22.251 Systems Analysis of the Nuclear Fuel Cycle Fall 2009

Lab #1: CASMO-4 Pin Cell Calculations

A sample PWR unit cell burnup calculation using CASMO-4 for a standard case of UO2 fuel enriched to 5 w/o U-235 (in total U) (the current US licensed limit) has been given in the class. Perform burnup calculations for the additional two combinations of fertile and fissile nuclides:

Case No.	Fissile (all ~5 w/o in HM)	Fertile
1	U-233	Th-232
2	Pu-239	U-238

For simplicity, assume all fissile and fertile number densities are the same as for the reference case. The fuel remains as dioxide in the form of $(HM)O_2$. Burn the fuel to 80 MWd/kg

(a) Plot reactivity, $\rho_\infty = \dfrac{k_\infty - 1}{k_\infty}$, vs. burnup for all cases and determine B_1 at $\rho_\infty = 0.03$ i.e. assuming leakage reactivity worth of 3% ;

(b) Qualitatively explain the relative behavior of the plots as determined by the relevant nuclear properties of the fissile and fertile species involved.

(c) For each fissile - fertile combination, determine the fissile enrichment (weight % of fissile nuclide in total HM) required to achieve 18 calendar months fuel cycle assuming a capacity factor of 90% and 3-batch fuel management.

(d) Repeat the calculations of (c) for a 5-batch core.

(e) Assuming a 20% power uprate is desired, determine the required initial enrichment for each considered fissile-fertile combination if the cycle length is fixed to 18 months and the fuel is managed in 3-batches.

(f) If the coolant flow rate in this high power density core is also increased by 20%, what would be the implications to the MDNBR constraint? What would be the effect of this power uprate on reactivity control requirements?