Exam 4: NE533: Nuclear Fuel Performance

Show all work. Label question number in your response. Pay attention to units. Point values correspond to expected depth of response.

1. (18 pts) A ZIRLO cladding tube is in reactor at 625 K for 400 days. The initial wall thickness is 500 μm.
2. Estimate the oxide thickness after this time?
3. Assuming the hydrogen pickup fraction is 18%, what is the weight PPM of hydrogen in the cladding after one year? Assume PBR = 1.56, ρZr = 6.5 g/cc, ρZrO2 = 5.68 g/cc.
4. (4 pts) What is the rate-limiting step in the aqueous corrosion of Zr cladding?
5. (4 pts) What is the Pilling-Bedworth ratio? What does it tell us?
6. (14 pts) Where do hydrides form in the cladding? Why? What impacts do hydrides have?
7. (14 pts) What is a RIA? What is a typical RIA in a PWR or BWR. Describe what happens during a RIA.
8. (14 pts) What is a LOCA? Describe the impacts of a LOCA. How is it different than a RIA?
9. (5 pts) How does burnup impact the type of failure and the failure probability during an accident?
10. (8 pts) What are the four pathways to make the fuel/cladding system more accident tolerant? Provide an ATF option being considered that targets one of these pathways.
11. (6 pts) What happens to zirconium cladding when it is exposed to high temperature steam?
12. (6 pts) List three examples of limiting phenomena governing LWR operation.
13. (6 pts) What fuel performance and safety impacts does CRUD have?
14. (6 pts) List two water chemistry controls that have been implemented in LWRs, including why they were implemented.