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Preliminary criticality analysis of the EFIT fuel cycle

This work is intended to confirm the preliminary results of the European Facility for Industrial Transmutation (EFIT) fuel cycle obtained by ENEA with the deterministic ERANOS transport code in the framework of the neutronic design of an European Transmutator Demonstrator (EDT). The Beginning Of Life (BOL), Beginning Of Cycle (BOC) and End Of Cycle (EOC) configurations have been studied with the Monte Carlo MCNP5 code for criticality calculations, using the equivalent material compositions relative to a uniform 0-, 1- and 2-years whole burnt fuel respectively.

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Abstract

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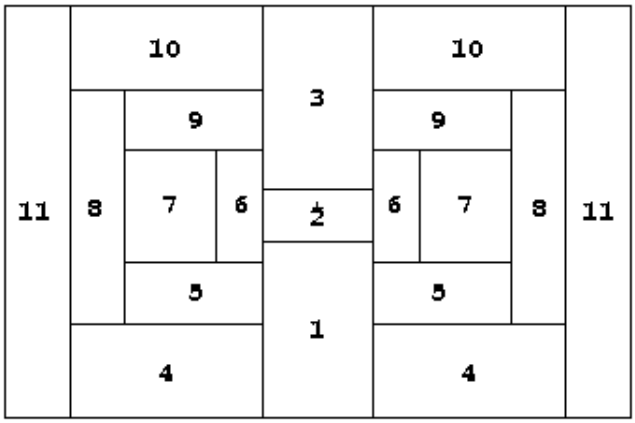
1 Introduction

Within the neutronic design of the EFIT core [1, 2, 3], several simulations have been made with the deterministic ERANOS [4] transport code, in order to study the criticality of the system and the fuel (both fissile and MAs) burn up evolution. The initial fresh fuel composition was loaded into the program, and the whole system studied for a working period of three years. Such a simulation can be considered equivalent to the real fuel evolution: the true BOC and EOC configurations (where the fuel is not homogeneous within the system, having undergone different burning periods, replacements and rearrangements) can be represented by the averaged conditions of - respectively - 1 and 2 years whole burned fuel.

The present work represents a comparative study to complement the existing results with MCNP5 [5] statistical simulations, in order to get more exact directions for the reactor design.

2 Computation specifics

The MCNP input geometry has been simplified with respect to the ERANOS one [6] assuming a cylindrical geometry and modeling the fuel region by means of two cells only, an internal and an external one. No single assembly description has been made, but an homogeneous composition of both fuel (fissile, Minor Actinides (MAs), Fission Products (FPs) and the magnesium oxide matrix) and structural materials (see Figure 1). At least two fuel cells are still needed indeed for the different composition and geometry of fuel rods within the real system (due to flux leveling strategy). A 75 FPs scheme was considered for fuel composition to model fuel burn up.



Cell	Description
1	Internal Lead
2	Target
3	Beam Line
4	Foot Assembly
5	Foot Plenum
6	Inner Fuel
7	Outer Fuel
8	Dummy Box
9	Top Plenum
10	Top Assembly
11	External Lead

Figure 1: The EFIT reactor geometric scheme used for MCNP simulation.

The cross sections library chosen for MCNP simulation was JEFF2.2 [7], reprocessed for temperature effects (mainly Doppler broadening of resonance absorption peaks) with NJOY99.161 [8]. The material temperature scheme assumed is shown in Table 1.

Cell	Material	Temperature [K]
Fuel	Pellet	1023.15
	Clad	753.15
	Others	713.15
Structurals		713.15
Lead		713.15

Table 1: Material temperatures table within cells.

3 Results and discussion

The results of BOL, BOC and EOC k_{eff} for the three simulations are shown in Figure 2 for comparison. They were obtained with 2000 cycles of 10000 particles each simulations, run on a GNULinux cluster of 5 Athlon bi-processor units at Nuclear Engineering Laboratory (LIN) of the University of Bologna. The MCNP input file is presented in Appendix A.

