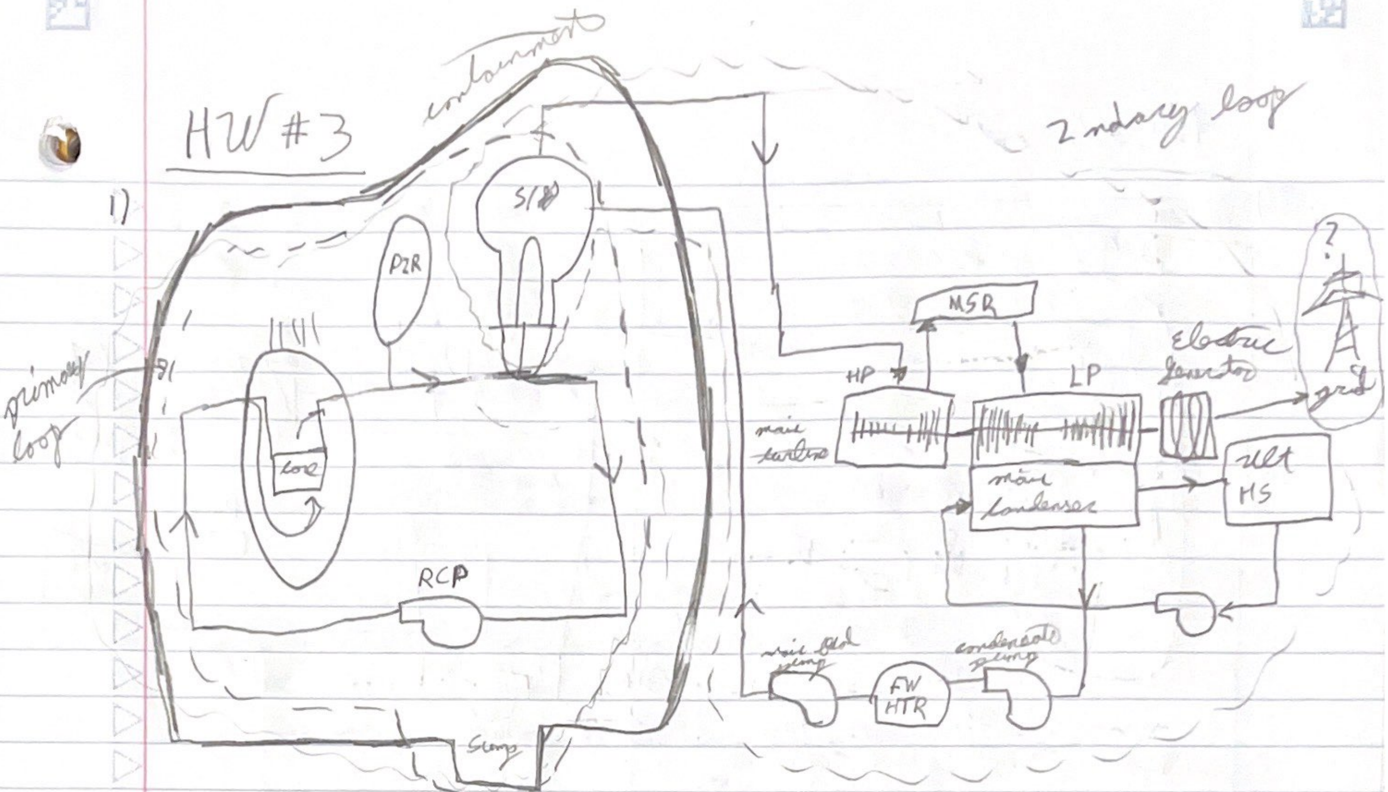
HW #3

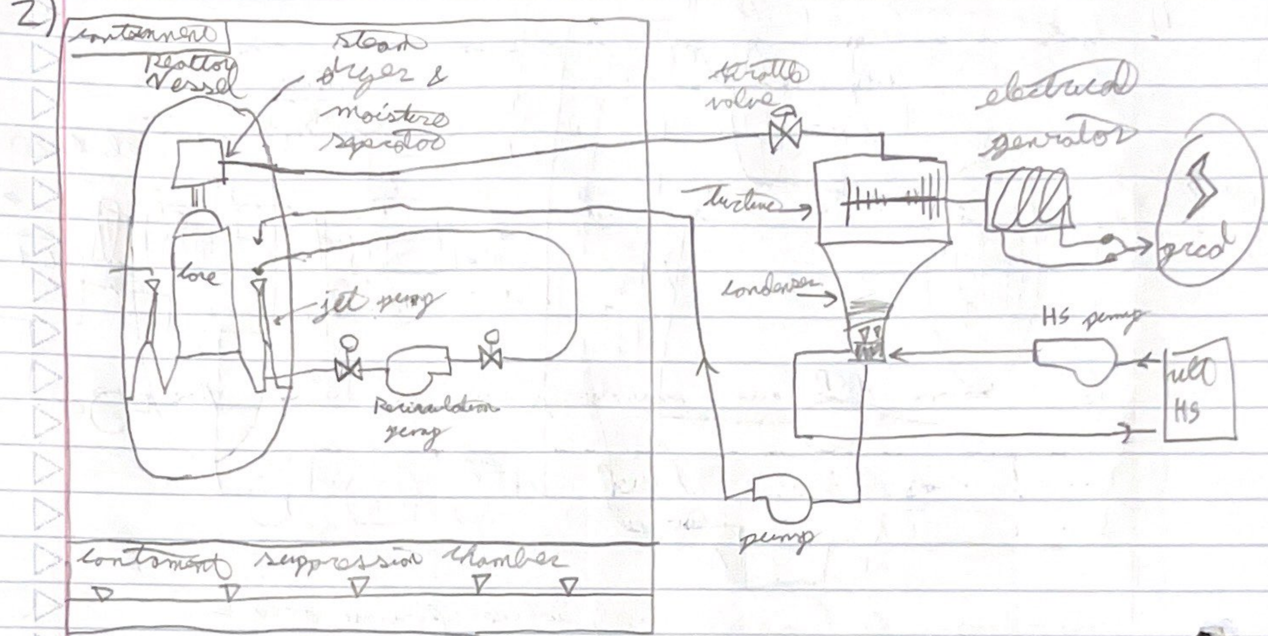
1)



