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Technical Resource Center

Processes and Properties of Dry Air

Dry-bulb, wet-bulb, dew-point temperatures, relative humidity-these terms are so closely related that if two properties are known, all others shown in the figure below may be read from the chart. When air is saturated, dry-bulb, wet-bulb, and dew-point temperatures are identical. (See Example 2.)

Enthalpy of air for any given condition is the enthalpy at saturation corrected by the enthalpy deviation due to the air not being in a saturated state. The enthalpy (h) in Btu per pound of dry air is the enthalpy at the saturation h_{wb} plus the enthalpy deviation h_d. See Example 2.

$h = h_{wb} + h_d$

If the air's moisture content increases or decreases in a psychrometric process, the heat added (q) or removed (-q) is the difference between the enthalpy of the final or leaving air h_{la} and the initial or entering air h_{ea} minus the enthalpy of the moisture (water in liquid or ice state) added h_w or rejected h_w.

$q = h_{la} - h_{ea} - h_w$

See Examples 4 and 5.

The enthalpy of added or rejected moisture is shown in the small graphs at the top of the chart.

Enthalpy of added or rejected moisture and enthalpy deviation are usually omitted in applications not requiring precise results — for example, comfort air conditioning. Errors due to omissions for wet-bulb temperatures below 32°F are much larger than for omissions above 32°F.

Sensible heat factor. This is part of certain calculations for installing air conditioning equipment. A scale along the right side of the figure in Example 4 below used with an origin at 80° dry-bulb temperature and 50 percent rh provide a reasonable heat factor value. See Example 4.

Barometric pressures. In comfort air conditioning, a mercury reading of one inch or less either above or below the standard 29.92 inches of mercury is considered a standard reading.

When dry-bulb and dew-point temperatures are know for air at non-standard barometric pressures, values of percent rh and grains of moisture per cubic foot are correct on a standard chart. But for given dry-bulb and wet-bulb readings at non-standard barometric pressures, all properties must be corrected.

Interpreting the Air Conditioning Charts

Generally, in graphic presentations, humidifying is shown by an upward line and dehumidifying is shown by a downward line.

Heating and cooling air without changes in moisture content involve only a change in sensible heat and appear as a horizontal line, to right or left respectively. Changes occur in dry-bulb, wet-bulb, rh, and enthalpy. Specific humidity and dew-point temperature remain constant.

In *heating and humidifying*, both sensible heat and specific humidity increase — shown as a line sloping upward and to the right. Changes occur in dry-bulb, wet-bulb, dew point temperatures, and enthalpy. A difference in rh depends on the slope of the line.

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For *cooling and dehumidifying*, both sensible heat and specific humidity decrease, so the line slopes downward and to the left. Dry-bulb, wet-bulb, dew-point temperatures, and enthalpy all change. Changes in rh are dependent on the slope of the line.

Evaporative cooling refers to air brought in contact with spray water at a temperature equal to the wet-bulb temperature of the air. The process takes place upward along the wet-bulb line. As sensible heat of the initial air vaporizes the water, the air's dry-bulb temperature falls. The sensible heat used to vaporize the water enters the air as latent heat in added vapor; thus no heat is added or removed. Wet-bulb temperature remains constant. Dew-point temperature, rh, specific humidity, and enthalpy increase. (In most evaporative cooling installations, heat may be added or removed during the process due to outside sources, this amount is usually negligible.)

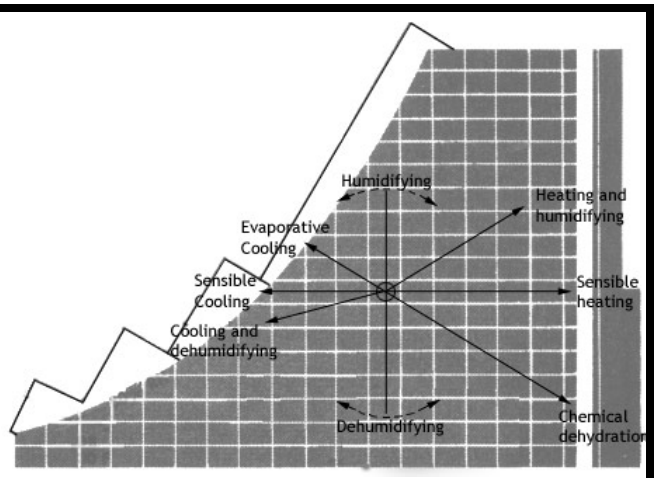

Figure 1: Air Conditioning Process

In chemical dehydration, the air that contacts the chemical either adsorbs or absorbs moisture from the air. Thus in this energy constant process, heat is liberated and added to the air-and this amount is basically equally to the latent heat of vaporization of the moisture removed. Indicated by a downward sloping line approximating the wet-bulb line, the slope of the chemical dehydration line may be either slightly greater or less than the wet-bulb line, depending on if heat is stored, liberated, or absorbed.

