. 4028.06c -0.45935 389. 14028.06c -0.02415 390. 14030.06c -0.0165 391. * Vanadium 392. 23000.06c -0.2 393. * Chromim 394. 24052.06c -0.3762 395. 24052.06c -0.2205 398. * Manganese 399. 24054.06c -0.2205 398. * Manganese 399. 24052.06c -0.1484 402. 42094.06c -0.1484 402. 42094.06c -0.1484 402. 42095.06c	374	20043 060	-0.000405
376. 20048.06c -0.0000551 377. % Iron 378. 26054.06c -3.692501 379. 26056.06c -60.060326 380. 26057.06c -1.41164640 381. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14028.06c -0.02415 390. 14029.06c -0.0165 391. % Vanadium 392. 23000.06c -0.13762 393. % Chomium 394. 24050.06c -0.2205 395. 24052.06c -0.7533 396. 24053.06c -0.1484 402. 42054.06c -0.1592 404. %Molybdenum 401.42092.06c -0.1484 402. 42054.06c -0.1592 404. 42055.06c -0.1592 404. 42056.06c -0.1592 404. 42095.06c <td< th=""><th>275</th><th>20043.000</th><th>0.000(35)</th></td<>	275	20043.000	0.000(35)
376. 20048.06c -0.0000561 377. % Iron 378. 26054.06c -3.692501 379. 26056.06c -60.060326 380. 26057.06c -1.41164640 381. 26058.06c -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 600.06c -0.1 387. % Carbon 386. 10028.06c -0.45935 389. 14028.06c -0.02415 390. 14030.06c -0.0165 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24050.06c -0.205 395. 24053.06c -0.6 4002.06c -0.1484 401. 42050.06c -0.1484 402. 42094.06c -0.1592 403. 42095.06c -0.1484 402. 42094.06c -0.1952	3/5.	20044.060	-0.0006258
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378. 26054.06c -3.692501 379. 26056.06c -60.060326 380. 26057.06c -1.41164640 381. 26058.06c -0.1895266 382. 383. 384. mat fmst9_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14029.06c -0.02415 390. 14030.06c -0.0165 391. % Vanadium 392. 2300.06c -0.2 393. % Chromium 394. 24050.06c -0.2205 395. 24052.06c -7.533 396. 24050.06c -0.2205 398. * Manganese 399. 25055.06c -0.6 400. %Manganese 399. 25055.06c -0.1592 404. 42094.06c -0.1955 404. 4205.06c -0.1592 404. 4205.06c -0.2413 <th>377.</th> <th>% Iron</th> <th></th>	377.	% Iron	
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<pre>381. 20058.0cc -0.1895266 382. 383. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14028.06c -0.45935 389. 14028.06c -0.02415 390. 14030.06c -0.0165 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24050.06c -0.3762 395. 24052.06c -7.533 396. 24052.06c -0.6 400. %Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.1468 405. 42097.06c -0.1668 405. 42097.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 407. 42100.06c -0.0963 409. 28058.06c -0.1344 409. 28058.06c -0.1344 409. 28058.06c -0.1344 409. 28058.06c -0.1344 400. 28058.06c -0.092360 </pre>	380.	26057.06c	-1,41164640
<pre>322. 333. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14028.06c -0.45935 389. 14029.06c -0.02415 390. 14030.06c -0.2 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24050.06c -0.3762 395. 24052.06c -0.3762 395. 24052.06c -0.6 400. %Manganese 399. 25055.06c -0.6 400. %Malybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.1484 402. 42094.06c -0.1592 403. 42095.06c -0.1592 404. 42096.06c -0.1592 404. 42096.06c -0.2413 407. 42100.06c -0.2413 409. 28058.06c -0.1344 410. 28060.06c -0.02360 </pre>	381	26058 060	-0.1895266
<pre>333. 384. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14028.06c -0.02415 390. 14028.06c -0.0165 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24050.06c -0.3762 395. 24052.06c -0.8703 396. 24053.06c -0.8703 397. 24054.06c -0.8703 398. % Manganese 399. 25055.06c -0.6 400. %Wolybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.1668 405. 42095.06c -0.1668 405. 42097.06c -0.1668 405. 42097.06c -0.1668 405. 42097.06c -0.0955 406. 4208.06c -0.2413 407. 42100.06c -0.0955 406. 4208.06c -0.1344 409. 28058.06c -0.1344 409. 28058.06c -0.1344 410. 28060.06c -0.002360</pre>	302	20000.000	0.1095200
<pre>334. mat fmst91_713 -7.7359 tmp 713 rgb 115 115 115 moder gr800 6000 % FMS T91 for the wrapper (according to LEADER version) 385. % Carbon 386. 600.06c -0.1 387. % Silicon 388. 14029.06c -0.02415 390. 14030.06c -0.02415 390. 14030.06c -0.02 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24052.06c -0.3762 395. 24052.06c -0.3703 397. 24054.06c -0.205 398. % Manganese 399. 25055.06c -0.6 400. %Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.1484 402. 42094.06c -0.1592 403. 42095.06c -0.1668 405. 42097.06c -0.1668 405. 42097.06c -0.1668 406. 42098.06c -0.2413 407. 42100.06c -0.0935 406. 42098.06c -0.1344 410. 28058.06c -0.1344 410. 28058.06c -0.1344 410. 28058.06c -0.1344 410. 28058.06c -0.1344 411. 28061.06c -0.002360</pre>	202.		
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wrapper (according to LEADER version) 385. % Carbon 386. 6000.06c -0.1 387. % Silicon 388. 14028.06c -0.45935 389. 14029.06c -0.02415 390. 14030.06c -0.0165 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24050.06c -0.3762 395. 24052.06c -0.8703 397. 24054.06c -0.2205 398. % Manganese -0.2205 398. % Manganese -0.2205 398. % Manganese -0.1184 402. 42094.06c -0.1592 404. 42096.06c -0.1592 404. 42096.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0955 408. % Nickel 409. 28058.06c 409. 28058.06c -0.1344 410. 28060.06c -0.02360	384.	mat imst91_/13	-/./359 tmp /13 rgb 115 115 115 moder gr800 6000 % FMS T91 for the
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$386.$ $6000.06c$ -0.1 $387.$ $\$$ $$ $388.$ $14028.06c$ -0.45935 $389.$ $14029.06c$ -0.02415 $390.$ $14030.06c$ -0.0165 $391.$ $\$$ $$ $392.$ $23000.06c$ -0.2 $393.$ $\$$ $$ 8 $$ Chromium $394.$ $24050.06c$ -0.3762 $395.$ $24052.06c$ -7.533 $396.$ $24053.06c$ -0.8703 $397.$ $24054.06c$ -0.2205 $386.$ \ast $$ $400.$ $\$$ $$ $4029.06c$ -0.1484 $402.$ $42094.06c$ -0.0925 $403.$ $42095.06c$ -0.1592 $404.$ $42096.06c$ -0.1592 $404.$ $42097.06c$ -0.0943 $407.$ $42100.06c$ -0.0943 $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ $\$$ $$ $408.$ \bullet -0.05356 $411.$ $28060.06c$ -0.02360	385.	% Carbon	
387. $$$ $$ Silicon $388.$ $14028.06c$ -0.45935 $389.$ $14029.06c$ -0.02415 $390.$ $14030.06c$ -0.0165 $391.$ $$$ $$ Vanadium $392.$ $23000.06c$ -0.2 $393.$ $$$ $$ Chromium $394.$ $24050.06c$ -0.3762 $395.$ $24052.06c$ -7.533 $396.$ $24053.06c$ -0.8703 $397.$ $24054.06c$ -0.2205 $398.$ $*$ Manganese $399.$ $25055.06c$ -0.6 $400.$ $$$ $M0lybdenum$ $401.$ $42092.06c$ -0.1484 $402.$ $42094.06c$ -0.0925 $403.$ $42095.06c$ -0.1592 $404.$ $42096.06c$ -0.1668 $405.$ $42097.06c$ -0.0955 $406.$ $42098.06c$ -0.2413 $407.$ $42100.06c$ -0.0963 $408.$ $$$ $$ Nickel $409.$ $28058.06c$ -0.1344 $410.$ $28060.06c$ -0.05356 $411.$ $28061.06c$ -0.002360	386.	6000.06c	-0.1
388. $14028.06c$ -0.45935 389. $14030.06c$ -0.02415 390. $14030.06c$ -0.0165 391. $\$$ $$ 392. $23000.06c$ -0.2 393. $\$$ $$ 394. $24050.06c$ -0.3762 395. $24052.06c$ -7.533 396. $24053.06c$ -0.8703 397. $24054.06c$ -0.2205 398. $\$$ $$ Manganese399. $25055.06c$ -0.6 400. $\$$ $Molybdenum$ 401. $42092.06c$ -0.1484 402. $42094.06c$ -0.0925 403. $42095.06c$ -0.1592 404. $42096.06c$ -0.1668 405. $42097.06c$ -0.0955 406. $42098.06c$ -0.0963 408. $\$$ $$ Nickel409. $28058.06c$ -0.1344 410. $28060.06c$ -0.03356 411. $28061.06c$ -0.002360	387.	% Silicon	
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390. 14030.06c -0.0165 391. % Vanadium 392. 23000.06c -0.2 393. % Chromium 394. 24050.06c -0.3762 395. 24052.06c -7.533 396. 24053.06c -0.8703 397. 24054.06c -0.2205 398. % Manganese 399. 25055.06c -0.6 400. % Malybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. % Nickel 409. 28058.06c -0.1344 410. 28061.06c -0.05356 411. 28061.06c -0.002360	389	14029 060	-0.02415
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	300	14030 060	-0.0165
391. 6 vanaduum 392. 23000.06c -0.2 393. 8 Chromium 394. 24050.06c -0.3762 395. 24052.06c -7.533 396. 24053.06c -0.2205 398. 8 Manganese 399. 25055.06c -0.6 400. %Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42095.06c -0.1592 404. 42095.06c -0.1668 405. 42095.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. % Nickel 409.28058.06c 409. 28058.06c -0.1344 410. 28061.06c -0.002360	201	11000.000	0.0103
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	391.	♂ Vanadium	
393. * Chromium 394. 24050.06c -0.3762 395. 24052.06c -7.533 396. 24053.06c -0.8703 397. 24054.06c -0.2205 398. * Manganese 399. 25055.06c -0.6 400. *Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel -0.0963 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	392.	23000.06c	-0.2
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	393.	% Chromium	
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	394.	24050.06c	-0.3762
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	395.	24052.06c	-7.533
397. 24054.06c -0.2205 398. * Manganese 399. 25055.06c -0.6 400. *Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	396.	24053.06c	-0.8703
398. % Manganese 399. 25055.06c -0.6 400. %Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. % Nickel 409.28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	397	24054 060	-0.2205
399. 25055.06c -0.6 400. %Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel 409. 28058.06c -0.1344 410. 28061.06c -0.05356	200	2-00-1-00C	0.2203
$399.$ $25055.06c$ -0.6 $400.$ $\$$ $Molybdenum$ $401.$ $42092.06c$ -0.1484 $402.$ $42094.06c$ -0.0925 $403.$ $42095.06c$ -0.1592 $404.$ $42096.06c$ -0.1668 $405.$ $42097.06c$ -0.0955 $406.$ $42098.06c$ -0.2413 $407.$ $42100.06c$ -0.0963 $408.$ \bullet $$ $408.$ \bullet $$ $409.$ $28058.06c$ -0.1344 $410.$ $28061.06c$ -0.05356 $411.$ $28061.06c$ -0.002360	390.	a Maligaliese	
400. %Molybdenum 401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. %Nickel 409.28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	399.	25055.060	-0.6
401. 42092.06c -0.1484 402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel 409.28058.06c 410. 28060.06c -0.1344 411. 28061.06c -0.002360	400.	%Molybdenum	a
402. 42094.06c -0.0925 403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. • Nickel 410. 28058.06c -0.1344 411. 28061.06c -0.002360	401.	42092.06c	-0.1484
403. 42095.06c -0.1592 404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel 409. 28058.06c -0.1344 410. 28061.06c -0.05356	402.	42094.06c	-0.0925
404. 42096.06c -0.1668 405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	403.	42095.06c	-0.1592
405. 42097.06c -0.0955 406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	404	42096.060	-0.1668
406. 42098.06c -0.2413 407. 42100.06c -0.0963 408. * Nickel 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	405	42097 060	-0.0955
407. 42100.06c -0.0963 408. * Nickel 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	105.	12097.000	
407. 42100.00C -0.0903 408. % Nickel 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	1400.	12000.000	0.0062
408. * Nickel 409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	40/.	421UU.U6C	-0.0403
409. 28058.06c -0.1344 410. 28060.06c -0.05356 411. 28061.06c -0.002360	408.	% Nickel	
410. 28060.06c -0.05356 411. 28061.06c -0.002360	1 1 0 0		
411. 28061.06c -0.002360	409.	28058.06c	-0.1344
	410.	28058.06c 28060.06c	-0.1344 -0.05356



412.	28062.06c	-0.00766
413.	28064.06c	-0.00202
414.	% Niobium	
415.	41093.06c	-0.1
416.	% Iron	
417.	26054.06c	-4.98895
418.	26056.06c	-81.1477
419.	26057.06c	-1.90728
420.	26058.06c	-0.25607
421.		
422.		
423.	mat fmst91 753	-7.7359 tmp 753 rgb 115 115 115 moder gr800 6000 % Safety rod wrapper
(stainless steel)	
424.	% Carbon	
425.	6000.06c	-0.1
426.	% Silicon	
427.	14028.06c	-0.45935
428.	14029.06c	-0.02415
429.	14030.06c	-0.0165
430.	% Vanadium	
431.	23000.06c	-0.2
432.	% Chromium	
433.	24050.06c	-0.3762
434.	24052.06c	-7.533
435.	24053.06c	-0.8703
436.	24054.06c	-0.2205
437.	% Manganese	
438.	25055.06c	-0.6
439.	%Molybdenum	
440.	42092.06c	-0.1484
441.	42094.06c	-0.0925
442.	42095.06C	-0.1592
443.	42096.060	
444.	42097.060	-0.0955
445.	42098.060	-0.2415
440.	42100.00C	-0.0963
447.	28058 06g	-0.1344
440.	28060 060	-0.0556
449.	28061 060	-0.002360
450.	28062 06c	-0.00766
452	28064 06c	-0.0202
453	& Niobium	0.00202
454	41093.06c	-0.1
455.	% Tron	
456.	26054.06c	-4.98895
457.	26056.06c	-81.1477
458.	26057.06c	-1.90728
459.	26058.06c	-0.25607
460.		
461.	mat fmst91 673	-7.7359 tmp 673 rgb 115 115 115 moder gr700 6000 % Fuel rod wrapper
(stainless steel)	
462.	% Carbon	
463.	6000.06c	-0.1
464.	% Silicon	
465.	14028.06c	-0.45935
466.	14029.06c	-0.02415
467.	14030.06c	-0.0165
468.	% Vanadium	
469.	23000.06c	-0.2
470.	% Chromium	
471.	24050.06c	-0.3762
472.	24052.06c	-7.533
473.	24053.06c	
4/4.	24054.06C	-0.2205
4/5.	⅔ Manganese	
4/6.	20000.06C	-0.0
4//.		0 1484
4/8.	42092.060	
4/9.	42094.000	-0.0923
400.	42095.000	-0 1668
1 - 0	-2020.000	0.1000



482.	42097.06c	-0.0955			
483.	42098.06C 42100.06c	-0.2413			
485.	% Nickel	0.0900			
486.	28058.06c	-0.1344			
487.	28060.06c	-0.05356			
488.	28061.06c	-0.002360			
489.	28062.06C 28064 06c	-0.00766			
491.	% Niobium	0.00202			
492.	41093.06c	-0.1			
493.	% Iron				
494.	26054.06c	-4.98895			
495.	26056.06C 26057.06C	-81.14//			
497.	26058.06c	-0.25607			
498.					
499.					
500.	%				
501.	8	Coolant			
502.	mat cool_max -11.	017 tmp 753	rgb 112 81 57	80	Coolant
503.	82204.06C 82206.06C	-0.0142	∛ Lead		
505.	82207.06c	-0.2210			
506.	82208.06c	-0.5238			
507.					
508.		017 . 710	1 110 01 57		
509.	mat cool_avg -11.	-0 01/2	rgb 112 81 57	ð	Coolant
511.	82206.06c	-0.2410	o Ecau		
512.	82207.06c	-0.2210			
513.	82208.06c	-0.5238			
514.					
516.	mat cool min -11.	017 tmp 673	rgb 112 81 57	8	Coolant
517.	82204.06c	-0.0142	% Lead		
518.	82206.06c	-0.2410			
519.	82207.06c	-0.2210			
520.	82208.06C	-0.5238			
522.					
523.	8	Other stru	ctural materials		
524.	mat ZrYO -6 tmp 6	73 rgb 204	204 255		
525.	% Zirconium	-			
526.	40090.06c	-0.356267			
527.	40091.06c	-0.078558			
529.	40092.00C	-0.121398			
530.	40096.06c	-0.020683			
531.	% Oxygen				
532.	8016.06c	-0.257226			
534	39089.06c	-0.040162			
535.	0,000,000	0.010102			
536.					
537.	mat foll -5.68218	tmp 673 rg	b 204 204 255		
530.		-0 356267			
540.	40091.06c	-0.078558			
541.	40092.06c	-0.121398			
542.	40094.06c	-0.125705			
543.	40096.06c	-0.020683			
545	♂ Uxygen 8016 060	-0 257226			
546.	% Yttrium	0.201220			
547.	39089.06c	-0.040162			
548.					
549.	mat tine -5 610	tmp 753 rch	102 102 102	& Theulater	(same as coolant)
1,000	mat tills -3.019	curb 100 rdb	T 77 T 77 T 77	∿ INSUIALOI	(Same as COULdIL)



5.5.4		
551.	% Zirconium	1
552.	40090.06c	-0.356267
553.	40091.06c	-0.078558
554	40092 060	-0 121398
555	10092.000	0.125705
555.	40094.000	-0.123703
556.	40096.06C	-0.020683
557.	% Oxygen	
558.	8016.06c	-0.257226
559	% Vttrium	
560	20080 060	0.040162
560.	39089.060	-0.040162
561.		
562.		
563.	mat bins	-5.619 tmp 673 rgb 192 192 192 % Insulator (same as coolant)
564	% Zirconium	
565	10000 060	0.256267
505.	40090.000	-0.330207
566.	40091.06C	-0.078558
567.	40092.06c	-0.121398
568.	40094.06c	-0.125705
569.	40096.060	-0.020683
570	* Ovvaen	
570.	001 C OCYGEII	0.053000
5/1.	8010.000	-0.237226
572.	% Yttrium	
573.	39089.06c	-0.040162
574.		
575		
576	mat sor -0 600	72 tmp 753 rdb 204 0.204
J'0.	mat Spi -0.603	na cmp 755 rgb 204 0 204 model group 6000 % insulator
(same as coolant)	
577.	🗞 Carbon	
578.	6000.06c	-0.1
579.	% Silicon	
580	14028 066	-0.45935
501	14029.069	- 0.2415
1 201.	14029.000	-0.02415
582.	14030.06C	-0.0165
583.	% Vanadium	
584.	23000.06c	-0.2
585.	% Chromium	
586	24050 066	-0.3762
500.	24050.000	
587.	24052.060	-/.533
588.	24053.06c	-0.8703
589.	24054.06c	-0.2205
590.	% Manganese	
591.	25055.06c	-0.6
592	%Molybdenum	
E 0 2	42002 0Cm	0.1404
593.	42092.060	
594.	42094.06c	-0.0925
595.	42095.06c	-0.1592
596.	42096.06c	-0.1668
597.	42097.06c	-0.0955
598	42098 060	-0 2413
500	12000.000	0.0062
599.	421UU.U6C	-0.0203
600.	% Nickel	
601.	28058.06c	-0.1344
602.	28060.06c	-0.05356
603	28061.060	-0.002360
604	28062 060	-0.00766
605	20002.000	0.00702
005.	20004.UbC	-0.00202
606.	% Niobium	
607.	41093.06c	-0.1
608.	% Iron	
609		
610	26054.060	-4.98895
	26054.06c	-4.98895
C11	26054.06c 26056.06c	-4.98895 -81.1477
611.	26054.06c 26056.06c 26057.06c	-4.98895 -81.1477 -1.90728
611. 612.	26054.06c 26056.06c 26057.06c 26058.06c	-4.98895 -81.1477 -1.90728 -0.25607
611. 612. 613.	26054.06c 26056.06c 26057.06c 26058.06c	-4.98895 -81.1477 -1.90728 -0.25607
611. 612. 613. 614.	26054.06c 26056.06c 26057.06c 26058.06c	-4.98895 -81.1477 -1.90728 -0.25607
611. 612. 613. 614. 615	26054.06c 26056.06c 26057.06c 26058.06c	-4.98895 -81.1477 -1.90728 -0.25607
611. 612. 613. 614. 615.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as
611. 612. 613. 614. 615.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600 coolant)	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as
611. 612. 613. 614. 615. 616.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600 coolant) % Carbon	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as
611. 612. 613. 614. 615. 616. 617.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600 coolant) % Carbon 6000.06c	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as -0.1
611. 612. 613. 614. 615. 616. 617. 618.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600 coolant) % Carbon 6000.06c % Silicon	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as -0.1
611. 612. 613. 614. 615. 616. 616. 617. 618. 619.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600 coolant) % Carbon 6000.06c % Silicon 14028.06c	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as -0.1 -0.45935
611. 612. 613. 614. 615. 616. 617. 618. 619. 620.	26054.06c 26056.06c 26057.06c 26058.06c mat pln -0.600 coolant) % Carbon 6000.06c % Silicon 14028.06c 14029.06c	-4.98895 -81.1477 -1.90728 -0.25607 094 tmp 673 rgb 255 102 178 moder gr700 6000 % Insulator (same as -0.1 -0.45935 -0.02415



621.	14030.06c	-0.0165		
622.	<pre>% Vanadium</pre>			
623.	23000.06c	-0.2		
624.	% Chromium			
625.	24050.06c	-0.3762		
626.	24052.06c	-7.533		
627.	24053.06c	-0.8703		
628.	24054.06c	-0.2205		
629.	% Manganese			
631	25055.00C	-0.0		
632	42092 06c	-0 1484		
633.	42094.06c	-0.0925		
634.	42095.06c	-0.1592		
635.	42096.06c	-0.1668		
636.	42097.06c	-0.0955		
637.	42098.06c	-0.2413		
638.	42100.06c	-0.0963		
639.	% Nickel	0.1011		
640.	28058.06c	-0.1344		
641.	28060.06C	-0.05356		
642.	28062.060	-0.002380		
644	28064 06c	-0.00202		
645.	% Niobium	0.00202		
646.	41093.06c	-0.1		
647.	% Iron			
648.	26054.06c	-4.98895		
649.	26056.06c	-81.1477		
650.	26057.06c	-1.90728		
651.	26058.06c	-0.25607		
652.				
654	mat training -8/11	005 tmp 753 rgb 255 128 0	moder gr800 6000	& Ingulator (same as
1034.	oolant)	1005 thip 755 1gb 255 120 0	Model groot toot	8 Insulator (same as
CEE	% Lead			
1000.	U DCCCC			
656.	82204.06c	-2.13000000000000e-03		
655. 656. 657.	82204.06c 82206.06c	-2.1300000000000000e-03 -3.615000000000000e-02		
656. 657. 658.	82204.06c 82206.06c 82207.06c	-2.1300000000000000-03 -3.615000000000000-02 -3.3150000000000000-02		
655. 656. 657. 658. 659.	82204.06c 82206.06c 82207.06c 82208.06c	-2.13000000000000000000000 -3.6150000000000000000000 -3.31500000000000000000000 -7.8570000000000000000000000000		
655. 656. 657. 658. 659. 660.	82204.06c 82206.06c 82207.06c 82208.06c 82208.06c	-2.130000000000000000000000 -3.6150000000000000000000 -3.315000000000000000000000 -7.857000000000000000000000000		
655. 656. 657. 658. 659. 660. 661.	82204.06c 82206.06c 82207.06c 82208.06c % Carbon 6000.06c	-2.13000000000000000000000 -3.615000000000000000000 -3.315000000000000000000 -7.85700000000000000000000 -8.5000000000000000000000000000		
655. 656. 657. 658. 659. 660. 661. 662.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c	-2.1300000000000000000000 -3.615000000000000000000 -3.315000000000000000000 -7.85700000000000000000000 -8.5000000000000000000000000000000000000		
655. 656. 657. 658. 659. 660. 661. 662. 663. 664.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c	-2.130000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.857000000000000000000 -8.5000000000000000000000 -3.9044749999999999003 -2.05275000000000000000000000000000000000		
655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c	-2.130000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.85700000000000000000 -8.50000000000000000000 -3.90447499999999990 -3.9044749999999990 -03 -2.0527500000000000000000 -1.402500000000000000000000000000000000000		
655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium	-2.13000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.85700000000000000000 -8.50000000000000000000 -3.90447499999999990 -3.9044749999999990 -03 -2.052750000000000000000 -1.40250000000000000000		
655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c	-2.13000000000000000000 -3.6150000000000000000 -3.3150000000000000000 -7.85700000000000000000 -8.5000000000000000000 -3.90447499999999990 -3.9044749999999990 -03 -2.052750000000000000000 -1.40250000000000000000 -1.7000000000000000000000000000000000000		
655. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium	-2.130000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.85700000000000000000 -8.50000000000000000000 -3.90447499999999990 -3.9044749999999990 -03 -2.052750000000000000000 -1.40250000000000000000 -04		
655. 656. 657. 658. 659. 661. 662. 663. 664. 665. 666. 667. 668. 669.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c	-2.13000000000000000000 -3.6150000000000000000 -3.3150000000000000000 -7.85700000000000000000 -8.5000000000000000000 -3.90447499999999990 -2.05275000000000000000 -1.402500000000000000 -1.700000000000000000 -3.1977000000000000000		
053. 656. 657. 658. 659. 660. 661. 662. 663. 665. 666. 667. 668. 669. 670. 671.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c	-2.130000000000000000000000 -3.615000000000000000000000000000000000000		
053. 656. 657. 658. 659. 660. 661. 662. 663. 665. 666. 667. 668. 669. 670. 671.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c	-2.1300000000000000000000000 -3.615000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 673.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24054.06c 8 Manganese	-2.130000000000000000000000 -3.615000000000000000000000000000000000000		
033. 656. 657. 658. 659. 660. 661. 662. 663. 666. 667. 668. 669. 670. 671. 672. 674.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 8 Manganese 25055.06c	-2.130000000000000000000 -3.61500000000000000000 -3.315000000000000000000 -7.85700000000000000000 -8.500000000000000000 -3.90447499999999990 -2.05275000000000000000 -1.402500000000000000 -1.402500000000000000 -3.19770000000000000 -3.19770000000000000 -3.197755000000000000 -3.187425000000000000 -3.1874250000000000000 -3.1000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 674. 675.	<pre>82204.06c 82206.06c 82207.06c 82208.06c % Carbon 6000.06c % Silicon 14028.06c 14029.06c 14029.06c 14030.06c % Vanadium 23000.06c % Chromium 24050.06c 24052.06c 24053.06c 24054.06c % Manganese 25055.06c % Molybdenum</pre>	-2.13000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.85700000000000000000 -8.500000000000000000 -3.90447499999999990 -2.0527500000000000000 -1.40250000000000000 -1.4025000000000000 -3.1977000000000000 -3.1977000000000000 -3.19775500000000000 -3.18742500000000000 -3.18742500000000000 -3.18742500000000000 -3.1000000000000000 -3.1000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 674. 675. 676.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c	-2.13000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.85700000000000000000 -8.500000000000000000 -3.90447499999999990 -3.9044749999999990 -3.2.0527500000000000 -04 -1.4025000000000000 -03 -3.19770000000000000 -03 -3.1977000000000000 -03 -5.100000000000000 -03 -1.26140000000000000 -03		
055. 656. 657. 658. 659. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 674. 675. 676. 677.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c	-2.13000000000000000000 -3.61500000000000000000 -3.31500000000000000000 -7.85700000000000000000 -8.500000000000000000 -3.90447499999999990 -2.0527500000000000000 -1.4025000000000000 -1.4025000000000000 -3.1977000000000000 -3.1977000000000000 -3.1977550000000000 -3.197550000000000 -3.1874250000000000 -3.1000000000000 -3.1000000000000 -3.1874250000000000 -3.1874250000000000 -3.126140000000000 -3.7.86250000000000 -4.200000000000000000 -3.2000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 675. 676. 677. 678.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c</pre>	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 674. 675. 676. 677. 678. 679. 670.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 621.	82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c 42095.06c 42097.06c	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 682.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24053.06c 24053.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 42094.06c 42095.06c 42095.06c 42095.06c 42098.06c 42088.06c 420888.06c 420888.06c 420888.06c 42088888888.06c 42088888</pre>	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24053.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c 42095.06c 42097.06c 42098.06c 42100.06c 8 Nickel</pre>	-2.13000000000000000000000000000000000000		
053. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 684.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c 42095.06c 42097.06c 42098.06c 42100.06c 8 Nickel 28058.06c</pre>	-2.13000000000000000000000000000000000000		
055. 055. 057. 058. 059. 060. 061. 062. 063. 064. 065. 066. 067. 068. 069. 070. 071. 072. 073. 074. 075. 076. 077. 078. 079. 080. 081. 082. 083. 084. 085.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c 42095.06c 42095.06c 42097.06c 42098.06c 42100.06c 8 Nickel 28058.06c 28060.06c</pre>	-2.13000000000000000000000000000000000000		
055. 055. 057. 058. 059. 060. 061. 062. 063. 064. 065. 066. 067. 068. 069. 070. 071. 072. 073. 074. 075. 076. 077. 078. 079. 080. 081. 082. 083. 084. 085. 086.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c 42095.06c 42095.06c 42096.06c 42097.06c 42098.06c 42100.06c 8 Nickel 28058.06c 28060.06c 28061.06c</pre>	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42094.06c 42095.06c 28060.06c 28061.06c 28062.06c</pre>	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 680. 681. 682. 683. 684. 685. 686. 687. 688.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24052.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 8 Manganese 25055.06c 8 Mickel 28058.06c 28061.06c 28061.06c 28062.06c 28064.06c</pre>	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c % Carbon 6000.06c % Silicon 14028.06c 14029.06c 14030.06c % Vanadium 23000.06c % Chromium 24050.06c 24052.06c 24053.06c 24054.06c % Manganese 25055.06c % Malybdenum 42092.06c 42094.06c 42095.06c 42096.06c 42096.06c 42096.06c 42096.06c 42096.06c 8 Nickel 28058.06c 28061.06c 28062.06c 28064.06c % Nicbium </pre>	-2.13000000000000000000000000000000000000		
055. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690.	<pre>82204.06c 82206.06c 82207.06c 82208.06c 82208.06c 8 Carbon 6000.06c 8 Silicon 14028.06c 14029.06c 14029.06c 14030.06c 8 Vanadium 23000.06c 8 Chromium 24050.06c 24053.06c 24053.06c 24054.06c 8 Manganese 25055.06c 8 Molybdenum 42092.06c 42096.06c 42096.06c 42096.06c 42096.06c 42096.06c 42096.06c 42096.06c 8 Nickel 28058.06c 28061.06c 28061.06c 28062.06c 28064.06c 8 Niobium 41093.06c</pre>	-2.13000000000000000000000000000000000000		



692.	26054.06c	-4.24060750000000e-02							
693.	26056.06c	-6.897554499999999e-01							
694.	26057.06c	-1.62118800000000e-02							
695.	26058.060	-2.17659500000000e-03							
696.									
697.	mat hala _9 25	$5670 \pm mn 673$ nmb 255 128 0	modor	ar700	6000	& Thoul	ator	(2.0
0.00.	(nat bpig -0.2)	5670 Chip 675 TGD 255 126 0	moder	g1 /00	0000	∿ INSUI	ator	(Salle	as
699	% Lead								
700.	82204,06c	-1,420000000000000e-03							
701.	82206.06c	-2.41000000000000000000000000000000000000							
702.	82207.06c	-2.210000000000000e-02							
703.	82208.06c	-5.23800000000001e-02							
704.	% Carbon								
705.	6000.06c	-9.0000000000001e-04							
706.	% Silicon								
707.	14028.06c	-4.13415000000000e-03							
708.	14029.06c	-2.17350000000000e-04							
709.	14030.06c	-1.485000000000000e-04							
710.	% Vanadium								
711.	23000.06c	-1.8000000000000000000000000000000000000							
712.	% Chromium								
713.	24050.06c	-3.38580000000000e-03							
714.	24052.06C	-6.7/970000000001e-02							
710	24053.06C	-7.8327000000000000000							
717	24054.06C	-1.984500000000000000000							
718	25055 06c	-5 400000000000000000							
719	<pre>%Molybdenum</pre>	n							
720	42092.06c	-1.335600000000000e-03							
721.	42094.06c	-8.32500000000000e-04							
722.	42095.06c	-1.432800000000000e-03							
723.	42096.06c	-1.50120000000000e-03							
724.	42097.06c	-8.59500000000000e-04							
725.	42098.06c	-2.17170000000000e-03							
726.	42100.06c	-8.66700000000000e-04							
727.	% Nickel								
728.	28058.06c	-1.20960000000000e-03							
729.	28060.06c	-4.82040000000000e-04							
730.	28061.06c	-2.124000000000000e-05							
731.	28062.06c	-6.894000000000000e-05							
732.	28064.06c	-1.8180000000000000e-05							
733.	41002 060	0.0000000000000000000000000000000000000							
735	41095.00C	-9.000000000000000000							
736	26054 06c	-4 4900550000000000-02							
737.	26056.06c	-7.303293000000000000000000000000000000000							
738.	26057.06c	-1.71655200000000e=02							
739.	26058.06c	-2.30463000000000e-03							
740.									
741.									
742.	mat tref -10.40	040 tmp 753 rgb 255 229 204	moder	gr800	6000 9	🖁 Upper a	nd lov	ver	
r	eflector (same a	as coolant)							
743.	% Lead	1 1000000000000000000000000000000000000							
/44.	82204.06c	-1.136000000000000e-02							
145.	02200.06C	-1.928000000000000000000000000000000000000							
746.	82207.060	-1.7680000000000000000000							
74/.	82208.00C	-4.19040000000000000000							
749	6000.06c	-2.000000000000000000000000000000000000							
750	% Silicon	2.0000000000000000000000000000000000000							
751	14028.06c	-9.186999999999999e-04							
752.	14029.06c	-4.83000000000001e-05							
753.	14030.06c	-3.300000000000000e-05							
754.	% Vanadium								
755.	23000.06c	-4.000000000000000000000000000000000000							
756.	% Chromium								
757.	24050.06c	-7.52400000000000e-04							
758.	24052.06c	-1.50660000000000e-02							
759.	24053.06c	-1.74060000000000e-03							
760.	24054.06c	-4.4100000000000000000000000000000000000							
	😤 Manganese	2							



762.	25055.06c	-1.2000000000000000000000000000000000000		
763.	<pre>%Molybdenum</pre>	1		
764.	42092.06c	-2.9680000000000000000		
765.	42094.060	-1.85000000000000000000000000000000000000		
767	42096 06c	-3 3360000000000000000000000000000000000		
768.	42097.06c	-1.910000000000000000e-04		
769.	42098.06c	-4.82600000000000e-04		
770.	42100.06c	-1.92600000000000e-04		
771.	% Nickel			
772.	28058.06c	-2.68800000000000e-04		
774	28060.06C	-1.07120000000000000000000000000000000000		
775	28062 066	-4.72000000000000000000000000000000000000		
776.	28064.06c	-4.0400000000000000e-06		
777.	% Niobium			
778.	41093.06c	-2.000000000000000000000000000000000000		
779.	% Iron			
780.	26054.06c	-9.97790000000001e-03		
/81.	26056.06C	-1.62295400000000e-01		
783.	26058.06c	-5.121400000000000000000000000000000000000		
784.	20000.000	0.1211000000000000000000000000000000000		
785.				
786.	mat bref -10.64	90 tmp 673 rgb 204 255 255	moder gr700 6000	% Upper and lower
r	eflector (same a	is coolant)		
787.	% Lead	1 0 4 0 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		
/88.	82204.06C	-1.249600000000000e-02		
789.	82206.06C 82207 06c	-2.12080000000000000000000000000000000000		
791.	82208.06c	-4.60944000000000000000		
792.	% Carbon			
793.	6000.06c	-1.2000000000000000000000000000000000000		
794.	% Silicon			
795.	14028.06c	-5.512199999999999e-04		
796.	14029.06c	-2.898000000000000e-05		
797.	14030.00C % Vanadium	-1.98000000000000000000000000000000000000		
799.	23000.06c	-2.400000000000000e-04		
800.	% Chromium			
801.	24050.06c	-4.51440000000000e-04		
802.	24052.06c	-9.03960000000000e-03		
803.	24053.06c	-1.04436000000000e-03		
804.	24054.06C	-2.646000000000000e-04		
806	25055 06c	-7 1999999999999999		
807.	%Molybdenum	1		
808.	42092.06c	-1.78080000000000e-04		
809.	42094.06c	-1.11000000000000e-04		
810.	42095.06c	-1.91040000000000e-04		
811.	42096.06c	-2.00160000000000e-04		
812.	42097.060	-1.14600000000000000000000000000000000000		
814.	42100.06c	-1.15560000000000000000000000000000000000		
815.	% Nickel			
816.	28058.06c	-1.61280000000000e-04		
817.	28060.06c	-6.42720000000000e-05		
818.	28061.06c	-2.83200000000000e-06		
819.	28062.06c	-9.192000000000000e-06		
820.	28064.06C	-2.424000000000000000		
82.2	41093.06c	-1.20000000000000000e-04		
823.	% Iron			
824.	26054.06c	-5.986739999999999e-03		
825.	26056.06c	-9.73772400000000e-02		
826.	26057.06c	-2.28873600000000e-03		
827.	26058.06c	-3.0/284000000000e-04		
820				
830	mat barrel -9 0	0799 tmp 673 rab 80 170 80	moder ar700 6000	% Upper and lower
_ r	eflector (same a	is coolant)		
831.	% Lead			



832.	82204.06c	-9.4004000000001e-03
833.	82206.06c	-1.59542000000000e-01
834	82207 060	-1 46302000000000-01
0.00	02207.000	
835.	82208.060	-3.46/5560000000000000000000000000000000000
836.	% Carbon	
837.	6000.06c	-3.3800000000000e-04
838.	% Silicon	
830	14028 066	-1 55260300000000-03
0.3.5.	14020.000	
840.	14029.06C	-8.1627000000000000000000000000000000000000
841.	14030.06c	-5.5770000000000000000000000000000000000
842.	% Vanadium	
843.	23000.06c	-6.7600000000001e-04
844	& Chromium	
015	24050 069	1 271556000000000 02
045.	24030.080	-1.2/13/5/0000000000000000000000000000000000
846.	24052.06c	-2.546154000000000e-02
847.	24053.06c	-2.94161400000000e-03
848.	24054.06c	-7.4529000000000e-04
849.	% Manganese	2
850	25055 060	-2.0280000000000000-03
050.	20000.000	
0.51.	*Molybaenun	
852.	42092.06C	-5.0159200000000000000000000000000000000000
853.	42094.06c	-3.12650000000000e-04
854.	42095.06c	-5.3809600000001e-04
855.	42096.06c	-5.63784000000000e-04
856.	42097.06c	-3.2279000000000e-04
857	42098 060	-8 1559400000000000-04
050	12100.069	-3 25494000000000000000
050.	Nichol	5.25454000000000000000000000000000000000
0.59.	& NICKEI	4 5 4 6 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
860.	28058.06C	-4.542/200000000e-04
861.	28060.06c	-1.810328000000000e-04
862.	28061.06c	-7.97680000000001e-06
863.	28062.06c	-2.58908000000000e=05
864.	28064.06c	-6.82760000000000e-06
865	& Niobium	
0000.	11002 0Ce	2 2000000000000 04
000.	41093.080	-3.3800000000000000000000000000000000000
867.	% Iron	
868.	26054.06c	-1.68626510000000e-02
869.	26056.06c	-2.742792260000000e-01
870.	26057.06c	-6.44660640000001e-03
871.	26058.06c	-8.6551660000002e-04
872.		
873.	8	homogenised compositions
874	mix fuelihom	
075	fueld	0.22252
075.		
8/6.	T11515_743	-0.07539
8.1.1	fmst91_713	-0.06948
878.	cool_avg	-0.53261
879.		
880.	mix fuelohom	
881.	fuelo	-0.32291
882	Ti1515 743	-0.07535
002.	$f_{mat} = 01 - 712$	0.06044
003.	INSU91_/13	-0.00944
884.	cool_avg	-0.53230
885.		
886.	mix safehom	
887.	safe	-0.09409
888.	Ti1515 753	-0.02218
889.	fmst.91 753	-0.20561
890	cool may	-0.67813
0.01	coor_max	0.07013
000	mirr annth	
892.	MIX CONTHOM	
893.	cont	-0.202841
894.	Ti1515_753	-0.063590
895.	fmst91 753	-0.087845
896.	cool min	-0.645724
1	_	



E.2 Input files for the 3D core model

In the following, the input file "ALFRED_ECCO.ge" used to reproduce all the geometrical features of the 3D core model is reported. It should be noticed that all the CR and SR movements are controlled in the main script with the command "*trans*".

2 З. % Geometry definitions for ALFRED reactor, LEADER version Δ 6. & ------- GEOMETRIC SURFACES DEFINITIONS ---------- Radial coordinate ---8. 10. % Core 11 surf s1 cyl 0.0 0.0 233 % core external perimeter 12. % Hexagonal assembly 13. % Hexagonal assembly surf w1 hexyc 0.0 0.0 7.9 surf w2 hexyc 0.0 0.0 8.3 % wrapping outer perimeter 14. 15. 16. % wrapping inner perimeter % wrapping outer perimeter surf w3 hexyc 0.0 0.0 7.39 surf w4 hexyc 0.0 0.0 8.3 17. 18. 19. % wrapping inner perimeter
% wrapping outer perimeter surf w5 hexyc 0.0 0.0 8.02 20. 21. surf w6 hexyc 0.0 0.0 8.3 23. 8 --------- Axial coordinate ------% Reactor 24. surf z_core_u pz 170.0 surf z_core_b pz -170.0 25. % Core axial upper limit. 26. % Core axial lower limit surr _____ % Fuel rod (FR) surf z_tref_fr pz 170.0 surf z_bplg_fr pz 48.0 surf z_sprn_fr pz 43.0 surf z_ins_u pz 31.0 ______ vz 30.0 ______ z 0 27. 28. % Fuel pin upper limit % Fuel pin upper limit % Fuel pin upper limit % Insulator upper limit % Fuel active zone upper limit % Fuel active zone lower limit % Insulator lower limit % Plenum fuel pin lower limit % Bottom plug % Bottom reflector 29. 30
 surf z_sprn_li
 p

 surf z_ins u
 pz
 30.0

 surf z_fuel u
 pz
 -30.0

 surf z_fuel_b
 pz
 -30.0

 surf z_ins b
 pz
 -31.0

 -urf z_plen
 pz
 -86.0

 -urf z_plen
 pz
 -91.0
 31. 32. 34. surf z_ins_b pz -31.0 surf z_plen pz -86.0 surf z_bplg_fr pz -91.0 surf z_bref_fr pz -170.0 35. 36. 37. 38. 39. 40. % Control rod (CR) % Top reflector upper limit
% Spring upper limit
% Follower upper limit
% Follower lower limit
% Control rod zone upper limit
% Bottom insulator zone lower limit
% Bottom plug
% Bottom reflector surf z_tref_cr pz 300.0 surf z_sprn_cr pz 94.0 41. 42.
 surf z_sprn_cr
 pz
 94.0

 surf z_frod_u
 pz
 -34.0

 surf z_frod_cr
 pz
 -34.0

 surf z_crod_cr
 pz
 -102.0

 surf z_bins_cr
 pz
 -103.0

 surf z_bplg_cr
 pz
 -300.0
 34.0 43. 44. 45. 46. 47. 48. 49. 50. % Safety rod (SR) % Safety rod (SR) surf z_tref_sr pz 300.0 % Fuel pin upper limit surf z_sprn_sr pz 137.0 % Fuel pin upper limit surf z_tins_sr pz 127.0 % Fuel pin upper limit surf z_srod_sr pz 126.0 % Insulator upper limit surf z_bplg_sr pz 42.0 % Fuel active zone uppe surf z_bref_sru pz 37.0 % Upper reflector surf z_bref_srb pz -300.0 % Bottom reflector 51. 52. 53. % Fuel pin upper limit
% Insulator upper limit
% Fuel active zone upper limit
% Upper reflector
% Bottom reflector 54. 55. 56. 57. 58. 59. 60. % Dummy rod (DR) % Fuel pin upper limit % Fuel pin upper limit % Fuel pin upper limit % Insulator upper limit % Fuel active zone upper limit % Fuel active zone upper limit surf z tref_dr pz 170.0 surf z tplg_dr pz 48.0 surf z sprn_dr pz 43.0 surf z dumm u pz 31.0 61. 62. surf z_dumm_u pz 31.0 surf z_dumm_b pz -86.0 surf z_bplg_dr pz -91.0 surf z_bref_dr pz -170.0 63. 64. % Fuel active zone upper limit 65. 66. % Bottom reflector 67. 68. % ----- PIN DEFINITION ----69. % Plenum pin 70. pln 0.465 Ti1515_713 0.525 71. 72. 73. 74. cool_min 75. pin tg % Top plug "pin" 76. tplg 0.465 Ti1515 753 0.525 77. 78. 79. cool_max pin bg 80. % Bottom plug "pin" 0.465 81. bplg 0.465 Ti1515 713 0.525 82. cool_min 83. 84. pin ti % Top insulator "pin" 85. 0.465 86. tins



87. 88.	Ti1515_713 0.525 cool max	
89. 90.	– pin bi	% Bottom insulator "pin"
91.	bins 0.465	
92. 93.	Til515_/13 0.525 cool min	
94. 95	-	8 Dummer "Prin"
96.	foll 0.465	2 Domini Din
97. 98	Ti1515_713 0.525	
99.	cool_avg	
100.	pin sp spr 0.465	% Spring "pin"
102.	Ti1515_713 0.525	
103.	cool_max	
105.	pin sl	% Safety pin
106.	Ti1515_753 2.64	
108.	cool_max	
110.	pin s2	% Safety pin
111.	safe 1.83 Ti1515 753 1.89	
113.	cool_max	
114. 115.	pin cl	% Control pin
116.	cont 1.49	
118.	cool_min	
119. 120	pin ce	% Control pin plenum
121.	foll 1.49	· · · · · · · · · · · · · · · · · · ·
122. 123.	fmst91_713 1.55 cool avg	
124.	-	% Control min follower
125.	foll 1.49	S CONCION PIN TOTIOWER
127.	fmst91_713 1.55	
129.		
130. 131.	pin 11 cool min	% Pure lead (empty lattice positions)
132.	-	8 Duro load (ampty lattice positions)
100.	prii vv	a rure read (empty rattice positions)
134.	void	
134. 135. 136.	void %	ASSEMBLY DEFINITION
134. 135. 136. 137.	<pre>void % Top insulator assembly lat top ing 2 0 0 0 0 15 15</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 ll ll</pre>	ASSEMBLY DEFINITION 1.386 1 11 11 11 11
134. 135. 136. 137. 138. 139. 140. 141.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 l1 ti ti l1 l1 l1 l1 l1 l1 lt ti ti </pre>	ASSEMBLY DEFINITION 1.386 1.11 11 11 11 ti ti ti ti 11 ti ti ti ti 11 ti ti ti ti 11
134. 135. 136. 137. 138. 139. 140. 141. 142.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 l1 it it l1 l1 l1 l1 l1 l1 ti ti l1 l1 l1 l1 l1 l1 ti ti ti l1 l1 l1 l1 l1 l1 ti ti ti ti </pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 l1 ti ti l1 l1 l1 l1 l1 l1 ti ti ti l1 l1 l1 l1 l1 l1 ti ti ti ti l1 l1 l1 l1 l1 ti ti ti ti l1 l1 l1 l1 lt ti ti ti ti l1 l1 l1 l1 ti ti ti ti ti l1 l1 l1 l1 ti ti ti ti ti </pre>	ASSEMBLY DEFINITION 1.386 .1 11 11 11 11 .t i t i t i t 11 . t i t i t i t i 11 .t i t i t i t i 11 t i t i t i t i 11 .t i t i t i t i 11
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 ll 11 11 11 11 11 11 11 ll 11 11 11 11 11 11 ll 11 11 11 11 11 ti ti ti ll 11 11 11 11 ti ti ti ti ll 11 11 11 ti ti ti ti ll 11 11 11 ti ti ti ti ll 11 11 ti ti ti ti ti </pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 l1 11 11 11 11 11 11 11 l1 11 11 11 11 11 11 l1 11 11 11 11 11 11 l1 11 11 11 11 11 ti ti ti l1 11 11 11 11 ti ti ti ti l1 11 11 11 ti ti ti ti l1 11 11 ti ti ti ti ti l1 11 11 ti ti ti ti ti l1 11 11 ti ti ti ti ti l1 11 ti ti ti ti ti l1 11 ti ti ti ti ti l1 ti ti ti ti ti ti l1 ti ti ti ti ti ti </pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 146. 147. 148. 149.	<pre>void % % Top insulator assembly lat top_ins 2 0.0 0.0 15 15 ll ll</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 143. 144. 145. 146. 147. 148. 149. 150.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 l1 ti ti ti l1 l1 l1 l1 l1 l1 ti ti ti l1 l1 l1 l1 l1 ti ti ti ti l1 l1 l1 l1 ti ti ti ti l1 l1 l1 lt ti ti ti ti l1 l1 l1 ti ti ti ti ti l1 lt ti ti ti ti ti l1 ti ti ti ti ti ti l1 ti ti ti ti ti ti ti l1 ti ti ti ti ti ti ti l1 ti ti ti ti ti ti ti ti ti l1 ti ti</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 146. 147. 148. 149. 150. 152.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 15 15 l1 l1 i1 l1 it it it l1 l1 l1 l1 l1 l1 it it it l1 l1 l1 l1 lt it it it it l1 l1 l1 l1 lt it it it it l1 l1 l1 lt it it it it l1 l1 l1 lt it it it it l1 lt it it it it it </pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 144. 145. 146. 150. 151. 152. 153.	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 144. 145. 144. 145. 147. 151. 152. 153. 155.	<pre>void % % Top insulator assembly lat top ins 2 0.0 0.0 5 15 ll ll</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 144. 145. 146. 147. 150. 151. 155. 156. 157.	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 144. 144. 145. 144. 145. 150. 151. 155. 155. 155. 156. 157. 158.	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 144. 145. 150. 151. 152. 153. 154. 155. 156. 157. 158. 156. 157. 158.	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 140. 141. 142. 144. 144. 144. 145. 150. 151. 152. 155. 155. 156. 157. 158. 159. 160. 161.	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 144. 145. 147. 148. 149. 150. 151. 155. 155. 155. 156. 157. 158. 159. 160. 151. 156. 157. 158. 156. 157. 157. 156. 157.	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 144. 144. 145. 144. 145. 144. 145. 151. 151	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 144. 144. 144. 144. 144. 144	<pre>void %</pre>	ASSEMBLY DEFINITION
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 144. 145. 144. 145. 144. 145. 144. 147. 148. 147. 148. 155. 155. 155. 155. 156. 157. 158. 155. 161. 162. 162. 165. 164. 165. 168.	<pre>void %</pre>	<pre>ASSEMBLY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 144. 145. 144. 145. 144. 145. 151. 153. 154. 155. 155. 155. 156. 157. 158. 162. 163. 164. 165. 166. 167. 168. 167. 168. 167. 168.	<pre>void %</pre>	<pre>ASSEMBLY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 142. 144. 144. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 156. 157. 158. 155. 156. 157. 158. 166. 167. 168. 167. 168. 167. 168. 167. 177.	<pre>void %</pre>	<pre>ASSEMELY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 144. 145. 144. 144. 145. 144. 145. 144. 145. 144. 155. 155. 155. 155. 155. 156. 157. 158. 156. 157. 158. 156. 157. 158. 157. 164. 165. 164. 165. 164. 167. 168. 167. 168. 167. 177.	<pre>void %</pre>	<pre>ASSEMELY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 144. 145. 144. 145. 144. 155. 155. 155. 155. 155. 155. 155. 156. 157. 166. 167. 168. 167. 168. 167. 168. 167. 173. 173. 173. 175. 177. 177. 177. 175. 175. 175. 175. 175. 175. 175. 175. 175. 175. 175. 175. 175. 175. 175. 177. 175.	<pre>void %</pre>	<pre>ASSEMELY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 151. 152. 153. 155. 155. 155. 156. 157. 166. 167. 168. 169. 167. 168. 167. 168. 167. 168. 167. 168. 167. 173. 173. 174. 175. 176. 177. 176. 176. 176. 176. 176. 176. 176. 176. 176. 176. 176. 176. 176. 177. 176. 176. 176. 177. 176. 176. 177. 176. 176. 176. 177. 176. 176. 176. 177. 176. 176. 177. 176. 177. 176. 177. 176. 177. 176. 177. 176. 177. 176. 177. 176. 176. 177. 176. 176. 177. 176. 176. 177. 176. 176. 177. 176. 176. 176. 177. 176. 176. 176. 177. 176. 176. 177. 176. 176. 177. 176. 176. 176. 176. 177. 176. 176. 176. 176. 176. 176. 176. 177. 176. 176. 176. 176. 176. 176. 177. 176. 177. 176. 176. 177. 177. 177. 177. 177. 177. 177. 177.	<pre>void </pre>	<pre>ASSEMBLY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 144. 145. 146. 147. 148. 159. 155. 155. 156. 157. 166. 167. 168. 169. 161. 162. 163. 164. 165. 166. 167. 168. 167. 168. 167. 177. 176. 177. 178. 177. 177. 176. 177. 178. 178. 178. 178. 178. 178. 178. 178. 178. 178. 178. 177. 178. 178. 178. 177. 178. 177. 178. 177. 178. 178. 178. 177. 178. 178. 177. 178. 177. 178. 177. 178. 177. 177. 177. 176. 177. 178. 178. 178. 177. 178. 178. 178. 178. 177. 178. 177. 178. 178. 178. 178. 177. 178. 178. 178. 178. 178. 178. 178. 178. 178. 178. 177. 178.	<pre>void </pre>	<pre>ASSEMBLY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 144. 144. 145. 144. 145. 144. 145. 144. 145. 155. 156. 157. 158. 159. 166. 167. 168. 169. 170. 171. 173. 176. 177. 178. 177. 177. 177. 177. 178. 177. 178. 178. 178. 178. 178. 178. 178. 177. 178. 177. 178. 177. 178. 177. 178. 177. 178. 178. 178. 178. 178. 179. 178. 179. 178. 179. 178. 179. 178. 179. 178. 179. 178. 179. 178. 179. 178. 179. 178.	<pre>void </pre>	<pre>ASSEMBLY DEFINITION</pre>
134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177. 177.	<pre>void </pre>	ASSEMBLY DEFINITION


183 184. 185 ll da ll ll ll 186. 187. 188. 189. 190 ll ll ll ll bi bi bi bi bi bi bi bi bi ll ll ll ll bi bi bi bi bi bi bi bi bi ll ll ll bi ll 197 198. ll ll bi ll 199. 200. 201. ll bi ll ll ll ll bi bi bi bi bi bi bi bi bi ll ll ll ll 202. 203. 11 bi 11 11 11 11 11 bi bi bi bi bi bi bi bi bi 11 11 11 11 11 bi bi bi bi bi bi bi bi 11 11 11 11 11 11 bi bi bi bi bi bi bi bi 11 11 11 11 11 11 204. 205. 206. 207. 208. 225 226. 230. 11 11 11 11 11 11 12 tg tg tg tg tg tg tg tg tg 1 231. 11 11 11 11 11 11 tg 1 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 11 11 11 11 11 11 bg bg bg bg bg bg bg l1 11 11 11 11 11 bg bg bg bg bg bg bg b1 11 11 11 11 11 bg bg bg bg bg bg bg l1 11 11 11 11 bg bg bg bg bg bg bg bg bg l1 11 11 11 bg bg bg bg bg bg bg bg bg l1 11 11 bg l1 11 11 bg l1 249. 250. 251. 252. 253. 254. 255. 256 257. 258. 259. 260. 261. 262. 268. 269. 270 271. 272. 273. 274. 275 276. 277. 278.



