PSYCHROMETRY

Psychrometrics or psychrometry or hygrometry

- They are terms used to describe or determine the physical and thermodynamic properties of gas-vapor mixtures.
- The term derives from the Greek *psuchron* meaning "cold"and *metron* meaning "means of measurement”
- the principles of psychrometry apply to any physical system consisting of gas-vapor mixtures,
- But the most common system of interest is the mixture of water vapor and air, because of its application in heating, ventilating, and air-conditioning

PSYCHROMETRIC TERMS

- **Dry air**
- Pure dry air is a mixture of various gases
- theoretical sample of air that has no water vapor
- Pure dry air doesn't exist in nature

- **Moist Air**
- Mixture of dry air and water vapour

- **Saturated Air**
- Air that contains the maximum amount of water vapour that is possible at the given temperature and pressure

PSYCHROMETRIC PROPERTIES

- **Dry-bulb temperature (DBT)(tdb)**

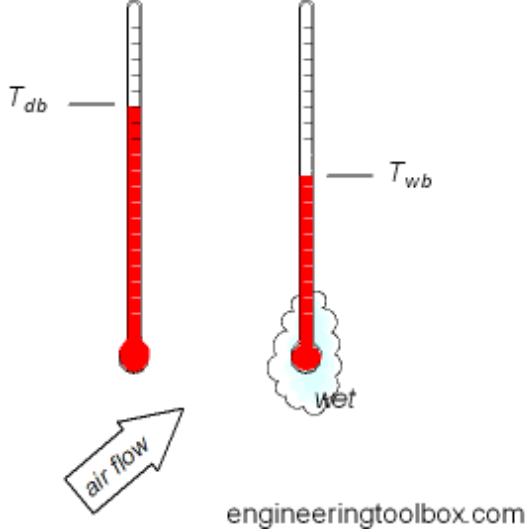
- The dry-bulb temperature is the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.
- In psychrometrics the word temperature by itself without a prefix usually means dry-bulb temperature.

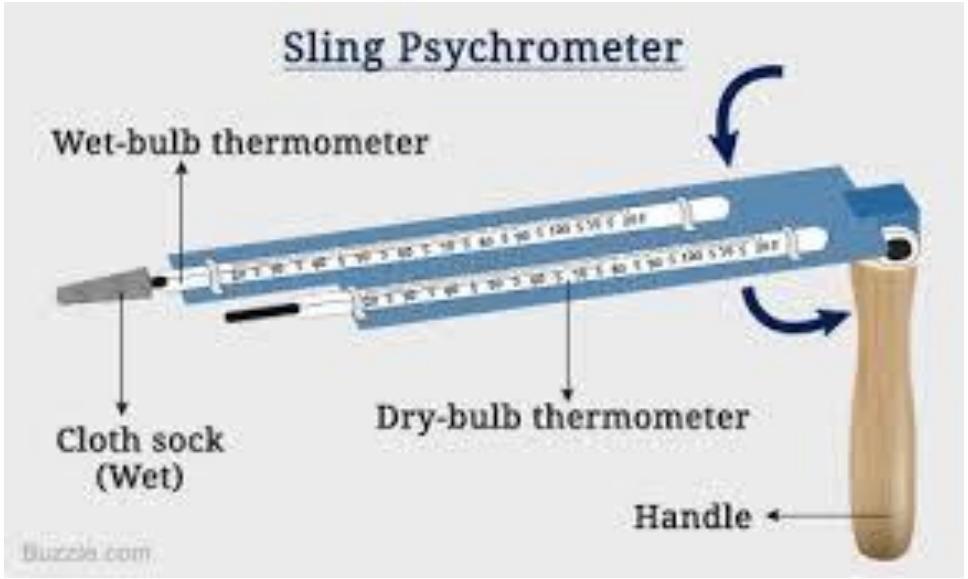
- **Wet-bulb temperature (WBT)(twb)**

- It is the temperature a parcel of air would have if it were cooled to saturation by the evaporation of water into it
- Wet Bulb temperature can be measured by using a thermometer with the bulb wrapped in wet muslin.
- A wet bulb temperature taken with air moving at about 1–2 m/s is referred to as a **screen** temperature,
- a temperature taken with air moving about 3.5 m/s or more is referred to as **sling** temperature.

- **Wet bulb depression**

- Difference between dry and wet bulb temperature



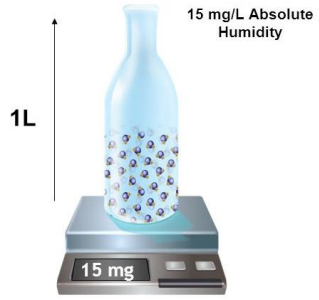


- **psychrometer**

- is a device that includes both a dry-bulb and a wet-bulb thermometer.
- A **sling psychrometer** requires manual operation to create the airflow over the bulbs
- a **powered psychrometer** includes a fan for this function.
- Knowing both the dry-bulb temperature (DBT) and wet-bulb temperature (WBT), one can determine the relative humidity (RH) from the psychrometric chart appropriate to the air pressure.

- **Dew point temperature(tdp)**
- The saturation temperature of the moisture present in the sample of air
- it can also be defined as the temperature at which the vapour changes into liquid (condensation).
- is the temperature at which a moist air sample at the same pressure would reach water vapor "saturation."
- **Dew point Depression**
- Difference between tdb and tdp

- **Humidity**
- Humidity is the amount of water vapor in the air.
- There are three main measurements of humidity:
  - absolute,
  - relative and
  - specific.
- **Absolute humidity**
- The mass of water vapor per unit volume of air containing the water vapor at a given temperature and pressure.
- This quantity is also known as the water vapor density
- It is expressed in gram per cubic metre.



- **Relative humidity**

- is the ratio of actual mass of water vapour present in a given volume of moist air to the mass of water vapour in the same volume of moist air when it is saturated at the same temperature and pressure
- RH is dimensionless, and is usually expressed as a percentage.

- **Specific humidity**

- is a ratio of the water vapor content of the mixture to the total air content on a mass basis in the moist air sample (dry air plus the water vapor)
- sometimes referred to as the humidity ratio
- It is also known as the moisture content or mixing ratio.
- Specific Humidity is defined as:

SH=m of {v}/m of {a}

- **Degree of Saturation (Percentage Humidity)**

- Degree of Saturation is the ratio of the humidity ratio of moist air - to the humidity ratio of saturated moist air at the same temperature and pressure.

- **Specific enthalpy**

- is the sum of the internal (heat) energy of the moist air in question
- In psychrometrics, the term quantifies the total energy of both the dry air and water vapour per kilogram of dry air.

- **Specific volume**

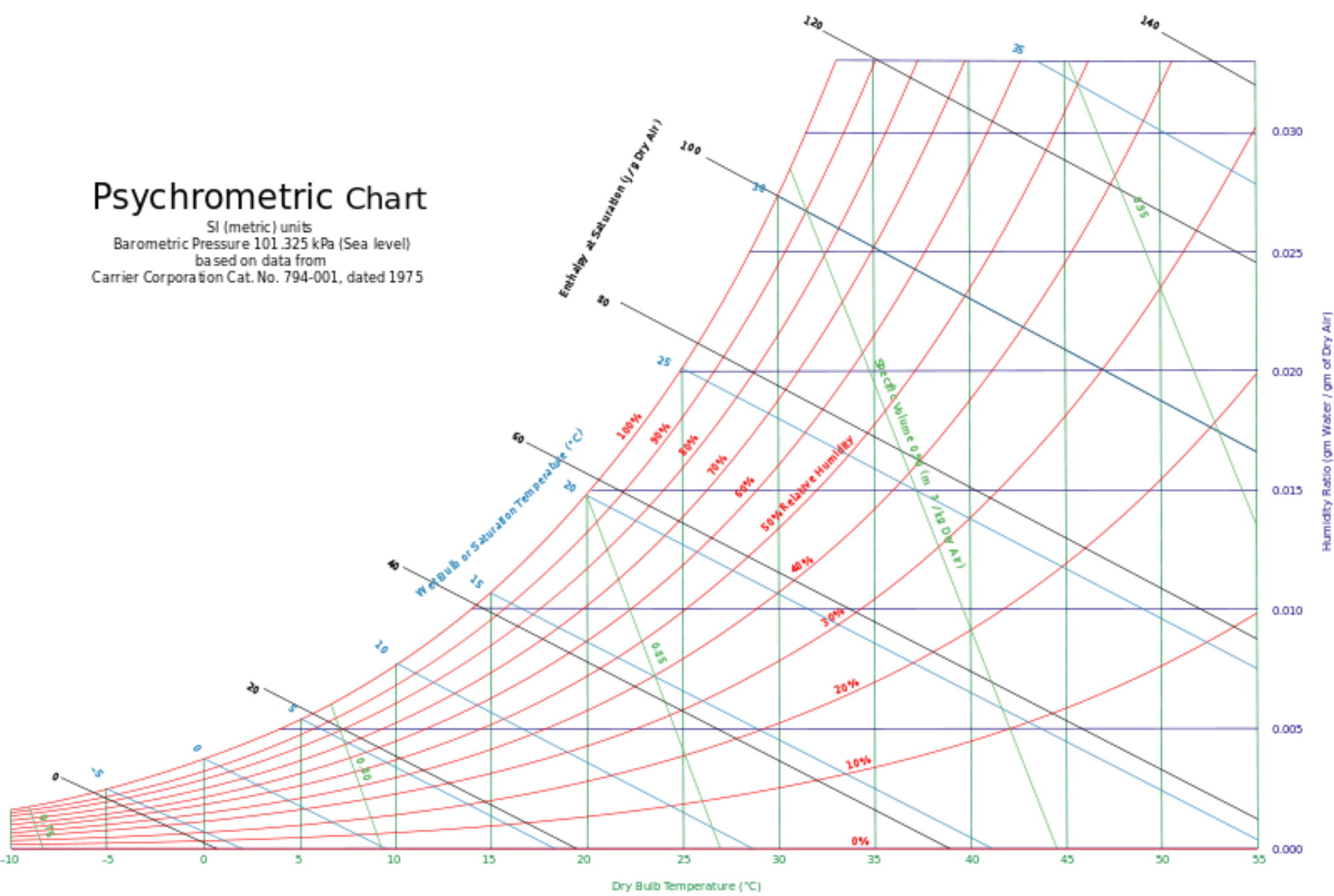
- is the volume of the mixture (dry air plus the water vapor) containing one unit of mass of "dry air".
- The SI units are cubic meters per kilogram of dry air

