For Official Use **NEA/NSC/DOC(2001)4**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

28-Mar-2001

English - Or. English

NEA/NSC/DOC(2001)4
For Official Use

NUCLEAR ENERGY AGENCY
NUCLEAR SCIENCE COMMITTEE

Expert Group on 3-D Radiation Transport Benchmarks

BENCHMARK SPECIFICATION FOR DETERMINISTIC 2-D/3-D MOX FUEL ASSEMBLY TRANSPORT CALCULATIONS WITHOUT SPATIAL HOMOGENISATION (C5G7 MOX)

English - Or. English

JT00105087

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

Expert Group on 3-D Radiation Transport Benchmarks

Benchmark specification for Deterministic 2-D/3-D MOX fuel assembly transport calculations without spatial homogenisation (C5G7 MOX)

E. E. Lewis
Northwestern University
Department of Mechanical Engineering
Evanston, Illinois 60208

M. A. Smith & N. Tsoulfanidis
University of Missouri, Rolla
Department of Nuclear Engineering
Rolla, Missouri 65409

G. Palmiotti, T. A. Taiwo & R. N. Blomquist
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Outline

Benchmark specification
Appendix 1: Description of computational model used to obtain benchmark solutions
Appendix 2: Results to be reported

Problem Specification

We hereby propose that a seven-group form of the C5 MOX fuel assembly problem specified by Cavarec *et. al*. be used as a basis to test the ability of current transport codes to treat reactor core problems without spatial homogenisation. The two-dimensional and three-dimensional configurations are shown in Figure 1. For the two-dimensional domain, vacuum boundary conditions are applied to the right and to the bottom of the geometry while reflected boundary conditions are applied to the top and left of the geometry as indicated. The overall dimensions of the two-dimensional problem geometry, as seen in Figure 1, are 64.26×64.26 cm, while each assembly is 21.42×21.42 cm. For the three-dimensional configuration, the fuel assemblies are extended in the z direction 192.78 cm and an additional 21.42 cm water reflector is added above them. The z boundary conditions are reflected below and vacuum above as indicated in Figure 1. The overall dimensions for the three-dimensional configuration as seen in Figure 1 are 64.26×64.26×214.20 cm, while each assembly is 21.42×21.42×192.78 cm.

Each fuel assembly is made up of a 17x17 lattice of square fuel-pin cells, as seen in Figure 2. The side length of every fuel-pin cell is 1.26 cm and every cylinder is of radius 0.54 cm. As indicated in Figure 2, there are two compositions for every fuel-pin cell. For this benchmark problem a single moderator composition is provided for use in all of the fuel-pin cells and in the water reflector (moderator) surrounding the assemblies. The composition layout for the fuel-pin cell *cylinders* is provided in Figure 3 for all four assemblies.

Table I provides seven group, transport corrected, isotropic scattering cross-sections for UO_2, the three enrichments of MOX, the guide tubes and fission chamber, and the moderator described in the problem specification. To obtain these cross-sections, the number densities and the dimensions of the fuel, cladding and assemblies specified by S. Cathalau *et al*. were used with the collision probability code DRAGON (G. Marleau et al) and the WIMS-AECL 69 group library. Each fuel type was represented as a single pin cell in an infinite-lattice fine-mesh collision probability calculation. A full anisotropic collision probability calculation was performed and standard flux weighting was used to collapse to seven energy groups and to homogenise fuel, gap, and cladding materials into homogenised fuel compositions. The seven-group moderator cross-sections in Table I were obtained using the UO_2 pin cell spectrum. The cross-sections for the homogenised guide tube and fission chamber regions were also obtained using a UO_2 fuel spectrum to be consistent with the moderator cross-sections.

