Overview of Psychrometrics

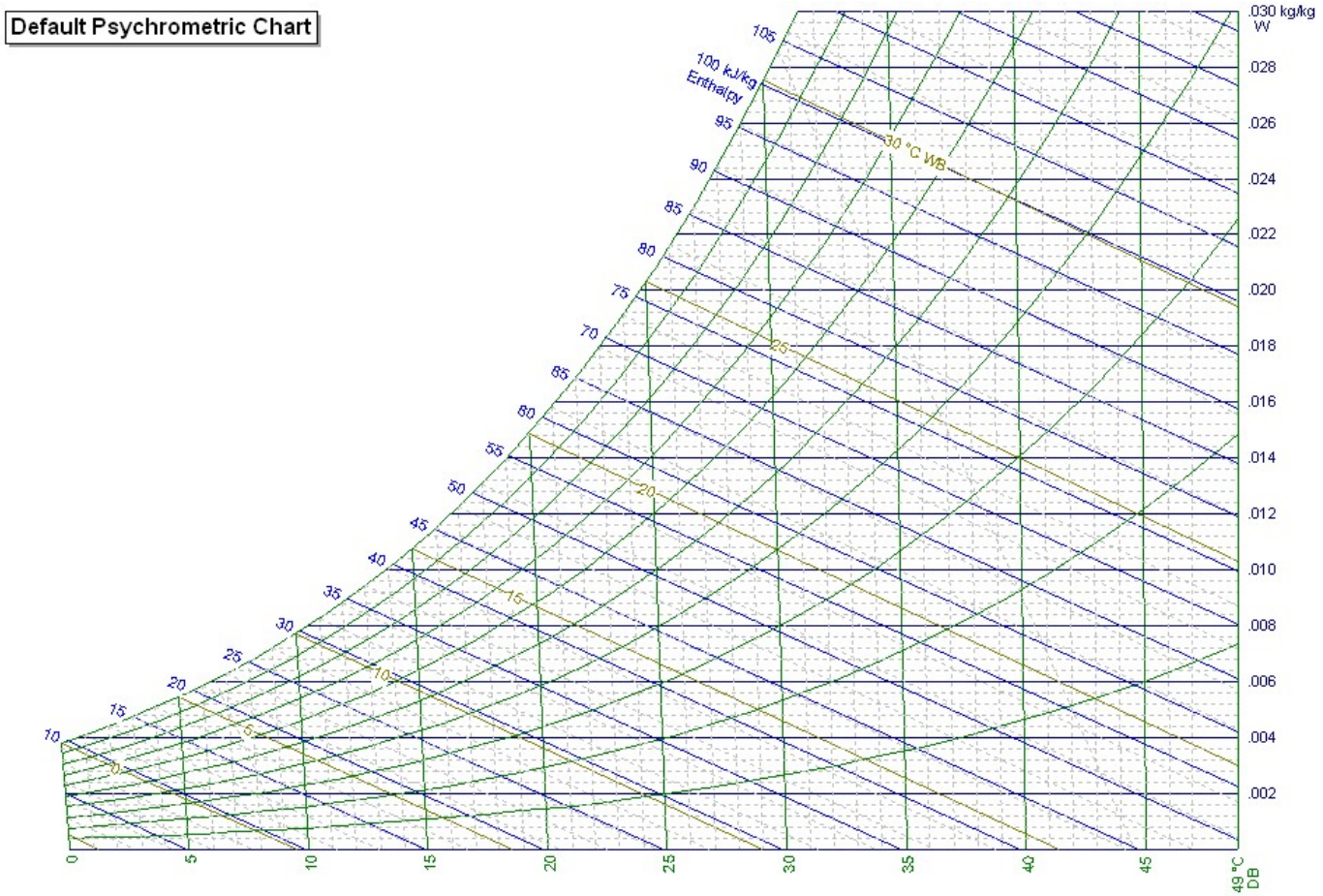
By Eng. Ibrahim Gebreel

Psychrometrics is the science of moist air properties and processes, which is used to illustrate and analyze air-conditioning cycles

The most commonly used psychrometric quantities include

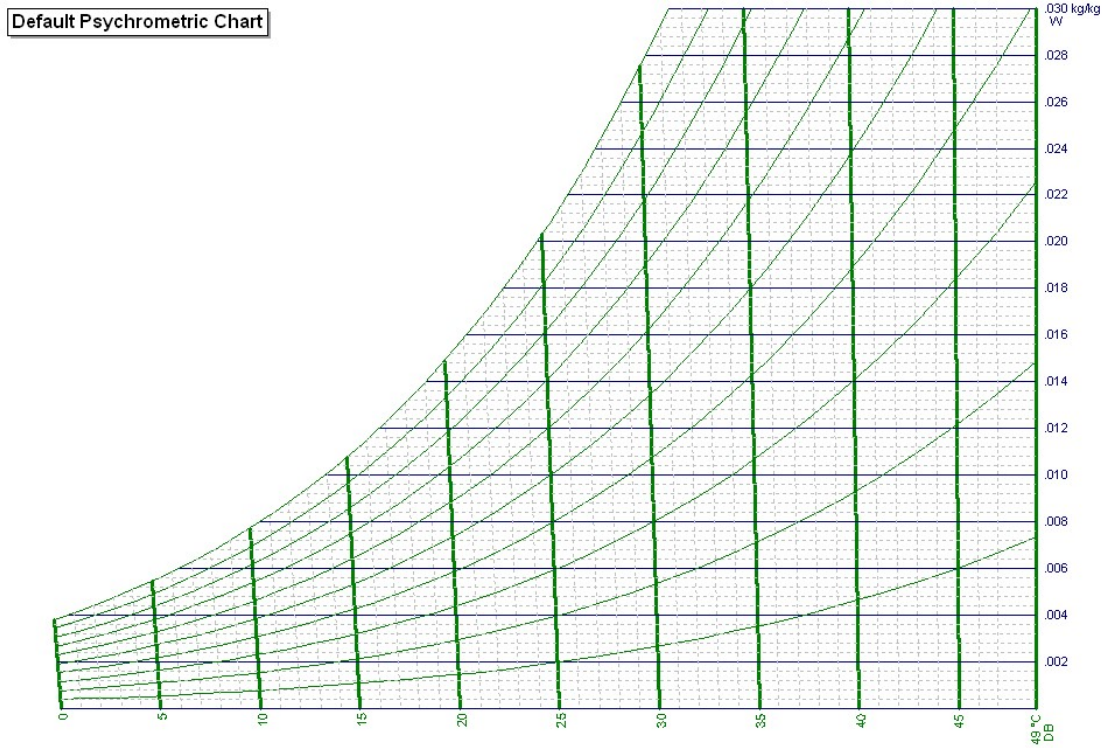
- Dry bulb temperature
- Wet bulb temperature
- Humidity ratio
- Specific Volume
- Relative humidity
- Dew point
- Enthalpy

Default Psychrometric Chart



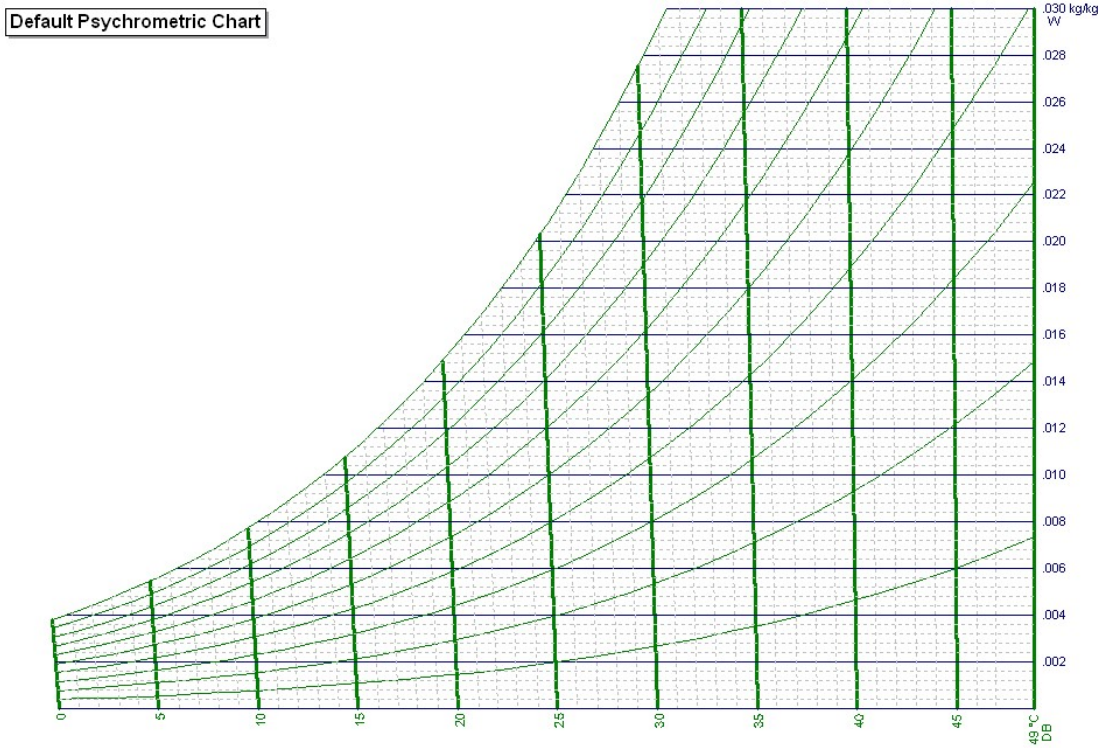
Dry Bulb Temperature

It is an indication of the amount of heat in the air and is directly proportional to the mean kinetic energy of the air molecules.

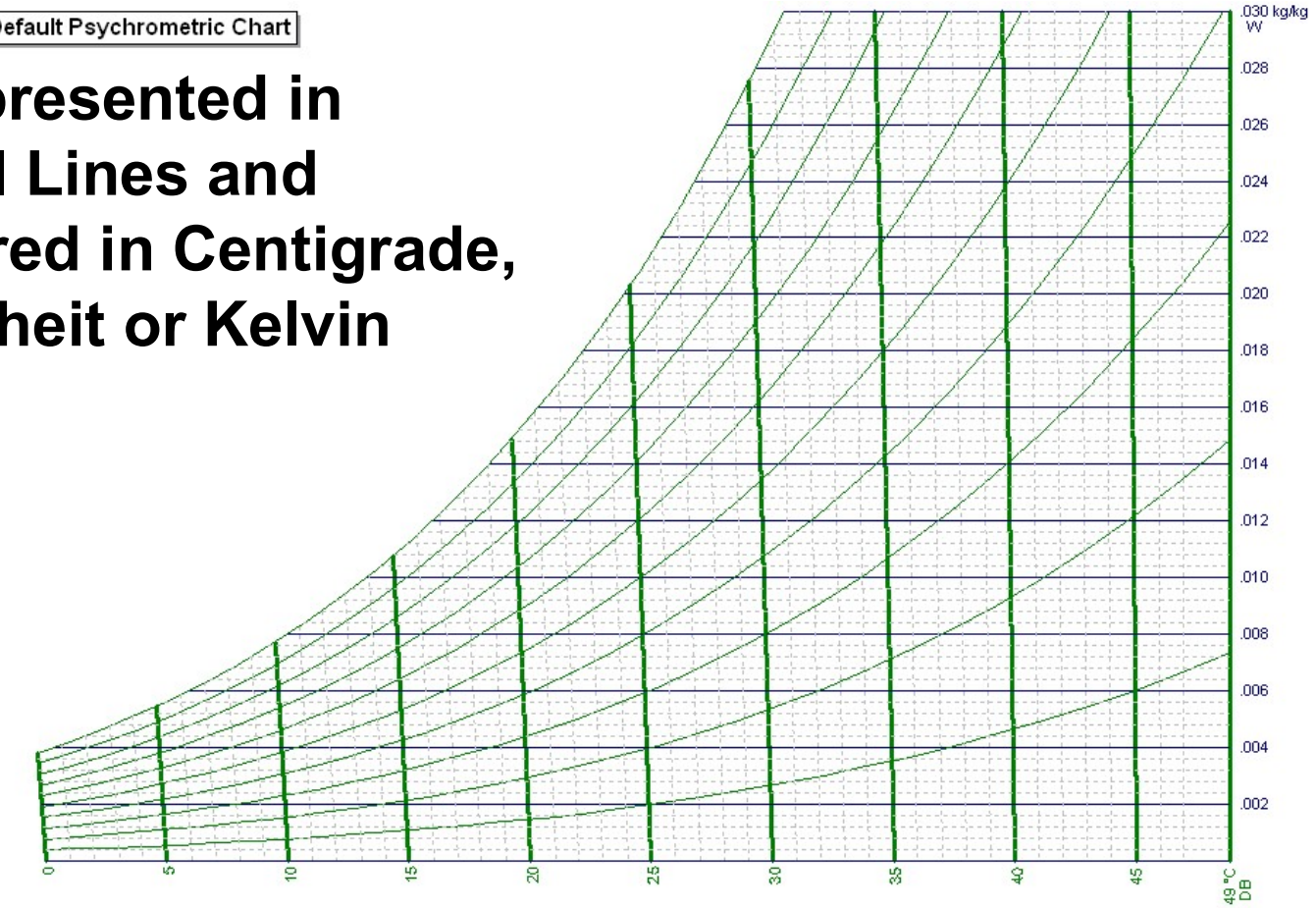


Dry Bulb Temperature

It can be measured by a thermometer freely exposed to air, but shielded from radiation and moisture.



