Air properties in Psychrometric chart

PSYCHROMETRIC CHART

Psychrometric charts are complex graphs that can be used to assess the physical and thermodynamic properties of gas-vapour mixtures at a constant pressure. They are often used to assess the properties of moist air. This can be useful in the design of heating, ventilation and air-conditioning systems for buildings, and psychrometric charts often include a zone in the middle that represents the range of conditions that people find comfortable under different circumstances (such as summer and winter).

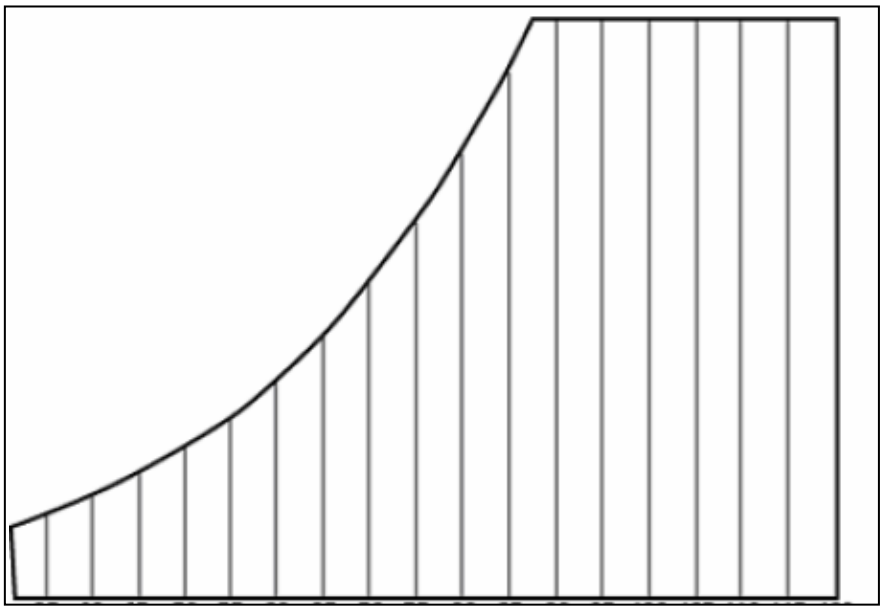
Typically, the properties represented on psychrometric charts are:

- Dry-bulb temperature: A measure of air temperature recorded by a thermometer exposed to the air but shielded from radiation and moisture.
- Wet-bulb temperature: The temperature recorder by a thermometer that has its bulb wrapped in cloth and moistened with distilled water. The rate of evaporation from the wet bulb, and so the temperature it records varies depending on the humidity of the air it is exposed to.
- Relative humidity: The ratio of the actual vapour pressure relative to the vapour pressure of saturated air at the same temperature, expressed as a percentage.
- Specific volume: The volume of a unit weight of dry air.
- Dew point temperature: The highest temperature at which water vapour will condense.
- Humidity ratio: The dry-basis moisture content of air expressed as the weight of water vapour per unit weight of dry air.
- Enthalpy: The energy content of air.

The state of moist air can be determined from any two of these properties, from which all other properties can then be determined.

Dry Bulb Temperature (DBT): it is the temperature that we measure with a standard thermometer that has no water on its surface. When people refer to the temperature of the air, they are commonly referring to its dry bulb temperature. Several temperature scales commonly are used in measuring the temperature.

Dry-bulb temperature is located on the X-axis, of the psychrometric chart and lines of constant temperature are represented by vertical chart lines.

