Chapter 16 Problem 52 [†]

Given
$P = 10\% \; of \; 3.0 \; GW$
$V = 420 \; m^3$
$T = 20 \; {}^\circ C$
$c = 1 \; kcal/kgK$
$\rho = 1000 \; kg/m^3$

Solution
Find the time for the water to reach the boiling point.

First find the amount of heat required to reach the boiling point.

$$\Delta Q = mc\Delta T$$

The mass of water is equal to its volume times density

$$\Delta Q = \rho V c \Delta T$$

$$\Delta Q = (1000 \; kg/m^3)(420 \; m^3)(1 \; kcal/kg \cdot K)(80 \; {}^\circ C)$$

$$\Delta Q = 3.36 \times 10^7 \; kcal$$

Convert the kcal to joules

$$\Delta Q = 3.36 \times 10^7 \; kcal \left(\frac{4184 \; J}{1 \; kcal} \right) = 1.41 \times 10^{11} \; J$$

The heat flow is equal to the energy provided by the reactor. Since power is energy per time we have

$$P = \frac{\Delta Q}{\Delta t}$$

The power provided to warm up the water is 10% of 3 GW. This comes out to

$$P = 3 \times 10^8 \; W$$

Solving for time gives us

$$\Delta t = \frac{\Delta Q}{P} = \frac{(1.41 \times 10^{11} \; J)}{(3.0 \times 10^8 \; W)} = 469 \; s$$

This would be 7.81 minutes.

[†] Problem from Essential University Physics, Wolfson