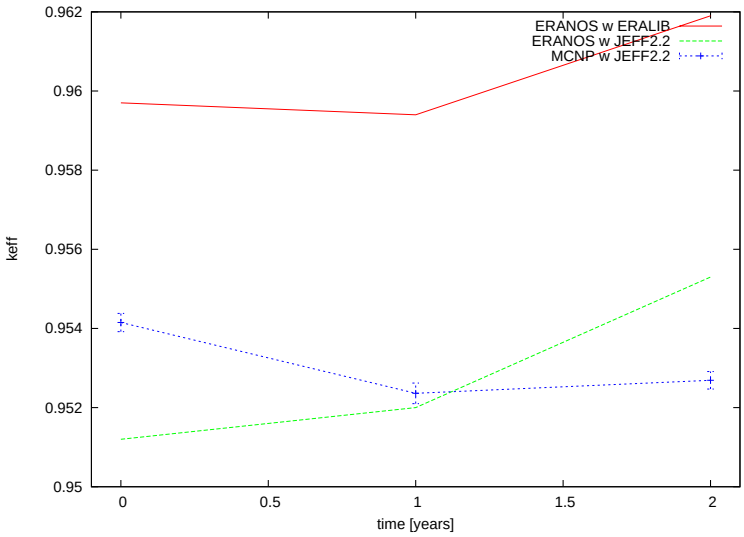


Figure 2: The EFIT BOL, BOC and EOC multiplication factor k_{eff} comparison between ERANOS and MCNP calculations. For MCNP results, the standard deviation shown is 11 pcm.

Besides the main difference (systematically about 650 pcm less for MCNP) introduced by different libraries used (JEFF2.2 vs ERALIB), the MCNP and ERANOS results differ (within a neighborhood of about 350 pcm) in general behavior: while the first one shows a reduction of k_{eff} with time and a stationarity during the regime fuel cycle, ERANOS calculations have an opposite behavior, with an increasing multiplication factor during the whole reactor life.

The main reasons of this difference can be ascribed to a couple concurring factors:

1. a systematic different importance imputed by the two codes to neutronic cross sections: while MCNP considers the cross sections continuous with respect to energy, ERANOS works with a finite set of energy bins, therefore with a finite set of cross sections values, averaged and approximated within the bins. Such an approximation leads to a different estimate of both fissions and captures, and a consequently slightly modified equilibrium between the latter two.

2. a progressive reduction of reactivity at BOC and EOC, due to the absence of a fuel burn up model. In ERANOS simulations, PFs production and fissile breeding are distributed proportionally to spatial flux within the fuel region, redistributing the fuel reactivity introduced by BU proportionally to the importance of the region (where the flux is the highest and the evolution of the fuel composition is greater). In MCNP simulation the

MAs (absorbers) reduction and new fuel production are uniformly distributed instead, penalizing the most important fuel regions and leading to a progressive reduction of the reactivity with reactor life.

The superposition of these aspects leads to a qualitative behavior similar to the one depicted in Figure 2.

For completion, further simulations have been run for spectral analysis within the fuel cells at BOL, BOC and EOC. The inner cell, the outer one and both of those simultaneously have been tallied: the volume flux spectra and several comparisons between those are depicted in Figures 3-6.

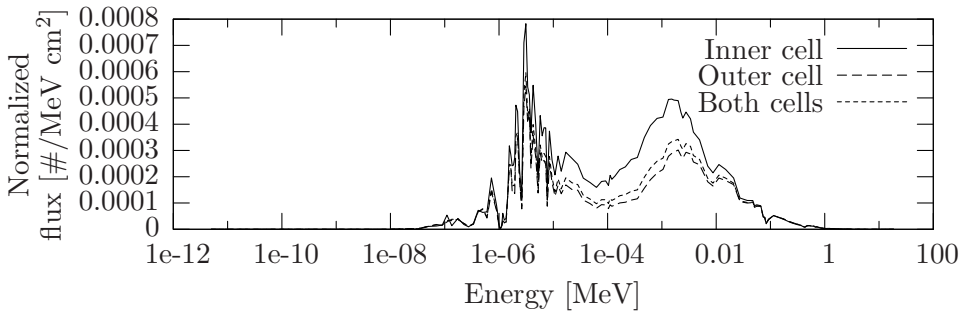


Figure 3: The normalized neutronic spectrum of EFIT at BOL within inner and outer fuel cells and within both of them.