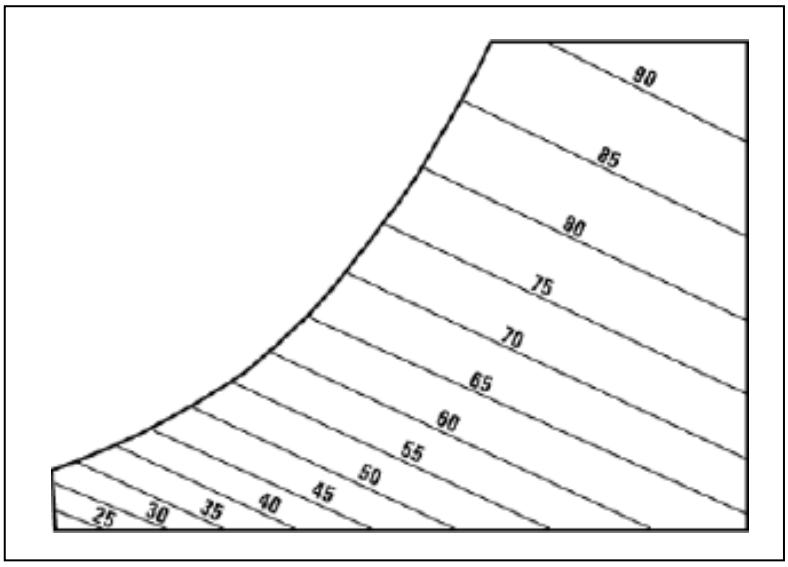


Dry bulb temperature lines shown on the Psychrometric Chart

The wet bulb temperature (WBT): it is a temperature associated with the moisture content of the air. Wet bulb temperature is taken by surrounding the thermometer with a wet wick and measuring the reading as the water evaporates. Because of the evaporative cooling effect, Wet bulb temperatures are always lower than dry bulb temperatures and the

only time that they will be the same is at saturation (i.e. 100% relative humidity).

The wet bulb temperature (WBT) relates relative humidity to the dry bulb temperature. If the relative humidity is low and the temperature is high, moisture will evaporate very quickly so its cooling effect will be more significant than if the relative humidity was already high, in which case the evaporation rate would be much lower. Wet bulb temperature on psychrometric chart is represented by lines that slant diagonally from the upper right of the chart (along the line of saturation) down to the lower left of the chart. These follows lines of constant enthalpy but values are read off at the upper, curved, saturation temperature boundary.

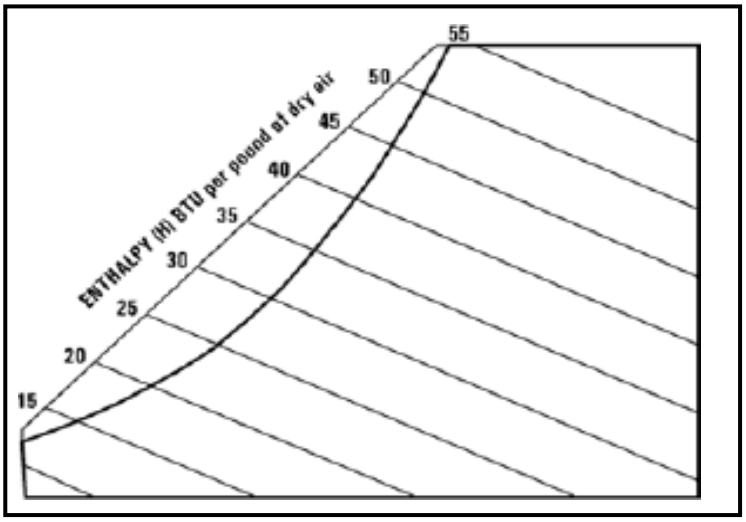


Wet bulb temperature lines shown on the Psychrometric Chart

Enthalpy: it is the measure of heat energy in the air due to sensible heat or latent heat. Sensible heat is the heat (energy) in the air due to the temperature of the air and the latent heat is the heat (energy) in the air due to the moisture of the air. The sum of

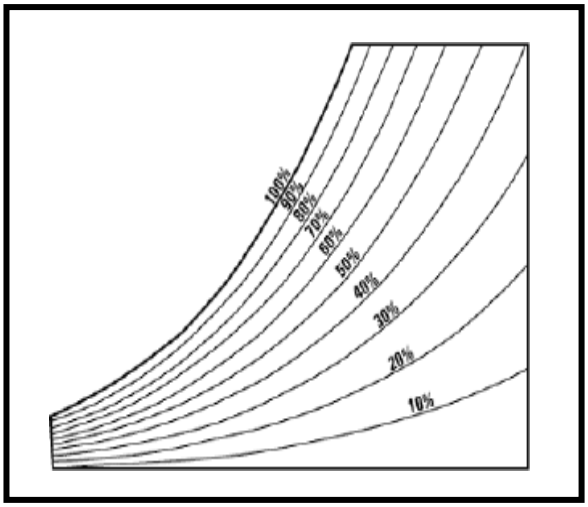
the latent energy and the sensible energy is called the air enthalpy. Enthalpy is expressed in Btu per pound of dry air (Btu/lb of dry air) or kilojoules per kilogram (kJ/kg). Enthalpy is useful in air heating and

cooling applications. Air with same amount of energy may either be dry hot air (high sensible heat) or cool moist air (high latent heat). The enthalpy scale is located above the saturation, upper boundary of the chart. Lines of constant enthalpy run diagonally downward from left to right across the chart; follow almost exactly the line of constant wet bulb temperature.