core - houses fuel assembly, where fission occurs
PZR - pressurizer, maintains pressure & gives leeway for pipes to not burst
S/G - steam generator, interfaces b/w primary & secondary loop, takes primary heat to vaporize secondary water
RCP - reactor coolant pump, forces primary coolant through the loop
Sump - collects water to help w/ flooding core
main turbine - converts steam kinetic energy to rotational energy
  hp - high pressure segment
  lp - low pressure segment
MSR - moisture seperator, removes liquid from steam to preserve turbine health
Electric Generator - converts rotational energy from turbine into useful energy
main condenser - condenses water-steam mixture from secondary loop into water by heat ejection to ult hs
ult hs - ultimate heat sink, resevoir of "cold" for TD cycle
condensate pump - pumps condensate to FW HTR
FW HTR - feedwater heater, preheats the feedwater after condensation
main feed pump - pumps water through secondary loop

HW #3 - cont

2)



core - contains fuel assembly, where fission occurs
steam dryer & moisture separator - raises vapor quality, rejects liquid back to containment, sends steam to turbine
jet pump - pumps that use entrainment to force water down into core
recirculation pump - provides water for the jet pump to use
throttle valve - vents steam if pressure is too high
turbine - converts steam kinetic energy to rotational energy
electrical generator - converts rotational energy from turbine into useful electrical power
condensor - ~~rejects~~ heat from low quality steam to ult hs
ult hs - ultimate heat sink, resorvoir for "cold" in TD cycle
HS pump - heat sink pump, pumps heat sink water into condenser
pump - pumps condensate from condenser to reactor vessel
containment suppression chamber - condense steam released from RPV if it becomes overpressured

HW#3 - cont

3) The thermal design limit is the maximum temperature the reactor can operate at without failing.
- First failure temp is zircalloy, which is the cladding & oxidizes $\geq 700°C$
- second failure temp is UO_2, which is the fuel & melts $> 2800°C$

Fuel & clad is the same for both LWRs

The termal design margin is the difference between the failure temp & the operating temp.
- 10s of °C for LWRs
- 100s of °C for HTGRs

HW#3-cont

4) TK 2-1. find core avg values of q''' in fuel & surface q''

Reactor types 2-3

Geometry params 1-3

$\left\{ \begin{array}{l} BWR \quad q''' = 224 \text{ MW/m}^3 \\ q'' = 492.9 \text{ kW/m}^2 \end{array} \right\}$

The linear heat generation rate relates to q'' & q''' as

$$q' = \pi \overset{r\,clad}{D_c} q''_c = \pi r_f^2 q'''$$

using ↑ & the given values, we can find

	BWR	PWR	PHWR	HTGR	AGR	LMFBR
q' [kW]	19.0	17.8	25.7	7.87	17.0	29.0
clad Ø, D_c [mm]	12.27	9.5	13.1	15.7	14.89	8.65
Fuel Radius R_f [mm]	5.2	4.1	6.1	7.85	7.255	3.5
q''' [mW/m³]	223.664	337.056	219.846	40.652	102.807	753.500
q'' [kW/m²]	492.900	596.412	624.471	159.560	363.416	1067.166

5) Fig 2-5 $q' = 17.8$ kW/m. failure limit is from centerline melt @ 70 kW/m: radial flux = 1.55, axial & local flux factor = 1.70

A = 1.29 engineering uncertainty factor = 1.05, overpower factor = 1.15

$$\text{margin} = \frac{\text{failure limit}}{\text{max power expected}}$$

max power expected = product of $\bar{P}$ & all scaling factor

$$P_{max} = 17.8 \text{ kW/m} (1.55)(1.70)(1.05)(1.15)$$
$$= 56.635 \text{ kW/m}$$

$$\text{margin} = \frac{70 \text{ kW/m}}{56.635 \text{ kW/m}} = \boxed{1.236 \approx 1.24}$$