Properties of Air-Water Mixtures

Definitions and Concepts

- HVAC – Heating, Ventilation, and Air conditioning
- Psychrometrics –The behavior of mixtures of air and water vapor under varying conditions of heat
- Enthalpy = Total heat in the air = Sensible plus Latent heat
  - Sensible Heat – Changes in temperature that do not alter the moisture content of air
  - Latent Heat – Related to level of moisture in the air
- BTU (British Thermal Unit) – The amount of heat that must be added to or subtracted from a pound of water at 60°F to affect a temperature change of 1°F
  - BTUH or BTU/H – BTU's per hour
  - MBTUH – 1000 BTUH
- Ton
  - 1 Ton equals the amount of heat needed to melt 1 ton of ice in one day
  - 12,000 BTUH's
- Drybulb Temperature – The temperature reading given by a dry thermometer that gives a direct indication as to the sensible heat content of air
- Wetbulb Temperature – The temperature reading from a wetted bulb that gives a direct indication as to the total heat content of air
- Dew Point Temperature – Temperature at which air will begin to release moisture.
- Relative Humidity (RH)
  - The actual amount of moisture in the air expressed as a percentage of the amount of moisture the air is capable of holding.

  More technically:
  - The amount of water vapor in the air divided by the amount of water vapor the air can hold (at the same temperature and pressure.)
  - The ratio of the air's vapor pressure to its saturation vapor pressure.
  - Example: An air sample that is at 50% RH is holding half the moisture it is capable of holding at the same temperature (at dew point or saturated.)
  - RH is inversely relational to temperature for the same moisture level (grains of moisture per pound of dry air) – warm air can hold more moisture
  - RH is what we sense
  - High RH: Sticking, mold
  - Low RH
    - Affects electronics, promotes static
    - Low RH air is seeking saturation, absorbing moisture wherever it can
- Specific Humidity or Humidity Ratio
  - The weight of the water vapor in each pound of dry air
  - Typically grains of moisture/pound of dry air
  - Grain = 1/7000 pound
- Density – Unit weight of dry air at a given temperature and moisture content, lb/ft^3
- Specific Volume – Space occupied by dry air at a given temperature and moisture content (the reciprocal of density), ft^3/lb

The Psychrometric Chart [SEE PAGE 4 FOR PSYCHROMETRIC CHART]

❶ Constant Drybulb Temperature: Vertical Lines

❷ Constant Wetbulb temperature: Upward left sloping lines

❸ Relative humidity: Curving lines (100% line is the saturation curve or correlates with Dew Point)

❹ Left hand scale: Constant Dew Point (°F):
Right hand scale: Humidity Ratio (grains of moisture/lb of dry air) and Vapor Pressure (in of Hg)

❺ Enthalpy or total heat, BTU/lb of dry air: Staggered scale left of saturation curve and left sloping lines

❻ Constant specific volume, ft^3/lb of dry air: Sloping lines

❼ Saturation Curve: 100% RH Curve (or the point at which an air mixture can hold no additional moisture at a given temperature); temperature on the curve is the Dew Point

Latent vs. Sensible Changes

— Latent Changes move in the direction of the y-axis
— Sensible changes move in the direction of the x-axis

Relationship of Drybulb (DB), Relative Humidity (RH), Dewpoint (DP) , and Wetbulb (WB)

Impact to Relative Humidity from Sensible Changes

Temperature and Relative Humidity are inversely related:
— the higher the temperature, the lower the RH
— the lower the temperature, the higher the RH

Example 1. See Psychrometric Chart, next page

If the air temperature of 75°F at 40% RH is warmed to 90°F without adding moisture, what is the new RH?
RH = 25%

What is the RH is the air is cooled to 55°F?
RH = 80%

Dehumidification

What happens when the RH is 100%? **It Rains! Saturation**
— As air cools, it eventually reaches its dewpoint and moisture begins to appear.

If the air is continued to be cooled, at what temperature will the saturation point be reached?
DB = 49°F

What happens if the air is continued to be cooled below 49°F?
Cooling below 49°F removes water i.e. The air can be de-humidified by over cooling it.

Humidification

If the air temperature of 75°F at 40% RH what is the new RH if 12 gr/lb of moisture is added to the air?
RH = 50%

What is the new DP?
DP = 55°F

Enthalpy Changes

- Enthalpy = Total heat in the air = Sensible plus Latent heat
  - Sensible Heat – Changes in temperature that do not alter the moisture content of air
  - Latent Heat – Related to level of moisture in the air
- Enthalpy is measured in BTU/lb dry air

What is the change in enthalpy when air at 75°F at 40% RH changes to 80°F at 60% RH?

@75°F H_i = 26.2 BTU/lb DA

@80°F H_f = 33.8 BTU/lb DA

Δ Enthalpy = ΔH = 33.8 – 26.2 = 7.6 BTU/lb DA

Example 2.

A space at sea level is 70°F and RH = 50%. Find the other properties of the air in that space.
Solution. Use Psychrometric Chart

DB =	70°F
RH =	50%
WB =	58.5°F
Humidity Ratio=	55 gr/lb of dry air
VP =	0.37 in Hg
Enthalpy =	25.5 BTU/lb of dry air
Vs =	13.5 ft^3/lb of dry air
Dew Point =	50.5°F

Example 3.

A saturated mixture contains 100 lb of dry air. How much heat is required (Btu) to raise the dry bulb temperature from 30°F to 70°F?

Solution. Use Psychrometric Chart

@30°F H_i = 10.9 BTU/lb DA

@70°F H_f = 20.8 BTU/lb DA

ΔH = 20.8 – 10.9 = 9.9 BTU/lb DA

Q = m ΔH = 100 lb x 9.9 BTU/lb DA = 990 BTU