279.	vv vv	. AA AA AA AA AA	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	VV VV VV	
281.					
282. 283. 284. 285. 286. 287. 288. 290. 291. 292. 292. 293. 294. 295. 296. 297.	<pre>% Lead assembly lat la 2 0.0 0.0 15 l1</pre>	15 1.386 1 11 11 11 11 11 11 11 11		1 11 1 1 1 11 11 11 11 11 1 11 11 1 11 1	
298.	11 11	11 11 11 11	11 11 11 11 11 11	11 11 11	
300.	% Safety rod ass lat safe2 4 0 0 0 0	embly (circul	ar array)		
302.	3 2.0 0 s1 s1 s1				
303.	9 5.5 U si si si si	si si si si	sl		
305. 306. 307.	<pre>% Safety rod ass lat safe1 4 0.0 0.0 1 0 0 s1</pre>	embly (circul	ar array) Active section		
308.	6 5.25 30 S2 S2 S2	SZ SZ SZ			
310. 311.	<pre>% Control rod as lat cont1 4 0.0 0.0</pre>	sembly (circu	lar array) Active section		
312. 313.	1 0.0 0 c1 6 3.3 30 c1 c1 c1 c	1 c1 c1			
314.	12 6.37511 15 c1 c1	c1 c1 c1 c1	cl cl cl cl cl cl cl		
316.	lat continact 4 0.0	0.0 3 % Inac	tive section		
317.	6 3.3 30 fp fp fp f	p fp fp			
319. 320.	12 6.37511 15 fp fp	fp fp fp fp	fp fp fp fp fp fp		
321. 322.	****	****	%%%%%%%%% INNER F1	UEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	******
323.	% Inner fuel	ulfuel	fuelihom	-w1	<pre>% filling the channel</pre>
325. 326.	cell clr1 cell clr2	ulfuel ulfuel	fuelihom fuelihom	w1 -w2 w2	<pre>% filling the wrapper % filling the external region</pre>
328. 329. 330. 331.	cell c1r0_GCU cell c1r1_GCU cell c1r2_GCU	INN_FUEL INN_FUEL INN_FUEL	fuelihom fuelihom fuelihom	-w1 w1 -w2 w2	<pre>% filling the channel % filling the wrapper % filling the external region</pre>
332. 333.	/* cell u1r0	ulhom	fuelihom	-w2	% filling the channel
334.	cell c1r1 cell c1r2	ulfuel ulfuel	fill u1hom fill u1hom	-w2 w2	<pre>% filling the channel % filling the external region</pre>
336.	coll circ CCU	wihomCCU	fueliher	2	<pre>% filling the channel</pre>
338.	cell clr1_GCU	INN_FUEL	fill ulhomGCU	-w2 -w2	% filling the channel
339. 340.	cell clr2_GCU */	INN_FUEL	fill ulhom	W2	% filling the external region
341. 342.	% Top plug				
343.	cell ultplgr0 cell ultplgr1	ultplg ultplg	fill top_plg fmst91 753	-w1 w1 -w2	<pre>% filling the channel % filling the wrapper</pre>
345.	cell ultplgr2	ultplg	cool_max	w2	<pre>% filling the external region</pre>
340.	cell ultplgr0_GCU	IF_TOP_PLUG	fill top_plg	-w1	% filling the channel
348. 349.	cell ultpigr1_GCU cell ultplgr2_GCU	IF_TOP_PLUG IF_TOP_PLUG	cool_max	w⊥ =w∠ w2	<pre>% filling the wrapper % filling the external region</pre>
350. 351.	% Spring				
352. 353.	cell ulsprnr0 cell ulsprnr1	ulspr ulspr	fill spring fmst91 753	-w1 w1 -w2	<pre>% filling the channel % filling the wrapper</pre>
354.	cell ulsprnr2	ulspr	cool_max	w2	<pre>% filling the external region</pre>
356.	cell ulsprnr0_GCU	IF_SPRING	fill spring	-w1	<pre>% filling the channel % filling the wrapper</pre>
358.	cell ulsprnr2_GCU	IF_SPRING	cool_max	with with with with with with with with	<pre>% filling the external region</pre>
359. 360.	% Top insulator				
361. 362.	cell ultinsr0 cell ultinsr1	ultins ultins	till top_ins fmst91_753	-w1 w1 -w2	<pre>% filling the channel % filling the wrapper</pre>
363. 364.	cell ultinsr2	ultins	cool_max	w2	<pre>% filling the external region</pre>
365.	cell ultinsr0_GCU	IF_TOP_INS	fill top_ins fmst91 753	-w1 w1 -w2	<pre>% filling the channel % filling the wrapper</pre>
367.	cell ultinsr2_GCU	IF_TOP_INS	cool_max	w2	<pre>% filling the external region</pre>
369.	% Bottom insulator				
370. 371.	cell ulbinsr0 cell ulbinsr1	ulbins ulbins	IIII bot_ins fmst91_673	-w⊥ w1 -w2	<pre>% Filling the channel % filling the wrapper</pre>
372. 373.	cell ulbinsr2	ulbins	cool_min	w2	<pre>% filling the external region</pre>
374.	cell u1binsr0_GCU	IF_BOT_INS	fill bot_ins	-w1	% filling the channel



375. cell u1bi 376. cell u1bi	.sr1_GCU IF_BOT_INS .sr2_GCU IF_BOT_INS	fmst91_673 cool_min	w1 -w w2	12	<pre>% filling the wrapper % filling the external</pre>	region
377.						
378. % Fienum 379. cell u1pl	r0 u1pln	fill plen	-w1		% filling the channel	
380. cell ulpl	rl ulpln	fmst91_673	w1 -w	12	<pre>% filling the wrapper % filling the outernal</pre>	ragion
382.	iz uipin	C001_1111	WZ		<pre>% IIIIIIg the external</pre>	region
383. cell u1pl	r0_GCU IF_PLEN	fill plen fmst91 673	-w1 w1 -w	12	<pre>% filling the channel % filling the wrapper</pre>	
385. cell u1pl	r2_GCU IF_PLEN	cool_min	w2	-	% filling the external	region
386. 387. % Bottom	lug					
388. cell u1bp	gr0 u1bplg gr1 u1bplg	fill bot_plg fmst91_673	-w1	72	<pre>% filling the channel % filling the wrapper</pre>	
390. cell ulbp	gr2 u1bp1g	cool_min	w2	-	% filling the external	region
391. 392. cell u1bp	gr0 GCU IF BOT PLUG	fill bot plg	-w1		% filling the channel	
393. cell ulbp	gr1_GCU IF_BOT_PLUG	fmst91_673	w1 -w	12	<pre>% filling the wrapper % filling the outernal</pre>	ragion
395.	giz_GC0 ir_BO1_FL0G	C001_1111	WZ		<pre>% IIIIIIg the external</pre>	region
396. % Inner f 397. cell c1tr	el assembly axial sca f ulref tref	n z tplg fr -z tre	f fr 🖁	upper reflector		
398. cell c1a1	u1 fill u1ref	z_tplg_fr -z_tre	f_fr %	upper reflector		
400. cell cla2	ul fill ultplg ul fill ulspr	z_sprn_fr -z_tpl z ins u -z spi	nfr 8	s upper plug spring		
401. cell c1a4	ul fill ultins	z_fuel_u -z_ins	u 8	insulator		
403. cell clas	ul fill ulbins	z_ins_b -z_fue	l_b	insulator		
404. cell cla7 405. cell cla8	ul fill ulpin ul fill ulbplg	z_plen -z_ins z bplq fr -z ple	_b %	s plenum s bottom plug		
406. cell c1re	bo ulref bref	z bref fr -z bpl	g_fr %	bottom reflector		
407. Cell Cla9 408.	ui iiii uirei	z_prei_ir -z_ppi	g_rr «	5 DOLLOM FEITECLOF		
409. % Inner f	el assembly axial sca f GCU IF TOP REF	n (universe definit tref z tpl	ion to a fr -z	compute group-wis tref fr % upper	e constants) reflector	
411. cell cla1	GCU IF fill IF_	TOP_REF z_tpl	g_fr -z	_tref_fr % upper	reflector	
412. cell cla2 413. cell cla3	GCU IF fill IF_ GCU IF fill IF	TOP_PLUG z_spi SPRING z ins	n_fr - 2 u - 2	_tplg_fr % upper sprn fr % sprin	a bīna	
414. cell c1a4	GCU IF fill IF	TOP_INS z_fue	1_u -z	ins u % insul	ator	
416. cell clas	GCU IF fill INN	BOT_INS z_ins	_b -z	_fuel_b % insul	ator	
417. cell c1a7 418. cell c1a8	GCU IF fill IF GCU IF fill IF	PLEN Z_ple BOT PLUG Z bpl	n -z afr-z	_ins_b % plenu plen % botto	m m plua	
419. cell clre	bo_GCU IF_BOT_REF	bref z_bre	f_fr -z	bplg_fr % botto	m reflector	
420. Cell Clay 421.	GCU IF IIII IF_	BOT_REF Z_Dre	I_IT -2	pig_ir % botto	m reilector	
422. %%%%%%%%% 423 % Outer F	%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	%%%%%%%%% OUTER FU	EL %%%%	\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$	\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	****
424. cell c2r1	u2fuel fuel	ohom	-w1		<pre>% filling the channel</pre>	
425. cell c2r2 426. cell c2r3	u2fuel fuel u2fuel fuel	ohom ohom	w1 -w2 w2	2	<pre>% filling the wrapper % filling the external :</pre>	region
427.	COLL OUR FUEL for	alaham	1		- filling the channel	
429. cell c2r2	GCU OUT_FUEL fu	elohom	w1 -w2	2	<pre>% filling the wrapper</pre>	
430. cell c2r3	GCU OUT_FUEL fu	elohom	w2		<pre>% filling the external :</pre>	region
432. % Top plu	0.0.1	C'11	1			
433. cell u2tp 434. cell u2tp	gr0 u2tp1g gr1 u2tp1g	fmst91_753	w1 -w2	2	% filling the wrapper	
435. cell u2tp	gr2 u2tplg gr0_GCUOF_TOP_PLUG	cool_max fill_top_plg	w2 -w1		<pre>% filling the external : % filling the channel</pre>	region
437. cell u2tp	gr1_GCU OF_TOP_PLUG	fmst91_753	w1 -w2	2	<pre>% filling the wrapper</pre>	
438. cell u2tp 439.	gr2_GCU OF_TOP_PLUG	cool_max	w2		<pre>% filling the external :</pre>	region
440. % Spring		fill enving	-111		filling the channel	
442. cell u2sp	nr1 u2spr	fmst91_753	wı w1 -w2	2	<pre>% filling the wrapper</pre>	
443. cell u2sp 444. cell u2sp	nr2 u2spr nr0 GCU OF SPRING	cool_max fill_spring	w2 -w1		<pre>% filling the external : % filling the channel</pre>	region
445. cell u2sp	nr1_GCU OF_SPRING	fmst91_753	w1 -w2	2	% filling the wrapper	
446. cell u2sp 447.	nr2_GCU OF_SPRING	cool_max	w2		<pre>% filling the external :</pre>	region
448. % Top ins	lator	fill top ins	-w1		& filling the channel	
450. cell u2ti	srl u2tins	fmst91_753	w1 -w2	2	<pre>% filling the wrapper</pre>	
451. cell u2ti 452. cell u2ti	.sr2 u2tins .sr0 GCU OF TOP INS	cool_max fill top ins	w2 -w1		<pre>% filling the external : % filling the channel</pre>	region
453. cell u2ti	sr1_GCU OF_TOP_INS	fmst91_753	w1 -w2	2	% filling the wrapper	
454. cell u2ti 455.	STZ_GCU OF_TOP_INS	cool_max	₩∠		o IIIIIng the external :	region
456. % Bottom	nsulator sr0 u2bins	fill bot ins	-w1		& filling the channel	
458. cell u2bi	srl u2bins	fmst91_673	w1 -w2	2	<pre>% filling the wrapper</pre>	
459. cell u2bi 460. cell u2bi	sr2 u2bins sr0 GCU OF BOT INS	cool_min fill bot ins	w2 -w1		<pre>% filling the external : % filling the channel</pre>	region
461. cell u2bi	sr1_GCU OF_BOT_INS	fmst91_673	w1 -w2	2	% filling the wrapper	
463. 463.	STZ_GCU OF_BOT_INS	cool_min	W∠		6 flifting the external :	region
464. % Plenum	ר 112mlm	fill plen	-w1		% filling the channel	
466. cell u2pl	rl u2pln	fmst91_673	w1 -w2	2	<pre>% filling the wrapper</pre>	
467. cell u2pl 468. cell u2pl	r2 u2pln r0 GCU OF PLEN	cool_min fill plen	w2 -w1		<pre>% filling the external : % filling the channel</pre>	region
469 0011 1201	T COU OF DIEN	fmst.91 673	w1 -w2		<pre>% filling the wrapper</pre>	
409. Cell u2pi	r2 CCU OF DIEN	cool min	1.12		<pre>% filling the outerral</pre>	rogion



471. 472. % Bottom plug % filling the channel
% filling the wrapper 473. cell u2bplgr0 474. cell u2bplgr1 fill bot_plg -w1 fmst91_673 w1 u2bplg u2bplg w1 -w2 cool_min w2 % filling the external region u2bplg 475. cell u2bplgr2 fill bot_plg fmst91_673 476. cell u2bplgr0_GCU 477. cell u2bplgr1_GCU OF_BOT_PLUG OF BOT PLUG -w1 % filling the channel w1 -w2 % filling the wrapper 478. cell u2bplgr2_GCU OF_BOT_PLUG cool_min w2 % filling the external region 479. 480. 480. 481. % Outer fuel assembly axial scan 482. cell c2tref u2ref tref 483. cell c2a1 u2 fill u2ref 484. cell c2a2 u2 fill u2tplg 485. cell c2a3 u2 fill u2spr z_tplg_fr -z_tref_fr % upper reflector universe definition z_tplg_fr -z_tref_fr % upper reflector z_sprn_fr -z_tplg_fr % upper plug z_sprn_ir -z_tpig_tr % upper j z_ins_u -z_sprn_fr % spring z_fuel_u -z_ins_u % insulat z_fuel_b -z_fuel_u % fuel_u z_ins_b -z_fuel_b % insulat z_plen_-z_ins_b % insulat 486. cell c2a4 u2 fill u2tins % insulator 487. cell c2a5 488. cell c2a6 u2 fill u2fuel u2 fill u2bins % fuel universe definition
% insulator _____ 2____ % % Insulator z_plen -z_ins_b % plenum z_bplg_fr -z_plen % bottom plug z_bref_fr -z_bplg_fr % bottom reflector universe definition z_bref_fr -z_bplg_fr % bottom reflector u2 fill u2pln 489. cell c2a7 u2 fill u2bplg 490. cell c2a8u2 fill u21491. cell c2ref_bou2ref bref 492. cell c2a9 u2 fill u2ref 493. 494. % Outer fuel assembly axial scan495. cell c2tref_GCUOF_TOP_REF tref496. cell c2a1_GCUOF fill OF_TOP_REF497. cell c2a2_GCUOF fill OF_TOP_PEF498. cell c2a3_GCUOF fill OF_TOP_PEF499. cell c2a4_GCUOF fill OF_SPRINC209. cell c2a4_GCUOF fill OF_TOP_INS210. cell c2a5_GCUOF fill OF_TOP_INS210. cell c2a6_GCUOF fill OF_TOP_INS210. cell c2a6_GCUOF fill OF_DOT_INS211. cell c2a6_GCUOF fill OF_DOT_INS202. cell c2a7_GCUOF fill OF_DOT_INS211. cell c2a6_GCUOF fill OF_DOT_INS202. cell c2a7_GCUOF fill OF_DOT_INS203. cell c2a6_GCUOF fill OF_BOT_REF204. cell c2ref bo_GCUOF_BOT_REF_bref205. cell c2a6_GCUOF fill OF_BOT_REF206. cell c2a6_GCUOF fill OF_BOT_REF207. cell c2a6_GCUOF fill OF_BOT_REF208. cell c2a6_GCUOF fill OF_BOT_REF209. cell c2a6_GCU 494. % Outer fuel assembly axial scan 506. 508. 509. % Safety rod 510. cell c3r1 SR_ACT fill safe1 511. cell c3r2 SR_ACT fmst91_753 512. cell c3r4 SR_ACT cool_max % Filling the channel -w3 w3 -w4 w4 % Filling the cladding % Filling the external region 513. 514. % Spring 515. cell u3sprr0 SR_SPRING fill spring 516. cell u3sprr1 SR_SPRING fmst91_753 517. cell u3sprr2 SR_SPRING cool_max -w3 w3 -w4 w4 % Filling the channel % Filling the cladding % Filling the external region 518 519. % Top insulator 520. cell u3tinsr0 SR_TOP_INS fill top_ins 521. cell u3tinsr1 SR_TOP_INS fmst91_753 522. cell u3tinsr2 SR_TOP_INS cool_max % Filling the channel % Filling the cladding % Filling the external region -w3 w3 -w4 w4 523 524. % Bottom plug 525. cell u3bplgr0 SR_BOT_PLUG fill bot_plg 526. cell u3bplgr1 SR_BOT_PLUG fmst91_673 527. cell u3bplgr2 SR_BOT_PLUG cool_min -w3 % Filling the channel w3 -w4 % Filling the cladding w4 % Filling the external region 528. 529. % Safety rod axial scan 529. % Safety rod axial scan 530. cell c3tref SR_TOP_REF tref 531. cell c3a1 SR_fill SR_TOP_REF 532. cell c3a2 SR_fill SR_SPRING 533. cell c3a3 SR_fill SR_TOP_INS 534. cell c3srod SR_fill SR_ACT 535. cell c3a4 SR_fill SR_BOT_PLUG 536. cell c3ref_bo SR_BOT_REF bref 537. cell c3a5 SR_fill SR_BOT_REF 538 z_sprn_sr -z_tref_sr % upper reflector universe definition z_sprn_sr -z_tref_sr % upper reflector z_tins_sr -z_sprn_sr % spring z_srod_sr -z_tins_sr % insulator z_bplg_sr -z_srod_sr % safety rod universe definition z_bref_sru -z_bplg_sr % bottom plug z_bref_srb -z_bref_sru % bottom reflector universe definition z_bref_srb -z_bref_sru % bottom reflector 541. % Control rod 542. cell c4r1 CR_ACT fill cont1 543. cell c4r2 CR_ACT fmst91_673 -w5 w5 -w6 % Filling the channel % Filling the cladding
% Filling the external 544. cell c4r3 CR_ACT cool_min wб % Filling the external region 546. % Dummy rod 547. cell c4r4 CR_DUMM fill continact 548. cell c4r5 CR_DUMM fmst91_713 549. cell c4r6 CR_DUMM cool_avg -w5 w5 -w6 % Filling the channel % Filling the cladding wб % Filling the external region 550. 551. % Spring 552. cell u4sprr0 CR_SPRING fill spring 553. cell u4sprr1 CR_SPRING fmst91_753 554. cell u4sprr2 CR_SPRING cool_max -w3 w3 -w4 % Filling the channel % Filling the cladding
% Filling the externa w4 % Filling the external region 555. 556. % Bottom insulator 557. cell u4tinsr0 CR_BOT_INS fill bot_ins 558. cell u4tinsr1 CR_BOT_INS fmst91_673 559. cell u4tinsr2 CR_BOT_INS cool_min -w3 w3 -w4 % Filling the channel % Filling the cladding
% Filling the external region 560. 560. 561. & Bottom plug 562. cell u4bplgr0 CR_BOT_PLUG fill spring 563. cell u4bplgr1 CR_BOT_PLUG fmst91_673 564. cell u4bplgr2 CR_BOT_PLUG cool_min ----w3 % Filling the channel w3 -w4 % Filling the cladding w4 % Filling the external region 565. 566.



567. % Control rod axial scan -z_tref_cr -z_tref_cr -z_sprn_cr -z_frod_u 568. cell c4ref u CR_TOP_REF tref 569. cell c4al CR_fill CR_TOP_REF 570. cell c4a2 CR_fill CR_SPRING % upper reflector universe definition z sprn cr z_sprn_cr z_frod_u % upper reflector % spring 570. cell c4a2 CR fill CR_SPRING 571. cell c4frod CR fill CR_DUMM 572. cell c4crod CR fill CR_ACT % follower z frod b -z_frod_b % absorber z_crod_cr

 573. cell c4a3
 CR fill CR_BOT_INS

 574. cell c4a4
 CR fill CR_BOT_PLUG

 575. cell c4ref_b
 CR_BOT_REF bref

 576. cell c4a5
 CR fill CR_BOT_REF

 -z_crod_cr z bins cr % bottom insulator -z_bins_cr -z_bplg_cr -z_bplg_cr z_bplg_cr z_bref_cr % bottom plug % bottom reflector universe definition z bref cr % bottom reflector 579. 580. % Dummy element 581. cell c5r1 DR_DUMM fill dr_dumm 582. cell c5r2 DR_DUMM fmst91_713 -w1 % Filling the channel w1 -w2 % filling the wrapper 583. cell c5r3 DR DUMM cool avg w2 % Filling the external region 584. 585. % Top plug 586. cell u5tplgr0 DR_TOP_PLUG fill top_plg 587. cell u5tplgr1 DR_TOP_PLUG fmst91_673 588. cell u5tplgr2 DR_TOP_PLUG cool_max % Filling the channel
% filling the wrapper -w1 w1 -w2 w2 % Filling the external region 589. 590. % Spring 591. cell u5sprr0 DR_SPRING fill spring 592. cell u5sprr1 DR_SPRING fmst91_753 593. cell u5sprr2 DR_SPRING cool_max -w1 w1 -w2 % Filling the channel % filling the wrapper % Filling the external region ът 2 594. 595. % Bottom plug 596. cell u5bplgr0 DR_BOT_PLUG fill bot_plg 597. cell u5bplgr1 DR_BOT_PLUG fmst91_673 -w1 % Filling the channel w1 -w2 % filling the wrapper 598. cell u5bplgr2 DR_BOT_PLUG cool_min w2 % Filling the external region 599.

 599.

 600. % Dummy rod axial scan

 601. cell c5tref
 DR_TOP_REF tref

 602. cell c5al
 DR fill DR_TOP_REF

 603. cell c5a2
 DR fill DR_TOP_FLUG

 604. cell c5a3
 DR fill DR_DUMM

 605. cell c5dum
 DR fill DR_DUMM

 606. cell c5a4
 DR fill DR_DTPLUG

 607. cell c5a5
 DR fill DR_DT FLUG

 608. cell c5a5
 DR fill DR_BOT_REF

 609. cell c5a5
 DR fill DR_BOT_REF

 z_tplg_dr z_tplg_dr z_sprn_dr -z_tref_dr -z_tref_dr -z_tplg_dr % upper reflector universe definition % upper reflector % top plug z dumm u -z sprn dr spring z_dumm_b -z_dumm_u dummy element % bottom plug
% bottom reflector universe definition -z_dumm_b -z_bplg_dr z_bplg_dr z_bref_dr % bottom reflector z_bref_dr -z_bplg_dr 609. 611. 612. % Barrel element 613. cell c6r1 B_ass barrel -w1 614. cell c6r2 B_ass barrel w1 -w2 615. cell c6r3 B_ass barrel w2 % Filling the channel % Filling the wrapper % Filling the external region 616. 617. cell c6 BA fill B_ass z_core_b -z_core_u 618. 619, ** -------- Core lattice loading -----% Core with CR and SR extracted 620. lat core 3 0.0 0.0 32 32 17.1 622. vv 623. 624. 625. 626. 627 628. 629. 630. 631. 632. 633 634. VV VV VV 11 11 BA DR DR U2 U2 U2 U1 U1 SR U1 U1 U1 U1 U1 U2 U2 U2 DR DR BA 11 11 VV VV VV VV VV VV VV 11 11 11 BA DR U2 OF U2 U1 U1 U1 U1 IF U1 U1 U1 U1 U2 OF U2 DR BA 11 11 11 VV VV VV VV VV VV VV 11 11 BA DR DR U2 U2 U2 U1 U1 U1 U1 SR U1 U1 U2 U2 U2 DR DR BA 11 11 VV VV VV VV 635. 636 637. vv vv vv 11 11 BA DR DR u2 CR u2 u1 u1 SR u1 u1 u1 u2 CR u2 DR DR BA 11 11 vv vv vv vv vv vv vv vv 11 11 BA DR DR u2 CR u2 u1 u1 SR u1 u1 u1 u2 CR u2 DR DR BA 11 11 vv vv vv vv vv vv vv vv vv 11 BA DR DR u2 u2 u2 u2 u1 u1 u1 u1 u1 u1 u2 u2 u2 u2 DR DR BA 11 vv vv vv vv vv vv vv 638 639. 640. 641. 642. 643 644. 645. 646. 647. 648. 3737 649. vv 650. vv vv 651. vv vv 652. vv vv vv vv vv vv vv vv 653. 654. cell c100 0 fill core -s1 z_core_b -z_core_u $\ \%$ Filling the cylinder with the core 655. cell c101 0 outside s1 z_core b -z_core u % Placing the vacuum outside the reactor 656. cell c104 0 outside z_core u % Placing the vacuum above the reactor



657. cell c105 0 outside -z_core_b % Placing the vacuum

 $\$ Placing the vacuum below the reactor

It should be remarked that the multi-group constants computed with the 3D FC model presented throughout the report have been obtained with the geometry model described in the previous file "ALFRED_ECCO.ge" but with the SRs rotated with an angle of 60 degrees. It has been assumed that the SR orientation has a negligible impact on the values of the multi-group constants. All the other calculations regarding the core characterisation have been performed using the 3D model defined in "ALFRED_ECCO.ge" without any modification.

E.3 Input files for the assembly cell model

In the following, the input files needed to reproduce the assembly cell model are reported.

E.3.1 Inner Fuel, 3D axially finite cell

The following file refers to the definition of a 3D assembly cell which is radially infinite (*i.e.*, finite with reflective boundary conditions) and axially finite. This file can be run independently.

```
%% -- EXTERNAL FILE INCLUSION
     include
              "/home/abrate/ricerca/enea_sarotto/alfred/alfred_ecco/cell_calculation/eranos_jeff31" 💲 materials
3.
     %% -- LIBRARY FOR NUCLEAR DATA
    set acelib "/opt/serpent/xsdata/jeff31/sss jeff31.xsdata"
5.
                  ----- GEOMETRIC SURFACES DEFINITIONS ------
7.
     % ----- Radial coordinate -
8.
9.
10.
    surf s1 sqc 0.0 0.0 25
                                  % wrapping inner perimeter
11.
12
    % Hexagonal assembly
surf w1 hexyc 0.0 0.0 7.9
surf w2 hexyc 0.0 0.0 8.3
surf w1 hexyc 0.0 0.0 8.3
surf w1 hexyc 0.0 0.0 7.9
surf w0 hexyc 0.0 0.0 8.3
% wrapping inner perimeter
% wrapping outer perimeter
13.
     % Hexagonal assembly
14.
16.
17.
18.
19.
     % Fuel rod (FR)
                                    % Upper reflector
% Fuel active zone upper limit
% Fuel active zone lower limit
% Bottom reflector
    surf z_tref pz 130.0
surf z_tref pz 30.0
surf z_fuel_u pz 30.0
surf z_fuel_b pz -30.0
surf z_bref pz -130.0
20.
21.
22.
23.
                                          % Bottom reflector
24.
25.
26.
27.
    & ----- PIN DEFINITION ------
     pin pi %
fueli 0.465
Ti1515_743 0.525
28.
                      % Inner fuel pin
29.
30.
31.
    cool_avg
32.
33.
                       % Outer fuel pin
     pin po
                 0.465
34.
     fuelo 0.465
Ti1515 743 0.525
35.
36.
37.
    cool_avg
38.
    pin ll
cool_min
                  % Pure lead (empty lattice positions)
39.
40.
41.
     pin vv
              % Pure lead (empty lattice positions)
42.
     void
43.
     8 -----
                            ----- ASSEMBLY DEFINITION -----
44.
45
46.
     % -- Inner fuel assembly
     47.
48.
     49.
50.
51.
52.
53.
54.
55.
56.
57.
58.
                    pi pi pi pi pi pi pi pi pi ll ll ll ll
l pi pi pi pi pi pi pi pi ll ll ll ll ll
59
                 11
60.
61.
                   ll pi pi pi pi pi pi ll ll ll ll ll ll ll
```



62 63. 64. % -- Outer fuel assembly 65. lat ass2 2 0.0 0.0 15 15 1.386 11 11 11 11 11 11 10 po po po po po 11 11 11 11 11 11 11 po po po po po po po 11 67 68. 69 11 11 11 11 11 po po po po po po po po po 11 11 11 11 11 po po po po po po po po po 11 70. 11 11 11 11 po 11 11 11 11 po 11 11 11 po 11 71. 72. 74. 75. 76. 77. 78 79. 80. 81. 82. 83 84.
 85.
 % Inner fuel

 86.
 % Inner fuel

 87.
 cell c1r0
 INN_FUEL

 88.
 cell c1r1
 INN_FUEL

 89.
 cell c1r2
 INN_FUEL
 fill ass1 fmst91_713 cool_avg % filling the channel -w1 w1 -w2 w2 % filling the wrapper
% filling the external region 89. cell clr2 INN_FUEL cool_avg w2 % f: 90. % Inner fuel assembly axial scan (universe definition to compute group-wise constants) 91. cell cltref_GCU IF_TOP_REF tref z_fuel_u -z_tref % upper reflector 92. cell clal_GCU IF fill IF_TOP_REF z_fuel_u -z_tref % upper reflector 93. cell cla5_GCU IF fill INN_FUEL z_fuel_b -z_fuel_u % fuel 94. cell clref_bo_GCU IF_BOT_REF bref z_bref -z_fuel_b % bottom reflector 95. cell cla9_GCU IF fill IF_BOT_REF z_bref -z_fuel_b % bottom reflector 96. 96. 97. %% ------98. 99. lat core 3 0.0 0.0 5 5 17.1 % Core with CR and SR extracted 100. IF IF IF IF IF 101. IF IF IF IF F IF 102. 103. 104. 105. 106. %% ------107. 108. cell c100 0 fill core -s1 z bref -z tref % Filling the cylinder with the core 109. cell c101 0 outside s1 z bref -z tref % Placing the vacuum outside the reactor 110. cell c104 0 outside z tref % Placing the vacuum above the s 111 cell c105 0 outside z tref % Placing the vacuum above the s % Placing the vacuum above the reactor % Placing the vacuum below the reactor 111. cell c105 0 outside -z_bref 112. 113 %% -- PLOTS 114. plot 3 2000 2000 0 115. plot 3 2000 2000 48 116. plot 3 2000 2000 43 117. plot 3 2000 2000 31 118. plot 1 1000 1000 29.18505 119. plot 2 1000 1000 120. 121. %% -- SIMULATION SETUP 122. set bc 2 123. set fum nj19 1 0 %[BTCH DUMMY LIM] B1 leakage-corrected mode 124. set pop 1000000 40 300 125. 126. %set csw IF_src_3D 127. %set nps 10000000 1000 128. %src IF_1M_1000a_250i_3D sf src_IF_1M_1000a_250i_3D 1 129. 130. \$ aggiunta il 3-09-18 per risolvere le risonanze dello spettro veloce \$ Check on fission source convergence 131. set ures 1 132. set his yes 133. 134. %% -- GROUP CONSTANT GENERATION 135. set micro nj19 % ECCO-33 groups 136. set nfg nj19 137. 138. 139. % --- Detector for tallying the flux energy spectrum 140. 141. % Detector to tally flux spectrum 142. ene ECCO_1968 4 nj20 143. ene ECCO_33 4 nj19 144. 145. det flx_spectrum_1968 de ECCO_1968 df IF_src_1968_1M_500a -1 146. det flx_spectrum_33 de ECCO_33 df IF_src_33_1M_500a 147. 148. set gcu INN_FUEL 149. IF TOP_REF 150. IF_BOT_REF



E.3.2 Inner Fuel, 3D infinite cell

The following file refers to the definition of a 3D assembly cell which is infinite both radially (*i.e.*, finite with reflective boundary conditions) and axially. This file can be run independently.

%% -- EXTERNAL FILE INCLUSION 1. 2.3. include "/home/abrate/ricerca/enea_sarotto/alfred/alfred_ecco/cell_calculation/eranos_jeff31.ml" % materials 4. ** -- LIBRARY FOR NUCLEAR DATA 5. set acelib "/opt/serpent/xsdata/jeff31/sss_jeff31.xsdata 6. 7. % ----- GEOMETRIC SURFACES DEFINITIONS -----8 % ------ Radial coordinate -----10. % Core 11. surf s1 sqc 0.0 0.0 25 % wrapping inner perimeter 12. 13. % Hexagonal assembly % wrapping inner perimeter % wrapping outer perimeter % wrapping inner perimeter % wrapping outer perimeter surf w1 hexyc 0.0 0.0 7.9 surf w2 hexyc 0.0 0.0 8.3 surf w1 hexyc 0.0 0.0 7.9 14. 15. 16. 17. surf wo hexyc 0.0 0.0 8.3 18.
 19.
 % Safety rod

 20.
 surf cyl1 cyl 0.0 0.0 7.35

 21.
 surf cyl2 cyl 0.0 0.0 8.35
 % cladding inner perimeter
% cladding outer perimeter 22 23. % Control Rod 24. surf cyl3 cyl 0.0 0.0 8.05 25. surf cyl4 cyl 0.0 0.0 8.35 % cladding inner perimeter
% cladding outer perimeter 25. 26. 27. 8-----28. % ------ PIN DEFINITION ------29. 29. 30. pin pi % Inner fuel pin 31. fueli 0.465 fueli 0.465 Ti1515_743 0.525 32. 33. cool avg 34.
 34.

 35.
 pin po
 %

 36.
 fuelo
 0.465

 37.
 Ti1515_743
 0.525
 % Outer fuel pin cool avg 38. 39. 40. pin pl % Plenum pin pin pl % void 0.4 pln 0.465 Ti1515_713 0.525 41. 42. 43. 44. cool_min 45. 46. 47. pin tg % Top plug "pin"
0.465 tplg 0.465 Ti1515_753 0.525 48. 49. cool_max 50. pin bg % Bo 51. % Bottom plug "pin" 52. bplg 0.465 Ti1515_713 0.525 53. 54. cool_min 55. pin ti % Top insulator "pin" tins 0.465 Til55_713 0.525 56. pin ti 57. 58. 59. cool max 60. 61. pin bi % Bottom insulator "pin" bins 0.465 Ti1515_713 0.525 62. 63. 64. cool_min 65. pin dp % Dummy "pin" 66. foll 0.465 Ti1515_713 0.525 67 68. 69. cool_avg 70. % Spring "pin" 71. pin sp 72. spr 0.465 73. Ti1515_713 0.525 74. cool_max pin sl 76. % Safety pin 77. safe 2.58 78. Ti1515_753 2.64 79. cool_max 80. 81. pin s2 % Safety pin safe 1.83 Ti1515_753 1.89 82. 83. 84. cool_max 85. % Control pin 1.49 86. pin cl 87. cont



88. 89.	Ti1515_673 1.55 cool min
90. 91	nin ce & Control nin plenum
92.	foll 1.49
93.	fmst91_713 1.55 cool avg
95.	rie franzel al Castrol air fallour
96.	foll 1.49
98.	fmst91_713 1.55
100.	cool_avg
101.	pin ll % Pure lead (empty lattice positions) cool min
103.	- Pin ur & Pure load (ampty lattice positions)
104.	void
106.	% % ASSEMBLY DEFINITION
108.	% Top insulator assembly
109.	lat top_ins 2 0.0 0.0 15 15 1.386 11 11 11 11 11 11 11 11 11 11 11 11 11
111.	11 11 11 11 11 11 ti ti ti ti ti 11
112.	11 11 11 11 11 11 ti ti ti ti ti ti ti ti 11
114.	ll ll ll ti ll
115.	
117.	ll ti ll
119.	li ti li ll ll
120.	ll ti ti ti ti ti ti ti ti ll ll ll ll ti ti ti ti ti ti ti ti ll ll ll
122.	ll ti ti ti ti ti 11 ll ll ll ll ll
123.	11 ti ti ti ti ti ti 11 11 11 11 11 11 11 11 11 11 11 11 11
125.	
126.	% Spring assembly lat spring 2 0.0 0.0 15 15 1.386
128.	
129.	ll ll ll ll ll sp sp sp sp sp sp sp ll
131.	ll ll ll ll sp sp sp sp sp sp sp sp ll
133.	ll ll ll sp ll
134.	11 11 sp 11 11 sp 11
136.	l sp l l ll
137.	II sp iI II II II sp sp sp sp sp sp sp sp sp iI II II II
139.	ll sp sp sp sp sp sp sp sp sp ll ll ll ll ll
140.	11 sp sp sp sp sp sp sp 11 11 11 11 11 11 sp sp sp sp sp sp sp 11 11 11 11 11 11
142.	11 11 11 11 11 11 11 11 11 11 11 11 11
144.	% Inner fuel assembly
145.	lat ass1 2 0.0 0.0 15 15 1.386 11 11 11 11 11 11 11 11 11 11 11 11 11
147.	11 11 11 11 11 11 pi pi pi pi pi pi 11
148.	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
150.	ll ll ll pi pi pi pi pi pi pi pi pi ll
151.	ll ll pi
153.	ll pi ll
155.	l pi li li li
156. 157.	11 pi pi pi pi pi pi pi pi pi 11 ll ll ll pi pi pi pi pi pi pi pi ll ll ll ll
158	ll pi pi pi pi pi pi pi ll ll ll ll ll
160.	11 11 11 11 11 11 11 11 11 11 11 11 11
161.	& Outor fuel accombly
163.	lat ass2 2 0.0 0.0 15 15 1.386
164.	
166.	11 11 11 11 11 po po po po po po 11
167.	11 11 11 11 po po po po po po po po 11 11 11 11 11 og og og og og og li
169.	11 11 10 00 00 00 00 00 00 00 00 00 11
171.	II po
172.	ll po ll ll
174.	ll po ll ll ll
175. 176	11 וו 11 וו 10 מס מס מס מס מס גע
177.	ll po po po po po po ll ll ll ll ll ll
178. 179	11 11 11 11 11 11 11 11 11 11 11 11 11
180.	<pre>% Dummy assembly</pre>
181.	Lat dr_dumm 2 0.0 0.0 15 15 1.386 11 11 11 11 11 11 11 11 11 11 11 11 11
183.	



184.	ll ll ll ll ll dp dp dp dp dp dp dp ll
185.	ll ll ll ll dp dp dp dp dp dp dp ll
187.	11 11 11 11 dp 11 11 11 11 dp 11
188.	ll ll dp
190.	ll dp
191.	ll dp l1 l1 l1 11 dp 11 11 11
193.	ll dp dp dp dp dp dp dp dp l1 ll ll ll ll
194.	li dp dp dp dp dp dp li li li li li li 11 dp dp dp dp dp dp li li li li li li
196.	11 11 11 11 11 11 11 11 11 11 11 11 11
198.	<pre>% Inactive fuel assembly lat hat ima 2 0 0 0 0 15 15 1 286</pre>
200.	11 11 11 11 11 11 11 11 11 11 11 11 11
201.	ll ll ll ll ll ll bi bi bi bi bi bi ll ll ll ll ll ll bi bi bi bi bi bi bi ll
203.	11 11 11 11 bi bi bi bi bi bi bi bi bi 11
204.	11 11 11 bi 11
206.	ll ll bi ll ll bi ll
208.	ll bi ll ll
210.	ll bi bi bi bi bi bi bi bi bi ll ll ll
211.	ll bi bi bi bi bi bi bi bi ll ll ll ll ll ll bi bi bi bi bi bi bi ll ll ll ll ll ll
213.	11 bi bi bi bi bi bi 11 11 11 11 11 11 11 11 11 11 11 11 11
215.	
216.	<pre>% Plenum assembly lat plen 2 0.0 0.0 15 15 1.386</pre>
218.	ון וו ו
220.	
221.	
223.	ll ll pl ll ll ll pl ll
225.	ll pl ll
227.	li pi li li li
228.	
230.	ון 10 בן 10 בן 10 בן 10 ב
232.	
233.	% Outer fuel assembly
235.	lat top_plg 2 0.0 0.0 15 15 1.386 11 11 11 11 11 11 11 11 11 11 11 11 11
237.	ll ll ll ll ll tg tg tg tg tg tg ll ll ll ll ll ll tg tg tg tg tg tg tg ll
239.	11 11 11 11 tg 1
240.	ll ll lg tg ll
242.	ll ll tg ll ll ta
244.	ll tg l] ll
245.	ll tg ll ll ll
247.	li tg tg tg tg tg tg tg tg li li li li 11 tg tg tg tg tg tg tg tg 11 11 11 11 11
249.	
251.	۰
253.	lat bot_plg 2 0.0 0.0 15 15 1.386
254.	11 11 11 11 11 11 11 11 11 11 11 11 11
256.	ll ll ll ll ll bg bg bg bg bg bg bg ll ll ll ll ll bg bg bg bg bg bg bg bg ll
258.	ll ll ll bg bg bg bg bg bg bg bg bg ll
259.	ll ll bg
261.	11 bg ll 11 bg ll 11
263.	11 bg 11 11 11 bg 11 11
265.	l bg bg bg bg bg bg bg bg ll ll ll ll
266.	11 bg bg bg bg bg bg bg 11 11 11 11 11 11 11 bg bg bg bg bg bg 11 11 11 11 11
268.	11 11 11 11 11 11 11 11 11 11 11 11 11
270.	% Void assembly
272.	AA
273.	VA V
275.	VV
277.	
279.	AA



-						
280.	vv vv vv vv	· vv vv vv vv	vv vv vv vv vv v	v vv		
281.						
202. 202						
283.						
285.	$ \ \ \ \ \ \ \ \ \ \ \ \ \ $					
286.	VV VV	. AA AA AA AA AA	vv vv vv vv vv v	v vv vv vv		
288.						
289.	<pre>% Lead assembly</pre>					
290.	lat la 2 0.0 0.0 15	15 1.386 1 11 11 11 11	11 11 11 11			
292.		11 11 11 11 1	1 11 11 11 11			
293.						
294.			$\begin{array}{cccccccccccccccccccccccccccccccccccc$			
296.	11 11 11 11 11	11 11 11 11	11 11 11 11 11 1	1		
297.				11		
299.	11 11 11 11			1 11		
300.	11 11 11 1	1 11 11 11 11	. 11 11 11 11 11	11 11		
301.			$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1 11 11		
303.	11 11 1	1 11 11 11 11	11 11 11 11 11	11 11 11		
304.	11 11					
306.	11 11					
307.	% Safety rod ass	embly (circul	ar array)			
308.	1at sare2 4 0.0 0.0 3 2.0 0 s1 s1 s1	Z % ACT1	ve section			
310.	9 5.5 0 s1 s1 s1 s1	s1 s1 s1 s1	s1			
311.	8 Safoty rod ass	ombly (circul	ar arrau)			
313.	lat safe1 4 0.0 0.0	2 % Acti	ve section			
314.	1 0 0 s1					
315.	6 5.25 30 SZ SZ SZ	SZ SZ SZ				
317.	% Control rod as	sembly (circu	ılar array)			
318.	lat cont1 4 0.0 0.0	3 % Acti	ve section			
320.	6 3.3 30 c1 c1 c1 c	1 c1 c1				
321.	12 6.37511 15 c1 c1	c1 c1 c1 c1	c1 c1 c1 c1 c1 c	1		
322.	lat continact 4 0.0	0.0 3 % Inac	tive section			
324.	1 0.0 0 fp					
325.	6 3.3 30 fp fp fp f 12 6 37511 15 fp fp	p fp fp fp fp fp fp	fn fn fn fn fn f	n		
1 220.	12 6.37511 15 fp					
327.	8			P 		
327. 328.	е			۲ 		
327. 328. 329. 330.	8 8 888888888888888888888888		**************************************	۲ FUEL %%%%%%%%%%%%%%		
327. 328. 329. 330. 331.	<pre>% % % % % % Inner fuel</pre>		**************************************	۲ 		
327. 328. 329. 330. 331. 332. 333.	<pre>% % % ***********************</pre>	f1	fill ass1 fmst91 713	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper</pre>	
327. 328. 329. 330. 331. 332. 333. 334.	<pre>% % % Inner fuel cell clr1 cell clr1 cell clr2</pre>	f1 f1 f1	fill ass1 fmst9_713 cool_avg	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336	<pre>%% %</pre>		fill ass1 fill ass1 fill ass1	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337.	<pre>%% %% % Inner fuel cell clr1 cell clr1 cell clr2 cell clr2 cell clr2 cell clr2 cell clr1_GCU</pre>	fl fl fl IF IF	fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fill ass1	FUEL %%%%%%%%%%%%%% -w1 w1 -w2 w2 -wi wi -wo	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338.	<pre>%% % Inner fuel cell clr0 cell clr1 cell clr2 cell clr2 cell clr2_GCU cell clr2_GCU</pre>	fl fl fl IF IF IF	fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fist91_713 cool_avg	FUEL %%%%%%%%%%% -w1 w1 -w2 w2 -wi wi -wo wo	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the channel % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340.	<pre>%% % Inner fuel cell clr0 cell clr1 cell clr2 cell clr2 cell clr2_GCU % Top plug</pre>	fl fl fl IF IF IF	fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fill ass1 fist91_713 cool_avg	FUEL %%%%%%%%%%% -w1 w1 -w2 w2 -wi wi -wo wo	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341.	<pre>% % % Inner fuel cell clr0 cell clr1 cell clr1 cell clr2 cell clr2_GCU cell clr2_GCU cell clr2_GCU % Top plug cell ultplgr0</pre>	fl fl fl fl fl IF IF IF IF	<pre>fill ass1 fmst91_713 ccol_avg fill ass1 fmst91_713 ccol_avg fill ass1 fmst91_713 ccol_avg fill top_plg</pre>	FUEL %%%%%%%%%% -w1 w2 -wi w2 -wi wi -wo wo -w1	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the external region % filling the channel</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342.	<pre>%*******************************</pre>	fl fl fl fl IF IF IF Ultplg ultplg ultplg	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool max	FUEL %%%%%%%%%%% -w1 w1 -w2 w2 -wi wi -wo wo -w1 w1 -w2 w2 -w1 w1 -w2 w2	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the channel % filling the external region % filling the channel % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343.	<pre>%*******************************</pre>	fl fl fl fl IF IF IF Ultplg ultplg ultplg	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max	FUEL &&&&&&& FUEL &&&&&& -w1 -w2 w2 -w1 w1 -w0 w0 -w1 w1 -w2 w2	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 344. 345.	<pre>%</pre>	fl fl fl fl IF IF IF IF IF IF IF IF IF IF IF IF IF	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the external region % filling the channel % filling the external region % filling the channel % filling the channel % filling the channel % filling the wrapper</pre>	
327. 328. 329. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 344. 344. 344. 344. 344.	<pre>%*******************************</pre>	fl fl fl fl IF IF IF IF IF IF IF TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the channel % filling the channel % filling the external region % filling the channel % filling the channel % filling the wrapper % filling the wrapper % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 346. 347. 346. 347. 348. 347. 347. 348. 347.	<pre>%*******************************</pre>	fl fl fl fl IF IF IF IF IF IF IF IF TOP_PLUG IF_TOP_PLUG	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753 cool_max	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the external region % filling the channel % filling the external region % filling the channel % filling the channel % filling the wrapper % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 334. 335. 336. 337. 338. 340. 341. 342. 343. 344. 344. 344. 344. 344. 344. 344. 345. 344. 344. 345. 344. 345. 344. 345. 344. 345. 346. 347. 348. 35. 35. 35. 35. 35. 35. 35. 35	<pre>%*******************************</pre>	fl fl fl fl IF IF IF IF IF IF Ultplg ultplg ultplg IF_TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG Ulspr ulspr	<pre>fill as1 fmst91_713 cool_avg fill as1 fmst91_713 cool_avg fill as1 fmst91_713 cool_avg fill top_plg fmst91_753 cool_max fill top_plg fmst91_753 cool_max fill spring fmst91_753</pre>		<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the external region % filling the channel % filling the channel</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 343. 344. 344. 344. 344. 346. 346. 347. 348. 350. 351.	<pre>%*******************************</pre>	fl fl fl fl IF IF IF IF IF IF Ultplg ultplg ultplg IF_TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG Ulspr ulspr ulspr	<pre>fill as1 fmst91_713 cool_avg fill as1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max</pre>	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the channel % filling the external region % filling the channel % filling the channel % filling the channel % filling the channel % filling the external region % filling the channel % filling the channel % filling the channel % filling the channel % filling the wrapper % filling the wrapper % filling the wrapper % filling the external region</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 337. 338. 341. 342. 343. 344. 345. 344. 345. 344. 345. 347. 348. 347. 348. 347. 348. 347. 348. 347. 348. 347. 348. 347. 348. 347. 347. 347. 347. 347. 347. 347. 347	<pre>%*******************************</pre>	f1 f1 f1 f1 IF IF IF IF IF IF Ultplg ultplg ultplg IF_TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG Ulspr ulspr ulspr	<pre>fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_plg fmst91_753 cool_max fill top_plg fmst91_753 cool_max fill spring fmst91_753 cool_max</pre>	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the wrapper % filling the wrapper % filling the channel % filling the channel</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 337. 338. 337. 338. 340. 341. 342. 343. 344. 345. 344. 345. 344. 351. 352. 354.	<pre>%</pre>	f1 f1 f1 f1 IF IF IF IF IF IF TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG ISPT ulspr ulspr ulspr IF_SPRING IF_SPRING	<pre>fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_plg fmst91_753 cool_max fill top_plg fmst91_753 cool_max fill spring fmst91_753</pre>	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the external region % filling the channel % filling the channel % filling the wrapper % filling the wrapper % filling the external region % filling the external region % filling the channel % filling the wrapper</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 340. 343. 344. 345. 346. 347. 346. 345. 346. 345. 346. 349. 350. 351. 352. 354. 354. 354. 354.	<pre>%</pre>	fl fl fl fl iF iF iF iF iF iF iF iF iF iF iF iF iF	<pre>fill as1 fmst91_713 cool_avg fill as1 fmst91_713 cool_avg fill top_plg fmst91_753 cool_max fill top_plg fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max</pre>	FUEL & & & & & & & & & & & & & & & & & & &	<pre>% filling the channel % filling the wrapper % filling the external region % filling the channel % filling the channel % filling the external region % filling the channel % filling the channel % filling the channel % filling the external region % filling the channel % filling the channel</pre>	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 340. 343. 344. 345. 346. 347. 348. 349. 345. 346. 349. 350. 351. 352. 355. 354. 355. 357.	<pre>% GCU % Top plug cell ultplgr0 GCU cell ultplgr0 cell ultplgr1 cell ultplgr2 cell ultprn7 cell ulsprn7 cell ulsprn7 cell ulsprn7 cell ulsprn7 cell ulsprn7 cell ulsprn7 GCU % Top insulator</pre>	fl fl fl fl IF IF IF IF IF IF IF IF IF IF SPRING IF_SPRING IF_SPRING	<pre>fill as1 fmst91_713 cool_avg fill as1 fmst91_713 cool_avg fill top_plg fmst91_753 cool_max fill top_plg fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max</pre>	FUEL & & & & & & & & & & & & & & & & & & &	 filling the channel filling the wrapper filling the external region filling the channel filling the channel filling the external region filling the channel filling the external region filling the external region filling the channel filling the wrapper filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 343. 343. 344. 343. 344. 343. 344. 345. 350. 351. 354. 355. 356. 358.	<pre>%%******************************</pre>	fl fl fl fl iF iF iF iF iF iF iF iF iF iF iF iF iF	<pre>ip ip i</pre>	FUEL & & & & & & & & & & & & & & & & & & &	 filling the channel filling the wrapper filling the external region filling the channel filling the wrapper filling the external region filling the channel filling the external region filling the channel filling the channel filling the channel filling the external region filling the channel filling the wrapper filling the wrapper filling the channel filling the channel filling the channel filling the channel filling the wrapper filling the wrapper filling the wrapper filling the channel filling the channel filling the wrapper filling the wrapper filling the wrapper filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 344. 345. 355. 356. 355. 356. 358. 358. 358. 358. 358. 358. 358. 358	<pre>%%******************************</pre>	fl fl fl fl IF IF IF IF IF IF SPRING IF_TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG Ulspr ulspr ulspr IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING	<pre>fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_plg fmst91_753 cool_max fill top_plg fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max</pre>		 filling the channel filling the wrapper filling the external region filling the channel filling the channel filling the external region filling the channel filling the external region filling the channel filling the external region filling the channel filling the channel filling the wrapper filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 344. 345. 346. 357. 355. 355. 355. 356. 355. 358. 359. 361. 361.	<pre>%</pre>	fl fl fl fl IF IF IF IF Ultplg ultplg ultplg IF_TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG Ulspr uls	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max		 filling the channel filling the wrapper filling the external region filling the channel filling the external region filling the external region filling the channel filling the external region filling the channel filling the channel filling the channel filling the external region filling the external region filling the external region filling the external region filling the channel filling the external region filling the external region filling the channel filling the channel filling the external region filling the external region filling the external region filling the channel filling the channel filling the channel filling the external region 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 341. 342. 343. 344. 345. 344. 345. 344. 345. 356. 357. 357. 357. 358. 357. 358. 359. 356. 357. 357. 358. 359. 356. 357. 357. 357. 357. 358. 357.	<pre>%</pre>	fl fl fl fl IF IF IF IF IF TOP_PLUG IF_TOP_PLUG IF_TOP_PLUG Ulspr Ulspr Ulspr Ulspr IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING IF_SPRING	<pre>fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max</pre>	FUEL & & & & & & & & & & & & & & & & & & &	 filling the channel filling the wrapper filling the external region filling the channel filling the channel filling the channel filling the channel filling the external region filling the channel filling the external region filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 341. 342. 343. 344. 345. 344. 345. 344. 345. 344. 345. 344. 345. 356. 357. 358. 359. 356. 357. 358. 359. 356. 357. 358. 359. 356. 357. 358. 359. 356. 357. 358. 359. 359. 356. 357. 358. 359. 359. 359. 359. 359. 359. 340. 341. 344. 345. 359. 361. 359. 361. 359. 361. 359. 361. 359. 361. 362. 364. 359. 361. 362. 364. 359. 361. 362. 364. 362. 363. 364. 369. 369. 369. 369. 369. 369. 361. 362. 364. 369. 361. 362. 364. 364. 364. 365. 367. 366. 367.	<pre>%</pre>	fl fl fl fl fl iF iF iF iF iF iF iF top_pLUG iF_TOP_PLUG iF_TOP_PLUG iF_TOP_PLUG ispr ulspr ulspr iF_SPRING iF_SPRING iF_SPRING iF_SPRING iF_TOP_INS iF_TOP_INS iF_TOP_INS	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the external region filling the channel 	
327. 328. 329. 330. 331. 332. 333. 3340. 335. 336. 337. 338. 333. 341. 342. 343. 344. 345. 344. 345. 351. 354. 355. 354. 355. 356. 357. 358. 359. 360. 361. 362. 364. 365. 364. 365.	<pre>%</pre>	fl fl fl fl fl IF IF IF IF IF SPRING IF_TOP_PLUG Ulspr Ulspr Ulspr Ulspr Ulspr Ulspr IF_SPRING IF_SPRING IF_SPRING IF_TOP_INS IF_TOP_INS IF_TOP_INS	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the external region filling the channel 	
327. 328. 329. 330. 331. 332. 333. 3340. 335. 336. 337. 338. 333. 340. 341. 344. 345. 344. 345. 344. 345. 351. 354. 355. 354. 355. 356. 357. 358. 359. 360. 361. 362. 364. 365. 364. 365. 364. 365. 364. 365. 366. 367.	<pre>%</pre>	fl fl fl fl fl IF IF IF IF IF SPRING IF_TOP_PLUG Ulspr Ulspr Ulspr Ulspr Ulspr Ulspr Ulspr IF_SPRING IF_SPRING IF_SPRING IF_TOP_INS IF_TOP_INS IF_TOP_INS IF_TOP_INS IF_TOP_INS IF_TOP_INS	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill top p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the external region filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 344. 345. 351. 354. 355. 356. 355. 356. 359. 366. 366. 367. 368. 368.	<pre>%</pre>	fl fl fl fl fl iF iF iF iF iF iF iF iF iF iF top_pLUG iF_TOP_PLUG iF_TOP_PLUG iF_TOP_PLUG iF_SPRING iF_SPRING iF_SPRING iF_SPRING iF_SPRING iF_TOP_INS iF_TOP_INS iF_TOP_INS iF_TOP_INS iF_TOP_INS iF_TOP_INS iF_TOP_INS	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the external region filling the channel filling the channel filling the external region filling the external region filling the channel filling the external region filling the channel filling the external region filling the external region filling the channel filling the external region filling the external region filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 344. 345. 351. 354. 355. 354. 355. 356. 359. 360. 355. 366. 367. 368. 366. 366. 366. 366. 366. 366. 366	<pre>%</pre>	fl fl fl fl fl fl iF iF iF iF iF iF iF iF iF iF iF iF iF	fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the external region filling the channel filling the channel filling the external region filling the channel filling the channel filling the external region filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 340. 341. 343. 344. 343. 344. 343. 344. 344	<pre>%</pre>	fl fl fl fl fl iF iF iF iF iF iF iF iF iF iF iF iF iF	<pre>fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill ass1 fmst91_713 cool_avg fill top_p1g fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill spring fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max fill top_ins fmst91_753 cool_max</pre>	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the external region filling the channel filling the channel filling the channel filling the wrapper filling the wrapper filling the channel filling the channel filling the channel filling the channel filling the wrapper filling the channel filling the channel filling the channel filling the wrapper filling the channel 	
327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 340. 341. 343. 344. 345. 344. 344. 345. 351. 352. 354. 355. 354. 355. 355. 356. 357. 358. 355. 366. 363. 366. 366. 366. 366. 366	<pre>%</pre>	fl fl fl fl fl iF iF iF iF iF iF iF iF iF iF iF iF iF	<pre>ip ip i</pre>	FUEL %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%	 filling the channel filling the wrapper filling the channel filling the channel filling the channel filling the channel filling the wrapper filling the channel 	
327. 328. 329. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 343. 344. 343. 344. 355. 356. 357. 358. 355. 356. 357. 358. 359. 354. 355. 356. 357. 358. 359. 356. 357. 358. 359. 356. 357. 358. 359. 356. 357. 358. 359. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 356. 357. 358. 357. 357. 357. 358. 357. 377.	<pre>%%******************************</pre>	fl fl fl fl fl iF iF iF iF iF iF iF iF iF iF iF iF iF	<pre>ip ip i</pre>	FUEL ************************************	 filling the channel filling the wrapper filling the external region filling the channel filling the wrapper filling the external region filling the channel filling the external region filling the channel filling the channel filling the channel filling the channel filling the external region filling the channel filling the external region filling the channel 	