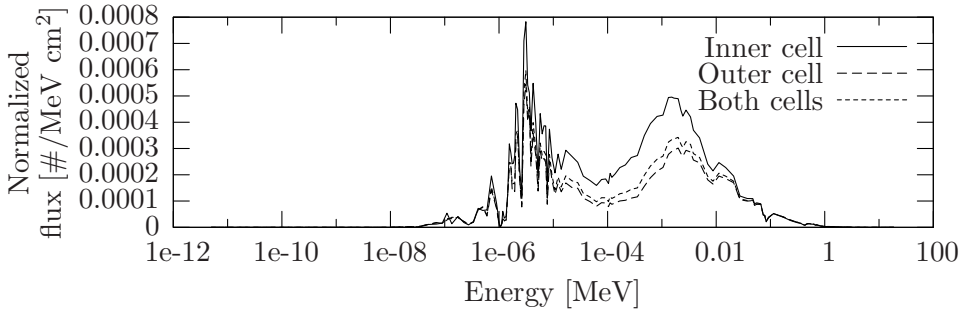


Figure 4: The normalized neutronic spectrum of EFIT at BOC within inner and outer fuel cells and within both of them.

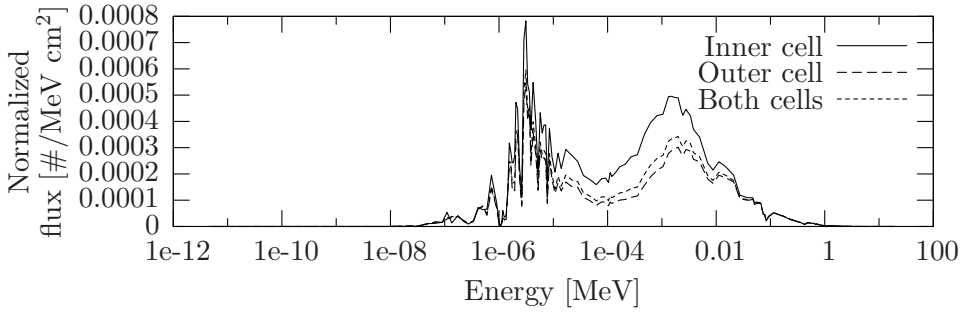


Figure 5: The normalized neutronic spectrum of EFIT at EOC within inner and outer fuel cells and within both of them.

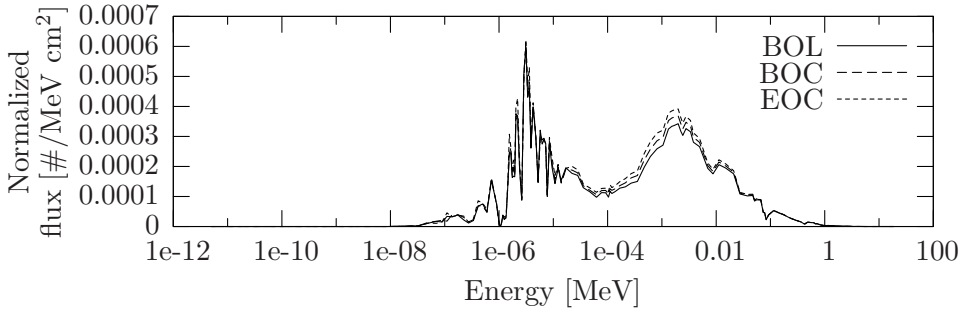


Figure 6: Evolution of the normalized neutronic spectrum of EFIT: BOL, BOC and EOC results within both the fuel cells plotted for comparison.

