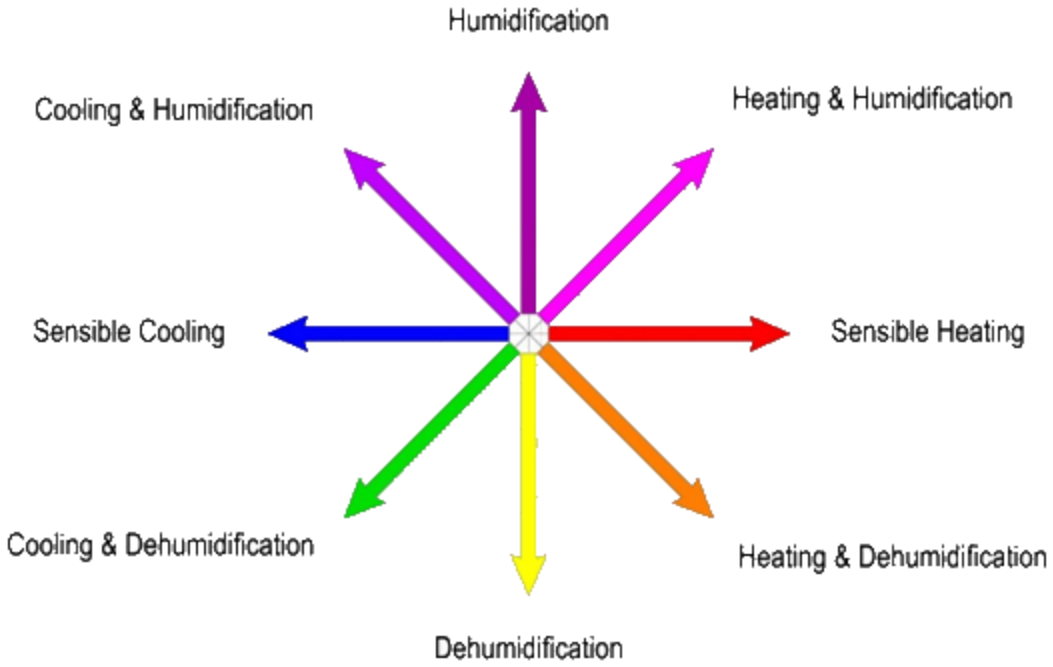
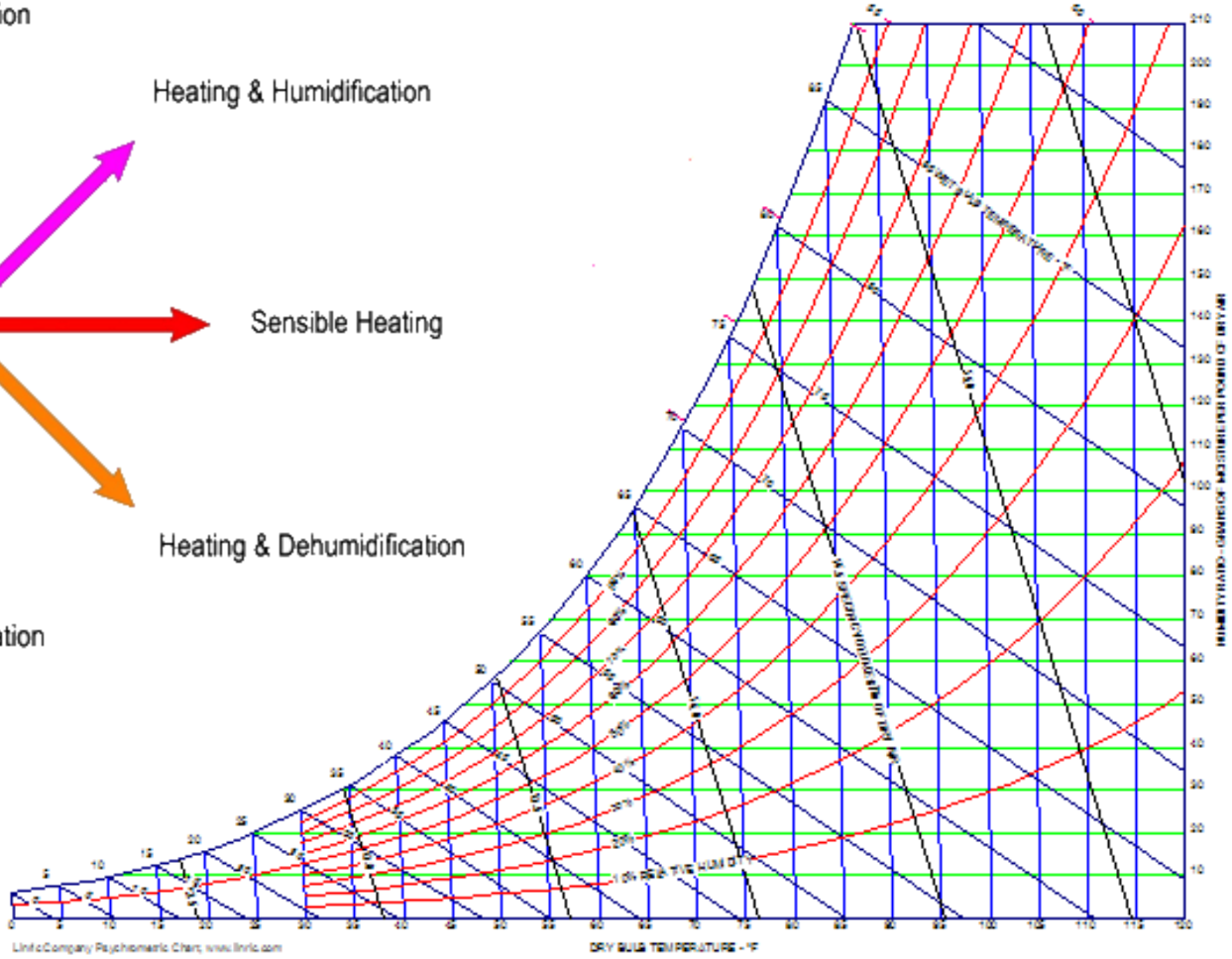