376. cell u1plnr0 377. cell u1plnr1 fill plen fmst91_673 % filling the channel u1pln -w1 w1 -w2 u1pln % filling the wrapped 378. cell u1plnr2 u1pln cool min w2 % filling the external region 379. % filling the channel 380. cell u1plnr0_GCU IF_PLEN IF_PLEN fill plen -w1 381. cell u1plnr1_GCU 382. cell u1plnr2_GCU w1 -w2 fmst91_673 % filling the wrappen IF PLEN w2 % filling the external region cool min 383. 384. % Bottom plug 385. cell ulbplgr0 386. cell ulbplgr1 fill bot_plg fmst91 673 ulbplg -w1 % filling the channel w1 -w2 ulbplg % filling the wrapper 387. cell u1bplgr2 ulbplg cool min w2 % filling the external region 388. 389. cell ulbplgr0_GCU IF_BOT_PLUG fill bot_plg 390. cell ulbplgr1_GCU IF_BOT_PLUG fmst91_673 391. cell ulbplgr2_GCU IF_BOT_PLUG cool_min -w1 % filling the channel w1 -w2 % filling the wrapper % filling the external region w2 392 393. %% --------- Core lattice loading ------394. 394. 11 core 3 0.0 0.0 5 5 17.1 % Core with CR and SR extracted 396. 11 f1 f1 f1 397. f1 f1 f1 f1 f1 f1 398. f1 399. 400. f1 f1 f1 f1 f1 f1 401. 402. %% -----403. 404. cell c100 0 fill core -s1 % Filling the cylinder with the core 405. cell c101 0 outside s1 % Placing the vacuum outside the reactor 406. 407. %% - PLOTS 400. %% -- PLOTS 408. plot 3 2000 2000 135 409. plot 3 2000 2000 48 410. plot 3 2000 2000 43 411. plot 3 2000 2000 31 412. plot 1 1000 1000 29.18505 413. plot 2 1000 1000 414. 415. %% -- SIMULATION SETUP 416. set bc 2 417. set fum nj19 %[BTCH DUMMY LIM] B1 leakage-corrected mode 418. set pop 1000000 1000 50 419. src OF_1M_500a_250i_2D sf src_OF_1M_500a_250i_2D 1 420. % aggiunta il 3-09-18 per risolvere le risonanze dello spettro veloce 421. set ures 1 422 423. 424. set his yes % Check on fission source convergence 425. 426. %% -- GROUP CONSTANT GENERATION 427. ene 172xmas 4 nj18 428. set micro nj19 % ECCO-33 groups 429. set nfg nj19 430. 431. 431. 432. % --- Detector for tallying the flux energy spectrum 433. % The energy grid used for tallying will be defined later 434. %det IF_src_in_1g ds wi -1 df if_src_500k_1g 1 435. %det IF_src_in_172g de 172xmas ds wi -1 df if_src_500k_172g 1 436. %det IF_src_out ds wi 1 df if_src_500k -437 -0 8 437 437. % Detector to tally flux spectrum 438. ene MyEnergyGrid 3 2000 1e-11 2e1 440. det flx_spectrum de MyEnergyGrid df IF_src_1M_500a -1

E.3.3 Safety rod, 3D infinite cell with external source (fission spectrum)

In the following, the input file that defines a non-multiplying region cell (the absorbing bundle of the SR in this case), both axially and radially infinite (*i.e.*, finite with reflective boundary conditions) with an external neutron source. In order to simulate the behaviour of a different region, it is sufficient to change the assembly definition. The complete set of all the different assembly types is present in the *"ALFRED_ECCO.ge"* and *"ALFRED_ECCO_v2.ge"* files (§E.2). This file can be run independently.

In this case (SR), the external source is distributed in energy as the fission spectrum of the inner fuel, computed in the previous input (see §E.3.2) with the card "*det flx_spectrum de MyEnergyGrid df IF_src_1M_500a -1*".

```
1. %% -- EXTERNAL FILE INCLUSION
2. include "/home/abrate/ricerca/enea_sarotto/alfred/alfred_ecco/cell_calculation/eranos_jeff31.ml" % materials
3.
4.
```



```
5
        88 -- LIBRARY FOR NUCLEAR DATA
6.
7.
       set acelib "/opt/serpent/xsdata/jeff31/sss jeff31.xsdata"
8.
9.
..
10. % ----- Radial coordinate ------
11. % Core
     surf s1 sqc 0.0 0.0 25
12.
                                                  % wrapping inner perimeter
13.
14.
11. % Hexagonal assembly
16. surf w1 hexyc 0.0 0.0 7.39
17. surf w2 hexyc 0.0 0.0 8.3
                                                      % wrapping inner perimeter
% wrapping outer perimeter
18.

      19. % Safety rod

      20. surf cyl1 cyl 0.0 0.0 7.35

      21. surf cyl2 cyl 0.0 0.0 8.35

                                                % cladding inner perimeter
% cladding outer perimeter
22.
23.
       §-----
24.
       % ------ PIN DEFINITION ------
24. * ------ P1
25. pin s1 * Safety pin
26. safe 2.58
27. Ti1515_753 2.64
28. cool max
29.

      29.

      30. pin s2
      % S

      31. safe
      1.83

      32. Ti1515_753
      1.89

                         % Safety pin
33. cool_max
34.
35. % -- Safety rod assembly (circular array)
36. lat safe1 4 0.0 0.0 2 % Active section
37. 1 0 0 s1

      6 5.25 30 s2 s2 s2 s2 s2 s2
3.8
39.
40.
      8---
41.

        42. * Safety rod
        -w1

        43. cell c3r1 SR_ACT fill safe1
        -w1

        44. cell c3r2 SR_ACT fmts91_753
        w1 -w2

        45. cell c3r4 SR_ACT cool_max
        w2

                                                                                         % Filling the channel
                                                                                       % Filling the cladding
% Filling the external region
46.
       lat core 3 0.0 0.0 5 5 17.1
47.
                                                        % Core with CR and SR extracted
      lat core 3 0.0 0.0 5 5 17.1 %
SR_ACT SR_ACT SR_ACT SR_ACT SR_ACT
48.
49.
50.
51.
52.
53.
54.
      88 -----
55.
56.
57.
      cell c100 0 fill core -s1 % Filling the cylinder with the core
cell c101 0 outside s1 % Placing the vacuum outside the reactor
58.
59.
            -- PLOTS

        %
        --
        PLOTS

        plot 3 2000 2000 135
        135

        plot 3 2000 2000 48
        1014

        plot 3 2000 2000 43
        1014

        plot 3 2000 2000 31
        115

        plot 1 1000 1000 29.18505
        1165

60.
61.
62.
63.
64.
65.
66.
      %% -- SIMULATION SETUP
67.
68. set bc 2
69. set fum nj19 %[ BTCH DUMMY LIM ] B1 leakage-corrected mode
70
      %set pop 1000000 500 250 % Population data
71.
72.
73.
      set nps 1000000000 5000
74.
75.
76.
77.
     set ures 1
                                           % aggiunta il 3-09-18 per risolvere le risonanze dello spettro veloce
78.
                                % Check on fission source convergence
      set his yes
79.
80.
      %% -- GROUP CONSTANT GENERATION
                                           % ECCO-33 groups
81.
      set micro nj19
     set nfg nj19
set gcu SR_ACT
82.
83.
84.
85. ene ene_grid 4 nj19
86.
     % --- Detector for tallying the flux energy spectrum
% The energy grid used for tallying will be defined later
det SR_ACT_FLX du SR_ACT de ene_grid
det SR_ACT dr -3 void dr -16 void du SR_ACT de ene_grid
87.
88.
89.
90.
91.
92.
96.
                                5.9500000000000e-09 3.5222600000000e-06
                                 8.45000000000000e-09 9.483829999999999e-06
97.
98.
                                1.2500000000000e-08 2.7127300000000e-05
99.
                                1.75000000000000e-08 4.53558000000000e-05
```



100.	2.250000000000000e-08	6.5730100000000e-05
101	2 750000000000000e-08	9 134400000000000000000000000000000000000
102	2.2500000000000000000000000000000000000	
102.	3.25000000000000000000000000000000000000	1.21/1900000000000000000000000000000000000
103.	3.850000000000000e-08	2.2753500000000e-04
1 1 0 4	4 (000000000000000000000000000000000000	2 4515000000000- 04
104.	4.6000000000000000e-08	3.4515900000000000000000000000000000000000
105	5 4000000000000000000000000000000000000	4 49657000000000-04
100	C. 25000000000000000000000000000000000000	
106.	6.250000000000000e-08	6.405/1000000000e-04
107.	7.200000000000000e-08	8.81992000000000e-04
108	7 85000000000000000-08	3 02633000000000=04
100.	0.2500000000000000000000000000000000000	3. 20035000000000 04
109.	8./500000000000000e-08	1.790750000000000000000000000000000000000
110.	9.75000000000001e-08	7.0156700000000e-04
1111.	1.075000000000000e-07	2.4301200000000e=03
110	1 245000000000000 07	2. 8051(000000000-03
112.	1.245000000000000000000000000000000000000	3.80318000000000000000000000000000000000
113.	1.3/0000000000000e-0/	1.3650800000000000000000000000000000000000
114.	1.431850000000000e-07	1.53447000000000e-03
115	1 497000000000000e-07	1 703700000000000-03
116	1 565150000000000 07	1 8527000000000 03
110.	1.3031300000000000000000	1.8853700000000000000000000000000000000000
117.	1.648550000000000e-07	2.80450000000000e-03
118.	1.748550000000000e-07	3.18573000000000e-03
119	1 84500000000000000-07	2 972570000000000-03
100	1 02005000000000 07	2.4240200000000000000000000000000000000
120.	1.939030000000000000000	3.424920000000000000000000000000000000000
121.	2.039750000000000e-07	3.821360000000000=-03
122.	2.145700000000000e-07	4.23844000000000e-03
123	2 2679000000000000-07	5 601420000000000000000000
104	2.20790000000000000000000000000000000000	5.001420000000000000000000000000000000000
124.	2.40/900000000000000	0.32031000000000000000000000000000000000
125.	2.55755000000000e-07	7.20597000000000e=03
126.	2.71755000000000e-07	8.10130000000001e-03
127	2 90000000000000000000000	1 038210000000000=-02
120	2.07250000000000000000000000000000000000	
120.	3.07230000000000000000000000000000000000	1.00132333333333339990-03
129.	3.17250000000000e-07	3.0646000000000e=03
130.	3.273300000000000e-07	8.36457000000000e-03
131	3 42330000000000000000000000000000000000	9.02957000000000000000
100	5.4255660000000000000000000000000000000000	3. 0233103000000000 03
132.	3.599650000000000e-07	1.21181000000000e=02
133.	3.804650000000000e-07	1.32939000000000e-02
134.	3.9550000000000000000	5.79848000000000e-03
135	4 069950000000000000000000000000000000000	1789200000000000-03
100	4.0040500000000000000000000000000000000	3.170220000000000000000000000000000000000
136.	4.234950000000000e-07	1.2/313000000000e=02
137.	4.413400000000000e-07	1.14232000000000e-02
138	4 583450000000000e-07	1 2094100000000000000000000000000000000000
100.	4.36945000000000000000000000000000000000000	
139.	4./60050000000000e-0/	1.2/54500000000000000000000000000000000000
140.	4.925000000000001e-07	1.0789000000000e=02
141.	5.098100000000000e-07	1.43081000000000e-02
1/12	5 2560000000000000-07	8 82283000000000000000
112.	5.2500000000000000000000000000000000000	0.02235000000000000000000000000000000000
143.	5.35/90000000000e-0/	6.24843000000000e-03
144.	5.534800000000000e-07	2.0243200000000e=02
145.	5.811200000000000e-07	2.1571600000000e=02
146	6 101400000000000 07	2 28286000000000 02
140.	6.101400000000000e-07	2.29386000000000000000000000000000000000000
147.	6.390750000000000e-07	2.19876000000000e-02
148.	6.678550000000000e-07	2.3157600000000e-02
149	6 937800000000000e-07	1 7781900000000000000000000000000000000000
150	3.33375000000000000000000000000000000000	
150.	7.23275000000000e-07	2.91437000000000000000000000000000000000000
151.	7.607750000000000e-07	3.085700000000000000000000000000000000000
152.	7.850000000000000e-07	8.0513400000001e-03
153	8 0472500000000000-07	2 37662000000000=02
155.	0.0472500000000000000000000000000000000000	
154.	8.3472500000000000000	2.4681800000000000000000000000000000000000
155.	8.550000000000000e-07	8.0895600000001e-03
156.	8.68213000000001e-07	1.32919000000000e-02
157	8 9321300000000000-07	2 72164000000000=02
150	0.0021000000000000000000000000000000000	
100.	5.2000000000000000000000000000000000000	1.023420000000000000000000000000000000000
159.	9.400000000000000e-07	1.62101000000000e=02
160.	9.610000000000000e-07	1.78258000000000e-02
161.	9.790000000000001e-07	1.133440000000000000-02
162	0.0000000000000000000000000000000000000	
102.	a.anaaaaaaaaaaaaaaaaaaaa	o.ususauuuuuuuuuuuuuuuu
163.	1.008000000000000e-06	1.94357000000000e=02
164.	1.027500000000000e-06	1.21312000000000e-02
165.	1.04000000000000000e-06	8.07506000000000000-03
166	1 05800000000000000000000000000000000000	2.09741000000000-02
100.	1.03500000000000000000000000000000000000	2.05/110000000000000000000000000000000000
16/.	1.0/55000000000000e-06	/.252//000000000e=03
168.	1.088500000000000e-06	1.36868000000000e-02
169.	1.1035000000000000e-06	1.04606000000000e-02
170	1 11650000000000000000000000000000000000	1.043660000000000000000000000000000000000
171	1.1265000000000000000000	
L 1 / 1 .	1.1302000000000000e-06	2.100980000000000000000000000000000000000
172.	1.160000000000000e-06	1.60281000000000e-02
173.	1.186030000000000e-06	2.56285000000000e-02
174	1 21853000000000000000	2 625640000000000=-02
175	1.2510400000000000000000000000000000000000	2.52330000000000000000000000000000000000
1/5.	1.251040000000000e-06	2.34663000000000000002
176.	1.283540000000000e-06	2.6054400000000e=02
177.	1.318750000000000e-06	2.95697000000000e-02
178	1 3537500000000000000000	2 5527400000000000000000000000000000000000
170	1.333/300000000000e=06	2.332/10/00/00/00/00/00/00/00/00/00/00/00/00/
1/9.	1.38728000000000e-06	2.70388000000000e=02
180.	1.422280000000000e-06	2.7620300000000e-02
181.	1.457500000000000000000000000000000000000	2.7161800000000e-02
102	1 4975000000000000000000000000000000000000	
102.	1.40/000000000000000000	1.5312300000000000000000000000000000000000
183.	1.522170000000000e-06	3.40993000000000e=02
184.	1.567170000000000e-06	3.49357000000000e-02
185	1 609760000000000000000000000000000000000	3 001860000000000=02
100.	1.00970000000000000e=06	3.05100000000000000000000000000000000000
186.	1.64976000000000e-06	3.05802000000000e=02
187.	1.690990000000000e-06	3.1503400000000e-02
188	1 73349000000000000	3 2085900000000000-02
100	1.77600000000000000000000000000000000000	
T83.	1.//60000000000000000e-06	3.1103000000000000000000000000000000000
190.	1.818500000000000e-06	3.1621600000000e=02
191.	1.8476900000000000e-06	1.126910000000000e-02
102	1 860300000000000000000000000000000000000	2.120170000000000-02
192.	T.00332000000000000000	2.1201/000000000000000000000000000000000
193.	1.907230000000000e-06	3.3006400000000e=02
194.	1.952250000000000e-06	3.19989000000000e-02
105	1 9972400000000000000000000000000000000000	3.2523800000000000000000
	1.00/240000000000000000000000000000000000	5.2020000000000000



196.	2.039800000000000e-06	2.8134000000000e-02
107	2 0708000000000000	2 84926000000000 02
197.	2.079800000000000000000000000000000000000	2.8492800000000000000000000000000000000000
198.	2.115000000000000e-06	2.1023800000000e=02
199.	2.15765000000000e-06	3.84927000000000e-02
200	2 2136800000000000-06	3 912020000000000000000000
200.	2.2130800000000000000000000000000000000000	3.912020000000000000000000000000000000000
201	2 27116000000000e-06	3 97909000000000e-02
2011	2.2/110000000000000000000000000000000000	
202.	2.33013000000000e-06	4.04067000000000e-02
202	2 271100000000000 06	1 50385000000000 02
203.	2.37119000000000000000000	1.50585000000000000000000000000000000000
204.	2.402040000000000e-06	2.63219000000000e-02
205.	2.453370000000000e-06	4.19652000000000e-02
206	2 5175200000000000-06	4 26404000000000000000000000000000000000
200.	2.5175200000000000000000000000000000000000	1.2010100000000000000000000000000000000
207.	2.5/500000000000e-06	3.2468200000000000000000000000000000000000
208.	2.629660000000000e-06	3.81714000000000e-02
209	2 68966000000000000	3 8759000000000000000000000000000000000000
2005.	2.0090000000000000000000000000000000000	3.07355500000000000000000000000000000000
210.	2./43960000000000e-06	3.03/7500000000000000000000000000000000000
211.	2.80295000000000e-06	4.41582000000000e-02
212	2 8739100000000000-06	4 488890000000000=-02
212.	2.0/39100000000000000000000000000000000000	1.1000000000000000000000000000000000000
213.	2.946660000000000e-06	4.55896000000000e=02
214.	3.021260000000000e-06	4.6271600000000e-02
215	3 0981800000000000-06	4 7452500000000000000000000000000000000000
210.	5.0501000000000000000000000000000000000	1.71325000000000000000000000000000000000000
210.	3.1//480000000000e-06	4.80875000000000e=02
217.	3.258820000000000e-06	4.87451000000000e-02
218	3 340380000000000e-06	4 72809000000000e-02
210.	3.3403000000000000000000000000000000000	
219.	3.423540000000000e-06	4.94765000000000000000000000000000000000000
220.	3.51021000000000e-06	5.0147300000000e-02
221.	3.5990700000000000-06	5.076820000000000=02
1 222	2.00170000000000000000000000000000000000	
222.	2.0201/00000000000000000	J.140/40000000000000000000000000000000000
223.	3.783590000000000e-06	5.20077000000000e=02
224.	3.879370000000000e-06	5.26716000000000e-02
225	3 96393000000000000000000000000000000000	3 87308000000000000000
223.	3.9039300000000000e-06	5.6755555555555555555555555555555555555
226.	4.064630000000000e-06	6.84957000000001e-02
227.	4.1815200000000000e-06	5.45639000000000e-02
228	4 2873700000000000000000000000000000000000	5 515380000000000000
220.		5.5555566666666666
229.	4.39591000000000e-06	5.591/900000000e-02
230.	4.507190000000000e-06	5.6600100000000e-02
231	4 6212900000000000000000000000000000000000	5 7246200000000000000000000000000000000000
231.	4.72000000000000000000000000000000000000	
232.	4./38280000000000e-06	5.79547000000000e=02
233.	4.85823000000000e-06	5.8613000000000e-02
234	4 98122000000000000-06	5 9266890000000000000000000000000000000000
201.	4.901220000000000000000000000000000000000	3. 3200000000000000000000000000000000000
235.	5.064580000000000e-06	1.9901000000000000000000000000000000000
236.	5.10696000000000e-06	1.99477000000000e-02
237	5 149700000000000e-06	2 0038900000000e-02
220	E 102700000000000 00	
238.	5.192/9000000000000000	2.00921000000000000000000000000000000000
239.	5.236240000000000e-06	2.01788000000000e-02
240.	5.28006000000000e-06	2.0241000000000e-02
241	5 224250000000000 06	
241.	5.52425000000000000000000000000000000000	2.03530000000000000000000000000000000000
242.	5.368800000000000e-06	2.0366900000000e-02
243.	5.413730000000000e-06	2.0444000000000e-02
244	5 450020000000000 06	2 05202000000000 02
244.	5.45905000000000000000000000000000000000	2.0330200000000000000000000000000000000
245.	5.504/10000000000e-06	2.05992000000000e-02
246.	5.55078000000000e-06	2.0685400000000e-02
247	5 597230000000000e-06	2 0757400000000e-02
2.10	5.64406000000000000000000000000000000000	
248.	5.644060000000000e-06	2.08204000000000000000000000000000000000
249.	5.691290000000000e-06	2.08962000000000e-02
250	5 738920000000000e-06	2 0955800000000e-02
251	5 78694000000000000000000000000000000000000	2 1018300000000e=02
231.	5.78634000000000000000000	2.101830000000000000000000000000000000000
252.	5.835370000000000e-06	2.11102000000000e-02
253.	5.884200000000000e-06	2.1178900000000e-02
254	5 933440000000000000000000000000000000000	2 123890000000000=-02
255	E 0020000000000000000000000000000000000	2 12220000000000 02
200.	2.302030000000000000e-06	2.13230000000000000000000000000000000000
256.	6.033160000000000e-06	2.1401100000000e=02
257.	6.083650000000000e-06	2.14675000000000e-02
258	6 134560000000000 - 00	2 153580000000000000000
230.	0.13430000000000000000	2.15355555555555555555555555555555555555
259.	6.185890000000000e-06	2.160440000000000-02
260.	6.237650000000000e-06	2.1670900000000e-02
261.	6.2898500000000000-06	2.17606000000000e-02
1 2 6 2	6 24240000000000000000000000000000000000	2 18284000000000 02
202.	0.342490000000000000000	2.10234000000000000000
263.	6.39556000000000e-06	2.19022000000000e-02
264.	6.4490800000000000000	2.19658000000000e-02
265	6 50305000000000000000000000000000000000	2 20378000000000000000
200.	5.303030000000000e-06	2.2037900000000000000000000000000000000000
266.	6.557470000000000e-06	2.21024000000000e-02
267.	6.612340000000000e-06	2.21700000000000e-02
268.	6.6676700000000000000000000000000000000	2.2272400000000000=-02
260	6 702470000000000000000000000000000000000	
209.	0./∠34/00000000000e-06	2.2555000000000000000000000000000000000
270.	6.77973000000000e-06	2.2426600000000e=02
271.	6.8364700000000000e-06	2.25256000000000e-02
272	6 8936800000000000000000000000000000000000	2.2589100000000000000
675	5.055000000000000000000000000000000000	
2/3.	0.921300000000000e-06	2.26667000000000000000000000000000000000
274.	7.009530000000000e-06	2.27669000000000e-02
275	7 0681900000000000-06	2 286220000000000=-02
276	7 1072400000000000000000000000000000000000	
2/6.	/.12/340000000000e-06	2.29404000000000000000000000000000000000
277.	7.18698000000000e-06	2.3031900000000e=02
278.	7.247120000000000000000	2.30987000000000e-02
270	7 3077700000000000000000000000000000000	2 3188500000000000000
2/3.	1.30///000000000000e=06	2.315555500000000000000000000000000000000
280.	/.368920000000000e-06	2.325930000000000=02
281.	7.430580000000000e-06	2.33369000000000e-02
282	7 49276000000000000000000000000000000000000	2 34057000000000e=02
202.	7.492700000000000000e=06	2.345376500000000000000000000000000000000000
283.	/.5554600000000000e-06	2.34/26000000000000000000000000000000000000
284.	7.618690000000000e-06	2.3519800000000e-02
285	7 68244000000010 06	2 35824000000000=-02
2007	7.0024400000001e-06	
286.	/./46/30000000000e-06	2.3655200000000000000000000000000000000000
287.	7.811560000000001e-06	2.3740000000000e-02
288.	7.87693000000000000000	2.38276000000000e-02
1 200	7.0400400000000000000000000000000000000	
209.	/.94∠8400000000000000000000000000000000000	2.35255000000000000000000000000000000000
290.	8.00931000000000e-06	2.4031000000000e=02
291.	8.0763300000000000e-06	2.41397000000000e-02
and the second		



292.	8.143910000000001e-06	2.4233500000000e=02
2.02	0.14551000000000000000000000000000000000	
293.	8.2120599999999999e-06	2.43167000000000e-02
294.	8.28078000000001e-06	2.4376000000000e-02
295.	8.35008000000000e-06	2.44434000000000e-02
206	8.4100E0000000001c 06	2.4597000000000000000000000000000000000000
290.	8.419950000000000000	2.4508700000000000000000000000000000000000
297.	8.490410000000000e-06	2.45818000000000e-02
298.	8.561460000000000e-06	2.46517000000000e-02
1 200	0 63310000000000- 06	2 4729800000000- 02
299.	8.0331033333333333336-00	2.4728800000000000000000000000000000000000
300.	8.705350000000000e-06	2.48297000000000e-02
301.	8.778200000000000e-06	2.4891400000000e=02
202	0.0516500000000000	
302.	8.8516500000000000000000	2.4974300000000000000000000000000000000000
303.	8.92573000000000e-06	2.5063600000000e-02
304	9 00042000000001e-06	2 5121900000000e=02
205	0.07572000000001-06	2 5195600000000 02
303.	9.073730000000010-00	2.515560000000000000000000000000000000000
306.	9.1516799999999999e-06	2.52622000000000e=02
307.	9.228260000000000e-06	2.5315000000000e-02
200	0 2054000000000000000000	2 52801000000000 02
508.	9.30349000000000000000000000000000000000	2.338310000000000000000000000000000000000
309.	9.383360000000000e-06	2.54566000000000e-02
310.	9.461880000000000e-06	2.55539000000000e-02
311	9 5410600000000000-06	2 5612000000000000000000000000000000000000
511.	9.341000000000000000000000000000000000000	2.30120000000000000000000000000000000000
312.	9.620900000000000e-06	2.56702000000000e-02
313.	9.701410000000001e-06	2.57443000000000e-02
314	9 78259000000000000000	2 5825700000000000000000000000000000000000
514.	5.7625500000000000000000000000000000000000	2.30237000000000000000000000000000000000
315.	9.864450000000000e-06	2.58964000000000000000000000000000000000000
316.	9.947000000000000e-06	2.59694000000000e-02
317	1 0030200000000000000000	2 60208000000000-02
210	1.0114000000000000000000000000000000000	
318.	1.011420000000000e-05	2.0090200000000000000000000000000000000
319.	1.019880000000000e-05	2.6171500000000e-02
320.	1.028420000000000000000000000000000000000	2.6249700000000e-02
221	1 02702000000000000000000000000000000000	
321.	1.03/020000000000000	2.030/3000000000000000000000000000000000
322.	1.045700000000000e-05	2.63/0100000000e=02
323.	1.05445000000000000000000000000000000000	2.6420900000000000000000000000000000000000
324	1 0632700000000000000000000000000000000000	2 65180000000000000000
324.	1.0032/0000000000000	2.05100000000000000000000000000000000000
325.	1.072170000000000e-05	2.6557000000000e=02
326.	1.0811400000000000e-05	2.66441000000000e-02
327	1 09019000000000000	2 67057000000000-02
220	1.0002100000000000000000000000000000000	
328.	T.0223T00000000006-02	2.0001000000000000000000000000000000000
329.	1.108510000000000e-05	2.6865100000000e-02
330.	1.117790000000000e-05	2.69637000000000e-02
221	1 10714000000000- 05	2 20074000000000 02
331.	1.12/140000000000000000	2.708740000000000000000000000000000000000
332.	1.136570000000000e-05	2.7135600000000e-02
333.	1.146090000000000e-05	2.72461000000000e-02
224	1 1556900000000000000000000000000000000000	2 72992000000000 02
554.	1.1556800000000000000000000000000000000000	2.72893000000000000000000000000000000000000
335.	1.165350000000000e-05	2.73563000000000e-02
336.	1.175100000000000e-05	2.74218000000000e-02
337	1 184930000000000-05	2 74742000000000000000000000000000000000
557.	1.1049500000000000000000000000000000000000	2.74742000000000000000000000000000000000
338.	1.194850000000000e-05	2.7540600000000e=02
339.	1.204850000000000e-05	2.7638500000000e-02
340	1 214930000000000-05	2 778840000000000000000000000000000000000
540.	1.21495000000000000000000000000000000000000	2.775540000000000000000000000000000000000
341.	1.22510000000000e-05	2.7939400000000000000000000000000000000000
342.	1.235350000000000e-05	2.80557000000000e-02
343.	1.245690000000000e-05	2.81519000000000e-02
244	1 256110000000000 05	3 81984000000000 03
544.	1.2301100000000000000000	2.013040000000000000000000000000000000000
345.	1.266620000000000e-05	2.82940000000000e-02
346.	1.277220000000000e-05	2.83677000000000e-02
347	1 287910000000000-05	2 84514000000000-02
340	1.2079100000000000000000000000000000000000	2.013140000000000000000000000000000000000
348.	1.298690000000000e-05	2.85152000000000e-02
349.	1.309550000000000e-05	2.8578300000000e-02
350.	1.320510000000000e-05	2.86475000000000e-02
351	1 3315600000000000000000000000000000000000	2,87148000000000000000
252	1.3313000000000000000000000000000000000	2.071300000000000000000000000000000000000
352.	1.342/00000000000e-05	2.874080000000000000000000000000000000000
353.	1.353940000000000e-05	2.88421000000000e-02
354	1 36527000000000000000	2 89143000000000=-02
357.	1.005270000000000000000000000000000000000	
355.	1.3/6690000000000e-05	2.900530000000000000000000000000000000000
356.	1.388220000000000e-05	2.90644000000000e-02
357.	1.3998300000000000-05	2.91571000000000e-02
250	1 41155000000000000000000000000000000000	
330.	1.4110000000000000000000000000000000000	2.5104300000000000000000000000000000000000
359.	1.423360000000000e-05	2.9234000000000e=02
360.	1.43527000000000000-05	2,9333900000000000=02
361	1 447280000000000000000	2 9374200000000000=-02
	1.447200000000000000000000000000000000000	
362.	1.459390000000000e-05	2.944//0000000000000000000000000000000000
363.	1.471600000000000e-05	2.95239000000000e-02
364.	1.4839200000000000e-05	2.96041000000000e-02
365	1 4963400000000000000000000000000000000000	2,97396000000000000000
303.	1.43034000000000000000	2. 373360000000000000000000000000000000000
366.	1.508860000000000e-05	2.98318000000000e=02
367.	1.521480000000000e-05	2.99418000000000e-02
368.	1.53422000000000000-05	3.001190000000000=-02
260	1 547050000000000000000000000000000000000	
202.	1.54/050000000000e-05	3.0001000000000000000000000000000000000
370.	1.560000000000000e-05	3.0177000000000e-02
371.	1.573050000000000e-05	3.0237400000000000000-02
272	1.50.0000000000000000000000000000000000	
312.	⊥.586∠∠0000000000e-05	3.034/1000000000=02
373.	1.599490000000000e-05	3.0387000000000e=02
374.	1.612880000000000e-05	3.047890000000000e-02
375	1 626370000000000000000	3.056040000000000=-02
373.	1.6203700000000000e=05	3.0500000000000000000000000000000000000
3/6.	1.639980000000000e-05	3.06285000000000e=02
377.	1.653710000000000e-05	3.07043000000000e-02
378	1 6675500000000000000	3.0773200000000000=-02
270	1.0015000000000000000000000000000000000	3.07/32/0000000000000000000000000000000000
3/9.	1.681500000000000e-05	3.0859300000000000000000000000000000000000
380.	1.695570000000000e-05	3.09157000000000e-02
381	1 709760000000000000000000000000000000000	3 0980700000000002
202	1 724070000000000000000000000000000000000	
302.	1.12401000000000000e-05	5.1047200000000000000000000000000000000000
383.	1.738490000000000e-05	3.1110000000000e=02
384.	1.753040000000000e-05	3.111890000000000e-02
205	1 7677100000000000 05	1121120000000000 02
303.	1.707710000000000000000	5.12010000000000000000000000000000000000
386.	1.782500000000000e-05	3.1272600000000e=02
387.	1.7974200000000000e-05	3.14397000000000e-02



388	1 812460000000000e-05	3 1534400000000e=02
1 200	1 027620000000000000000000000000000000000	2 16117000000000 02
389.	1.827630000000000e-05	3.1811/0000000000000000000000000000000000
390.	1.842920000000000e-05	3.1685600000000e-02
391.	1.858340000000000e-05	3.1757600000000e-02
392	1 873900000000000000000	3 1834000000000000000000000000000000000000
392.	1.8739000000000000000000000000000000000000	3.1834000000000000000000000000000000000000
393.	1.889580000000000e-05	3.18997000000000e-02
394.	1.905390000000000e-05	3.1980100000000e-02
-		
395.	1.921330000000000e-05	3.2063000000000e-02
396.	1.937410000000000e-05	3.2126500000000e-02
397	1 9536200000000000-05	3 219860000000000=-02
	1.0000200000000000000000000000000000000	
398.	1.9699/0000000000e-05	3.226070000000000000000000000000000000000
399.	1.986460000000000e-05	3.2308800000000e=02
400.	2.003080000000000e-05	3.2345000000000e=02
401	2.01084000000000000	2 24225000000000 02
401.	2.01984000000000000000000	3.24223000000000000000000000000000000000
402.	2.036/4000000000e-05	3.24502000000000e-02
403.	2.053790000000000e-05	3.2507800000000e-02
404.	2.070970000000000e-05	3.25426000000000e-02
405	2 08830000000000000=05	3 2620900000000000-02
405.	2.0005000000000000000000000000000000000	
406.	2.10578000000000e-05	3.26377000000000e=02
407.	2.123400000000000e-05	3.2743400000000e=02
408.	2.141170000000000e-05	3.2866200000000e=02
400	2 15000000000000000000000000000000000000	2 20026000000000 02
405.	2.139090000000000000000000000000000000000	3.2365000000000000000000000000000000000000
410.	2.1//16000000000e-05	3.34587000000000000000000000000000000000000
411.	2.195370000000000e-05	3.3755600000000e=02
412.	2.213750000000000e-05	3.38305000000000e=02
413	2 23227000000000000000000000000000000000	3 384270000000000=-02
414	2.25227000000000000000000000000000000000	
414.	2.250950000000000e-05	3.37829000000000000000000000000000000000000
415.	2.26979000000000e-05	3.32730000000000e=02
416.	2.28878000000000e-05	3.49768000000000e-02
417	2 307930000000000000000000000000000000000	3 5972200000000000000000000000000000000000
410	2.22725000000000000000000000000000000000	2.471500000000000000000
410.	2.32/2300000000000e-05	3.4/135000000000000000000000000000000000000
419.	2.34672000000000e-05	3.395270000000000e=02
420.	2.366360000000000e-05	3.39372000000000e-02
421	2 3861600000000000000000000000000000000000	3 38927000000000=-02
1.00	2.4061200000000000000000000000000000000000	
422.	∠.406130000000000e-05	3.3033900000000000000000000
423.	2.42626000000000e-05	3.42581000000000e-02
424.	2.446570000000000e-05	3.4741900000000e-02
425	2 467040000000000000000000000000000000000	3 4983300000000000000000000000000000000000
425.	2.40704000000000000000000000000000000000	5.450554000000000 02
426.	2.48/680000000000e-05	3.507740000000000000000000000000000000000
427.	2.508500000000000e-05	3.5018000000000e=02
428.	2.529490000000000e-05	3.4756300000000e-02
429	2 55066000000000000	3 4768700000000000-02
42.5.	2.5500000000000000000000000000000000000	3.47007000000000000000000000000000000000
430.	2.5/201000000000e-05	3.59924000000000e-02
431.	2.593530000000000e-05	3.5894000000000e=02
432.	2.615230000000000e-05	3.4768700000000e=02
133	2 637120000000000000	3 4737900000000000000000
455.	2.03/12000000000000000	3.47373000000000000000000000000000000000
434.	2.659180000000000e-05	3.49337000000000e=02
435.	2.681440000000000e-05	3.5050400000000e-02
436.	2.703870000000000e-05	3.5115600000000e=02
427	2 7265000000000000	3 51745000000000 02
437.	2.726500000000000e-05	3.51/43000000000000000000000000000000000000
438.	2.749320000000000e-05	3.52387000000000e=02
439.	2.772320000000000e-05	3.5342400000000e=02
440.	2.79552000000000e-05	3.54213000000000e=02
4.4.1	2 8189200000000000000	3 54591000000000000000000
111.	2.01092000000000000000000000000000000000	3.54391000000000000000000000000000000000000
442.	2.842510000000000e-05	3.5538900000000000000000000000000000000000
443.	2.866290000000000e-05	3.55958000000000e-02
444.	2.89028000000000e-05	3.56433000000000e-02
445	2 91446000000000000	3 572010000000000-02
115.	2.03005000000000000000000000000000000000	3.572500000000000000000000000000000000000
440.	2.938850000000000e-05	3.37939000000000000000000000000000000000
447.	2.963450000000000e-05	3.5854500000000e=02
448.	2.98824000000000e-05	3.59443000000000e-02
449.	3.013250000000000e-05	3.60057000000000e-02
450	3 0384700000000000000000000000000000000000	60756000000000a-02
451	2.000000000000000000000000000000000000	
431.	3.00389000000000000e-05	3.01401000000000000000000000000000000000
452.	3.08953000000000e-05	3.61911000000000e-02
453.	3.115380000000000e-05	3.62445000000000e-02
454.	3.141450000000000e-05	3.634770000000000=02
455	3 1677400000000000000000000000000000000000	3 63977000000000e=02
100.	3.104050000000000000000000000000000000000	5.65577600000000000000000000000000000000
436.	3.194250000000000e-05	3.646700000000000000000000000000000000000
457.	3.22098000000000e-05	3.6503300000000e=02
458.	3.247930000000000e-05	3.6566700000000e-02
459	3 2751100000000000000000000000000000000000	3 66564000000000=-02
160	3 30252000000000000000000000000000000000	3 671740000000000-02
	5.3023200000000000000	5.071790000000000000000000000000000000000
461.	3.33016000000000e-05	3.680450000000000e=02
462.	3.35802000000000e-05	3.68545000000000e-02
463.	3.38612000000000000000000000000000000000000	3.69264000000000e-02
164	3 414460000000000000000000000000000000000	3 6980500000000000-02
104.	5.41440000000000000000000000000000000000	3.0300000000000000000000000000000000000
465.	3.443030000000000e-05	3.7052300000000000000000000000000000000000
466.	3.47184000000000e-05	3.7116500000000e-02
467.	3.500900000000000e-05	3.71685000000000e-02
468	3 53019000000000000000	3 7247800000000000=-02
4.60	3.55515666666666666	2 720770000000000 02
469.	3.55973000000000e-05	3.7297700000000000=02
470.	3.58952000000000e-05	3.73659000000000e-02
471.	3.6195600000000000e-05	3.7324700000000e-02
472	3 649850000000000000000000	3 7354300000000000000000000000000000000000
172	5.049030000000000000000000000000000000000	5.7555500000000000000000000000000000000
4/3.	3.680390000000000e-05	3./428000000000000000000000000000000000000
474.	3.711190000000000e-05	3.7569600000000e=02
475.	3.742250000000000e-05	3.77334000000000=-02
176	3 7735600000000000000000000000000000000000	3 7828900000000000000000
4/0.	3.7733600000000000e=05	3.70203000000000000000000000000000000000
4//.	3.80514000000000e-05	3./846300000000000000=02
478.	3.83698000000000e-05	3.78890000000000e-02
479.	3.869090000000000e-05	3.80458000000000e-02
180	3 901/70000000000000000	3 82081000000000002
400.	3.9014/0000000000e-05	3.8205100000000000000000000000000000000000
481.	3.934110000000000e-05	3.82921000000000e=02
482.	3.967040000000000e-05	3.8412000000000e-02
193	4 00023000000000000000000000000000000000	3 8548200000000000-02
1 400.		5.03492000000000 02



484	4 033710000000000e-05	3 8669500000000000000000000000000000000000
404.	4.055710000000000000000000000000000000000	3.0003300000000000000000000000000000000
485.	4.06/460000000000e-05	3.8669300000000000000000000000000000000000
486.	4.101500000000000e-05	3.85933000000000e-02
487.	4.135820000000000e-05	3.83801000000000e-02
100	4 170420000000000 05	8.8245000000000000000000000000000000000000
400.	4.1704300000000000000000	3.8243300000000000000000000000000000000000
489.	4.205330000000000e-05	3.85178000000000e-02
490.	4.240520000000000e-05	3.91717000000000e-02
401	4 276010000000000 05	4 00278000000000 02
491.	4.2/0010000000000000000000000000000000000	4.002/50000000000000000000000000000000000
492	4 311790000000000e-05	4 07647000000000e-02
102	4 34707000000000000	
493.	4.34/8/00000000000000000	4.0394500000000000000000000000000000000000
494.	4.384250000000000e-05	3.9086200000000e-02
495	4 42094000000000000000000000000000000000	3 64834000000000=-02
495.	4.42034000000000000000000000000000000000	3.0403400000000000000000000000000000000
496.	4.45/94000000000e-05	3.267800000000000e-02
497.	4.495240000000000e-05	3.19794000000000e-02
498	4 53286000000000000-05	3 832430000000000=02
400	4.55200000000000000000000000000000000000	3.052450000000000000000000000000000000000
499.	4.5/0/9000000000e-05	4.3124200000000000000000000000000000000000
500.	4.609040000000000e-05	4.45011000000000e-02
501	4 647610000000000e-05	4 49370000000000e=02
500	1.01/02000000000000000000000000000000000	
502.	4.68650000000000000e-05	4.5210700000000000000000000000000000000000
503.	4.72572000000000e-05	4.53574000000000e-02
504	4 7652600000000000-05	4 55041000000000000000000000000000000000
504.	4.705200000000000000000000000000000000000	4.553410000000000 02
505.	4.805140000000000e-05	4.56/41000000000000000000000000000000000000
506.	4.84535000000000e-05	4.57917000000000e-02
507	4 885900000000000e-05	4 589240000000000=-02
600	4 026700000000000000000000000000000000000	4.507130000000000 02
308.	4.9∠0/80000000000000000	4.557150000000000000000000000000000000000
509.	4.96801000000000e-05	4.60183000000000e-02
510.	5.009580000000000e-05	4.60831000000000e-02
511	5 0515000000000000	4 62587000000000000000
510	5.0010000000000000000000000000000000000	1. 525770500000000 02
512.	5.093780000000000e-05	4.64293000000000e-02
513.	5.136400000000000e-05	4.648440000000000e-02
514	5 179380000000000000000	4 65500000000000000000000000000000000000
515	5.1,555000000000000000000000000000000000	
1 212.	5.222/20000000000e-05	4.6548800000000000000000000000000000000000
516.	5.266430000000000e-05	4.65843000000000e-02
517.	5.31050000000000000000000000000000000000	4.67145000000000e-02
510	E 3E404000000000000000000000000000000000	
1 2TR.	5.354940000000000e-05	4.0/0920000000000000000000000000000000000
519.	5.399750000000000e-05	4.6996100000000e-02
520.	5.444940000000000e-05	4.71362000000000e-02
501	5 4005000000000000000000000000000000000	7,721410000000000,02
521.	5.49050000000000000000000000000000000000	4.7214100000000000000000000000000000000000
522.	5.536440000000000e-05	4.72436000000000000000000000000000000000000
523.	5.582770000000000e-05	4.72990000000000e-02
524	5 6294900000000000-05	4 7421500000000000000000
524.	5.02545000000000000000000000000000000000	4.74215000000000000000000000000000000000000
525.	5.6/6600000000000e-05	4./482/000000000e-02
526.	5.724100000000000e-05	4.75192000000000e-02
527	5 77200000000000000-05	4 7583100000000000000000
527.	5.77200000000000000000000000000000000000	
528.	5.820300000000000e-05	4.//1880000000000000000000000000000000000
529.	5.86901000000000e-05	4.78020000000000e-02
530	5 918120000000000e-05	4 78560000000000e-02
500.	5.05265000000000000000000000000000000000	
551.	5.96/650000000000e-05	4.799170000000000000000000000000000000000
532.	6.017580000000000e-05	4.81541000000000e-02
533.	6.067940000000000e-05	4.82189000000000e-02
624	6 119720000000000 05	4 83258000000000 03
554.	0.118/200000000000000000000000000000000000	4.05250000000000000000000000000000000000
535.	6.169919999999999e-05	4.84126000000000e-02
536.	6.221549999999999e-05	4.84827000000000e-02
537	6 273610000000000-05	4 858300000000000-02
507.	6.205110000000000000000000000000000000000	
536.	6.32611000000000e-05	4.86591000000000000000000000000000000000000
539.	6.37905000000001e-05	4.87714000000000e-02
540.	6.432430000000000e-05	4.88603000000000e-02
541	6 486260000000000	4 89767000000000000-02
540	5.4054000000000000000000000000000000000	
542.	6.54054000000000e-05	4.88148000000000e=02
543.	6.595270000000000e-05	4.8756400000000e-02
544	6 65046000000000000000000000000000000000	4 88833000000000e-02
545	6 70610000000000000000000000000000000000	4.913950000000000 02
343.	0.100T03333333336-02	4.5136300000000000000000000000000000000000
546.	6.762230000000001e-05	4.94092000000000e-02
547.	6.818820000000001e-05	4.95792000000000e-02
5/8	6 87588000000000000	4 8678200000000000000
540	6.0004000000000000000000000000000000000	1.0010200000000000000000000000000000000
349.	₀.9334∠0000000000e-05	4.9/21/00000000000000000000000000000000000
550.	6.991440000000000e-05	4.97354000000000e-02
551.	7.049940000000001e-05	4.96704000000000e-02
552	7 1089400000000000000000000000000000000000	4 97482000000000000=02
552	7.10034000000000000e=05	
353.	/.168420000000000e-05	5.02400000000000000000000000000000000000
554.	7.228410000000000e-05	5.0312000000000e-02
555	7 288900000000000000000000000000000000000	5.02528000000000e-02
556	7 24000000000000000000000000000000000000	
		5.0455500000000000000000000000000000000
557.	7.41140000000000e-05	5.0519400000000e=02
558.	7.47341999999999999	5.05403000000000e-02
550	7 5359600000000000000000	5.0688800000000000000
500	7.53555000000000000e=05	
200.	/.5990∠0000000000e-05	5.10012000000000e=U2
561.	7.66261000000000e-05	5.1116200000000e-02
562.	7.7267300000000000000	5.123470000000000e-02
1.500	7 70120000000000000000000000000000000000	
363.	1.13T3A00000000016-02	5.1263300000000000000000000000000000000000
564.	7.85659000000000e-05	5.1331600000000e=02
565.	7.922330000000000e-05	5.139690000000000000-02
566	7 088620000000000000000000000000000000000	5.143440000000000-02
200.	1.3000733333333336-02	5.14544000000000000000000000000000000000
567.	8.055480000000000e-05	5.12828000000000e=02
568.	8.122890000000000e-05	5.15116000000000e-02
569	8 1908600000000000000000000000000000000000	5.1721100000000000=-02
503.	0.1500000000000000000000000000000000000	5.172110000000000000000000000000000000000
5/0.	8.259410000000000e-05	5.181600000000000000000000000000000000000
571.	8.32852000000000e-05	5.18645000000000e-02
572	8 39822000000000000-05	5 1990700000000000=-02
572.	0.4604000000000000000000000000000000000	5. 2022500000000000000000000000000000000
5/3.	8.468490000000000e-05	5.20335000000000000000000000000000000000
574.	8.53936000000000e-05	5.19995000000000e-02
575.	8.6108200000000000-05	5.224480000000000000000000000000000000000
576	0.6000700000000000000000000000000000000	
3/6.	a.6828/0000000000e-05	5.2461600000000000000000000000000000000000
577.	8.75553000000001e-05	5.2628300000000e=02
578.	8.828800000000001e-05	5.27177000000000e-02
570	0.0000000000000000000000000000000000000	
J/J.	0.90200000000000000000000	J.2/J3200000000000000000000000000000000000



