

(20.1) The gas space (volume 6000 m³) in the PS system of a large BWR is filled with N₂ at 97 kPa and 25 °C. Assume the same temperature in the dry and wet wells and that the heat of evaporation of water and its heat capacity are ~2.26 MJ/kg and ~4.18 kJ/kg °C, respectively, up to ~100 °C. The 2000 m³ water in the condensation pool is at 25 °C. The primary system contains steam at 287 °C and 7 MPa (energy content ~2.8 MJ/kg steam). How many kg of such steam could be dumped into the condensation pool before the pressure in the PS system exceeds 0.1 MPa?

$$C_{pool} := 4.18 \cdot 10^3 \cdot \text{joule} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$$

$$\rho_{water} := 1 \cdot \text{gm} \cdot \text{cm}^{-3}$$

$$V_{pool} := 2000 \cdot \text{m}^3$$

$$C_{steam} := 2.26 \cdot 10^6 \cdot \text{joule} \cdot \text{kg}^{-1}$$

$$T_{0pool} := (25 + 273) \cdot \text{K}$$

$$m_{0pool} := V_{pool} \rho_{water}$$

From expansion of N₂:

$$T_{max} := T_{0pool} \frac{0.1}{0.097}$$

A first approximation is to regard the mass of pool water as constant:

$$m_{steam} := (T_{max} - T_{0pool}) \cdot C_{pool} \frac{m_{0pool}}{C_{steam}} \quad m_{steam} = 3.409 \cdot 10^4 \cdot \text{kg}$$

$$\Delta m := \frac{m_{steam}}{m_{0pool}} \quad \Delta m = 1.705 \cdot \% \quad \left(\frac{\Delta m}{2} + 1 \right) \cdot m_{0pool} = 2.017 \cdot 10^6 \cdot \text{kg}$$

Second approximation:

$$m_{0pool} := 2.017 \cdot 10^6 \cdot \text{kg}$$

$$m_{steam} := (T_{max} - T_{0pool}) \cdot C_{pool} \frac{m_{0pool}}{C_{steam}} \quad m_{steam} = 3.438 \cdot 10^4 \cdot \text{kg}$$

$$\Delta m := \frac{m_{steam}}{m_{0pool}} \quad \Delta m = 1.705 \cdot \% \quad \left(\frac{\Delta m}{2} + 1 \right) \cdot m_{0pool} = 2.034 \cdot 10^6 \cdot \text{kg}$$

Answer: about 3.4*10⁴ kg = 34 ton