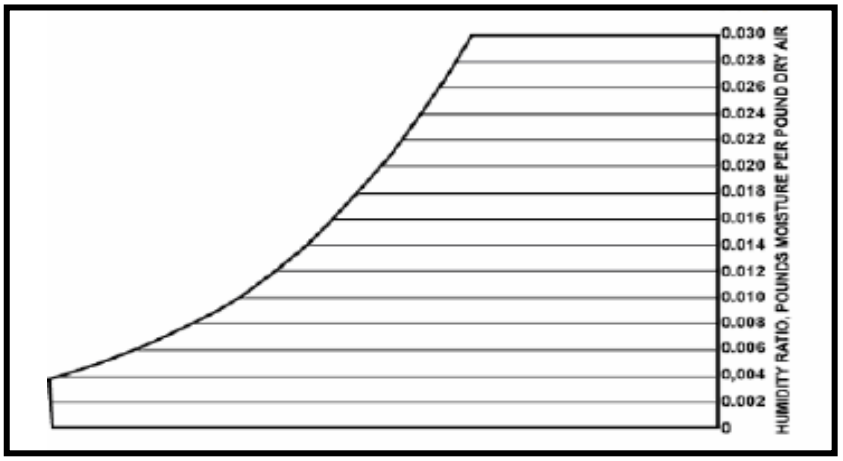
Enthalpy lines shown on the Psychrometric Chart

Relative humidity (RH): it is a measure of the amount of water air can hold at a certain temperature. Air temperature (dry-bulb) is important because warmer air can hold more moisture than cold air. As a rule of thumb, the maximum amount of water that the air can hold doubles for every 20°F increase in temperature. Lines of constant relative humidity are represented by the curved lines running from the bottom left and sweeping up through to the top right of the chart. The line for 100 percent relative humidity, or saturation, is the upper, left boundary of the chart. 100 % RH (saturation) line corresponds to the wet bulb and the dew-point temperature scale line and the line for zero percent RH falls along the dry-bulb temperature scale line



Relative Humidity lines shown on the Psychrometric

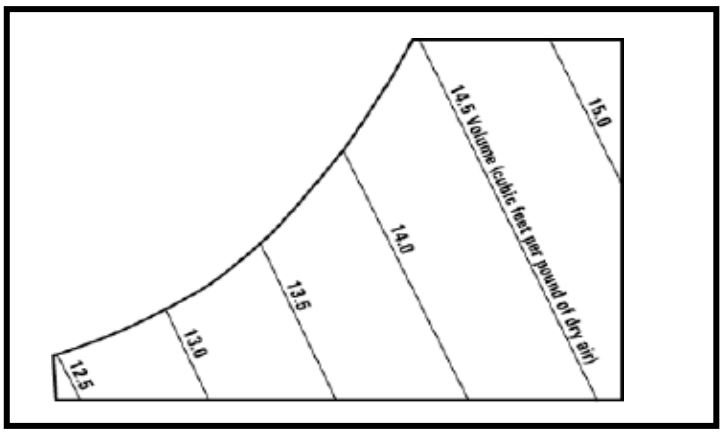
Absolute Humidity: it is the vapor content of air, given in grams or lb of water vapor per lb of dry air (i.e., lb of moisture/lb of d.a). It is also known as moisture content or humidity ratio. Air at a given temperature can support only a certain amount of moisture and no more. This is referred to as the saturation humidity. Humidity ratio is represented on the chart by lines that run horizontally and the values are on the right hand side (Y-axis) of the chart increasing from bottom to top.



Moisture content lines shown on the Psychrometric Chart

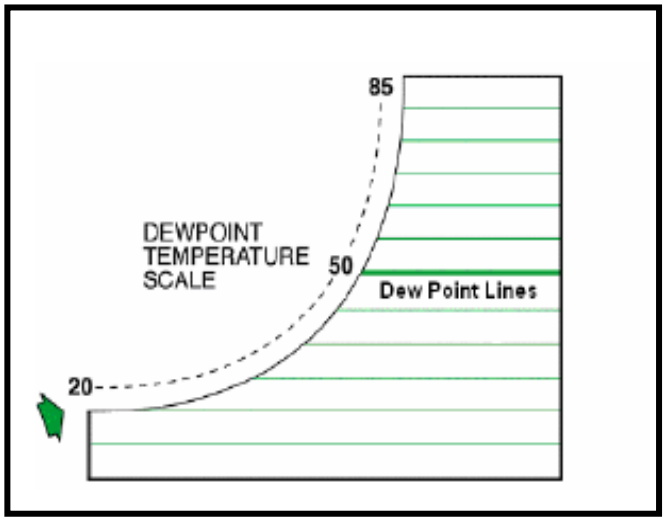
Specific Volume: it is the volume that a certain weight of air occupies at a specific set of conditions. The specific volume of air is basically the reciprocal of air density. As the temperature of the air increases, its density will decrease as its molecules vibrate more and take up more space (as per Boyle's law). Thus the specific volume will

increase with increasing temperature. Since warm air is less dense than cool air which causes warmed air to rise. This phenomenon is known as thermal buoyancy. By similar reasoning, warmer air has greater specific volume and is hence lighter than cool air.



