

**22.251 Systems Analysis of the Nuclear Fuel Cycle**  
**Fall 2009**  
**PROBLEM SET #8**

**Problem 1: The purpose of this problem is to appreciate the reactivity changes as a function of H/HM ratio in the core, and to examine the implications of the thermal-hydraulic considerations on the H/HM limits in the core.**

1. a) Verify that the PWR 17x17 Westinghouse fuel assembly falls in region (2) in that attached Figures.

1.b) Explain the behavior of the attached  $k$ -H/HM and  $B1$ -H/HM plots in terms of basic reactor physics phenomena and principles. The plots show the initial  $k$ -effective (i.e. at zero burnup) and the reactivity-limited single batch burnup,  $B1$  as a function of the ratio H/HM of hydrogen to heavy metal atoms. The curves are all based on the standard Westinghouse PWR 17x17 fuel geometry and dimensions. The variations in H/HM were obtained by arbitrarily changing the water density in CASMO. Address the dominant causes of the trends in each of the three regions designated, with emphasis on slope, minima and maxima.

1.c) What are the implications for operation in region (3) rather than (2) in Figure 1 for

- Core compactness?
- Reactivity control during a loss of flow and a loss of coolant accident?

1.d) Consider the engineering aspects of the core design, where would you expect to draw lines in Figure 1 to represent heat transfer limiting lines for steady state operations?

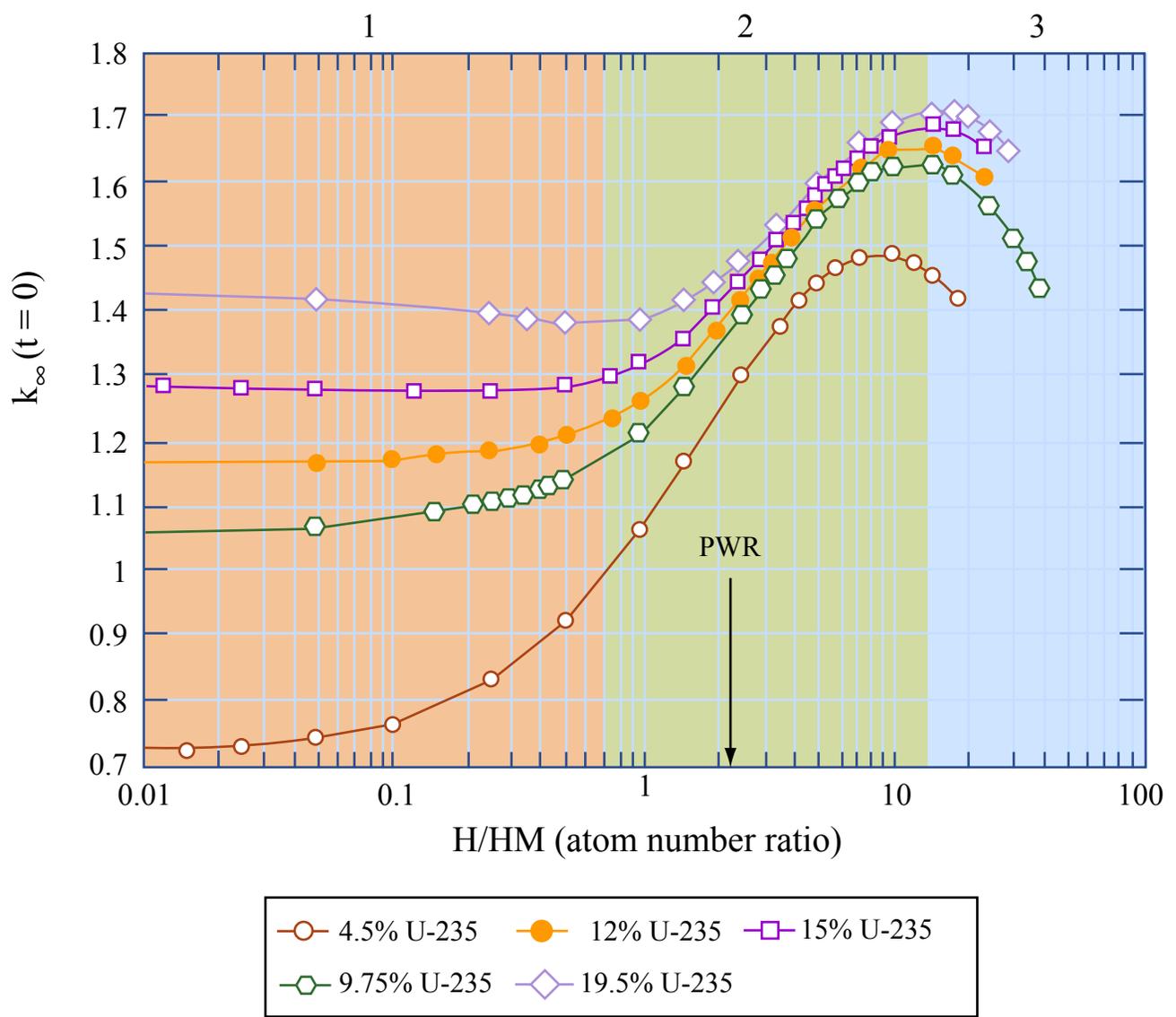
1.e) Would you want the reactor to be designed at the point of maximum  $B$ , between (2) and (3)? Explain your answer.