Problem Objectives

Stage I. Two-dimensional configuration

Calculate:
- (a) The eigenvalue
- (b) Each of the pin powers (with average pin power normalised to 1 fission/sec/cell)

Stage II. Three-dimensional configuration

Calculate:
- (c) The eigenvalue
- (d) Each of the pin powers (with average pin power normalised to 1 fission/sec/cell)

It is suggested that the eigenvalue be compared to that of the approximate reference solution eigenvalues provided below to ensure that the geometry is setup correctly (*actual reference eigenvalues are known to* $\pm$*0.00004*). For either configuration an Excel spreadsheet is provided for the insertion of pin power information as indicated by the numbering convention in Figure 3. *If you are unable to obtain pin powers and can only obtain pin production rates, accommodations are available.* Both the pin power and pin production rate reference solutions for the two and three dimensional configurations were obtained via a multi-group Monte Carlo calculation utilizing 300 million histories. A 0.14% RMS statistical pin power percent error was achieved for both two and three-dimensional configurations.

Reference Seven-group Monte Carlo Eigenvalue Answers

Approximate eigenvalue for the two-dimensional configuration: 1.19
Approximate eigenvalue for the three-dimensional configuration: 1.18

Comments:

We are well aware that the homogenisation and group collapse introduced some error into the cross-sections. Our object, however, is not to examine the validity of the group collapse, or fuel-cladding homogenisation. Instead, it is to provide a reasonable set of multigroup cross-sections in which there is no fuel-coolant homogenisation. Moreover, for brevity in data input we utilise a single set of water cross-section in both the UO_2 and MOX assembles and in the reflector. The geometry specification combined with these transport-corrected, isotropic scattering, seven-group cross-sections provides a basis for comparing the accuracy of deterministic transport codes with reference seven-group Monte Carlo solutions. Each reference solution required approximately one week of CPU time on a Sun 60. The solutions may also serve to test the validity of spatial fuel-coolant homogenisation procedures at the fuel-pin cell and/or at the fuel assembly level.

References

Cavarec, C., et al., “The OECD/NEA Benchmark Calculations of Power Distributions within Assemblies,” Electricity de France, Sept. 1994.

S. Cathalau, J.C. Lefebvre, J.P. West, "Proposal for a Second Stage of the Benchmark on Power Distributions within Assemblies," An earlier version of the published OECD/NEA Benchmark, April 1996.

