STEAM AND DRYNESS FRACTION

Steam is water in vapourous phase. The mass fraction of vapour present is indicated by the symbol *'x'*, which is a property of the mixture and is known as the DRYNESS FRACTION or QUALITY.

The values of temperature during vapourisation are independent and remain constant as x varies from *zero* to *unity*.

A value of $x = 0$ means that the fluid is all water.
A value of $x = 1$ means that the fluid is dry vapour or steam.

The dryness fraction, x is defined as:

DRYNESS FRACTION (x)
= MASS OF DRY STEAM / MASS OF WET STEAM CONTAINING THE DRY STEAM

Mathematically, it is given by,

$$x = \frac{m_g}{m} = \frac{m_g}{m_{f+}m_g}$$

Where:

$m = m_f + m_g = (1 - x)m + m_g$

Where:

m_f	=	*mass of liquid*
m_g	=	*mass of vapour*
m	=	*total mass of mixture*

The TOTAL VOLUME of the mixture, $v = v_f + v_g$

Thus,

$$mv = m_f v_f + m_g v_g$$

$$v = (1 - x)v_f + xv_g$$

$$v = v_f + x(v_g - v_f)$$

$$v = v_f + xv_{fg}$$

Where:

$v_{fg} = (v_g - v_f)$ = change in specific volume from saturated liquid to saturated vapour.

If x is very large and T does not approach T_{CR}, i.e. v_f is very small, then

$v = xv_g$

which is sufficiently accurate.
Note:

1. For other specific properties such as u, h, and s, similar expressions hold accurate, i.e.

$$u = u_f + xu_{fg}$$
$$h = h_f + xh_{fg}$$
$$s = s_f + xs_{fg}$$

2. h_{fg} is the latent heat of vapourisation
3. Steam Tables list properties such as v, u, h and s against t_s and p_s.
4. Relations for saturated water and steam are given in tables.
5. Since a wet vapour cannot behave as an ideal gas, the equation of state does not apply.
6. Apart from P-V-T diagram, the T-S and h-S diagrams are useful for illustrating water-steam mixtures.