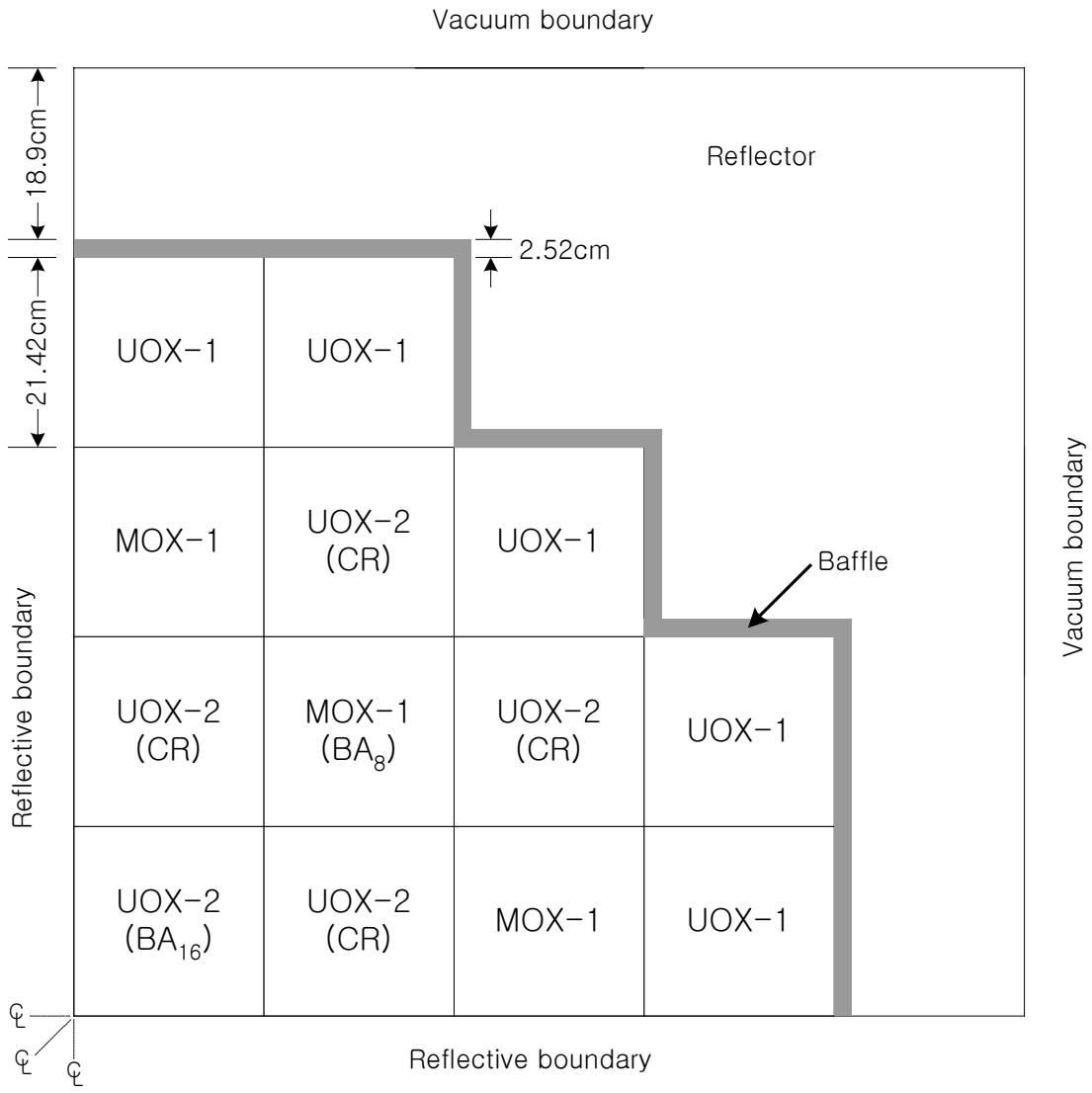
Benchmark Problem 1A : MOX Fuel-Loaded Small PWR Core (MOX Fuel with Zoning)

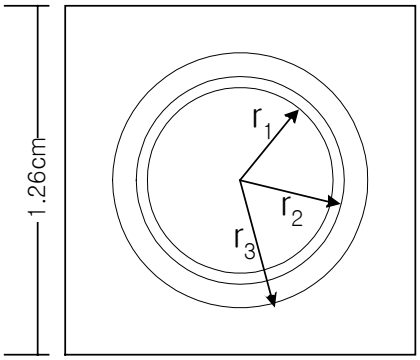
1) The problem is to calculate effective multiplication factor (k_{eff}) and power distribution.