G. Marleau, A. Hébert, R. Roy, “A User’s Guide for DRAGON, “ Ecole Polytechnique de Montréal, December 1997.

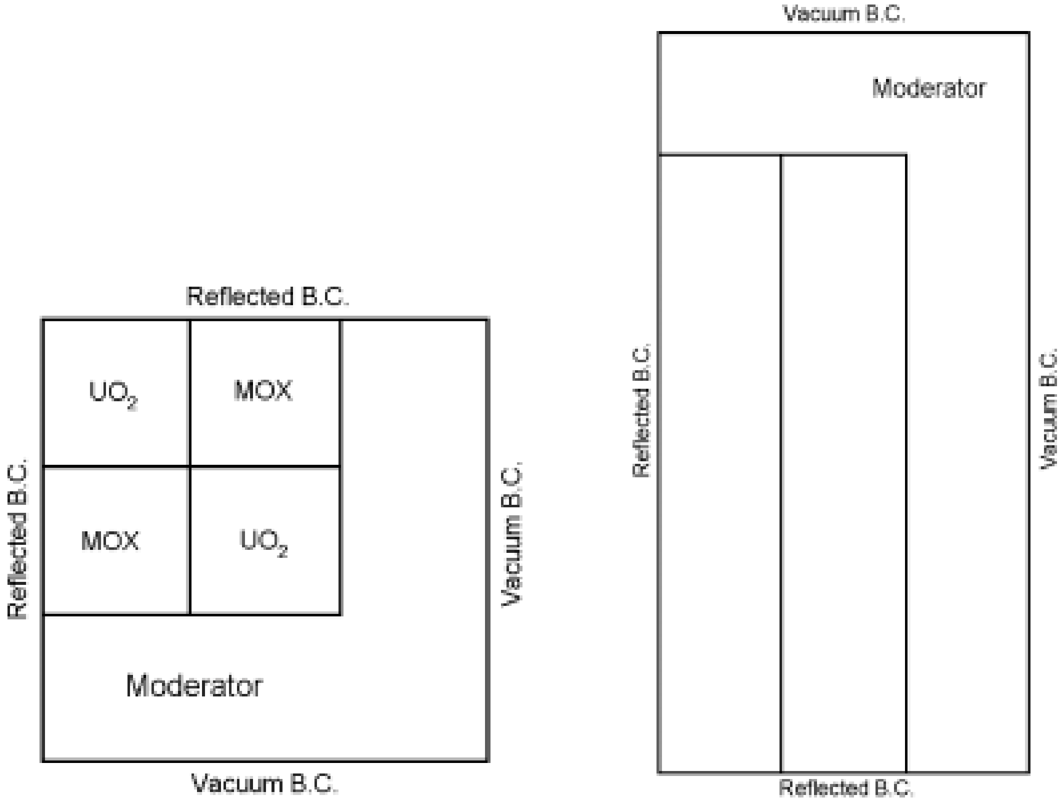

Figure 1. Core Configuration for the C5 Benchmark Problem

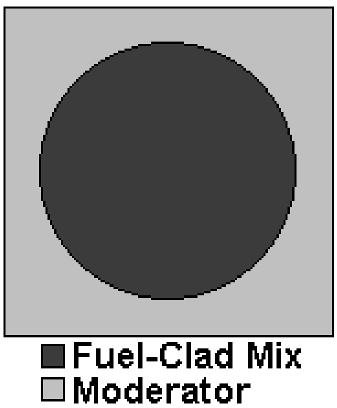

Figure 2. Fuel Pin Layout

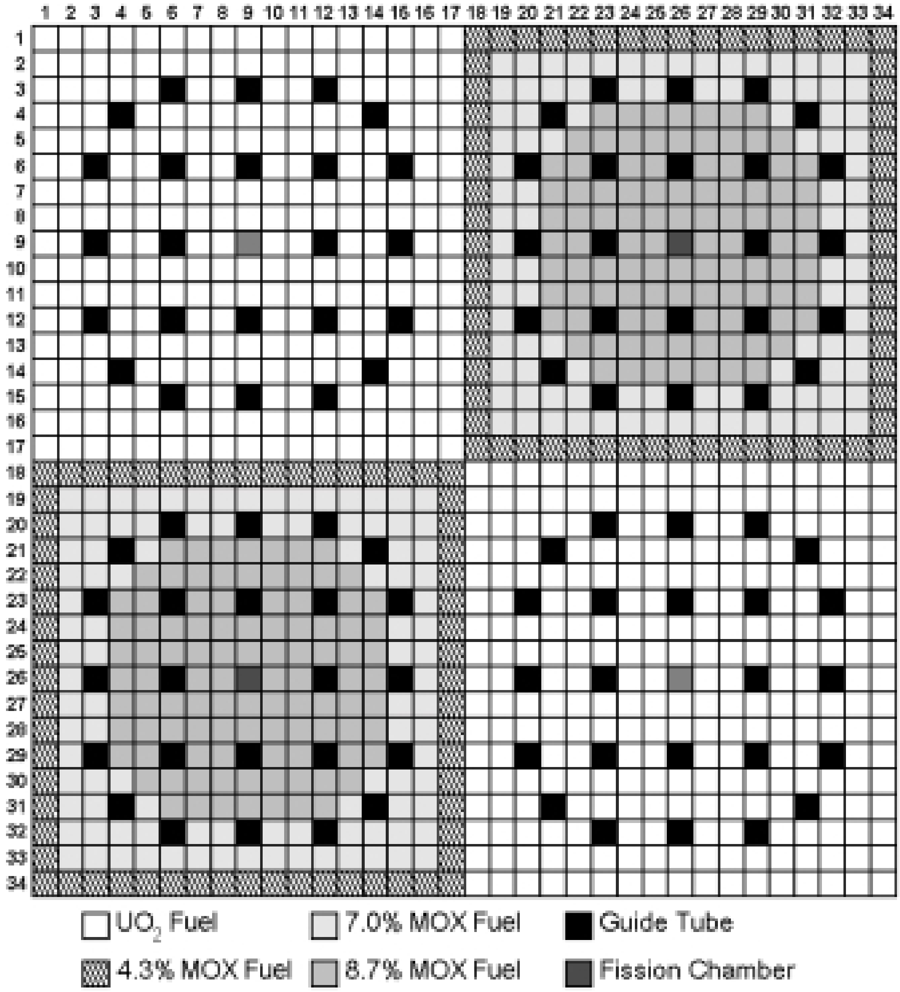

Figure 3. Benchmark Fuel Pin Compositions and Numbering Scheme

Table 1a. UO_2 Fuel-Clad Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section	Fission Cross-section	Nu	Chi
Group 1	2.12450E-01	1.77949E-01	8.02480E-03	8.12740E-04	7.21206E-03	2.78145E+00	5.87910E-01
Group 2	3.55470E-01	3.29805E-01	3.71740E-03	2.89810E-03	8.19301E-04	2.47443E+00	4.11760E-01
Group 3	4.85540E-01	4.80388E-01	2.67690E-02	2.03158E-02	6.45320E-03	2.43383E+00	3.39060E-04
Group 4	5.59400E-01	5.54367E-01	9.62360E-02	7.76712E-02	1.85648E-02	2.43380E+00	1.17610E-07
Group 5	3.18030E-01	3.11801E-01	3.00200E-02	1.22116E-02	1.78084E-02	2.43380E+00	0.00000E+00
Group 6	4.01460E-01	3.95168E-01	1.11260E-01	2.82252E-02	8.30348E-02	2.43380E+00	0.00000E+00
Group 7	5.70610E-01	5.64406E-01	2.82780E-01	6.67760E-02	2.16004E-01	2.43380E+00	0.00000E+00

Scattering Block

	to Group 1	to Group 2	to Group 3	to Group 4	to Group 5	to Group 6	to Group 7