A MCNP input file

An example input file for MCNP simulations is given: it refers to the BOL configuration, without any lack of generality: the same conditions are considered for BOC and EOC ones, just modifying the fuel cells material compositions coherently with BU informations. The complete list of BOL, BOC and EOC compositions are tabulated in Appendix B for comparison.

```
c     Created on: Wednesday, December 13, 2006 at 12:59
c
c ------------- Cell cards ------------------------------------------------
c
c --- Internal Lead
    1   2  0.0397981     1  -4  -9          imp:n=1   TMP=6.1460E-08
c
c --- Target
    2   3  0.0379720     4  -5  -9          imp:n=1   TMP=6.1460E-08
c
c --- Beamline
    3   4  0.0376446     5  -8  -9          imp:n=1   TMP=6.1460E-08
c
c --- Foot Assembly
    4   5  0.0427720     9 -12   1  -2      imp:n=1   TMP=6.1460E-08
c
c --- Lower Plenum
    5   6  0.0340539     2  -3 -11   9      imp:n=1   TMP=6.1460E-08
c
c --- Inner Fuel
    6   8  0.04568713    3  -6   9 -10      imp:n=1   TMP=6.1460E-08
c
c --- Outer Fuel
    7   9  0.04489399    3  -6  10 -11      imp:n=1   TMP=6.1460E-08
c
c --- Dummy Box
    8   7  0.0356763    -7  11 -12   2      imp:n=1   TMP=6.1460E-08
c
c --- Upper Plenum
    9   6  0.0340539     6 -11   9  -7      imp:n=1   TMP=6.1460E-08
c
c --- Top Assembly
   10   5  0.0427720     7  -8   9 -12      imp:n=1   TMP=6.1460E-08
c
c --- Pb Ext
   11   1  0.032024      1  -8  12 -13      imp:n=1   TMP=6.1460E-08
c
c --- Universe
   12   0  13:  8: -1                       imp:n=0

c ------------- Surface cards ---------------------------------------------
c
    1        pz          0                    $Base
    2        pz      75.65                    $Lower Plenum 1
    3        pz   126.0825                    $Lower Plenum 2
    4        pz   141.2124                    $Lower Target
    5        pz   184.3927                    $Upper Target
    6        pz    216.862                    $Upper Plenum 1
```

```
 7       pz     263.88                  $Upper Plenum 2
 8       pz     332.858                 $Top
 9      c/z           0        0    43.9327 $Internal Lead
10      c/z           0        0       82.5 $Inner Fuel
11      c/z           0        0    156.466 $Outer Fuel
12      c/z           0        0     200.82 $Dummy Box
13      c/z           0        0      253.2 $External Cyl
```

B Inner and outer fuel cells compositions

Tables 2 and 3 represent the inner and outer cells fuel isotopic composition, expressed in atoms per barn centimeter, as used into the MCNP criticality calculations.

Table 2: Inner fuel isotopic composition.

Isotope	BOL	BOC	EOC
MAT number	Density [atoms/barn cm]		
47109	2.867878E-25	1.348691E-06	2.624243E-06
95241	7.561512E-04	6.624636E-04	5.801769E-04
95242	3.274547E-11	1.842324E-07	1.629132E-07
95242	2.540335E-06	1.027702E-05	1.548644E-05
95243	1.607673E-04	1.462441E-04	1.336096E-04
56138	2.475393E-25	4.431406E-06	8.723125E-06
35081	3.513531E-25	8.921209E-08	1.708331E-07
6000	6.223968E-05	6.223968E-05	6.223968E-05
48111	2.834259E-25	4.981574E-07	9.838129E-07
48112	2.817907E-25	3.021612E-07	6.112896E-07
48113	2.801786E-25	1.873980E-07	3.724545E-07
48114	2.785997E-25	1.252418E-07	2.510071E-07
58140	2.454318E-25	3.664123E-06	7.257955E-06
58141	2.443979E-25	4.413465E-07	4.298846E-07
58142	2.433803E-25	3.396504E-06	6.679295E-06
58144	2.413857E-25	1.699113E-06	2.359579E-06
96242	2.303194E-25	3.050808E-05	3.304385E-05
96243	6.630009E-07	1.173525E-06	1.992064E-06
96244	3.005636E-05	4.267098E-05	5.291828E-05
96245	1.140806E-05	1.091665E-05	1.088780E-05
96246	8.864701E-07	8.602235E-07	8.347083E-07
96247	1.678625E-08	2.734619E-08	3.651923E-08
96248	1.010299E-09	1.433746E-09	2.051744E-09
24050	5.805360E-05	5.805360E-05	5.805360E-05
24052	1.084884E-03	1.084884E-03	1.084884E-03
24053	1.213576E-04	1.213576E-04	1.213576E-04
24054	2.968439E-05	2.968439E-05	2.968439E-05
55133	2.530842E-25	4.598812E-06	9.011752E-06
55134	2.519411E-25	6.259838E-08	2.262819E-07
55135	2.508166E-25	5.222727E-06	1.022186E-05
55137	2.486141E-25	4.550197E-06	8.851267E-06
63153	2.330654E-25	3.376761E-07	6.271415E-07
63154	2.322005E-25	2.627478E-08	9.554864E-08
63155	2.313481E-25	1.554752E-07	2.900905E-07
26054	7.121743E-04	7.121743E-04	7.121743E-04
26056	1.081603E-02	1.081603E-02	1.081603E-02
26057	2.538826E-04	2.538826E-04	2.538826E-04
26058	3.759734E-05	3.759734E-05	3.759734E-05
64156	2.305072E-25	1.227972E-07	2.598362E-07
64157	2.296750E-25	8.060125E-08	1.522443E-07
53127	2.603166E-25	3.419229E-07	6.576626E-07
53129	2.578311E-25	9.506558E-07	1.854526E-06
53131	2.554204E-25	8.723053E-08	8.357360E-08