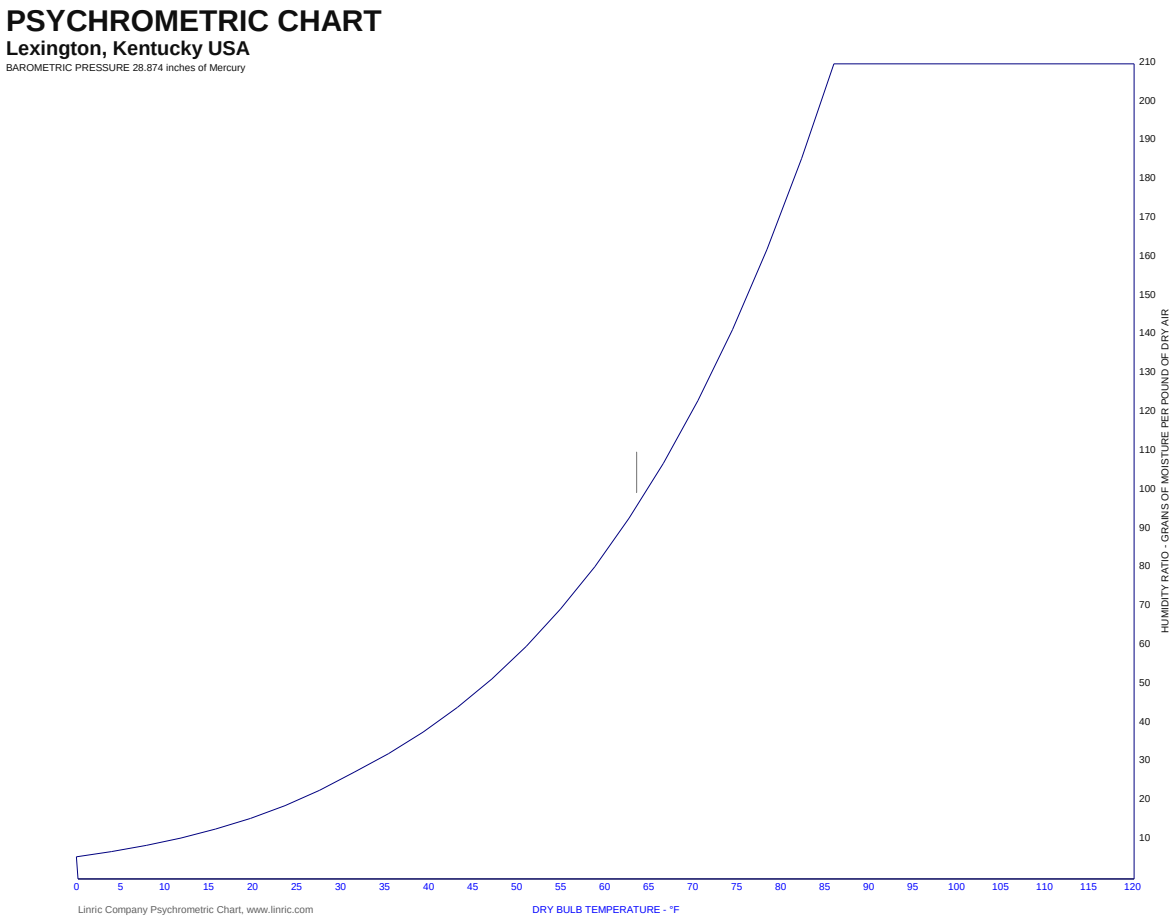
Psychrometric Chart Basics