Group 1	1.27537E-01	4.23780E-02	9.43740E-06	5.51630E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	3.24456E-01	1.63140E-03	3.14270E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 3	0.00000E+00	0.00000E+00	4.50940E-01	2.67920E-03	0.00000E+00	0.00000E+00	0.00000E+00
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	4.52565E-01	5.56640E-03	0.00000E+00	0.00000E+00
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	1.25250E-04	2.71401E-01	1.02550E-02	1.00210E-08
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.29680E-03	2.65802E-01	1.68090E-02
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	8.54580E-03	2.73080E-01

Table 1b. 4.3% MOX Fuel-Clad Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section	Fission Cross-section	Nu	Chi
Group 1	2.11920E-01	1.78731E-01	8.43390E-03	8.06860E-04	7.62704E-03	2.85209E+00	5.87910E-01
Group 2	3.55810E-01	3.30849E-01	3.75770E-03	2.88080E-03	8.76898E-04	2.89099E+00	4.11760E-01
Group 3	4.88900E-01	4.83772E-01	2.79700E-02	2.22717E-02	5.69835E-03	2.85486E+00	3.39060E-04
Group 4	5.71940E-01	5.66922E-01	1.04210E-01	8.13228E-02	2.28872E-02	2.86073E+00	1.17610E-07
Group 5	4.32390E-01	4.26227E-01	1.39940E-01	1.29177E-01	1.07635E-02	2.85447E+00	0.00000E+00
Group 6	6.84950E-01	6.78997E-01	4.09180E-01	1.76423E-01	2.32757E-01	2.86415E+00	0.00000E+00
Group 7	6.88910E-01	6.82852E-01	4.09350E-01	1.60382E-01	2.48968E-01	2.86780E+00	0.00000E+00

