CONVERSION FACTORS

1. Force:

1 newton = kg-m/sec^2 = 0.012 kgf

1 kgf = 9.81 N

2. Pressure:

1 bar = 750.06 mm Hg = 0.9869 atm = 10^5 N/m^2 = 10^3 kg/m-sec^2

1 N/m^2 = 1 pascal = 10^{-5} bar = 10^{-2} kg/m-sec^2

1 atm = 760 mm Hg = 1.03 kgf/cm^2 = 1.01325 bar

= 1.01325×10^5 N/m^2

3. Work, Energy or Heat:

1 joule = 1 newton metre = 1 watt-sec

= 2.7778×10^{-7} kWh = 0.239 cal

= 0.239×10^{-3} kcal

1 cal = 4.184 joule = 1.1622×10^{-6} kWh

1 kcal = 4.184×10^3 joule = 427 kgf-m

= 1.1622×10^{-3} kWh

1 kWh = 8.6042×10^5 cal = 860 kcal = 3.6×10^6 joule

4. Power:

1 watt = 1 joule/sec = 0.860 kcal/h

1 h.p. = 75 m kgf/sec = 0.1757 kcal/sec = 735.3 watt

1 kW = 1000 watts = 860 kcal/h

5. Specific heat:

1 kcal/kg-°K = 0.4184 joules/kg-K

6. Thermal conductivity:

1 watt/m-K = 0.8598 kcal/h-m-°C

1 kcal/h-m-°C = 1.16123 watt/m-K = 1.16123 joules/s-m-K.

7. Heat transfer coefficient:

1 watt/m^2-K = 0.86 kcal/m^2-h-°C

1 kcal/m^2-h-°C = 1.163 watt/m^2-K.

Nomenclature

Table 1.1 *SI system of units*

Quantity	*Unit*	*Symbol*
Basic Units		
Length (L)	Metre	m
Mass (M)	Kilogram	kg
Time (t)	Second	s
Temperature (T)	Kelvin	K
Plane angle	Radian	rad
Solid angle	Steradian	sr
Luminous intensity	Candela	cd
Molecular substance	Mole	mol.
Electric Current	Ampere	A
Derived Units		
Force (F)	Newton	N {kg.m/s^2}
Energy (E)	Joule	J {N.m = kg. m^2/s^2}
Power	Watt	W {J/s = kg. m^2/s^3}
Pressure	Pascal	Pa {N/m^2 = kg/(ms^2)}

1. Steam

1.1 Introduction

What is steam? The English language is a little fuzzy here. Some definitions say that any water vapor (H2O in gaseous form instead of liquid) is steam. By that definition, the atmosphere itself is a very low-temperature steam engine. Other definitions say that steam is water vapor if the water vapor happens to be boiling. (Which brings up another question: what does "boiling," mean?)