Basic Concepts

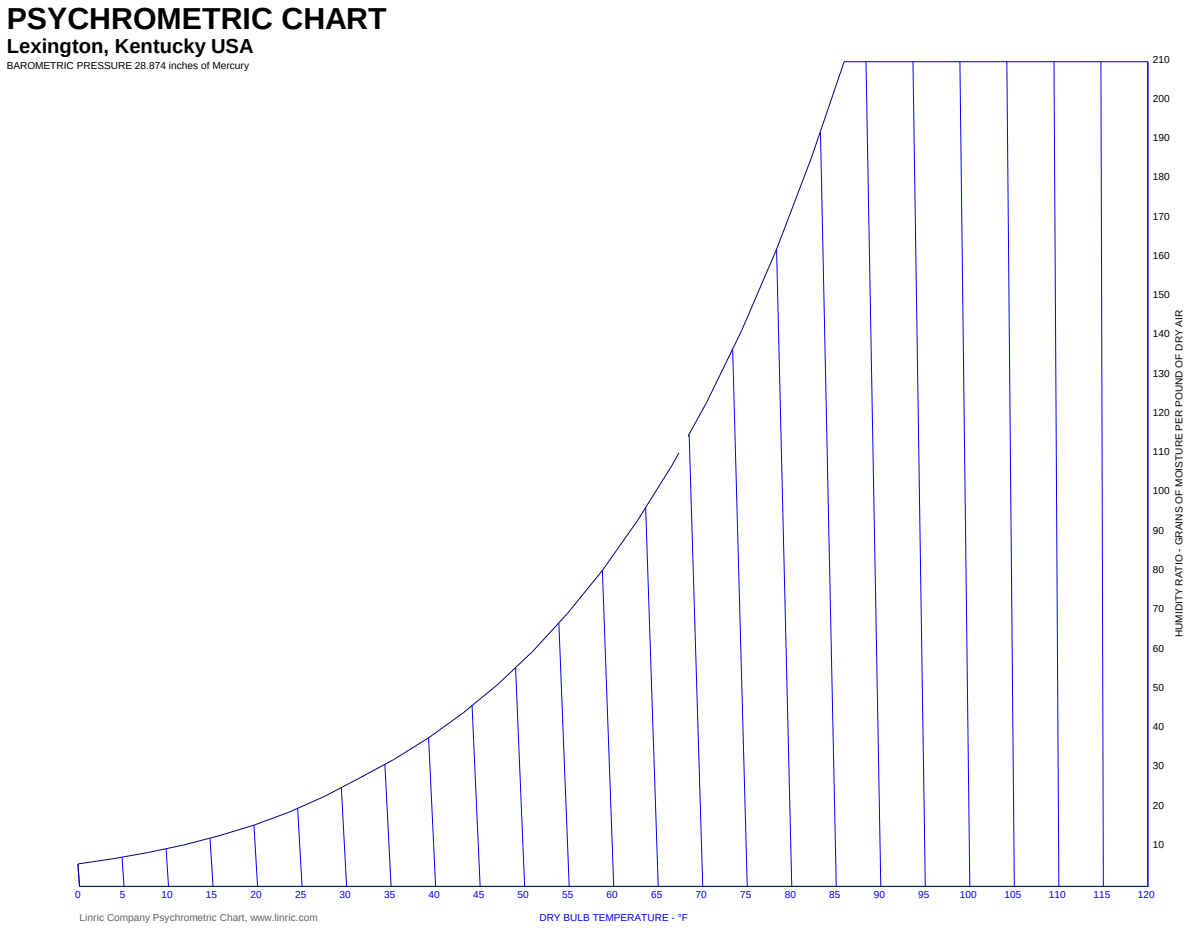




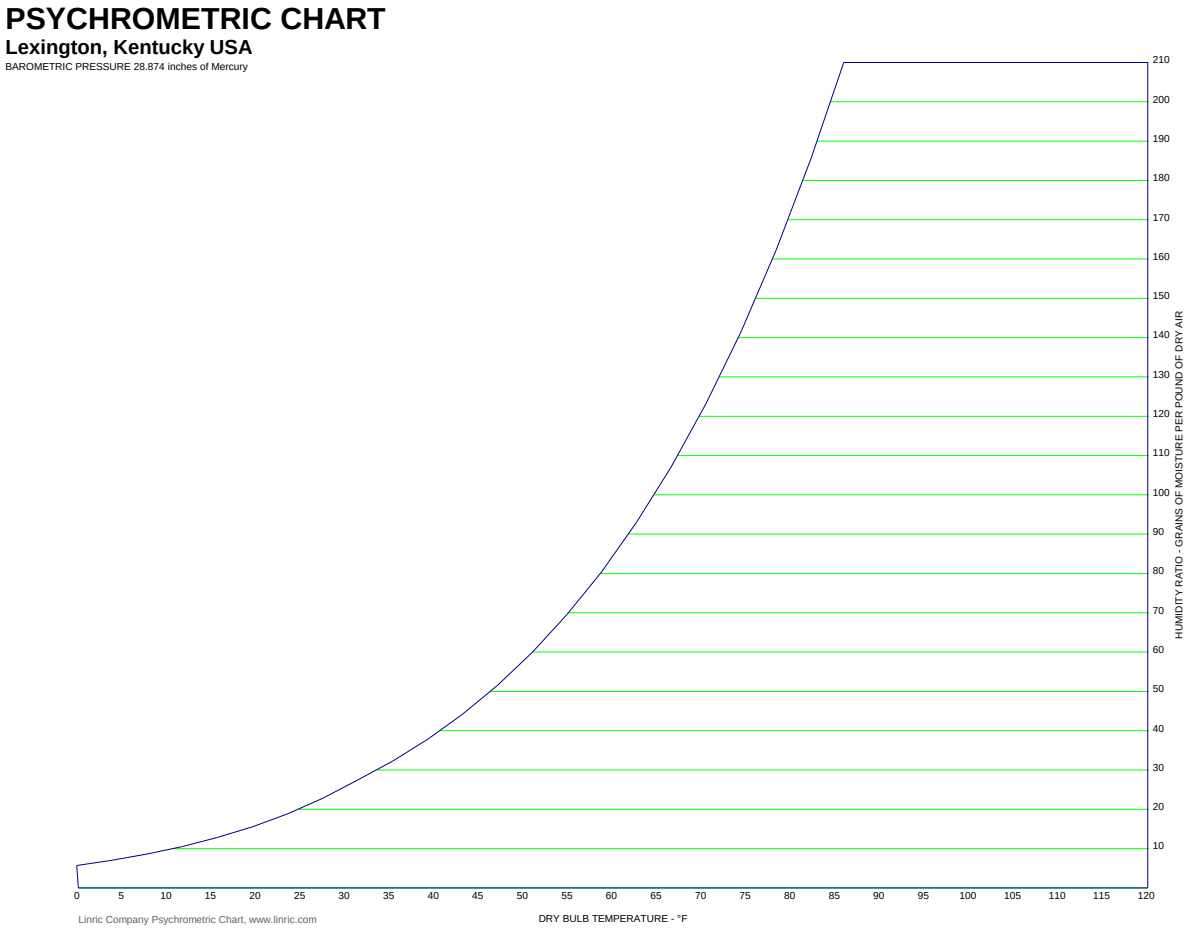