Dry Bulb Temperature

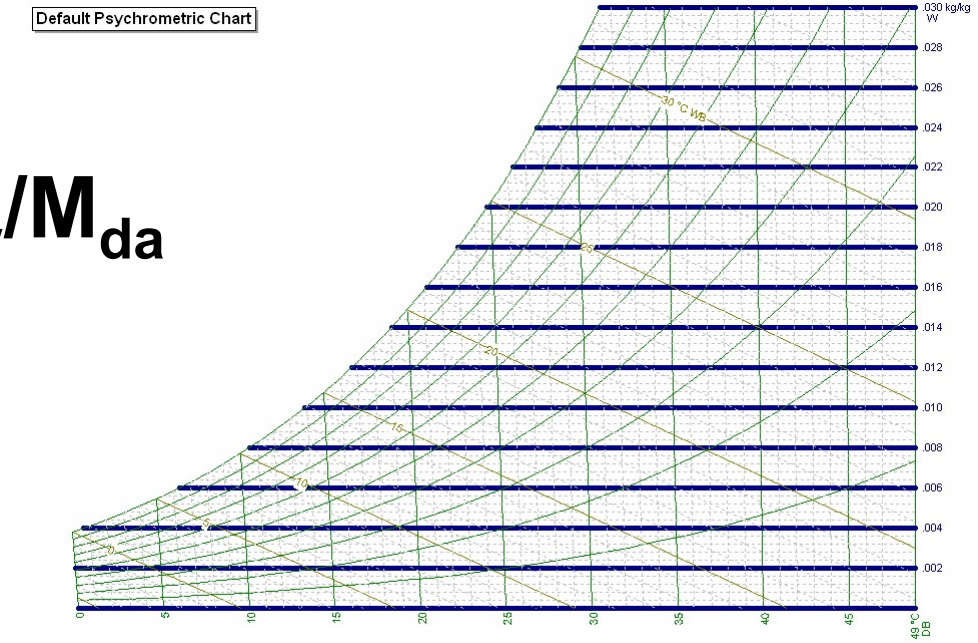


It is represented in Vertical Lines and measured in Centigrade, Fahrenheit or Kelvin

Humidity ratio (W)

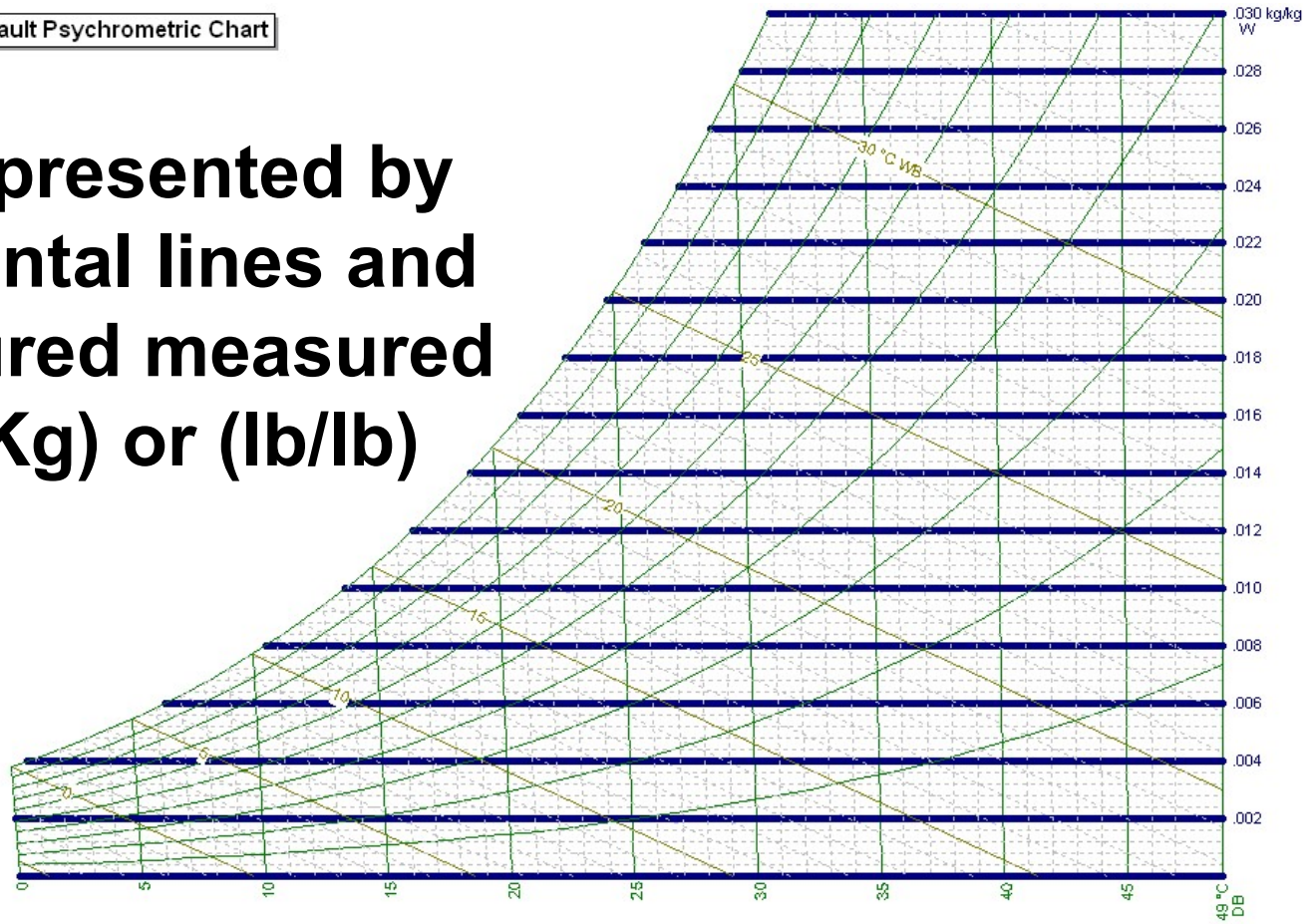
Humidity Ratio: is the ratio of the mass of water vapor to the mass of dry air contained in the mixture of moist air. (it represent the moisture content in the air)

$$W = M_w / M_{da}$$



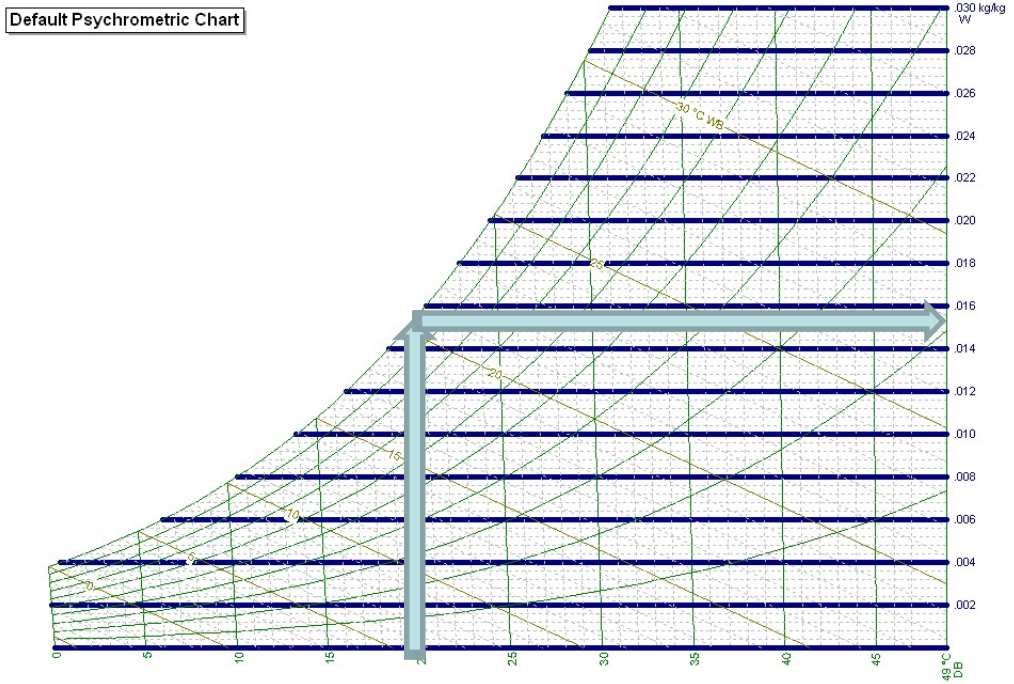
Humidity ratio (W)

It is represented by Horizontal lines and measured measured in (gr/Kg) or (lb/lb)



Saturated Humidity Ratio W_s

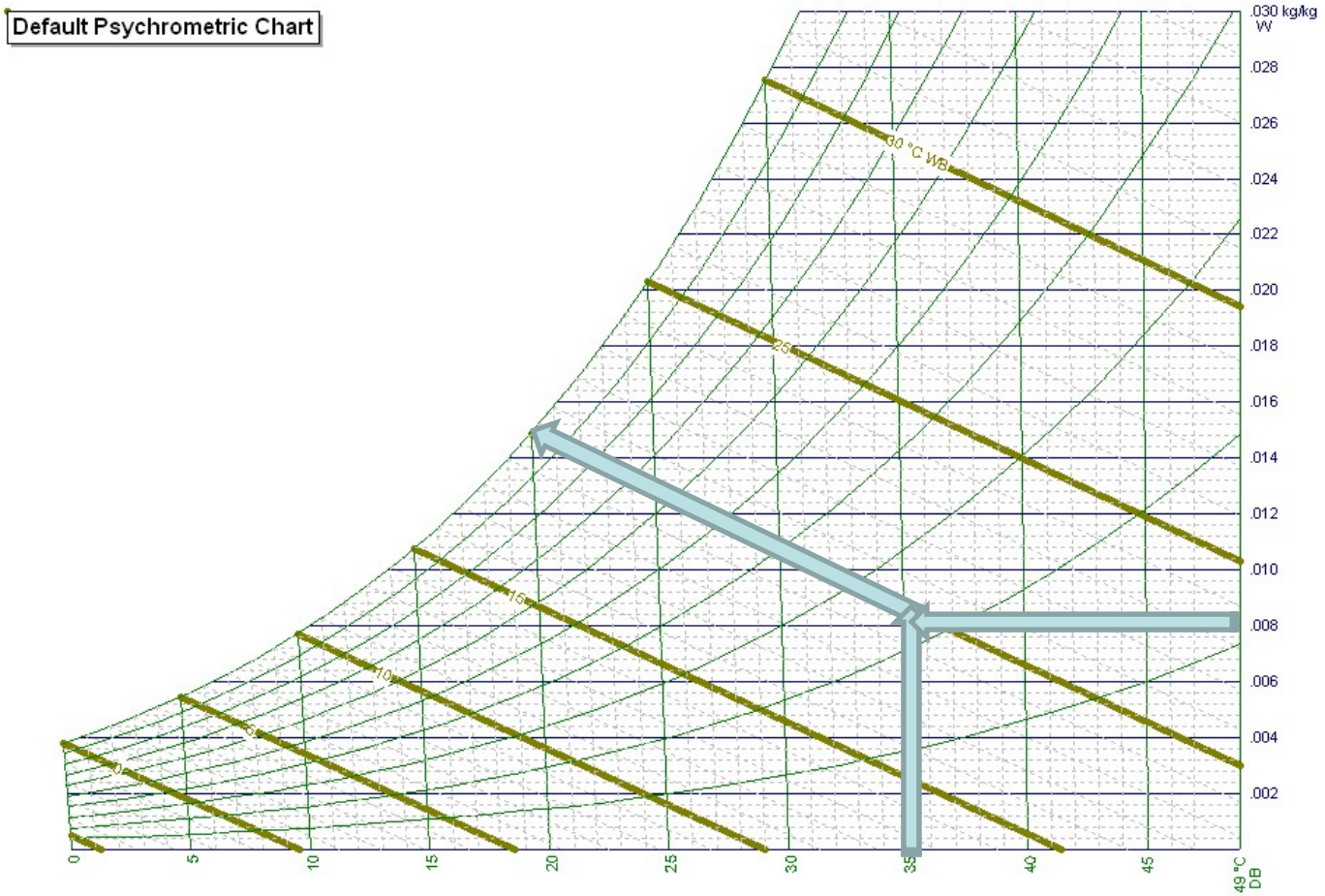
W_s (t, p) is the humidity ratio of moist air saturated with respect to water (or ice) at the same temperature t and pressure p.