49115	2.770461E-25	7.777616E-08	1.511718E-07
36083	3.453000E-25	2.023172E-07	3.897752E-07
36084	3.423858E-25	3.236064E-07	6.325408E-07
36086	3.367490E-25	5.537907E-07	1.084700E-06
57139	2.464769E-25	4.139452E-06	8.134893E-06
57140	2.454276E-25	2.453233E-08	2.391688E-08
12000	6.420684E-03	6.420684E-03	6.420684E-03
25055	6.803104E-05	6.803104E-05	6.803104E-05
42000	7.792125E-05	7.792125E-05	7.792125E-05
42100	3.036003E-25	4.470024E-06	8.752895E-06
42095	3.143229E-25	1.874902E-06	4.772666E-06
42097	3.099021E-25	3.409522E-06	6.650662E-06
42098	3.077609E-25	3.833430E-06	7.573554E-06
42099	3.056569E-25	4.399943E-08	4.279560E-08
41093	8.045721E-06	8.045721E-06	8.045721E-06
41095	3.143207E-25	4.063523E-07	4.118043E-07
60143	2.423778E-25	2.847233E-06	5.726665E-06
60144	2.413889E-25	8.940650E-07	2.821884E-06
60145	2.404121E-25	2.214123E-06	4.305399E-06
60146	2.394499E-25	1.929772E-06	3.874488E-06
60147	2.384988E-25	6.466027E-08	6.373563E-08
60148	2.375628E-25	1.278403E-06	2.509361E-06
60150	2.357253E-25	7.771578E-07	1.521753E-06
28058	3.502972E-05	3.502972E-05	3.502972E-05
28060	1.309633E-05	1.309633E-05	1.309633E-05
28061	6.133971E-07	6.133971E-07	6.133971E-07
28062	1.750205E-06	1.750205E-06	1.750205E-06
28064	4.677132E-07	4.677132E-07	4.677132E-07
93237	3.889807E-05	3.567291E-05	3.263773E-05
93239	1.001389E-30	1.277641E-10	1.167791E-10
8016	9.893075E-03	9.893075E-03	9.893075E-03
8017	3.760798E-06	3.760798E-06	3.760798E-06
82000	1.400382E-02	1.400382E-02	1.400382E-02
46105	2.939075E-25	3.790375E-06	7.329069E-06
46106	2.920803E-25	1.007271E-06	3.355640E-06
46107	2.902823E-25	2.494788E-06	4.798507E-06
46108	2.885225E-25	1.831227E-06	3.763071E-06
46110	2.850920E-25	8.159240E-07	1.614993E-06
61147	2.384997E-25	1.204145E-06	2.073556E-06
61148	2.375619E-25	1.477765E-08	2.866485E-08
61149	2.366384E-25	8.686491E-09	8.578552E-09
59141	2.443990E-25	2.983904E-06	6.298297E-06
59143	2.423774E-25	1.632118E-07	1.591819E-07
94238	3.191150E-05	6.178033E-05	1.070364E-04
94239	3.949418E-04	3.453548E-04	3.034665E-04
94240	2.889332E-04	2.861474E-04	2.825799E-04
94241	3.242097E-05	3.520432E-05	3.742571E-05
94242	9.951217E-05	1.078461E-04	1.145540E-04
94243	8.363016E-31	1.873233E-15	2.695155E-15
94244	9.610291E-09	9.341255E-09	9.076150E-09
37085	3.395323E-25	4.075933E-07	7.908973E-07
37087	3.340304E-25	7.122493E-07	1.398546E-06