580.	8.97718000000001e-05 5	.28672000000000e-02
581	9 052300000000000e-05 5	2677400000000e-02
502	0 120050000000000 05 5	200000000000000000000000000000000000000
502.	9.1280300000000000000000000000000000000000	.23003000000000000000000000000000000000
583.	9.204440000000000e-05 5	.31775000000000e-02
584.	9.28146000000000e-05 5	.3276400000000e-02
585	9 35913000000000000000	33934000000000=-02
505.	9.33913000000000000000000000000000000000	
586.	9.43/45000000000e-05 5	.34//2000000000e-02
587.	9.51642000000000e-05 5	.34957000000000e-02
588	9 596060000000000e-05 5	3569600000000e-02
500.	9.5900000000000000000000000000000000000	
589.	9.67636000000000e-05 5	.36482000000000000000000000000000000000000
590.	9.75733000000000e-05 5	.3824600000000e-02
591	9 838990000000001e-05 5	3914900000000e=02
502	0.001000000000000000000000000000000000	
592.	9.92132000000000e-05 5	.40844000000000000000000000000000000000
593.	1.00043000000000e-04 5	.42497000000000e-02
594	1 00881000000000e-04 5	45028000000000e-02
505	1.01725000000000-04 5	
595.	1.01/2500000000000000000000000000000000000	.40/5200000000000000000000000000000000000
596.	1.02576000000000e-04 5	.3717600000000e-02
597.	1.034340000000000e-04 5	.4058300000000e-02
598	1 04300000000000000000000000000000000000	434430000000000=-02
550.	1.0517200000000000000000000000000000000000	
599.	1.051/300000000000000000000000000000000000	.4266900000000000000000000000000000000000
600.	1.06053000000000e-04 5	.4636100000000e-02
601	1 069400000000000e-04 5	46788000000000e-02
602	1.07025000000000-04 5	
002.	1.0783500000000000000000000000000000000000	.5047200000000000000000000000000000000000
603.	1.08738000000000e-04 5	.52221000000000e-02
604.	1.096480000000000e-04 5	.5270800000000e=02
605	1 105650000000000 04 5	525250000000000000000000000000000000000
005.	1.10363000000000000000000000000000000000	.5382500000000000000000000000000000000000
606.	1.114900000000000e-04 5	.54606000000000e-02
607.	1.124230000000000e-04 5	.5561100000000e-02
608	1 1336400000000000000	55738000000000e-02
	1.1.00000000000000000000000000000000000	
009.	1.14313000000000e-04 5	.5680500000000e=02
610.	1.15269000000000e-04 5	.5846100000000e-02
611	1 16234000000000000000000000000000000000000	5468000000000000000000000000000000000000
610	1 1700700000000000000000000000000000000	
012.	1.1/20/0000000000e-04 5	.33990000000000000000000000000000000000
613.	1.18187000000000e-04 5	.5969600000000e-02
614.	1.191760000000000-04 5	-59652000000000e-02
615	1 2017402020000000000000000000000000000000	
12.	1.201/4000000000e-04 5	.0300300000000000000000000000000000000
616.	1.21179000000000e-04 5	.6167700000000e-02
617.	1.221930000000000e-04 5	.60983000000000e-02
C10	1.2221000000000000000000000000000000000	
010.	1.2321600000000000000000000000000000000000	.642660000000000000000000000000000000000
619.	1.24247000000000e-04 5	.697870000000000e=02
620.	1.25287000000000e-04 5	.7688000000000e-02
621	1 26335000000000000000	875880000000000000000000000000000000000
021.	1.20333000000000000000000000000000000000	.873880000000000000000000000000000000000
622.	1.27392000000000e-04 5	.86470000000000e-02
623.	1.28458000000000e-04 5	.7172800000000e-02
624	1 2953300000000000000000000000000000000000	509120000000000=02
024.	1.295550000000000000000000000000000000000	
625.	1.3061/000000000e-04 5	.1248400000000000000000000000000000000000
626.	1.31710000000000e-04 4	.8651000000000e-02
627	1 328120000000000e=04 5	71237000000000e-02
620	1.330240000000000 04 5	
020.	1.339240000000000000000	.84404000000000000000000000000000000000
629.	1.350440000000000e-04 5	.87187000000000e-02
630.	1.36175000000000e-04 5	-9088000000000e-02
C31	1 373140000000000 04 5	
031.	1.3/31400000000000000000000000000000000000	.930960000000000000000000000000000000000
632.	1.384630000000000e-04 5	.95274000000000e-02
633.	1.396220000000000e-04 5	.9596400000000e-02
634	1 407900000000000000000	8677500000000000000000000000000000000000
054.	1.407900000000000000000000000000000000000	
635.	1.41968000000000000000000000000000000000000	.9763700000000000000000000000000000000000
636.	1.43156000000000e-04 5	.9706000000000e-02
637.	1.443540000000000e-04 5	.99056000000000e-02
630	1.455(20000000000-04 5	
030.	1.4556200000000000000000000000000000000000	.983800000000000000000000000000000000000
639.	1.46780000000000e-04 6	.0075600000000e-02
640.	1.480090000000000e-04 6	.03714000000000e-02
641	1 49247000000000000000	0338600000000e-02
C40	1.50400000000000000000000000000000000000	0495100000000000000000000000000000000000
642.	1.504960000000000e-04 6	.04851000000000e=02
643.	1.51756000000000e-04 6	.04764000000000e-02
644.	1.530260000000000000000	.07631000000000e=02
645	1 5420600000000- 04 0	08757000000000 02
043.	1.34300000000000000000000000000000000000	.00/0/00000000000000000000000000000000
646.	1.55597000000000e-04 6	.0908400000000e-02
647.	1.56899000000000e-04 6	.0850900000000e-02
648	1 58212000000000000000	1081300000000e-02
640	1.50521200000000000000000000000000000000	
649.	1.595360000000000e-04 6	.11241000000000e=02
650.	1.60871000000000e-04 6	.14548000000000e-02
651.	1.622170000000000e-04 6	.14284000000000e-02
652	1 63575000000000- 04 0	1484200000000000000000000000000000000000
552.	1.0000000000000000000000000000000000000	
653.	1.64944000000000e-04 6	.10648000000000e-02
654.	1.66324000000000e-04 6	.17348000000000e-02
655	1 6771600000000000000	197000000000000000000000000000000000000
	1.0011000000000000000000000000000000000	
000.	1.091190000000000e-04 6	.221420000000000e=02
657.	1.70534000000000e-04 6	.2165000000000e-02
658.	1.7196200000000000-04 6	.25383000000001e-02
659	1 7340100000000- 04 0	262473080808080800000
039.	1.73401000000000000e-04 6	.2024/555555599900
660.	1.74852000000000e-04 6	.27366000000000e=02
661.	1.76315000000000e-04 6	.2720200000000e-02
662	1 77790000000000000000000000000000000000	28027000000000=-02
002.	1.77750000000000000000000000000000000000	2002/0000000000000000000000000000000000
663.	1./92/8000000000e-04 6	.29665000000000e=02
664.	1.80778000000000e-04 6	.3122100000000e-02
665.	1.8229100000000000000	.31565000000000e-02
	1.02231000000000000000000000000000000000	22520000000000 02
000.	1.0381000000000000000 6	.5557200000000000=02
667.	1.85355000000000e-04 6	.34548000000001e-02
668.	1.869060000000000e-04 6	.4308000000000e-02
669	1 884700000000000000000000000000000000000	3195699999999999
003.	1.004/0000000000000000000000000000000000	· JIJJUJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJ
670.	1.90047000000000e-04 6	.2276800000000e-02
671.	1.916370000000000e-04 6	.308759999999999e-02
672	1 9324100000000000000	33473000000000-02
V/2.	1.3324100000000000000000000000000000000000	
673.	1.94858000000000e-04 6	.3/3/800000000e=02
674.	1.96489000000000e-04 6	.38788000000000e-02
675.	1.981330000000000-04 6	.4264900000000e-02
676	1.0070100000000000000000000000000000000	42472000000001= 02
0/0.	+.55/510000000000000000000000000000000000	• 121//00000001E-02



677.	2.014630000000000e-04	6.4587300000000e-02
670	2.02140000000000000000000000000000000000	
6/8.	2.03149000000000000000	6.4570500000000e-02
679.	2.048490000000000e-04	6.4643400000000e=02
600	2 065620000000000 04	6 54151000000000 02
000.	2.00303000000000000000000	0.34131000000000000000000000000000000000
681.	2.08291000000000e-04	6.3869600000000e-02
682.	2.100340000000000e-04	6.4807400000000e=02
602	2 11702000000000- 04	
000.	2.11/920000000000e-04	0.5370200000000000000000000000000000000000
684.	2.13564000000000e-04	6.5474900000000e-02
685	2 1535100000000000000000	6 5541800000000e-02
000.	2.133310000000000000000	0.33410000000000000000000000000000000000
686.	2.171530000000000e-04	6.5569400000000e-02
687	2 18971000000000e-04	6 57988999999999999999999
	2.209/2000000000000000000000000000000000	
688.	2.208030000000000e-04	6.5710200000000e-02
689.	2.22651000000000e-04	6.6029800000000e=02
600	0.04514000000000000000000000000000000000	
690.	2.245140000000000e-04	6.6123300000000e-02
691.	2.26393000000000e-04	6.6232400000000e-02
692	2 2828700000000000-04	6 6257700000000000000000000000000000000000
0.02	2.2020700000000000000	
693.	2.301980000000000e-04	6.6364600000000e=02
694.	2.321240000000000e-04	6.6321400000000e=02
COF	2 2406600000000- 04	
695.	2.340660000000000e-04	6.6558300000000e-02
696.	2.360250000000000e-04	6.6590100000000e-02
607	2 2800000000000000000000000000000000000	6 59108000000000 02
097.	2.38000000000000000000000000000000000000	6.3810800000000e-02
698.	2.399920000000000e-04	6.6943900000000e-02
699	2 4200000000000000000000000000000000000	6 72081000000001e-02
0000.	2.4200000000000000000000000000000000000	
700.	2.440250000000000e-04	6.7272600000000e=02
701.	2.46067000000000e-04	6.7485500000000e-02
702	2 491260000000000 04	6 733310000000010 03
/02.	2.48120000000000000000	0.7555100000001E-02
703.	2.502030000000000e-04	6.73287999999999e-02
704	2 5229600000000000000000000000000000000000	6 73157000000001e=02
705	2.5225000000000000000000000000000000000	
/05.	∠.544080000000000e-04	0./00J1000000000e=U2
706.	2.5653600000000000e-04	6.76554000000000e-02
707	2 50602000000000000000000000000000000000	
101.	∠.⊃000⊃UUUUUUUUUUUU0000e-04	0.//0/200000000000000000000000000000000
708.	2.608480000000000e-04	6.75752000000000e-02
709	2 630310000000000 04	6 78031999999999999999
109.	2.030310000000000e-04	0.70051555555777202
/10.	2.65232000000000e-04	6.7988200000000e=02
711.	2.674510000000000e-04	6.80343000000001e-02
710	2.0.10100000000000000000000000000000000	
/12.	2.69689000000000e-04	6.8045900000000le=02
713.	2.719460000000000e-04	6.7847200000000e-02
714	2 74222000000000- 01	6 6806000000000 02
/14.	2.742220000000000000000	6.6806000000000e-02
715.	2.76517000000000e-04	6.79078999999999e-02
716.	2.7883100000000000000000000000000000000000	6.824909999999999e-02
710.	2.7003100000000000000	
/1/.	2.811640000000000e-04	6.8254600000000e=02
718.	2.835170000000000e-04	6.7874800000000e-02
710	2 858890000000000000000000000000000000000	6 73158000000000000000000000000000000000000
/19.	2.8388900000000000000000	0.75155000000000000000000000000000000000
720.	2.882820000000000e-04	6.7460300000000e-02
721	2 906940000000000e-04	6 64607000000000e=02
721.	2.90094000000000000000	0.0400700000000000000000000000000000000
722.	2.931270000000000e-04	6.72838000000001e-02
723.	2.955790000000000e-04	6.70845999999999e=02
724	2 000520000000000 04	6.6270500000000000000000000000000000000000
/24.	2.980550000000000000000	0.02/93999999999999002
725.	3.005470000000000e-04	6.5673500000000e-02
726	3 0306200000000000-04	6 468409999999999999999
720.	5.0500200000000000000000000000000000000	
127.	3.055980000000000e-04	6.39099000000001e-02
728	3 081550000000000e-04	6.25068000000000e=02
7201	2.1072400000000000000000000000000000000000	
129.	3.10/34000000000000000	6.0787800000000e-02
730.	3.133340000000000e-04	5.8792400000000e-02
731	3 1595600000000000-04	5 6516300000000000000000000000000000000000
1 7 3 5	2.1000000000000000000000000000000000000	
/32.	з.1860000000000000e-04	3.30643000000000000000000000000000000000
733.	3.212670000000000e-04	4.91938000000000e-02
734	3 2395500000000000000000000000000000000000	4 519100000000000000000000000000000000000
/34.	3.239550000000000000000	4.519100000000000000000000000000000000000
735.	3.26666000000000e-04	4.09787000000000e-02
736	3 2939900000000000-04	3 696440000000000000000000000000000000000
	2.201500000000000000000	3.35044000000000000000000000000000000000
/3/.	3.321560000000000e-04	3.3599800000000000000000000000000000000000
738.	3.3493500000000000e-04	3.16124000000000e-02
730	3 3773800000000000 04	3 1558600000000000000
133.	5.5775600000000000000	5.15566660000000000000000000000000000000
740.	3.40564000000000e-04	3.37311000000000e-02
741.	3.43414000000000000000000000000000000000	3.7574000000000e-02
740	2.1012100000000000000000000000000000000	4 157770000000000000000000000000000000000
/42.	3.46∠880000000000e-04	4.13/0/0000000000000000000000000000000000
743.	3.491860000000000e-04	4.58694000000000e-02
744	3 5210800000000000000000	5 10042000000000e-02
745	2.5210000000000000000000	
/45.	3.550540000000000e-04	5.49331000000000e-02
746.	3.58026000000000e-04	5.70257000000000e-02
747	3 6102200000000000 04	6.0555600000000000000
/*/.	5.0102200000000000000	0.0000000000000000000000000000000000000
/48.	3.640430000000000e-04	6.11352000000000e-02
749.	3.670890000000000e-04	6.54394000000000e-02
750	3 701610000000000 04	6 711850000000000000
/50.	5./0101000000000000000	0.71105000000000000000000000000000000000
751.	3.73258000000000e-04	6.852949999999999e-02
752.	3.76382000000000000	6.965399999999999e-02
752	2.70522000000000000000000000000000000000	
/53.	s./953∠0000000000e-04	/.089010000000000000000000000000000000000
754.	3.82707000000000e-04	7.18585000000001e-02
755	3 8591000000000000000000000000000000000000	7 27546000000000000000000000000000000000000
755	2.0012000000000000000000000000000000000	
/56.	3.891390000000000e-04	/.353990000000000000000000000000000000000
757.	3.923960000000000e-04	7.41411000000000e-02
759	3 9567900000000000 04	7 4387300000000000000
100.	3.930/900000000000e-04	1.430/3000000000000000
759.	3.98991000000000e-04	7.49403000000000e-02
760	4 023290000000000000000000000000000000000	7 565300000000000000000000000000000000000
7.00.	4.050000000000000000000	7.55350000000000000000000000000000000000
/61.	4.056960000000000e-04	/.554/1000000001e=02
762.	4.0909100000000000e-04	7.59522000000000e-02
763	4 1251400000000000 04	7 6836000000000000000
/03.	4.12314000000000000000	7.03500000000000000000000000000000000000
764.	4.15966000000000e-04	7.80137000000001e-02
765.	4.1944700000000000000000000000000000000000	7.81729000000000e-02
700	4 220570000000000000000000000000000000000	7 864440000000000000000000000000000000000
/00.	4.2295/0000000000e-04	/.0044400000000000000000000000000000000
767.	4.2649700000000000e-04	7.8814700000000e-02
768	4 30066000000000000000000000000000000000	7 855080000000102
/00.		7.0000000000000000000000000000000000000
769.	4.336640000000000e-04	7.8650900000000e=02
770.	4.372930000000000e-04	7.99275000000000e=02
771	4 40052000000000000000000000000000000000	A 02804000000001 - 02
//1.	4.4090000000000000e-04	0.03004000000001E-02
772.	4.44643000000000e-04	8.0911100000000e-02
1	4 4836300000000000000000000000000000000000	8 147359999999999999999
1 7773		



774.	4.521160000000000e-04	8.19317000000000e-02
775	4 55900000000000000000000000000000000000	9.161450000000010.02
113.	4.558990000000000000000000000000000000000	8.101430000000010-02
776.	4.597140000000000e-04	8.11519000000000e-02
777.	4.635610000000000e-04	8.03963000000000e-02
770	4 67440000000000000000000000000000000000	2 66138000000000 02
//0.	4.6/4400000000000000000	7.6613800000000000000000000000000000000000
779.	4.713520000000000e-04	8.17407000000000e-02
780.	4.752960000000000e-04	8.2936200000000e=02
701	4 70272000000000- 04	
/01.	4./92/3000000000000000	8.28240000000000000000000000000000000000
782.	4.832840000000000e-04	8.3790200000000e=02
783.	4.873280000000000e-04	8.3907000000000e=02
704	4 01406000000000 04	42225000000000-02
/04.	4.91406000000000000000	8.4232500000000000000000000000000000000000
785.	4.955180000000000e-04	8.4570000000001e-02
786.	4.99665000000001e-04	8.46815000000001e-02
202	5 00046000000000000000000000000000000000	
/0/.	5.038460000000000000000	8.4461800000000000000000000000000000000000
788.	5.08062000000000e-04	8.5056800000000e=02
789.	5.123140000000000e-04	8-5351899999999999999999
700	5 166010000000000 04	460640000000000000000000000000000000000
750.	J.1000100000000000000000	8.4004000000000000000000000000000000000
791.	5.209240000000000e-04	8.46633000000000e-02
792.	5.25283000000000e-04	8.57945000000000e=02
702	5 2067000000000000 04	
195.	3.290790000000000000000	8.65661000000010-02
794.	5.341110000000000e-04	8.53788000000001e-02
795.	5.385810000000000e-04	8.6847700000000e=02
706	E 420880000000000 04	9.7621000000000000000000000000000000000000
750.	3.4300000000000000000000000000000000000	3.702100000000000000000000000000000000000
797.	5.476320000000000e-04	8.7429000000000e=02
798.	5.52215000000000e-04	8.7601200000000e-02
799.	5.5683600000000000-04	8.74569999999999999
1 000	E 614060000000000000000000000000000000000	8.82260000000000 02
000.	J.014900000000000000000	0.0302000000000000000000000000000000000
801.	5.66194000000000e-04	8.89926000000001e-02
802.	5.709320000000000e-04	9.02205000000000e-02
903	5 7571000000000- 04	8 95367000000000000000
003.	5.75710000000000e=04	3.3337700000000000000000000000000000000
804.	5.80528000000000e-04	8.8085800000000le-02
805.	5.85386000000000e-04	9.14940000000001e-02
806	5 902840000000000000000	9 25215000000016-02
007	5.90204000000000000000	J.2222000000000000000000000000000000000
807.	5.95224000000000e-04	8.//6360000000000000000000000000000000000
808.	6.002050000000000e-04	9.13784000000000e-02
909	6 052270000000000 04	9 16281000000000-02
010	5.00227000000000000e=04	- 17501000000000 02
810.	ь.102920000000000e-04	a.t/20/aaaaaaaaaaaaae=02
811.	6.153990000000000e-04	9.28832000000000e-02
912	6 2054900000000000-04	9 04414999999999990-02
012.	6.2034900000000000000000000000000000000000	
813.	6.25/42000000000e-04	9.2765900000000e=02
814.	6.309780000000000e-04	9.2890400000000e-02
815.	6.362580000000000e-04	9.38023999999999999999
016	6 4159200000000000 04	455030000000000000000000000000000000000
010.	6.41382000000000e-04	9.45505000000000000000000000000000000000
817.	6.469510000000000e-04	9.4973600000001e-02
818.	6.523650000000000e-04	9.6566799999999999=02
010	6 579240000000000 04	9.56197000000000000000000000000000000000000
019.	0.3782400000000000000000	3.3613700000000000000000000000000000000000
820.	6.63329000000001e-04	9.053100000000000000000000000000000000000
821.	6.688800000000000e-04	9.4654900000000e=02
822	6 74477000000000000-04	9 506080000000000000000000000000000000000
022.	0.7447700000000000000000000000000000000	3.3000000000000000000000000000000000000
823.	6.80121000000000e-04	9.4369800000000e=02
824.	6.85813000000000e-04	9.6594800000000e=02
825	6 9155200000000000-04	9 4622700000000000000000000000000000000000
025.	6.9133200000000000000000000000000000000000	
826.	6.9/339000000001e-04	9.66393000000000000000000000000000000000
827.	7.03174000000000e-04	9.7764900000000e=02
828.	7.09058000000000e-04	9.5391599999999999=02
020	7 1400200000000000 04	7678900000000000000000000000000000000000
020	7.149920000000000000e=04	
830.	/.209/50000000000e-04	a.80at2000000006=02
831.	7.27008000000000e-04	9.86989000000001e-02
832	7 3309200000000000000	9.83702000000001e-02
002.		
833.	7.39227000000000e-04	9.8/4960000000000=02
834.	7.45412000000000e-04	9.92225000000001e-02
835.	7.516500000000000000000000000000000000000	9.85922000000001e-02
1026	7 57040000000000000000000000000000000000	0.95247000000000000000000000000000000000000
0.00.	7.3/940000000000000000	9.9334700000000000000000000000000000000000
837.	7.64283000000000e-04	9.94099000000000e=02
838.	7.706780000000000e-04	1.00648000000000e-01
839	7 7712700000000000-04	1 00521000000000000000000000000000000000
040	7 02/21/00/00/00/00/00/00/00	
040.	/.836310000000000e-04	1.00302000000000000000000000000000000000
841.	7.90188000000000e-04	1.00465000000000e=01
842.	7.96801000000000e-04	1.01638000000000e-01
843	8 0346800000000000000000000000000000000000	1 0276100000000e-01
013.	0.101000000000000000000000000000000000	
844.	o.101920000000001e-04	T.0100000000000000000000000000000000000
845.	8.16972000000000e-04	1.0266700000000e-01
846.	8.238080000000000e-04	9.96332000000001e-02
847	8 307020000000000000000000000000000000000	034600000000000000000000000000000000000
047.	5.307020000000000e=04	1.03400000000000000000000000000000000000
848.	8.37653000000001e-04	1.04371000000000e=01
849.	8.44663000000000e-04	1.05605000000000e-01
850	8 517310000000000-04	1 009710000000000=01
050.	0.517510000000000000e=04	
1 851.	o.sxxsy0000000000e-04	T.010/0000000000000000000000000000000000
852.	8.66046000000000e-04	1.0454400000000e-01
853.	8.732930000000000e-04	1.05367000000000e-01
854	8 806010000000000 04	0.018300000000000=-01
0.54.	5.80001000000000e=04	1.0103000000000000000000000000000000000
855.	8.87970000000000e-04	1.0589600000000000000000000000000000000000
856.	8.95400000000000e-04	1.06034000000000e-01
857	9 028930000000000-04	1 04452000000000000=01
057.	5.02055000000000000e=04	
858.	9.104490000000000e-04	T.00130000000000=01
859.	9.18068000000000e-04	1.07892000000000e-01
860.	9.25750000000000e-04	1.07808000000000e-01
0.61	0.22407000000000000000000000000000000000	
001.	9.3349/0000000000e-04	1.0/00000000000000000000000000000000000
862.	9.413090000000000e-04	1.05204000000000e-01
863.	9.49186000000000e-04	1.11641000000000e-01
864	9 57128000000000 04	1 05557000000000-01
004.	5.571280000000000e=04	1.03370000000000000000000000000000000000
865.	9.65138000000000e-04	1.0906/0000000000000000000000000000000000
866.	9.73214000000000e-04	1.0966000000000e-01
867.	9.81358000000001e-04	1.13255000000000e-01
0.00	0.0057100000000010 04	
000.	9.895/1000000001e-04	1.0000000000000000000000000000000000000
869.	9.978509999999999e-04	1.066200000000e-01
870.	1.0062000000000000-03	1.09627000000000e-01
1 · · ·		



871.	1.014620000000000e-03	1.11331000000000e-01
070	1 022110000000000 02	1 1160000000000 01
072.	1.02511000000000000000000000000000000000	
8/3.	1.0316/0000000000e-03	1.11995000000000e-01
874.	1.040310000000000e-03	1.11853000000000e-01
875.	1.049010000000000e-03	1.089770000000000=-01
076	1 057700000000000 02	
870.	1.037790000000000000000000000000000000000	1.0101200000000000000000000000000000000
877.	1.066640000000000e-03	9.99601000000000e=02
878.	1.075570000000000e-03	9.3592000000000e-02
879	1 084570000000000e-03	8 8354400000000000000000000000000000000000
000	1.003640000000000-03	
000.	1.09304000000000000000000	8.13038000000000000000000000000000000000
881.	1.102800000000000e-03	8.74299999999999999e-02
882.	1.112020000000000e-03	1.0523400000000e=01
883.	1.121330000000000e-03	1.1501200000000e=01
004	1 130710000000000 03	
884.	1.130/1000000000e-03	1.13813000000000000000000000000000000000
885.	1.140180000000000e-03	1.09677000000000e=01
886.	1.149720000000000e-03	8.2894200000000e-02
887.	1.159340000000000e-03	1.36268000000000e-01
888	1 1690400000000000-03	1 358880000000000000000000000000000000000
000	1 17002000000000000000000000000000000000	
889.	1.178820000000000e-03	1.3879700000000000000000000000000000000000
890.	1.188690000000000e-03	1.39596000000000e=01
891.	1.198630000000000e-03	1.3667600000000e-01
892.	1.208660000000000e-03	1.4078800000000000=01
803	1 2187800000000000-03	1 4248100000000000000000000000000000000000
0.00	1.210/0000000000000000000000000000000000	1.42401000000000000000000000000000000000
894.	1.22898000000000000000	1.4507200000000000000000000000000000000000
895.	1.239260000000000e-03	1.45038000000000e-01
896.	1.249630000000000e-03	1.3647300000000e-01
897.	1.260090000000000e-03	1.43059000000000e-01
898	1 270630000000000 03	1 40120000000000000000000000000000000000
000	1 2012700000000000000000	
0.55.	1.2012/000000000000000	1.320920000000000000000000000000000000000
900.	1.291990000000000e-03	1.459/5000000000e=01
901.	1.302800000000000e-03	1.44008000000000e-01
902.	1.313700000000000e-03	1.460370000000000=-01
903	1 3247000000000000000000000000000000000000	1 4520900000000000000000000000000000000000
	1.325700000000000000000	1.45255555555555555555555555555555555555
904.	1.335/80000000000e-03	1.4341600000000000000000000000000000000000
905.	1.34696000000000e-03	1.48065000000000e-01
906.	1.358230000000000e-03	1.48602000000000e-01
907.	1.3696000000000000e-03	1.505350000000000=01
000	1.3010000000000000000000000000000000000	
908.	1.381060000000000e-03	1.520230000000000000000000000000000000000
909.	1.392610000000000e-03	1.44784000000000e-01
910.	1.404270000000000e-03	1.4574500000000e-01
911.	1.416020000000000e-03	1.490370000000000=01
012	1 4278700000000000000000	1 48741000000000000000000
010	1.427070000000000000000000000000000000000	
913.	1.4398200000000000000	1.50/5/000000000000000000000000000000000
914.	1.451870000000000e-03	1.5216200000000e-01
915.	1.464010000000000e-03	1.5508700000000e-01
916	1 476270000000000000	1 4875200000000000-01
017	1.400/20000000000000000000000000000000000	
917.	1.488620000000000e-03	1.5417400000000000000000000000000000000000
918.	1.501080000000000e-03	1.55780000000000e=01
919.	1.513640000000000e-03	1.5761000000000e-01
920.	1.526300000000000e-03	1.449270000000000=01
021	1 5390800000000000000000	1 537850000000000000000000
521.	1.55900000000000000000000000000000000000	
922.	1.551960000000000e-03	1.55030000000000000000000000000000000000
923.	1.564940000000000e-03	1.55458000000000e-01
924.	1.578040000000000e-03	1.57487000000000e-01
925	1 591240000000000e-03	1 57566000000000000-01
926	1 6045600000000000000000	1 503850000000000000000000
520.	1.00450000000000000000000000000000000000	
927.	1.61/99000000000000000	1.536060000000000000000000000000000000000
928.	1.631530000000000e-03	1.55699000000000e-01
929.	1.645180000000000e-03	1.64961000000000e-01
930.	1.658950000000000e-03	1.62521000000000e-01
931	1 67283000000000000000000000000000000000000	1.658930000000000=-01
022	1 66602000000000000000000000000000000000	
532.	1.0000300000000000000000	1.230/4000000000000000000000
933.	1.70094000000000e-03	1.6003900000000e=01
934.	1.71518000000000e-03	1.60794000000000e=01
935.	1.729530000000000e-03	1.65903000000000e-01
936.	1.74400000000000000000000000000000000000	1.6937000000000000000000000000000000000000
037	1 7586000000000000000000000000000000000000	1.653320000000000-01
0.20	1.77221000000000000000000000000000000000	
330.	1.7/3310000000000e-03	1.7216200000000000000000000000000000000000
939.	1.78815000000000e-03	1.55787000000000e=01
940.	1.80312000000000e-03	1.64348000000000e-01
941.	1.818200000000000e-03	1.67849000000000e-01
942.	1.8334200000000000000000000000000000000000	1.67631000000000e-01
943	1 8487600000000000000000000000000000000000	1 669640000000000-01
044	1 9642200000000000000000000000000000000000	
244.	1.0042300000000000e-03	1.00530000000000000000000000000000000000
945.	1.87983000000000e-03	1.69390000000000e-01
946.	1.895560000000000e-03	1.68577000000000e-01
947.	1.9114300000000000e-03	1.66662000000000e-01
948	1 9274200000000000000000000000000000000000	1.709250000000000=-01
040	1 042550000000000000000000000000000000000	1.755250000000000000000000000000000000000
243.	1.943330000000000000e=03	1.7555555555555555555555555555555555555
950.	1.95981000000000e-03	1./5284000000000e=01
951.	1.976210000000000e-03	1.5126900000000e-01
952.	1.992750000000000000	1.6601000000000e-01
953	2 009430000000000 03	1.69421000000000e=01
	2.00943000000000000000	1.0342100000000000000000000000000000000000
954.	2.026240000000000e-03	T.28T3/0000000006-0T
955.	2.04320000000000e-03	1.6407000000000e=01
956.	2.060290000000000e-03	1.6361200000000e-01
957.	2.077540000000000000000000000000000000000	1.62688000000000000=-01
050	2.0040200000000000000000000000000000000	
538.	2.0949200000000000000000	1.5510000000000000000000000000000000000
959.	2.11245000000000e-03	1.6068200000000000000
960.	2.13013000000000e-03	1.6119900000000e=01
961.	2.147950000000000e-03	1.50266000000000e-01
962	2 16593000000000000000000000000000000000000	1.5637500000000000=-01
062	2.104050000000000000000000000000000000000	
303.	∠.184050000000000e-03	1.465450000000000000000000000000000000000
964.	2.20233000000000e-03	1.4426000000000e=01
965.	2.220760000000000e-03	1.46322000000000e-01
966.	2.23934000000000000	1.46732000000000e-01
967	2 25808000000000000000000000000000000000	
201.	2.20000000000000000000	1.3120900000000000000000000000000000000000



968.	2.2769800000000e=03 1.3590100000000e=01
0.60	2 28602000000000 02 1 2872000000000 01
509.	2.23603000000000000000000000000000000000
970.	2.31525000000000e-03 1.3892900000000e-01
971.	2.3346200000000e-03 1.4052700000000e-01
972.	2.3541600000000e=03 1.3851800000000e=01
973	2,3738600000000000000000000000000000000000
573.	2.3738600000000000000000000000000000000000
974.	2.3937200000000e-03 1.4753600000000e-01
975.	2.4137500000000e-03 1.5362200000000e-01
976	2 4339500000000000000000000000000000000000
077	
577.	2.4345200000000000000000000000000000000000
9/8.	2.4/486000000000000000 1.38265000000000000000000000000000000000000
979.	2.49557000000000e-03 1.5130800000000e-01
980.	2.5164500000000e=03 1.6772800000000e=01
0.01	
901.	2.53/5100000000000000000000000000000000000
982.	2.55874000000000e-03 1.6148600000000e-01
983.	2.5801500000000e-03 1.7067400000000e-01
984.	2.6017400000000e=03 1.6522000000000e=01
985	2 6235200000000000000000000000000000000000
505.	
986.	2.6454/000000000e-03 1./852100000000e-01
987.	2.6676100000000e-03 1.7710600000000e-01
988.	2.68993000000000e=03 1.8045700000000e=01
0.90	2 7124400000000000000000000000000000000000
505.	
990.	2.73514000000000000000000000000000000000000
991.	2.7580300000000e-03 1.8394900000000e-01
992.	2.78111000000000e-03 1.8769900000000e-01
993	2 804380000000000000000000000000000000000
994.	2.82/8500000000000000000000000000000000000
995.	2.85151000000000e-03 1.9715200000000e-01
996.	2.8753700000000e-03 1.8338100000000e-01
997.	2.89943000000000e-03 1.88841000000000e-01
0.00	2,923700000000000-03, 1,9232000000000-01
220.	
399.	2.948160000000000000 I.9341100000000000000000000000000000000000
1000.	2.97283000000000e-03 1.9606600000000e-01
1001.	2.99771000000000e-03 1.944960000000000e-01
1002	3.0228000000000-03.1.9344800000000-01
1002.	
1003.	3.0480900000000000 1.966460000000000000000000000000000000000
1004.	3.0736000000000e=03 1.8963800000000e=01
1005.	3.09932000000000e-03 2.0005000000000e-01
1006	3 12525000000000-03 1 9942200000000-01
1000.	3.1232500000000000000000000000000000000000
1007.	3.1514100000000e=03 2.00/3600000000e=01
1008.	3.17778000000000e-03 1.9713000000000e-01
1009.	3.20437000000000e-03 1.9970400000000e-01
1010	3 2311900000000000000000000000000000000000
1010.	
1011.	3.258220000000000000000000000000000000000
1012.	3.2854900000000e-03 1.9992200000000e-01
1013.	3.31298000000000e-03 2.0147200000000e-01
1014	3 34071000000000-03 2 015230000000000000-01
1014.	
1015.	3.36866000000000000000000000000000000000
1016.	3.3968500000000e-03 2.0847500000000e-01
1017.	3.42528000000000e-03 2.074000000000e-01
1018.	3.45394000000000e=03 2.0016400000000e=01
1010	2 48284000000000 02 2 02266000000000 01
1019.	5.4828400000000000000205 2.053880000000000000000000000000000000000
1020.	3.5119900000000e-03 2.0788500000000e-01
1021.	3.54138000000000e-03 2.1151300000000e-01
1022	3 57101000000000-03 1 95755000000000-01
1022	
1023.	
1024.	3.63103000000000000000000000000000000000
1025.	3.66141000000000e-03 2.0385900000000e-01
1026.	3.6920500000000e-03 1.9870800000000e-01
1027	3 72285000000000-03 1 85814000000000000000000
1027.	
1028.	3./541000000000000000000000000000000000000
1029.	3.78552000000000e-03 1.8691800000000e-01
1030.	3.8171900000000e-03 1.8896200000000e-01
1031.	3.8491400000000e-03 1.7977300000000e-01
1032	3.88135000000000-03 1.7361100000000-01
1032.	
1033.	5.9155500000000000000000 1.0515500000000000
1034.	3.9465800000000e-03 1.6376100000000e-01
1035.	3.9796000000000e-03 1.6908800000000e-01
1036.	4.01291000000000e-03 1.73088000000000e-01
1037	4 046490000000000=03 1 76073000000000=01
1020	
1030.	4.0005000000000000000000000000000000000
1039.	4.1144900000000e=03 1.8246500000000e=01
1040.	4.14892000000000e-03 1.8647600000000e-01
1041.	4.18364000000000e-03 1.8464300000000e-01
1042	4 21865000000000-03 1 88274000000000-01
1042	4.250500000000 03 1.022/3000000000 01
1043.	4.23330000000000=03 1.926400000000000000000
1044.	4.28955000000000e-03 1.9196700000000e-01
1045.	4.32545000000000e-03 1.9172500000000e-01
1046.	4.36164000000000e-03 1.9460200000000e-01
1047	4.39814000000000-03 1.98788000000000-01
104/.	
1048.	4.43495000000000000000000 I.9945300000000000000000000000000000000000
1049.	4.4720600000000e-03 2.0392800000000e-01
1050.	4.5094800000000e-03 1.9930100000000e-01
1051	4 547220000000000=03 2 024210000000000=01
1051.	4.94/2200000000000000000000000000000000000
1052.	4.58527000000000000 2.0324100000000000000000000000000000000000
1053.	4.62364000000000e-03 2.0608300000000e-01
1054.	4.6623300000000e-03 2.0742000000000e-01
1055.	4.701350000000000=03 2.04929000000000=01
1056	
1030.	4.4050000000000000000000000000000000000
1057.	4.7803600000000e=03 2.1113900000000e=01
1058.	4.8203600000000e-03 2.1011900000000e-01
1059.	4.8607000000000e=03 2.11487000000000e=01
1060	4.01370000000000-03 2.11520000000000 01
1000.	4.301370000000000000003 2.1162300000000000000000000000000000000000
1061.	4.94239000000000e-03 2.1016800000000e-01
1062.	4.98375000000000e-03 2.1418900000000e-01
1063	5.02545000000000-03.2.126550000000000-01
1003.	5.0254505050000002=03 2.12653000000000000000000000000000000000000
1064.	5.06/51000000000e-03 2.144/4000000000e-01



1065.	5.109910000000000e-03	2.13198000000000e-01
1066	5 152670000000000 02	2 14982000000000 01
10000.	5.1520700000000000000000000000000000000000	2.14962200000000000000000000000000000000000
1067.	5.195/90000000000e-03	2.1665/00000000e-01
1068.	5.239270000000000e-03	2.15738000000000e-01
1069.	5.283110000000000e-03	2.14293000000000e-01
1070	5 3273200000000000-03	2 15284000000000000000000000000000000000000
1070.	5.321320000000000000000000000000000000000	
10/1.	5.3/1900000000000e-03	2.1095400000000000000000000000000000000000
1072.	5.416860000000000e-03	2.10207000000000e-01
1073.	5.462190000000000e-03	2.08788000000000e-01
1074	5 507890000000000e-03	1 98474000000000=01
1075	5 5520000000000000000000000000000000000	
1075.	5.5555500000000000000000000000000000000	1.9010000000000000000000000000000000000
10/6.	5.600460000000000e-03	1.954540000000000000000000000000000000000
1077.	5.647330000000000e-03	1.85042000000000e-01
1078	5 694590000000000e-03	1 90239000000000=01
1079	5 742240000000000000000000000000000000000	2 011780000000000000000000
1075.	5.742240000000000000000000000000000000000	
1080.	5./90290000000000e-03	2.114550000000000000000000000000000000000
1081.	5.838740000000000e-03	2.11535000000000e-01
1082.	5.88760000000000e-03	2.15185000000000e-01
1083.	5.936870000000000e-03	2.0910800000000e-01
1084	5 98655000000000000000	2 081040000000000000000000000000000000000
1004.	5.98855000000000000000000000000000000000	2.051040000000000000000000000000000000000
1085.	6.036650000000000e-03	1.9721100000000000000000000000000000000000
1086.	6.087170000000000e-03	1.91639000000000e-01
1087.	6.138100000000000e-03	1.92244000000000e-01
1088	6 18947000000000000000000000000000000000000	1 686730000000000=01
1000.	6.2412600000000000000000000000000000000000	1.7152000000000000000000000000000000000000
1089.	6.241260000000000e-03	1.71529000000000000000000000000000000000000
1090.	6.293490000000000e-03	1.74773000000000e-01
1091.	6.346150000000000e-03	1.75019000000000e-01
1092.	6.39926000000000e-03	1.83821000000000e-01
1093	6 45281000000000000000000000000000000000000	1 834590000000000-01
1004	C. E0C010000000000000000000000000000000000	
1094.	0.3000100000000000000000	1.30023000000000000000000000000000000000
T032.	6.561260000000000e-03	1.88082000000000e-01
1096.	6.61616000000000e-03	1.97031000000000e-01
1097.	6.6715300000000000e-03	1.99801000000000e-01
1098	6 7273600000000000000000000000000000000000	1 88787000000000000000000000000000000000
1000	6 7026500000000000000000000000000000000000	
T033.	0./030300000000000000000000000000000000	1.33/32/00/00/00/00/00
1100.	6.840420000000000e-03	1.9499000000000e-01
1101.	6.897660000000000e-03	1.85212000000000e-01
1102.	6.955380000000000e-03	1.81845000000000e-01
1103	7 0135900000000000000	1 788550000000000000000000000000000000000
1105.	7.01333000000000000000000000000000000000	
1104.	7.072280000000000e-03	1.73337000000000000000000000000000000000
1105.	7.131460000000000e-03	1.7151300000000e-01
1106.	7.19113000000000e-03	1.62920000000000e-01
1107.	7.25131000000000e-03	1.62584000000000000=01
1100	7 21100000000000000000000000000000000000	1.5297000000000000000000000000000000000000
1100.	7.311990000000000e-03	1.53879000000000000000000000000000000000000
1109.	/.3/3180000000000e-03	1.5197900000000000000000000000000000000000
1110.	7.434880000000000e-03	1.44129000000000e-01
11111.	7.497100000000000e-03	1.40992000000000e-01
1112	7 5598300000000000000000000000000000000000	1 336050000000000=01
1112	7.0000000000000000000000000000000000000	
1113.	7.623090000000000e-03	1.28201000000000000000000000000000000000
1114.	7.686890000000000e-03	1.25959000000000e-01
1115.	7.75121000000000e-03	1.24893000000000e-01
1116	7 816070000000000e-03	1 202930000000000=01
1117	7 991490000000000000000000000000000000000	1,22910000000000,000,01
1117.	7.881480000000000000000000000000000000000	1.22310000000000000000000000000000000000
1118.	7.947430000000000e-03	1.26435000000000e=01
1119.	8.013940000000001e-03	1.30122000000000e-01
1120.	8.08100000000000e-03	1.3014000000000e-01
1121.	8.148620000000001e-03	1.3912600000000e-01
1122	8 216810000000000000000	1.422620000000000000000000000000000000000
1122.	8.21081000000000000000000000000000000000	1.422620000000000000000000000000000000000
1123.	8.2855/000000001e-03	1.49651000000000000000000000000000000000000
1124.	8.354910000000000e-03	1.50199000000000e-01
1125.	8.424820000000000e-03	1.47731000000000e-01
1126	8 495320000000001e-03	1 634620000000000=01
1127	8 5664100000000000000000000000000000000000	1 6822700000000000000000000000000000000000
1120	0.0001100000000000000000000000000000000	1.7342700000000000000000000000000000000000
1128.	0.0300333333333333336-03	1./44/30000000000=01
1129.	8.71038000000000e-03	1.//035000000000e-01
1130.	8.783269999999999e-03	1.83329000000000e-01
1131.	8.85677000000000e-03	1.87937000000000e-01
1132.	8.93089000000000000	1.96422000000000e-01
1133	9 005620000000010 02	2 04752000000000000000000
1124	5.0050200000000000000000000000000000000	
1134.	5.000300000000001e-03	2.11424000000000000000000000000000000000
1135.	9.15697000000000e-03	2.1/69/000000000e-01
1136.	9.233600000000000e-03	2.25980000000000e-01
1137.	9.31087000000001e-03	2.34610000000000e-01
1138.	9.38877999999999999	2.37183000000000e-01
1130	9 4673499999999999999	2, 37053000000000000000
1140	J.40/J49999999999999990-03	2.57055000000000000000000000000000000000
1140.	9.5465/0000000001e-03	2.304/80000000000-01
1141.	9.626460000000000e-03	2.4655600000000e-01
1142.	9.70702000000000e-03	2.54881000000000e-01
1143.	9.788250000000000e-03	2.63481000000000e-01
1144	9 8701500000000000000000000000000000000000	2 6416000000000000000000
1145	2.0/UIJ22222222222222	2.391000000000000000000000000000000000000
1145.	9.952/5000000000e-03	2.103640000000000-01
1146.	1.003600000000000e-02	2.72625000000000e-01
1147.	1.012000000000000e-02	2.70749000000000e-01
1148.	1.020470000000000000000000000000000000000	2.650500000000000e-01
11/0	1 0200100000000000000000000000000000000	2,751180000000000000000
1149.	1.0290100000000000e-02	2.751150000000000000000000000000000000000
1150.	1.03762000000000e=02	2.72024000000000e-01
1151.	1.046300000000000e-02	2.78876000000000e-01
1152.	1.055060000000000e-02	2.86044000000000e-01
1153.	1.0638900000000000000	2.87661000000000e-01
1154	1 072790000000000000000000000000000000000	2 9339500000000000=01
1155	1.0/2/30000000000000000000000000000000000	2.35550000000000000000000000000000000000
1155.	1.08177000000000e-02	2.93/82000000000e-01
1156.	1.090820000000000e-02	2.91267000000000e-01
1157.	1.099950000000000e-02	2.97090000000000e-01
1158.	1.10915000000000000000000000000000000000	3.006050000000000e-01
1150	1 119/300000000000000000000000000000000000	2 865830000000000-01
11.00	1.1077000000000000000000000000000000000	2.03555500000000000000000000000000000000
1160.	1.12779000000000e-02	3.08189000000000e-01
1161.	1.137230000000000e-02	3.08241000000000e-01



1162.	1.146750000000000e-02	3.1237600000000e-01
1162	1 15624000000000000000000000000000000000000	2.08600000000000000000000000000000000000
1105.	1.13034000000000000000000000000000000000	3.0000000000000000000000000000000000000
1164.	1.166020000000000e-02	3.1106100000000e-01
1165.	1.175780000000000e-02	3.10814000000000e-01
1166.	1.185620000000000e-02	3.12343000000000e-01
1167	1 1955400000000000000000000000000000000000	3 1053800000000000000000000000000000000000
1107.	1.1955400000000000000000000000000000000000	
1108.	1.205540000000000e-02	3.12749000000000000000000000000000000000000
1169.	1.215630000000000e-02	3.10037000000000e-01
1170.	1.225800000000000e-02	3.07352000000000e-01
1171	1 236060000000000000000	3 03738000000000000000000000000000000000
1170	1.23000000000000000000000000000000000000	
11/2.	1.246410000000000e-02	3.202460000000000000000000000000000000000
1173.	1.256840000000000e-02	3.21275000000000e-01
1174.	1.267350000000000e-02	3.22020000000000e-01
1175	1 27796000000000000000	3 282440000000000000000000000000000000000
1175.	1.277900000000000000000000000000000000000	
11/6.	1.288650000000000e-02	2.98988000000000000000000000000000000000
1177.	1.299440000000000e-02	3.20854000000000e-01
1178.	1.310310000000000e-02	3.2554000000000e-01
1179	1 32127000000000000-02	3 32172000000000e-01
1100	1 2222200000000000000000000000000000000	
1100.	1.332330000000000e-02	5.51/5600000000000000000000000000000000000
1181.	1.343480000000000e-02	3.451100000000000000000000000000000000000
1182.	1.354720000000000e-02	3.48275000000000e-01
1183	1 36606000000000000-02	3 51746000000000e-01
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1104.	1.3774900000000000000000	3.36849000000000000000000000000000000000000
1185.	1.389020000000000e-02	3.6380900000000000000000000000000000000000
1186.	1.400640000000000e-02	3.67664000000000e-01
1187.	1.412360000000000e-02	3.6856800000000e=01
1199	1 42418000000000000000000	3 6073200000000000000000000000000000000000
1100	1.4261000000000000000000000000000000000000	2 71070000000000 01
TT83.	1.43610000000000e-02	3./19/8000000000e-01
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1192	1 4724500000000000000000000000000000000000	3 588750000000000=-01
1102	1.40470000000000000000000000000000000000	
1123.	1.484/80000000000e-02	2.202040000000000=0T
1194.	1.497200000000000e-02	3.41612000000000e-01
1195.	1.509730000000000e-02	3.32219000000000e-01
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1107	1.522300000000000000000000000000000000000	
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1198.	1.54795000000000e-02	3.3094600000000000000000000000000000000000
1199.	1.560900000000000e-02	3.34455000000000e-01
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1200.	1.573300000000000000000000000000000000000	
1201.	1.58/13000000000e-02	3.506200000000000000000000000000000000000
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1203.	1.613810000000000e-02	3.63560000000000e-01
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1201	1 (40030000000000000000000000000000000000	
1205.	1.640930000000000e-02	3.81627000000000000000000000000000000000000
1206.	1.654660000000000e-02	3.88689000000000e-01
1207.	1.668510000000000e-02	3.27762000000000e-01
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1209.	1.696550000000000e-02	3.84167000000000000000000000000000000000000
1210.	1.710750000000000e-02	3.9577300000000000000000000000000000000000
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1010	1 7540600000000000 02	4 10570000000000 01
1213.	1.754060000000000e-02	4.105700000000000000000000000000000000000
1214.	1.768730000000000e-02	4.14759000000000000000000000000000000000000
1215.	1.783530000000000e-02	4.17661000000000e-01
1216.	1.798460000000000e-02	4.079780000000000e-01
1217	1 813510000000000000000	4 27102000000000-01
1010	1.0133100000000000000000000000000000000	
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1219.	1.843990000000000e-02	4.395720000000000e-01
1220.	1.859420000000000e-02	4.4479600000000e-01
1221	1 87498000000000000-02	4 494370000000000-01
1000	1.00067000000000000000000000000000000000	
1222.	1.890670000000000e-02	4.530080000000000000000000000000000000000
1223.	1.90649000000000e-02	4.59382000000000e-01
1224.	1.922440000000000e-02	4.61369000000000e-01
1225.	1.9385300000000000e-02	4.65052000000000e-01
1226	1 9547500000000000000	4 679090000000000000000000000000000000000
1007	1.0711100000000000000000000000000000000	
1221.	1.9/1110000000000000000	4.00142000000000000000000000000000000000
1228.	1.98761000000000e-02	4.6419000000000000000-01
1229.	2.00424000000000e-02	4.71920000000000e-01
1230.	2.021010000000000e-02	4.73417000000000e-01
1231	2 0379200000000000000000000000000000000000	4 74321000000000e-01
1232	2 05/080000000000000000000000000000000000	734630000000000000000
1022	2.0345600000000000000000	1.754550000000000000000000000000000000000
1233.	2.0/21/000000000e-02	4./38/80000000000000000000000000000000000
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1235.	2.107000000000000e-02	4.85422000000000e-01
1236	2 12463000000000000000000000000000000000000	4 979120000000000e-01
1007	2 14241000000000000000000000000000000000	
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1238.	2.16034000000000e-02	5.14396000000000000000000000000000000000000
1239.	2.178410000000000e-02	5.19253000000000e-01
1240.	2.1966400000000000e-02	5.32981000000000e-01
1241	2 215030000000000 02	5 2682900000000000=01
1040	2.21303000000000000000000	
1242.	2.233560000000000e-02	5.33416000000000e-01
1243.	2.25225000000000e-02	5.48357000000000e-01
1244.	2.27110000000000000e-02	5.55413000000001e-01
1245	2 29010000000000 02	5 552400000000000=01
1046	2.23010000000000000000000000000000000000	5.55524000000000000000000000000000000000
1∠46.	2.3092/0000000000e-02	5.8/58300000000e-01
1247.	2.32859000000000e-02	5.97591000000000e-01
1248.	2.348080000000000e-02	6.1083000000000e-01
1249.	2.367730000000000000000000000000000000000	6.254280000000000e-01
1250	2 39754000000000000000000000000000000000000	5.580610000000000000000
1230.	2.30/3400000000000e=02	0.35051000000000000000000000000000000000
1251.	2.40752000000000e-02	6./4959000000000e-01
1252.	2.427670000000000e-02	6.78764000000000e-01
1253.	2.4479800000000000000000000000000000000000	7.13793000000000e-01
1254	2 4684700000000000000000000000000000000000	7.27640000000000000000
1234.	2.4004/00000000000e=02	7.2764000000000000000000000000000000000000
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1256.	2.509950000000000e-02	7.15639000000000e-01
1257.	2.53096000000000000	5.92093000000000e-01
1258	2 55214000000000- 02	5 27438000000000000000
±200.	2.JJ21400000000000000000000000000000000000	2.7.43000000006_01