- **Psychrometric ratio**

- It is the ratio of the heat transfer coefficient to the product of mass transfer coefficient and humid heat at a wetted surface.

- **Adiabatic Saturation Temperature.**

- Also called The thermodynamic wet-bulb temperature
- It is the lowest temperature which may be achieved by evaporative cooling of a water-wetted (or even ice-covered), ventilated surface.


Psychrometric Chart
SI (metric) units
Barometric Pressure 101.325 kPa (Sea level)
based on data from
Carrier Corporation Cat. No. 794-001, dated 1975
Enthalpy at Saturation (j/g Dry Air)
Wet Bulb or Saturation Temperature (°C)
Specific Volume 0.80 (m³/kg Dry Air)
0.85
0.90
100%
90%
80%
70%
60%
50% Relative Humidity
40%
30%
20%
10%
0%
Dry Bulb Temperature (°C)
Humidity Ratio (gm Water / gm of Dry Air)

Terminology

- A psychrometric chart is a graph of the thermodynamic parameters of moist air at a constant pressure, often equated to an elevation relative to sea level.

➢ Dry-bulb temperature

➢ Wet-bulb temperature

➢ Dew point temperature

- At this point further removal of heat would result in water vapor condensing into liquid water fog or, if below freezing point, solid hoarfrost.
- Relative humidity
- Humidity ratio
- It is typically plotted as the ordinate (vertical axis) of the graph.
- For a given DBT there will be a particular humidity ratio for which the air sample is at 100% relative humidity