2) Core Configuration (1/4 Core)

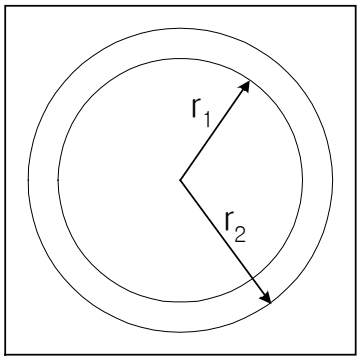


3) Fuel Rod Configuration

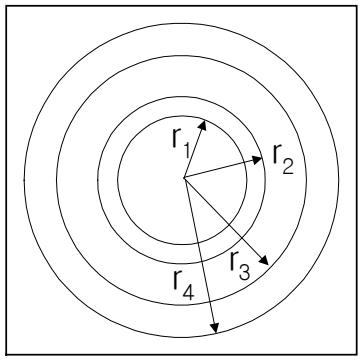
Cell Type	Region	Radius
Fuel (UOX, MOX, and Gd Rod)	r0 – r1 : Fuel	r1 = 0.4095 cm
	r1 – r2 : Gap	r2 = 0.4180 cm
	r2 – r3 : Clad	r3 = 0.4750 cm
Instrumentation guide tube	r0 – r1 : Water	r1 = 0.5715 cm
	r1 – r2 : Clad	r2 = 0.6120 cm
Control rod	r0 – r1 : Control material	r1 = 0.3823 cm
	r1 – r2 : Clad	r2 = 0.4839 cm
	r2 – r3 : Water	r3 = 0.5715 cm
	r3 – r4 : Clad (guide tube)	r4 = 0.6120 cm