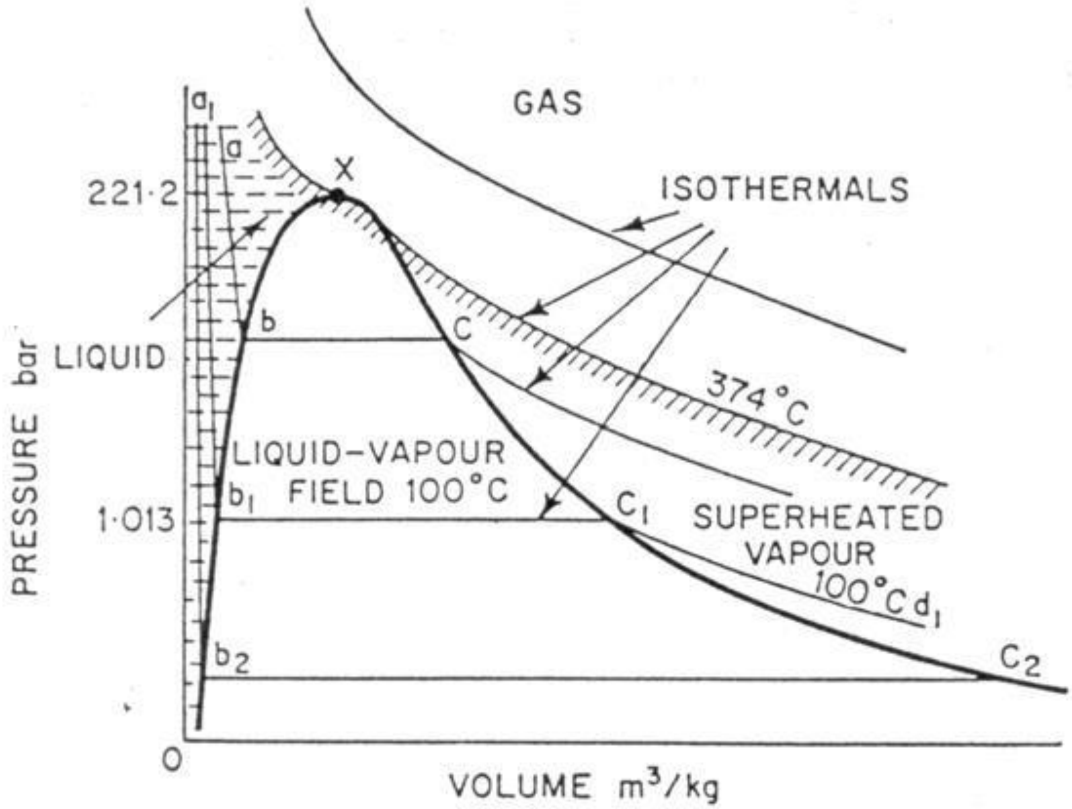
Finally, a third definition says that steam is "pressurized water vapor", i.e. water vapor at a pressure higher than 1 atmosphere. Those are incompatible definitions, which makes clear thinking difficult.

***Steam** is the technical term for the gaseous phase of water*, which is formed when water boils. Technically speaking, in terms of the chemistry and physics, steam is invisible and cannot be seen; however, in common language it is often used to refer to the visible mist or aerosol of water droplets formed as this water vapor condenses in the presence of (cooler) air. At lower pressures, such as in the upper atmosphere or at the top of high mountains water boils at a lower temperature than the nominal 100 °C (212 °F) at standard temperature and pressure. If heated further it becomes superheated steam.

The enthalpy of vaporization is the energy required to turn water into the gaseous form when it increases in volume by 1,700 times at standard temperature and pressure; this change in volume can be converted into mechanical work by steam engines such as reciprocating piston type engines and steam turbines, which are a sub-group of steam engines. Piston type steam engines played a central role to the Industrial Revolution and modern steam turbines are used to generate more than 80% of the world's electricity. If liquid water comes in contact with a very hot substance (such as lava, or molten metal) it can create a steam explosion. Steam explosions have been responsible for many foundry accidents, and may also have been responsible for much of the damage to the plant in the Chernobyl disaster.

Dryness Fraction

The figure below shows a typical P-v diagram for steam, which you will all be familiar with by now. On the diagram are shown isothermals (lines of constant temperature). Within the Liquid-Vapor mixture region, these lines are horizontal. Any horizontal line on a P-v diagram is an isobar (line of constant pressure). It is therefore clear that if the temperature and pressure of wet steam are stated then it is not enough information to completely specify the state of the steam. For we will not know the fraction of it which is liquid and what fraction of it is vapor.



The ratio of the mass of vapor to the mass of mixture is called the dryness fraction, x

$$x = \frac{\text{mass of vapour}}{\text{mass of liquid\& vapour mixture}}$$

How is the dryness fraction of the wet steam actually determined in practice? Well,we use a calorimeter.

1.2 Calorimeters

Calorimeters, in general, are to do with measuring heat. Many, such as the bomb calorimeter, are used to determine the amount of heat generated by burning a certain mass of a certain substance. Here we are concerned with those calorimeters which we might use to determine the dryness fraction of wet steam.

1.2 DETERMINATION OF DRYNESS FRACTION OF STEAM

The dryness fraction of steam can be measured by using the following *calorimeters:*

1. Tank or bucket calorimeter
2. Throttling calorimeter