➢ Specific enthalpy

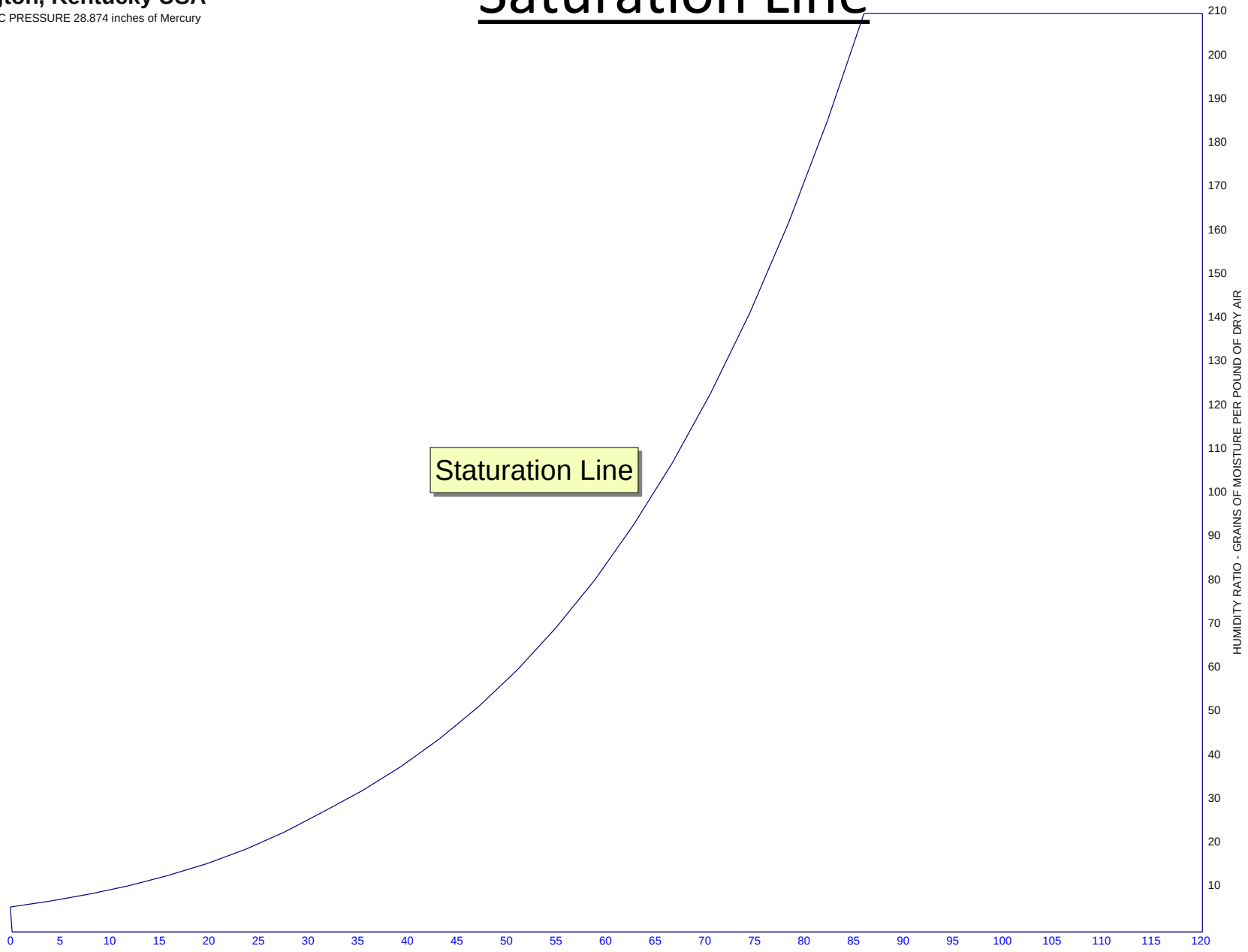
➢ Specific volume

PSYCHROMETRIC CHART

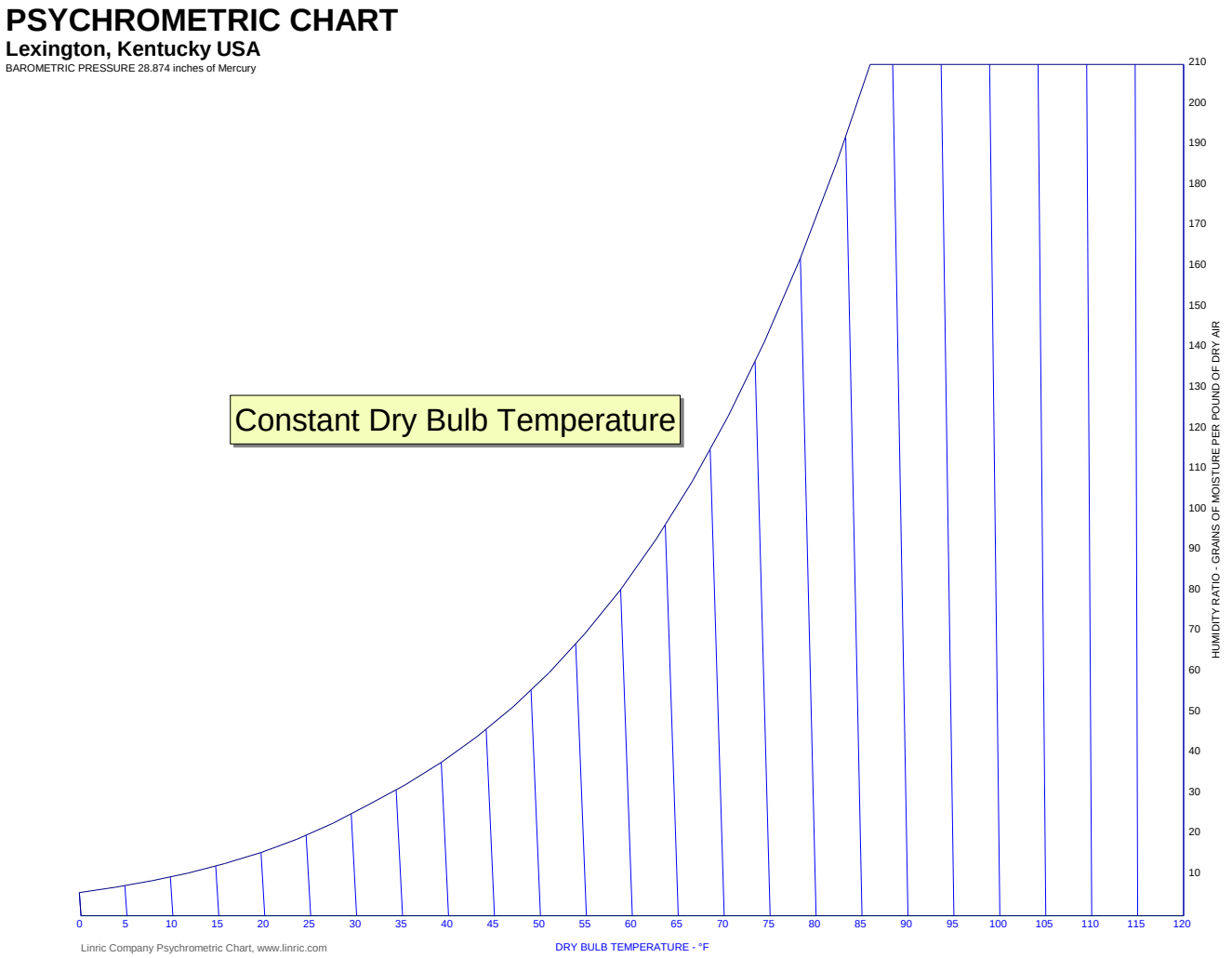
Lexington, Kentucky USA

BAROMETRIC PRESSURE 28.874 inches of Mercury

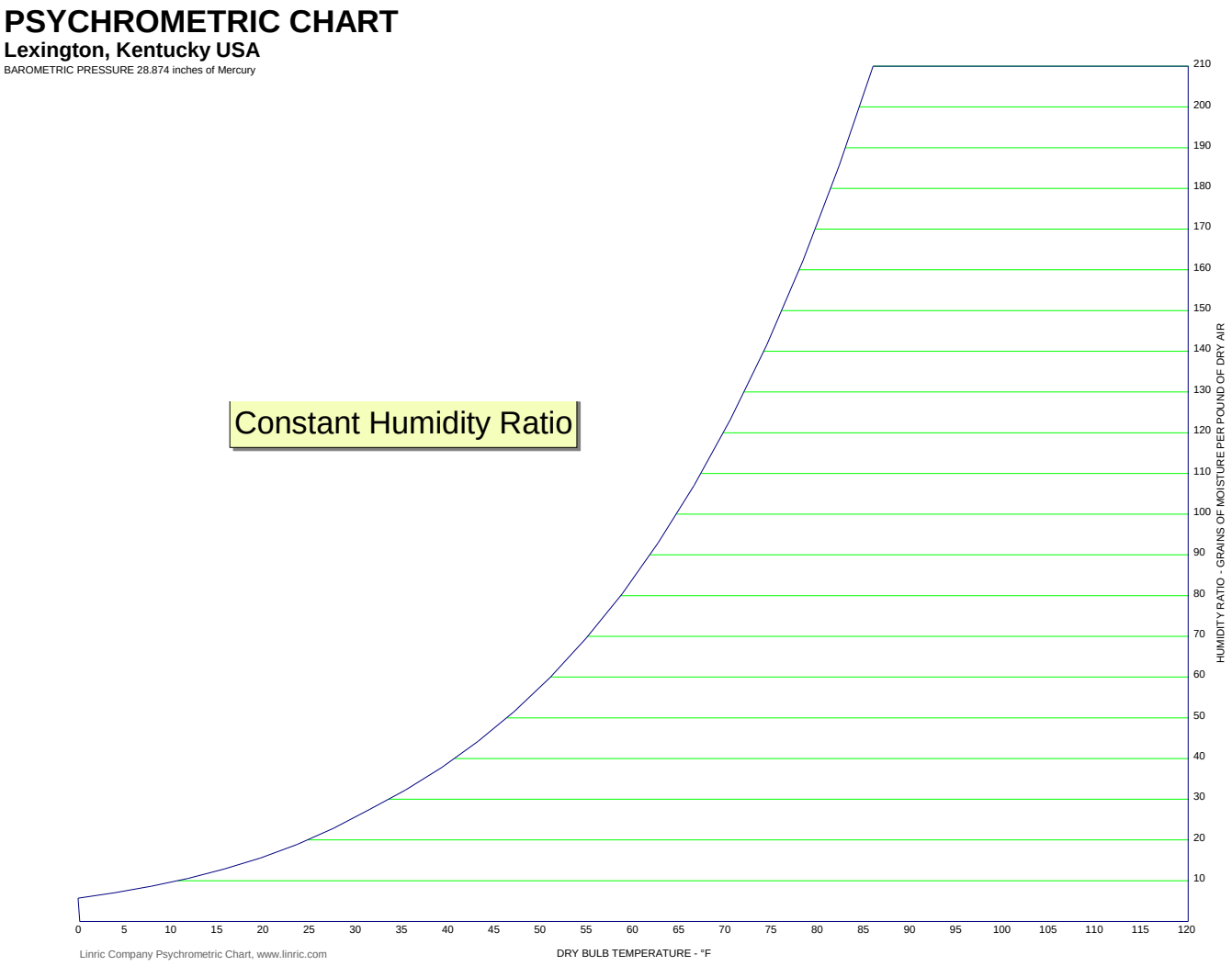
Saturation Line