Saturation Line



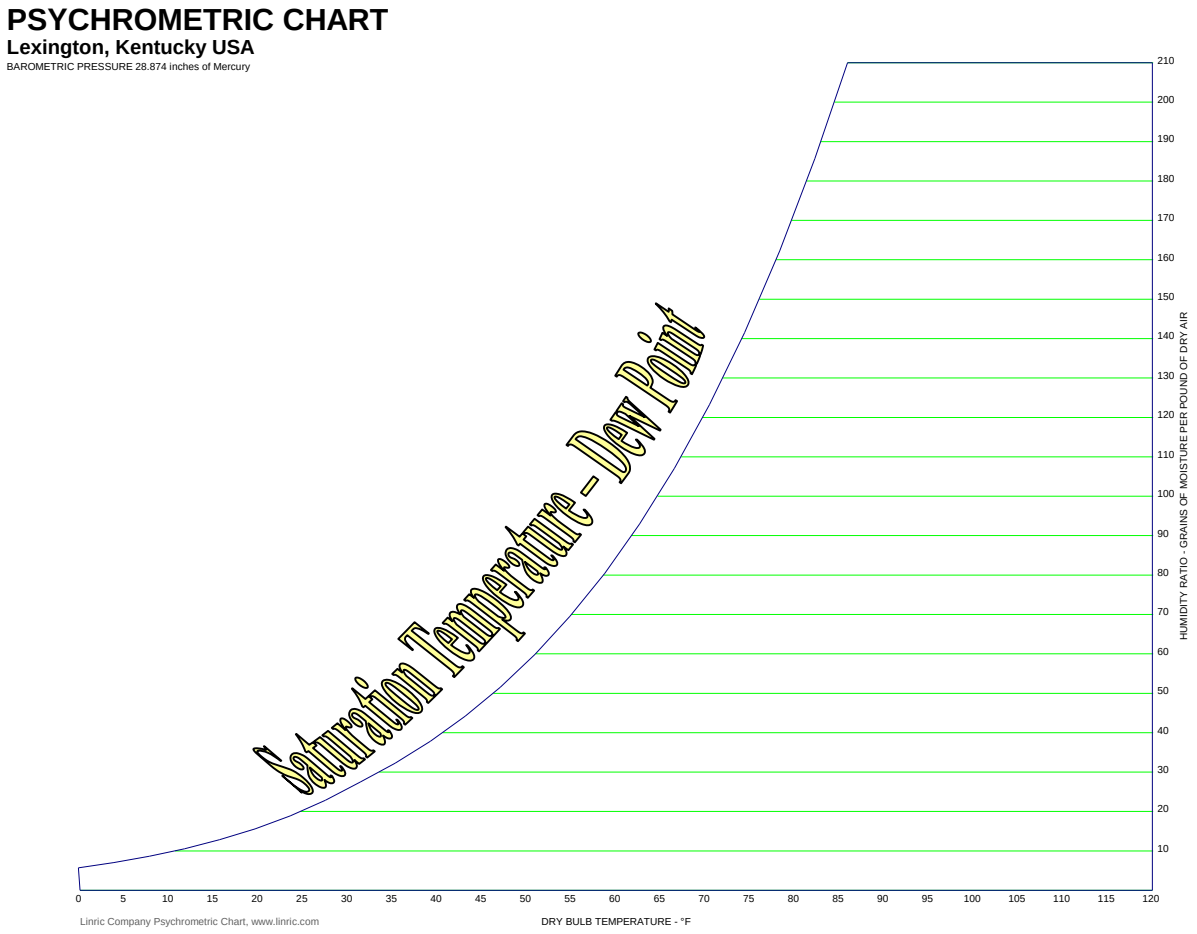