Scattering Block

	to Group 1	to Group 2	to Group 3	To Group 4	to Group 5	to Group 6	to Group 7
Group 1	1.28876E-01	4.14130E-02	8.22900E-06	5.04050E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	3.25452E-01	1.63950E-03	1.59820E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 3	0.00000E+00	0.00000E+00	4.53188E-01	2.61420E-03	0.00000E+00	0.00000E+00	0.00000E+00
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	4.57173E-01	5.53940E-03	0.00000E+00	0.00000E+00
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	1.60460E-04	2.76814E-01	9.31270E-03	9.16560E-09
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	2.00510E-03	2.52962E-01	1.48500E-02
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	8.49480E-03	2.65007E-01

Table 1c. 7.0% MOX Fuel-Clad Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section	Fission Cross-section	Nu	Chi
Group 1	2.14540E-01	1.81323E-01	9.06570E-03	8.11240E-04	8.25446E-03	2.88498E+00	5.87910E-01
Group 2	3.59350E-01	3.34368E-01	4.29670E-03	2.97105E-03	1.32565E-03	2.91079E+00	4.11760E-01
Group 3	4.98910E-01	4.93785E-01	3.28810E-02	2.44594E-02	8.42156E-03	2.86574E+00	3.39060E-04
Group 4	5.96220E-01	5.91216E-01	1.22030E-01	8.91570E-02	3.28730E-02	2.87063E+00	1.17610E-07
Group 5	4.80350E-01	4.74198E-01	1.82980E-01	1.67016E-01	1.59636E-02	2.86714E+00	0.00000E+00
Group 6	8.39360E-01	8.33601E-01	5.68460E-01	2.44666E-01	3.23794E-01	2.86658E+00	0.00000E+00
Group 7	8.59480E-01	8.53603E-01	5.85210E-01	2.22407E-01	3.62803E-01	2.87539E+00	0.00000E+00

Scattering Block

	to Group 1	to Group 2	to Group 3	To Group 4	to Group 5	to Group 6	to Group 7
Group 1	1.30457E-01	4.17920E-02	8.51050E-06	5.13290E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	3.28428E-01	1.64360E-03	2.20170E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 3	0.00000E+00	0.00000E+00	4.58371E-01	2.53310E-03	0.00000E+00	0.00000E+00	0.00000E+00
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	4.63709E-01	5.47660E-03	0.00000E+00	0.00000E+00
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	1.76190E-04	2.82313E-01	8.72890E-03	9.00160E-09
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	2.27600E-03	2.49751E-01	1.31140E-02
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	8.86450E-03	2.59529E-01

Table 1d. 8.7% MOX Fuel-Clad Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section	Fission Cross-section	Nu	Chi
Group 1	2.16280E-01	1.83045E-01	9.48620E-03	8.14110E-04	8.67209E-03	2.90426E+00	5.87910E-01
Group 2	3.61700E-01	3.36705E-01	4.65560E-03	3.03134E-03	1.62426E-03	2.91795E+00	4.11760E-01
Group 3	5.05630E-01	5.00507E-01	3.62400E-02	2.59684E-02	1.02716E-02	2.86986E+00	3.39060E-04
Group 4	6.11170E-01	6.06174E-01	1.32720E-01	9.36753E-02	3.90447E-02	2.87491E+00	1.17610E-07
Group 5	5.08900E-01	5.02754E-01	2.08400E-01	1.89142E-01	1.92576E-02	2.87175E+00	0.00000E+00
Group 6	9.26670E-01	9.21028E-01	6.58700E-01	2.83812E-01	3.74888E-01	2.86752E+00	0.00000E+00
Group 7	9.60990E-01	9.55231E-01	6.90170E-01	2.59571E-01	4.30599E-01	2.87808E+00	0.00000E+00

Scattering block

	to Group 1	to Group 2	to Group 3	To Group 4	to Group 5	to Group 6	to Group 7
Group 1	1.31504E-01	4.20460E-02	8.69720E-06	5.19380E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	3.30403E-01	1.64630E-03	2.60060E-09	0.00000E+00	0.00000E+00	0.00000E+00
Group 3	0.00000E+00	0.00000E+00	4.61792E-01	2.47490E-03	0.00000E+00	0.00000E+00	0.00000E+00
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	4.68021E-01	5.43300E-03	0.00000E+00	0.00000E+00
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	1.85970E-04	2.85771E-01	8.39730E-03	8.92800E-09
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	2.39160E-03	2.47614E-01	1.23220E-02
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	8.96810E-03	2.56093E-01