AIR CONDITIONING PROCCESSES such as heating, cooling, humidifying and dehu-midifying may be shown graphically on the chart. See Figure 1.

Example 1. Reading Properties Of Air

Given: { DB = 70°F, WB = 60°F } Find: { % RH, DP, Volume, GR of moisture per lb dry air, GR of moisture per cu ft }

Locate point of intersection on the chart of vertical line representing 700DB and oblique line representing 600WB. All values are read from this point of intersection.

Interpolate between relative humidity lines on 700DB line, read RH = 56%.

Follow horizontal line left to saturation curve, read DP = 53.6°F.

Interpolate between lines representing cubic feet per pound of dry air, read v = 13.53 cu ft.

Follow horizontal line to right, read grains of moisture per pound of dry air, W - 61.4 gr.

Grains of moisture per pound of dry air (61.4) divided by cubic feet per pound of dry air (13.53) = 4.54 gr per cu ft

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Example 2. Reading Properties of Air

Given: { RH = 50%, WB = 60°F } Find: { DB, DP, Gr. of moisture per lb. of dry air, Enthalpy }

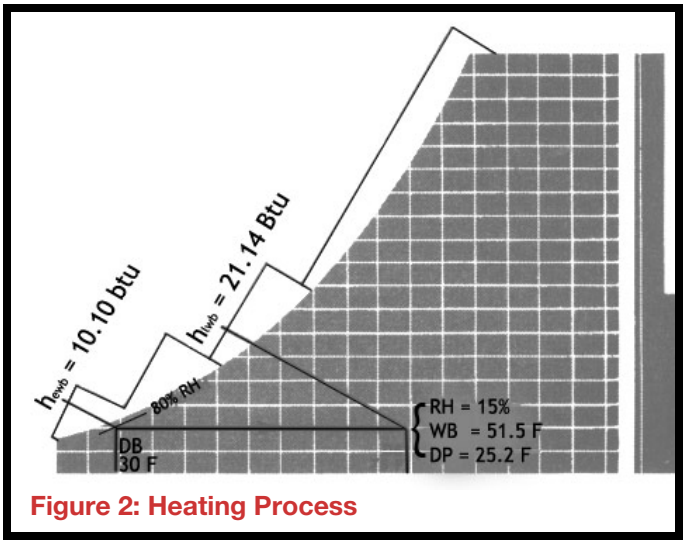

Figure 2: Heating Process

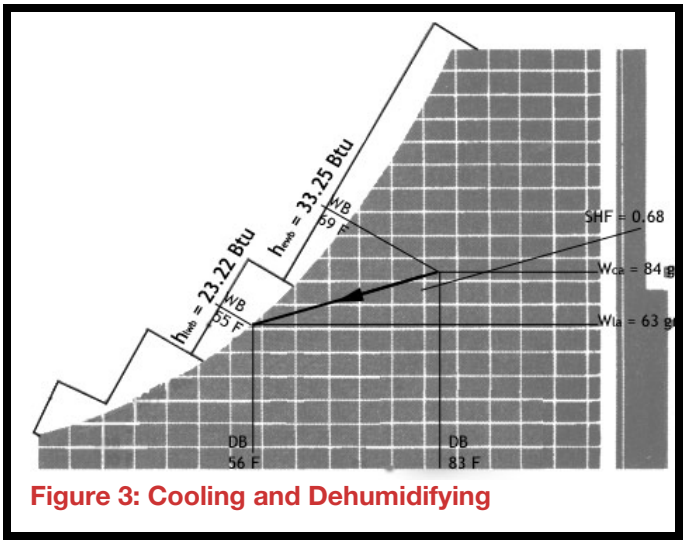

Figure 3: Cooling and Dehumidifying

Locate point of intersection on the chart of 50% RH lind and oblique line representing 600WB. All values are read from this point.

Follow vertical line downward to dry-bulb temperature scale, read DB = 71.9°F

Follow horizontal line left to saturation curve, read DP = 52.3°F.

Follow horizontal line to right, read grains of moisture per pound of dry air, W = 58.4 gr.

Follow wet-bulb line to "Enthalpy at saturation" scale and read H_{wb} = 26.46 Btu. Read enthalpy deviation for point of intersection h_d = -.08 Btu.

Enthalpy of air at given condition
$h = h_{wb} + h_d = 26.46 + (-.08) = 26.38$ Btu per lb of dry air.