Wet Bulb Temperature

It is the temperature at which water (liquid or solid), by evaporating into moist air at dry bulb temperature t and humidity ratio W, can bring air to saturation adiabatically at the same temperature t_{WB} while total pressure p is constant.

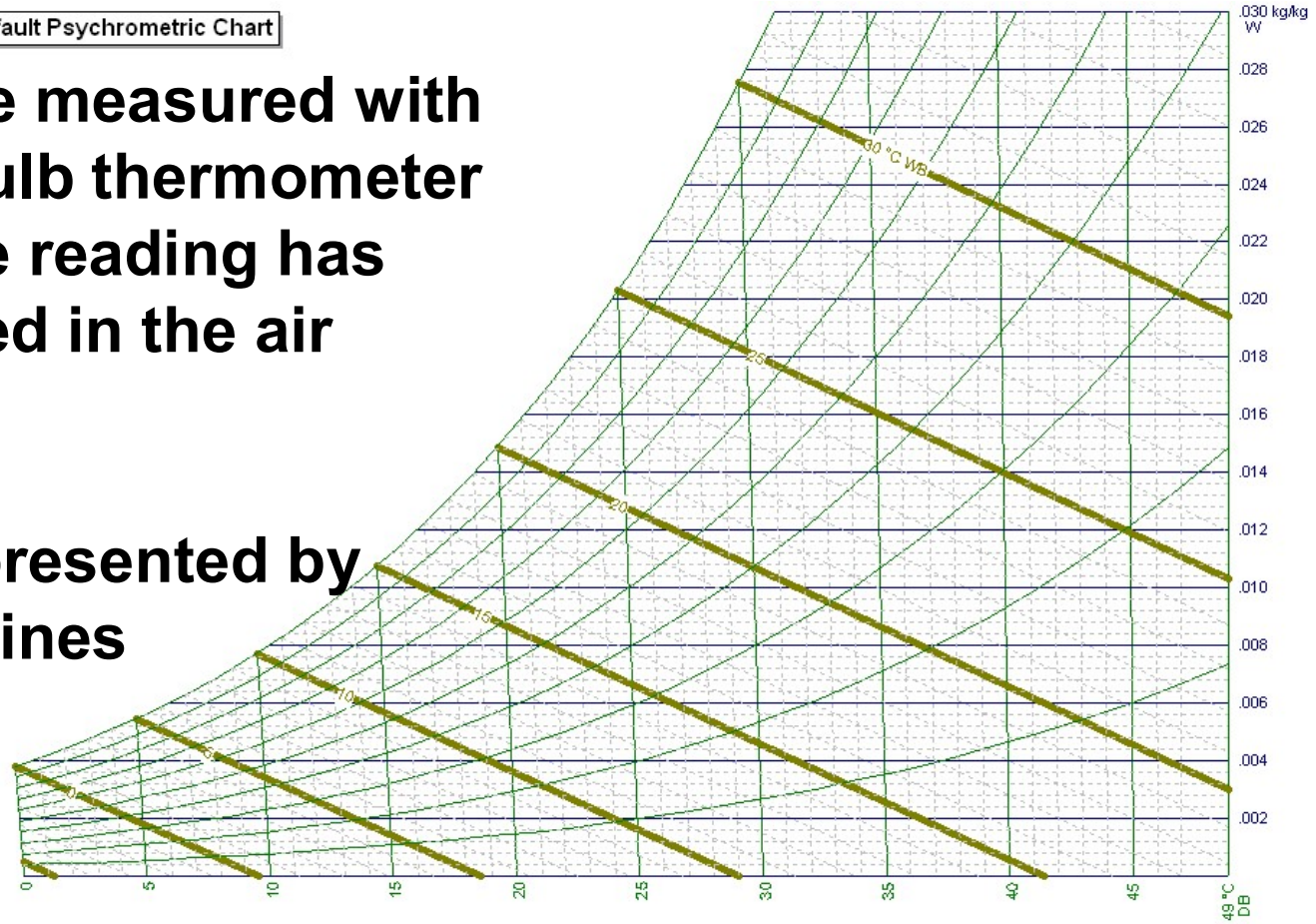
Wet Bulb Temperature



Wet Bulb Temperature

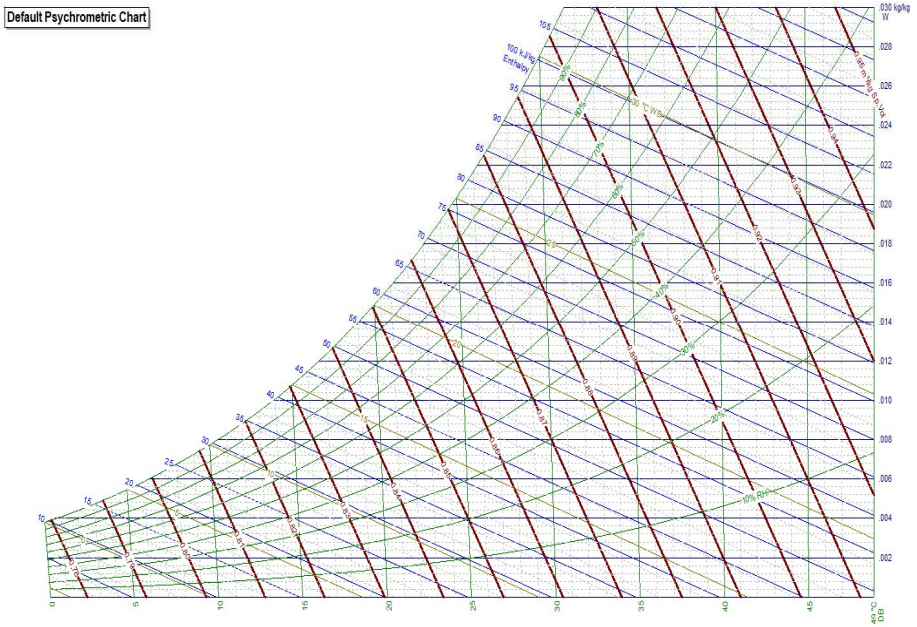
It can be measured with a wet-bulb thermometer after the reading has stabilized in the air stream.

It is represented by sloped lines



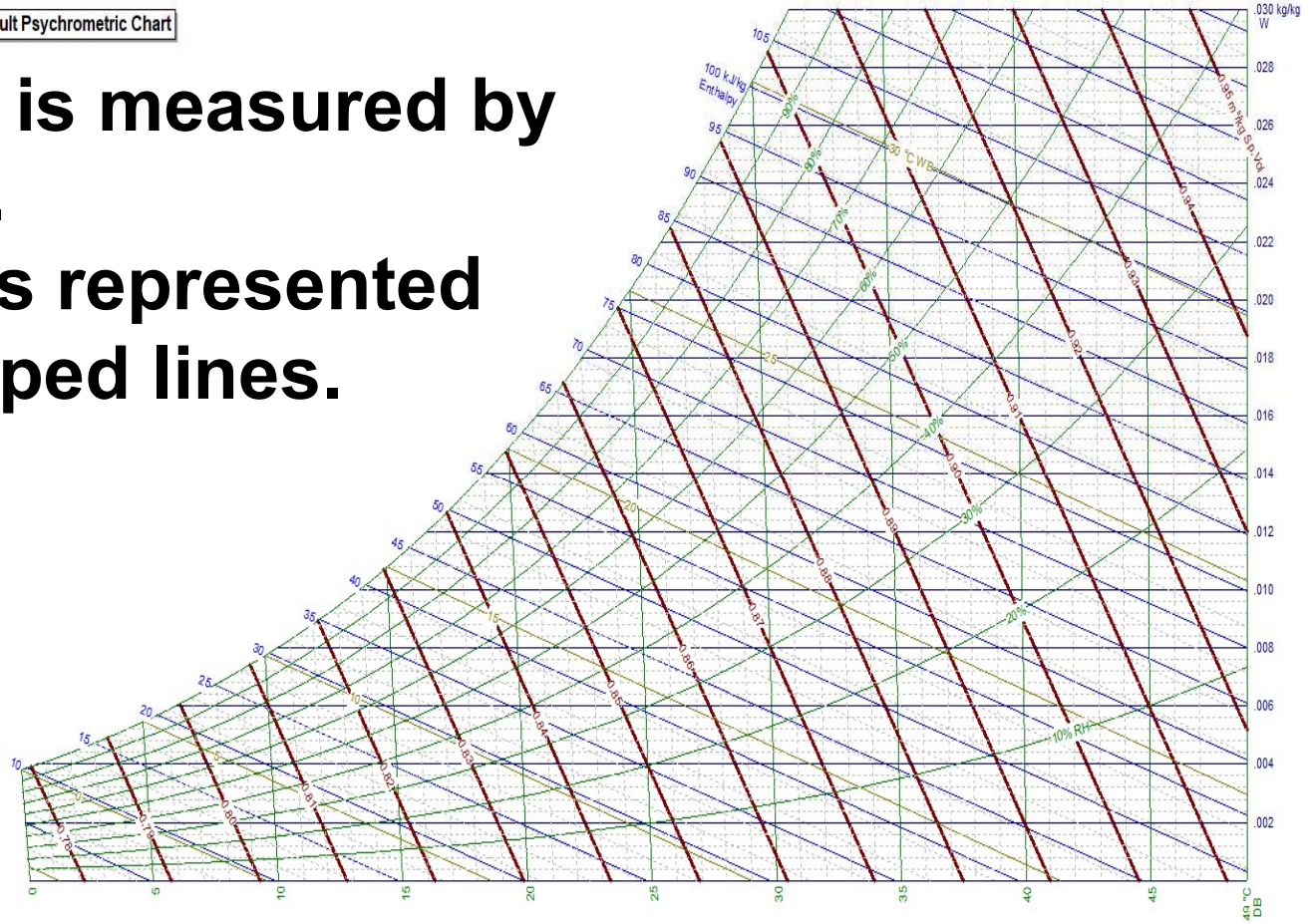
Specific Volume

This is the number of cubic meters occupied by one kilogram of a dry air (1/Density)



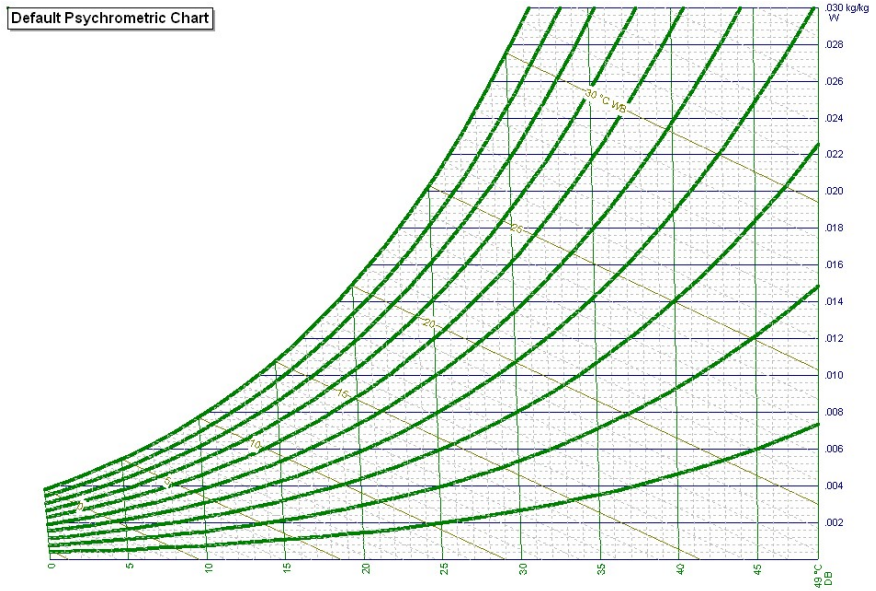
Specific Volume

And it is measured by m^3/kg.
And its represented by sloped lines.