Table 1e. Fission Chamber Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section	Fission Cross-section	Nu	Chi
Group 1	1.90730E-01	1.26032E-01	5.11320E-04	5.11315E-04	4.79002E-09	2.76283E+00	5.87910E-01
Group 2	4.56520E-01	2.93160E-01	7.58130E-05	7.58072E-05	5.82564E-09	2.46239E+00	4.11760E-01
Group 3	6.40700E-01	2.84250E-01	3.16430E-04	3.15966E-04	4.63719E-07	2.43380E+00	3.39060E-04
Group 4	6.49840E-01	2.81020E-01	1.16750E-03	1.16226E-03	5.24406E-06	2.43380E+00	1.17610E-07
Group 5	6.70630E-01	3.34460E-01	3.39770E-03	3.39755E-03	1.45390E-07	2.43380E+00	0.00000E+00
Group 6	8.75060E-01	5.65640E-01	9.18860E-03	9.18789E-03	7.14972E-07	2.43380E+00	0.00000E+00
Group 7	1.43450E+00	1.17214E+00	2.32440E-02	2.32419E-02	2.08041E-06	2.43380E+00	0.00000E+00

Scattering Block

	to Group 1	to Group 2	to Group 3	to Group 4	to Group 5	to Group 6	to Group 7
Group 1	6.61659E-02	5.90700E-02	2.83340E-04	1.46220E-06	2.06420E-08	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	2.40377E-01	5.24350E-02	2.49900E-04	1.92390E-05	2.98750E-06	4.21400E-07
Group 3	0.00000E+00	0.00000E+00	1.83425E-01	9.22880E-02	6.93650E-03	1.07900E-03	2.05430E-04
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	7.90769E-02	1.69990E-01	2.58600E-02	4.92560E-03
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	3.73400E-05	9.97570E-02	2.06790E-01	2.44780E-02
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.17420E-04	3.16774E-01	2.38760E-01
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	4.97930E-02	1.09910E+00

Table 1f. Guide Tube Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section
Group 1	1.90730E-01	1.26032E-01	5.11320E-04	5.11320E-04
Group 2	4.56520E-01	2.93160E-01	7.58010E-05	7.58010E-05
Group 3	6.40670E-01	2.84240E-01	3.15720E-04	3.15720E-04
Group 4	6.49670E-01	2.80960E-01	1.15820E-03	1.15820E-03
Group 5	6.70580E-01	3.34440E-01	3.39750E-03	3.39750E-03
Group 6	8.75050E-01	5.65640E-01	9.18780E-03	9.18780E-03
Group 7	1.43450E+00	1.17215E+00	2.32420E-02	2.32420E-02

Scattering Block

	to Group 1	to Group 2	to Group 3	to Group 4	to Group 5	to Group 6	to Group 7
Group 1	6.61659E-02	5.90700E-02	2.83340E-04	1.46220E-06	2.06420E-08	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	2.40377E-01	5.24350E-02	2.49900E-04	1.92390E-05	2.98750E-06	4.21400E-07
Group 3	0.00000E+00	0.00000E+00	1.83297E-01	9.23970E-02	6.94460E-03	1.08030E-03	2.05670E-04
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	7.88511E-02	1.70140E-01	2.58810E-02	4.92970E-03
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	3.73330E-05	9.97372E-02	2.06790E-01	2.44780E-02
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.17260E-04	3.16765E-01	2.38770E-01
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	4.97920E-02	1.09912E+00