1259.	2.573490000000000e-02	5.87640000000001e-01
1260	2 595030000000000000000000000000000000000	5 2604900000000000000000000000000000000000
1001	2.0000000000000000000000000000000000000	
1261.	2.616/4000000000e-02	4.6594000000000000000000000000000000000000
1262.	2.638640000000000e-02	3.9050600000000e-01
1263.	2.660720000000000e-02	3.13627000000000e-01
1264	2 6829900000000000-02	2 41682000000000-01
1005	2.0029900000000000000000000000000000000	
1265.	2.697080000000000e-02	5.176070000000000000000000000000000000000
1266.	2.708360000000000e-02	1.27132000000000e-01
1267.	2.728080000000000e-02	1.31571000000000e-01
1268	2 7509100000000000-02	9.96565000000000000000000000000000000000
1200.	2.730310000000000000000000000000000000000	
1209.	2.77333000000000000000000000000000000000	8.3234400000001E-02
1270.	2./9/14000000000e-02	8.07902000000001e-02
1271.	2.82055000000000e-02	8.8262700000000e-02
1272	2 841150000000000e-02	7 413050000000000-02
1070	2 95200000000000000000000000000000000000	2 66520000000000 02
12/3.	2.83300000000000000000000000000000000000	2.0332000000000000000000000000000000000
12/4.	2.86/95000000000e-02	1.1/2//000000000000000000000000000000000
1275.	2.891950000000000e-02	1.37058000000000e-01
1276.	2.916150000000000e-02	1.55638000000000e-01
1277	2 9405500000000000000000	1 632330000000000000000000000000000000000
12/7.	2.9405300000000000000000000000000000000000	1.03233000000000000000000000000000000000
12/8.	2.965160000000000e-02	1.8924900000000000000000000000000000000000
1279.	2.989970000000000e-02	2.0760600000000e-01
1280.	3.0149900000000000e-02	2.24021000000000e-01
1291	3 04022000000000000000000	2 3968600000000000000000000000000000000000
1000	3.04022000000000000000000000000000000000	
1282.	3.065660000000000e-02	2.5250200000000e-01
1283.	3.091320000000000e-02	2.68614000000000e-01
1284.	3.117190000000000e-02	2.7992100000000e-01
1285.	3.143270000000000e-02	2.91781000000000e-01
1286	3 16957000000000- 00	2 950210000000000-01
1007	5.10557000000000000000000	2.3502100000000000000000000000000000000000
128/.	э.тэртолололоолое-05	3.11/2400000000000000000000000000000000000
1288.	3.22284000000000e-02	3.21277000000000e-01
1289.	3.2498100000000000e-02	3.28664000000000e-01
1290	3 27701000000000000000	3 361580000000000e-01
1201	3.277010000000000000000000000000000000000	
1721.	3.3044300000000000e-02	2.43/330000000000e-01
1292.	3.33208000000000e-02	3.52415000000000e-01
1293.	3.359970000000000e-02	3.59676000000000e-01
1294	3 3880800000000000000000000000000000000	3 650240000000000=-01
1205	3 4164300000000000000000000000000000000000	3 66620000000000000000
1273.	5.4104500000000000000000	5.00902000000000000000000000000000000000
1296.	3.445020000000000e-02	3.76801000000000e-01
1297.	3.473850000000000e-02	3.8005000000000e-01
1298	3 502920000000000e-02	3 82168000000000-01
1200	2 5222200000000000000000000000000000000	
1299.	3.552250000000000e-02	3.848990000000000000000000000000000000000
1300.	3.561/90000000000e-02	3.9534900000000000000000000000000000000000
1301.	3.591600000000000e-02	3.99929000000000e-01
1302.	3.621650000000000e-02	3.529770000000000e-01
1303	3 6519600000000000000000000000000000000000	4 058870000000000000000000000000000000000
1000.	2.0000000000000000000000000000000000000	
1304.	3.682520000000000e-02	4.123230000000000000000000000000000000000
1305.	3.713340000000000e-02	4.25418000000000e-01
1306.	3.744410000000000e-02	4.25116000000000e-01
1307	3 7757400000000000-02	3 849770000000000-01
1200	2 00724000000000000000000000000000000000	
1308.	3.807340000000000e-02	4.34411000000000000000000000000000000000
1309.	3.839200000000000e-02	4.3923700000000000000000000000000000000000
1310.	3.871330000000000e-02	4.49659000000000e-01
1311	3 903720000000000e-02	4 616210000000000-01
1212	2 0262000000000000000000000000000000000	
1312.	3.9303900000000000000000	4.73377000000000000000000000000000000000
1313.	3.969330000000000e-02	4.79268000000000000000000000000000000000000
1314.	4.002550000000000e-02	5.09189000000000e-01
1315.	4.036040000000000e-02	5.21820000000000e-01
1316	4 069810000000000e-02	4 962610000000000-01
1217	4 1039700000000000000000000000000000000000	
1317.	4.1038/0000000000000000	4.1556400000000000000000000000000000000000
1318.	4.138210000000000e-02	3.48562000000000e-01
1319.	4.172840000000000e-02	3.44055000000000e-01
1320.	4.207760000000000e-02	3.67370000000000e-01
1321	4 2429700000000000000000000000000000000000	3 9325000000000000000000000000000000000000
1222	4 27040000000000000000000000000000000000	
1322.	4.2/040000000000000000	4.12220000000000000000000000000000000000
1323.	4.314280000000000e-02	4.23196000000000e-01
1324.	4.350380000000000e-02	4.40394000000000e-01
1325.	4.386790000000000000	4.51360000000000e-01
1326	4 4235000000000000000000000000000000000000	4 61494000000000e=01
1227	4 4605100000000000000000000000000000000000	
1227.	4.4000100000000000000000000000000000000	
1328.	4.49/840000000000e-02	4./858900000000000000000000000000000000000
1329.	4.53548000000000e-02	4.84886000000000e-01
1330.	4.573430000000000e-02	4.96949000000000e-01
1331.	4.6117000000000000000	4.85713000000000e-01
1332	4 650300000000000000000000000000000000000	5 21922000000000e=01
1000	4.600010000000000000000	
1333.	4.689210000000000e-02	2.13/0/0000000000000000000000000000000000
1334.	4.728450000000000e-02	4.72845000000000e-01
1335.	4.76802000000000e-02	4.66224000000000e-01
1336.	4.80792000000000000	4.977450000000000c-01
1337	4 8481500000000000000000000000000000000000	4.946300000000000000000
1000	4.8481300000000000000000000000000000000000	4.5405000000000000000000000000000000000
1338.	4.88872000000000e-02	4./6422000000000e-01
1339.	4.929630000000000e-02	4.43641000000000e-01
1340.	4.970880000000000e-02	4.10778000000000e-01
1341	5 012480000000000 02	3 7846500000000000000000000
1242	5.012480000000000000000	5. /6452000000000000000000000000000000000000
1342.	5.054420000000000e-02	3.65432000000000000000000000000000000000000
1343.	5.096720000000000e-02	3.78241000000000e-01
1344.	5.139370000000000e-02	3.86953000000000e-01
1345.	5.182380000000000=-02	3.965730000000000e-01
1246	5.10250000000000000000000	3.557800000000000000000000000000000000000
1340.	5.225/4000000000e-02	2.02/06000000000=01
1347.	5.269470000000000e-02	4.01180000000000000000-01
1348.	5.313570000000000e-02	4.08588000000000e-01
1349.	5.358030000000000000	4.22311000000000e-01
1350	5 4028700000000000000000000000000000000000	4.374950000000000000000
1051	5.402070000000000000000	
1351.	5.448080000000000e-02	4.601180000000000000000000000000000000000
1352.	5.493670000000000e-02	4.70261000000000e-01
1353.	5.53965000000000e-02	4.74107000000000e-01
1354	5 58600000000000000000000000000000000000	4 86541000000000e-01
1055	5.555555000000000000000000000000000000	
1333.	5.632/50000000000e-02	4.33070000000000000000



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	1356.	5.679880000000000e-02	5.02238000000000e-01
	1357	5 7274100000000000-02	5 05414000000000000000000
	1007.	5.7274100000000000000000000000000000000000	3.03414000000000000000000000000000000000
	1358.	5.//5340000000000e-02	4.8659000000000000000000000000000000000000
	1359.	5.82367000000000e-02	5.3517300000000e-01
	1360	5 872400000000000e-02	5 44971000000000e-01
	1261	5 021540000000000 02	5 2547000000000 01
	1301.	5.921340000000000000000	3.3234700000000000000000000000000000000000
	1362.	5.971100000000000e-02	5.52395000000000e-01
	1363.	6.021060000000000e-02	5.49289000000000e-01
	1364	6 071450000000000e-02	5 4974200000000000-01
	1364.	6.1000000000000000000000000000000000000	
	1365.	6.12226000000000e-02	5.4551300000000000000000000000000000000000
	1366.	6.173490000000000e-02	5.38884000000000e-01
	1367.	6.22515000000000e-02	5.35837000000000e-01
	1368	6 27724000000001e-02	5 32748000000000e-01
	1360	6.2002200000000000000000000000000000000	
	1369.	6.32977000000000e=02	5.2910/00000000000000000000000000000000000
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	1371.	6.436150000000000e-02	5.4369900000000e-01
	1372.	6.490010000000000e-02	5.60725000000000e-01
	1272	6 544220000000010 02	
	1373.	0.544520000000000000000	5.88288000000000000000000000000000000000
	13/4.	6.599080000000000e-02	5.5090000000000e-01
	1375.	6.654300000000001e-02	5.48332000000000e-01
	1376	6 70999000000000000000000000000000000000	5 90132000000000e-01
	1077	6.76614000000000-02	
	13//.	6.76614000000000e-02	6.14064000000000000000000000000000000000
	1378.	6.822760000000000e-02	6.32250000000000e-01
	1379.	6.87985000000000e-02	6.6641300000000e-01
	1380	6 937420000000000e-02	6 917940000000000-01
	1201	6 00540000000000000000000000000000000000	
	1381.	0.993480000000000000000	0.35354000000000000000000000000000000000
	1302.	/.0540∠0000000000e-02	0.4042200000000000000000000000000000000
	1383.	7.11305000000000e-02	4.57813000000000e-01
	1384.	7.17257000000000e-02	5.71200000000000e-01
	1385	7 2325900000000000000000000000000000000000	5 33327000000000e-01
	1200	7.20211000000000000000000000000000000000	
	1300.	7.293110000000000e-02	4.05190000000000000000
	1387.	7.354140000000001e-02	3.97236000000000e=01
	1388.	7.415680000000000e-02	2.53805000000000e-01
	1389	7 477739999999999999	3 872710000000000=-01
	1200	7 540220000000000000000000000000000000000	
	±330.	/.3403∠00000000000e=02	2.0420000000000000000000000000000000000
	1391.	7.603409999999999e-02	5.70164000000000e-01
	1392.	7.66704000000000e-02	5.95322000000000e-01
	1393	7 731200000000001e-02	5 202610000000000-01
	1304	7.7050000000000000000000000000000000000	
	1394.	7.79589000000000e-02	5.242470000000000000000000000000000000000
	1395.	7.86113000000000e-02	3.2590400000000000000000000000000000000000
	1396.	7.921940000000000e-02	4.32407000000000e-01
	1397.	7.954970000000000e-02	8.66344000000000e=02
	1308	7 993250000000000000000	6.2648600000000000000000000000000000000000
	1390.	7.99922000000000000000000000000000000000	
	1399.	8.060140000000000e-02	6.18631000000000e-01
	1400.	8.127590000000000e-02	6.50751000000000e-01
	1401.	8.195600000000000e-02	5.70982000000000e-01
	1402	9 22097000000001- 02	1 52401000000000 01
	1402.	0.2390700000000000000000000000000000000000	
	1403.	8.2/431000000000e-02	3.03593000000000000000000000000000000000
	1404.	8.333340000000000e-02	2.89940000000000e-01
	1405.	8.40307000000000e-02	2.44380000000000e-01
	1406	8 473390000000000e-02	3 237290000000000=-01
	1400.	0.47555000000000000000000000000000000000	
	1407.	8.54430000000001e-02	3.9269700000000000000000000000000000000000
	1408.	8.615800000000000e-02	4.2398900000000000000000000000000000000000
	1409.	8.68789000000000e-02	4.29137000000000e-01
	1410	8 760600000000000e-02	4 85997000000000e-01
	1411	8 832010000000000 02	
	1410	0.0030000000000000000000000000000000000	
	1412.	8.90/83000000000e-02	5.2530600000001e-01
	1413.	8.98237000000001e-02	4.74314000000000e-01
	1414.	9.057540000000000e-02	4.86847000000000e-01
	1415	9 1333300000000010-02	5 474150000000000-01
	1416	9.200760000000000000000000000000000000000	5 543700000000000 01
	1410.	9.20976000000000e-02	5.5437000000000000000000000000000000000000
	141/.	9.286830000000000e-02	5.2610400000000000000000
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	1419.	9.442910000000000e-02	4.98008000000000e-01
	1420	9 521930000000010-02	4 79364000000000e-01
	1401	0.6016000000000000000000000000000000000	
	1421.	2.0010033333333336-02	4.05/05000000000000000000000000000000000
	1422.	9.68196000000001e-02	4.64/66000000000e-01
	1423.	9.76298000000000e-02	4.61124000000000e-01
	1424.	9.844670000000000e-02	4.32114000000000e-01
	1425	9 9270600000000000000000000000000000000000	4 6921300000000e-01
	1426	1 0010100000000000000000000000000000000	5 018780000000000000000
	1407	1.001010000000000000000	5.1675750000000000 01
	142/.	T.0033300000000000e-01	3.100/3000000000000000000000000000000000
	1428.	1.017840000000000e-01	5.36013000000000e-01
	1429.	1.026350000000000e-01	5.17499000000000e-01
	1430	1 034940000000000000000000000000000000000	5 31129000000000e-01
	1421	1 042600000000000000000000000000000000000	
	1431.	1.04300000000000000e-01	5.725470000000000-01
	1432.	1.052340000000000e-01	5.83694000000001e-01
	1433.	1.061140000000000e-01	5.79145000000000e-01
	1434.	1.070020000000000e-01	5.87215000000000e-01
	1435	1 078980000000000000-01	5 74586000000000000000000000000000000000000
	1426	1 0000000000000000000000000000000000000	5.633040000000000000000000000000000000000
	1430.	1.0880000000000000000000000000000000000	3.09394000000000000000000000
	1437.	1.097110000000000e-01	5.86429000000000e-01
	1438.	1.106290000000000e-01	5.90212000000000e-01
	1439.	1.1155500000000000000000000000000000000	5.82446000000000c=-01
	1440	1 12400000000000000000000000000000000000	
	1440.	1.1240000000000000000000	5.5550700000000000000000000000000000000
	1441.	1.13430000000000e-01	6.405930000000000e-01
	1442.	1.14379000000000e-01	6.1601300000000e-01
	1443.	1.153360000000000e-01	5.68628000000000e-01
	1444.	1.16301000000000000000000000000000000000	6.29743000000001e-01
	1445	1 1727400000000000000000000000000000000000	4.3790700000000000000000
	1443.	1.1/2/40000000000000	4.375070000000000000000000000000000000000
	1446.	1.182560000000000e-01	6.1800400000000e-01
	1447.	1.192450000000000e-01	6.60588000000000e-01
	1448.	1.202430000000000000000000000000000000000	6.70036000000000e-01
	1449	1 2124900000000000000000000000000000000000	6 93246000000000e-01
	1450	1.222490000000000000000000000000000000000	
	1400.	1.222640000000000e-01	6.303340000000000-01
	1451.	1.23287000000000e-01	6.55077000000000e-01
	1452.	1.243190000000000e-01	5.87973000000000e-01
- 1			



1453.	1.253590000000000e-01	6.59757000000000e-01
1454	1 2640800000000000-01	7 0674100000000000000000000000000000000000
1455	1.2746600000000000000000000000000000000000	5.0001000000000000000000000000000000000
1455.	1.2/46600000000000e-01	5.8921000000000000000000000000000000000000
1456.	1.285330000000000e-01	5.9734000000000e-01
1457.	1.296080000000000e-01	5.1059600000001e-01
1458	1 30693000000000000	5 31490000000000=01
1450.	1.3003300000000000000000000000000000000	
1459.	1.31/860000000000e-01	/.1652400000001e-01
1460.	1.328890000000000e-01	8.11977000000000e-01
1461.	1.340010000000000e-01	8.51754000000000e-01
1462	1 3512300000000000000000	8 397930000000000000000000000000000000000
1402.	1.3512300000000000000000000000000000000000	
1463.	1.362530000000000e-01	8.01021000000000000000000000000000000000
1464.	1.373940000000000e-01	7.2606900000000e-01
1465.	1.385430000000000e-01	5.98885000000000e-01
1466	1 3970300000000000000000	3 80014000000000-01
1400.	1.397030000000000000000000000000000000000	5.50014000000000000000000000000000000000
1467.	1.408/20000000000e-01	2.84253000000000e-01
1468.	1.420500000000000e-01	3.24343000000000e-01
1469.	1.432390000000000e-01	3.81351000000000e-01
1470	1 444380000000000000000000000000000000000	4 312850000000000=01
1471	1.44450000000000000000000000000000000000	
14/1.	1.4564600000000000e-01	4.6955300000000000000000000000000000000000
1472.	1.468650000000000e-01	4.71807000000000e-01
1473.	1.480940000000000e-01	5.05681000000001e-01
1474	1 493340000000000000	4 973990000000000=01
1475	1.50503000000000000000000000000000000000	
14/3.	1.303830000000000000000000000	4.6486700000000000000000000000000000000000
1476.	1.518430000000000e-01	5.7175200000000e-01
1477.	1.531140000000000e-01	5.3621500000000e-01
1478	1 543950000000000e-01	5 90210000000000=01
1470	1 5569700000000000000000000000000000000000	
14/9.	1.3308/00000000000000000	5.998100000000000000000000000000000000000
1480.	1.569900000000000e-01	6.10/6400000000e-01
1481.	1.583040000000000e-01	6.33007000000000e-01
1482.	1.5962900000000000e-01	6.27564000000000e-01
1483	1 609640000000000000000000000000000000000	6.55061000000000e=01
1404	1.0000000000000000000000000000000000000	
1484.	1.623110000000000e-01	0.02881000000000000000000000000000000000
1485.	1.636690000000000e-01	6.68885000000000e-01
1486.	1.6503900000000000e-01	6.74264000000000e-01
1487	1 664200000000000000000000000000000000000	6 5568400000000e-01
1400	1.6701200000000000000000	
1488.	1.6/8130000000000e-01	0.2191400000000000000000000000000000000000
1489.	1.692170000000000e-01	4.29683000000000e-01
1490.	1.706330000000000e-01	4.72635000000000e-01
1491	1 72061000000000000	5 6055600000001e-01
1400	1.72001000000000000000000000000000000000	
1492.	1./35010000000000e-01	5.7323800000000000000000000000000000000000
1493.	1.749530000000000e-01	6.6781900000001e-01
1494.	1.764170000000000e-01	7.29907000000000e-01
1495	1 778930000000000e-01	7 58124000000000=01
1400	1.70303000000000000000000000000000000000	7 35503000000000 01
1496.	1./93820000000000e-01	7.3559200000000000000000000000000000000000
1497.	1.808830000000000e-01	7.11221000000000e-01
1498.	1.823960000000000e-01	7.33726000000000e-01
1499	1 839230000000000e-01	6.859070000000000-01
1500	1.95462000000000000000000000000000000000000	5.00980000000000000000000000000000000000
1500.	1.854620000000000e-01	5.90889000000000000000000000000000000000
1501.	1.870140000000000e-01	4.40778000000000000000000000000000000000
1502.	1.885790000000000e-01	3.38542000000000e-01
1503.	1.901570000000000e-01	3.69074000000000e-01
1504	1 0174900000000000 01	4 22148000000000 01
1504.	1.91/480000000000000000	4.2214800000000000000000000000000000000000
1505.	1.933530000000000e-01	4.5081200000000000000000000000000000000000
1506.	1.949710000000000e-01	4.83527000000000e-01
1507.	1.966020000000000e-01	5.05593000000000e-01
1508	1 9824700000000000-01	5.06984000000000-01
1500.	1.0000000000000000000000000000000000000	5.051340000000000-01
1509.	1.9990600000000000000000	3.4613400000000000000000000000000000000000
1510.	2.015790000000000e-01	5.54424000000000000000000000000000000000
1511.	2.032660000000000e-01	5.78064000000000e-01
1512	2 049670000000000e-01	5 91138000000001e-01
1513	2 0668200000000000-01	6 740700000000000e-01
1515.	2.0000200000000000000000000000000000000	
1314.	2.084120000000000e-01	2.8/6/00000000000000000000000000000000000
1515.	2.101560000000000e-01	5.48289000000000e-01
1516.	2.119140000000000e-01	6.11983000000001e-01
1517.	2.136880000000000e-01	6.335600000000000e-01
1519	2 15476000000000000000000000000000000000000	6.663500000000000000000
1510	2.1347000000000000000000000000000000000000	
1218.	2.1/2/9000000000e-01	6./13/900000000e-01
1520.	2.190970000000000e-01	7.2848600000000e-01
1521.	2.209310000000000e-01	4.576650000000000e-01
1522.	2.227790000000000000	5.00119000000000e-01
1523	2 24644000000000000000000000000000000000	5 45363000000000e=01
1524	2.2404400000000000000000000000000000000	
1505	2.20324000000000000000	5.5555555000000000000000000000000000000
1525.	2.28419000000000e-01	6.1008100000000e-01
1526.	2.30331000000000e-01	5.82117000000000e-01
1527.	2.322580000000000e-01	6.01622000000000e-01
1528	2 3420200000000000 01	5 92132000000000000000000
1520.	2.3420200000000000000000	5.95152000000000000000
1529.	∠.36162000000000e-01	2.9202100000000e-01
1530.	2.381380000000000e-01	6.25763000000000e-01
1531.	2.401300000000000e-01	6.29145000000000e-01
1532.	2.42140000000000000000	6.08076000000000e-01
1533	2 441660000000000000000000000000000000000	6 02971000000000000000
1533.	2.44100000000000000000000000000000000000	
1534.	∠.462090000000000e-01	5.300480000000000000000000000000000000000
1535.	2.482700000000000e-01	5.76492000000000e-01
1536.	2.5034700000000000000000000000000000000000	5.64842000000000e-01
1537	2 52442000000000000000000000000000000000	6.273500000000000000000
1001	2.5244200000000000000000	0.27550000000000000000000000000000000000
1538.	2.545550000000000e-01	6.5368/000000000e-01
1539.	2.56685000000000e-01	7.04609000000000e-01
1540.	2.5883300000000000e-01	6.12720000000000e-01
1541	2 60999000000000000000000000000000000000	6 69364000000000e=01
1540	2.0000000000000000000000000000000000000	
1542.	∠.b318300000000000e-01	0.347320000000006-01
1543.	2.65385000000000e-01	6.82689000000000e-01
1544.	2.6760600000000000e-01	6.62895000000000e-01
1545	2 69845000000000000000000000000000000000000	6 40671000000000e=01
1540	2.0000000000000000000000000000000000000	
1346.	2.121030000000000e-01	0.00252000000000000000
1547.	2.74380000000000e-01	6.18896000000000e-01
1548.	2.766760000000000e-01	4.40027000000000e-01
1549	2 7899200000000000000000000000000000000000	4 0691800000000e-01
1010.	2.70552000000000000000000000000000000000	1.00010000000000 01



1550.	2.813260000000000e-01	4.97965000000000e-01
1551	2 8368100000000000-01	5 3155800000000000000000000000000000000000
1331.	2.830810000000000000000000000000000000000	5.51559000000000000000000000000000000000
1552.	2.860540000000000e-01	5.8398900000000e-01
1553.	2.8844800000000000e-01	6.10410000000000e-01
1664	2 009620000000000 01	6 26475000000000 01
1001.	2.0000000000000000000000000000000000000	
1555.	2.932960000000000e-01	6.2640000000000e-01
1556.	2.957500000000000e-01	7.09485000000000e-01
1557	2 97091000000000e-01	6 510940000000000-02
1557.	2.970910000000000000000000000000000000000	
1558.	2.978500000000000e-01	3.70843000000000e-01
1559.	2.989840000000000e-01	2.8547000000000e-01
1560.	3.007210000000000e-01	7.4193900000000e=01
1661	2 022270000000000 01	7.652200000000000000000000000000000000000
1301.	3.0323/000000000e-01	1.8592900000000000000000000000000000000000
1562.	3.057750000000000e-01	7.30176000000001e-01
1563.	3.083340000000000e-01	7.285350000000000e-01
1564	3 10914000000000000000000	6.84237000000000000000000000000000000000000
1004.	3.109140000000000000000000000000000000000	0.84237000000000000000000000000000000000000
1565.	3.135160000000000e-01	6.24460000000000000000000000000000000000
1566.	3.161390000000000e-01	5.63253000000000e-01
1567	3 18785000000000000-01	3 8418900000000000000000000000000000000000
15007.	3 214520000000000 01	
1308.	3.21452000000000e-01	3.9482200000000000000000000000000000000000
1569.	3.241420000000000e-01	4.3552200000000e-01
1570.	3.268550000000000e-01	4.88596000000000e-01
1571	3 295900000000000000000000000000000000000	5 43443000000000000000000000000000000000
13/1.	3.29390000000000000000000000000000000000	5.43443000000000000000000000000000000000
1572.	3.323480000000000e-01	5.12989000000000e-01
1573.	3.351290000000000e-01	5.58743000000000e-01
1574	3 37933000000000000-01	6 155840000000000e-01
1574.	3.37555000000000000000000000000000000000	
15/5.	3.40/61000000000e-01	6.2805800000000e-01
1576.	3.436130000000000e-01	7.0446400000000e-01
1577	3 46488000000000000-01	7 0425300000000000000000000000000000000000
1578	3 4938800000000000000000000000000000000000	5.537620000000000-01
10/0.	5.49500000000000000000000000000000000000	3.3575250000000000000000000000000000000000
12/9.	3.523110000000000e-01	4.3866/00000000000000000000000000000000000
1580.	3.55260000000000e-01	3.84225000000000e-01
1581.	3.5823300000000000=-01	3.91519000000000e-01
1500	3.612200000000000000000000000000000000000	
1302.	3.0123000000000000e-01	3./40/90000000000e-01
1583.	3.64253000000000e-01	3.58367000000000e-01
1584.	3.673010000000000e-01	4.10708000000000e-01
1505	2 70275000000000 01	4.750200000000000000000000000000000000000
1000.	3.7037300000000000e=01	4.7504200000000000000000000000000000000000
1586.	3.734740000000000e-01	5.2731000000000e-01
1587.	3.766000000000000e-01	4.94112000000000e-01
1588	3 7975100000000000-01	4 40580000000000000000000000000000000000
1300.	3.757510000000000000000000000000000000000	
1589.	3.829290000000000e-01	3./36/6000000000e-01
1590.	3.861330000000000e-01	3.1766000000000e-01
1591	3 8936400000000000-01	3 413430000000000=01
1502	3.026220000000000.01	
1392.	3.926230000000000e-01	3.8230700000000000000000000000000000000000
1593.	3.959080000000000e-01	4.0411900000000e-01
1594.	3.992210000000000e-01	3.87504000000000e-01
1505	4 025620000000000 01	2 46884000000000 01
1393.	4.02302000000000000000000	3.40084000000000000000000000000000000000
1596.	4.059310000000000e-01	3.5213000000000000000000000000000000000000
1597.	4.093280000000000e-01	3.38948000000000e-01
1598	4 127530000000000e-01	3 526410000000000=01
1590.	4.127000000000000000000000000000000000000	
1399.	4.1620700000000000000000	3.3694400000000000000000000000000000000000
1600.	4.196900000000000e-01	3.1664000000000e-01
1601	4 232020000000000e-01	3 7644500000000000000000000000000000000000
1602	4 2674200000000000000000000000000000000000	
1602.	4.2674300000000000000000	5.4656900000000000000000000000000000000000
1603.	4.303140000000000e-01	3.70776000000000e-01
1604.	4.339150000000000e-01	3.74850000000000e-01
1605	4 37546000000000000000000000000000000000000	4 009370000000000000000000000000000000000
1000.	4.57540000000000000000000000000000000000	
1000.	4.41208000000000000000000	3.33911000000006-01
1607.	4.449000000000000e-01	3.9813600000000e-01
1608.	4.486230000000000e-01	4.02626000000000e-01
1600	4 522770000000000000000000000000000000000	4 49982000000000 01
1609.	4.523770000000000000000000000000000	4.4998300000000000000000000000000000000000
1610.	4.561620000000000e-01	4.7240500000000000000000000000000000000000
1611.	4.599800000000000e-01	5.2227400000000e-01
1612.	4.6382900000000000e-01	5.61633000000001e-01
· 1613	4 677100000000000000000000000000000000000	6.04687000000000000000
1013.	4.0//10000000000000000	0.0408/000000000000000000000000000000000
1614.	4./1624000000000e-01	4.33211000000000e-01
1615.	4.75571000000000e-01	5.03899000000000e-01
1616	4 795500000000000000000000000000000000000	5 24305000000000e-01
	4 9256200000000000000000000000000000000000	5 7579800000000000 01
101/.	4.03303000000000000000	5.7526000000000000000000000000000000000000
1618.	4.87610000000000e-01	5.59617000000000e-01
1619.	4.916900000000000e-01	5.50204000000000e-01
1620.	4.9580500000000000-01	6.84633000000001e-01
1.001	4.0005400000000000000000	
1021.	4.99934000000000000e-01	0.201010000000000000000
1622.	5.04138000000000e-01	5.55510000000000e-01
1623.	5.083560000000000e-01	6.26000000000000e-01
1624	5 12610000000000 01	5 6388000000000000000
1027.	5.12010000000000000000000	5.005000000000000000000000000000000000
1625.	5.16900000000000e-01	6./308/00000000e-01
1626.	5.21225000000001e-01	6.29769000000000e-01
1627.	5.255870000000000e-01	4.52684000000000e-01
1620	E 2000E00000000000000000000000000000000	4.21425000000000000000000
1020.	J.29983000000000000000	4.5142500000000000000000000000000000000000
1629.	5.344200000000000e-01	5.23035000000000e-01
1630.	5.38892000000000e-01	5.12142000000000e-01
1631.	5.4340200000000101	5.37387000000000e-01
1 6 3 9	5.1340200000000000000000000000000000000000	
1632.	5.4/9490000000000e-01	2./313200000000000000000000000000000000000
1633.	5.52534000000000e-01	6.19684000000000e-01
1634.	5.571580000000000e-01	5.84328000000000e-01
1625	5 6192100000000000 01	5 117860000000000 01
	J.010∠1000000000000000000000000000000000	5.11/800000000000000000000000000000000000
1636.	5.66522000000000e-01	5.35367000000000e-01
1637.	5.71263000000000e-01	5.25263000000000e-01
1638	5 7604300000000000000000000000000000000000	5 102930000000000000000
1030.	5.700430000000000000000	5.1023500000000000000000000000000000000000
1639.	5.808630000000000e-01	5.15/05000000000e-01
1640.	5.85724000000000e-01	5.86388000000000e-01
1641	5 906260000000000000000000000000000000000	5 82733000000000e-01
1 6 4 0	5.5002000000000000000000	
1042.	5.955680000000000e-01	2.801/6000000000e-01
1643.	6.00552000000000e-01	5.87127000000000e-01
1644	6 05577000000000000000000000000000000000	5 55081000000001e-01
1 0 1 1 1	C.10C4E00000000000000000	
. C+01	0.1004300000000000e-01	2.0040200000000000=0T
1646.	6.15755000000001e-01	4.55091000000000e-01



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	1647.	6.209080000000000e-01	5.33924000000000e-01
	1648.	6.261040000000000e-01	5.4510500000000e-01
	1649.	6.313430000000000e-01	5.35572000000001e-01
	1650.	6.366260000000000e-01	4.77471000000000e-01
	1651.	6.419530000000000e-01	5.55345000000000e-01
	1652	6 473250000000000000	4 664130000000000-01
	1652.	6.5774200000000000000000000000000000000000	
	1655.	6.527420000000000e-01	5.3414900000000000000000000000000000000000
	1654.	6.582040000000000e-01	4.58455000000000e=01
	1655.	6.637120000000000e-01	4.7401200000000e-01
	1656.	6.692660000000000e-01	4.20796000000000e-01
	1657.	6.748670000000000e-01	4.060600000000000e-01
	1658	6 805140000000000e-01	4 44910000000000000000000000000000000000
	1650	6 96200000000000000000000000000000000000	4.45524000000000000000000000000000000000
	1035.	0.8620900000000000000000000000000000000000	4.4652400000000000000000000000000000000000
	1660.	6.919510000000000e-01	4.80514000000000e=01
	1661.	6.977420000000000e-01	4.29583000000000e-01
	1662.	7.03581000000000e-01	5.0292200000000e-01
	1663.	7.094680000000000e-01	5.13278000000000e-01
	1664.	7.154050000000000e-01	4.00837000000000e-01
	1665	7 213920000000000e-01	3 012920000000000000000000000000000000000
	1666	7.27420000000000000000000000000000000000	2,27255000000000000000000000000000000000
	1000.	7.2742900000000000000000000000000000000000	3.3726300000000000000000000000000000000000
	1667.	7.335160000000000e-01	3.96216000000000e=01
	1668.	7.396540000000000e-01	4.04089000000000e-01
	1669.	7.45843000000000e-01	3.6012800000000e-01
	1670.	7.520850000000000e-01	3.67037000000000e-01
	1671	7 58378000000000e-01	3 4359400000000000000000000000000000000000
	1672	7 64725000000000000000000000000000000000000	3 499480000000000000000000000000000000000
	1672	7.7112400000000000000000000000000000000000	
	10/3.	7.7112400000000000000000000000000000000000	3.49297000000000000000000
	1674.	7.775770000000000e-01	3.416050000000000e=01
	1675.	7.84084000000000e-01	3.51401000000000e-01
	1676.	7.90645000000000e-01	3.17714000000000e-01
	1677.	7.97261000000000e-01	3.60656000000000e-01
	1678.	8.0393300000000000=01	3.65318000000000e-01
	1679	8 10660000000000000000000000000000000000	3 539260000000000a-01
	1,000	0.1744400000000000000	
	1000.	8.1/444000000000e-01	2.30//0000000000000000000000000000000000
	1681.	8.24284000000000e-01	2.895540000000000=01
	1682.	8.31182000000000e-01	2.9810600000000e-01
	1683.	8.38138000000001e-01	3.01549000000000e-01
	1684.	8.451510000000000e-01	2.6724300000000000000=01
	1685	8 522240000000000000000000000000000000000	2 5299100000000000000000000000000000000000
	1696	8 50255000000000000000000000000000000000	2, 297510000000000 01
	1000.	8.5555500000000000000000000000000000000	
	1687.	8.6654600000000000e-01	2.361010000000000000000000000000000000000
	1688.	8.73798000000000e-01	2.403070000000000000000000000000000000000
	1689.	8.811100000000000e-01	2.45517000000000e-01
	1690.	8.88483000000000e-01	2.1951900000000e-01
	1691.	8.959180000000000e-01	2.43957000000000e-01
	1692	9 03415000000000000=01	2 153320000000000-01
	1602	9.1097500000000000000000000000000000000000	2.16947000000000000000000000000000000000000
	1093.	9.1097300000000000000000000000000000000000	2.1004/0000000000000000000000000000000000
	1694.	9.185980000000000e-01	2.12151000000000000000000000000000000000
	1695.	9.262850000000000e-01	2.15628000000000000000000000000000000000000
	1696.	9.34037000000000e-01	2.1475600000000e-01
	1697.	9.41853000000001e-01	2.12242000000000e-01
	1698.	9.497340000000000e-01	1.73705000000000e-01
	1699	9 57682000000000000=01	1 87965000000000000000000000000000000000000
	1700	9.65696000000000000000000000000000000000	1.602300000000000000000000000000000000000
	1700.	9.0309000000000000000000000000000000000	
	1701.	9.737770000000000e-01	1.5425900000000000000000000000000000000000
	1702.	9.819260000000000e-01	1.63164000000000e-01
	1703.	9.901430000000000e-01	1.4033500000000e-01
	1704.	9.984280000000000e-01	1.54242000000000e-01
	1705.	1.006780000000000e+00	1.51032000000000e-01
	1706.	1.015210000000000e+00	1.644210000000000000=01
	1707	1 023700000000000000000000000000000000000	1 7882600000000000000000000000000000000000
	1700	1.02070000000000000000000000000000000000	
	1700.	1.04001000000000000000000	1.55252000000000000000000000000000000000
	1/09.	1.04091000000000000000000000000000000000	1. 5000000000000000000000000000000000000
	1/10.	1.049620000000000e+00	1.6198000000000000000000000000000000000000
	1711.	1.058400000000000e+00	1.65950000000000e-01
	1712.	1.067260000000000e+00	1.67922000000000e-01
	1713.	1.076190000000000e+00	1.90834000000000e-01
	1714.	1.085200000000000000000	1.97802000000000e-01
	1715.	1.0942800000000000e+00	2.02300000000000e-01
	1716.	1.1034300000000000+00	2.05862000000000e-01
	1717	1 1126700000000000000000000000000000000000	2 036780000000000000000000
	1719	1 12108000000000000000000000000000000000	1 8385800000000000-01
	1710	1 12127000000000000000000	1.05053000000000000000000000000000000000
	1700	1.1313/000000000000000000000000000000000	2.005/0000000000000000000000000000000000
	1/20.	1.14084000000000e+00	2.03215000000000e-01
	1721.	1.150380000000000e+00	1.84462000000000e-01
	1722.	1.16001000000000e+00	2.04090000000000e-01
	1723.	1.169720000000000e+00	2.1163700000000e-01
	1724.	1.1795000000000000000000000000000000000000	2.0879200000000000-01
	1725	1 18937000000000000000000000000000000000000	1 93100000000000000000000
	1726	1 1003300000000000000000000000000000000	2.13353000000000001
	1707	1.19933000000000000000000000000000000000	2.15555000000000000000000000000000000000
	1/2/.	1.2093600000000000e+00	1.340/200000000000000000000000000000000000
	1728.	1.219480000000000e+00	2.19009000000000e-01
	1729.	1.229690000000000e+00	1.60915000000000e-01
	1730.	1.239980000000000e+00	1.71937000000000e-01
	1731.	1.250350000000000000000000000000000000000	1.8629400000000e-01
	1732	1 260820000000000000000000000000000000000	1 704270000000000000000000
	1722	1.271270000000000000000000	1.709200000000000000000000000000000000000
	1/33.	1.2/13/000000000e+00	1./092800000000000000000000000000000000000
	1/34.	1.28201000000000e+00	1.4/5260000000000000000
	1735.	1.292740000000000e+00	1.481550000000000e-01
	1736.	1.303550000000000e+00	1.40954000000000e-01
	1737.	1.314460000000000e+00	1.4416400000000e-01
	1738.	1.32546000000000000+00	1.44176000000000e-01
	1739	1 33655000000000000000	1 56322000000000=-01
	1740	1 347740000000000000000000000000000000000	1.650900000000000000000000000000000000000
	1741	1.35000000000000000000000000000000000000	1.30032000000000000000000000000000000000
	1/41.	1.35902000000000e+00	1./293/00000000000000000000000000000000000
	1742.	1.370390000000000e+00	1.84759000000000000000000000000000000000000
	1743.	1.38186000000000e+00	1.52796000000000e-01
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4.5.4.		
1744.	1.393420000000000e+00	1.62497000000000e-01
1745.	1.405080000000000e+00	1.69145000000000e-01
1746.	1.416840000000000e+00	1.5587100000000e-01
1747.	1.428690000000000e+00	1.6565100000000e-01
1748.	1.440650000000000e+00	1.60487000000000e-01
1749	1 4527000000000000000000	1 578050000000000000000000000000000000000
1750	1.4527666666666666666	
1/50.	1.464860000000000000000000000000000000000	1.4292800000000000000000000000000000000000
1751.	1.477120000000000e+00	1.45008000000000e-01
1752.	1.489480000000000e+00	1.48769000000000e-01
1753.	1.501940000000000e+00	1.5950100000000e-01
1754.	1.514510000000000e+00	1.47653000000000e-01
1755	1 52719000000000000000	3811600000000000000000000000000000000000
1756	1.5292700000000000000000000000000000000000	
1/30.	1.339970000000000000000000000000000000000	1.4323800000000000000000
1/5/.	1.552850000000000e+00	1.323340000000000000000000000000000000000
1758.	1.565850000000000e+00	1.37449000000000e-01
1759.	1.578950000000000e+00	1.55542000000000e-01
1760.	1.592160000000000e+00	1.3742000000000e-01
1761.	1.605490000000000e+00	1.4024600000000e-01
1762	1 618920000000000e+00	1 2986200000000000000000000000000000000000
1762	1.6224700000000000000000000000000000000000	
1/03.	1.0324700000000000000000000000000000000000	1.44210000000000000000000000000000000000
1/64.	1.646130000000000e+00	1.3587800000000000000000000000000000000000
1765.	1.659910000000000e+00	1.3200600000000e=01
1766.	1.673800000000000e+00	1.3181300000000e-01
1767.	1.687800000000000e+00	1.42375000000000e-01
1768	1 701930000000000e+00	1 3212700000000000000000000000000000000000
1769	1 716170000000000000000	1.372730000000000000000000000000000000000
1770	1.7101/00000000000000000	
1//0.	1./30530000000000e+00	1.33/1400000000000000000000000000000000000
1771.	1.745010000000000e+00	1.17813000000000e-01
1772.	1.759610000000000e+00	1.177050000000000e-01
1773.	1.774340000000000e+00	1.31638000000000e-01
1774.	1.789190000000000e+00	1.34717000000000e-01
1775.	1.804160000000000000000	1.243800000000000e-01
1776	1 81926000000000000000000000000000000000000	1 207420000000000=-01
1777	1.02440000000000000000000000000000000000	
1///.	1.834480000000000e+00	1.04/10000000000000000000000000000000000
1778.	1.84983000000000e+00	1.12188000000000e=01
1779.	1.86531000000000e+00	1.1187600000000e-01
1780.	1.880920000000000e+00	1.09893000000000e-01
1781.	1.896660000000000e+00	1.13643000000000e=01
1782	1 91253000000000000000	9 75491000000000000000000000000000000000000
1702	1.022530000000000000000000000000000000000	
1704	1.92853000000000000000000	
1/84.	1.9446/000000000e+00	1.02621000000000000000000000000000000000
1785.	1.960950000000000e+00	1.05908000000000e-01
1786.	1.977360000000000e+00	1.0910000000000e-01
1787.	1.993900000000000e+00	1.1024700000000e-01
1788.	2.010590000000000e+00	1.09794000000000000-01
1789	2 0274100000000000000	1 09586000000000-01
1700	2.02/4100000000000000000000000000000000000	
1/90.	2.044380000000000e+00	1.00861000000000000000000000000000000000
1791.	2.061490000000000e+00	1.01845000000000e-01
1792.	2.07874000000000e+00	1.03098000000000e-01
1793.	2.09613000000000e+00	1.12858000000000e-01
1794.	2.113670000000000e+00	1.01651000000000e=01
1795	2 1313600000000000000	1 08578000000000-01
1700	2.13130000000000000000000000000000000000	
1/96.	2.149200000000000e+00	1.0495800000000000000000000000000000000000
1797.	2.167180000000000e+00	1.06234000000000e-01
1798.	2.185320000000000e+00	1.04223000000000e=01
1799.	2.203600000000000e+00	1.0668400000000e-01
1800.	2.22204000000000e+00	1.1194600000000e-01
1801.	2.240640000000000e+00	1.12979000000000e-01
1802	2 25939000000000000+00	1 1532300000000000000000000000000000000000
1002.	2.23939000000000000000000000000000000000	
1803.	2.2/8290000000000e+00	1.0/48200000000000000000000000000000000000
1804.	2.297360000000000e+00	1.09803000000000e-01
1805.	2.31658000000000e+00	1.093200000000000=-01
1806.	2.335970000000000e+00	1.06278000000000e-01
1807.	2.35552000000000e+00	1.11697000000000e-01
1808.	2.375230000000000e+00	1.1416600000000e-01
1809.	2.395110000000000+00	1.0061700000000000=-01
1810	2 415150000000000000000000000000000000000	9.9115100000000000000
1011	2.4252600000000000000000000000000000000000	
1011	2.433360000000000000000000	5.20404000000000000000000000000000000000
1812.	∠.455/4000000000e+00	9.7955200000000000000000000000000000000000
1813.	2.47629000000000e+00	9.598530000000000=02
1814.	2.49701000000000e+00	8.97231000000000e=02
1815.	2.51790000000000e+00	9.1457200000000e-02
1816.	2.538970000000000e+00	8.62159000000000e-02
1817.	2.560220000000000e+00	8.9831600000000e-02
1818	2 581650000000000000000	9.3786700000000000000000000000000000000000
1910	2 6032500000000000000000000000000000000000	
1000	2.00323000000000000000000	2.16020000000000000000000000000000000000
1820.	2.625030000000000e+00	8.76423000000001e-02
1821.	2.647000000000000e+00	8.74975000000001e-02
1822.	2.66915000000000e+00	8.29805000000000e-02
1823.	2.691490000000000e+00	8.31231999999999999=02
1824.	2.714010000000000e+00	8.225739999999999e-02
1825	2 7367200000000000000000	8 03737000000001e-02
1926	2 75962000000000000000000000000000000000000	7.536510000000000-02
1020.	2./5962000000000e+00	/.3501U0U0U0U0U0U0U0U0-U2
1827.	2./82/20000000000e+00	7.32247000000000e=02
1828.	2.80600000000000e+00	7.71862000000000e-02
1829.	2.82948000000000e+00	7.49448000000001e-02
1830.	2.85316000000000e+00	6.9700500000000e-02
1831.	2.877040000000000e+00	7.23903000000001e-02
1832	2 90111000000000000000000	7 10360000000000=-02
1932	2 9253900000000000000000000000000000000000	7 0///83080808080000000
1000	2.9233900000000000000000	·
1834.	∠.9498/000000000e+00	6.62263000000000e=02
1835.	2.97455000000000e+00	6.7447999999999999e-02
1836.	2.999440000000000e+00	6.73392000000000e=02
1837.	3.024540000000000e+00	6.39907000000000e-02
1838.	3.049850000000000000000	6.541360000000000=-02
1839	3 0753800000000000000000000000000000000000	6_33349000000000e=02
1037.	3.0/338000000000000000000000000000000000	
1040.	2.IUIII000000000000000000000000000000000	0.4200000000000000000000000000000000000



1841.	3.127060000000000e+00	6.02851000000000e=02
1842.	3.153230000000000e+00	5.9140300000000e-02
1843.	3.179620000000000e+00	5.8563600000000e=02
1844.	3.206220000000000e+00	5.61259000000000e-02
1845.	3.23305000000000e+00	5.44978000000000e-02
1846.	3.260110000000000e+00	5.1320300000000e-02
1847	3 287390000000000e+00	4 909350000000000000000000000000000000000
1848	3 3149000000000000000000000	4 874400000000000000000
1849	3 342640000000000000000000	4 799790000000000000
1045.	3.3726100000000000000000	
1050.	3.3700100000000000000000	4.6282700000000000000000000000000000000000
1051.	3.33882000000000000000000	4. 62734000000000000000000000000000000000000
1052.	3.427260000000000000000000000000	4.8093100000000000000000000000000000000000
1853.	3.45594000000000000000000	4.4831300000000000000000000000000000000000
1854.	3.484860000000000e+00	4.25428000000000e-02
1855.	3.514020000000000e+00	4.38670000000000e-02
1856.	3.543430000000000e+00	4.19776000000000e-02
1857.	3.57308000000000e+00	4.15877000000000e=02
1858.	3.60298000000000e+00	4.01903000000000e=02
1859.	3.63313000000000e+00	3.98824000000000e-02
1860.	3.66353000000000e+00	3.8610900000000e-02
1861.	3.694190000000000e+00	3.84014000000000e-02
1862.	3.72510000000000e+00	3.77474000000000e-02
1863.	3.756270000000000e+00	3.47288000000000e-02
1864.	3.78771000000000e+00	3-582820000000000e=02
1865	3 819400000000000e+00	3 7120900000000000000000000000000000000000
1866	3 8513600000000000000000	3 64157000000000000000
1867	3 883580000000000000000	3. 628470000000000000000
1007.	3.0000000000000000000000000000000000000	
1969	3 9488600000000000000000000000000000000000	3.48716000000000000000000000000000000000000
1070	2 0010100000000000000000000000000000000	3.50900000000000000000000000000000000000
1071	3.981910000000000000000000000000000000000	3.3355500000000000000000000000000000000
1072	4.01523000000000000e+00	3.49375000000000000000000000000000000000000
1072	4.048830000000000e+00	5.402900000000000000000000000000000000000
18/3.	4.082/1000000000e+00	3.53123000000000000000
1874.	4.11687000000000e+00	3.4168400000000000000000000000000000000000
1875.	4.151320000000000e+00	3.17831000000000e=02
1876.	4.18606000000000e+00	3.01911000000000e=02
1877.	4.22109000000000e+00	3.09817000000000e=02
1878.	4.256410000000000e+00	3.06948000000000e-02
1879.	4.29203000000000e+00	2.90019000000000e-02
1880.	4.327950000000000e+00	2.5919000000000e-02
1881.	4.364170000000000e+00	2.6062900000000e-02
1882.	4.400690000000000e+00	2.63217000000000e-02
1883.	4.43751000000000e+00	2.66200000000000e-02
1884.	4.474650000000000e+00	2.61712000000000e=02
1885.	4.512090000000000e+00	2.59135000000000e-02
1886	4 549850000000000e+00	2 457520000000000e-02
1887	4 587920000000000e+00	2 51091000000000e=02
1888	4 626310000000000e+00	2 4253400000000000000000000000000000000000
1889	4 66503000000000000000000	2 49653000000000000000
1890	4.70407000000000000000000	2.43152000000000000000000
1891	4.74343000000000000000000000000000000000	2.45205000000000000000000000000000000000
1002	4.7931300000000000000000000000000000000000	2.3584400000000000000000000000000000000000
1092.	4.783120000000000000000000	2.3584400000000000000000000000000000000000
1095.	4.82313000000000000000000	2.1615300000000000000000000000000000000000
1894.	4.863510000000000000000000	2.1156900000000000000000000000000000000000
1895.	4.90421000000000000000000	2.1686500000000000000000000000000000000000
1896.	4.945250000000000e+00	2.1457000000000e-02
1897.	4.986630000000000e+00	2.11802000000000e-02
1898.	5.028360000000000e+00	2.04520000000000e-02
1899.	5.070440000000000e+00	1.91959000000000e-02
1900.	5.11287000000000e+00	1.78451000000000e-02
1901.	5.15565000000000e+00	1.8018000000000e=02
1902.	5.198800000000000e+00	1.8486500000000e-02
1903.	5.24230000000000e+00	1.8406100000000e=02
1904.	5.28617000000000e+00	1.7906200000000e-02
1905.	5.330400000000000e+00	1.7014600000000e-02
1906.	5.37501000000000e+00	1.71595000000000e-02
1907.	5.419990000000000e+00	1.69879000000000e-02
1908.	5.46534000000000e+00	1.6411600000000e-02
1909.	5.51108000000000e+00	1.59620000000000e-02
1910.	5.55720000000000e+00	1.52726000000000e-02
1911.	5.60370000000000e+00	1.42994000000000e-02
1912.	5.65059000000000e+00	1.38479000000000e-02
1913.	5.69788000000000e+00	1.38023000000000e-02
1914.	5.74556000000000e+00	1.3676000000000e-02
1915.	5.793640000000000e+00	1.34541000000000e-02
1916.	5.842120000000000e+00	1.3306800000000e-02
1917.	5.891010000000000e+00	1.2867900000000e-02
1918.	5.94031000000000e+00	1.20896000000000e-02
1919.	5.990010000000000e+00	1.23652000000000e-02
1920.	6.0401400000000000e+00	1,19873000000000e-02
1921.	6.0906800000000000+00	1.17323000000000e-02
1922.	6.1416500000000000e+00	1.17175000000000e-02
1923.	6.1930500000000000+00	1,143180000000000=-02
1924.	6.2448700000000000e+00	1,105700000000000=-02
1925.	6.297130000000000e+00	1.082770000000000=-02
1926.	6.34982000000000000000000000000000000000000	1.02419000000000e=02
1927	6 402960000000000000000	9 650350000000000e=03
1928	6 4565400000000000000000	1 00512000000000e=02
1929	6 51057000000000000000000	8.847779080809090e_03
1930	6 5650500000000000000000000000000000000	3.3290000000000-03
1021	6.51000000000000000000000000000000000000	9.95455000000000000000000000000000000000
1931.	0.0133300000000000000000000000000000000	0.95455000000000000000000000000000000000
1932.	0.0/03900000000000e+00	0.051/10000000010-03
1933.	6./31250000000000e+00	8.3684/39333939990000
1934.	6.78758000000000e+00	/.9108600000000le-03
1935.	6.84438000000000e+00	/.8008900000000e=03
1936.	6.901650000000000e+00	7.78487000000000e=03
1937.	6.959400000000000e+00	7.5777900000000e-03