Relative Humidity ϕ (RH%)

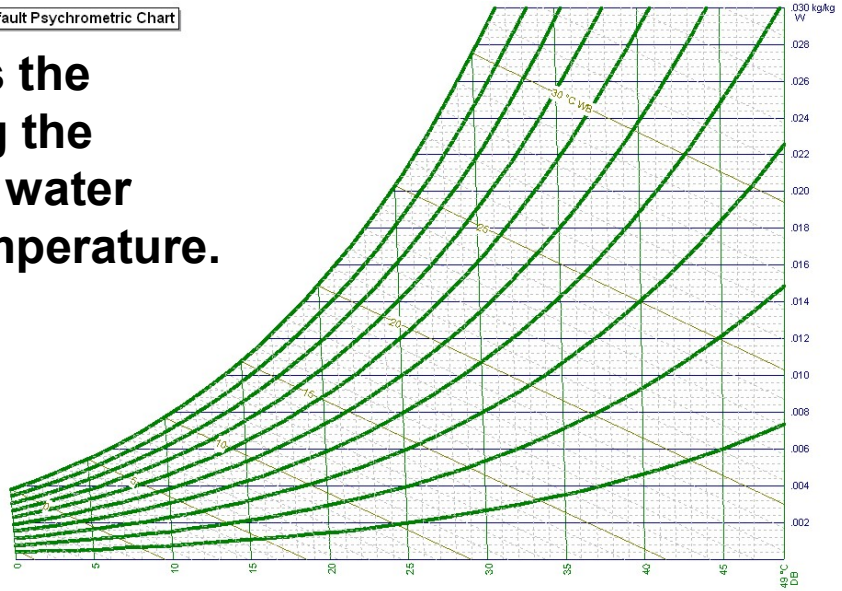
is the ratio of the mole fraction of water vapor in a moist air sample to the mole fraction of water Vapor in a saturated moist air sample at The same temperature and pressure.



Relative Humidity ϕ (RH%)

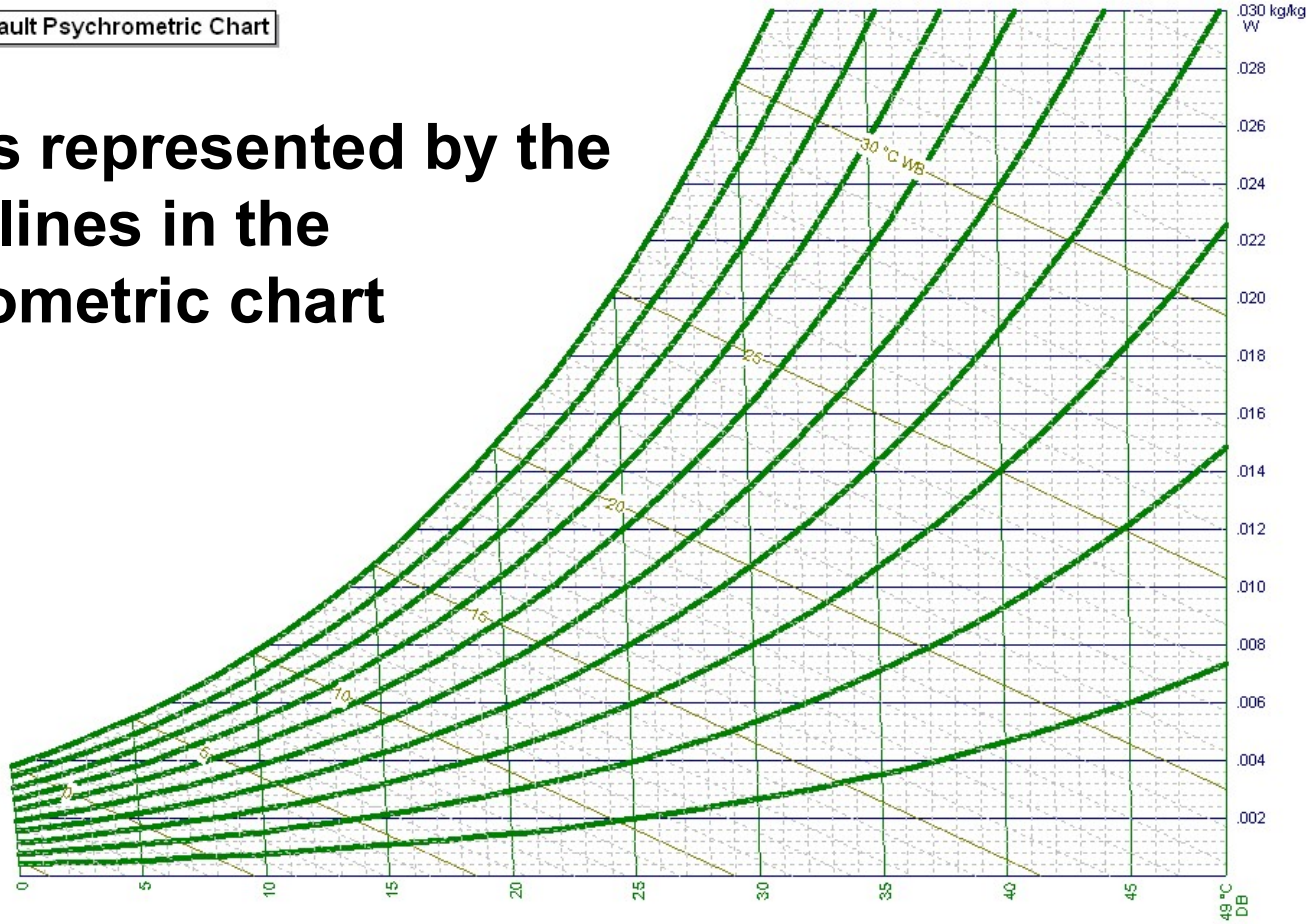
Or it is the ratio of the actual water vapour pressure of the air to the saturated water vapour pressure of the air at the same temperature.

Note: Saturated air is the volume of air holding the maximum amount of water vapour at a given temperature.



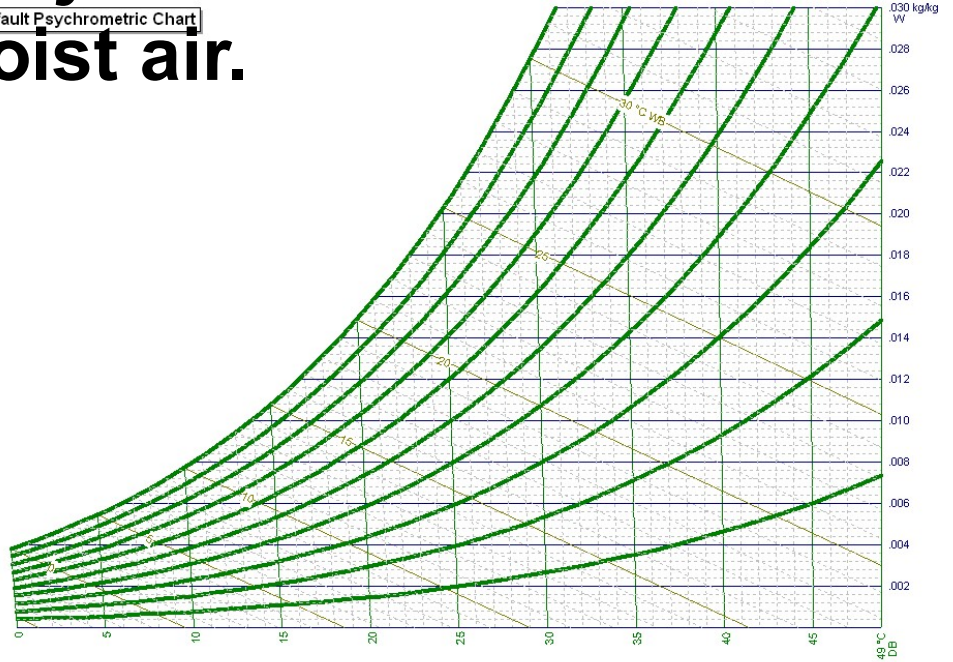
Relative Humidity ϕ (RH%)

And it is represented by the curved lines in the psychrometric chart

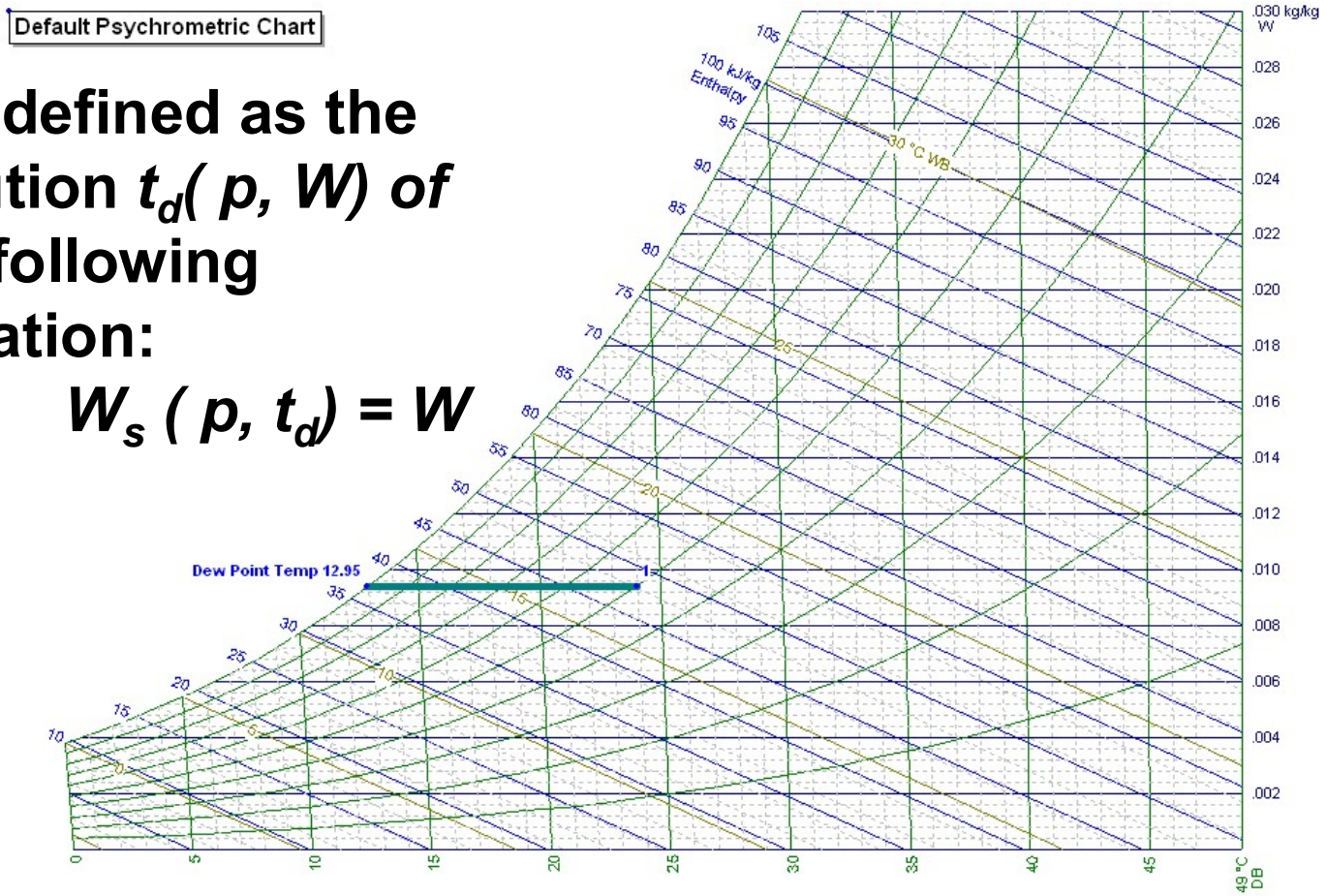


Dew Point Temperature DP (t_d)

Dew-point temperature t_d *is the temperature of moist air saturated* at pressure *p, with the same humidity ratio W as that of the* given sample of moist air.