Constant Dry Bulb Temperature



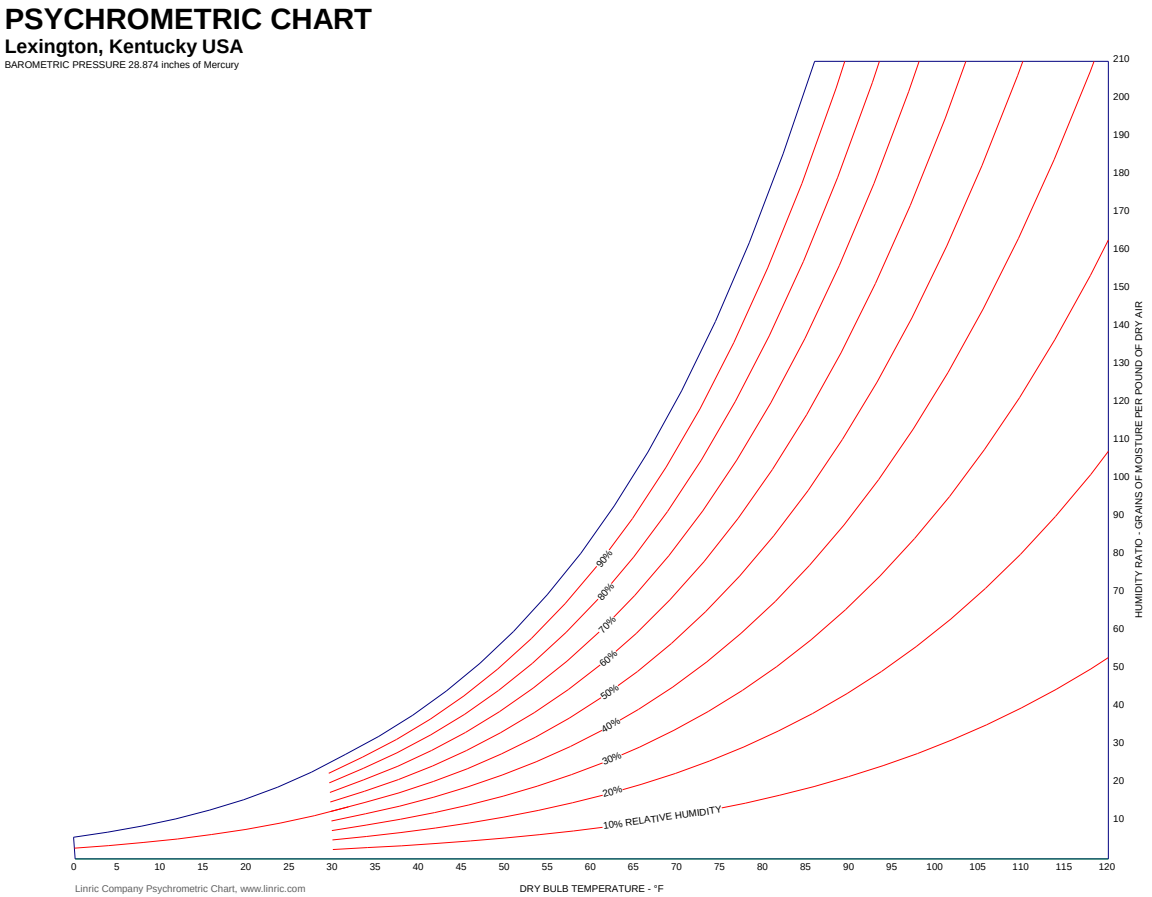