<Fuel and Gd Rod>



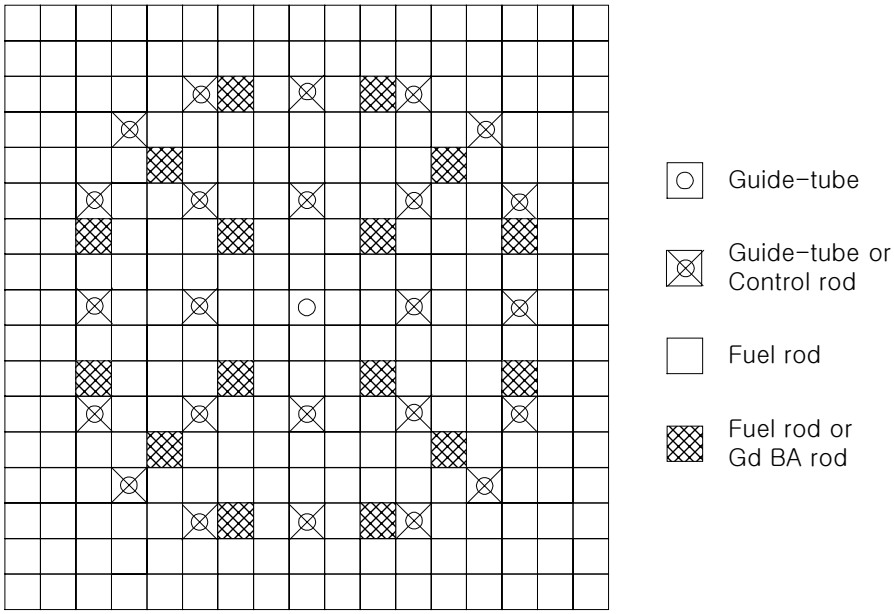
<Guide Tube>



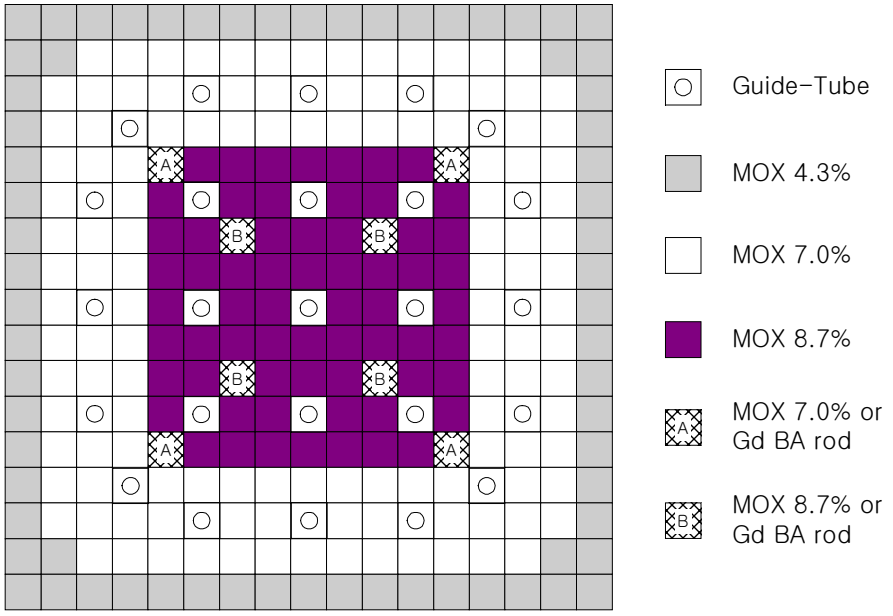
<Control Rod>

4) Fuel Assembly Configuration

- Lattice: 17 X 17	- Assembly pitch: 21.42 cm
- Number of fuel pins: 264	- Pin pitch: 1.26 cm
- Number of control rod guide tubes: 24	- Active fuel length: 365.76 cm
- Number of instrumentation guide tubes: 1	



<UOX Fuel Assembly>



<MOX-1 Fuel Assembly>

5) Material Composition

Fuel Materials

Assembly type	HM Material [a]	
UOX-1	U235 : 2.0 w/o, U238 : 98.0 w/o	
UOX-2	U235 : 3.3 w/o, U238 : 96.7 w/o	
MOX-1	Peripheral zone: Pu-tot=4.3 w/o	U235 : 0.225 w/o Pu-tot : Pu238/239/240/241/242/Am241 = 1.83/57.93/22.50/11.06/5.60/1.08 w/o [b]
	Intermediate zone: Pu-tot=7.0 w/o	
	Central zone: Pu-tot=8.7 w/o	

[a] UOX and MOX fuel density : 10.4 g/cm^3

[b] Derived from UO_2 PWR fuel of 33,000 MWd/t burnup, reprocessed after 3-yr cooling and 2-yr storage.

Absorber Materials

Control rod	B_4C, density : 1.84 g/cm^3 (73% of theoretical density 2.52 g/cm^3)
Burnable absorber	UO_2 (0.711 w/o U235) + Gd_2O_3 (9.0 w/o) [c], density : 10.06 g/cm^3

[c] Content of godolinia isotopes

Gadolinium Isotopes	Content of isotopes (w/o)	Gadolinium isotopes	Content of isotopes (w/o)
Gd-152	0.1932	Gd-157	15.6674
Gd-154	2.0555	Gd-158	24.9061
Gd-155	14.5809	Gd-160	22.1710
Gd-156	20.4259		

Other Materials

Clad	Zircaloy (Zr-97.91%, Sn-1.59%, Fe-0.5%), density : 6.44 g/cm^3
Baffle	SS-304 (Fe-70.351%, Cr-19.152%, Ni-8.483%, Mn-2.014%), density : 7.82 g/cm^3
Gap	He (320psig/700 °K)
Coolant/Reflector (Water)	density : 1.0 g/cm^3 at 300 °K, 0.7295 g/cm^3 at 570 °K Soluble boron concentration : 800 ppm

6) Reactor Operating Condition

- Total thermal power of the core: 900 MWth
- Water coolant average temperature: 570 °K
- Cladding average temperature: 630 °K
- Fuel average temperature: 900 °K

7) Problem Cases

- Case 1 : All rods in
- Case 2 : All rods out