Dew Point Temperature DP (t_d)

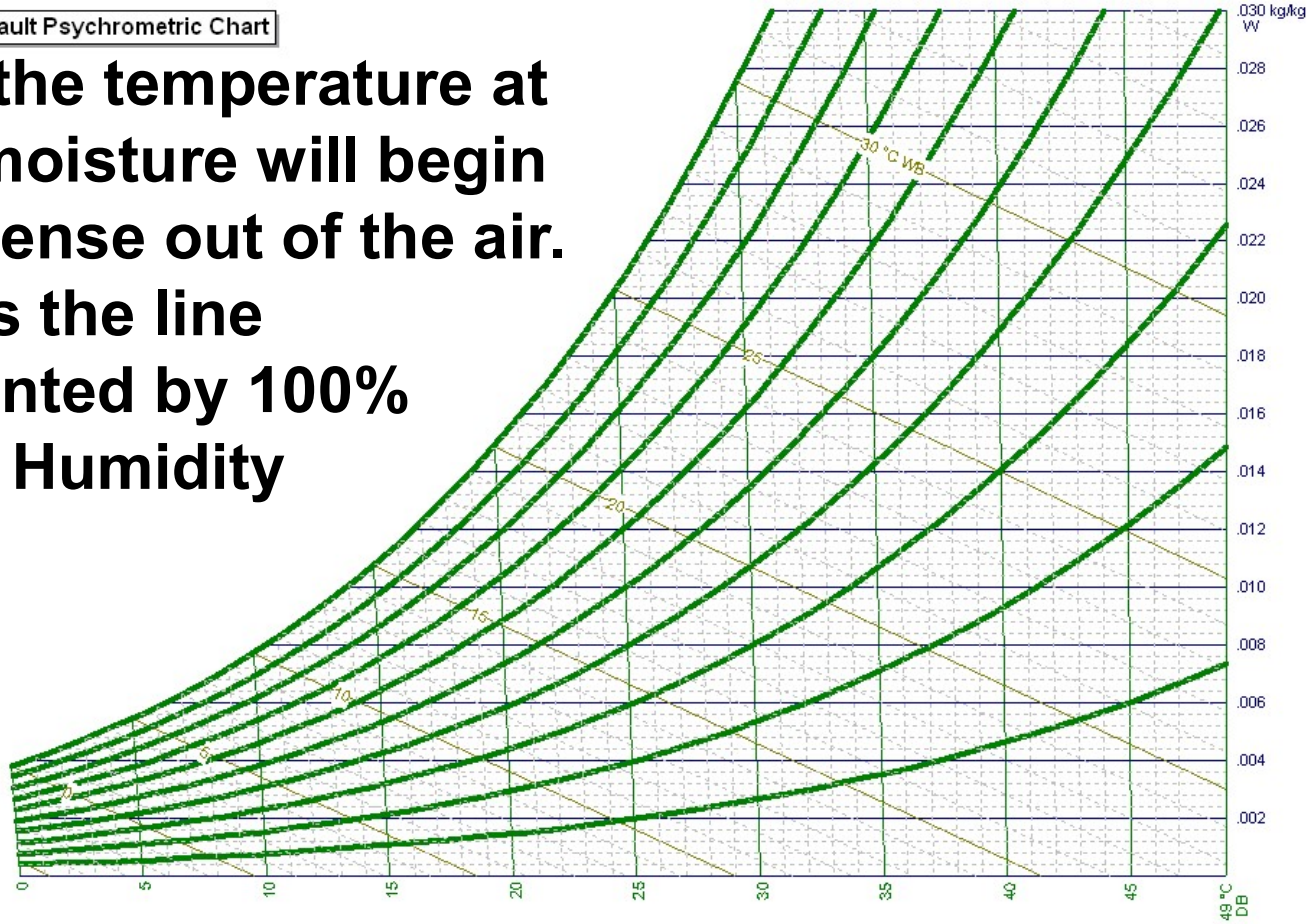


It is defined as the solution $t_d(p, W)$ *of the* following equation:

$$W_s (p, t_d) = W$$

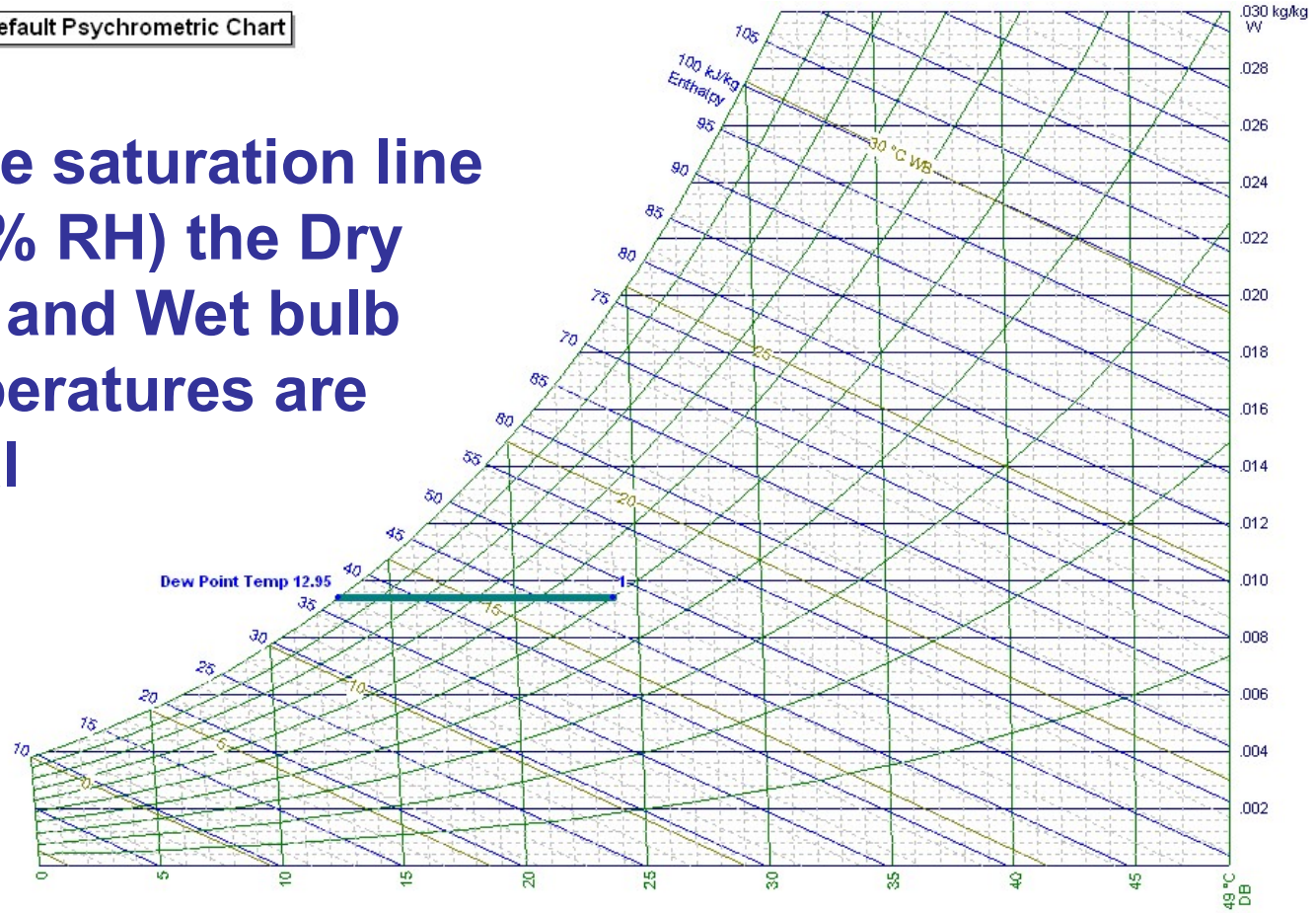
Dew Point Temperature DP (t_d)

This is the temperature at which moisture will begin to condense out of the air. And It is the line represented by 100% relative Humidity

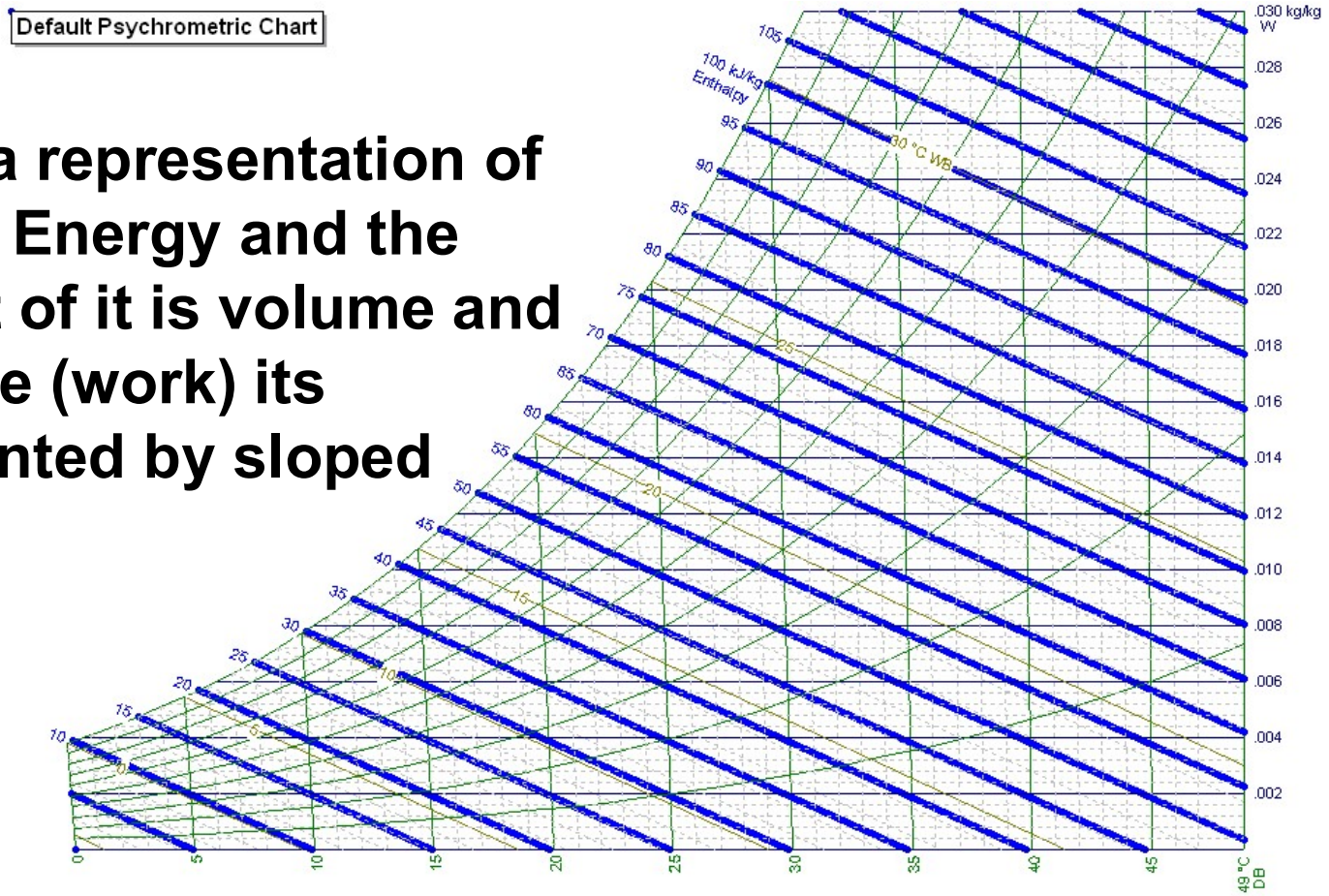


Dew Point Temperature DP (t_d)