Constant Humidity Ratio



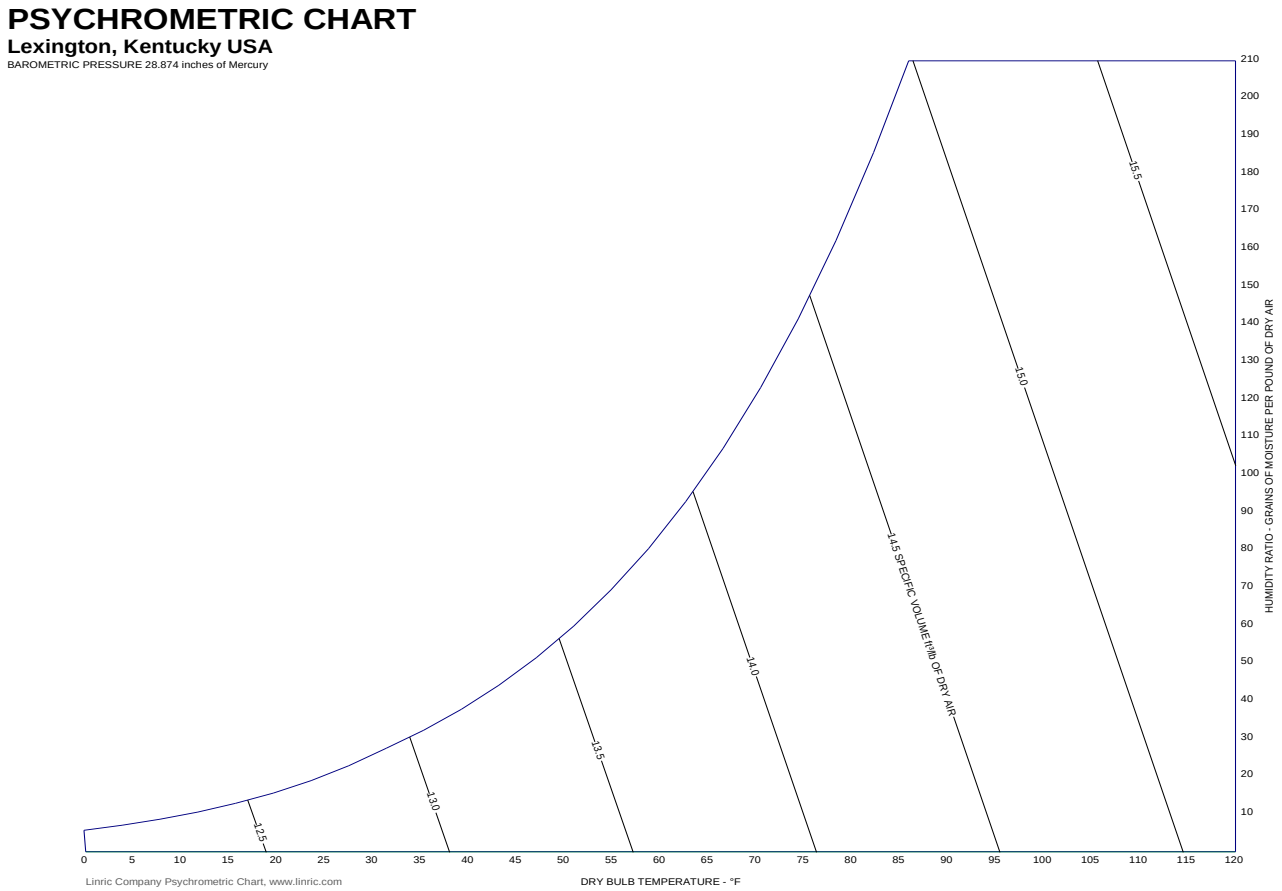
