^{135}Xe-^{135}I Exercise

The ^{135}Xe/^{135}I kinetics can be represented by the following equations:

$$\frac{dI}{dt} = \gamma_i \hat{\Sigma}_f \hat{\phi}_F - \lambda_i I \qquad (1)$$

$$\frac{dX}{dt} = \gamma_x \hat{\Sigma}_f \hat{\phi}_F + \lambda_i I - \lambda_x X - \hat{\sigma}_X X \hat{\phi}_F \qquad (2)$$

where

X = average concentration of ^{135}Xe in atoms cm^{-3}

I = average concentration of ^{135}I in atoms cm^{-3}

γ_X = direct yield of ^{135}Xe per fission (averaged over all fissions)

γ_I = direct yield of ^{135}I in fission, including yields of ^{135}Te and ^{135}Sb (averaged over all fissions)

λ_X = decay constant of ^{135}Xe in s^{-1}

λ_I = decay constant of ^{135}I in s^{-1}

$\hat{\phi}$ = average flux in the fuel in n.cm^{-2}s^{-1}

$\hat{\Sigma}_f$ = macroscopic fission cross section of the fuel in cm^{-1}

and $\hat{\sigma}_x$ = microscopic ^{135}Xe cross section in cm^2

Assume:

$\lambda_X = 2.92*10^{-5}$ s^{-1}

$\lambda_I = 2.12*10^{-5}$ s^{-1}

$\gamma_X = 0.00246$

$\gamma_I = 0.0638$

$\hat{\Sigma}_f = 0.002$ cm^{-1}

$\hat{\sigma}_x = 3.2*10^{-18}$ cm^2

Also assume that at full power:

The flux in the fuel is $\hat{\phi} = 7.0*10^{13}$ n.cm^{-2}s^{-1}

The steady-state Xe-135 concentration is $X = 3.781*10^{13}$ n.cm^{-3}

The steady-state I-135 concentration is $I = 3.057*10^{14}$ n.cm^{-3}

and The steady-state Xe-135 reactivity = -28 milli-k.

The exercise is to determine the “poison prevent” power. That is, if there is a sudden decrease in power from full power, what is the lowest power to which the reactor can go without being subject to Xe-135 poisoning, assuming the Reactor Regulating System (RRS) has 15 milli-k of positive reactivity available for xenon override?