Table 1g. Moderator Macroscopic Cross-sections

	Total Cross-section	Transport Cross-section	Absorption Cross-section	Capture Cross-section
Group 1	2.30070E-01	1.59206E-01	6.01050E-04	6.01050E-04
Group 2	7.76460E-01	4.12970E-01	1.57930E-05	1.57930E-05
Group 3	1.48420E+00	5.90310E-01	3.37160E-04	3.37160E-04
Group 4	1.50520E+00	5.84350E-01	1.94060E-03	1.94060E-03
Group 5	1.55920E+00	7.18000E-01	5.74160E-03	5.74160E-03
Group 6	2.02540E+00	1.25445E+00	1.50010E-02	1.50010E-02
Group 7	3.30570E+00	2.65038E+00	3.72390E-02	3.72390E-02

Scattering Block

	to Group 1	to Group 2	to Group 3	To Group 4	to Group 5	to Group 6	to Group 7
Group 1	4.44777E-02	1.13400E-01	7.23470E-04	3.74990E-06	5.31840E-08	0.00000E+00	0.00000E+00
Group 2	0.00000E+00	2.82334E-01	1.29940E-01	6.23400E-04	4.80020E-05	7.44860E-06	1.04550E-06
Group 3	0.00000E+00	0.00000E+00	3.45256E-01	2.24570E-01	1.69990E-02	2.64430E-03	5.03440E-04
Group 4	0.00000E+00	0.00000E+00	0.00000E+00	9.10284E-02	4.15510E-01	6.37320E-02	1.21390E-02
Group 5	0.00000E+00	0.00000E+00	0.00000E+00	7.14370E-05	1.39138E-01	5.11820E-01	6.12290E-02
Group 6	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	2.21570E-03	6.99913E-01	5.37320E-01
Group 7	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	1.32440E-01	2.48070E+00

APPENDIX 1

Description of computational model used to obtain benchmark solutions
(preferred format is WORD)

We would like to have as detailed a description as you are able to provide on your treatment of the space-angle variables and the procedures by which you carried out the calculations, (but limited to 5 pages). Please include the following:

1. Name of participant(s)

2. Establishment(s)

3. Name of code system(s) used

4. Computational method used (e.g. S_N, P_N, collision probability, characteristic, etc.)

5. Type and level of angular approximation (e.g. S_8, P_7, number of characteristic angles, etc.)

6. Type and level of spatial discretisation (e.g. linear-triangular finite elements, flat source region collision probabilities, etc.). Provide number of mesh points, source regions, tracking pitch etc. per lattice cell. If possible include a drawing or diagram of the spatial mesh for one lattice cell

7. Convergence
   a. eigenvalue (at least 10 E-5)
   b. pointwise (e.g. flux, fission source, etc.)

8. Machine on which the calculations were performed and (if possible) CPU time

9. Other assumptions and characteristics, comments useful for interpreting correctly the results

APPENDIX 2

Results to be reported*
(requested format is EXCEL)

1. Stage I: Two-dimensional configuration

Table I.1. Eigenvalue

Eigenvalue	

Table I.2. UO_2 Normalised pin powers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
1																		1
2																		2
3																		3
4																		4
5																		5
6																		6
7																		7
8																		8
9																		9
10																		10
11																		11
12																		12
13																		13
14																		14
15																		15
16																		16
17																		17

* The Tables I.2 to I.4 are shown here only to clarify their from. For result submittal, the EXCEL templates should be used.

Table I.3. UO_2 Normalised pin powers

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
18																		18
19																		19
20																		20
21																		21
22																		22
23																		23
24																		24
25																		25
26																		26
27																		27
28																		28
29																		29
30																		30
31																		31
32																		32
33																		33
34																		34

Table I.4. MOX Normalised pin powers

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
1																		1
2																		2
3																		3
4																		4
5																		5
6																		6
7																		7
8																		8
9																		9
10																		10
11																		11
12																		12
13																		13
14																		14
15																		15
16																		16
17																		17

2. Stage II: Three-dimensional configuration

The following tables are to be filled in as in Stage I: Two-dimensional configuration.

Table II.1. Eigenvalue

Table II.2. UO_2 Normalised pin powers

Table II.3. UO_2 Normalised pin powers

Table II.4. MOX Normalised pin powers