At the saturation line (100% RH) the Dry bulb and Wet bulb temperatures are equal



Enthalpy



This is a representation of Internal Energy and the product of it is volume and pressure (work) its represented by sloped lines

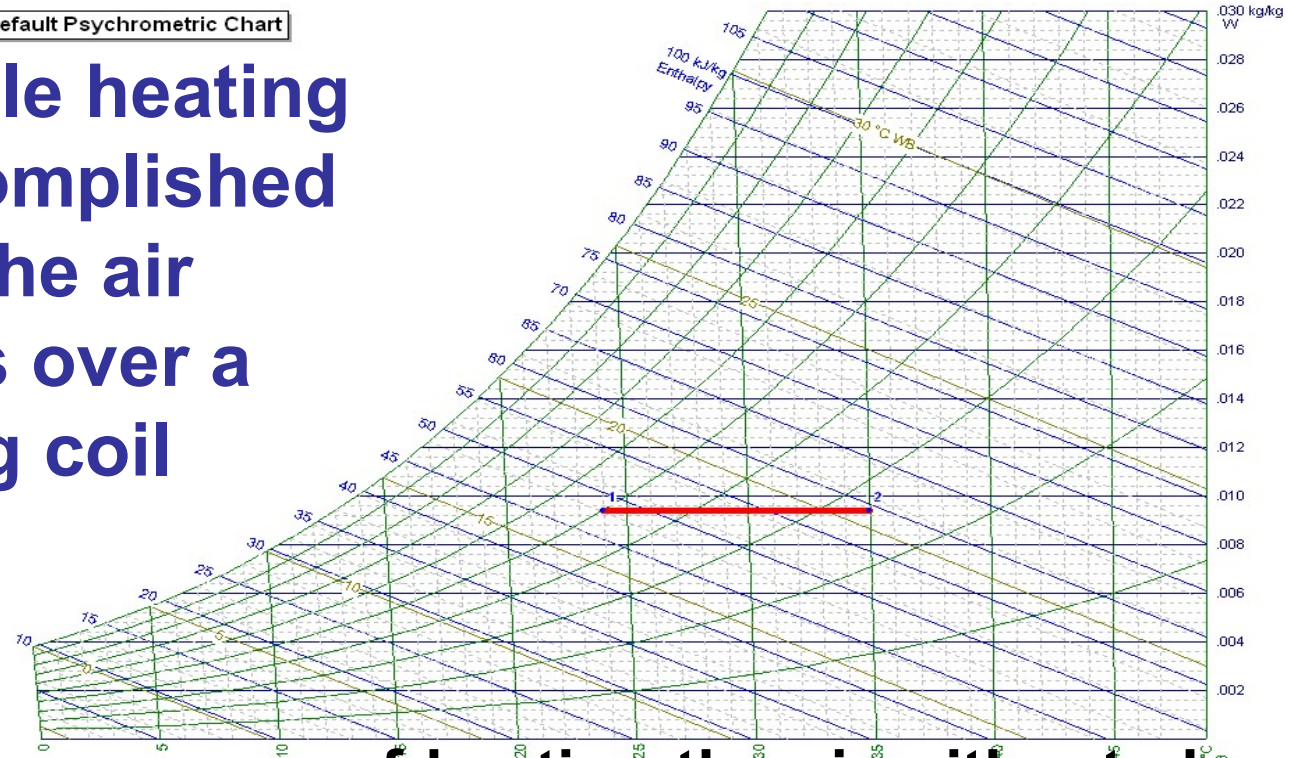
Psychrometric Processes

- Sensible Heating
- Sensible Cooling
- Humidifying
- Dehumidifying
- Heating and Humidifying
- Cooling and Humidifying
- Heating and Dehumidifying
- Cooling and Dehumidifying
- Air Mixing

Sensible Heating

Sensible Heating (Watts)=Q X 1.232 X (T2 – T1)
Sensible Heating (Btu/h)=Q X 1.10 X (T2 – T1)

Sensible heating is accomplished when the air passes over a heating coil

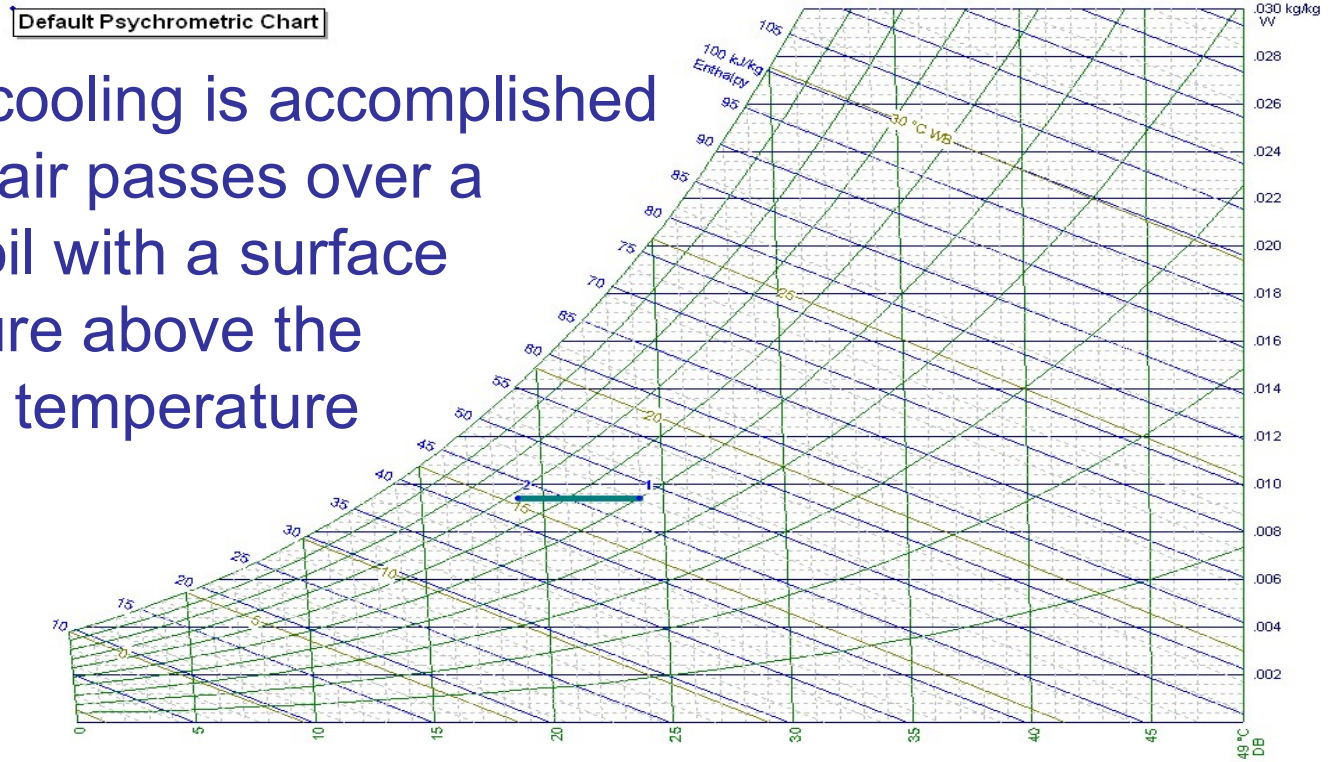


This is the process of heating the air without changing its moisture content. It is represented by lines of constant humidity ratio on the psychometric chart (from left to right)

Sensible Cooling

Sensible Cooling (Watts)=Q X 1.232 X (T1 – T2)
Sensible Cooling (Btu/h)=Q X 1.10 X (T1 – T2)

Sensible cooling is accomplished when the air passes over a cooling coil with a surface temperature above the dew-point temperature of the air



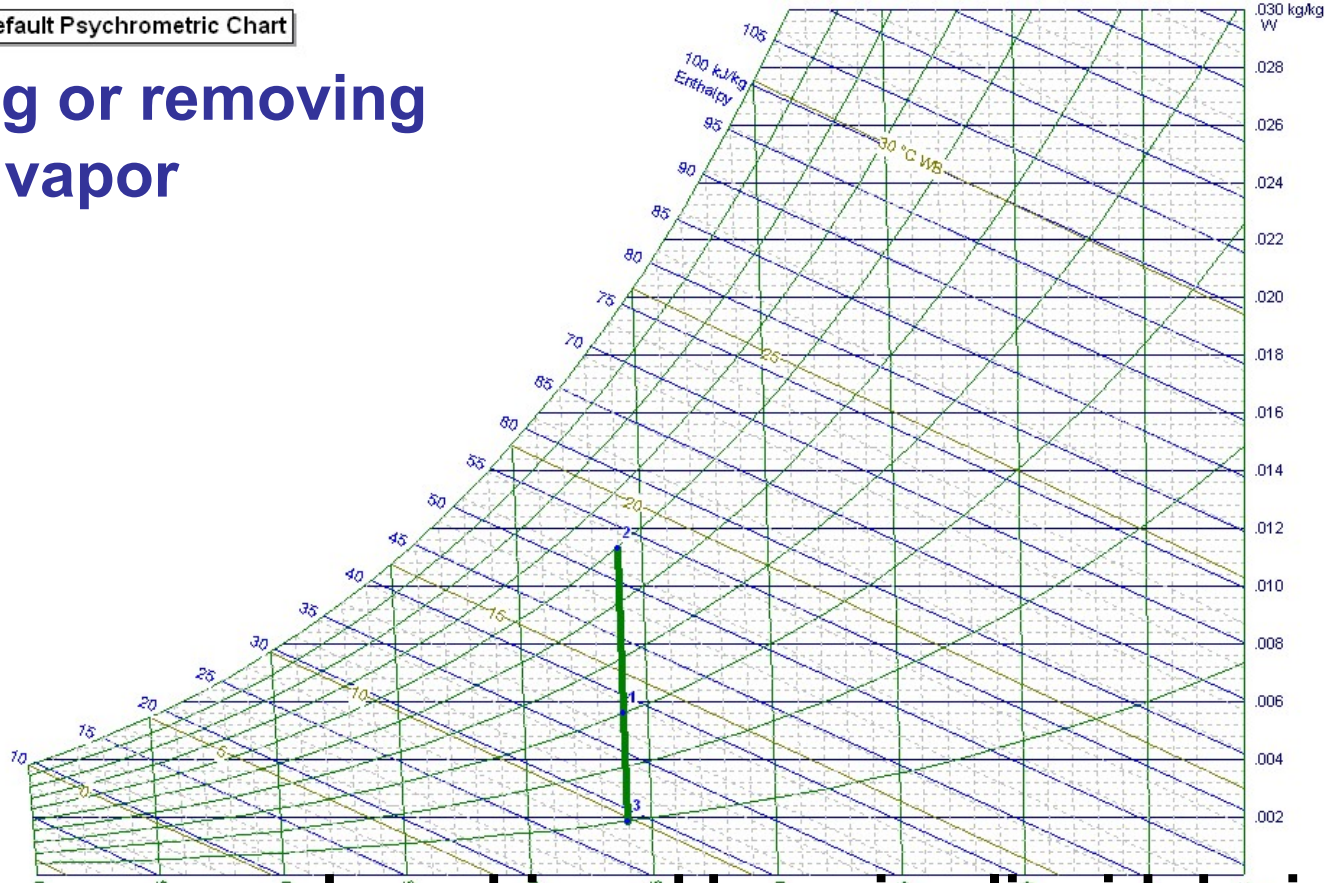
This is the process of Cooling the air without changing its moisture content. It is represented by lines of constant humidity ratio on the psychometric chart (from right to left)

Pure Humidifying or Dehumidifying (Vertical Line Process)

Latent Cooling (Watts)=Q X 3012 X (w1 – w2)