45103	2.976732E-25	3.834395E-06	8.115662E-06
45105	2.939067E-25	2.293179E-08	2.251521E-08
44101	3.015882E-25	4.554289E-06	8.771861E-06
44102	2.996130E-25	4.999849E-06	9.949263E-06
44103	2.976708E-25	7.186718E-07	7.031952E-07
44104	2.957714E-25	4.721464E-06	9.237608E-06
44106	2.920735E-25	2.394862E-06	3.542270E-06
51121	2.682670E-25	3.115295E-08	5.963312E-08
51125	2.628806E-25	9.135909E-08	1.581559E-07
14000	1.064608E-04	1.064608E-04	1.064608E-04
62147	2.385001E-25	1.563197E-07	5.650350E-07
62149	2.366396E-25	9.072062E-07	1.678135E-06
62150	2.357289E-25	7.362497E-08	2.764284E-07
62151	2.348283E-25	5.514903E-07	9.892615E-07
62152	2.339420E-25	5.314304E-07	1.124725E-06
62154	2.322010E-25	2.355667E-07	4.569683E-07
38090	3.262297E-25	1.356765E-06	2.682664E-06
65159	2.280435E-25	2.334538E-08	4.319031E-08
43099	3.056600E-25	3.916877E-06	7.619061E-06
52128	2.590643E-25	5.762264E-07	1.131556E-06
52130	2.566156E-25	1.846155E-06	3.610358E-06
92234	8.685366E-31	3.338725E-07	9.653418E-07
92235	8.648306E-31	1.542301E-08	4.534366E-08
92236	8.611606E-31	3.144512E-08	6.251279E-08
92238	8.539066E-31	1.888462E-10	3.864077E-10
23000	2.934733E-05	2.934733E-05	2.934733E-05
54131	2.554217E-25	2.631487E-06	5.184537E-06
54132	2.542455E-25	3.611131E-06	7.137091E-06
54133	2.530841E-25	9.898995E-08	9.601504E-08
54134	2.519421E-25	5.122783E-06	1.008478E-05
54136	2.497063E-25	5.016394E-06	9.861428E-06
39089	3.287775E-25	1.110686E-06	2.192428E-06
39091	3.237438E-25	3.796137E-07	3.763492E-07
40091	3.237478E-25	1.281087E-06	2.900561E-06
40092	3.213163E-25	2.051413E-06	4.051917E-06
40093	3.189322E-25	2.476598E-06	4.866164E-06
40094	3.166027E-25	2.798355E-06	5.528387E-06
40095	3.143179E-25	7.570123E-07	7.494685E-07
40096	3.120843E-25	3.236389E-06	6.369084E-06

Table 3: Outer fuel isotopic composition.