Constant Dry Bulb Temperature



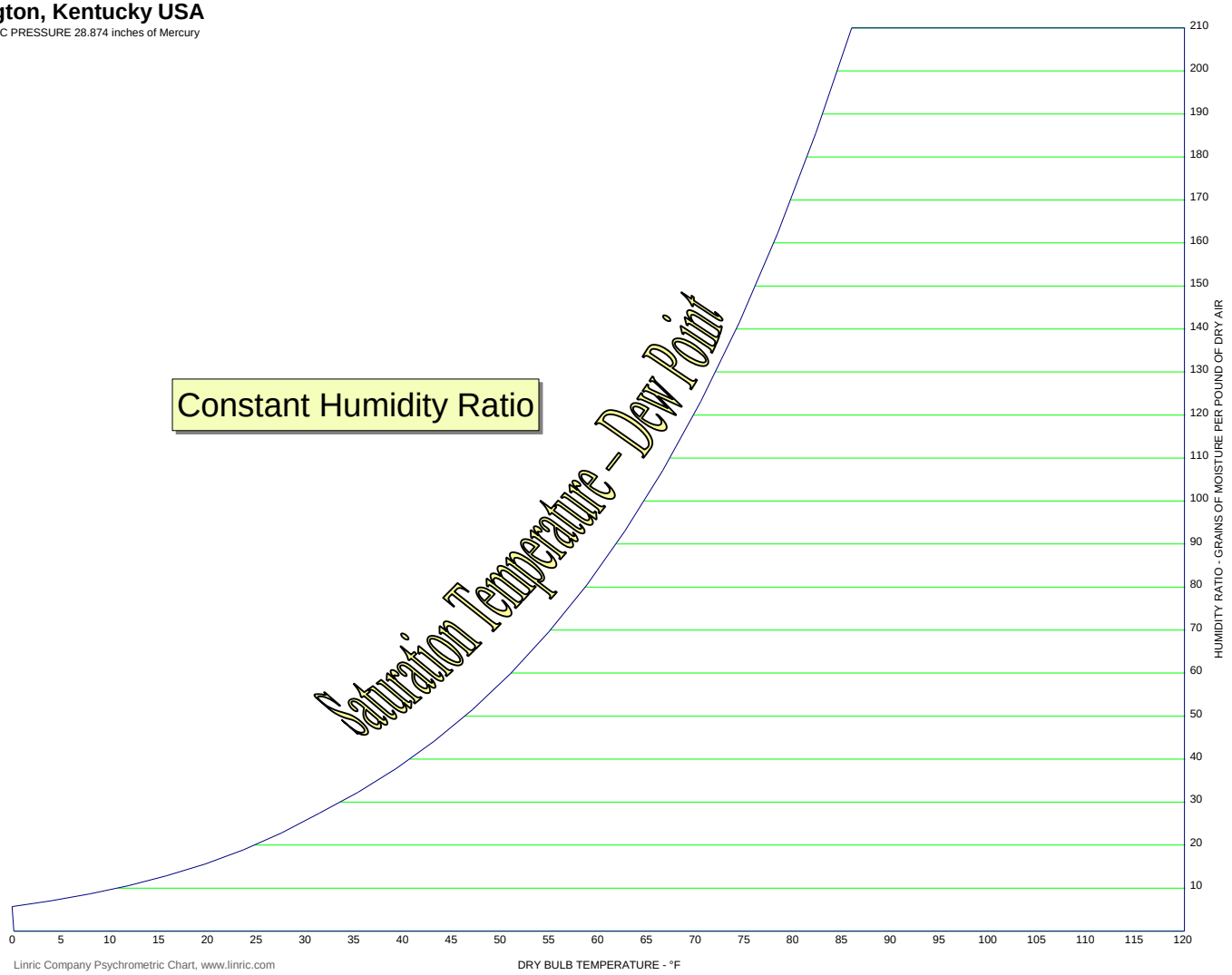
Constant Humidity Ratio



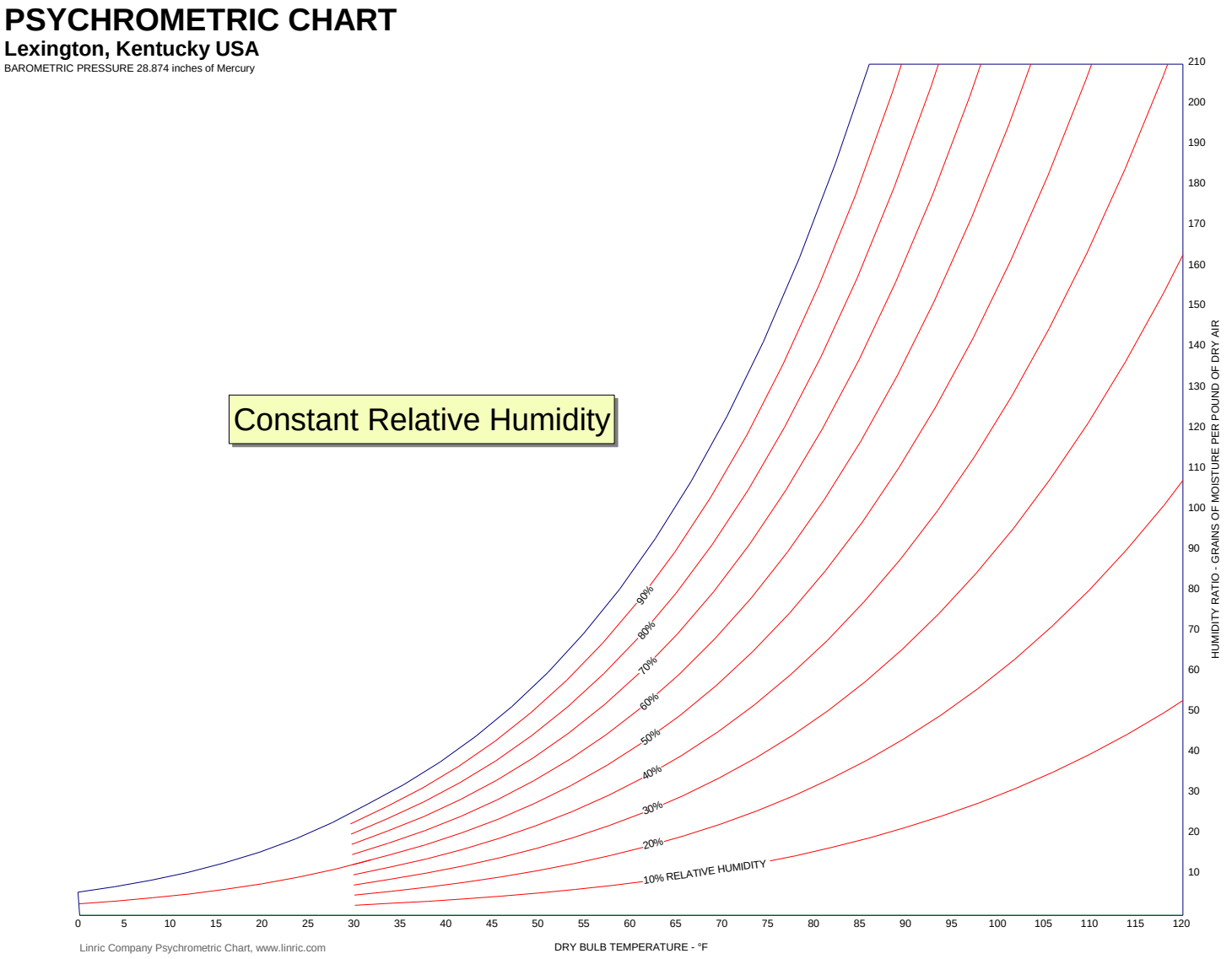
PSYCHROMETRIC CHART

Lexington, Kentucky USA

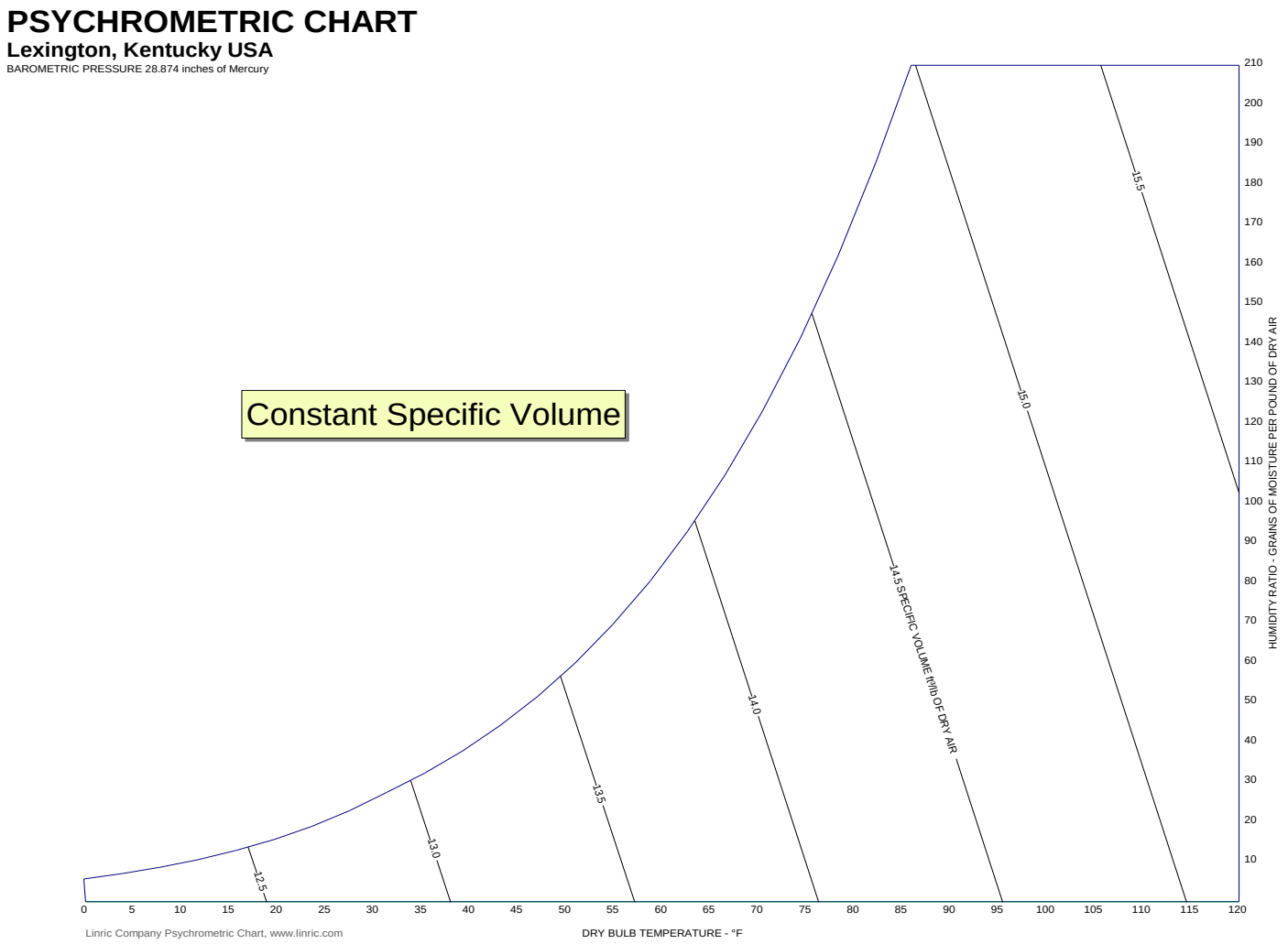
BAROMETRIC PRESSURE 28.874 inches of Mercury