Constant Humidity Ratio



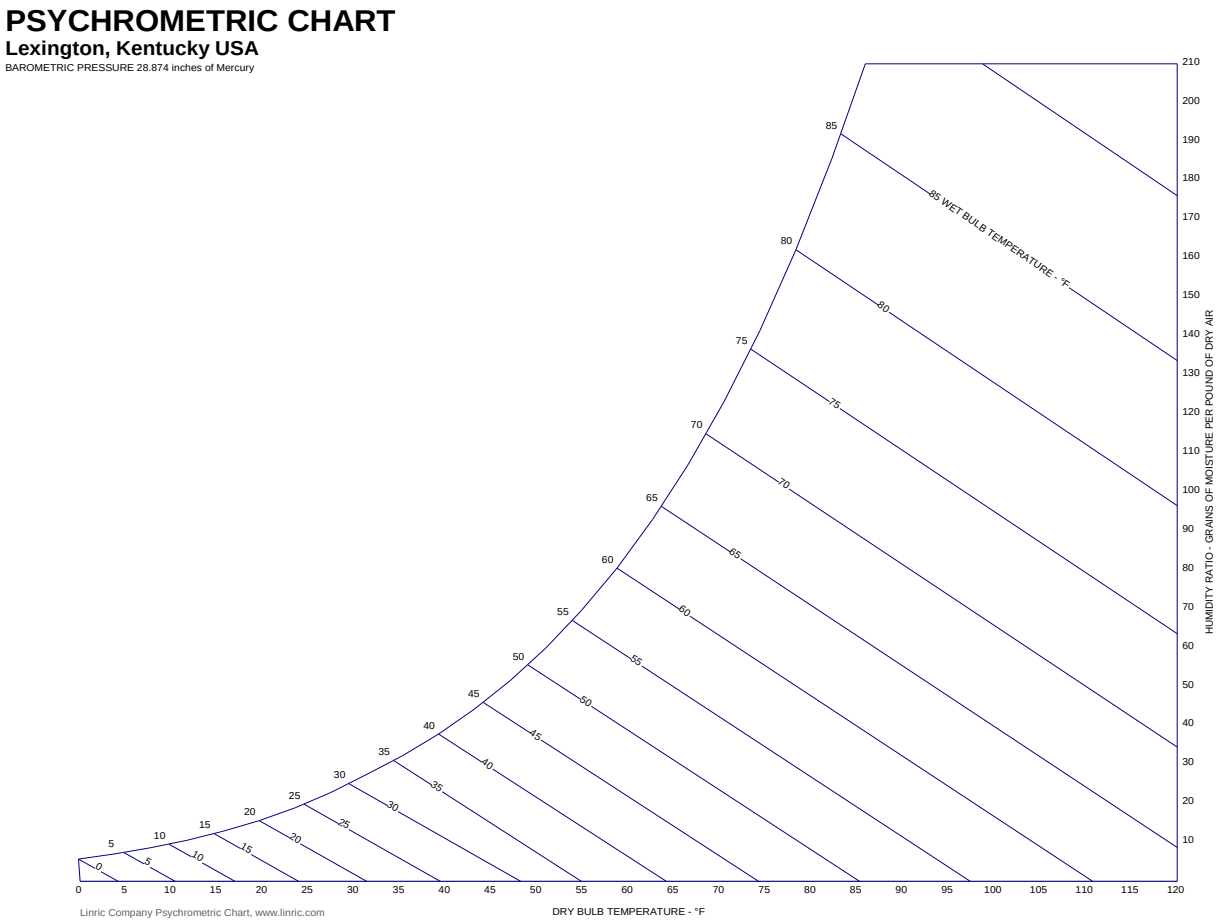
Constant Relative Humidity