Isotope	BOL	BOC	EOC
MAT number	Density [atoms/barn cm]		
47109	3.823835E-25	9.802006E-07	1.930544E-06
95241	1.008201E-03	9.485412E-04	8.919592E-04
95242	4.366060E-11	1.166023E-07	1.111768E-07
95242	3.387111E-06	8.380092E-06	1.260399E-05
95243	2.143564E-04	2.051085E-04	1.963556E-04
56138	3.300523E-25	3.180843E-06	6.307135E-06
35081	4.684705E-25	6.428644E-08	1.260646E-07
6000	6.223967E-05	6.223967E-05	6.223967E-05
48111	3.779011E-25	3.624859E-07	7.185222E-07
48112	3.757208E-25	2.197239E-07	4.396757E-07
48113	3.735714E-25	1.373240E-07	2.728588E-07
48114	3.714661E-25	9.059840E-08	1.806091E-07
58140	3.272423E-25	2.611880E-06	5.204303E-06
58141	3.258638E-25	3.149261E-07	3.106270E-07
58142	3.245071E-25	2.409558E-06	4.777686E-06
58144	3.218476E-25	1.211596E-06	1.694683E-06
96242	3.070925E-25	1.903792E-05	2.206837E-05
96243	8.840010E-07	9.568732E-07	1.147305E-06
96244	4.007514E-05	4.667812E-05	5.257959E-05
96245	1.521074E-05	1.473064E-05	1.437818E-05
96246	1.181960E-06	1.163435E-06	1.145135E-06
96247	2.238166E-08	2.812399E-08	3.351368E-08
96248	1.347065E-09	1.553233E-09	1.809777E-09
24050	5.805357E-05	5.805357E-05	5.805357E-05
24052	1.084884E-03	1.084884E-03	1.084884E-03
24053	1.213576E-04	1.213576E-04	1.213576E-04
24054	2.968436E-05	2.968436E-05	2.968436E-05
55133	3.374455E-25	3.294064E-06	6.564283E-06
55134	3.359214E-25	1.842910E-08	6.736113E-08
55135	3.344220E-25	3.735987E-06	7.393953E-06
55137	3.314853E-25	3.257035E-06	6.384550E-06
63153	3.107538E-25	2.516725E-07	4.858911E-07
63154	3.096006E-25	8.176427E-09	3.157945E-08
63155	3.084642E-25	1.186731E-07	2.281450E-07
26054	7.121741E-04	7.121741E-04	7.121741E-04
26056	1.081603E-02	1.081603E-02	1.081603E-02
26057	2.538826E-04	2.538826E-04	2.538826E-04
26058	3.759732E-05	3.759732E-05	3.759732E-05
64156	3.073428E-25	8.562730E-08	1.755524E-07
64157	3.062332E-25	6.010632E-08	1.169880E-07
53127	3.470887E-25	2.464151E-07	4.841061E-07
53129	3.437747E-25	6.825360E-07	1.348180E-06
53131	3.405604E-25	6.244215E-08	6.111522E-08
49115	3.693947E-25	5.667825E-08	1.115577E-07
36083	4.603997E-25	1.461752E-07	2.873690E-07
36084	4.565144E-25	2.314892E-07	4.578805E-07
36086	4.489985E-25	3.997707E-07	7.914075E-07
57139	3.286358E-25	2.973620E-06	5.892076E-06
57140	3.272367E-25	1.747200E-08	1.723238E-08