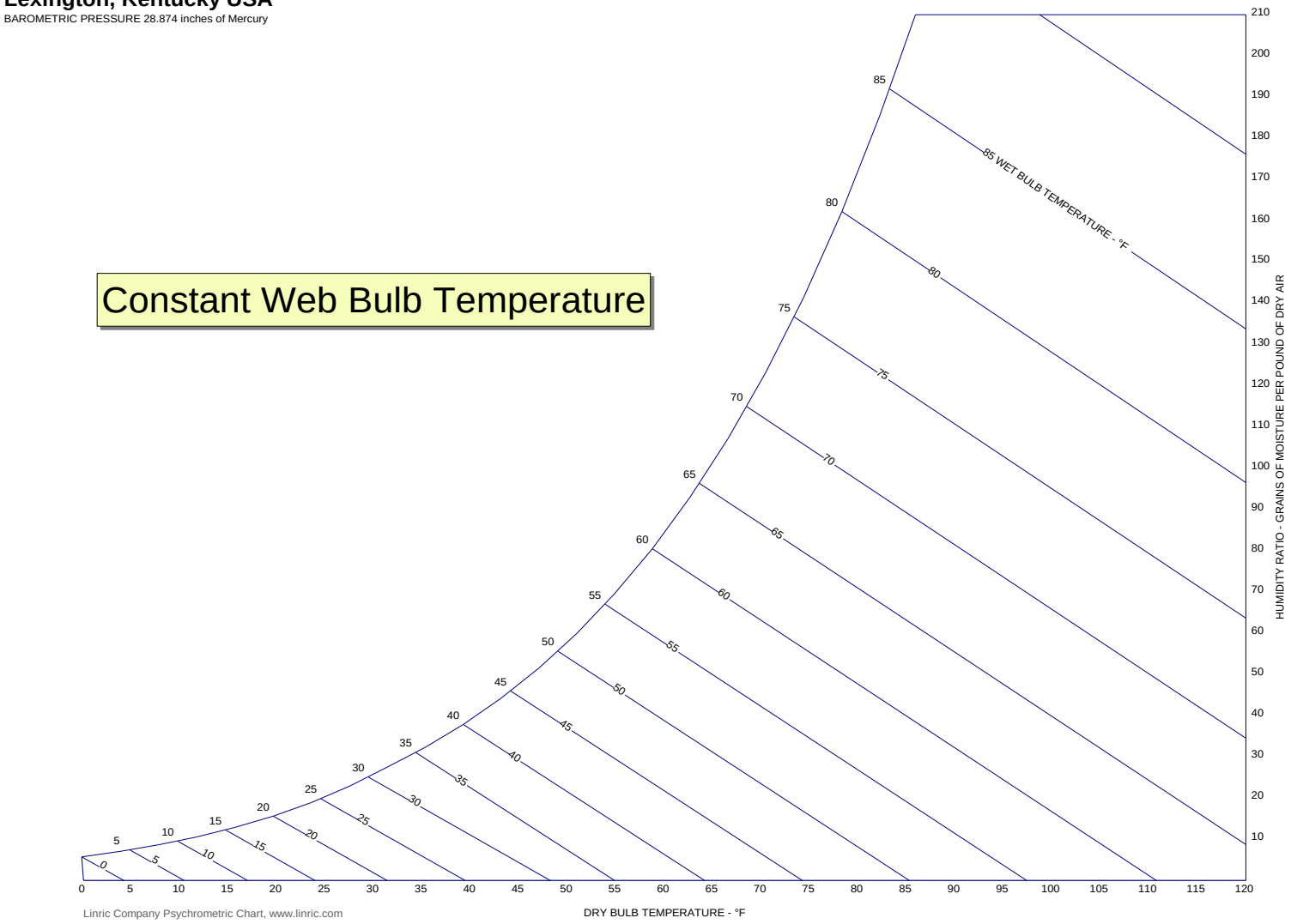
Constant Relative Humidity



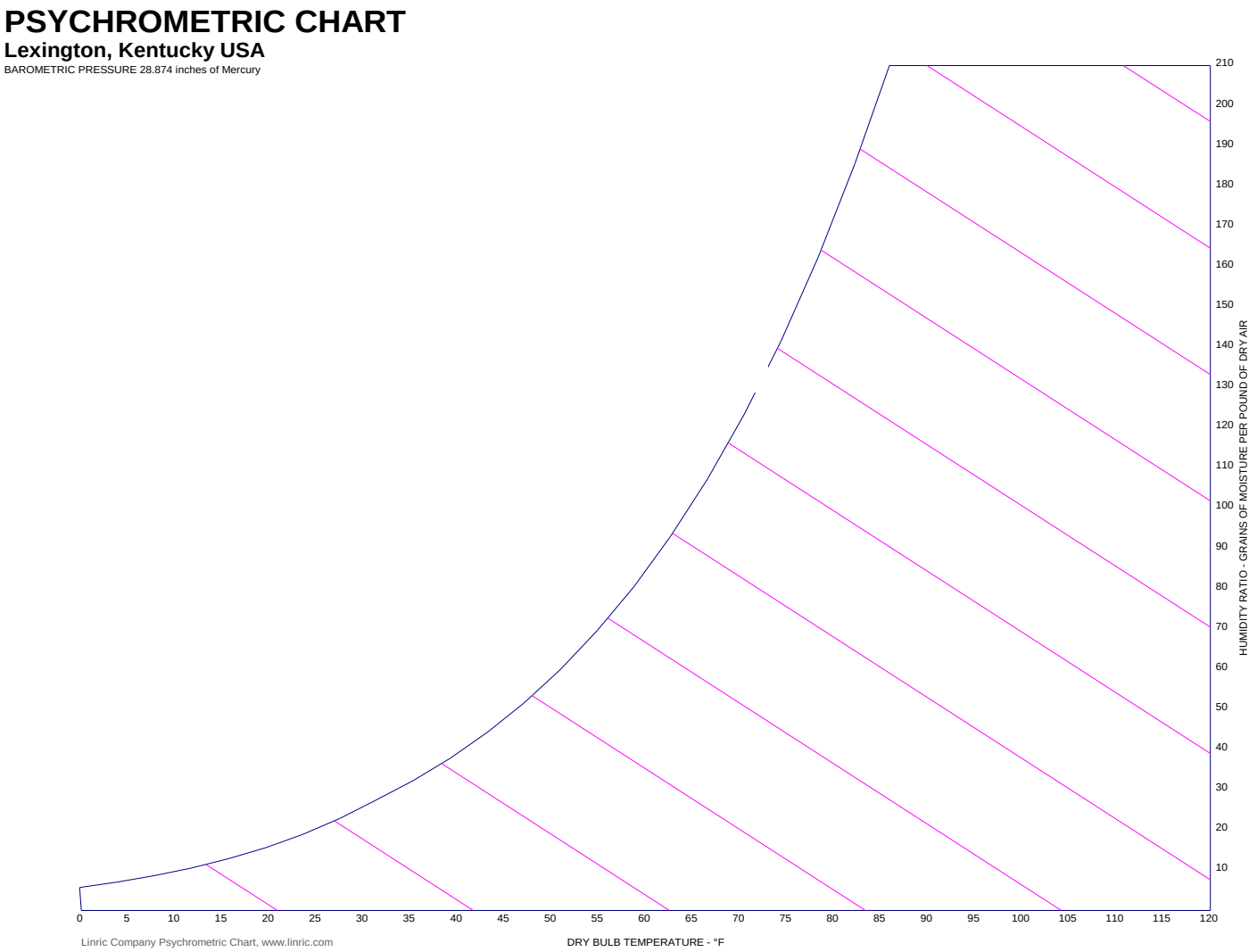
Constant Specific Volume



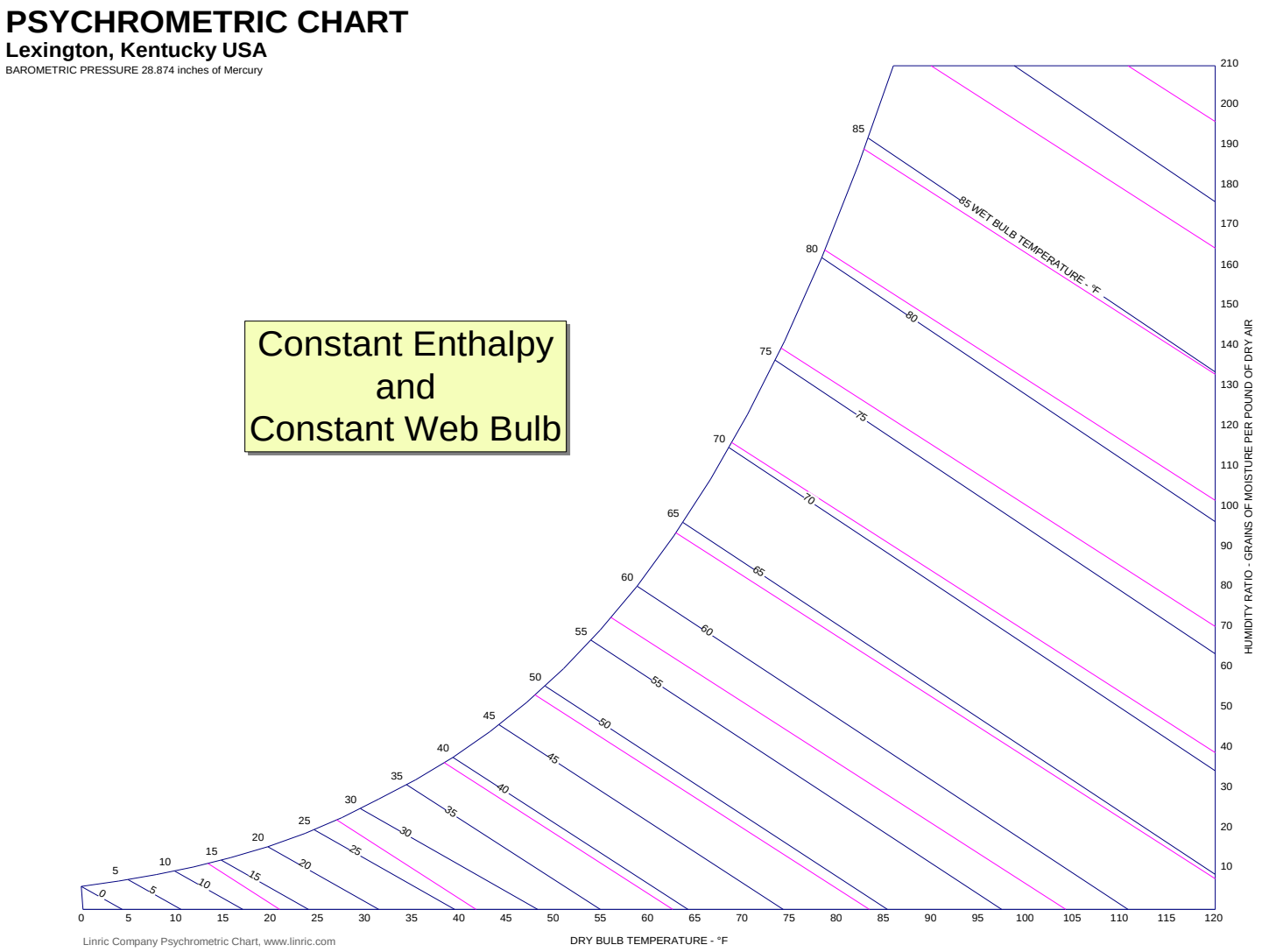
Constant Wet Bulb Temperature



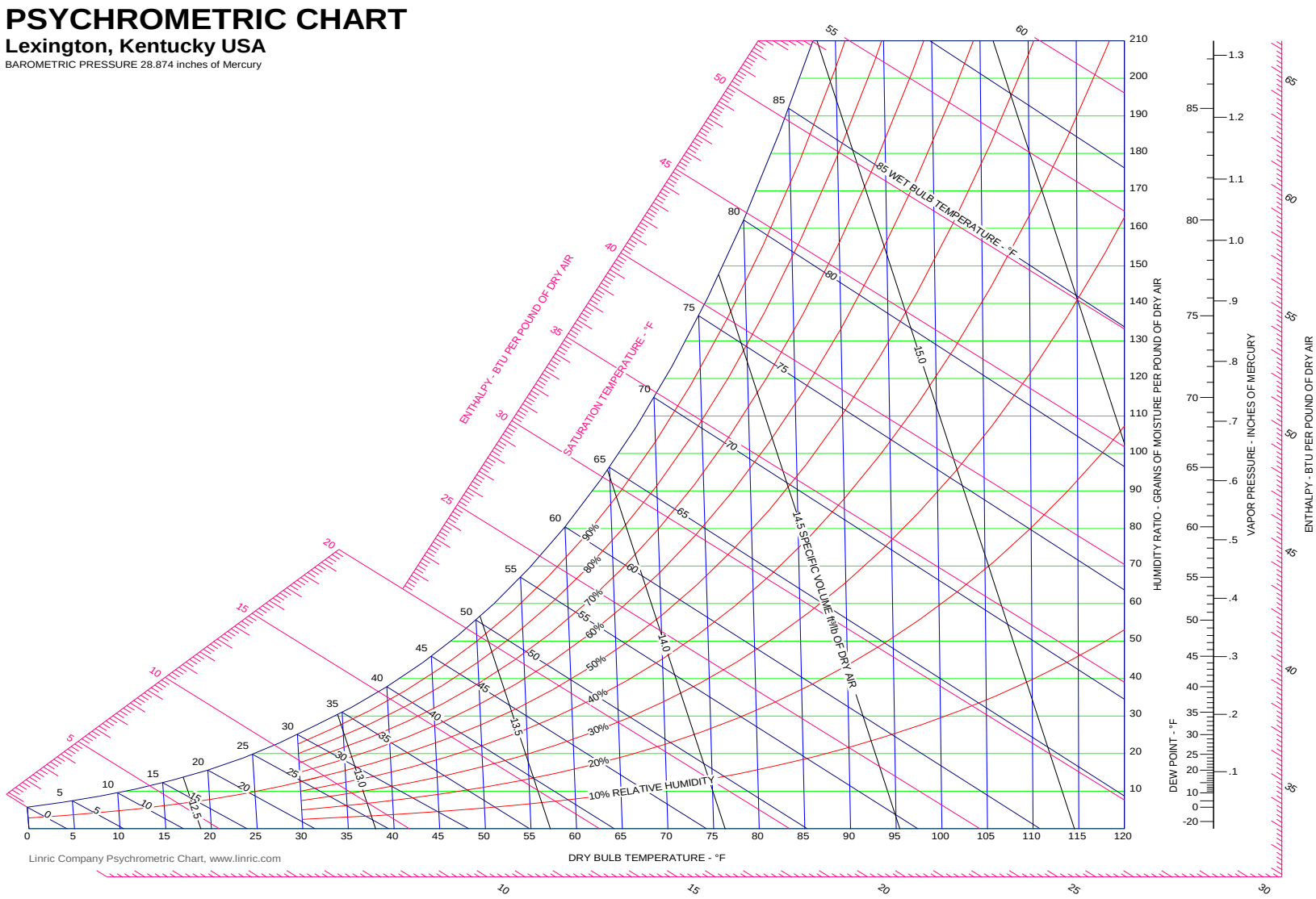
Constant Enthalpy



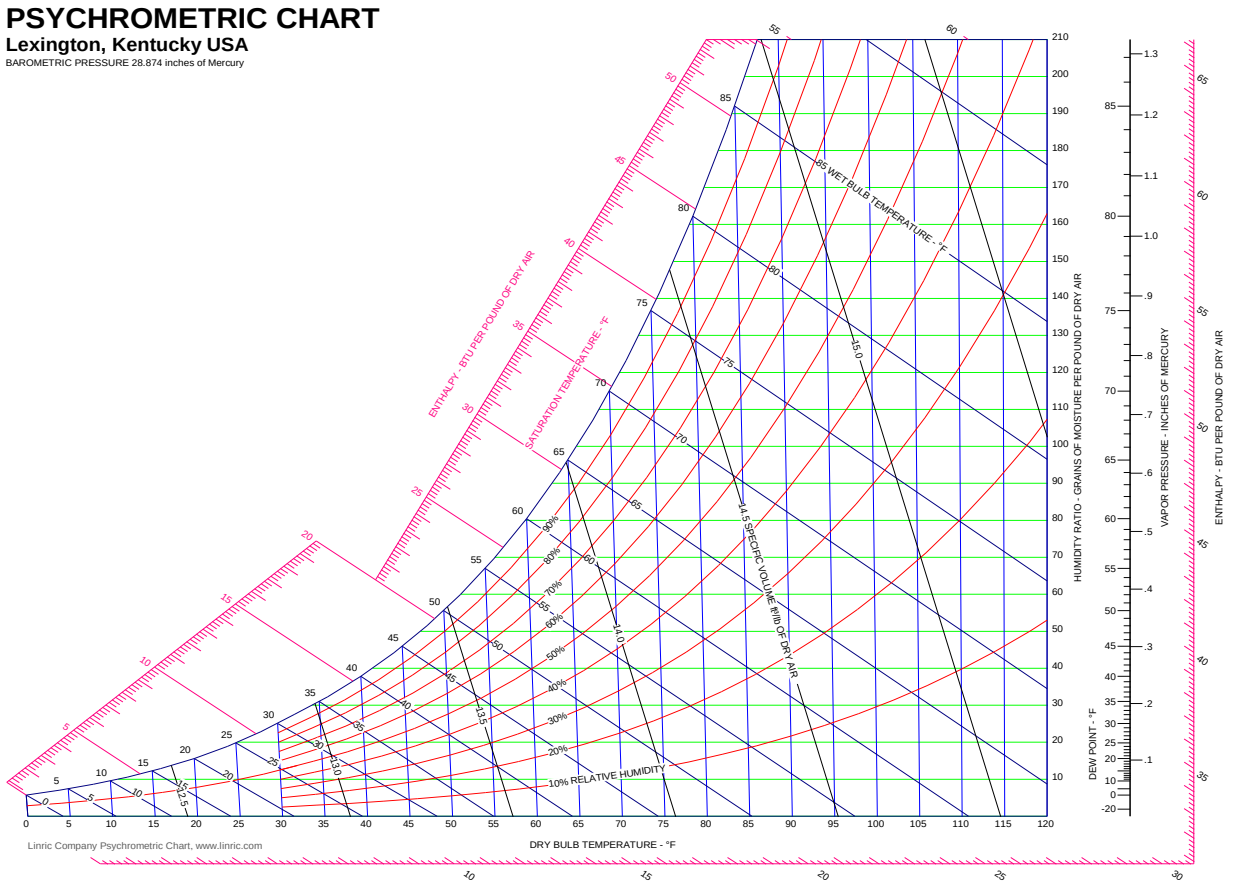
Constant Enthalpy and Wet Bulb



Typical Chart With Enthalpy Lines



Typical Chart Without Enthalpy Lines



Psychrometric Relations

- Specific Humidity(w)

$$W = 0.622 \times \frac{p_v}{p_a} = 0.622 \times \frac{p_v}{p_b - p_v}$$

$$W_s = W_{max} = 0.622 \times \frac{p_s}{p_b - p_s}$$

- Degree of Saturation