Latent Cooling (Btu/h)=Q X 4840 X (w1 –w2)

Adding or removing water vapor



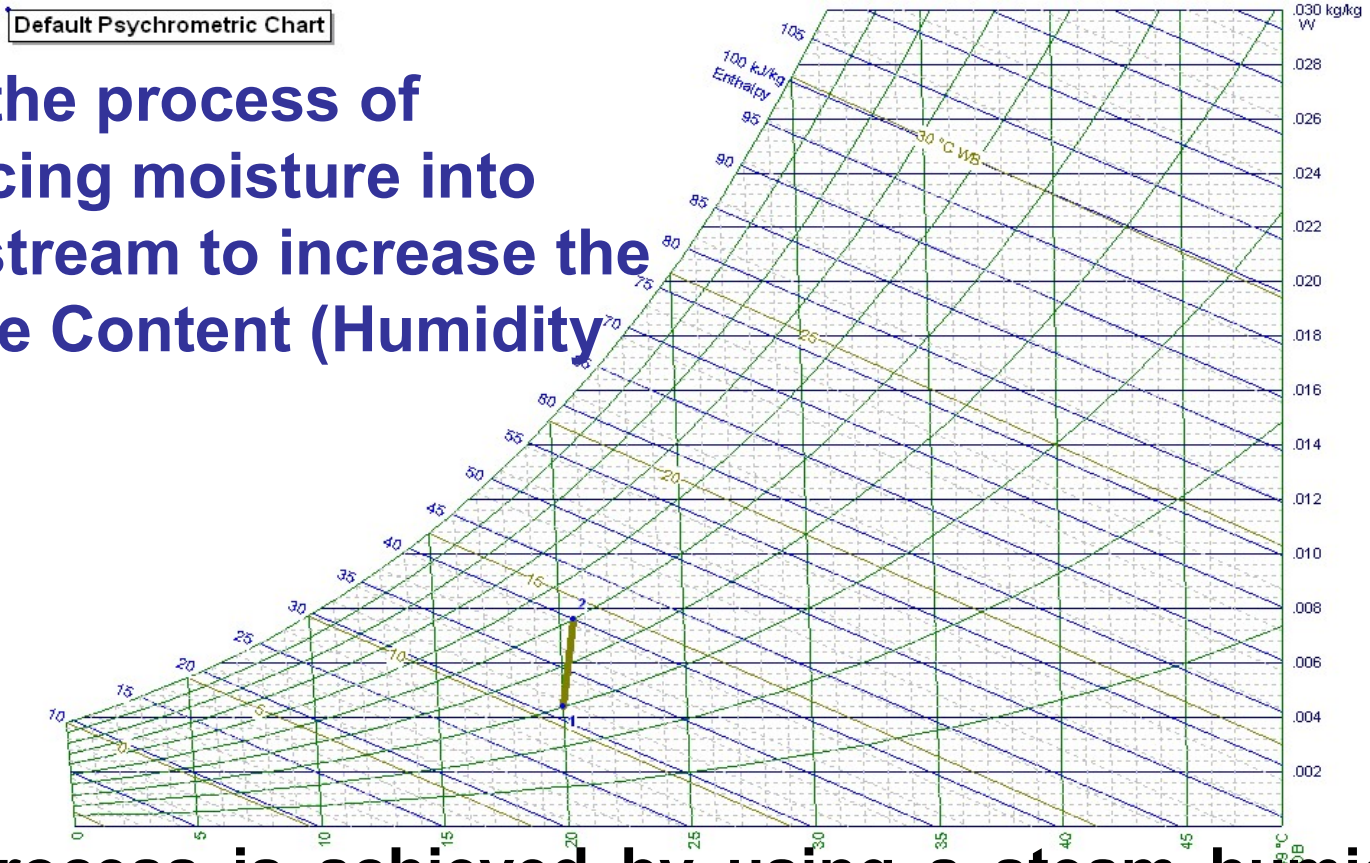
This process can be achieved by using liquid desiccant

Heating and Humidifying

Total Heating (Watts)=Q X 1.20 X (h2 – h1)

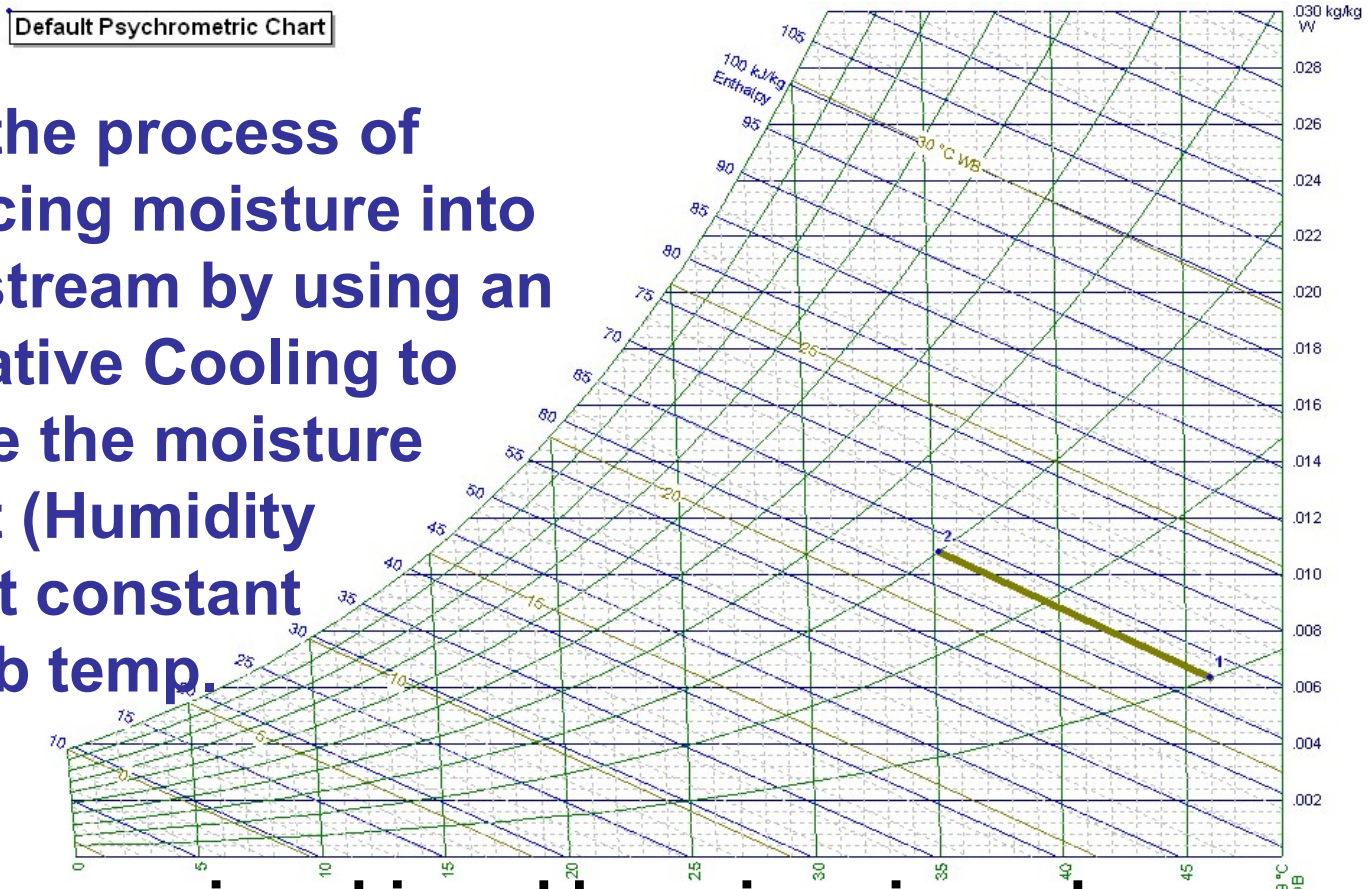
Total Heating (Btu/h)=Q X 4.50 X (h2 – h1)

This is the process of Introducing moisture into the air stream to increase the moisture Content (Humidity Ratio)



This process is achieved by using a steam humidifier, and there will be always an increase in the dry pulp Temperature (sensible Heating).

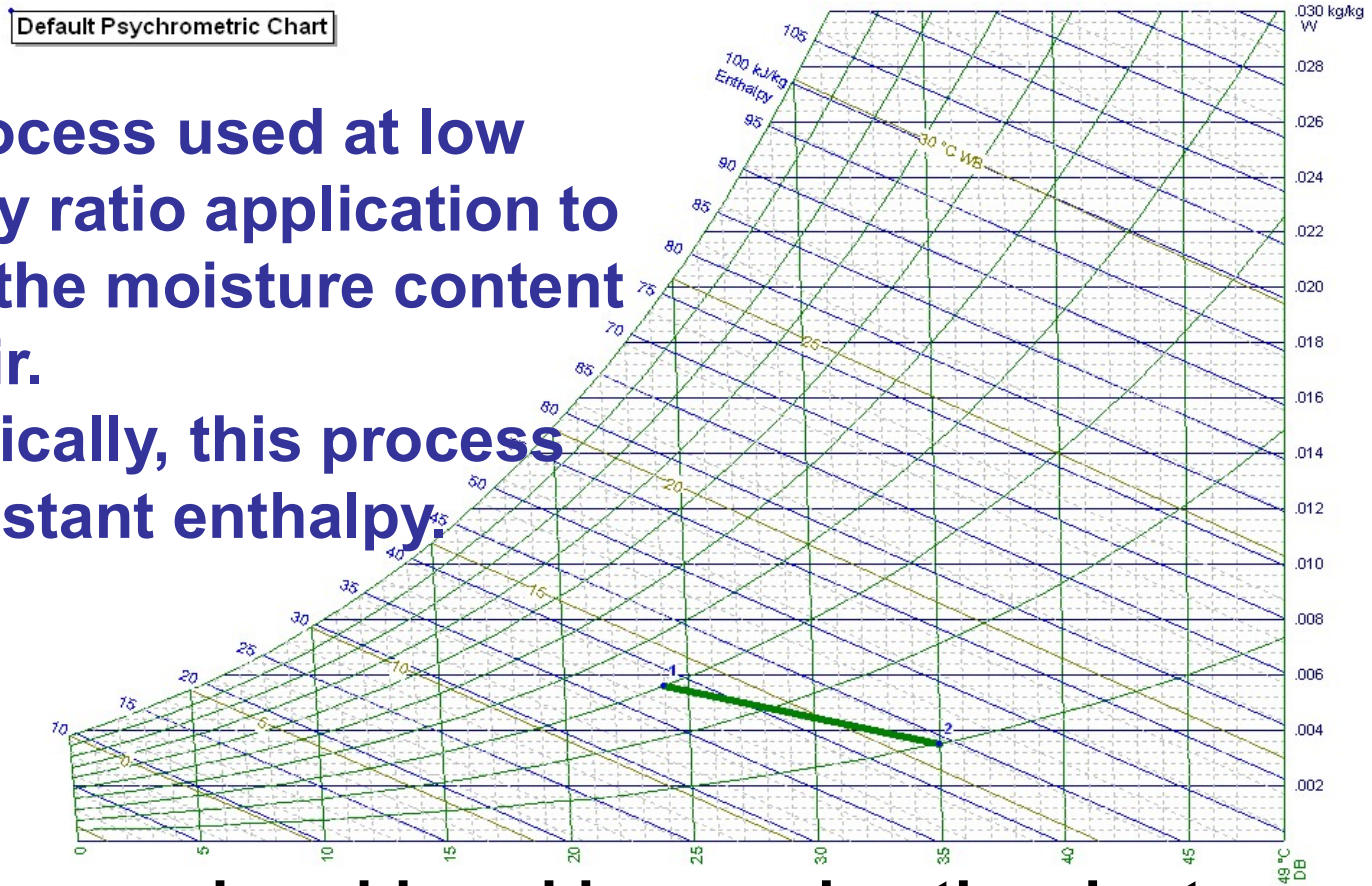
Cooling and Humidifying



This is the process of Introducing moisture into the air stream by using an Evaporative Cooling to increase the moisture Content (Humidity Ratio) at constant Wet bulb temp.

This process is achieved by using air washers or cooling pads, and there will be always a decrease in the dry pulp Temperature (sensible cooling).

