Heat and Thermodynamics - Course PI 25

CRITERION TESTS

## PI 25-1 - CRITERION TEST

1. Define:

   (a) heat
   (b) temperature
   (c) enthalpy

2. State the meaning of each of the following as it applies to water:

   (a) saturation temperature
   (b) subcooled liquid
   (c) saturated liquid
   (d) wet steam
   (e) saturated steam
   (f) superheated steam
   (g) sensible heat
   (h) latent heat of vaporization

3. Sketch a temperature vs enthalpy graph for water at constant pressure. Label the following on your sketch:

   (a) saturation temperature
   (b) subcooled liquid region
   (c) saturated liquid
   (d) wet steam region
   (e) saturated steam
   (f) superheated steam region
   (g) sensible heat region
   (h) latent heat region

4. State whether each of the following represents subcooled liquid, saturated liquid, wet steam, saturated steam, or superheated steam. You may use steam tables as an aid.

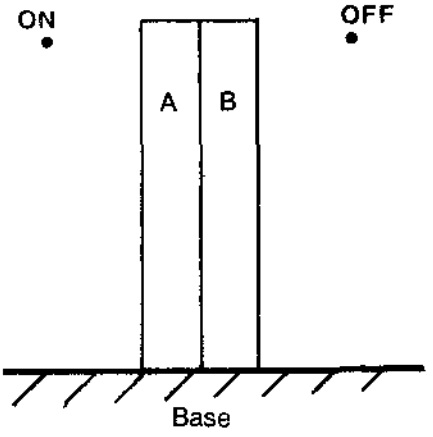
   (a) 190°C, 10 bar, 2802.0 kJ/kg
   (b) 144.5°C, 4.1 bar, 1864.3 kJ/kg
   (c) 295°C, 86 bar, 1317.3 kJ/kg
   (d) 29°C, 0.04 bar, 121.4 kJ/kg
   (e) 65°C, 0.25 bar, 568.1 kJ/kg
   (f) 222°C, 24.1 bar, 2800.5 kJ/kg

5. How much heat is added to 10 kg of water at 95°C to produce 13% wet steam at 194°C?

## PI 25-2 - CRITERION TEST

1. A pipe run is 500 m long at 20°C. The pipe is carbon steel ($\alpha$ = 10 x $10^{-6}$ $°C^{-1}$) and it operates at 200°C normally. What is the amount of expansion that occurs as the pipe goes from 20°C to 200°C?

2. A bimetal strip is shown below. If A is iron ($\alpha_A$ = 12 x $10^{-6}°C^{-1}$) and B is brass ($\alpha_B$ = 18 x $10^{-6}$ $°C^{-1}$), towards which contact will the strip move as it is heated? Briefly explain why.




3. Determine the ratio of the change in volume that occurs as steam (10% moisture content) at 33°C is condensed to water at 33°C.

4. Explain shrink and swell as they apply to:

   (a) a liquid (eg, the PHT $D_2O$) as its temperature is changed
   (b) water in a boiler that experiences a step increase or decrease in steam flow.

5. Explain why the programmed level of water in the boiler changes as power changes.

6. Explain how steam entering the condenser at a CANDU station can be at about 30°C and 4 kPa(a).

## PI 25-3 - CRITERION TEST

1. The high pressure feedheater at BNGS-A uses 151 kg/s of extraction steam at 173°C (moisture content = 70.5%) to heat 1070 kg/s of feedwater. The extraction steam condensate exits the feedheater at 155°C. If the feedwater enters the heater at 149°C, to what temperature is it heated?