1938.	7.017640000000000e+00	7.26566000000000e-03
1939.	7.076370000000000e+00	6.9341500000000e=03
1040	7 1255000000000-100	
1940.	7.133380000000000000000000000000000000000	0.00439000000000000000000000000000000000
1941.	7.195290000000000e+00	6.1236800000000e-03
1942.	7.255500000000000e+00	6.0306100000000e-03
1943	7 31622000000000000+00	5 85007000000000000000000000000000000000
1010.	7.510220000000000000000000000000000000000	
1944.	1.3//44000000000e+00	3.0//300000000e=03
1945.	7.439180000000000e+00	5.54385000000000e-03
1946.	7.501430000000000e+00	5.40672000000000e-03
19/7	7 564200000000000000000	5 22021000000000000000000000000000000000
1947.	7.3642000000000000000000000000000000000000	5.22021000000000000000000000000000000000
1948.	7.627500000000000e+00	5.0269100000000e-03
1949.	7.691330000000000e+00	4.80642000000000e-03
1950.	7.755690000000000e+00	4.55944000000000e-03
1051	7.0000000000000000000000000000000000000	
1951.	7.820390000000000e+00	4.32916000000000000000000000000000000000000
1952.	7.886040000000000e+00	4.2084700000000000000000000000000000000000
1953.	7.95203000000000e+00	4.17959000000000e-03
1954.	8.018570000000000e+00	4.10121000000000e=03
1055	0.00567000000000000000000000000000000000	2 20582200000000 02
1999.	0.0000000000000000000000000000000000000	3.5055500000000000000000000000000000000
1956.	8.153340000000000e+00	3.6477900000000000000000000000000000000000
1957.	8.22156000000000e+00	3.4465200000000e-03
1958	8 290360000000000e+00	3 294950000000000-03
1050	9 2507400000000000000000000000000000000000	2 1975000000000 02
1939.	8.339740000000000000000000	3.18/39000000000000000000000000000000000000
1960.	8.42969000000001e+00	3.07836000000000e-03
1961.	8.500230000000000e+00	3.0032200000000e-03
1962.	8.57137000000000e+00	2.88935000000000e=03
1062	9 642000000000010100	2 73736000000000 03
1903.	0.0450500000000000000000000000000000000	2.73736666666666666
1964.	8.71542000000000e+00	2.5812500000000e-03
1965.	8.788349999999999e+00	2.48547000000000e-03
1966.	8.861890000000001e+00	2.41596000000000e-03
1967	8 9360500000000000000000000000000000000000	2 3379600000000000000
1000	0.010000000000000000000000000000000000	2.337500000000000000000000000000000000000
TA08.	a.0108300000000006+00	2.20092000000000e=03
1969.	9.08623000000001e+00	2.09463000000000e-03
1970.	9.1622700000000000e+00	2.03402000000000e-03
1971	9 2389400000000000000000	1 94518000000000e-03
1070	0.21005000000000000000000000000000000000	
1972.	9.310220000000000e+00	T.000000000000000000000000000000000000
1973.	9.394209999999999e+00	1.74630000000000e-03
1974.	9.47282000000001e+00	1.67075000000000e-03
1975	9 55209000000000000000000000000000000000	1 580170000000000=03
1076	9.5320900000000000000000000000000000000000	
1976.	9.632030000000000e+00	1.5046100000000e-03
1977.	9.712630000000001e+00	1.43341000000000e-03
1978.	9.793910000000000e+00	1.34973000000000e-03
1070	0 97595000000000000000000000000000000000	1 2873000000000000000000000000000000000000
1000	0.0700000000000000000000000000000000000	
1980.	9.958510000000000e+00	1.2321800000000000000000000000000000000000
1981.	1.004180000000000e+01	1.1705600000000e-03
1982.	1.012590000000000e+01	1.10444000000000e-03
1093	1 0210600000000000000000	1 049300000000000000000000000000000000000
1004	1.0210000000000000000000000000000000000	1.043500000000000000000000000000000000000
1984.	1.0296100000000000000000	9.96/62999999999999999
1985.	1.038220000000000e+01	9.3870600000000e-04
1986.	1.046910000000000e+01	9.08480000000000e-04
1987	1 0556700000000000+01	8 63579000000000-04
1000	1.0000000000000000000000000000000000000	
1900.	1.064500000000000000000000000000000000000	8.170130000000000000000000000000000000000
1989.	1.073410000000000e+01	7.79267000000001e-04
1990.	1.082390000000000e+01	7.33432000000000e-04
1001	1 09145000000000000000	6.947070000000000000000000000000000000000
1000	1.10014300000000000000000000000000000000	
1992.	1.100580000000000e+01	6.4124600000001e-04
1993.	1.109800000000000e+01	5.9240000000000e-04
1994.	1.119080000000000e+01	5.60949000000000e-04
1995	1 128450000000000e+01	5 25487000000001e-04
1006	1 1278000000000000000000000000000000000000	
1990.	1.137890000000000000000	4.90903000000000000000000000000000000000
1997.	1.147410000000000e+01	4.69618000000000e-04
1998.	1.157010000000000e+01	4.33069000000000e-04
1999.	1.1667000000000000000+01	4.17768000000000e-04
2000	1 1764600000000000000000	3 89444000000000000000
2000.	1.10630000000000000000000	5.63446000000000000
2001.	1.186300000000000e+01	3.6434500000000000000000000000000000000000
2002.	1.196230000000000e+01	3.43379000000000e-04
2003.	1.206240000000000e+01	3.22027000000000e-04
2004	1 216330000000000000000	3 093200000000000=04
2005	1 2265100000000000000000	
2003.	1.220310000000000e+01	2.0000000000000000000000000000000000000
2006.	1.236/80000000000e+01	2.6849800000000000000000000000000000000000
2007.	1.24713000000000e+01	2.51741000000000e-04
2008.	1.2575600000000000e+01	2.36132000000000e-04
2009.	1.2680900000000000+01	2.16799000000000e-04
2010	1 279700000000000000000000000000000000000	2 065550000000000 04
2010.	1.2/8/0000000000e+01	2.0000000000000000000000000000000000000
2011.	1.289400000000000e+01	1.91129000000000e-04
2012.	1.300190000000000e+01	1.81020000000000e-04
2013.	1.311070000000000+01	1.6597900000000000-04
2014	1 22204000000000000000000000000000000000	1 51690000000000 04
2014.	1.32204000000000000000000	1.316350000000000000000000
2015.	1.33310000000000e+01	1.42695000000000e-04
2016.	1.344260000000000e+01	1.32980000000000e-04
2017.	1.3555100000000000e+01	1.27284000000000e-04
2018	1 3668500000000000000000	1 1442200000000000000
2010	1.3703000000000000000000000000	1.0550000000000000000000000000000000000
2019.	1.3/8290000000000e+01	1.0666000000000000000000000000000000000
2020.	1.389820000000000e+01	9.95941000000000e-05
2021.	1.4014500000000000e+01	9.10512000000001e-05
2022	1 413180000000000000000	8 6236000000000000000000
2022	1.4250100000000000000000000000000	
2023.	1.425010000000000e+01	/.894900000000000000000000000000000000000
2024.	1.436930000000000e+01	7.19254000000000e-05
2025.	1.448950000000000e+01	6.94507000000000e-05
2026	1 4610800000000000000	6 41465000000000e-05
2027	1 4722100000000000000000	5 8204700000000000 05
2027.	1.4/3310000000000e+01	3.8204700000000000000000000000000000000000
2028.	1.48563000000000e+01	5.08017000000000e-05
2029.	1.4980700000000000e+01	4.60273000000000e-05
2030	1 5106000000000000000000	4 34838000000000000000000000000000000000
2030.	1.5100000000000000000000000000000000000	4.0000000000000000000000000000000000000
2031.	1.523240000000000e+01	4.08200000000000000000000000000000000000
2032.	1.535990000000000e+01	3.76767000000000e-05
2033.	1.5488400000000000e+01	3.41362000000000e-05
2034	1 5618000000000000000000000000000000000000	3 2858600000000000000
2007.	1.3010000000000000000000000000000000000	5.2000000000000000000000000000000000000



2035.	1.574870000000000e+01	2.8518900000000e-05
2036.	1.58805000000000000000000	2./361300000000000000000000000000000000000
2037.	1.601340000000000e+01	2.41884000000000e-05
2038.	1.614740000000000e+01	2.2378000000000e-05
2039.	1.628250000000000e+01	2.03562000000000e=05
2040.	1.641880000000000e+01	1.78739000000000e-05
2041.	1.65562000000000e+01	1.73288000000000e-05
2042.	1.669470000000000e+01	1.61382000000000e-05
2043.	1.683440000000000e+01	1.40002000000000e-05
2044.	1.697530000000000e+01	1.31777000000000e-05
2045.	1.711740000000000e+01	1.20317000000000e-05
2046.	1.726060000000000e+01	1.12534000000000e-05
2047.	1.740500000000000e+01	9.941349999999999e-06
2048.	1.75507000000000e+01	9.94803000000001e-06
2049.	1.769760000000000e+01	7.98501000000000e-06
2050.	1.784570000000000e+01	7.04159000000000e-06
2051.	1.799500000000000e+01	5.70553000000000e-06
2052.	1.814560000000000e+01	6.06294000000000e-06
2053.	1.829740000000000e+01	5.28886000000000e-06
2054.	1.845050000000000e+01	4.70913000000000e-06
2055.	1.860490000000000e+01	4.79583000000000e-06
2056.	1.87606000000000e+01	4.18165000000000e-06
2057.	1.891760000000000e+01	3.3911200000000e-06
2058.	1.907590000000000e+01	3.35380000000000e-06
2059.	1.923560000000000e+01	2.41454000000000e-06
2060.	1.939650000000000e+01	2.70109000000000e-06
2061.	1.955880000000000e+01	2.38485000000000e=06
1		

E.3.4 Safety rod, 3D axially finite cell with external source (fission spectrum)

In the following, the input file that defines a non-multiplying region cell (the absorbing bundle of the SR in this case) axially finite and radially infinite (*i.e.*, finite with reflective boundary conditions) with an external neutron source is defined. This file can be run independently.

Also in this case, the source is distributed in energy as the fission spectrum of the inner fuel, computed in the previous input (see §E.3.2) with the card "*det flx_spectrum de MyEnergyGrid df IF_src_1M_500a -1*".

```
%% -- EXTERNAL FILE INCLUSION
      include "/home/abrate/serpent2models/models/alfred/materials/eranos_jeff31.ml" % materials
%% -- LIBRARY FOR NUCLEAR DATA
2.
3.
      set acelib "/opt/serpent/xsdata/jeff31/sss_jeff31.xsdata"
4.
5.
 7.
      8 -
              ----- Radial coordinate -----
8.
      % Core
      surf s1 sqc 0.0 0.0 25
                                           % wrapping inner perimeter
9.
10
      % Safety rod (SR)
11.
11. • Safely rod (SR)

12. surf z_tref pz 80.0

13. surf z_safe_u pz 30.0

14. surf z_safe_b pz -30.0

15. surf z_bref pz -80.0
                                                     % Upper reflector
                                                    % Fuel active zone upper limit
% Fuel active zone lower limit
                                                  % Bottom reflector
16.
17.
      <u>8</u>_____
18.
      19.
     $ safety rod assembly axial scan (universe definition to compute group-wise constants)
cell cltref_GCU SR_TOP_REF tref z_safe_u -z_tref % upper reflector
cell cla1_GCU SR fill SR_TOP_REF z_safe_u -z_tref % upper reflector
cell c3srod_u AZ safehom z_safe_b -z_safe_u % safety rod universe definition
cell c3srod_SR fill AZ z_safe_b -z_safe_u % safety rod universe definition
cell c1ref_bo_GCU SR_BOT_REF bref z_bref -z_safe_b % bottom reflector
cell c1a9_GCU SR fill SR_BOT_REF z_bref -z_safe_b % bottom reflector
20.
21.
22.
23.
24.
26.
27.
28.
      29
                                                 % Core with CR and SR extracted
30.
      lat core 3 0.0 0.0 5 5 17.1
      SR SR SR SR SR
31.
33.
34.
35.
36.
37.
      88 -----
38.
     cell c100 0 fill core -s1 z bref -z tref
                                                              % Filling the cylinder with the core
% Placing the vacuum outside the reactor
% Placing the vacuum above the reactor
39.
      cell c101 0 outside s1 z_bref -z_tref
cell c104 0 outside z_tref
40.
 41.
42.
      cell c105 0 outside
                                       -z_bref
                                                                       % Placing the vacuum below the reactor
43.
44.
             PLOTS
     plot 3 2000 2000 135
plot 3 2000 2000 48
plot 3 2000 2000 43
45.
46.
47.
```



<pre>5 p. p.c. 2 (00 100</pre>	48.	. plot 3 2000 2000 31 . plot 1 1000 1000 29.18505		
<pre>Side in the second second</pre>	50.	plot 2 1000 1000		
<pre>Start F1 set, up / 10000000 100 set, up / 00000000000 set, up / 0000000000000000000000000000000000</pre>	52.	%% SIMULATION SETUP		
<pre>style="tailog: tailog: ta</pre>	53.	set bc 2		
<pre>set Large :</pre>	55.	sset num nji s (nich bummi nim) ni leakage-corrected mode		
<pre>id this yee</pre>	56.	set unes 1		
<pre>set</pre>	58.	set his yes & Check on fission source convergence		
<pre>6. Junc 113 /</pre>	59.	%% GROUP CONSTANT GENERATION		
<pre>Bit ext of 0.13 set exp of 0.13 set exp of 0.13 set exp of 1.13 set exp of 1.13 s</pre>	61.	set micro nj19 % ECCO-33 groups		
is a set 2003 i 2003 i 101 is est 2003 i 2003 i 111 20 is est 2003 i 2003 i 111 20 <th>62.</th> <th>set nfg nj19 set ngu AZ</th>	62.	set nfg nj19 set ngu AZ		
10 com com< com< <th>64.</th> <th></th>	64.			
6 -	65.	ene ECC033 4 nj19 ene e2C03 3 2000 1e-11 20		
is a Apple dot is a first die AS die 2003 is de term is - is val die AS die 2003 is de term is - is val die AS die 2003 is de term is - is val die AS die 2003 is de term is - is val die AS die 2003 is de term is - is val die AS die 2003 is de term is - is val die AS die 2003 is de term is - is val die AS die 2003 is de term is - is - is val die AS die 2003 is de term is - is - is val die AS die 2003 is de term is -	67.	ast vanlet 2000 1e 11 20		
70. det tot, dr - 1 vold de Al de XCO33 71. det tot, dr - 2 vold de Al de XCO33 72. det tilsine du Al de 2000 73. det tilsine du Al de 2000 74. det tilsine du Al de 2000 75. 5.00000000000-01 1.110/00000000-06 76. 5.0000000000-01 1.210/0000000-06 76. 5.0000000000-01 1.210/0000000-06 76. 5.00000000000-01 1.210/0000000-06 76. 5.00000000000-01 1.2110/0000000-06 76. 5.00000000000-01 1.2110/0000000-06 76. 2.00000000000-01 1.2110/00000000-01 76. 2.00000000000-01 1.2110/00000000-01 76. 2.00000000000-01 1.2110/00000000-01 76. 2.00000000000-01 1.2110/00000000-01 77.0000000000000-01 1.2110/00000000-01 77.0000000000000-01 1.2110/00000000-01 77.0000000000000-01 1.2110/000000000-01 77.00000000000000-01 1.2110/000000000-01 77.00000000000000-01 1.2120/0000000-01 77.00000000000000-01 1.2120/00000000-01 77.000000000000000-01 1.	69.	Set ASPICE 2000 16 11 20		
12. det Tist det Tist det Tist 1. det Tist	70.	det tot dr -1 void du AZ de ECC033 det cant dr -2 void du AZ de ECC033		
1. test I z bi 190 31 1.00000000000-1 0.00000000000-0 1. 5.000000000000-0 1.01000000000-0 0.0000000000-0 1. 5.00000000000-0 2.411700000000-0 0.00000000-0 1. 1.00000000000-0 2.411700000000-0 0.0000000-0 1. 1.0000000000-0 2.411700000000-0 0.0000000-0 1. 2.00000000000-0 2.4117000000000-0 0.0000000-0 1. 2.00000000000-0 2.4117000000000-0 0.0000000-0 1. 2.000000000000-0 2.1173000000000-0 0.000000-0 1. 2.00000000000-0 1.341000000000-0 0.0000000-0 1. 2.00000000000-0 1.341000000000-0 0.0000000-0 1. 2.00000000000-0 1.341000000000-0 0.000000-0 1. 2.00000000000-0 1.341000000000-0 0.000000-0 1. 1.00000000000-0 1.0000000000-0 0.0000000-0 0.00000000-0 1. 1.00000000000-0 1.0000000000-0 0.00000000-0 0.00000000-0 0.000000000-0 0.0000000000-0 0.0000000000-0	72.	det flx du AZ de ECCO33 % flux		
15. 0.00000000000-0 3.0000000000-0 1.100000000000-0 1.000000000000-0 1.000000000000-0	73.	det fixfine du AZ de e2000		
11. 3.4.00000000000-0-0 3.42240000000-0 12. 3.42240000000-0 3.42242000000-0 13. 3.40000000000-0 3.42242000000-0 14. 1.50000000000-0 3.42242000000-0 14. 3.4000000000-0 3.42242000000-0 15. 3.4000000000-0 3.424420000000-0 14. 3.4000000000-0 3.4440000000-0 15. 3.40000000000-0 4.4555000000000-0 14. 3.80000000000-0 4.4555000000000-0 15. 3.80000000000-0 4.4557000000000-0 16. 4.70000000000-0 4.4557000000000-0 16. 4.70000000000-0 4.4557000000000-0 16. 4.70000000000-0 4.455700000000-0 16. 4.70000000000-0 4.455700000000-0 16. 4.450000000000-0 4.4557000000000-0 16. 4.450000000000-0 4.4557000000000-0 16. 4.450000000000-0 4.4577000000000-0 16. 4.450000000000-0 4.4577000000000-0 4.4577000000000-0 16. 4.4500000000000-0 <td< th=""><th>75.</th><th>src IF sb 1969 2 1.00000000000000000001 0.000000000000</th></td<>	75.	src IF sb 1969 2 1.00000000000000000001 0.000000000000		
78. 6.900000000000-0 3.22220000000000-06 71. 1.00000000000-0 4.333293939-06 81. 2.000000000000-0 4.3332939393-06 82. 2.00000000000-0 6.373100000000-0-0 83. 3.0000000000-0 1.34400000000-0 84. 3.0000000000-0 1.34300000000-0 84. 3.0000000000-0 1.34300000000-0 85. 3.0000000000-0 1.34300000000-0 86. 3.0000000000-0 1.34300000000-0 86. 3.00000000000-0 1.34300000000-0 86. 5.00000000000-0 1.34300000000-0 86. 5.00000000000-0 1.22330000000-0 87. 1.00000000000-0 1.223300000000-0 86. 1.00000000000-0 1.3434000000000-0 86. 1.0000000000-0 1.3434000000000-0 86. 1.80000000000-0 1.3434000000000-0 86. 1.80000000000-0 1.3434000000000-0 87. 1.80000000000-0 1.3434000000000-0 87. 1.80000000000-0 1.80000000000-0	77.	5.0000000000000000-09 2.241170000000000-06		
14. 1.100000000000000000000000000000000000	78.	6.9000000000000e-09 3.522260000000000e-06		
81. 2.000000000000000000000000000000000000	80.	1.5000000000000000000000000000000000000		
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64. 3.50000000000000000-08 1.21719000000000-04 61. 4.2000000000000-04 2.273500000000-04 62. 5.000000000000-04 4.4657000000000-04 63. 6.700000000000-06 6.4057100000000-04 63. 7.7000000000000-06 6.4057100000000-04 63. 7.7000000000000-07 6.4057100000000-04 63. 9.50000000000-07 7.4017500000000-04 63. 1.300000000000-07 7.405100000000-03 63. 1.400000000000-07 7.405100000000-03 63. 1.400000000000-07 7.405100000000-03 63. 1.400000000000-07 7.405100000000-03 63. 1.60710000000000-07 7.2845000000000-03 63. 1.60710000000000-07 7.2845000000000-03 64. 1.4837000000000-07 7.2845000000000-03 65. 2.280000000000-07 7.2845000000000-03 66. 2.48000000000-07 7.2845000000000-03 66. 2.48000000000-07 7.2845000000000-03 66. 2.48000000000-07 7.2845000000000-03 67. <td< th=""><th>83.</th><th>3.000000000000000000-08 9.134400000000000-05</th></td<>	83.	3.000000000000000000-08 9.134400000000000-05		
64 5.0000000000000-08 4.4857000000000-04 87. 5.0000000000000-08 4.485700000000-04 88. 6.700000000000-08 8.159200000000-04 89. 7.700000000000-08 8.159200000000-04 91. 8.0000000000-07 8.159200000000-04 91. 8.0000000000-07 7.015700000000-04 93. 1.50000000000-07 7.015700000000-04 94. 1.300000000000-07 7.015700000000-03 94. 1.400000000000-07 1.5347000000000-03 94. 1.60000000000-07 1.5347000000000-03 94. 1.60000000000-07 2.9757000000000-03 94. 1.60000000000-07 2.9757000000000-03 95. 1.60000000000-07 2.9757000000000-03 96. 1.60000000000-07 2.9757000000000-03 97. 2.9757000000000-03 98. 1.60000000000-07 2.9757000000000-03 99. 1.6352000000000-07 2.9757000000000-03 99. 2.358000000000-07 3.444200000000-03 99. 2.0551000000000-07 3.945700000000-03 <th>84.</th> <th>3.50000000000000=08 1.21719000000000e=04</th>	84.	3.50000000000000=08 1.21719000000000e=04		
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92. 1.00000000000000007 7.0156700000000000000 93. 1.300000000000007 7.00570000000000000 94. 1.30000000000007 7.0057000000000000 95. 1.4507000000000007 7.0057000000000000 97. 1.65070000000000007 7.00570000000000000 98. 1.66070000000000007 7.00570000000000000000 99. 1.661700000000000007 7.0057000000000000000000000000000000000	90.	8.000000000000000=08 3.02633000000000e=04 9.50000000000000000e=08 1.79075000000000e=03		
93. 1.1500000000000000000000000000000000000	92.	1.00000000000000e-07 7.01557000000000e-04		
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98. 1.6000000000000-07 1.88537000000000-03 100. 1.800000000000-07 3.18573000000000-03 101. 1.80000000000-07 3.14573000000000-03 102. 1.988100000000-07 3.424200000000-03 103. 2.01400000000-07 3.424200000000-03 104. 2.035800000000-07 3.628100000000-03 105. 2.480000000000-07 7.2059700000000-03 106. 2.6351000000000-07 7.20597000000000-03 107. 2.6351000000000-07 7.0587000000000-03 108. 2.000000000000-07 1.03821000000000-03 111. 3.00000000000-07 3.0646000000000-03 112. 3.3460000000000-07 8.025299999999-03 113. 3.00000000000-07 8.0257000000000-03 114. 3.6930000000000-07 8.0257000000000-03 115. 3.91000000000-07 1.3239000000000-03 114. 3.693000000000-07 1.323900000000-02 115. 4.193000000000-07 1.7245000000000-02 116. 4.09000000000-07 1.72450000000000-02 117. 4.193000000000-07 1.72450000000000-02 1	97.	1.5303000000000000000 - 07 1.7037000000000000 - 03		
100. 1.8000000000000000000000000000000000000	98.	1.6000000000000000000000000000000000000		
101. 1.89000000000000000000000000000000000000	100.	1.8000000000000000000000000000000000000		
103. 2.031400000000000000000000000000000000000	101.	1.89000000000000=07 2.972570000000000=03 1.988100000000000000=07 3.424920000000000=03		
108. 2.2.0000000000000000000000000000000000	103.	2.0914000000000e-07 3.82136000000000e-03		
106. 2.480000000000000-07 6.32891000000000-03 107. 2.633100000000000-07 7.2059700000000-02 110. 3.14500000000000-07 7.855929999999-03 111. 3.2000000000000-07 7.8559299999999-03 112. 3.34660000000000-07 8.36457000000000-03 113. 3.5000000000000-07 9.0255700000000-03 114. 3.693000000000-07 1.2181000000000-02 115. 3.910000000000-07 1.2333000000000-02 116. 4.00000000000-07 1.2333000000000-02 117. 4.1399000000000-07 1.27343000000000-02 118. 4.330000000000-07 1.27343000000000-02 120. 4.6701000000000-07 1.27343000000000-02 121. 4.850000000000-07 1.27343000000000-02 122. 5.00000000000-07 1.27343000000000-02 123. 5.19420000000000-07 1.27345000000000-02 124. 5.19420000000000-07 1.24323000000000-02 125. 5.400000000000-07 2.2432000000000-02 126. 5.65660000000000-07 2.2432000000000-02 127. 5.952800000000000-07 2.143716000000000-02	104.	2.200000000000000000000000000000000000		
130. 2.0300000000000000000000000000000000000	106.	2,4800000000000=07 6.32891000000000=03		
109, 3.000000000000000000000000000000000000	107.	2.850100000000000000-07 /.20350000000001e-03		
111. 3.2000000000000000000000000000000000000	109.	3.00000000000000=07 1.038210000000000=02 3.14500000000000000=07 7.8859299999999999		
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114. 3.69930000000000000000000000000000000000	112.	3.345500000000000e-07 8.35457000000000e-03 3.5000000000000e-07 9.02957000000001e-03		
113. 3.51000000000000000000000000000000000000	114.	3.69930000000000e-07 1.2118100000000e-02		
117. 4.1390000000000e-07 9.17892000000000e-03 118. 4.330000000000e-07 1.27313000000000e-02 120. 4.6701000000000e-07 1.204100000000e-02 121. 4.8500000000000e-07 1.275450000000000e-02 122. 5.00000000000e-07 1.4381000000000e-02 123. 5.19620000000000e-07 1.4381000000000e-02 124. 5.13580000000000e-07 8.8229300000000e-03 125. 5.40000000000e-07 8.8229300000000e-02 126. 5.65690000000000e-07 2.4387000000000e-02 127. 5.95280000000000e-07 2.91876000000000e-02 128. 6.2500000000000e-07 2.9386000000000e-02 129. 6.53150000000000e-07 2.9387000000000e-02 130. 6.82560000000000e-07 2.9387000000000e-02 131. 7.050000000000e-07 2.91837000000000e-02 133. 7.800000000000e-07 2.91837000000000e-02 134. 7.900000000000e-07 2.91837000000000e-02 135. 8.19450000000000e-07 2.37662000000000e-02 136. 8.19450000000000e-07 2.37662000000000e-02 137. 8.600000000000e-07	116.	4.000000000000000000000000000000000000		
119. 4.4968000000000e-07 1.14232000000000e-02 120. 4.6701000000000e-07 1.2094100000000e-02 121. 4.8500000000000e-07 1.27545000000000e-02 122. 5.000000000000e-07 1.4308100000000e-02 123. 5.1962000000000e-07 8.822390000000e-03 125. 5.40000000000e-07 2.0243200000000e-03 126. 5.6696000000000e-07 2.1571600000000e-02 127. 5.95280000000000e-07 2.1937600000000e-02 128. 6.250000000000e-07 2.1937600000000e-02 129. 6.53150000000000e-07 2.1937600000000e-02 130. 6.82560000000000e-07 2.1937600000000e-02 131. 7.050000000000e-07 2.1937600000000e-02 133. 7.800000000000e-07 2.31576000000000e-02 134. 7.900000000000e-07 3.0857000000000e-02 135. 8.194500000000000e-07 3.0857000000000e-02 136. 8.500000000000e-07 2.364818000000000e-02 137. 8.600000000000e-07 3.0856000000000e-02 136. 8.500000000000e-07 1.32919000000000e-02 137. 8.600000000000e-07 <td< th=""><th>117.</th><th>4.1399000000000e-07 9.1789200000000e-03 4.3300000000000e-07 1.2731300000000e-02</th></td<>	117.	4.1399000000000e-07 9.1789200000000e-03 4.3300000000000e-07 1.2731300000000e-02		
120. 4.67010000000000000 1.275550000000000000000000000000000000000	119.	4.4968000000000e-07 1.14232000000000e-02		
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123. 5.1952000000000000000000000000000000000000	122.	5.000000000000000000000000000000000000		
125. 5.4000000000000000000000000000000000000	123.	5.19620000000000e=07 1.4308100000000e=02 5.3158000000000e=07 8.8229300000000e=03		
127. 5.95280000000000=07 2.15716000000000=02 128. 6.25000000000000=07 2.15716000000000=02 129. 6.53150000000000=07 2.19876000000000=02 130. 6.82560000000000=07 2.31876000000000=02 131. 7.050000000000=07 2.318776000000000=02 132. 7.41550000000000=07 2.914370000000000=02 133. 7.800000000000=07 3.08570000000000=02 134. 7.900000000000=07 8.05134000000000=02 135. 8.19450000000000=07 2.37662000000000=02 136. 8.500000000000=07 2.46818000000000=02 137. 8.600000000000=07 8.08356000000000=02 138. 8.764250000000000=07 1.32919000000000=02 141. 9.300000000000=07 1.62342000000000=02 142. 9.7200000000000=07 1.78258000000000=02 144. 9.960000000000=07 1.33440000000000=02	125.	5.4000000000000000000000000000000000000		
128. 6.25000000000001e-07 2.2938600000000e-02 129. 6.5315000000000e-07 2.3187600000000e-02 130. 6.8256000000000e-07 2.3157600000000e-02 131. 7.05000000000e-07 2.9143700000000e-02 132. 7.4155000000000e-07 3.0857000000000e-02 133. 7.80000000000e-07 3.0857000000000e-02 134. 7.90000000000e-07 8.0513400000000e-02 135. 8.1945000000000e-07 2.3766200000000e-02 136. 8.50000000000e-07 2.366200000000e-02 137. 8.60000000000e-07 8.0895600000000e-02 138. 8.76425000000000e-07 1.321900000000e-02 139. 9.10000000000e-07 1.6234200000000e-02 141. 9.5000000000e-07 1.6210100000000e-02 142. 9.720000000000e-07 1.7825800000000e-02 143. 9.86000000000e-07 1.334400000000e-02 144. 9.96000000000e-07 1.3344000000000e-02	127.	5.9528000000000e-07 2.1571600000000e-02		
130. 6.8256000000000e-07 2.3157600000000e-02 131. 7.050000000000e-07 2.3157600000000e-02 132. 7.4155000000000e-07 2.9143700000000e-02 133. 7.80000000000e-07 3.0857000000000e-02 134. 7.900000000000e-07 8.0513400000000e-02 135. 8.19450000000000e-07 2.3766200000000e-02 136. 8.500000000000e-07 2.36800000000e-02 137. 8.60000000000e-07 8.0895600000000e-02 138. 8.76425000000000e-07 1.321900000000e-02 139. 9.10000000000e-07 1.6214000000000e-02 141. 9.5000000000e-07 1.6214000000000e-02 142. 9.720000000000e-07 1.7384000000000e-02 143. 9.86000000000e-07 1.3344000000000e-02 144. 9.960000000000e-07 1.80958000000000e-02	128.	6.2500000000001e-07 2.2938600000000e-02 6.53150000000001e-07 2.1987600000000e-02		
131. 7.05000000000000e-07 1.7781900000000e-02 132. 7.4155000000000e-07 2.9143700000000e-02 133. 7.800000000000e-07 3.085700000000e-02 134. 7.90000000000e-07 8.0513400000000e-02 135. 8.1945000000000e-07 2.3766200000000e-02 136. 8.50000000000e-07 2.46818000000000e-02 137. 8.6000000000e-07 1.3291900000000e-02 138. 8.76425000000000e-07 1.3291900000000e-02 139. 9.10000000000e-07 1.6234200000000e-02 141. 9.5000000000e-07 1.6210100000000e-02 143. 9.86000000000e-07 1.7825800000000e-02 144. 9.96000000000e-07 1.1334400000000e-02	130.	6.8256000000000e-07 2.3157600000000e-02		
133. 7.8000000000000000000000000000000000000	131.	7.050000000000e-07 1.7781900000000e-02 7.4155000000000e-07 2.9143700000000e-02		
134. 7.9000000000000000000000000000000000000	133.	7.800000000001e-07 3.0857000000000e-02		
136. 8.5000000000000000000000000000000000000	134.	7.9000000000000000000000000000000000000		
138. 8.76425000000000000000000000000000000000000	136.	8.500000000000000000007 2.4681800000000000000000000000000000000000		
139. 9.1000000000000e-07 2.72164000000000e-02 140. 9.300000000000e-07 1.6234200000000e-02 141. 9.500000000000e-07 1.621000000000e-02 142. 9.7200000000000e-07 1.7825800000000e-02 143. 9.860000000000e-07 1.1334400000000e-02 144. 9.960000000001e-07 8.0905800000000e-03	137.	8.76425000000000e=07 1.3291900000000e=02		
141. 9.5000000000000000000000000000000000000	139.	9.1000000000000000000000000000000000000		
142. 9.7200000000000e-07 1.7825800000000e-02 143. 9.860000000000e-07 1.1334400000000e-02 144. 9.960000000001e-07 8.0905800000000e-03	140.	9.5000000000000e-07 1.6210100000000e-02		
144. 9.9600000000001e-07 8.0905800000000e-03	142.	9.7200000000000e-07 1.7825800000000e-02 9.8600000000000e-07 1.1334400000000e-02		
	144.	9.9600000000001e-07 8.09058000000000e-03		



145.	1.020000000000000e-06 1	1.94357000000000e=02
146.	1.03500000000000e-06 1	1.2131200000000e=02
147.	1.045000000000000e-06 8	3.0750600000000e=03
148	1 07100000000000e=06 2	2 097410000000000-02
1/9	1 0800000000000000000000000000000000000	25277000000000000000000
149.	1.0800000000000000000000000000000000000	
150.	1.09/00000000000000000000000000000000000	1.368680000000000000000000000000000000000
151.	1.110000000000000e-06 1	1.0460600000000e=02
152.	1.12300000000000e-06 1	1.0436600000000e=02
153.	1.150000000000000e-06 2	2.1669800000000e=02
154	1 1700000000000000e-06 1	6028100000000e-02
155	1 20206000000000000000000000000000000000	562850000000000000000000
150.	1.2220000000000000000000000000000000000	
136.	1.235000000000000000000000000000000000000	2.8258400000000000000000000000000000000000
157.	1.26708000000000e-06 2	2.54863000000000e=02
158.	1.300000000000000e-06 2	2.6054400000000e=02
159.	1.337500000000000e-06 2	2.9569700000000e-02
160	1 370000000000000e=06 2	2 55274000000000000-02
161	1 404560000000000000000000000000000000000	703880000000000000000
1.01.	1.40430000000000000000000000000000000000	750000000000000000000000000000000000000
102.	1.4400000000000000000000000000000000000	2.7620300000000000000000000000000000000000
163.	1.475000000000000e-06 2	2.71618000000000e=02
164.	1.500000000000000e-06 1	1.9312500000000e=02
165.	1.54434000000000e-06 3	3.4099300000000e-02
166.	1.590000000000000e-06 3	3.49357000000000e=02
167	1 629510000000000000000	3 001860000000000000000
1.00	1.02991000000000000000000000000000000000	
100.	1.67000000000000000000000000000000000000	5.05802000000000000000000000000000000000
109.	1./119/000000000e-06 3	3.1503400000000000000000000000000000000000
170.	1.7550000000000e-06 3	3.2085900000000e-02
171.	1.79700000000000e-06 3	3.1103500000000e-02
172.	1.840000000000000e-06 3	3.1621600000000e-02
173.	1.855390000000000e-06 1	1.1269100000000e-02
174	1 884460000000000000000000000000000000000	2 12017000000000-02
175	1 0200000000000000000000000000000000000	200640000000000 02
1/5.	T. 330000000000000000 3	5.3006400000000000=02
176.	1.97449000000000e-06 3	3.1998900000000e-02
177.	2.02000000000000e-06 3	3.25239000000000e-02
178.	2.05961000000000e-06 2	2.8134000000000e-02
179.	2.1000000000000000 e-06 2	2.8492600000000e-02
180	2 13000000000000000000000000000000000000	2 10238000000000-02
181	2 1853100000000000000000000000000000000000	84427000000000000000-02
192	2 24205000000000000000000000000000000000	912220000000000000000000000000000000000
102.	2.24203000000000000000000000000000000000	3.3120200000000000000000000002
103.	2.30027000000000000000000000000000000000	3. 3730 30000000000000000000000000000000
104.	2.36000000000000000000000000000000000000	4.0408/000000000000000000000000000000000
185.	2.38237000000000e-06 1	1.503850000000000000000000000000000000000
180.	2.421/1000000000e-06 2	2.63219000000000e=02
187.	2.48503000000000e-06 4	4.1965200000000e=02
188.	2.55000000000000e-06 4	4.2640400000000e=02
189.	2.60000000000000e-06 3	3.2468200000000e-02
190.	2.65932000000000e-06 3	3.8171400000000e-02
191	2 720000000000000e=06 3	3 8759000000000000-02
192	2 7679200000000000	3 037750000000000-02
102	2.92700000000000000000000000000000000000	
193.	2.83799000000000000000	1.41352000000000000000000000000000000000000
194.	2.90983000000000e-06 4	4.48889000000000000000000000000000000000
195.	2.98349000000000e-06 4	4.5589600000000e=02
196.	3.05902000000000e-06 4	4.6271600000000e=02
197.	3.13733000000000e-06 4	4.7452500000000e=02
198.	3.21763000000000e-06 4	4.8087500000000e=02
199.	3.300000000000000e-06 4	4.87451000000000e-02
200.	3.38075000000000e-06 4	4.7280900000000e=02
201.	3.46633000000000e-06 4	4.94765000000000e=02
202	3 55408000000000e=06 5	5 0147300000000000-02
203	3 644050000000000000000000000000000000000	0768200000000000000000
203.	3.04405000000000000000000000000000000000	
204.	3./36300000000000e-06 5	5.140/400000000e=02
205.	3.83088000000000e-06 5	.20077000000000e=02
206.	3.92786000000000e-06 5	.26716000000000e-02
207.	4.000000000000000e-06 3	3.8730800000000e-02
208.	4.12925000000000e-06 6	6.84957000000001e-02
209.	4.23378000000000e-06 5	5.4563900000000e-02
210.	4.340960000000000e-06 5	5.5153900000000e-02
211.	4.4508500000000000 5	5.5917900000000e-02
212.	4.563530000000000e-06 5	5.6600100000000e-02
213.	4.67905000000000000	5.72462000000000e-02
214.	4.797500000000000000000000000000000000000	5.7954700000000000=-02
215	4 9189500000000000000000000000000000000000	8613000000000000000000000000000000000000
216	5 043480000000000000000000000000000000000	5 9266800000000000000000000000000000000000
217	5 08568000000000000000000000000000000000	
210	5.000000000000000000000000000000000000	
210.	5.120240000000000e-06 1	1. 334 / 000000000000000000000000000000000
219.	5.1/115000000000e-06 2	2.00389000000000=02
220.	5.21443000000000e-06 2	2.00921000000000e-02
221.	5.25806000000000e-06 2	2.01788000000000e-02
222.	5.30206000000000e-06 2	2.0241000000000e-02
223.	5.34643000000000e-06 2	2.0335600000000e-02
224.	5.39117000000000e-06 2	2.0366900000000e-02
225.	5.43628000000000e-06 2	2.0444000000000e-02
226.	5.481770000000000e-06 2	2.05302000000000e-02
227	5 5276500000000000000000000000000000000000	0592000000000000000
228	5 5739000000000000000000000000000000000000	068540000000000=02
229	5 62055000000000000000000000000000000000	07574000000000
230	5 66758000000000000000000 2	2.08204000000000000000000000000000000000
230.	5.00/30000000000000 00 2	2.020400000000000=02
231.	5./1501000000000e-06 2	2.03520000000000=02
232.	5.76283000000000e-06 2	2.095580000000000e=02
233.	5.81106000000000e-06 2	2.10183000000000e=02
234.	5.85968000000000e-06 2	2.11102000000000e-02
235.	5.90872000000000e-06 2	2.1178900000000e-02
236.	5.95816000000000e-06 2	2.1238900000000e-02
237.	6.0080200000000000 e-06 2	2.1323000000000e-02
238	6.058300000000000e=06 2	2.140110000000000=-02
239.	6.108990000000000000000000000000000000000	2.146750000000000=-02
240	6 16012000000000000000000000000000000000	1535800000000000000000000000000000000000
240.	6.1107200000000000000 05 2	2.1595660000000000000000000000000000000000
241.	0.2110/000000000000 2	2.10044000000000000000000000000000000000


242.	6.263650000000000e-06	2.1670900000000e-02
243	6 31606000000000000000000000000000000000	2.176060000000000-02
243.	0.3100000000000000000000000000000000000	2.17000000000000000000000000000000000000
244.	6.368910000000000e-06	2.18294000000000e=02
245.	6.422210000000000e-06	2.19022000000000e-02
246	6 475950000000000e=06	2 19658000000000000000000000000000000000000
240.	0.4/555000000000000000000000000000000000	2.190500000000000000000000000000000000000
247.	6.530140000000000e-06	2.203/900000000e=02
248.	6.584790000000000e-06	2.2102400000000e=02
249.	6.639890000000000e-06	2.2170000000000e=02
250	6 695450000000000 06	2,22724000000000,000
250.	6.695450000000000e-06	2.22/24000000000000000000000000000000000
251.	6.751480000000000e-06	2.23350000000000e-02
252.	6.807980000000000e-06	2.2426600000000e-02
253	6 864950000000000e-06	2 2525600000000e-02
255.	6.00334000000000000000000000000000000000	2.25201000000000000000000000000000000000
254.	6.922400000000000e-06	2.25891000000000000000000000000000000000000
255.	6.980330000000000e-06	2.2666700000000e=02
256.	7.038740000000000e-06	2.2766900000000e-02
257	7 0976400000000000-06	2 28622000000000=-02
257.	7.1570300000000000000000000000000000000000	
238.	7.15703000000000e-06	2.29404000000000000000000000000000000000
259.	7.216930000000000e-06	2.3031900000000e-02
260.	7.27732000000000e-06	2.30987000000000e-02
261	7 338210000000000e-06	2 3188500000000000000000000000000000000000
201.	7.330210000000000000000000000000000000000	
262.	7.399620000000000e-06	2.32593000000000e=02
263.	7.461540000000000e-06	2.33369000000000e-02
264.	7.523980000000000e-06	2.3405700000000e-02
265	7 58694000000000000-06	2 3472600000000000000000
203.	7.50054000000000000000000000000000000000	2.3512000000000000000000000000000000000000
200.	7.65042999999999999e-06	2.35198000000000000000000000000000000000000
267.	7.714450000000000e-06	2.35824000000000e-02
268.	7.77901000000000e-06	2.36552000000000e-02
269	7 844110000000010-06	2 37400000000000000-02
270	7 000750000000000000000	
2/0.	1.909/3000000000000e-06	2.302/0000000000000000000000000000000000
271.	7.975940000000000e-06	2.39299000000000e=02
272.	8.042680000000000e-06	2.4031000000000e-02
273	8 10998000000010-06	2 41397000000000000-02
274	0.17705000000000000000000000000000000000	
2/4.	0.1//85000000000000000	2.42330000000000000000000000000000000000
275.	8.246280000000000e-06	2.4316700000000e=02
276.	8.315290000000001e-06	2.4376000000000e-02
277	8 3848700000000000000000	2 44434000000000000000000000000000000000
270	9 AEE040000000000000000000000000000000000	
278.	8.45504000000001e-06	2.450870000000000e=02
279.	8.525790000000000e-06	2.4581800000000e=02
280.	8.597140000000001e-06	2.4651700000000e-02
281	8 6690800000000000-06	2 4728800000000000000000000000000000000000
201.	0.0090000000000000000000000000000000000	
282.	8./4161999999999999e-06	2.48297000000000e=02
283.	8.814770000000000e-06	2.4891400000000e=02
284.	8.88854000000001e-06	2.49743000000000e-02
285	8 96292000000000000000	2 50636000000000-02
203.	8.90292000000000000000000000000000000000	2.5005000000000000000000000000000000000
286.	9.03/920000000000e-06	2.51219000000000e=02
287.	9.11355000000000e-06	2.5195600000000e-02
288.	9.189810000000000e-06	2.5262200000000e=02
200	0.266710000000000000000	2 5315000000000 02
205.	9.200710000000000 00	2.55150000000000000000000000000000000000
290.	9.344260000000000e-06	2.5389100000000e=02
291.	9.422460000000001e-06	2.5456600000000e=02
292.	9.50130000000000e-06	2.5553900000000e=02
202	0 5002000000000000000000000000000000000	
293.	9.580810000000010-06	2.5612000000000000000000000000000000000000
294.	9.660990000000001e-06	2.56702000000000e-02
295.	9.741829999999999e-06	2.57443000000000e-02
296	9 823350000000000e-06	2 582570000000000=-02
207	9.02555500000000000000000000000000000000	
257.	9.9033300000000000000000	2.55540000000000000000000000000000000000
298.	9.98844999999999999e-06	2.59694000000000e=02
299.	1.007200000000000e-05	2.6020800000000e-02
300.	1.015630000000000e-05	2.60962000000000e-02
201	1 0241200000000000 05	2 61715000000000 02
202	1.029700000000000000000	
302.	1.032/00000000000e-05	2.62497000000000e=02
303.	1.041340000000000e-05	2.6307300000000e=02
304.	1.050060000000000e-05	2.63701000000000e-02
305	1 058840000000000000000000000000000000000	2 6420900000000000000000000000000000000000
206	1 06770000000000000000000000000000000000	
300.	1.00//00000000000000000	2.031800000000000000000000000000000000000
307.	1.076640000000000e-05	2.655/000000000e=02
308.	1.085650000000000e-05	2.66441000000000e-02
309.	1.09473000000000000-05	2.670570000000000e-02
310	1 1038900000000000000	2 680150000000000=-02
211	1 1121200000000000000000000000000000000	
311.	1.1131300000000000e-05	2.00031000000000000000000000000000000000
312.	1.122450000000000e-05	2.69637000000000e=02
313.	1.131840000000000e-05	2.70674000000000e-02
314.	1.1413100000000000e-05	2.71356000000000e-02
315	1 1508600000000000000000000000000000000000	2,724610000000000=-02
515.	1.13080000000000000e=05	2.7240300000000000000000000000000000000000
316.	1.160490000000000e-05	2.72893000000000e=02
317.	1.170200000000000e-05	2.7356300000000e=02
318.	1.18000000000000000e-05	2.7421800000000e-02
319	1 1898700000000000	2 74742000000000000=02
220	1 1000000000000000000000000000000000000	2.77772600000000000000000000000000000000
320.	T.TAA8300000000006-02	2.7340500000000000000000000000000000000000
321.	1.209870000000000e-05	2.7638500000000e=02
322.	1.219990000000000e-05	2.77984000000000e-02
323.	1.23020000000000000000000000000000000000	2.79394000000000e=02
224	1.240500000000000000000000000000000000000	
324.	1.240500000000000e-05	2.805570000000000000002
325.	1.250880000000000e-05	2.8151900000000e=02
326.	1.261340000000000e-05	2.81984000000000e-02
327	1 271900000000000000	2 8294000000000000=02
220	1.202540000000000000000000000000000000000	
328.	1.282540000000000e-05	2.000//00000000000000000000000000000000
329.	1.293270000000000e-05	2.8451400000000e=02
330.	1.304100000000000e-05	2.85152000000000e-02
331	1 31501000000000000000000000000000000000	2.8578300000000000000000000000000000000000
222	1.3130100000000000000000000000000000000	
332.	1.32601000000000e-05	2.864/5000000000e=02
333.	1.337110000000000e-05	2.8714900000000e-02
334.	1.3483000000000000e-05	2.8740800000000e-02
335	1 3595800000000000000000000000000000000000	2,884210000000000=02
335.	1.33938000000000000000	2.00421000000000000000000000000000000000
336.	1.370960000000000e-05	2.8914300000000e=02
337.	1.382430000000000e-05	2.90053000000000e-02
338	1 394000000000000000000	2 906440000000000=02
1		



339	1 405670000000000e-05	2 91571000000000e-02
240	1 4174200000000000000000000000000000000000	2 91643000000000 02
340.	1.41/4300000000000000000000000000000000000	2.9104300000000000000000000000000000000000
341.	1.429290000000000e-05	2.9234000000000000000000000000000000000000
342.	1.441250000000000e-05	2.93339000000000e-02
343.	1.4533100000000000e-05	2.93742000000000e-02
344	1 4654700000000000000	2 94477000000000-02
544.	1.4034/00000000000000000	2.944770000000000000000000000000000000000
345.	1.47774000000000e-05	2.95239000000000e=02
346.	1.490100000000000e-05	2.9604100000000e=02
347	1 502570000000000e-05	2 9739600000000e-02
3/8	1 515140000000000000	2 98318000000000-02
540.	1.515140000000000000000	2.903100000000000000000000000000000000000
349.	1.52/820000000000e-05	2.9941800000000000000000000000000000000000
350.	1.540610000000000e-05	3.00119000000000e-02
351.	1.553500000000000e-05	3.0081800000000e=02
352	1 566500000000000000000	3 017700000000000-02
352.	1.5005000000000000000000000000000000000	3.017740000000000000000000000000000000000
353.	1.5/961000000000e-05	3.023/400000000000000000000000000000000000
354.	1.592830000000000e-05	3.0347100000000e-02
355.	1.606160000000000e-05	3.0387000000000e=02
356.	1.619600000000000e-05	3.0478900000000e=02
357	1 63315000000000000	3 05604000000000-02
557.	1.03313000000000000000	3.0304000000000000000000000000000000000
358.	1.646820000000000e-05	3.0628500000000000000000000000000000000000
359.	1.66060000000000e-05	3.0704300000000e=02
360.	1.674490000000000e-05	3.0773200000000e-02
361	1 68851000000000000	3 0859300000000000000000000000000000000000
362	1.7026400000000000000000000000000000000000	3.001520000000000 02
362.	1.702640000000000e-05	3.0915/00000000000000000000000000000000000
363.	1.716880000000000e-05	3.09807000000000e-02
364.	1.73125000000000e-05	3.1047200000000e=02
365.	1.745740000000000e-05	3.111000000000000e-02
366	1 7603500000000000	3 111890000000000-02
267	1 775080000000000000000000000000000000000	
307.	1.//JU00000000000000000000000000000000000	5.12010000000000000000000000000000000000
368.	1.78993000000000e-05	3.1272600000000e=02
369.	1.804910000000000e-05	3.14397000000000e-02
370.	1.820010000000000e-05	3.153440000000000e-02
371	1 83524000000000000000000000000000000000000	3 16117000000000e=02
272	1.0502400000000000000000	
3/2.	1.8506000000000000e-05	3.1685600000000000000000000000000000000000
373.	1.866090000000000e-05	3.1757600000000e=02
374.	1.881700000000000e-05	3.183400000000000e-02
375.	1.897450000000000e-05	3.1899700000000000=-02
376	1.01333000000000000	
376.	1.91333000000000000000	5.198010000000000000000000000000000000000
377.	1.929340000000000e-05	3.2063000000000e-02
378.	1.945480000000000e-05	3.2126500000000e=02
379.	1.961760000000000e-05	3.2198600000000e=02
380	1 97818000000000000	3 22607000000000-02
500.	1.978188888888	3.22007000000000000000000000000000000000
381.	1.994/30000000000e-05	3.23088000000000000000000000000000000000
382.	2.011430000000000e-05	3.2345000000000e=02
383.	2.028260000000000e-05	3.2422500000000e=02
384	2 045230000000000000	3 245020000000000000000000000000000000000
205	2.04323000000000000000000000000000000000	2.2507800000000000000000000000000000000000
385.	2.06234000000000000000	3.2307800000000000000000000000000000000000
386.	2.079600000000000e-05	3.25426000000000e=02
387.	2.09701000000000e-05	3.2620900000000e=02
388.	2.114550000000000e-05	3.2637700000000e-02
389	2 132250000000000e=05	3 2743400000000000000000000000000000000000
	2.15225000000000000000000000000000000000	5.274540606060606000
390.	2.150090000000000e-05	3.2866200000000e-02
391.	2.168080000000000e-05	3.2983600000000e=02
392.	2.186230000000000e-05	3.3458700000000e=02
393	2 204520000000000e-05	3 3755600000000000000000000000000000000000
394	2 22297000000000000	3 383050000000000-02
205	2.22257000000000000000000000000000000000	3.3545766666666666666
395.	2.2415/000000000000000	5.58427000000000000000000000000000000000000
396.	2.260330000000000e-05	3.37829000000000e=02
397.	2.279240000000000e-05	3.32730000000000e-02
398.	2.298320000000000e-05	3.4976800000000e-02
399	2 317550000000000000	3 59722000000000000=02
1400	2.3260400000000000000000000000000000000000	
400.	2.330940000000000e=05	3.47135000000000000000000000000000000000000
401.	∠.356500000000000e-05	3.39527000000000e=02
402.	2.376220000000000e-05	3.3937200000000e=02
403.	2.396100000000000e-05	3.389270000000000e-02
404.	2.416150000000000e-05	3.38559000000000e=02
105	2 4363700000000000000000000000000000000000	3.4259100000000000-02
105.	2.430370000000000000000000000000000000000	
400.	∠.450/60000000000e-05	5.4/41900000000000000002
407.	2.47732000000000e-05	3.49833000000000e=02
408.	2.49805000000000e-05	3.5077400000000e=02
409.	2.518950000000000e-05	3.5018000000000e-02
410.	2.5400300000000000000	3.4756300000000e-02
411	2 561290000000000000000	3.4768700000000000=-02
412	2.50125000000000000000000000000000000000	
412.	2.302/20000000000000	3.33324000000000000000000000000000000000
413.	2.604330000000000e-05	3.5894000000000e-02
414.	2.62613000000000e-05	3.47687000000000e-02
415.	2.648100000000000e-05	3.4737900000000e-02
416.	2.67026000000000000000000000000000000000	3.4933700000000000000000000000000000000000
117	2 6926100000000000000000000000000000000000	3 555040000000000000000
410	2.0520100000000000000	5.5354560000000000000000000000000000000000
418.	∠./1514000000000e-05	3.51156000000000e=02
419.	2.73786000000000e-05	3.5174500000000e-02
420.	2.760770000000000e-05	3.52387000000000e-02
421	2 7838700000000000	3 534240000000000=-02
100	2.703070000000000000e=05	3.53323000000000000000000000000000000000
422.	∠.80/1/0000000000e-05	3.54215000000000000-02
423.	2.83066000000000e-05	3.5459100000000e=02
424.	2.85435000000000e-05	3.5538900000000e-02
425.	2.878240000000000e-05	3.55958000000000e=02
426	2 90232000000000000	3 564330000000000=-02
107	2.9023200000000000e=05	3.5333300000000000000000000000000000000
427.	2.926610000000000e-05	3.572010000000000000002
428.	2.95110000000000e-05	3.5795900000000e-02
429.	2.975790000000000e-05	3.5854500000000e-02
430	3 0006900000000000000000	3 594430000000000=02
421	2.02501000000000000000000000000000000000	
431.	3.025810000000000e-05	5.6005/0000000000=02
432.	3.05113000000000e-05	3.6075600000000e=02
433.	3.076660000000000e-05	3.6140100000000e-02
434.	3.1024000000000000e=05	3.61911000000000e-02
125	2 12027000000000000000000000000000000000	
400.	3.1203/00000000000000	5.02775000000000000000000000000000000000