Heating and Dehumidifying (Desiccant Dehumidifying)



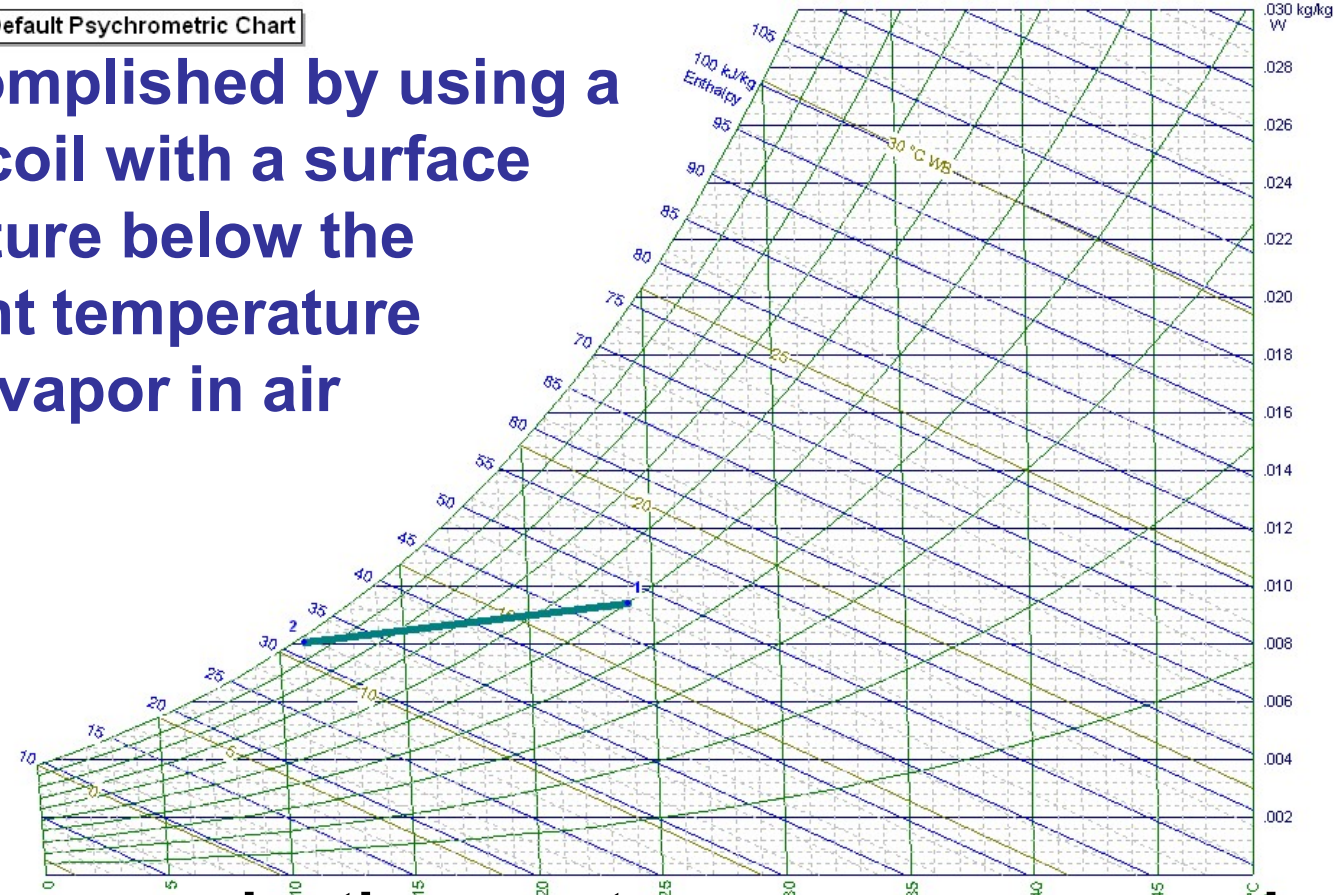
This process used at low humidity ratio application to reduce the moisture content in the air.
Theoretically, this process is a constant enthalpy.

This process is achieved by passing the air stream over a desiccant material, and there will be always an increase in the dry pulp Temperature (sensible Heating).

Cooling and Dehumidifying

Total Cooling (Watts)=Q X 1.20 X (h1 – h2)
Total Cooling (Btu/h)=Q X 4.50 X (h1 – h2)

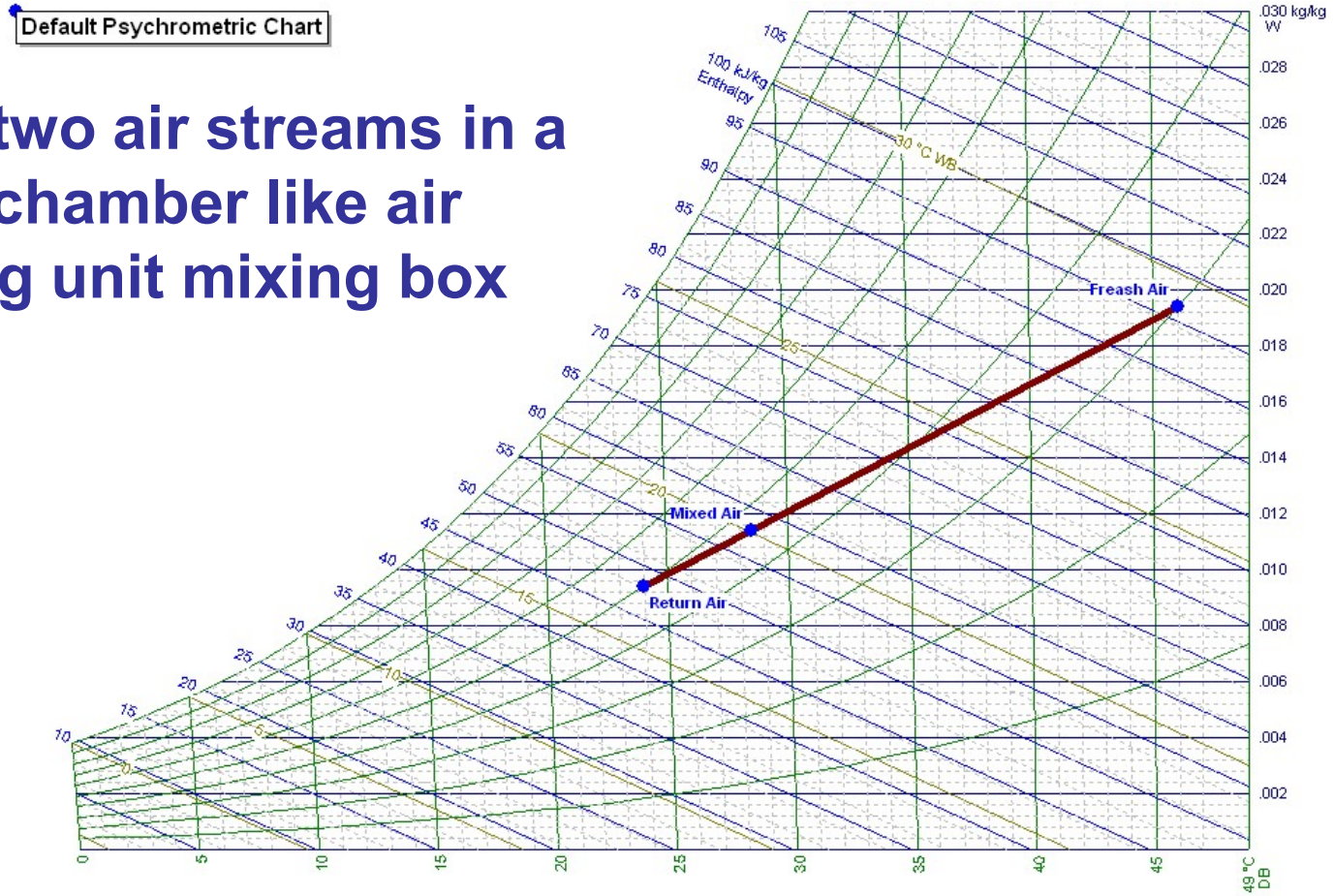
It is accomplished by using a cooling coil with a surface temperature below the dew-point temperature of water vapor in air



This process is the most common process in all air conditioning applications

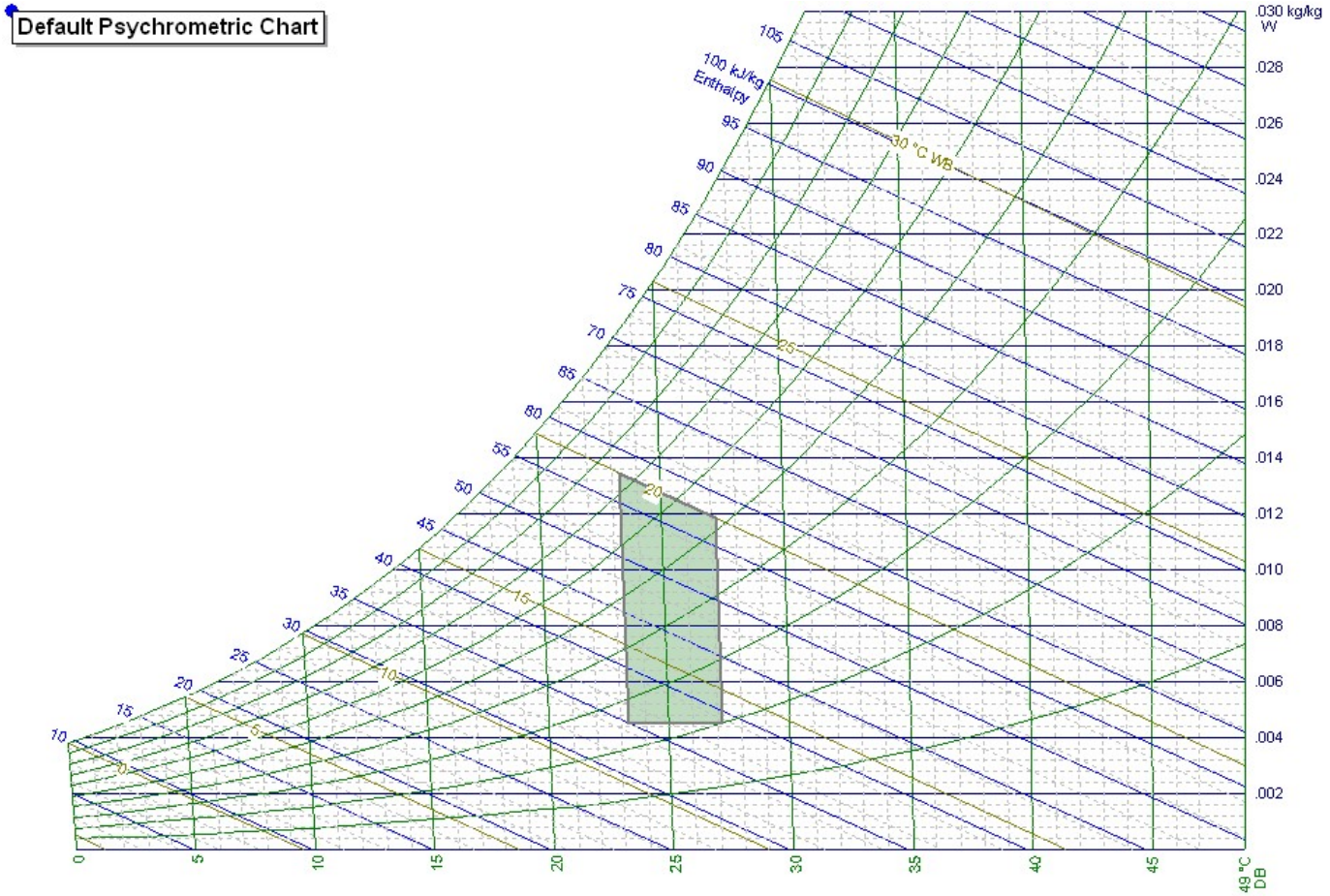
Air Mixing

Mixing two air streams in a closed chamber like air handling unit mixing box



Air Conditioning System is a Mixture of many of these processes together to achieve comfort environment to the people, or suitable conditions for specific applications.

Comfort Zone in Summer



Comfort Zone in Winter