NUCL 402 HMWK 9

1) Time to reach Containment Pressure Design Limit

$$m_w = 1.35 * 10^6\ kg$$
$$m_a = 5.05 * 10^4\ kg$$
$$T_0 = 385.8\ K$$
$$x_{st} = 0.023$$
$$m_{N2} = 1.25 * 10^3\ kg$$
$$R_{air} = 0.286 \frac{kJ}{kgK}$$
$$c_{va} = 0.719 \frac{kJ}{kgK}$$
$$R_{N2} = 0.296 \frac{kJ}{kgK}$$
$$c_{vN} = 0.742 \frac{kJ}{kgK}$$
$$P_{rated} = 2285\ MW_{th}$$
$$\dot{Q}_{decay} = .013 * P_{rated} = 29.71\ MW_{th}$$
$$p_{limit} = 0.75\ MPa$$
$$m_w(u_{w2} - u_{w1}) + m_a c_{va}(T_{a2} - T_{a1}) = Q_{n-wsys} - Q_{c-st}$$

Since we don't know anything about the containment, assuming no heat transfer to the containment structure:

$$m_w(u_{w2} - u_{w1}) + m_a c_{va}(T_{a2} - T_{a1}) = \dot{Q}_{decay} * t$$
$$t = \frac{m_w(u_{w2} - u_{w1}) + m_a c_{va}(T_2 - T_1)}{\dot{Q}_{decay}}$$
$$m_a c_{va} = \frac{\left(m_a c_{va} + m_{N_2} c_{vN_2}\right)}{m_a + m_{N_2}} = 37237 \frac{kJ}{K}$$
$$m_w = 1.35 * 10^6\ kg$$
$$T_1 = 385.8\ K$$
$$\rho_{w1} = \rho_{wl}(x - 1) + \rho_{wv}(x)$$
$$V_{w1} = \frac{m_w}{\rho_{w1}}$$
$$\Delta u = \Delta h - \Delta(pV) = h_{w2} - h_{w1} - p_1 V_{w2} + p_2 V_{w1}$$
$$t = \frac{m_w(h_{w2} - h_{w1} - p_2 V_{w2} + p_1 V_{w1}) + m_a c_{va}(T_2 - T_1)}{\dot{Q}_{decay}}$$
$$h_{w1}(113.65\ K, 0.023) = 527.8328 \frac{kJ}{kg} @\ 161.7475\ kPa$$
$$P_1(V - V_{w1}) = m_g R_g T_1 = P_2(V - V_{w2}) = m_g R_g T_2$$

Solving by iteration with ρ_{w2} and T_2:

$$T_2 = \left(P_2 \frac{m_g R_g T_1 + P_1 V_{w1}}{P_1} + P_2 V_{w2}\right) \frac{1}{m_g R_g} = 1867\ K$$
$$h_{w2}(750\ kPa, 1867\ K) = 6.213 * 10^3 \frac{kJ}{kg}$$
$$t = 5.122 * 10^{10}\ s$$