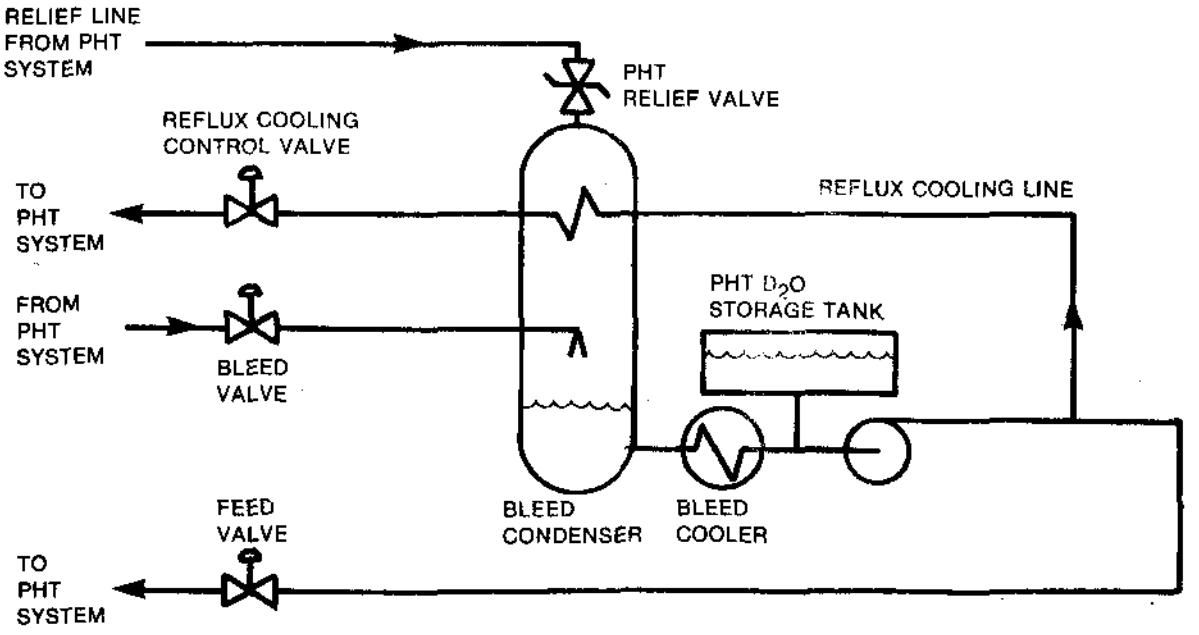
2. 24 kg/s of $D_2O$ is heated from 244°C to 300°C as it flows through a pressure tube. Assuming the $D_2O$ remains liquid, determine the reactor thermal power output if there are 412 pressure tubes in the reactor.

## PI 25-4 - CRITERION TEST

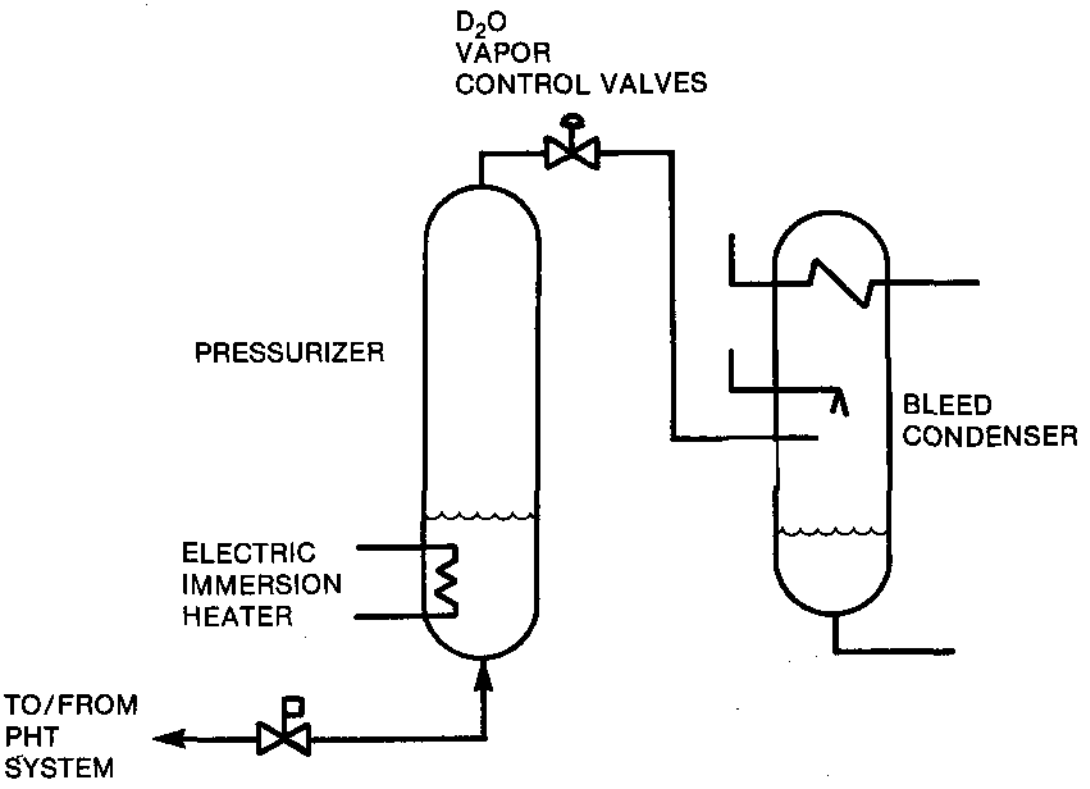
1. Describe the effects resulting from:

   (a) too high heat transport pressure
   (b) too low heat transport pressure

2. For the system shown below, explain how heat transport system pressure is controlled.



3. For the system shown below, explain how heat transport system pressure is controlled.




4. State why controlling boiler pressure is important.

5. List the three main heat sinks for the boiler in a CANDU station.

6. Briefly explain how the boiler pressure can:

   (a) remain constant as power increases
   (b) fall as power increases

   and what the effect is, in each case, on the PHT $D_2O$ average temperature.

## PI 25-5 - CRITERION TEST

1. Briefly explain heat transfer by:

   (a) conduction
   (b) natural convection
   (c) forced convection
   (d) radiation

2. State the factors that influence the rate of heat transfer by each mechanism in Question 1.

3. Briefly describe two examples of each mechanism from Question 1 in a CANDU generating station.

## PI 25-6 - CRITERION TEST

1. Sketch a Mollier diagram from memory, and include the following labels on your sketch:

   (a) constant enthalpy lines
   (b) constant entropy lines
   (c) saturation line
   (d) constant temperature lines
   (e) constant pressure lines
   (f) constant moisture content lines
   (g) constant degree of superheat lines

2. On your sketch from Question 1, show the overall turbine process, including:

   (a) expansion in the high pressure turbine
   (b) *moisture separation*
   (c) reheat
   (d) expansion in the low pressure turbine

3. Explain how moisture separation and reheat each increase the enthalpy of the steam flowing to the LP turbine.

4. Explain how moisture separation and reheat each each reduce the moisture content of the steam at the LP turbine outlet.

5. Define throttling.

6. Explain, using a Mollier diagram, how throttling of the steam supplied to the turbine affects:

   (a) the pressure, temperature and moisture content of the steam at the turbine inlet
   (b) the amount of heat which can be converted into *mechanical energy by the turbine*

## PI 25-7 - CRITERION TEST

1. Define:

   (a) efficiency
   (b) thermal efficiency

2. 2450 MW of heat are added in the boilers of a CANDU unit. The unit produces 796 MW of electricity and 6 MW are input to pump feedwater from the condenser to the boilers. Determine the thermal efficiency of the cycle.

3. (a) Explain how the thermal efficiency of the CANDU cycle can be improved by raising boiler pressure.
   (b) State the main limitation on the improvement in (a).

4. (a) Explain how the thermal efficiency of the CANDU cycle can be improved by lowering condenser pressure.
   (b) State two limitations on the improvement in (a).

5. (a) Explain how the thermal efficiency of the CANDU cycle can be improved by superheating in the boiler.
   (b) State the main limitation on the improvement in (a).

6. (a) Explain how the thermal efficiency of the CANDU cycle can be improved by:

      i) reheating between the high and low pressure turbines.
      ii) using extraction steam for feedheating.

   (b) State the main limitation on each improvement in (a).
   (c) State two practical benefits of each improvement in (a).

7. (a) Explain how the thermal efficiency of the CANDU cycle can be improved by moisture separation.
   (b) State the practical benefit of moisture separation.