436.	3.1545400000000000000000 3.6347700000000000000000000000000000000000	
437.	3.18094000000000e-05 3.63977000000000e-02	
438.	3.20756000000000e-05 3.6467000000000e-02	
439.	3.2344000000000e-05 3.6503300000000e-02	
440	3 26147000000000000000000000000000000000000	
441		
441.	3.267700000000000000000000000000000000000	
442.	3.316280000000000000000005 3.6717400000000000000000000000000000000000	
443.	3.34403000000000e-05 3.6804500000000e-02	
444.	3.37201000000000e-05 3.6854500000000e-02	
445.	3.40023000000000e-05 3.6926400000000e-02	
446	3 42869000000000000000000000000000000000000	
110.	3 45738000000000-5 3 705230000000000-02	
447.	3.43730000000000000000000000000000000000	
448.	3.48631000000000e-05 3.7116500000000e-02	
449.	3.51548000000000e-05 3.7168500000000e-02	
450.	3.54490000000000e-05 3.7247800000000e-02	
451.	3.57457000000000e-05 3.7297700000000e-02	
452.	3.60448000000000e-05 3.7365900000000e-02	
153	3 634640000000000000000 3 7324700000000000000000000000000000000000	
455.	2. CECCO000000000 C 2. 2. 724/0000000000 C 2.	
454.	3.665060000000000000-05 3.7354300000000000000000000000000000000000	
455.	3.695730000000000000000 3.7428000000000000000000000000000000000000	
456.	3.72665000000000e-05 3.7569600000000e-02	
457.	3.75784000000000e-05 3.7733400000000e-02	
458.	3.789290000000000e-05 3.7828900000000e-02	
159	3 820880000000000-05 3 78463000000000-02	
455.		
400.	3.83297000000000e-05 3.7889000000000e-02	
461.	3.8852100000000000000000 3.804580000000000000000000000000000000000	
462.	3.91772000000000e-05 3.8209100000000e-02	
463.	3.95051000000000e-05 3.8292100000000e-02	
464.	3.98356000000000e-05 3.8412000000000e-02	
465	4 016900000000000000000 3 85492000000000000000000000000000000000000	
166	4.05051000000000000000000000000000000000	
400.		
46/.	4.08441000000000=-05 3.866930000000000=-02	
468.	4.11859000000000e-05 3.8593300000000e-02	
469.	4.15305000000000e-05 3.8380100000000e-02	
470.	4.18781000000000e-05 3.8245900000000e-02	
471	4 22285000000000000000 3 8517800000000000000000000000000000000000	
472	4 2581900000000000 = 05 3 9177000000000= 02	
472		
4/3.	4.29382000000000e-05 4.002/900000000e-02	
474.	4.329750000000000e-05 4.0764700000000e-02	
475.	4.36599000000000e-05 4.0594500000000e-02	
476.	4.40252000000000e-05 3.9086200000000e-02	
477.	4.43936000000000e-05 3.6483400000000e-02	
478	4 476510000000000-05 3 2678000000000000-02	
470.		
4/9.	4.51397000000000000000000000000000000000000	
480.	4.55174000000000e-05 3.8324300000000e-02	
481.	4.58983000000000e-05 4.3124200000000e-02	
482.	4.62824000000000e-05 4.4501100000000e-02	
483.	4.66697000000000e-05 4.4937000000000e-02	
484	4 7060300000000000000 4 5210700000000000000000000000000000000000	
404.	4.7000000000000000000000000000000000000	
403.	4.7454100000000000000000000000000000000000	
486.	4.785120000000000000000 4.55041000000000000000000000000000000000	
487.	4.82516000000000e-05 4.5674100000000e-02	
488.	4.86554000000000e-05 4.5791700000000e-02	
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493.	5.07255000000000e-05 4.6258700000000e-02	
494.	5.1150000000000e-05 4.6429300000000e-02	
495.	5.1578000000000e-05 4.6484400000000e-02	
496.	5.20096000000000e-05 4.655000000000e-02	
497	5 244490000000000000000000000000000000000	
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499.	5.32555000000000e-05 4.0/143000000000e-02	
500.	5.3//25000000000=-05 4.6/692000000000=-02	
501.	5.42225000000000e-05 4.6996100000000e-02	
502.	5.46762000000000e-05 4.7136200000000e-02	
503.	5.51338000000000e-05 4.72141000000000e-02	
504.	5.55951000000000e-05 4.7243600000000e-02	
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506	5.6529500000000000000000000000000000000000	
507	5 700250000000000000000 5 4 7482700000000000000000000000000000000000	
500		
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509.	5./96050000000000e-05 4./583100000000e-02	
510.	5.84456000000000e-05 4.7718800000000e-02	
511.	5.89346000000000e-05 4.7802000000000e-02	
512.	5.94278000000000e-05 4.7856000000000e-02	
513	5 99251000000000c=05 4 79917000000000c=02	
514	6.04266000000000000000000000000000000000	
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516.	6.14421000000001e-05 4.8325800000000e-02	
517.	6.19563000000000e-05 4.8412600000000e-02	
518.	6.247469999999999e-05 4.8482700000000e-02	
519.	6.29975000000000e-05 4.8583000000000e-02	
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321.	6.405650000000000000 5 4.877140000000000-UZ	
522.	6.45923000000000e-05 4.886030000000e-02	
523.	6.513289999999999e-05 4.8976700000000e-02	
524.	6.56779000000000e-05 4.8814800000000e-02	
525.	6.62275000000000e-05 4.8756400000000e-02	
526	6 67817000000001e-05 4 8883300000000e-02	
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500	0.73405000000000000000 4.9156500000000000000000000000000000000000	
528.	6./90400000000000000 4.94092000000000e-02	
529.	6.84723000000000e-05 4.9579200000000e-02	
530.	6.904529999999999e-05 4.9678200000000e-02	
531.	6.962299999999999e-05 4.9721700000000e-02	
532	7.02057000000000000000000000000000000000	



533	7 079320000000000e-05	4 9670400000000e-02
	1.0193200000000000000000000000000000000000	1.5676466666666666666
534.	7.138560000000000e-05	4.97482000000000e=02
535	7 198290000000000e-05	5 02400000000000e=02
526	7 25952000000001 25	
	1.230330000000000000	J. UJIZUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
537.	7.31927000000000e-05	5.02528000000000e-02
620	7 2005200000000000	5 04003000000000 03
550.	7.38032000000000000000000	3.04353000000000000000000000000000000000
539.	7.442280000000000e-05	5.0519400000000e-02
540	7 5045600000000000-05	5 05403000000000000000000000000000000000
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541.	7.56736000000001e-05	5.0699900000000e-02
542	7 63068000000000000-05	5 10012000000000000000000000000000000000
J42.	7.0300000000000000000000000000000000000	3.10012000000000000000000000000000000000
543.	7.694540000000000e-05	5.11162000000000e=02
544.	7.758930000000000e-05	5.1234700000000e=02
5 4 F	7.0000000000000000000000000000000000000	
545.	7.823850000000000e-05	5.12855000000000e=02
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E 4 7	7 055240000000000 05	
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554.	8.433210000000000e-05	5.19907000000000e-02
555.	8.503779999999999e-05	5.2033500000000e=02
E E C	8 574040000000000 05	5 19955000000000 02
556.	8.5749400000000000000000	5.19995000000000000000000000000000000000
557.	8.646690000000000e-05	5.2244800000000e-02
558	8 719050000000010-05	5 24618000000000000000000000000000000000000
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JJY.	o./9∠010000000001e-05	J.2020JUUUUUUUUe=U2
560.	8.8655900000000010-05	5.27177000000000e-02
5 C 1	0.0007000000000000000000000000000000000	5. 2724200000000000 02
JU1.	0.303/000000000000000000	5.2/54200000000000000000000000000000000000
562.	9.014589999999999e-05	5.28672000000000e-02
563	9 090020000000000 05	5.26774000000000-02
	5.000000000000000000000000000000000000	3.2377433300000000 02
564.	9.166090000000000e-05	5.2900900000000e-02
565	9 242790000000000000000	5 317750000000000-02
	5.242,5000000000000e=03	
566.	9.320140000000001e-05	5.3276400000000e=02
567.	9.3981300000000000-05	5.33934000000000e-02
568.	9.4/6//000000000e-05	5.34//200000000e=02
569.	9.556080000000000e-05	5.34957000000000e-02
570	0 63604000000001 05	5.2569600000000000000000
570.	9.636040000000001e-05	5.3569600000000000000000000000000000000000
571.	9.71668000000000e-05	5.3648200000000e=02
570	0 7070000000000000000000000000000000000	5 28246000000000 02
572.	9.797990000000000e=05	3.38246000000000000000000000000000000000000
573.	9.879980000000000e-05	5.3914900000000e-02
574	9 96266000000000000-05	5 40844000000000000000000000000000000000
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5/5.	1.004600000000000e-04	5.42497000000000e=02
576	1 01301000000000e-04	5 45028000000000e=02
570.	1.0130100000000000000000000000000000000	
5//.	1.02149000000000000000	5.4075200000000000000000000000000000000000
578.	1.03003000000000e-04	5.3717600000000e=02
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5/9.	1.03865000000000000000	5.4058300000000000000000000000000000000000
580.	1.047340000000000e-04	5.4344300000000e-02
601	1 056110000000000 04	5 42669000000000 02
381.	1.056110000000000000000	5.4288900000000000000000000000000000000000
582.	1.064950000000000e-04	5.4636100000000e-02
593	1 0738600000000000-04	5 4678800000000000000000000000000000000000
505.	1.07500000000000000000000000000000000000	3.40/00000000000000000000000000000000000
584.	1.082850000000000e-04	5.5047200000000e-02
595	1 0919100000000000-04	5 52221000000000000000000000000000000000
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587	1 110260000000000e-04	5 53825000000000e=02
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200.	1.119550000000000000000	5.54808000000000000000000000000000000000
589.	1.128920000000000e-04	5.5561100000000e-02
500	1 120260000000000 04	5 55728000000000 02
590.	1.138360000000000000000	5.55/58000000000000000000000000000000000
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502	1 157500000000000 04	5 59461000000000 02
500	1.1373000000000000000000	5.5555555555555555555555555555555555555
593.	1.167180000000000e-04	5.5468000000000e-02
594.	1.176950000000000000	5.5399000000000e=02
	1 1000000000000000000000000000000000000	5 5000000000000000000000000000000000000
JYJ.	1.18680000000000000e-04	a.aaaaouuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuu
596.	1.19673000000000e-04	5.59652000000000e-02
597	1 206740000000000 04	5 63885000000000-02
<i>JJ</i> .	1.200/40000000000000	5.050555000000000=02
598.	1.21684000000000e-04	5.6167700000000e-02
599	1 22702000000000000000000	5 6098300000000002
	1.0070000000000000000000000000000000000	
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601.	1.247650000000000e-04	5.69787000000000e-02
602	1 2580900000000000000000000000000000000000	5. 76880000000000-02
002.	1.23009000000000000e=04	5.7050000000000000000000000000000000000
603.	1.268620000000000e-04	5.87588000000000e=02
604.	1.27923000000000000=04	5.8647000000000e=02
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. CU0	⊥.∠89930000000000e-04	5./1/200000000000000000000000000000000000
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607	1 31162000000000 04	5 12484000000000-02
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608.	1.322590000000000e-04	4.86510000000000e=02
609.	1.333660000000000000	5.71237000000000e-02
c10	1 24402000000000000000000000000000000000	
OTO.	1.3448∠0000000000e-04	J.0440400000000000000000000000000000000
611.	1.35607000000000e-04	5.87187000000000e-02
61.2	1 36742000000000000000000000000000000000000	5 90880000000000-02
V12.	1.30742000000000000000	
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615.	1.40204000000000e-04	5.95964000000000e=02
616.	1.4137700000000000e-04	5.96775000000000e=02
·	1 425000000000000000000000000000000000000	
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623	1 4986900000000000000000000000000000000000	6.0338600000000e-02
	1.4900900000000000000000	
624.	1.51123000000000e-04	6.0485100000000e=02
625.	1.523880000000000000	6.04764000000000e-02
	1 52000000000000000000000000000000000000	
b∠b.	1.536630000000000e-04	6.0/63100000000e=02
627.	1.5494900000000000e-04	6.0876700000000e-02
	1 50040000000000000000000000000000000000	
o∠d.	⊥.ɔb∠4bUUUUUUUU000e-04	0.09064000000000000000000000000000000000
629.	1.575530000000000000000	6.08509000000000e-02
 and the second		



630.	1.588710000000000e-04	6.1081300000000e-02
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0001.	1.00201000000000000000	0.11231000000000000000000000000000000000
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633.	1.628930000000000e-04	6.1428400000000e-02
634	1 6425700000000000-04	6 1484200000000000000000000000000000000000
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636.	1.670170000000000e-04	6.1734800000000e-02
637	1 68415000000000000000000000000000000000000	6 19700000000000e-02
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639.	1.712450000000000e-04	6.2165000000000e-02
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641	1 7412200000000000 04	6 262470000000000 02
041.	1.7412300000000000000000	0.2024/393939393990-02
642.	1.755800000000000e-04	6.2736600000000e-02
643.	1.770490000000000e-04	6.2720200000000e=02
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645.	1.800250000000000e-04	6.29665000000000e-02
646.	1.815320000000000e-04	6.3122100000000e-02
647	1 8305100000000000000000000000000000000000	6 31565000000000e-02
640	1.04500000000000000000000000000000000000	
648.	1.845820000000000e-04	6.33572000000000e=02
649.	1.861270000000000e-04	6.34548000000001e-02
650	1 876850000000000e-04	6 4308000000000e=02
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651.	1.892550000000000e-04	6.3195699999999999990-02
652.	1.908390000000000e-04	6.22768000000000e-02
653.	1.924360000000000e-04	6.308759999999999e=02
654	1 040460000000000 04	6 224720000000000 02
034.	1.94040000000000000000000000000000000000	0.33473000000000000000000000000000000000
655.	1.956700000000000e-04	6.37378000000000e-02
656.	1.97307000000000e-04	6.38788000000000e-02
657	1 989580000000000000000000000000000000000	6 426490000000000-02
657.	1.90930000000000000000000000000000000000	
000.	∠.006230000000000e-04	0.424//UUUUUUUUUUUUUUUUUU
659.	2.02302000000000e-04	6.4587300000000e-02
660.	2.03995000000000000	6.45705000000000e=02
661	2 05702000000000000000	6 464240000000000 02
001.	2.05/0200000000000e-04	0.4043400000000000000000000000000000000
662.	2.07423000000000e-04	6.5415100000000e-02
663.	2.091590000000000e-04	6.38696000000000e-02
664	2 1000000000000000000000000000000000000	6 4807400000000000000
	2.10909000000000000000	
665.	2.12674000000000e-04	6.53762000000000e=02
666.	2.144540000000000e-04	6.54749000000000e-02
667	2 162400000000000 04	6 55418000000000 02
007.	2.1024900000000000000000000000000000000000	0.55410000000000000000000000000000000000
668.	2.180580000000000e-04	6.55694000000000e-02
669.	2.198830000000000e-04	6.579889999999999e-02
670	2 217230000000000e-04	6 5710200000000e=02
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6/1.	2.23578000000000e-04	6.60298000000000e=02
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675.	2.311570000000000e-04	6.6364600000000e-02
676.	2.330910000000000e-04	6.6321400000000e-02
677	2 35042000000000000-04	6 6558300000000000000000000
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678.	2.370080000000000e-04	6.65901000000000e-02
679.	2.38992000000000e-04	6.5810800000000e-02
680	2 409920000000000e-04	6 6943900000000e-02
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681.	2.430080000000000e-04	6./2081000000001e-02
682.	2.450420000000000e-04	6.7272600000000e=02
683.	2.470920000000000e-04	6.74855000000000e=02
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685.	2.512450000000000e-04	6.732879999999999e-02
686.	2.533480000000000e-04	6.73157000000001e-02
687	2 5546800000000000000000000000000000000000	6 76831000000000-02
	2.534550000000000000000000000000000000000	
688.	∠.5/6050000000000e-04	6./6554UU0UUUUUUUU=U2
689.	2.597610000000000e-04	6.7787200000001e-02
690	2 61935000000000000000000000000000000000000	6 757520000000000-02
601	2 64127000000000000000	
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692.	2.66337000000000e-04	6.7988200000000e-02
693.	2.685660000000000e-04	6.80343000000001e-02
694	2 708130000000000 04	6 80458000000001c-02
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695.	∠./30/9000000000e-04	6./84/2000000000e=02
696.	2.75365000000000e-04	6.6806000000000e-02
697.	2.776690000000000000000000000000000000000	6.7907899999999999=-02
698	2 7000200000000000000000000000000000000	6 824000000000000000000000000000000000000
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699.	2.823350000000000e-04	6.82546000000000e=02
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701	2 87080000000000000000000000000000000000	6.73159000000000-02
702	2.0,00000000000000000000000000000000000	
/02.	∠.8948300000000000e-04	0./4003000000000000000000000000000000000
703.	2.91905000000000e-04	6.6460700000000e-02
704.	2.9434800000000000000000000000000000000000	6.72838000000001e-02
705	2.06011000000000000000000000000000000000	
/05.	∠.968110000000000e-04	0./U043333333333990=UZ
706.	2.99295000000000e-04	6.6279599999999999e-02
707.	3.017990000000000e-04	6.5673500000000e-02
708	3 0432500000000000000000000000000000000000	6 46840999999999990000
700	2.0007200000000000000000000000000000000	
103.	3.068/∠0000000000e-04	0.3303300000000TG=05
710.	3.094390000000000e-04	6.2506800000000e-02
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710	2.146400000000000000000000000000000000000	
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713.	3.17273000000000e-04	5.6516300000000e-02
714.	3.199280000000000e-04	5.30643000000000e-02
715	3 226050000000000000000000000000000000000	4 91938000000000a-02
/13.	3.22003000000000000e-04	4.515300000000000000000000000000000000000
/16.	3.25305000000000e-04	4.519100000000000e-02
717.	3.28027000000000e-04	4.09787000000000e-02
718	3 307720000000000000000	3 69644000000000000000
710	2.3357720000000000000000000000000000000000	
/19.	3.335400000000000e-04	3.359980000000000e=02
720.	3.363310000000000e-04	3.16124000000000e-02
721	3 39145000000000000000000000000000000000000	3 1558600000000000000000000000000000000000
722	2.41002000000000000000000000000000000000	
122.	3.4198300000000000e-04	3.3/3II000000000000000000000000000000000
723.	3.44845000000000e-04	3.7574000000000e-02
724.	3.47731000000000000	4.15767000000000e-02
725	3 5064100000000000000000000000000000000000	4 58694000000000002
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/26.	3.535/50000000000e-04	5.1004200000000000=02



727.	3.56534000000000e=04 5.49331000000000e=02	
728.	3.59517000000000e-04 5.70257000000000e-02	
729.	3.6252600000000e-04 6.0555600000000e-02	
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732.	3.717050000000000000000000000000000000000	
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736.	3.8430200000000e-04 7.18585000000001e-02	
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741.	4.0065300000000e-04 7.4940300000000e-02	
742.	4.0400600000000e-04 7.5653000000000e-02	
743.	4.07386000000000e-04 7.55471000000001e-02	
744	4 1079500000000000000000000000000000000000	
744.		
/45.	4.1425500000000000000000000000000000000000	
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747.	4.2119500000000e-04 7.8172900000000e-02	
748.	4.2472000000000e-04 7.8644400000000e-02	
749.	4.28274000000000e-04 7.8814700000000e-02	
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751.		
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759		
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762.	4.7727600000000e-04 8.2936200000000e-02	
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768.	5.01747000000000e-04 8.46815000000001e-02	
769	5 059460000000000-04 8 44618000000000-02	
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773.	5.2309500000000e-04 8.4663300000000e-02	
774.	5.27472000000000e-04 8.5794500000000e-02	
775.	5.3188600000000e=04 8.65661000000001e=02	
776	5 363370000000000-04 8 53780000000102	
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///·	5.4082500000000000000000000000000000000000	
778.	5.45351000000000e-04 8.7621000000000e-02	
779.	5.49914000000000e-04 8.74290000000001e-02	
780.	5.5451600000000e-04 8.7601200000000e-02	
781.	5.5915600000000e-04 8.7456999999999e-02	
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783	5.685540000000000-04.8.889260000000102	
783.	5.65540000000000000000000000000000000000	
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786.	5.8294700000000e-04 8.80858000000001e-02	
787.	5.87825000000000e-04 9.14940000000001e-02	
788.	5.9274400000000e-04 9.25215000000001e-02	
789	5.97704000000000e-04 8.77636000000000-02	
790		
750.		
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793.	6.1796300000000e-04 9.2883200000000e-02	
794.	6.2313400000000e-04 9.0441499999999e-02	
795.	6.28349000000001e-04 9.2765900000000e-02	
796.	6.3360700000000e-04 9.2890400000000e-02	
797.	6.3890900000000e-04 9.3802399999999-02	
798	6 442560000000000-04 9 4550300000000-02	
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800.	6.55083000000000e-04 9.65667999999999e-02	
801.	6.6056500000000e-04 9.56197000000000e-02	
802.	6.6609300000000e-04 9.0531000000000e-02	
803.	6.7166700000000e-04 9.4654900000000e-02	
804	6.77287000000001e-04 9.50608000000000-02	
805	6 829550000000000_04 9 43698000000000_02	
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807.	6.9443300000000le-04 9.46227000000000e-02	
808.	7.0024400000000e-04 9.6639300000000e-02	
809.	7.0610400000000e-04 9.7764900000000e-02	
810.	7.1201300000000e-04 9.5391599999999e-02	
811	7 179710000000000-04 9 76789000000000-02	
012		
012	7.20972000000000000000000000000000000000	
813.	7.3003/00000000e-04 9.86989000000001e-02	
814.	7.3614600000000e-04 9.83702000000001e-02	
815.	7.4230700000000e-04 9.8749600000001e-02	
816.	7.4851800000000e-04 9.92225000000001e-02	
817	7 547820000000000-04 9 859220000000001e-02	
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820.	7.7388900000000e-04 1.0064800000000e-01	
821.	7.80365000000000e-04 1.00521000000000e-01	
822.	7.8689600000000e-04 1.0096500000000e-01	
823	7.93481000000000-04.1.004650000000000-01	



824.	8.001210000000000e-04	1.01638000000000e-01
825.	8.06816000000000e-04	1.02761000000000e-01
826.	8.135680000000000e-04	1.01680000000000e-01
827	8 20376000000001e-04	1 026670000000000000000000000000000000000
929	8 272410000000000000000	9.963320000000010-02
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831.	8.48182000000000e-04	1.0560500000000e-01
832.	8.552800000000000e-04	1.00971000000000e-01
833	8 624370000000000e-04	1 010760000000000-01
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837.	8.916700000000000e-04	1.0589600000000e-01
838.	8.99131000000000e-04	1.06034000000000e-01
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041.	9.218930000000000000000	1.0789200000000000000000000000000000000000
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843.	9.373860000000000e-04	1.0786000000000e-01
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845.	9.531400000000000e-04	1.1164100000000e=01
846	9 6111600000000000000000	1.05557000000000000000000000000000000000
040.	9.6111000000000000000000	1.05557000000000000000000000000000000000
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848.	9.772690000000000e-04	1.0966000000000e-01
849.	9.85447000000000e-04	1.13255000000000e-01
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052.	1.0100500000000000000000000000000000000	
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854.	1.027380000000000e-03	1.116990000000000e-01
855.	1.035970000000000e-03	1.11995000000000e-01
856.	1.0446400000000000e-03	1.11853000000000e-01
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861.	1.089090000000000e-03	8.8354400000000e-02
862	1 098200000000000000000000000000000000000	8 1305800000000000000000000000000000000000
0.62	1 10720000000000000000000000000000000000	8.742000000000000 02
003.	1.1073900000000000000000000000000000000000	0.742333333333333339
864.	1.1166600000000000e-03	1.0523400000000000000000000000000000000000
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866.	1.135430000000000e-03	1.13813000000000e-01
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869.	1.164170000000000e-03	1.3626800000000e=01
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971	1 1837300000000000000000000000000000000000	1.3679700000000000000000000000000000000000
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8/2.	1.19364000000000000000	1.3959600000000000000000000000000000000000
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874.	1.213700000000000e-03	1.40788000000000e-01
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077	1 24442000000000000000000000000000000000	1.45672000000000000000000000000000000000000
077.	1.24442000000000000000000000000000000000	1.430380000000000000000000000000000000000
8/8.	1.254840000000000e-03	1.364/300000000000000000000000000000000000
8/9.	1.265340000000000e-03	1.43059000000000e=01
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881.	1.286600000000000e-03	1.44892000000000e-01
882.	1.297370000000000e-03	1.45975000000000e-01
883.	1.308230000000000000000000000000000000000	1.44008000000000e-01
884	1 31919000000000000000000000000000000000	1 46037000000000000000000
885	1 33022000000000000000000000000000000000	1 4520900000000000=-01
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000.	1.3413500000000000e-03	1.43416000000000000000000000000000
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888.	1.363890000000000e-03	1.48602000000000e-01
889.	1.375300000000000e-03	1.50535000000000e-01
890.	1.3868100000000000000000000000000000000000	1.52023000000000e-01
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002	1 41012000000000000000000000000000000000	
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895.	1.445820000000000e-03	1.50757000000000e-01
896.	1.457910000000000e-03	1.52162000000000e-01
897.	1.47011000000000000000000000000000000000	1.5508700000000000=-01
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	1.40402000000000000000000000000000000000	1.54/52/0000000000000000000000000000000000
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901.	1.519940000000000e-03	1.5761000000000e-01
902.	1.532660000000000e-03	1.44927000000000e-01
903.	1.545490000000000e-03	1.53785000000000e-01
904.	1.558420000000000e-03	1.5503000000000e-01
905.	1.57146000000000000000000000000000000000000	1.5545800000000000000-01
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007	1.503030000000000000000	
307.	T.22/8/0000000000e-03	1.5/500000000000000000000000000000000000
908.	1.611250000000000e-03	1.5038500000000000000000
909.	1.624730000000000e-03	1.53606000000000e=01
910.	1.63832000000000e-03	1.5569900000000e-01
911.	1.652030000000000e-03	1.64961000000000e-01
912.	1.665860000000000e-03	1.62521000000000e-01
913.	1.6798000000000000e-03	1.6589300000000e-01
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015	1 708030000000000000000000000000000000000	
010	1.700030000000000000000	1.0033000000000000000000000000000000000
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919.	1.76592000000000e-03	1.65332000000000e-01
920.	1.78070000000000e-03	1.72182000000000e-01
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521.	
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923.	1.82578000000000e-03 1.6784900000000e-01
924	1 8410600000000000000000000000000000000000
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925.	1.85646000000000e-03 1.6696400000000e-01
926.	1.87200000000000e-03 1.6893000000000e-01
927	1 887660000000000000000000000000000000000
927.	1.887660000000000000000000000000000000000
928.	1.9034600000000e-03 1.6857700000000e-01
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930.	1.9354500000000000000000000000000000000000
931.	1.9516500000000e-03 1.7566000000000e-01
932	1 96798000000000000001 1 75284000000000000000000000000000000000000
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935	2 01780000000000-03 1 69421000000000-01
5555.	
936.	2.0346800000000000000000000000000000000000
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938	2 06888000000000-03 1 6361200000000-01
550.	
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541.	2.12123000000000000000000000000000000000
942.	2.139000000000e=03 1.611990000000e=01
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944	2 17495000000000000000000000000000000000000
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947	2 23001000000000=03 1 46322000000000=01
948.	2.2400/000000000000000000000000000000000
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950.	2.2864700000000e=03 1.3590100000000e=01
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1 apt.	2.30500000000000000000000000000000000000
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954.	2.303300000000000000 1.3851800000000000000000000000000000000000
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956	2 4036900000000000000000000000000000000000
057	
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958.	2.4440900000000e-03 1.5499600000000e-01
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555.	2.40434000000000000000000000000000000000
960.	2.4851/000000000e=03 1.3826500000000e=01
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962	2 52694000000000000000000000000000000000000
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505.	2.39090000000000000000000000000000000000
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976.	2.83963000000000e-03 1.9208100000000e-01
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977.	2.8633900000000000000000000000000000000000
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979.	2.9115100000000e-03 1.8884100000000e-01
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983.	3.0102000000000e-03 1.9449600000000e-01
0.04	2.0252800000000000 02.1.024480000000000000000000000000000000000
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986.	3.0864000000000e-03 1.8963800000000e-01
987	3 11223000000000000000000000000000000000
988.	3.138280000000000000 1.994220000000000000000
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990.	3.1910200000000e-03 1.9713000000000e-01
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391.	5.21//2000000000000000 I.93/0400000000000000000000000000000000000
992.	3.2446500000000e-03 2.0399700000000e-01
993.	3.2718000000000e-03 2.06207000000000e-01
001	3 29180000000000-03 1 999220000000000 01
<i>22</i> 1 .	3.2371000000000000000000000000000000000000
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997	3 382700000000000-03 1 85856000000000-01
998.	3.4110000000000000023 2.084/500000000000000000000000000000000000
999.	3.43955000000000e-03 2.0740000000000e-01
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1001.	5.43/30/30/00/00/2002 20.3380/00/00/00/00/00 DI
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1007.	
1005.	3.61590000000000e-03 2.0380000000000e-01
1006.	3.6461600000000e-03 1.9796500000000e-01
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1009.	3.7384600000000e-03 1.9581400000000e-01
1010.	3.7697400000000e-03 1.965700000000000-01
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1011.	3.801730000000000-03 1.803180000000000-01
1012.	3.8331000000000e-03 1.8896200000000e-01
1013.	3.86518000000000e-03 1.7977300000000e-01
1014	2 80752000000000 02 1 7241000000000 01
1014.	5.85/5200000000000000000000000000000000000
1015.	3.93014000000000e-03 1.6513500000000e-01
1016.	3.9630200000000e-03 1.6376100000000e-01
1017	3 9961900000000000 1 60080000000000 01
±0±/.	5.5515555555556666 05 1.0905566666666 01



1018.	4.029630000000000e-03	1.73088000000000e-01
1010	4 062250000000000 02	1 76073000000000 01
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1022.	4.166210000000000e-03	1.8647600000000e-01
1023	4 2010800000000000000000	1 8464300000000000000000000000000000000000
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1026.	4.307430000000000e-03	1.91967000000000e-01
1027	4 3434700000000000000000	1.91725000000000000000000000000000000000000
1027.	4.34347000000000000000000000000000000000	1.91/23000000000000000000000000000000000000
1028.	4.3/982000000000000000	1.94602000000000e-01
1029.	4.416470000000000e-03	1.98788000000000e-01
1030.	4.453430000000000e-03	1.99453000000000e-01
1031	4 49069000000000000000000000000000000000	2 0392800000000000000000000000000000000000
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1033.	4.566160000000000e-03	2.02421000000000000000000000000000000000
1034.	4.604370000000000e-03	2.03241000000000e-01
1035.	4.642910000000000e-03	2.06083000000000e-01
1036	4 6817600000000000-03	2.07420000000000-01
1027	4.001/0000000000000000000000000000000000	
1037.	4.7209400000000000000000	2.04929000000000000000000000000000000000
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1040	4 840450000000000e-03	2 10119000000000-01
1041	4 000050000000000 03	2.1149300000000000000000000000000000000000
1041.	4.880950000000000e-05	2.1148700000000000000000000000000000000000
1042.	4.921800000000000e-03	2.1162900000000000000000000000000000000000
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1044.	5.004510000000000e-03	2.14189000000000e-01
1045	5 0463900000000000000000000000000000000000	2 1265500000000e-01
1046	5.0405500000000000000000000000000000000	2.1243400000000000000000000000000000000000
1040.	J.08882000000000000000000000000000000000	2.144/40000000000000000000000000000000000
1047.	5.13120000000000e-03	2.13198000000000e-01
1048.	5.174140000000000e-03	2.14982000000000e-01
1049.	5.2174400000000000000000000000000000000000	2.16657000000000e-01
1050	5 261100000000000000000000000000000000000	2 157380000000000000000
1051	5.20110000000000000000000000000000000000	2.13/330000000000000000000000000000000000
1051.	5.305130000000000e-03	2.14293000000000000000000000000000000000000
1052.	5.34952000000000e-03	2.15284000000000e-01
1053.	5.3942900000000000e-03	2.10954000000000e-01
1054.	5.439430000000000000000000000000000000000	2.102070000000000e-01
1054.	5.4554500000000000000000000000000000000	
1055.	5.484940000000000e-03	2.08/88000000000000000000000000000000000
1056.	5.530840000000000e-03	1.98474000000000e-01
1057.	5.57713000000000e-03	1.9610000000000e-01
1058.	5.623800000000000e-03	1.954540000000000e-01
1050	5 670860000000000000000000000000000000000	
1039.	5.87088000000000000000000000000000000000	1.8304200000000000000000000000000000000000
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1061.	5.76616000000000e-03	2.0117900000000e-01
1062.	5.814420000000000e-03	2.11455000000000e-01
1063	5 8630700000000000-03	2 115350000000000000000000000000000000000
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1064.	5.912130000000000e-03	2.151850000000000000000000000000000000000
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1067.	6.061800000000000e-03	1.97211000000000e-01
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1000.	0.11255000000000000000000000000000000000	
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1071.	6.267270000000000e-03	1.71529000000000e-01
1072	6 3197100000000000-03	1 747730000000000-01
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1073.	0.37200000000000000000000000000000000000	
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1076.	6.533920000000000e-03	1.90629000000000e-01
1077	6 58860000000000000000000000000000000000	1 8808200000000000-01
1077.	6.5000000000000000000000000000000000000	
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T0./a.	6.699330000000000e-03	1.9980100000000e-01
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1081.	6.811920000000000e-03	1.93752000000000e-01
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1084.	6.984360000000000e-03	1.8184500000000000000000000000000000000000
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1086.	7.10174000000000e-03	1.73337000000000e-01
1087.	7.161170000000000000000	1.71513000000000e-01
1088	7 22110000000000 03	1 62920000000000e=01
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1003.	7.201320000000000000000000000000000000000	1.52555000000000000000000000000000000000
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1091.	7.40390000000000e-03	1.51979000000000e-01
1092.	7.4658600000000000000	1,441290000000000e-01
1093	7 528330000000000 03	1 409920000000000000000000000000000000000
1093.	7.5265300000000000000000	1.305520000000000000000000000000000000000
1094.	1.2213300000000000e-03	1.3200300000000000-01
1095.	7.65486000000000e-03	1.28201000000000e-01
1096.	7.71891000000000e-03	1.25959000000000e-01
1097.	7.783510000000000e-03	1.24893000000000e-01
1098	7 84864000000010 03	1.2029300000000000=01
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1103	8 182580000000000 03	1 3912600000000000=01
1104	0.10230000000000000000000000000000000000	1.4091200000000000000000000000000000000000
1104.	8.251049999999999e-03	1.422620000000000000000000000000000000000
1105.	8.32009000000001e-03	1.49651000000000e-01
1106.	8.389720000000000e-03	1.50199000000000e-01
1107.	8.4599299999999999999	1.47731000000000e-01
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1108.	0.0307200000000000e-03	1.0340200000000000000000
1109.	8.602110000000000e-03	1.68227000000000e=01
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1112	8 81987000000010 03	1 8322900000000000 = 01
1112	0.0190/000000000000000000000000000000000	1.03323000000000000000000000000000000000
1113.	8.8936/99999999999e-03	T.8.43.0000000006-01
1114.	8.968100000000000e-03	1.96422000000000e-01



1115.	9.043150000000000e-03	2.0475200000000e-01
1116	9 118820000000000e-03	2 11424000000000000000000000000000000000
1117	0.105120000000000-03	
111/.	9.19512999999999999	2.1789700000000000000000000000000000000000
1118.	9.27207000000000e-03	2.2598000000000e-01
1119.	9.349659999999999e-03	2.3461000000000e-01
1120	9 42790000000000000-03	2 37183000000000e-01
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1121.	9.306/999999999999900	2.370550000000000000000000000000000000000
1122.	9.586350000000000e-03	2.50478000000000e-01
1123.	9.666569999999999e-03	2.46556000000000e-01
1124	9 747460000000000000000000000000000000000	2 54881000000000-01
1105	5.7474000000000000 05	
1125.	9.82903000000001e-03	2.63481000000000000000000000000000000000000
1126.	9.911280000000000e-03	2.6416000000000e-01
1127.	9.994220000000000e-03	2.70364000000000e-01
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1120.	1.00//8000000000e-02	2.7282500000000000000000000000000000000000
1129.	1.016220000000000e-02	2.707490000000000000000000000000000000000
1130.	1.024720000000000e-02	2.6505000000000e-01
1131.	1.033300000000000e-02	2.75119000000000e-01
1132	1 04194000000000000000000000000000000000	2 72024000000000000000000000000000000000
1152.	1.04154000000000000000000000000000000000	
1133.	1.050660000000000e-02	2.7887600000000e-01
1134.	1.059460000000000e-02	2.8604400000000e-01
1135	1 068320000000000e-02	2 8766100000000e-01
1120	1.077260000000000000000000000000000000000	
1130.	1.0772000000000000000000	2.93393000000000000000000000000000000000
1137.	1.086280000000000e-02	2.93782000000000000000000000000000000000000
1138.	1.095370000000000e-02	2.91267000000000e-01
1139	1 104530000000000e-02	2 97090000000000000000000000000000000000
1140	1 1127800000000000000000000000000000000000	
1140.	1.113/8000000000000000	3.0000000000000000000000000000000000000
1141.	1.123090000000000e-02	2.89583000000000e-01
1142.	1.132490000000000e-02	3.08189000000000e-01
1143.	1.1419700000000000e-02	3.08241000000000e-01
1144	1 15153000000000000000000000000000000000	3 123760000000000000000
1144.	1.15135000000000000000000000000000000000	5.1257000000000000000000000000000000000000
1145.	1.16116000000000e-02	3.08609000000000e-01
1146.	1.170880000000000e-02	3.1106100000000e-01
1147.	1.1806800000000000e-02	3.10814000000000e-01
1148	1 1905600000000000000000000000000000000000	3 123430000000000000000
1140.	1.19030000000000000000000000000000000000	5.1254500000000000000000000000000000000000
1149.	1.200520000000000e-02	3.1023A000000006-01
1150.	1.210570000000000e-02	3.12749000000000e-01
1151.	1.2207000000000000e-02	3.10037000000000e-01
1150	1 000010000000000 00	2.07352000000000.01
1152.	1.23091000000000e-02	5.0735200000000000000000000000000000000000
1153.	1.241210000000000e-02	3.0373900000000e-01
1154.	1.25160000000000e-02	3.20246000000000e-01
1155	1 262070000000000e-02	3 212750000000000-01
1150	1.272620000000000000000000000000000000000	
1130.	1.272630000000000000000	3.2202000000000000000000000000000000000
1157.	1.283280000000000e-02	3.282440000000000000000000000000000000000
1158.	1.294020000000000e-02	2.98988000000000e-01
1159.	1.304850000000000e-02	3.20854000000000e-01
1100	1 215770000000000 02	
1160.	1.315//000000000e-02	3.255400000000000000000000000000000000000
1161.	1.326780000000000e-02	3.32172000000000e-01
1162.	1.337880000000000e-02	3.31756000000000e-01
1163	1 3490800000000000000000000000000000000000	3 451100000000000000000000000000000000000
1100.	1.0400000000000000000000000000000000000	
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1165.	1.371750000000000e-02	3.51746000000000e-01
1166.	1.383230000000000e-02	3.56849000000000e-01
1167	1 39481000000000000000000000000000000000000	3 63809000000000-01
1107.	1.33401000000000000000000000000000000000	3.0305000000000000000000000000000000000
1108.	1.406480000000000000000	3.6766400000000e-01
1169.	1.418250000000000e-02	3.68568000000000e-01
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1171	1 442080000000000000000000000000000000000	3 719780000000000-01
1170	1.45415000000000000000000000000000000000	
11/2.	1.45415000000000000000000	3.6346800000000000000000000000000000000000
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1174.	1.478590000000000e-02	3.58875000000000e-01
1175	1 490960000000000000000000000000000000000	3 38904000000000=-01
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11/0.	1.303440000000000000000	5.4161200000000000000000000000000000000000
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1178.	1.528710000000000e-02	3.28744000000000e-01
1179.	1.5415000000000000e-02	3.31118000000000e-01
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1181.	1.56/41000000000e-02	3.34455000000000000000000000000000000000
1182.	1.58052000000000e-02	3.41765000000000e-01
1183.	1.593750000000000e-02	3.50620000000000e-01
1184	1 607090000000000000000000000000000000000	3 53775000000000e-01
1105	1 620520000000000000000000000000000000000	
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1187.	1.647770000000000e-02	3.81627000000000e-01
1188.	1.66156000000000000000000000000000000000	3.88689000000000e-01
1189	1 6754600000000000000000000000000000000000	3 27762000000000000000
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1191.	1.703620000000000e-02	3.84167000000000e-01
1192.	1.717880000000000e-02	3.957730000000000e-01
1103	1 7322500000000000000000000000000000000000	3 99/3600000000000000
1104	1.732230000000000000000	5.3535000000000000000000000000000000000
1194.	1.74675000000000e=02	4.090130000000000000000000000000000000000
1195.	1.76136000000000e-02	4.10570000000000e-01
1196	1 77610000000000000000000000000000000000	4 14759000000000e-01
1107	1.7000700000000000000000000000000000000	
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1200.	1.0516700000000000000000000000000000000000	
1201.	1.8516/000000000e-02	4.395/20000000000=01
1202.	1.86717000000000e-02	4.44796000000000e-01
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1204	1 898550000000000000000000000000000000000	4 530060000000000000000000000000000000000
1005	1.01442000000000000000000000000000000000	
1205.	1.914430000000000e-02	4.59382000000000000000000000000000000000000
1206.	1.930450000000000e-02	4.61369000000000e-01
1207.	1.9466100000000000e-02	4.65052000000000e-01
1208	1 962900000000000000000000000000000000000	4 679090000000000000000000000000000000000
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1209.	1.9/93200000000000e-02	4.60142000000000e-01
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1211	2 0125900000000000000000000000000000000000	4 719200000000000e-01
	2.31233000000000000000000000000000000000	1.,152000000000000000000000000000000000000



1212.	2.029430000000000e-02	4.73417000000000e-01
1213.	2.046410000000000e-02	4.74321000000000e-01
1214.	2.06354000000000e-02	4.73463000000000e-01
1215.	2.08081000000000e-02	4.73878000000000e-01
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1217	2 11578000000000000	4 8542200000000000000000000000000000000000
1010	2.123/000000000000000000000000000000000000	
1010	2.1334800000000000000000000000000000000000	4.3/31200000000000000000000000000000000000
1219.	2.15134000000000e-02	5.08360000000000e-DI
1220.	2.169340000000000e-02	5.14396000000000e-01
1221.	2.18749000000000e-02	5.19253000000000e-01
1222.	2.205800000000000e-02	5.32981000000000e-01
1223.	2.224250000000000e-02	5.26829000000000e-01
1224	2 24287000000000000	5 35416000000000000000000000000000000000000
1005	2.24207000000000000000000000000000000000	
1225.	2.261640000000000000000	5.4855700000000000000000000000000000000000
1226.	2.28056000000000e-02	5.55413000000001e-01
1227.	2.299650000000000e-02	5.53524000000000e-01
1228.	2.318890000000000e-02	5.87583000000000e-01
1229.	2.338290000000000e-02	5.97591000000000e-01
1230.	2.35786000000000e-02	6.1083000000000e-01
1231	2 377590000000000e=02	6 2542800000000000000000000000000000000000
1222	2 20740000000000000000000000000000000000	
1000	2.3974900000000000000000000000000000000000	
1233.	2.41/55000000000e-02	6.74959000000000e-DI
1234.	2.437780000000000e-02	6.78764000000000e-01
1235.	2.45818000000000e-02	7.13793000000000e-01
1236.	2.478750000000000e-02	7.2764000000000e-01
1237.	2.499490000000000e-02	7.34438000000000e-01
1238	2 520410000000000e=02	7 15639000000000000000000000000000000000000
1220	2 541500000000000000000000000000000000000	
1239.	2.54150000000000000000000	5. 32.0330000000000-01
1240.	2.562//000000000e-02	5.2/438000000000e-DI
1241.	2.58422000000000e-02	5.8/6400000000le-01
1242.	2.60584000000000e-02	5.2604900000000e-01
1243.	2.62765000000000e-02	4.65940000000000e-01
1244.	2.6496300000000000e-02	3.90506000000000e-01
1245	2 671810000000000000000	3 136270000000000=-01
1246	2 60/1700000000000000000	2.4162200000000000-01
1047	2.0541/00000000000e=02	2.1102200000000000000000000000000000000
1247.	2.700000000000000e-02	5.1/60/00000000e=02
1248.	2.716710000000000e-02	1.27132000000000e-01
1249.	2.73945000000000e-02	1.31571000000000e-01
1250.	2.762370000000000e-02	9.9656500000000e-02
1251.	2.785490000000000e-02	8.32544000000001e-02
1252	2 80879000000000000	8 07902000000001e-02
1050	2.00075000000000000000000000000000000000	
1255.	2.832300000000000000000	8.8262700000000000000000000000000000000000
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1255.	2.856000000000000e-02	2.69582000000000e-02
1256.	2.879900000000000e-02	1.17277000000000e-01
1257.	2.904000000000000e-02	1.37058000000000e-01
1258.	2.928300000000000e-02	1.5563800000000e=01
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1260.	2.97751000000000000000	1.8924900000000000000000000000000000000000
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1262.	3.02755000000000e-02	2.24021000000000e-01
1263.	3.052890000000000e-02	2.39686000000000e-01
1264.	3.078440000000000e-02	2.52502000000000e-01
1265	3 104200000000000e=02	2 6861400000000000000000000000000000000000
1266	3 13017000000000000	2 7992100000000000000000000000000000000000
1267	3.15627000000000000000000000000000000000000	
1207.	3.19037000000000000000000	
1268.	3.182780000000000e-02	2.9502100000000000000000000000000000000000
1269.	3.209420000000000e-02	3.11/24000000000e-01
1270.	3.236270000000000e-02	3.21277000000000e-01
1271.	3.263350000000000e-02	3.28664000000000e-01
1272.	3.290660000000000e-02	3.36158000000000e-01
1273.	3.318200000000000e-02	3.43733000000000e=01
1274.	3.34597000000000000000000000000000000000000	3.5241500000000000000000000000000000000000
1275	3 37397000000000000000000000000000000000	3.596760000000000-01
1076	2.4022000000000000000000000000000000000	
1077	3.40220000000000000e=02	3.050240000000000000000000000000000000000
12//.	3.4306/000000000e-02	3.00A07000000000000000000000000000000000
1278.	3.459380000000000e-02	3.7680100000000e-01
1279.	3.48833000000000e-02	3.8005000000000e-01
1280.	3.51752000000000e-02	3.82168000000000e-01
1281.	3.546950000000000e-02	3.8489900000000e-01
1282.	3.576630000000000e-02	3.95349000000000e-01
1283.	3.606560000000000e-02	3.99929000000000e-01
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1285	3 6671800000000000000000000000000000000000	4_058870000000000e=01
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1287.	3./2881000000000e-02	4.25418000000000000000
1288.	3.76001000000000e-02	4.2511600000000e-01
1289.	3.79148000000000e-02	3.84977000000000e-01
1290.	3.823200000000000e-02	4.34411000000000e-01
1291.	3.855200000000000e-02	4.39237000000000e-01
1292.	3.8874600000000000000	4.4965900000000000000000000000000000000000
1293	3 91999000000000000000000000000000000000	4 61621000000000e-01
1204	2.05070000000000000000000000000000000000	
1294.	3.952/9000000000e-02	4.75557000000000000000000000000000000000
1295.	3.9858/0000000000e-02	4./92680000000000000000
1296.	4.019220000000000e-02	5.0918900000000e-01
1297.	4.05286000000000e-02	5.2182000000000e-01
1298.	4.086770000000000e-02	4.96261000000000e-01
1299.	4.12097000000000000	4.15364000000000e-01
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1202	4.1502300000000000e=02	5. 7705500000000000000000000000000000000
1302.	4.225290000000000e-02	3.6/3/00000000000000000
1303.	4.26065000000000e-02	3.9325000000000e-01
1304.	4.29631000000000e-02	4.13598000000000e-01
1305.	4.332260000000000e-02	4,2319600000000e-01
1306.	4.368510000000000e-02	4.40394000000000e-01
1307	4 40507000000000000000000000000000000000	4 5136000000000000000000000000000000000000
1200	4.44102000000000000000000000000000000000	
	UZ	1.0133000000000000000000000000000000000



1309.	4.479100000000000e-02	4.70789000000000e-01
1310.	4.51658000000000e-02	4.78589000000000e-01
1311.	4.55438000000000e-02	4.84886000000000e-01
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1313.	4.63092000000000e-02	4.8571300000000e-01
1314.	4.66967000000000e-02	5.2192200000000e-01
1315.	4.70875000000000e-02	5.1970700000000e-01
1316.	4.748150000000000e-02	4.72845000000000e-01
1317.	4.787880000000000e-02	4.6622400000000000=01
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1319	4 86835000000000e=02	4 946300000000000=01
1320	4 9090900000000000000000000000000000000	764220000000000e=01
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1222	4.9501700000000000000000000000000000000000	
1222.	4.991390000000000000000000000000000000000	4.10//60000000000000000001
1224	5.0353000000000000000000000000000000000	2 (54/3200000000000 01
1325	5 1179600000000000000000000000000000000000	3 7824100000000000000000
1225.	5.1607800000000000000000000000000000000000	2 265520000000000 01
1227	5.202070000000000000000	3.055300000000000000000
1329	5.203370000000000000000000000000000000000	3.657.980.000.000.0000-01
1220.	5.24/5200000000000000000	
1220	5.2314300000000000000000	
1221	5.390360000000000000000000000000000000000	
1222	5.380380000000000000000	4.2231100000000000000000
1332.	5.425380000000000000000	4.5749500000000000000000000000000000000000
1333.	5.470780000000000000000	4.501180000000000000000000000000000000000
1334.	5.51656000000000000000	4.7026100000000000000000000000000000000000
1335.	5.562/3000000000000000	4./410/000000000000000000000000000000000
1336.	5.609280000000000e-02	4.8554100000000000000000000000000000000000
133/.	3.656∠∠UUUUUUU0000e-02	4.99020000000000000000000000000000000000
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1339.	5./5128000000000e-02	5.05414000000000e-01
1340.	5.79940000000000e-02	4.86590000000000e-01
1341.	5.84793000000000e-02	5.351/3000000000e-01
1342.	5.89687000000000e-02	5.449/1000000000e-01
1343.	5.946220000000000e-02	5.32547000000000e-01
1344.	5.99598000000000e-02	5.52395000000000e-01
1345.	6.04615000000000e-02	5.49289000000000e-01
1346.	6.09675000000000e-02	5.49742000000000e-01
1347.	6.14777000000000e-02	5.4551300000000e-01
1348.	6.19921000000000e-02	5.3888400000000e-01
1349.	6.251089999999999e-02	5.3583700000000e-01
1350.	6.30340000000001e-02	5.3274800000000e-01
1351.	6.35614000000000e-02	5.2910700000000e-01
1352.	6.40933000000001e-02	5.3393000000000e-01
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1354.	6.51705000000001e-02	5.6072500000000e-01
1355.	6.571589999999999e-02	5.8626600000000e-01
1356.	6.62658000000000e-02	5.5090000000000e-01
1357.	6.68203000000000e-02	5.4833200000000e-01
1358.	6.73795000000000e-02	5.9013200000000e-01
1359.	6.794330000000000e-02	6.14064000000001e-01
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1361.	6.908520000000000e-02	6.6641300000000000000000000000000000000000
1362	6 966330000000000e=02	6 9179400000000000e-01
1363	7 0246300000000000e=02	9355400000000000000000000000000000000000
1364.	7.08341000000000e-02	6.46422000000001e-01
1365.	7.142680000000000e-02	4.57813000000000000000000000000000000000000
1366.	7.2024599999999999e-02	5.712000000000000000000000000000000000000
1367.	7.26273000000001e-02	5.333270000000000000000000000000000000000
1368	7 323500000000000e=02	4 6319600000000000000000000000000000000000
1369	7 38478999999999999	3 9723600000000000e-01
1370.	7.4465800000000000e-02	2.53805000000000=-01
1371.	7.50890000000000000	3.87271000000000000000-01
1372.	7.571730000000000e-02	5.0436600000000000000-01
1373.	7.63509000000000000	5.70164000000000e-01
1374.	7.6989900000000000e-02	5.9532200000000e-01
1375.	7.763410000000000e=02	5.202610000000000=01
1376.	7.82838000000000000	3.242470000000000000000000000000000000000
1377.	7.893890000000001e-02	3.25904000000000e-01
1378.	7.95000000000000000	4.32407000000000e-01
1379.	7.9599400000000000e-02	8.663440000000000000000000000000000000000
1380.	8.02655000000000e-02	6.26486000000000e-01
1381.	8.09372000000000e-02	6.1863100000000e=01
1382.	8.16145000000001e-02	6.5075100000000e-01
1383.	8.22975000000000e-02	5.70982000000000e-01
1384.	8.250000000000000e-02	1.52401000000000e-01
1385.	8.298609999999999e-02	3.03593000000000e-01
1386.	8.368059999999999e-02	2.8994000000000e-01
1387.	8.43808000000001e-02	2.4438000000000e-01
1388.	8.508689999999999e-02	3.23729000000000e-01
1389.	8.579900000000000e-02	3.92697000000000e-01
1390.	8.651689999999999e-02	4.2398900000000e-01
1391.	8.724090000000000e-02	4.29137000000000e-01
1392.	8.797099999999999e-02	4.859970000000000e-01
1393.	8.87071000000000e-02	5.0643600000000e=01
1394.	8.94494000000000e-02	5.2530600000001e-01
1395.	9.019800000000000e-02	4.74314000000000e-01
1396.	9.09528000000000e-02	4.86847000000000e-01
1397.	9.171390000000000e-02	5.47415000000000e-01
1398.	9.24814000000001e-02	5.5437000000000e-01
1399.	9.32552000000000e-02	5.2610400000000e-01
1400.	9.4035600000000000e-02	5.1989400000000000000-01
1401.	9.4822500000000000e-02	4.98008000000000e-01
1402.	9.56160000000001e-02	4.79364000000000e-01
1403.	9.641619999999999e-02	4.65763000000000e-01
1404.	9.72230000000000e-02	4.64766000000000e-01
1405.	9.803660000000000000000000000000000000000	4.6112400000000e=01
1	1.0000000000000000000000000000000000000	



