



Open your mind. LUT.

Lappeenranta **University of Technology**

SCHOOL OF ENERGY SYSTEMS

NUCLEAR ENGINEERING

BH30A2103 Introduction to Reactor Dynamics

Exam 2016-02-02

Instructions:

- Allowed: pen(cil), eraser, ruler, function calculator.
- Not allowed: written material.
- Language: answers either in English or Finnish.

Good luck, prof. Juhani Hyvärinen

Question 1 (6 points)

Explain terms

- (1 points) Burnup
- (1 points) Prompt jump
- (1 points) Doppler coefficient
- (1 points) Poisoning
- (1 points) Delayed neutron fraction
- (1 points) Excess reactivity

Question 2 (6 points)

In graphite moderated molten salt reactor the control rods are pulled out of core by some amount. Due to this core temperatures increase $25\text{ }^\circ\text{C}$ and fuel salt density decreases $0.1\frac{\text{g}}{\text{cm}^3}$.

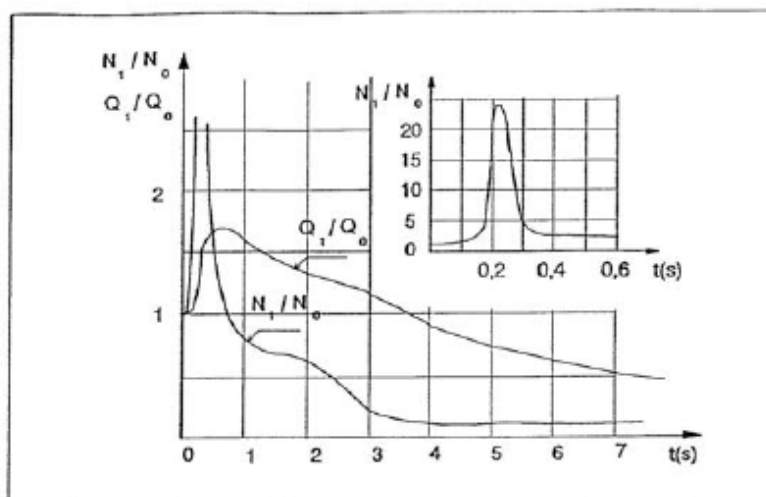
- Density coefficient of reactivity of fuel salt $\beta_\rho = 750\text{ pcm/g/cm}^3$
- Doppler coefficient of reactivity of fuel salt $\beta_f = -5\text{ pcm/}^\circ\text{C}$
- Temperature coefficient of reactivity of moderator $\beta_m = 1\text{ pcm/}^\circ\text{C}$

Calculate reactivity effect of control rods $\Delta\rho_{cr}$.

TURN!

Question 3 (6 points)

Experiments simulating rod ejection in VVER-reactors were done by Soviets and it was noticed that when single control rod ejected from reactor core the neutron flux changed as in figure 1. Flux was increased to 22-times the original during period of 0.10...0.20s. Estimate the reactivity change which caused the power increase. Make also some approximate estimation about temperature change in fuel rod when Doppler-coefficient is $-2 \frac{\text{pcm}}{^\circ\text{C}}$. Prompt neutron generation time $\Lambda = 7 \times 10^{-5} \text{ s}$ and delayed neutron fraction $\beta = 650 \text{ pcm}$.



Kuva 1. Reaktorin neutroniteho N_1/N_0 ja lämpöteho Q_1/Q_0 ajan funktiona säätösauvaryhmän uloslento-onnettomuuden yhteydessä.

Figure 1: Relative reactor fission power $\frac{N_1}{N_0}$ and heating power to coolant $\frac{Q_1}{Q_0}$ during rod ejection.

Question 4 (6 points)

Fuel conversion and breeding.

Question 5 (6 points)

Explain how the power plant output can be adjusted in a boiling water reactor (BWR). Which process parameters remain constant, which change, and how?