$$\mu = \frac{W}{W_s} = \frac{\dfrac{0.622\, p_v}{p_b - p_v}}{\dfrac{0.622\, p_s}{p_b - p_s}} = \frac{p_v}{p_s}\left(\frac{p_b - p_s}{p_b - p_v}\right) = \frac{p_v}{p_s}\left[\frac{1 - \dfrac{p_s}{p_b}}{1 - \dfrac{p_v}{p_b}}\right]$$

- Relative Humidity

$$\phi = \frac{m_v}{m_s} = \frac{p_v}{p_s}$$

$$\phi = \frac{\mu}{1 - (1 - \mu)\dfrac{p_s}{p_b}}$$

- Pressure of water vapour

$$p_v = p_w - \frac{(p_b - p_w)(t_d - t_w)}{1544 - 1.44\,t_w}$$

where, p_w = Saturation pressure corresponding to wet bulb temperature (from steam tables),

p_b = Barometric pressure,

t_d = Dry bulb temperature, and

t_w = Wet bulb temperature.

- Vapour density or Absolute Humidity

$$\rho_v = \frac{W\,p_a}{R_a\,T_d} = \frac{W\,(p_b - p_v)}{R_a\,T_d}$$

p_a = Pressure of air in kN/m^2,

R_a = Gas constant for air = 0.287 kJ/ kg K,

T_d = Dry bulb temperature in K.

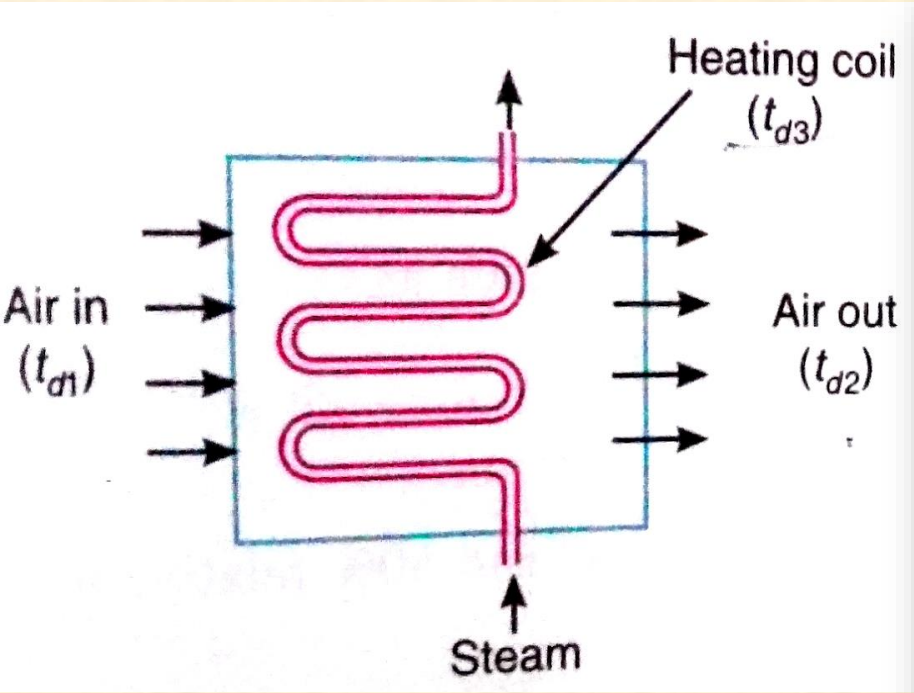
Psychrometric Processes

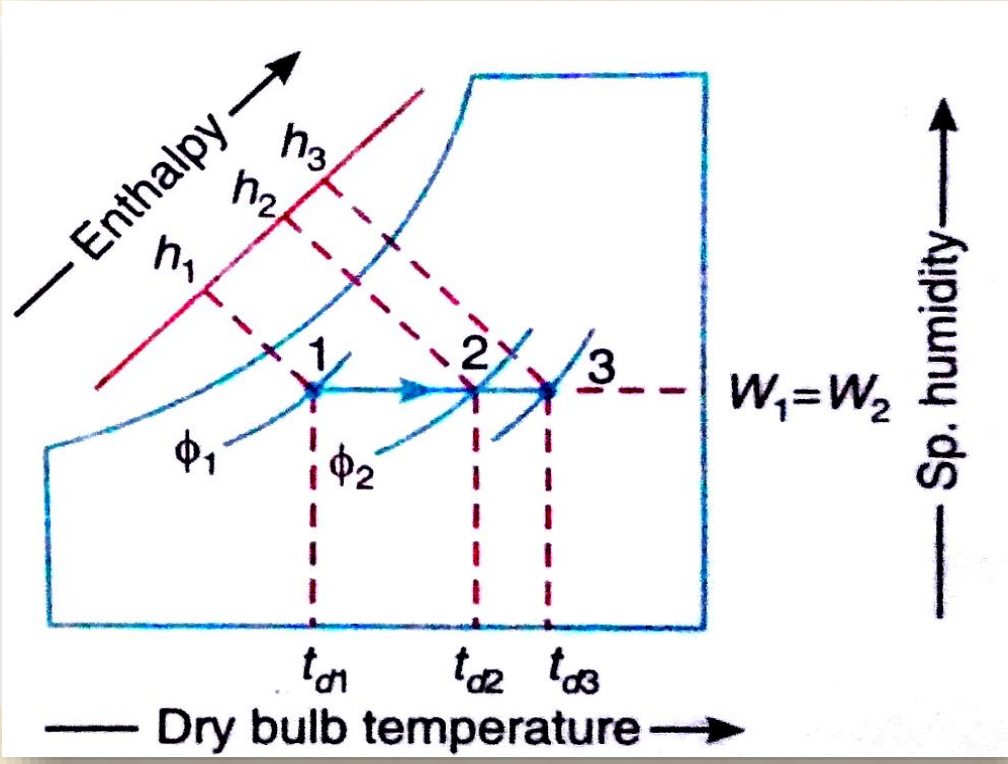
PSYCHROMETRIC PROCESSES

- Sensible heating
- Sensible cooling
- Humidification & dehumidification
- Cooling and adiabatic humidification
- Cooling and humidification by water injection
- Heating and humidification
- Humidification by steam injection
- Adiabatic chemical dehumidification
- Adiabatic mixing of air streams