4.49.5		
1406.	9.88569000000000e-02	4.3211400000000000000000000000000000000000
1407.	9.968420000000000e-02	4.69213000000000e-01
1408.	1.005180000000000e-01	5.01879000000000e=01
1409.	1.013600000000000e-01	5.1607500000000e-01
1410.	1.022080000000000e-01	5.36013000000000e-01
1411.	1.030630000000000e-01	5.17499000000000e-01
1/12	1 03925000000000000000	5 311280000000000-01
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1415.	1.04/9500000000000000000000000000000000000	5.7254700000000000000000000000000000000000
1414.	1.056/20000000000e-01	5.8369400000000e-01
1415.	1.065560000000000e-01	5.7914500000000e-01
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1417.	1.083470000000000e-01	5.7458600000000e-01
1418.	1.092540000000000e-01	5.6939400000000e=01
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1419.	1.1101080000000000000000000000000000000	5.004230000000000000000000000000000000000
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1422.	1.129570000000000e-01	5.99307000000000e-01
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1424.	1.148550000000000e-01	6.1601300000000e-01
1425	1 15817000000000e-01	5 686280000000000000000000000000000000000
1426	1 167860000000000 01	
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1431.	1.217550000000000e-01	6.9324600000000e-01
1432.	1.227730000000000e-01	6.50534000000000e-01
1433	1 2380100000000000000000000000000000000000	6 550770000000000-01
1434	1 24837000000000000000000000000000000000000	5.879730000000000e=01
1425	1.2403/0000000000000000	
1435.	1.25881000000000e-01	0.59/5/0000000000000000
1436.	1.269350000000000e-01	7.06741000000000e-01
1437.	1.279970000000000e-01	5.89210000000000e-01
1438.	1.290680000000000e-01	5.97340000000000e-01
1439.	1.301480000000000e-01	5.10596000000001e-01
1440.	1.3123700000000000=01	5.314900000000000e-01
1441	1 323350000000000000000000000000000000000	7 165240000000010-01
1441.	1.32333000000000000000	1.1527000000000000000000000000000000000000
1442.	1.33443000000000000000000	0.119//000000000000000000000000000000000
1443.	1.3456000000000000e-01	8.51754000000000e-01
1444.	1.356860000000000e-01	8.3979300000000e-01
1445.	1.368210000000000e-01	8.0102100000000e-01
1446.	1.379660000000000e-01	7.2606900000000e-01
1447.	1.391210000000000e-01	5-988850000000000e=01
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1453.	1.462530000000000e-01	4.69553000000000e-01
1454.	1.474770000000000e-01	4.71807000000000e-01
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1450.	1.499500000000000000000000000000000000000	4.573550000000000000000000000000000000000
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1462	1 57644000000000e-01	6 1076400000000000000000000000000000000000
1463	1 58963000000000000000000000000000000000000	6_3300700000000000000000
1405.	1.0000000000000000000000000000000000000	
1464.	1.602940000000000000000	6.2756400000000e-01
1465.	1.616350000000000e-01	6.55061000000000e-01
1466.	1.629880000000000e-01	6.62881000000001e-01
1467.	1.643510000000000e-01	6.68885000000000e-01
1468.	1.657270000000000e-01	6.74264000000000e-01
1469.	1.671140000000000e-01	6.55684000000000e-01
1470.	1.68512000000000000-01	6.2191400000000000000000000000000000000000
1471	1 699220000000000000000	4 296830000000000=-01
1472	1 7124400000000000000000000000000000000000	
1472	1.713440000000000000000	
1474	1.727780000000000000000	5.005300000000000000000000000000
14/4.	1./4224000000000000000000	5.7525000000000-01
14/5.	1./56820000000000e-01	0.01813000000016-01
14/6.	1.77152000000000e-01	/.2990/00000000000-01
1477.	1.786340000000000e-01	7.5812400000000e-01
1478.	1.801290000000000e-01	7.35592000000000e-01
1479.	1.816360000000000e-01	7.11221000000000e-01
1480.	1.8315600000000000e-01	7.33726000000000e-01
1481	1 84689000000000000000000	6_85907000000000e=01
1/82	1 86235000000000000000000000000000000000000	
1402	1.002000000000000000000	
1483.	1.8//9300000000000000000000000000000000000	4.4077800000000000000000000
1484.	1.893640000000000e-01	3.38542000000000000000
1485.	1.909490000000000e-01	3.69074000000000e-01
1486.	1.925470000000000e-01	4.22148000000000e-01
1487.	1.941580000000000e-01	4.50812000000000e-01
1488.	1.9578300000000000e-01	4.83527000000000e-01
1489.	1.97421000000000000000000000000000000000000	5.05593000000000e-01
1490	1 990730000000000000000000000000000000000	5 0698400000000000000000000000000000000000
1/01	2 00730000000000000000000000000000000000	5.461340000000000-01
1491.	2.00/390000000000000000	5.5401200000000000000000000000000000000000
1492.	2.024190000000000e-01	5.54424000000000e=01
1493.	2.041130000000000e-01	5.78064000000000e-01
1494.	2.05821000000000e-01	5.91138000000001e-01
1495.	2.075430000000000e-01	6.7407000000000e-01
1496.	2.092800000000000e-01	5.8767000000000000000-01
1497.	2.11031000000000000=-01	5.4828900000000000000000000000000000000000
1498	2 1279700000000000000000000000000000000000	6 119830000000001e-01
1499	2 14578000000000000000000000000000000000000	6 335600000000000=-01
1500	2.14378000000000000000	
1501	2.163/4000000000e-01	0.000000000000000000000000000000000000
1501.	∠.181840000000000e-01	P.173/2000000006=0T
1502.	2.200100000000000e-01	7.2848600000000e-01



1503.	2.218510000000000e-01	4.57665000000000e-01
1504	2 227090000000000 01	5 0011000000000 01
1504.	2.25700000000000000000000000000000000000	
1505.	2.255800000000000e-01	5.45363000000000e-01
1506.	2.274670000000000e-01	5.89861000000000e-01
1507.	2.293710000000000e-01	6.10081000000000e-01
1508	2 3129000000000000000000000000000000000000	5 8211700000000000000000000000000000000000
15000.	2.51250000000000000000000000000000000000	
1509.	2.332260000000000e-01	6.01622000000000e-01
1510.	2.351780000000000e-01	5.92132000000000e-01
1511.	2.371460000000000e-01	5.95651000000000e-01
1512	2 3913000000000000-01	6 25763000000000-01
1512.	2.33130000000000000000000000000000000000	
1513.	2.41131000000000e-01	6.29145000000000000000000000000000000000000
1514.	2.431490000000000e-01	6.08076000000000e-01
1515.	2.451830000000000e-01	6.02971000000000e-01
1516	2 47235000000000000000000000000000000000000	5 300480000000000000000000000000000000000
1517	2.4725500000000000000000000000000000000000	5.564020000000000-01
1517.	2.493040000000000e-01	5.76492000000000000000000000000000000000000
1518.	2.513900000000000e-01	5.6484200000000000000000000000000000000000
1519.	2.534940000000000e-01	6.2735000000000e-01
1520.	2.556150000000000e-01	6.53687000000000e-01
1521	2 577540000000000000000000000000000000000	7 04609000000000=01
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1522.	2.599110000000000e-01	6.127200000000000000000000000000000000000
1523.	2.620860000000000e-01	6.69364000000000e-01
1524.	2.642790000000000e-01	6.54295000000000e-01
1525	2 664910000000000e-01	6 82689000000000e=01
1500	2.00701000000000000000000000000000000000	
1526.	2.08/210000000000e-01	6.62895000000000000000000000000000000000000
1527.	2./09/00000000000e-01	6.406/1000000000e-01
1528.	2.732370000000000e-01	6.68355000000000e-01
1529.	2.75524000000000e-01	6.18896000000000e-01
1530	2 7782900000000000-01	4 4002700000000000=01
1521	2.015400000000000000000000000000000000000	
1001.	2.00134000000000000e-01	4.009180000000000000000000000000000000000
1532.	2.824990000000000e-01	4.97965000000000e-01
1533.	2.848630000000000e-01	5.315590000000000e-01
1534.	2.87246000000000000=01	5.839890000000000e-01
1535	2 8965000000000000000000000000000000000000	6 1041000000000000000000
1535.	2.0300000000000000000000000000000000000	
1036.	2.920/4000000000e-01	6.364/5000000000e-01
1537.	2.94518000000000e-01	6.2640000000000e-01
1538.	2.9698300000000000e-01	7.09485000000000e-01
1539.	2.97200000000000000000000000000000000000	6.51094000000000e-02
1540	2.97200000000000000000000000000000000000	
1540.	2.985000000000000e-01	3.7084300000000000000000000000000000000000
1541.	2.994680000000000e-01	2.8547000000000e=01
1542.	3.019740000000000e-01	7.41939000000000e-01
1543	3 045010000000000e-01	7 659290000000000=01
1544	2 07040000000000000000000000000000000000	
1344.	3.070490000000000000000000000000000000000	7.30170000000012-01
1545.	3.096180000000000e-01	/.2853500000000000000000000000000000000000
1546.	3.122090000000000e-01	6.84237000000000e-01
1547.	3.148220000000000e-01	6.24460000000000e-01
1548	3 174560000000000000000000	5 6325300000000000000000000000000000000000
1540.	3.1743000000000000000000000000000000000000	
1549.	3.201130000000000e-01	3.8418900000000000000000000000000000000000
1550.	3.227920000000000e-01	3.94822000000000e-01
1551.	3.254930000000000e-01	4.35522000000000e-01
1552	3 282170000000000e-01	4 885960000000000-01
1662	3.202170000000000000000000000000000000000	5.434420000000000000000000000000000000000
1000.	3.309630000000000e-01	5.43445000000000000000000000000000000000
1554.	3.337330000000000e-01	5.12989000000000e-01
1555.	3.365250000000000e-01	5.58743000000000e-01
1556.	3.393420000000000e-01	6.15584000000000e-01
1557	3 42181000000000000000000	6_280580000000000000000000000000000000000
1550	3.421010000000000000000000000000000000000	
1558.	3.450450000000000e-01	/.04464000000000000000000000000000000000
1559.	3.479320000000000e-01	7.04253000000000e-01
1560.	3.508430000000000e-01	5.53762000000000e-01
1561	3 5378000000000000e-01	4 386670000000000=01
15001	3 5 6 7 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
1362.	3.367400000000000e-01	3.8422500000000000000000000000000000000000
1563.	3.597250000000000e-01	3.91519000000000e-01
1564.	3.627350000000000e-01	3.74679000000000e-01
1565.	3.657710000000000e-01	3.58367000000000e-01
1566.	3.6883200000000000-01	4.107080000000000e-01
1567	3 71010000000000000000000000000000000000	4.750420000000000000000
1500	5.71918000000000000000000	1.7504200000000000000000000000000000000000
1208.	3./503000000000000e-01	2.2/31000000000e-01
1569.	3.78169000000000e-01	4.94112000000000e-01
1570.	3.813330000000000e-01	4.405800000000000e-01
1571.	3.845240000000000e-01	3.73676000000000e-01
1572	3 8774200000000000-01	3 176600000000000000000000000000000000000
1572	3.077420000000000000000000000000000000000	
13/3.	3.9098/00000000000e-01	3.41343000000000000000000000000000000000
1574.	3.942590000000000e-01	3.823070000000000=01
1575.	3.97558000000000e-01	4.04119000000000e-01
1576.	4.008850000000000e-01	3.875040000000000e-01
1577	4 0423900000000000000000000000000000000000	3 46884000000000000000000
1570	1.076220000000000000000000000000000000000	2 52120000000000 01
15/8.	4.0/6220000000000e-01	5.52150000000000000000000000000000000000
1579.	4.110330000000000e-01	3.38948000000000e-01
1580.	4.144730000000000e-01	3.52641000000000e-01
1581.	4.1794100000000000e-01	3.36944000000000e-01
1582	4 21438000000000000-01	3 166400000000000000000000000000000000000
1502.	4.2406500000000000000000000000000000000000	2.754450000000000000000000000000000000000
1083.	4.2496500000000000e-01	5./64400000000000000000000000000000000000
1584.	4.28521000000000e-01	3.46569000000000e-01
1585.	4.32107000000000e-01	3.70776000000000e-01
1586.	4.3572300000000000000000000000000000000000	3.74850000000000e-01
1597	1.337230000000000000000000000000000000000	4 00937000000000000000
100/.	4.3930900000000000e-01	4.053700000000000000000000000000000000000
1588.	4.430460000000000e-01	3.559110000000000=01
1589.	4.467540000000000e-01	3.9813600000000e-01
1590.	4.5049200000000000e-01	4.02626000000000e-01
1591	4 54262000000000000000000	4 49983000000000000000000
1500	4.5926200000000000000000000000000000000000	1.13505000000000000000000000000000000000
1292.	4.5806300000000000e-01	4./240300000000000000000000000000000000000
1593.	4.618960000000000e-01	5.22274000000000e-01
1594.	4.657610000000000e-01	5.61633000000001e-01
1595	4 696590000000000000000000000000000000000	6_04687000000000e=01
1506	4 725000000000000000000000000000000000000	
1000.	4./358900000000000e-01	4.332110000000000000000000000000000000000
1597.	4.775520000000000e-01	5.038990000000000e-01
1598.	4.815480000000000e-01	5.24305000000000e-01
1599.	4.85578000000000000000000	5.752880000000000e-01
	1.000,000000000000000000000000000000000	



1600.	4.896420000000000e-01	5.59617000000000e-01
1601	4 02720000000000000000000000000000000000	5 5020400000000 01
1001.	4.957590000000000000000000000000000000000	5.50204000000000000000000000000000000000
1602.	4.9/8/1000000000e-01	6.84633000000001e-01
1603.	5.020370000000000e-01	6.2616100000000e-01
1604.	5.062380000000000e-01	5.5551000000000e=01
1605	5 104740000000000000000000000000000000000	6 2600000000000000000000000000000000000
1003.	5.104/40000000000000000000000000000000000	0.2000000000000000000000000000000000000
1606.	5.147460000000000e-01	5.663880000000000000000000000000000000000
1607.	5.19053000000000e-01	6.73087000000000e-01
1608	5 233970000000000e-01	6 29769000000000e-01
1600	5.27777000000000000000000000000000000000	
1009.	5.2777700000000000000	4.32684000000000000000000000000000000000000
1010.	5.321930000000000e-01	4.31425000000000e-01
1611.	5.366470000000000e-01	5.2303500000000e-01
1612.	5.411380000000000e-01	5.12142000000000e-01
1613	5 45666000000000000000000000000000000000	5 373870000000000000000000000000000000000
1013.	5.4500000000000000000000000000000000000	5.5757700000000000000000000000000000000
1614.	5.50232000000001e-01	5.7919200000000e-01
1615.	5.548370000000000e-01	6.19684000000000e-01
1616.	5.594800000000000e-01	5.84328000000000e-01
1617	5 641610000000000e-01	5 117860000000000-01
1610	5.699920000000000000000000000000000000000	5.252570000000000 01
1010.	5.08882000000000000000	3.33367000000000000000000000000000000000
1619.	5.736430000000000e-01	5.2526300000000000000000000000000000000000
1620.	5.784430000000000e-01	5.10293000000000e-01
1621.	5.832840000000000e-01	5.15705000000000e-01
1622	5 881650000000010-01	5 863880000000000000000000000000000000000
1022.	5.881650000000000000	5.86588600000000000000000000000000000000
1623.	5.9308/0000000000e-01	5.8273300000000000000000000000000000000000
1624.	5.980500000000000e-01	5.80176000000000e-01
1625.	6.030540000000000e-01	5.87127000000000e-01
1626	6 0810100000000000-01	5.55081000000001e-01
1627	6 12100000000000000000000000000000000000	5 084050000000000 01
102/.	0.13109000000000000000000000000000000000	J. 064050000000000000000000
1028.	6.18321000000000e-01	4.550910000000000000000000000000000000000
1629.	6.234950000000000e-01	5.33924000000000e-01
1630.	6.28712000000001e-01	5.451050000000000e-01
1631	6 339730000000000 01	5 355720000000001e-01
1001.	5.55575000000000000e=01	
1032.	₀.392/900000000000e-01	4.//4/10/00000000=01
1633.	6.446280000000000e-01	5.55345000000000e-01
1634.	6.500220000000000e-01	4.66413000000000e-01
1635	6 5546200000000000000000000000000000000000	5 3414900000000000000000000000000000000000
1636	6 60047000000000000000000000000000000000	4.584555000000000000000
1030.	6.6094/0000000000e-01	4.38433000000000000000000000000000000000
1637.	6.664780000000000e-01	4.74012000000000e-01
1638.	6.720550000000000e-01	4.20796000000000e-01
1639	6 776790000000000e-01	4 06060000000000=01
1640	6 933500000000000000000000000000000000000	
1640.	6.8335000000000000e-01	4.44910000000000000000000000000000000000
1641.	6.890680000000000e-01	4.4652400000000000000000000000000000000000
1642.	6.948350000000000e-01	4.80514000000000e-01
1643.	7.006490000000000e-01	4.29583000000000e-01
1644	7 0651200000000000000000000000000000000000	5.02922000000000000000000000000000000000
1011.	7.003120000000000000000000000000000000000	
1645.	7.124240000000000e-01	5.13278000000000000000000000000000000000000
1646.	7.183860000000000e-01	4.00837000000000e-01
1647.	7.243980000000000e-01	3.01292000000000e-01
1648.	7.304590000000000e-01	3.37265000000000e-01
1640	7 3657300000000000000000000000000000000000	
1049.	7.30372000000000000000	3. 5621000000000000000000000000000000000000
1650.	7.42/360000000000e-01	4.04089000000000000000000000000000000000
1651.	7.489510000000000e-01	3.60128000000000e-01
1652.	7.552179999999999e-01	3.67037000000000e-01
1653	7 6153800000000010-01	3 4358400000000000000000000000000000000000
1000.	7.0100000000000000000000000000000000000	
1654.	1.0/9110000000000e-01	3.499480000000000000000000000000000000000
1655.	7.743370000000001e-01	3.49297000000000e-01
1656.	7.80817000000000e-01	3.41605000000000e-01
1657.	7.87351000000000e-01	3.51401000000000e-01
1650	7 0202000000000000000000000000000000000	
1030.	7.9393900000000000000000	3.1//140000000000000000000000000000000000
1659.	8.005830000000000e-01	3.606560000000000=-01
1660.	8.072830000000000e-01	3.65318000000000e-01
1661.	8.140380000000000e-01	3.53926000000000e-01
1662.	8.2085000000000000=-01	2.5077600000000e-01
1663	9 277100000000000000000000000000000000000	2 88554000000000000000
1003.	0.2//190000000000e-01	2.8353400000000000000000000000000000000000
1664.	8.346460000000000e-01	2.9810600000000e-01
1665.	8.416300000000000e-01	3.01549000000000e-01
1666.	8.48673000000000e-01	2.67243000000000e-01
1667.	8.557750000000000e-01	2.52991000000000e-01
1668	8 6293600000000000000000000000000000000000	2 3876100000000000000000
1.000	0.70157000000000000000000000000000000000	
1003.	6./015/0000000000e-01	2.33111000000000000000000000000000000000
16/0.	8.//4390000000000e-01	2.4030/0000000000000000000000000000000000
1671.	8.84781000000000e-01	2.45517000000000e-01
1672.	8.92185000000000e-01	2.19519000000000e-01
1673.	8.9965100000000000=01	2.43957000000000e-01
1674	9 07190000000000000000000000000000000000	2 1533200000000000-01
1074.	5.07100000000000000e=01	
16/5.	9.14//1000000000e-01	2.1084/00000000000000000000000000000000000
1676.	9.22426000000000e-01	2.1215100000000e-01
1677.	9.301450000000000e-01	2.15628000000000e-01
1678.	9.37929000000000000	2.14756000000000e-01
1679	9 4577700000000000 01	2 12242000000000000000
10/3.	5.45///0000000000000000	
1080.	9.536920000000000e-01	1./3/050000000000000000000000000000000000
1681.	9.61672000000000e-01	1.87965000000000e-01
1682.	9.6972000000000000e-01	1.60933000000000e-01
1683	9 7783400000000000000000000000000000000000	1 54239000000000000000000
1.003.	0.000170000000000000000	1.03104000000000000000000000000000000000
1084.	9.8601/0000000000e-01	1.03104000000000-01
1685.	9.94268000000000e-01	1.40335000000000e-01
1686.	1.002590000000000e+00	1.54242000000000e-01
1687.	1.0109800000000000+00	1.51032000000000e-01
1699	1 0104400000000000000000000000000000000	1.64/21000000000000000
1000.	1.01944000000000000000000000000000000000	1.04421000000000000000000000000000000000
1689.	1.02797000000000e+00	1.7882600000000000000000000000000000000000
1690.	1.036570000000000e+00	1.55292000000000e-01
1691.	1.0452400000000000+00	1.56009000000000e-01
1692	1 05300000000000000000000000000000000000	1 61980000000000000000
1092.	1.0001000000000000000000000000000000000	
T093.	1.005810000000000e+00	T.02320000000000=0T
1694.	1.071710000000000e+00	1.67922000000000e-01
1695.	1.080670000000000e+00	1.90834000000000e-01
1696	1 0897200000000000000000000000000000000000	1 978020000000e-01
	1.000/2000000000000000000000000000000000	T.9100200000000 0T



1697.	1.098840000000000e+00	2.0230000000000e-01
1698	1 1080300000000000+00	2 0586200000000000000000000000000000000000
1050.	1.1000500000000000000000000000000000000	
1099.	1.11/300000000000e+00	2.036/800000000e-01
1700.	1.126650000000000e+00	1.83859000000000e-01
1701.	1.136080000000000e+00	2.0357000000000e=01
1702	1 1455900000000000000000	2 03215000000000-01
1702.	1.14555000000000000000000000000000000000	2.05215000000000000000000000000000000000
1/03.	1.155180000000000e+00	1.8446200000000000000000000000000000000000
1704.	1.164840000000000e+00	2.0409000000000e-01
1705.	1.174590000000000e+00	2.11637000000000e-01
1706	1 1844200000000000000000	2 08782000000000000000000000000000000000
1700.	1.10442000000000000000000000000000000000	1.0010000000000000000000000000000000000
1/0/.	1.194330000000000e+00	1.93100000000000000000000000000000000000
1708.	1.204320000000000e+00	2.13353000000000e-01
1709.	1.214400000000000e+00	1.94872000000000e-01
1710	1 22456000000000000000	2 19009000000000000000000000000000000000
1711	1.22400000000000000000000000000000000000	
1/11.	1.23481000000000000000000000000000000000000	1.8091500000000000000000000000000000000000
1712.	1.245140000000000e+00	1.719370000000000e-01
1713.	1.255560000000000e+00	1.86294000000000e-01
1714.	1.266070000000000e+00	1.70427000000000e-01
1715	1 2766700000000000+00	1 709280000000000-01
1710	1.2073500000000000000000000000000000000000	1.455260000000000-01
1/10.	1.28/35000000000000000000000000000000000000	1.47526000000000000000000000000000000000000
1717.	1.298120000000000e+00	1.48155000000000e-01
1718.	1.308990000000000e+00	1.40954000000000e-01
1719	1 31994000000000000+00	1 44164000000000000000000000000000000000
1720	1 3300000000000000000000000000000000000	1.4417600000000000000000000000000000000000
1720.	1.330980000000000000000000000000000000000	1.441/0000000000000000000000000000000000
1/21.	1.342120000000000e+00	1.5632200000000000=01
1722.	1.353350000000000e+00	1.65099000000000e-01
1723.	1.364680000000000e+00	1.72937000000000e-01
1724	1 37610000000000000000	1 8475800000000000000000000000000000000000
1725	1 207610000000000000000000000	1.5275600000000000000000000000000000000000
1/23.	T.30/0T000000000000000000	1.32/3900000000000000000000000000000000000
1726.	1.399220000000000e+00	1.6249700000000e-01
1727.	1.410930000000000e+00	1.69145000000000e-01
1728.	1.42274000000000000000000	1.55871000000000e-01
1720	1 4346500000000000000000000000000000000000	1 65651000000000000000
1720	1.45405000000000000000000000000000000000	
1/30.	1.446650000000000e+00	1.6048/00000000000000000000000000000000000
1731.	1.45876000000000e+00	1.57805000000000e-01
1732.	1.4709700000000000e+00	1.42928000000000e-01
1733.	1.4832700000000000+00	1.45008000000000e-01
1704	1.4052700000000000000000000000000000000000	
1/34.	1.4956900000000000000000000000000000000000	1.48769000000000000000000000000000000000000
1735.	1.508200000000000e+00	1.59501000000000e-01
1736.	1.520820000000000e+00	1.47653000000000e-01
1737.	1.533550000000000e+00	1.38116000000000000=01
1720	1 54628000000000000000000000000000000000000	1 422280000000000 01
1/30.	1.3463800000000000000000000000000000000000	1.4323600000000000000000000000000000000000
1/39.	1.559320000000000e+00	1.323340000000000000000000000000000000000
1740.	1.572370000000000e+00	1.37449000000000e-01
1741.	1.585530000000000e+00	1.55542000000000e-01
1742	1 598800000000000000000000000000000000000	1 374200000000000=01
1742	1.61212020000000000000000000000000000000	
1/43.	1.6121800000000000e+00	1.402480000000000000000000000000000000000
1744.	1.625670000000000e+00	1.29862000000000e-01
1745.	1.639270000000000e+00	1.4421000000000e-01
1746.	1.652990000000000e+00	1.35878000000000e-01
1747	1 66682000000000000000	1 320060000000000000000000000000000000000
1/1/.	1.0000200000000000000000000000000000000	
1/48.	1.680//0000000000e+00	1.31813000000000000000000000000000000000
1749.	1.694830000000000e+00	1.42375000000000e-01
1750.	1.709020000000000e+00	1.32127000000000e-01
1751	1 723320000000000e+00	1 372730000000000=01
1752	1 737740000000000000000	1 3371400000000000000000000000000000000000
1752.	1.757740000000000000000000000000000000000	1.17712000000000000000000000000000000000
1/53.	1./52280000000000e+00	1.1/81300000000000000000000000000000000000
1754.	1.766940000000000e+00	1.17705000000000e-01
1755.	1.781730000000000e+00	1.31638000000000e-01
1756	1 796640000000000e+00	1 347170000000000=01
1757	1.9116700000000000000000000000000000000000	
1/5/.	1.8116/00000000000000000000000000000000000	1.2438000000000000000000000000000000000000
1/58.	1.826830000000000e+00	1.207420000000000000000000000000000000000
1759.	1.842120000000000e+00	1.04716000000000e-01
1760.	1.857540000000000e+00	1.12188000000000e-01
1761.	1.87308000000000000000000	1.11876000000000e-01
1762	1 8887600000000000000000	1.0989300000000000000000
1762	1.00450000000000000000000000000000000000	
1/03.	1.904300000000000000e+00	1.13043000000000000000000000000000000000
1/64.	1.920500000000000e+00	9.75491000000000e-02
1765.	1.936570000000000e+00	1.02015000000000e-01
1766.	1.952780000000000e+00	1.02621000000000e-01
1767.	1.9691200000000000e+00	1.05908000000000e-01
1768	1 98559000000000000	1 0910000000000000000
1760	2.0022100000000000000000000000000000000	1.1024700000000000 01
1770	2.0022100000000000000000000000000000000	1.027/00000000000000000000000000000000000
1/70.	2.018970000000000e+00	1.09/940000000000000000000000000000000000
1771.	2.035860000000000e+00	1.09586000000000e-01
1772.	2.052900000000000e+00	1.00861000000000e-01
1773	2 07008000000000000000000	1 0184500000000000000000000000000000000000
1774	2.097400000000000000000000000000000000000	
1775	2.00/40000000000000000e+00	1.1000500000000000000000000000000000000
1//5.	∠.1048/000000000e+00	1.1782800000000000000000000000000000000000
1776.	2.12248000000000e+00	1.01651000000000e-01
1777.	2.140240000000000e+00	1.08579000000000e-01
1778	2 15815000000000000000000	1 0495800000000000000000000000000000000000
1770	2 1762100000000000000000000000000000000000	1.05324000000000000000000
1//9.	2.1/621000000000e+00	1.002340000000000000000000000
1780.	2.194420000000000e+00	1.04223000000000e-01
1781.	2.21278000000000e+00	1.06684000000000e-01
1782.	2.231300000000000e+00	1.11946000000000e-01
1783	2 249970000000000000000	1 12979000000000000000000
1704	2.2499700000000000000000000000000000000000	1 152220000000000 01
1705	2.200000000000000000000000000000000000	1.07400000000000000000000000000000000000
1/85.	2.28//90000000000e+00	1.0/48200000000000000000000000000000000000
1786.	2.306930000000000e+00	1.09803000000000e-01
1787.	2.3262400000000000e+00	1.09320000000000e-01
1788	2 3457000000000000000000000000000000000000	1.06278000000000000000000
1700	2.2622000000000000000000000000000000000	1 116770000000000 01
1/89.	2.355330000000000e+00	1.1109/000000000000000000000000000000000
1790.	2.38513000000000e+00	1.14166000000000e-01
1791.	2.40509000000000e+00	1.00617000000000e-01
1792.	2.4252100000000000e+00	9.9115100000000e-02
1703	2 44550000000000000000000000000000000000	9.2648400000000010-02
±133.	2.3333000000000000000000000000000000000	9.20404000000000000000000000000000000000



1794.	2.465970000000000e+00	9.79352000000000e-02
1795	2 486600000000000e+00	9 598530000000000-02
1700	2.1000000000000000000000000000000000000	
1/90.	2.50/4100000000000000000000000000000000000	8.97231000000000000000000000000000000000000
1797.	2.528400000000000e+00	9.14572000000000e-02
1798.	2.549550000000000e+00	8.6215900000000e=02
1700	2 570890000000000000000	8, 98316000000000000000000000000000000000000
1155.	2.37003000000000000000000000000000000000	3.3031000000000000000000000000000000000
1800.	2.592400000000000e+00	9.378670000000000=-02
1801.	2.614100000000000e+00	9.1809600000001e-02
1802.	2.635970000000000e+00	8.76423000000001e-02
1002	2 6580200000000000000000000000000000000000	9 749750000000001 o 02
1803.	2.658030000000000e+00	8.74975000000001e-02
1804.	2.680270000000000e+00	8.2980500000000e-02
1805.	2.702700000000000e+00	8.312319999999999e-02
1806	2 7253200000000000+00	8 225739999999999999999
1000.	2.72552000000000000000000000000000000000	
1807.	2./48120000000000e+00	8.03/3/00000001e-02
1808.	2.771120000000000e+00	7.53651000000000e-02
1809.	2.794310000000000e+00	7.32247000000000e-02
1810	2 817690000000000e+00	7 718620000000000=-02
1011	2.01103000000000000000000000000000000000	7.404420000000001-02
1811.	2.8412/0000000000e+00	/.49448000000001e-02
1812.	2.865050000000000e+00	6.9700500000000e-02
1813.	2.88902000000000e+00	7.23903000000001e-02
1914	2 9132000000000000000000	7 103600000000000000000000000000000000000
1014.	2.9152000000000000000000000000000000000000	7.10300000000000000000000000000000000000
1812.	2.93/580000000000e+00	/.0448399999999999=-02
1816.	2.962160000000000e+00	6.6226300000000e-02
1817.	2.986950000000000e+00	6.744799999999999e-02
1919	3 011940000000000000000	6.7339200000000000000000000000000000000000
1010.	3.01134000000000000000000000000000000000	
1819.	3.03/15000000000e+00	6.3990/00000000e-02
1820.	3.06256000000000e+00	6.5413600000000e-02
1821.	3.0881900000000000e+00	6.33349000000000e-02
1822	3 1140300000000000000000	6.426680000000000e=02
1000	2.14000000000000000000000000000000000000	
1023.	3.1400900000000000e+00	p.0263100000000000000000000000000000000000
1824.	3.16637000000000e+00	5.91403000000000e=02
1825.	3.192860000000000e+00	5.85636000000000e-02
1826.	3.2195800000000000+00	5.612590000000000e-02
1927	3 24653000000000000000000000000000000000000	5 4/9780000000000000000
102/.	3.2403300000000000e+00	J. 4497800000000000000000000000000000000000
1828.	3.273690000000000e+00	5.1320300000000e-02
1829.	3.301090000000000e+00	4.909350000000000e-02
1830.	3.328710000000000e+00	4.874400000000000e-02
1931	3 3565700000000000000000000000000000000000	4 799790000000000000000
1001.	3.3363700000000000e+00	
1832.	3.384650000000000e+00	4.62627000000000e=02
1833.	3.412980000000000e+00	4.6279400000000e-02
1834.	3.441540000000000e+00	4.60931000000000e-02
1035	3 47034000000000000000000000000000000000	4.49312000000000000000000000000000000000000
1835.	3.4703400000000000e+00	4.4851500000000000000000000000000000000000
1836.	3.499380000000000e+00	4.2542800000000000000000000000000000000000
1837.	3.528660000000000e+00	4.38670000000000e-02
1838	3 55819000000000e+00	4 197760000000000=-02
1030	3 50707000000000000000000000000000000000	4 19770000000000 02
1839.	3.58/9/00000000000000000000000000000000000	4.1587700000000000000000000000000000000000
1840.	3.617990000000000e+00	4.01903000000000e-02
1841.	3.648260000000000e+00	3.9882400000000e=02
1842	3 678790000000000e+00	3 86109000000000=-02
1042	3.70050000000000000000000000000000000000	
1843.	3.7095800000000000e+00	3.840140000000000000000000000000000000000
1844.	3.740620000000000e+00	3.77474000000000e-02
1845.	3.771920000000000e+00	3.47288000000000e-02
1846	3 803490000000000000000	3 582820000000000000000000000000000000000
1040.	2.005490000000000000000000000000000000000	3. 51202000000000 02
1847.	3.835320000000000e+00	3./120900000000000000000000000000000000000
1848.	3.867410000000000e+00	3.64157000000000e-02
1849.	3.899770000000000e+00	3.6289700000000e=02
1850	3 932410000000000e+00	3 60040000000000=-02
1051	3.0653100000000000000000000000000000000000	2,40716000000000-02
1001.	3.965510000000000e+00	3.48/1800000000000000000000000000000000000
1852.	3.9985000000000000e+00	3.509890000000000000000000000000000000000
1853.	4.031960000000000e+00	3.4757500000000e-02
1854	4 06570000000000000+00	3 48296000000000=-02
1855	1 00072000000000000000000000000000000000	3 53123000000000000000
1000.		5.55125000000000000000000000000000000000
1826.	4.13403000000000e+00	3.4168400000000e-02
1857.	4.16862000000000e+00	3.17831000000000e-02
1858.	4.2035000000000000e+00	3.01911000000000e-02
1859	4 2386800000000000000000000000000000000000	3 09817000000000e-02
1000	4.0741E0000000000000000	
1000.	4.2/41300000000000000000000000000000	3.00348000000000000000000000000000000000
1861.	4.309920000000000e+00	2.90019000000000e-02
1862.	4.345980000000000e+00	2.59190000000000e-02
1863.	4.382350000000000e+00	2.60629000000000e-02
1864	4 4190200000000000000000000000000000000000	2 63217000000000e=02
10/5	1.4150200000000000000000000000000000000000	
T002.	4.45600000000000000e+00	2.0020000000000000000000000000000000000
1866.	4.493290000000000e+00	2.61/1200000000e-02
1867.	4.530890000000000e+00	2.59135000000000e-02
1868	4 568810000000000000	2_457520000000000e=02
1060	4 60704000000000000000000000000000000000	2 510210000000000 02
T00A.	4.60/040000000000e+00	2.310910000000000000000000000000000000000
1870.	4.645590000000000e+00	2.4253400000000e-02
1871.	4.684470000000000e+00	2.49653000000000e-02
1872.	4.723670000000000000000000	2.43152000000000e=02
1973	4 76319000000000000000000000000000000000000	2 4620600000000000000000
1073.	4.00015000000000000000000	2.35255550000000000000000000000000000000
18/4.	4.803050000000000e+00	2.3584400000000000000000000000000000000000
1875.	4.843250000000000e+00	2.1615300000000e-02
1876.	4.883770000000000000000	2.11569000000000e-02
1977	4 9246400000000000000000000000000000000000	2 16865000000000000000
1070	4.92404000000000000000000	2.10050000000000000000000000000000000000
18/8.	4.965850000000000e+00	2.145/000000000000000000000000000000000000
1879.	5.007410000000000e+00	2.1180200000000e-02
1880.	5.049310000000000e+00	2.04520000000000e-02
1881	5 0915600000000000000000000000000000000000	1 9195900000000e=02
1001.	5.05130000000000000000000000000000000000	1.31353500000000000000000000000000000000
1002.	5.1341/000000000e+00	1./04310000000000-02
1883.	5.17713000000000e+00	1.80180000000000e-02
1884.	5.22046000000000000000000	1.84865000000000e=02
1995	5 2641400000000000000000000000000000000000	1.8406100000000000000000
1005.	5.20414000000000000000000000000000000	
T880.	5.308200000000000e+00	1./906200000000000000000000000000000000000
1887.	5.35261000000000e+00	1.70146000000000e-02
1888.	5.397410000000000e+00	1.71595000000000e-02
1990	5 4425700000000000000000000000000000000000	1.69770000000000000000
1009.	J.4423/00000000000000000000000000000000000	1.030/50000000000000000000000000000000000
T890.	5.48812000000000e+00	1.0411000000000000000000000000000000000



1891.	5.534040000000000e+00	1.59620000000000e-02
1002	E E802E00000000000000000	1 52726000000000 02
1052.	5.5005500000000000000000000000000000000	1.327200000000000000000000000000000000000
1893.	5.62/050000000000e+00	1.429940000000000000000000000000000000000
1894.	5.674140000000000e+00	1.38479000000000e-02
1895	5 7216200000000000+00	1 3802300000000000-02
1000	E 7000000000000000000000000000000000000	1.367600000000000000000000000000000000000
1090.	5.769500000000000e+00	1.367600000000000000000000000000000000000
1897.	5.817780000000000e+00	1.34541000000000e-02
1898.	5.86646000000000e+00	1.33068000000000e-02
1899	5 915550000000000e+00	1 28679000000000000000000000000000000000000
1000	5.91999000000000000000000000000000000000	
1900.	5.965060000000000e+00	1.2089600000000e-02
1901.	6.014970000000000e+00	1.2365200000000e-02
1902.	6.065310000000000e+00	1.19873000000000e-02
1903	6 116060000000000000000	1 1732300000000000000000000000000000000000
1000.	0.1100000000000000000000000000000000000	1.1/32300000000000000000000000000000000000
1904.	6.167240000000000e+00	1.17175000000000e-02
1905.	6.218850000000000e+00	1.14318000000000e-02
1906.	6.270890000000000e+00	1.10570000000000e-02
1907	6 323370000000000000000	1 08277000000000-02
1007.	0.3233700000000000000000	1.002//000000000000000000000000000000000
1908.	6.3/6280000000000e+00	1.0241900000000e-02
1909.	6.429640000000000e+00	9.65035000000000e-03
1910.	6.483440000000000e+00	1.00512000000000e-02
1011	6 527700000000000000000000000000000000000	
1911.	6.53//00000000000e+00	9.84/0/999999999999999
1912.	6.592410000000000e+00	9.3328900000000000000000000000000000000000
1913.	6.647570000000000e+00	8.9543500000000e-03
1914	6 703200000000000e+00	8 63171000000001e-03
1015	6.750200000000000-100	
1913.	6.739290000000000e+00	0.3004/3333333339=03
1916.	6.815860000000000e+00	7.91086000000001e-03
1917.	6.87289000000000e+00	7.80089000000000e-03
1918.	6.9304100000000000000000	7.78487000000000e-03
1010	6 988400000000000000000000000000000000000	7 577780000000000-03
1919.	5.5054000000000000000000000000000000000	
1920.	/.U46880000000000e+00	/.20500000000000000000000000000000000000
1921.	7.10585000000000e+00	6.93415000000000e-03
1922.	7.165310000000000e+00	6.66439000000000e-03
1923	7 22527000000000000000000000000000000000	6 12368000000000e=03
1004		
1924.	7.28574000000000e+00	P.030PT000000006-03
1925.	7.34670000000000e+00	5.85007000000000e-03
1926.	7.408180000000000000000	5.67735000000000e-03
1927	7 4701800000000000000000	5 54385000000000e-03
1 527.	7.47010000000000000000000000000000000000	3.34363666666666666
1928.	7.532690000000000e+00	5.406/200000000e-03
1929.	7.59572000000000e+00	5.2202100000000e-03
1930.	7.659280000000000e+00	5.02691000000000e-03
1031	7 72338000000000000000	4 8064200000000000000000000000000000000000
1931.	7.7233800000000000000000000000000000000000	4.80042000000000000000000000000000000000
1932.	/./88010000000000e+00	4.55944000000000000000000000000000000000
1933.	7.853180000000000e+00	4.32916000000000e-03
1934.	7.918900000000000e+00	4.20847000000000e-03
1025	7 9951600000000000000000000000000000000000	4 17959000000000 03
1933.	7.9831800000000000000000000000000000000000	4.1/3330000000000000000000000000000000000
1936.	8.051980000000000e+00	4.10121000000000000000000000000000000000
1937.	8.11936000000000e+00	3.90583000000000e-03
1938.	8.187310000000000e+00	3.64779000000000e-03
1020	9 25592000000000000000000000000000000000	2 44652000000000 02
1939.	8.255820000000000e+00	5.4465200000000000000000000000000000000000
1940.	8.324909999999999e+00	3.29495000000000e-03
1941.	8.394570000000000e+00	3.18759000000000e-03
1942	8 46482000000000000+00	3 07836000000000-03
1042	0.4040200000000000000000000000000000000	
1943.	8.535650000000000e+00	3.0032200000000e-03
1944.	8.607080000000000e+00	2.88935000000000e-03
1945.	8.679100000000000e+00	2.7373600000000e-03
1946	8 751730000000000e+00	2 581250000000000-03
1047	0.001/000000000000000000000000000000000	2.405470000000000000000000000000000000000
1947.	8.8249700000000000e+00	2.4854700000000000000000000000000000000000
1948.	8.898820000000001e+00	2.41596000000000e-03
1949.	8.97328000000001e+00	2.33796000000000e-03
1950	9 048370000000000e+00	2 200920000000000-03
1051	0.124000000000001-100	2.2004/200000000000000000000000000000000
1951.	9.124090000000001e+00	2.034630000000000000000000000000000000000
1952.	9.200440000000000e+00	2.03402000000000000000000000000000000000
1953.	9.27744000000000e+00	1.94518000000000e-03
1954.	9.355070000000000e+00	1.86065000000000e-03
1955	9 433350000000001=+00	1 74630000000000000000000000
1056	0.51220000000000000000000000000000000000	1.677500000000000000000000000000000000000
1330.	5.3122900000000000e+00	1.0/0/2000000000000000000000000000000000
1957.	9.591889999999999e+00	1.5801/00000000e-03
1958.	9.67216000000000e+00	1.50461000000000e-03
1959.	9.75310000000000000000	1.43341000000000e-03
1960	9 8347000000000000000000000000000000000000	1 3497300000000000000000000000000000000000
1001	0.0170000000000000000000000000000000000	1.01979000000000000000000000000000000000
TA0T.	a.at\00aaaaaaaaaaaae+00	1.29/3000000000000000000000000000000000000
1962.	1.0000000000000000e+01	1.23218000000000e-03
1963.	1.008370000000000e+01	1.17056000000000e-03
1964.	1.016810000000000+01	1.10444000000000e-03
1005	1.0253100000000000000000000000000000000000	1.04030000000000000.03
7302.	1.025310000000000e+01	1.049500000000000000000000000000000000000
1966.	1.033900000000000e+01	9.9676299999999999e-04
1967.	1.042550000000000e+01	9.3870600000000e-04
1968.	1.05127000000000000+01	9.084800000000000e-04
1969	1 0600700000000000000000	8 6357800000000000000
1070	1.00007000000000000000000	0.130/3000000000000000000000000000000000
19.10.	1.06894000000000e+01	8.1/01300000000e-04
1971.	1.077880000000000e+01	7.79267000000001e-04
1972.	1.0869000000000000000+01	7.33432000000000e-04
1073	1 0060000000000000000000000000000000000	6.947070000000000000000
19/3.	1.09000000000000000000000000000000000	0.54707000000000000000000000000000000000
1974.	1.10517000000000e+01	6.41246000000001e-04
1975.	1.114420000000000e+01	5.92400000000000e-04
1976.	1.123750000000000e+01	5.609490000000000-04
1077	1 122150000000000000000	
19//.	1.1331300000000000e+01	5.2540700000000000000
1978.	1.14263000000000e+01	4.969850000000000e-04
1979.	1.152190000000000e+01	4.69618000000000e-04
1980.	1.161830000000000000	4.33069000000000e-04
1001	1 171560000000000000000	1.1775800000000000000000
1981.	1.1/1500000000000e+01	4.1//00/00/00/00/00/04
1982.	1.181360000000000e+01	3.89444000000000e-04
1983.	1.191250000000000e+01	3.64345000000000e-04
1984	1 20122000000000000000000	3 43379000000000000000000000
1005	1 21122000000000000000000000000	3.3337300000000000000000000000000000000
7382.	1.2112/0000000000e+01	5.22027000000000000000000000000000000000
1986.	1.221400000000000e+01	3.09320000000000e-04
1987.	1.231620000000000e+01	2.88086000000000e-04



1988.	1.241930000000000e+01	2.684980000000000=-04
1989.	1.252320000000000e+01	2.51741000000000e-04
1990.	1.262800000000000e+01	2.36132000000000e-04
1991.	1.273370000000000e+01	2.16799000000000e-04
1992.	1.284020000000000e+01	2.06558000000000e-04
1993.	1.294770000000000e+01	1.911290000000000e-04
1994.	1.305610000000000e+01	1.81020000000000e-04
1995.	1.316530000000000e+01	1.659790000000000e-04
1996.	1.327550000000000e+01	1.51699000000000e-04
1997.	1.338660000000000e+01	1.42695000000000e-04
1998.	1.349860000000000e+01	1.329800000000000e-04
1999.	1.361150000000000e+01	1.27284000000000e-04
2000.	1.37255000000000e+01	1.14422000000000e-04
2001.	1.38403000000000e+01	1.0666000000000e-04
2002.	1.395610000000000e+01	9.95941000000000e-05
2003.	1.407290000000000e+01	9.10512000000001e-05
2004.	1.419070000000000e+01	8.623699999999999⊖=-05
2005.	1.430940000000000e+01	7.89490000000001e-05
2006.	1.442920000000000e+01	7.19254000000000e-05
2007.	1.454990000000000e+01	6.94507000000000e-05
2008.	1.467170000000000e+01	6.41465000000000e-05
2009.	1.479440000000000e+01	5.82047000000000e-05
2010.	1.491830000000000e+01	5.08017000000000e-05
2011.	1.50431000000000e+01	4.60273000000000e-05
2012.	1.516900000000000e+01	4.34838000000000e-05
2013.	1.529590000000000e+01	4.08200000000000e-05
2014.	1.542390000000000e+01	3.76767000000000e-05
2015.	1.55530000000000e+01	3.41362000000000e-05
2016.	1.56831000000000e+01	3.28586000000000e-05
2017.	1.581440000000000e+01	2.85189000000000e-05
2018.	1.59467000000000e+01	2.73613000000000e-05
2019.	1.60801000000000e+01	2.41884000000000e-05
2020.	1.621470000000000e+01	2.23780000000000e-05
2021.	1.635040000000000e+01	2.03562000000000e-05
2022.	1.648720000000000e+01	1.78739000000000e-05
2023.	1.66252000000000e+01	1.732880000000000=-05
2024.	1.676430000000000e+01	1.61382000000000e-05
2025.	1.690460000000000e+01	1.40002000000000e-05
2026.	1.704610000000000e+01	1.31777000000000e-05
2027.	1.718870000000000e+01	1.20317000000000e-05
2028.	1.733250000000000e+01	1.12534000000000e-05
2029.	1.747760000000000e+01	9.941349999999999e-06
2030.	1.762380000000000e+01	9.94803000000001e-06
2031.	1.777130000000000e+01	7.98501000000000e-06
2032.	1.792000000000000e+01	7.04159000000000e-06
2033.	1.807000000000000e+01	5.70553000000000e-06
2034.	1.822120000000000e+01	6.06294000000000e-06
2035.	1.837370000000000e+01	5.288860000000000000-06
2036.	1.852740000000000e+01	4.709130000000000=06
2037.	1.868250000000000e+01	4.79583000000000e-06
2038.	1.883880000000000e+01	4.1816500000000000000000000000000000000000
2039.	1.899640000000000e+01	3.39112000000000000000
2040.	1.915540000000000e+01	3.35380000000000000000000000000000000000
2041.	1.931570000000000e+01	2.414540000000000000000000000000000000000
2042.	1.94//30000000000e+01	2.701090000000000000000000000000000000000
2043.	1.964030000000000e+01	2.3848500000000000000000000000000000000000

E.4 Input files for the core models

In the following, the main input file for the 3D core model is reported.

```
1. %% -- EXTERNAL FILE INCLUSION
2.
3. include "eranos_jeff31.ml" % materials
4. include "ALFRED_ECCO.ge" % geometry
5.
6. %% -- LIBRARY FOR NUCLEAR DATA
7. set acelib "/opt/serpent/xsdata/jeff31.xsdata"
8.
9. %% -- SIMULATION SETUP
10. trans u SR 0 0 -84 % Translate Control Rod to insert/withdrawn
11. trans u CR 0 0 68 % Translate Control Rod to insert/withdrawn
12.
13. set pop 1000000 500 100 % Population data
14. src ALFRED_FC_src_IM_500i sf ALFRED_FC_src_IM_500i 1 % external fisson source (scored from a previous run)
15.
16. set power 30000000 % Total thermal power [W]
17. set ures 1 % sample unresolved resonance region tables
18.
19. set his yes % Check on fission source convergence
20.
21. %% -- GROUP CONSTANT GENERATION
22. set micro nj19 % ECCO-33 groups
23. set nfg nj19
24. set gcu IF_TOP_REF
25. IF_TOP_PLUG
26. IF_SRTING
27. IF_TOP_LINS
```



28.	INN FUEL
29.	IF BOT INS
30.	IF_PLEN
31.	IF BOT_PLUG
32.	IF_BOT_REF
33.	OUT_FUEL
34.	SR_ACT
35.	CR_DUMM
36.	CR_ACT
37.	DR_DUMM
38.	BA
39.	11

E.5 Input files for the detector definitions ("traverses.de")

In this file, the tallies to score the flux and power values over each assembly are defined.

```
1. % assembly-wise power map
2. set cpd 1 [20 -30 30]
3.
4. % power
5. det POW dh 3 0 0 17.1 32 32 -30 30 20 du core dr -8 void
6.
7. % flux
8. det FLX dh 3 0 0 17.1 32 32 -170 170 17 du core
```