1.f) A new design is proposed in which U hydride instead of U oxide is to be used as fuel. What benefits you think might be derived from such a fuel change?

**Problem 2 The purpose of this problem is to examine the effect of Pu and U recycle on the need for uranium in LWRs, and consequently on the price of the fuel.**

2.a) Solve Problem 7.6 of the Textbook of Cochran and Tsoulfanidis

2.b) Solve Problem 7.7 of the textbook of Cochran and Tsoulfanidis



**Fig. 1** Initial  $k_{\infty}$  as a function of hydrogen-to-heavy-metal ratio for uranium fueled lattices.

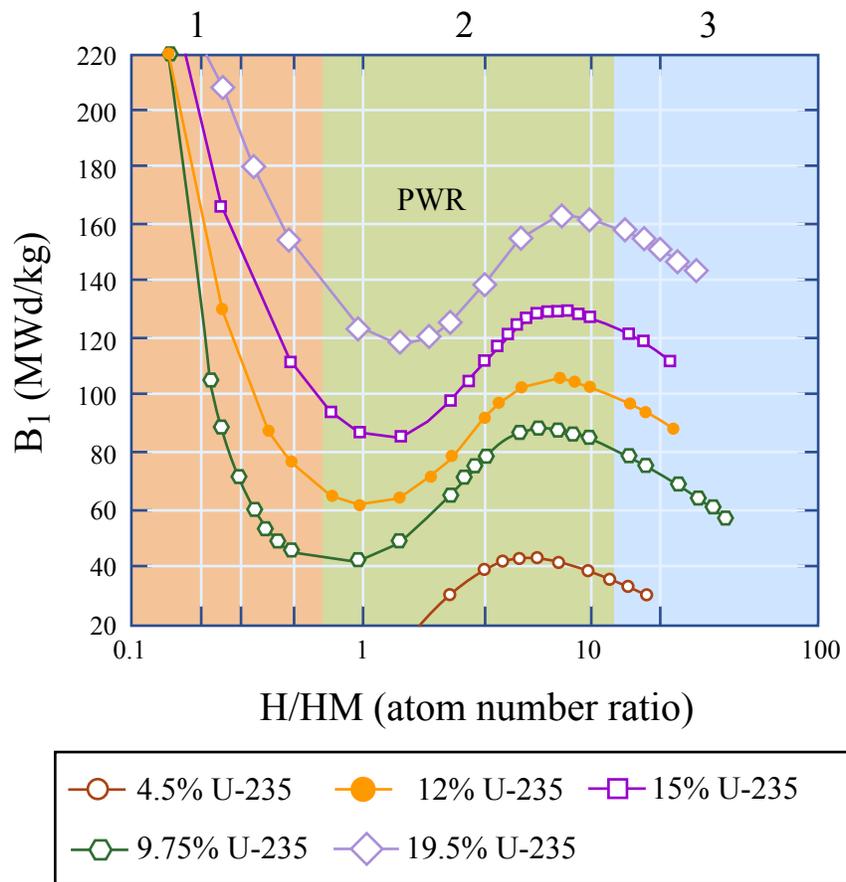


Figure 2. Reactivity-limited burnup as a function of hydrogen-to-heavy-metal ratio for uranium fueled lattices.

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