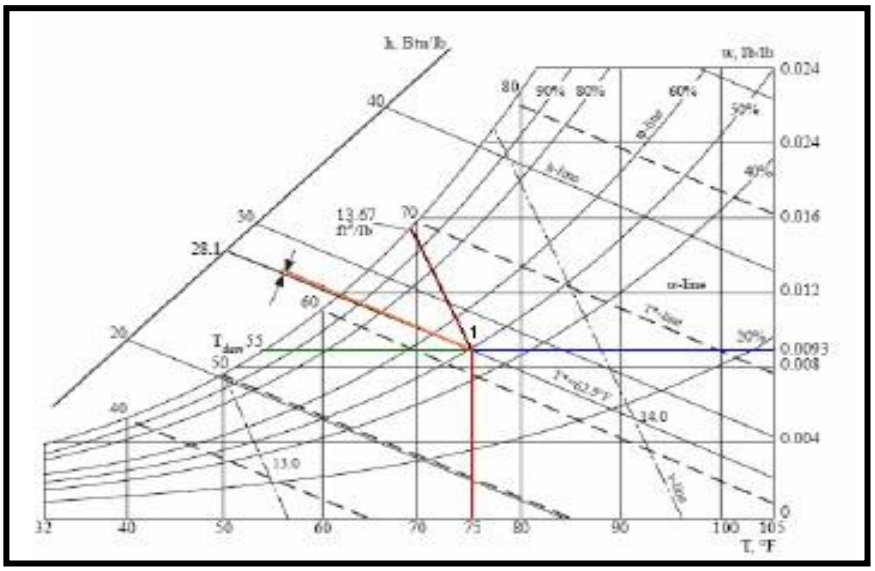
Specific volume lines shown on the Psychrometric Chart

Dew point temperature indicates the temperature at which water will begin to condense out of moist air. When air is cooled, the relative humidity increases until saturation is reached and condensation occurs. Condensation occurs on surfaces which are at or below the dew point temperature. Dew point is represented along the 100% relative humidity line on the psychrometric chart. Dew point temperature is determined by moving from a state point horizontally to the left along lines of constant humidity ratio until the upper, curved, saturation temperature boundary is reached. At dew point, dry bulb temperature and wet bulb temperature are exactly the same.



Dew Point Temperature lines shown on the Psychrometric Chart

An air-conditioned room at sea level has an indoor design temperature of °C and a relative humidity of determine the humidity ratio, enthalpy, density, dew point, and thermodynamic wet bulb temperature of the indoor air at design condition.



Solution

Since the air-conditioned room is at sea level, a psychrometric chart of standard atmospheric pressure of pa should be used to find the required properties.

1. Plot the state point of the room air at design condition on the psychrometric chart. First, find the room temperature on the horizontal temperature scale. Draw a line parallel to the temperature line. This line meets the relative humidity curve of at point 1, which denotes the state point of room air (refer figure above).
2. Draw a horizontal line toward the humidity ratio scale from point 1. This line meets the ordinate and thus determines the room air humidity ratio W =
3. Draw a line from point 1 parallel to the enthalpy line. This line determines the enthalpy of room air on the enthalpy scale, h1 =

4. Draw a line through point r parallel to the moist volume line. The perpendicular scale of this line indicates v =
5. Draw a horizontal line to the left from point 1. This line meets the saturation curve and determines the dew point temperature, T_{dew} =
6. Draw a line through point r parallel to the thermodynamic wet bulb line. The perpendicular scale to this line indicates that the thermodynamic wet bulb temperature T =

Example

A sling psychrometer gives information. Determine other moist air properties from this information..

NO.	T_d	T_w	h	RH%	w	v	$T_{d.p}$
1	25	20					
2	20		55				
3	25			60			
4	35				0.008		
5	25					0.86	
6					0.011	0.9	
7		15	35				
8		55		50			
9		55				13.5	
10		60			0.006		