12000	5.136547E-03	5.136547E-03	5.136547E-03
25055	6.803103E-05	6.803103E-05	6.803103E-05
42000	7.792122E-05	7.792122E-05	7.792122E-05
42100	4.048003E-25	3.188097E-06	6.310241E-06
42095	4.190971E-25	1.334906E-06	3.436524E-06
42097	4.132026E-25	2.449667E-06	4.841026E-06
42098	4.103477E-25	2.723086E-06	5.410803E-06
42099	4.075423E-25	3.129396E-08	3.083575E-08
41093	8.045718E-06	8.045718E-06	8.045718E-06
41095	4.190941E-25	2.881070E-07	2.962256E-07
60143	3.231702E-25	2.037395E-06	4.146528E-06
60144	3.218518E-25	6.247569E-07	1.969706E-06
60145	3.205494E-25	1.597759E-06	3.153907E-06
60146	3.192664E-25	1.368597E-06	2.735869E-06
60147	3.179983E-25	4.613275E-08	4.570718E-08
60148	3.167504E-25	9.165839E-07	1.815466E-06
60150	3.143002E-25	5.605387E-07	1.108709E-06
28058	3.502970E-05	3.502970E-05	3.502970E-05
28060	1.309633E-05	1.309633E-05	1.309633E-05
28061	6.133969E-07	6.133969E-07	6.133969E-07
28062	1.750205E-06	1.750205E-06	1.750205E-06
28064	4.677131E-07	4.677131E-07	4.677131E-07
93237	5.186406E-05	5.070112E-05	4.947768E-05
93239	1.335184E-30	1.792021E-10	1.715824E-10
8016	9.767755E-03	9.767755E-03	9.767755E-03
8017	3.713158E-06	3.713158E-06	3.713158E-06
82000	1.400382E-02	1.400382E-02	1.400382E-02
46105	3.918765E-25	2.734082E-06	5.386348E-06
46106	3.894403E-25	6.800205E-07	2.254417E-06
46107	3.870429E-25	1.820332E-06	3.569428E-06
46108	3.846966E-25	1.295132E-06	2.615940E-06
46110	3.801225E-25	5.915438E-07	1.173661E-06
61147	3.179995E-25	8.826931E-07	1.562452E-06
61148	3.167491E-25	4.272221E-09	8.536709E-09
61149	3.155178E-25	6.177104E-09	6.112323E-09
59141	3.258652E-25	2.134416E-06	4.545105E-06
59143	3.231699E-25	1.160540E-07	1.145022E-07
94238	4.254864E-05	6.071068E-05	9.137955E-05
94239	5.265887E-04	4.940182E-04	4.636803E-04
94240	3.852441E-04	3.830587E-04	3.808043E-04
94241	4.322794E-05	4.335621E-05	4.350183E-05
94242	1.326828E-04	1.376156E-04	1.421085E-04
94243	1.115068E-30	1.791303E-15	2.203177E-15
94244	1.281372E-08	1.263932E-08	1.246550E-08
37085	4.527094E-25	2.962068E-07	5.840049E-07
37087	4.453737E-25	5.138183E-07	1.018428E-06
45103	3.968975E-25	2.769840E-06	5.959319E-06
45105	3.918755E-25	1.624037E-08	1.604825E-08
44101	4.021175E-25	3.290590E-06	6.466186E-06
44102	3.994839E-25	3.567005E-06	7.105600E-06
44103	3.968943E-25	5.134927E-07	5.076893E-07
44104	3.943616E-25	3.348694E-06	6.623341E-06

44106	3.894312E-25	1.713003E-06	2.552096E-06
51121	3.576893E-25	2.216809E-08	4.345732E-08
51125	3.505074E-25	6.599867E-08	1.156613E-07
14000	1.064607E-04	1.064607E-04	1.064607E-04
62147	3.180001E-25	1.156982E-07	4.340164E-07
62149	3.155194E-25	6.784649E-07	1.315292E-06
62150	3.143051E-25	2.242022E-08	8.484073E-08
62151	3.131043E-25	4.187459E-07	7.994502E-07
62152	3.119226E-25	3.637823E-07	7.461718E-07
62154	3.096012E-25	1.725436E-07	3.397102E-07
38090	4.349728E-25	9.606703E-07	1.911029E-06
65159	3.040578E-25	1.807238E-08	3.486633E-08
43099	4.075465E-25	2.821776E-06	5.587110E-06
52128	3.454189E-25	4.083261E-07	8.092645E-07
52130	3.421540E-25	1.313854E-06	2.598690E-06
92234	1.158048E-30	3.845601E-07	9.647519E-07
92235	1.153107E-30	1.711506E-08	4.006197E-08
92236	1.148214E-30	4.164906E-08	8.286404E-08
92238	1.138542E-30	2.476743E-10	5.011752E-10
23000	2.934732E-05	2.934732E-05	2.934732E-05
54131	3.405621E-25	1.895167E-06	3.797054E-06
54132	3.389938E-25	2.559174E-06	5.083605E-06
54133	3.374454E-25	7.021471E-08	6.912534E-08
54134	3.359228E-25	3.636530E-06	7.213659E-06
54136	3.329417E-25	3.575653E-06	7.087638E-06
39089	4.383699E-25	7.888853E-07	1.568069E-06
39091	4.316582E-25	2.682501E-07	2.690510E-07
40091	4.316636E-25	9.064320E-07	2.065982E-06
40092	4.284215E-25	1.461424E-06	2.904475E-06
40093	4.252428E-25	1.756420E-06	3.484626E-06
40094	4.221368E-25	1.978499E-06	3.931861E-06
40095	4.190904E-25	5.366940E-07	5.392575E-07
40096	4.161124E-25	2.294874E-06	4.553705E-06

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