NUCL 402 HMWK 3

1) Research Power Reactor Reactivity

a) Power Increase

$$P_1 = \frac{\beta(1-\rho)}{\beta-\rho} * P_0$$
$$\frac{P_1}{P_0}(\beta-\rho) = \beta - \beta\rho$$
$$\frac{P_1}{P_0}\beta - \frac{P_1}{P_0}\rho = \beta - \beta\rho$$
$$\frac{P_1}{P_0}\beta - \beta = \frac{P_1}{P_0}\rho - \beta\rho$$
$$\rho = \frac{\frac{P_1}{P_0}\beta - \beta}{\frac{P_1}{P_0} - \beta} = \frac{\frac{3\ MW}{1\ MW}0.0065 - 0.0065}{\frac{3\ MW}{1\ MW} - 0.0065} = 0.00434\ \$ = 434\ pcm$$

b) Scram

$$\rho = \frac{\frac{P_1}{P_0}\beta - \beta}{\frac{P_1}{P_0} - \beta} = \frac{\frac{1\ MW}{3\ MW}0.0065 - 0.0065}{\frac{1\ MW}{3\ MW} - 0.0065} = -0.01326\ \$ = -1326\ pcm$$

2) PWR Rod Worth

$$\rho_w = \frac{f_R}{1-f_R}$$
$$\frac{1}{f_R} = \frac{(z^2-y^2)d}{2a} + E(y,z)$$
$$E(y,z) = \frac{z^2-y^2}{2y}\left[\frac{I_0(y)K_1(z) - K_0(y)I_1(z)}{I_1(z)K_1(y) - K_1(z)I_1(y)}\right]$$
$$R = 175\ cm$$
$$a = 0.6\ cm$$
$$N = 22$$
$$L_T = 1.4\ cm$$
$$D = 0.25\ cm$$
$$\Sigma_t = 2.5\ cm^{-1}$$
$$d = \frac{2.131D(a\Sigma_t + .9354)}{a\Sigma_t + .5098} = 0.6456$$
$$R_c = \sqrt{\frac{R^2}{N}} = \sqrt{\frac{(175\ cm)^2}{22}} = 37.31\ cm$$
$$y = \frac{a}{L_T} = \frac{0.6\ cm}{1.4\ cm} = 0.429, z = \frac{R_c}{L_T} = \frac{37.31\ cm}{1.4\ cm} = 26.65$$
$$E(y,z) = \frac{26.65^2 - 0.429^2}{2 * 0.429}\left[\frac{I_0(0.429)K_1(26.65) - K_0(0.429)I_1(26.65)}{I_1(0.429)K_1(26.65) - K_1(26.65)I_1(0.429)}\right] = -434.9288$$
$$\frac{1}{f_R} = \frac{(26.65^2 - 0.429^2)d}{20.6\ cm} - 434.9288$$

$$\rho_w = \frac{f_R}{1 - f_R} = -0.0185$$

$$\rho_{total} = \rho_w * N_{clusters} = (-0.0185 * 58) = -1.0752 = 107.52\%$$

3) Cruciform Rod Worth Spacing

$$\rho_w = \frac{f_R}{1 - f_R}$$

$$f_R = \frac{\rho_w}{1 + \rho_w}$$

$$\rho_w = -1.0752, \qquad L_T = 1.3\ cm, \qquad \Sigma_a = 0.21\ cm^{-1}, \qquad \mathrm{l} = 6.5\ \mathrm{cm}, \qquad a = 0.2\ cm$$

$$d = \frac{2.131D(a\Sigma_a + .9354)}{a\Sigma_a + .5098} = 0.9437$$

$$f_R = \frac{4(l-a)L_T}{(m-2a)^2} \frac{1}{\frac{d}{L_T} + \coth\left(\frac{m-2a}{2L_T}\right)} = \frac{\rho_w}{1+\rho_w}$$

$$m = 37.57\ cm$$

4) Reactor Reactivity Change with Temperature

$$\alpha_T = \frac{1}{k^2}\frac{dk}{dT} \approx \frac{1}{k}\frac{dk}{dT} \rightarrow k = c_1 e^{\alpha T} = e^{\alpha T}$$

$$\rho = \frac{\left(1 - \left(\frac{1}{k}\right)\right)}{\beta_{U235}}$$

$$\% = 100 * \rho$$

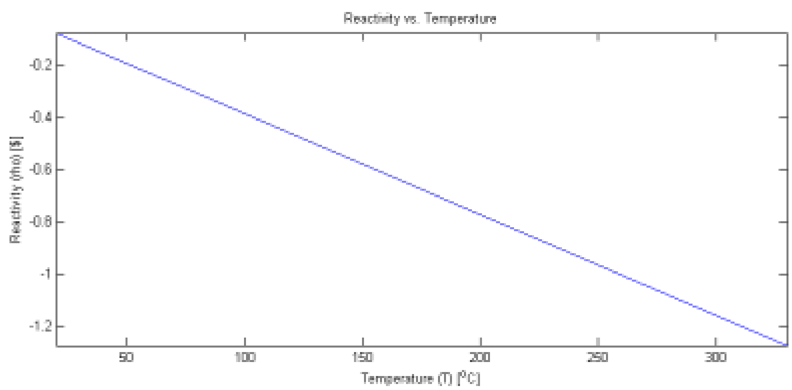

FIGURE 1 REACTIVITY VS TEMPERATURE (U235)

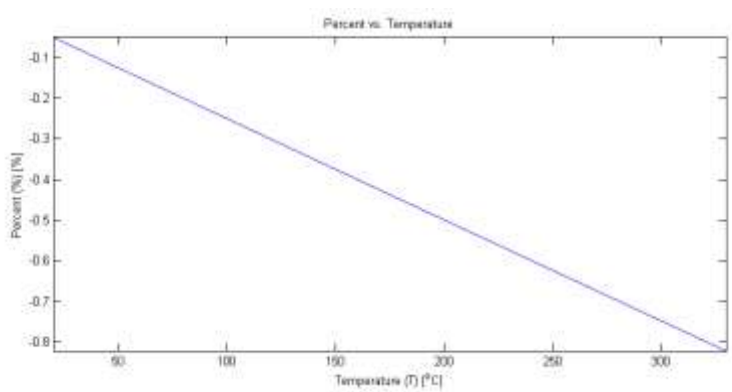

FIGURE 2 PRECENT VS TEMPERATURE (U235)