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Example 3. Heating Process

Given: { Initial Air: { DB = 30°F, RH = 80% } Air heated to 75° DB } Find: { Final Air: { %RH, WB, DP } Heat Added }

Locate the condition of initial air on the chart. Follow horizontal line to 75°DB.
Read: RH = 15%: WB = 51.5°F: DB = 25.2°F.

Exact Solution - Head added:

Read enthalpy at saturation initial air h_{cwb} = 10.10 Btu
Read enthalpy deviation initial air h_{cd}= .06 Btu
Enthalpy of initial air $h_{ca} = h_{cwb} + h_{cd}$ = 10.10 + .06 = 10.16 Btu
Read enthalpy at saturation of final air h_{lwb} = 21.14Btu
Read enthalpy deviation of final air h_{id} = 0.10 Btu
Enthalpy of final air $h_{la} = h_{lwb} + h_{ld}$ = 21 .14 + (-0.10)= 21.04 Btu
Heat added $q = h_{la} - h_{ca}$ = 21.04 - 10.16 = 10.88 Btu per lb of dry air

Approximate Solution - Head added:

$q = h_{lwb} - h_{cwb}$ = 21.14 -10.10 = 11.04 Btu per lb of dry air.

The approximate solution is 1.5% higher than exact solution.

Example 4. Cooling and Dehumidifying Process

(a) Moisture rejected as water condensate

Given: { Initial Air: { DB = 83°F, WB = 69°F } Final Air: { DB = 56°F, WB = 55°F } Condensate rejected at 55°F } Find: { Heat removed, Sensible Heat Factor }

Locate initial and final conditions of air on chart.

Read: h_{cwb} = 33.25 Btu
h_{lwb} = 23.22 Btu
H_{cd} = -0.12 Btu
h_{ld} = -0.01 Btu
H_{ca} = 33.25+ (-0.12) = 33.13 Btu
h_{la} = 23.22 +(-0.01)= 23.21 Btu

Read grains of moisture in initial air W_{ca} = 84
Read grains of moisture in final air W_{la} = 63
$w = W_{la} - W_{ca}$ = 63 - 84 = 21 (moisture rejected)

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Read enthalpy of rejected moisture (h_w) from diagrams at top of chart for 21 gr grains and 55 F = -0.08 Btu.

Exact Solution - Heat removed:

$q = h_{la} - h_{ca} - h_w = 23.21 - 33.13 - (0.08) = -9.84$ Btu per lb dry air.

Approximate Solution - Heat removed:

$q = h_{lwb} - h_{cwb} = 23.22 - 33.25 = -10.03$ Btu per lb dry air.

Approximate solution is 1.9% higher than exact solution.

To determine Sensible Heat Factor, draw a line between initial and final conditions. Draw a line parallel to this line from reference point (80 DB, 50 RH) to Sensible Heat Factor scale, read SHF = 0.68.

Example 5. Mixture Of Air

Given: { Inside Air: 3 parts by weight: { DB = 75°F, WB = 62°F ; Enter Air: 1 part by weight: { DB = 95°F, WB = 75°F } } Find: { Properties of Mixture }

Locate on chart conditions of inside and en-tering air. Draw line connecting two points. Measure off distance equal to 1/4 of line, starting from inside air condition. Point thus established represents condition of mixture of inside and entering air.

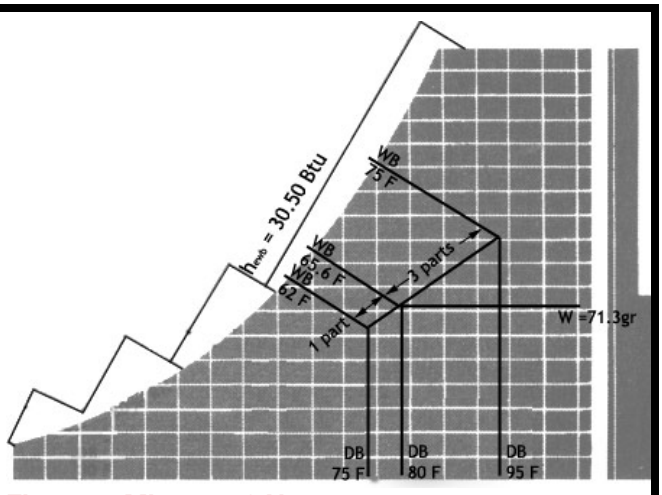

Figure 4: Mixture of Air

Read properties of mixture:

DB = 80°F, WB = 65.6°F, h = 30.50 + (-0.11) = 30.39 Btu
Moisture content (W) = 71.3 gr per lb of dry air.

When air quantities being mixed are at widely different temperatures, the above method is slightly in error. For exact solution calculate properties of mixture on basis of specific humidity and enthalpy.