Sensible heating

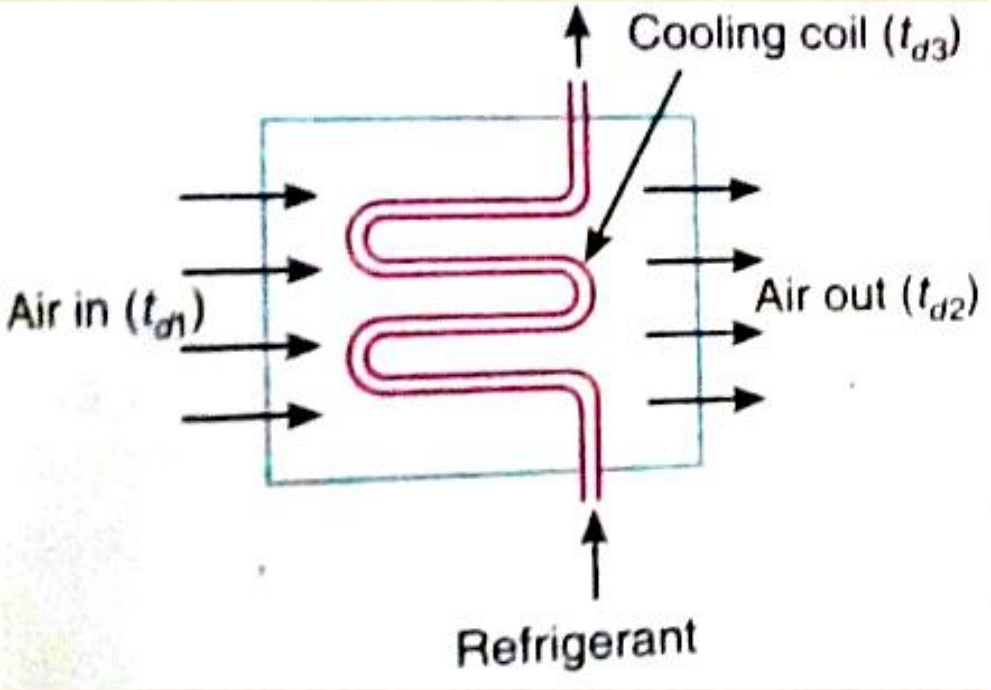
- Heating of air without changing specific humidity.

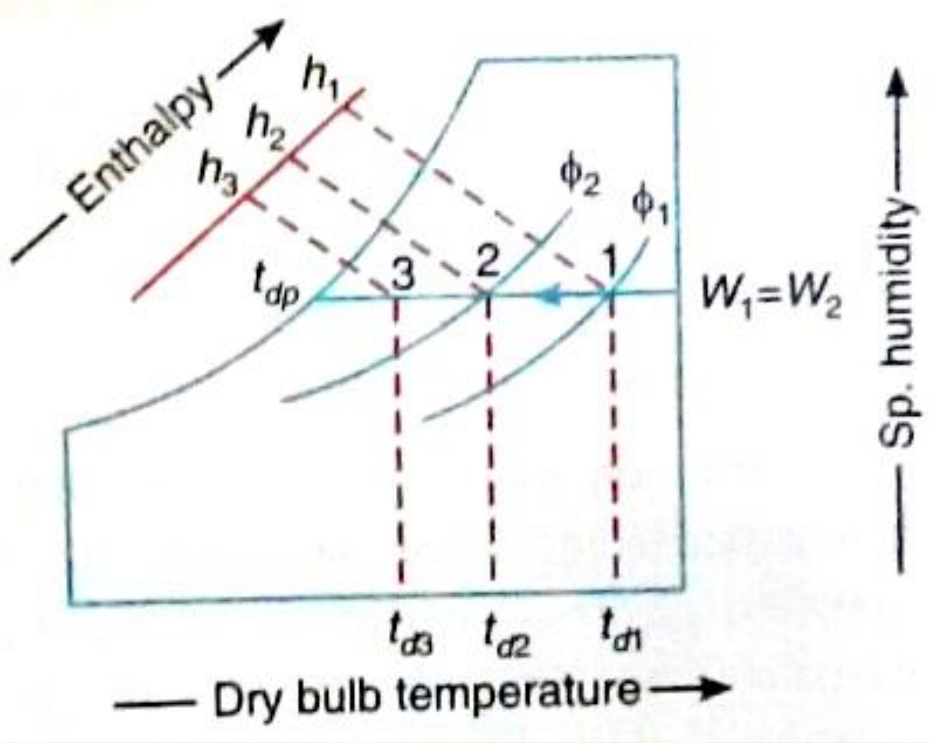




Sensible cooling

- Cooling of air without changing specific humidity.

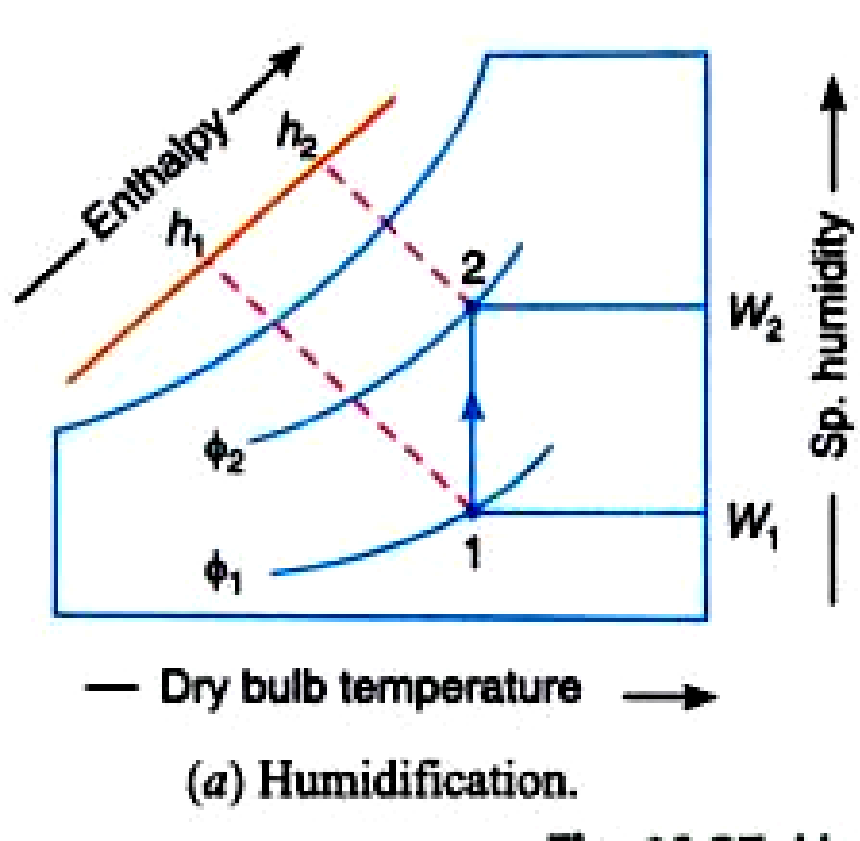




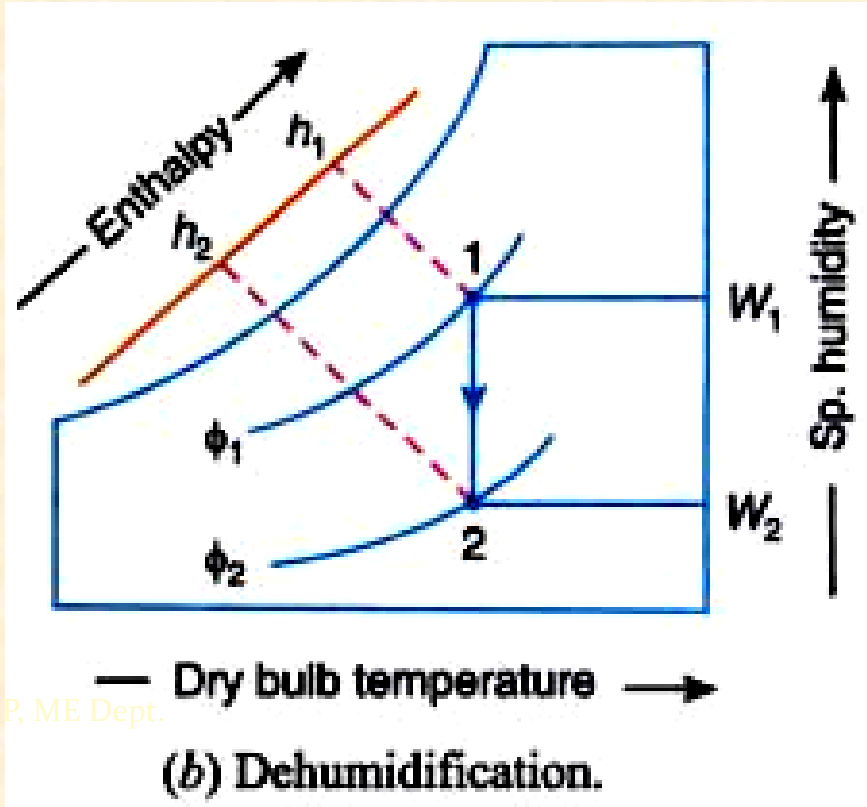
Humidification and Dehumidification

- Addition of moisture to air without change in its dry bulb temperature is known as humidification.

- Removal of moisture from air without change in its dry bulb temperature is known as dehumidification.



(*a*) Humidification.



(*b*) Dehumidification.

Basic Concepts