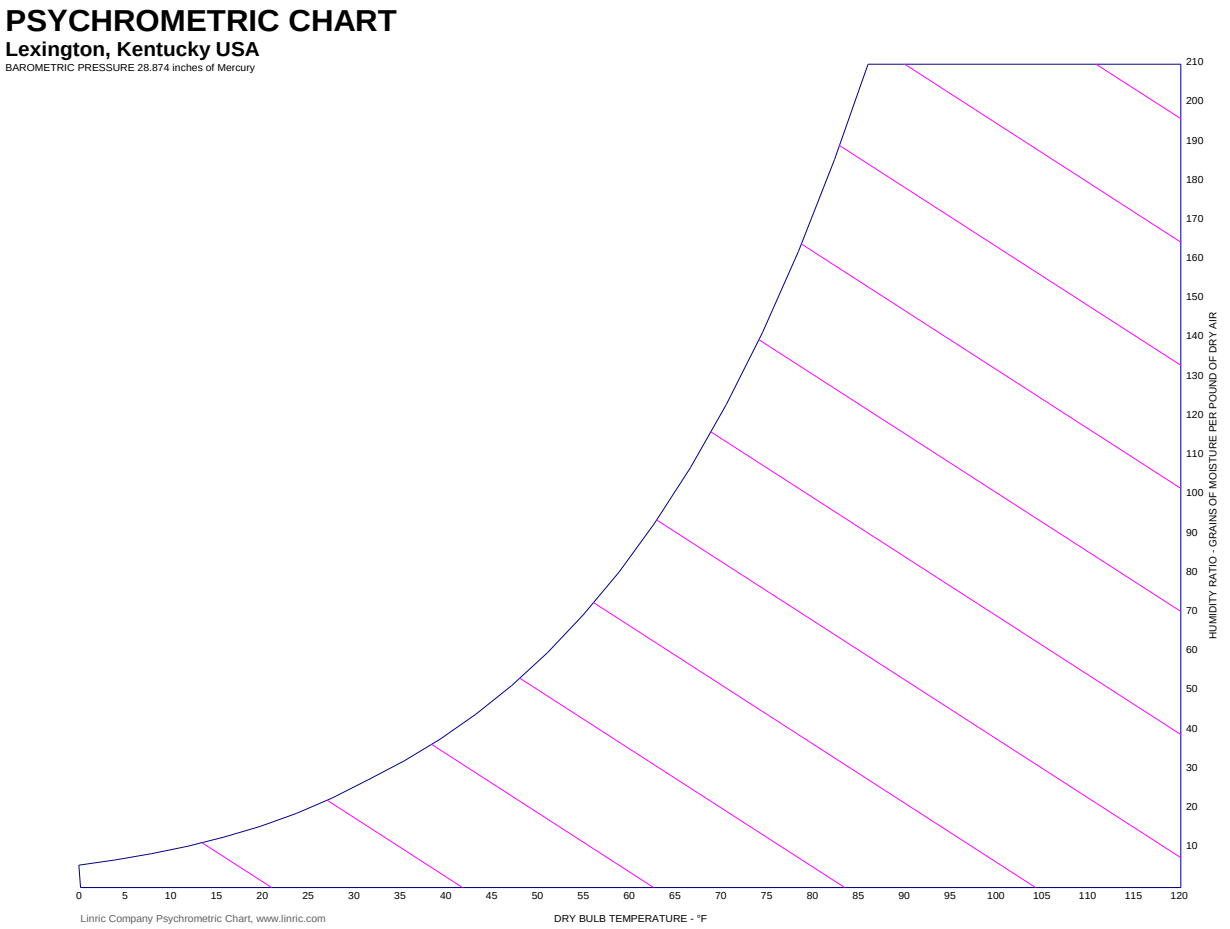
Constant Specific Volume



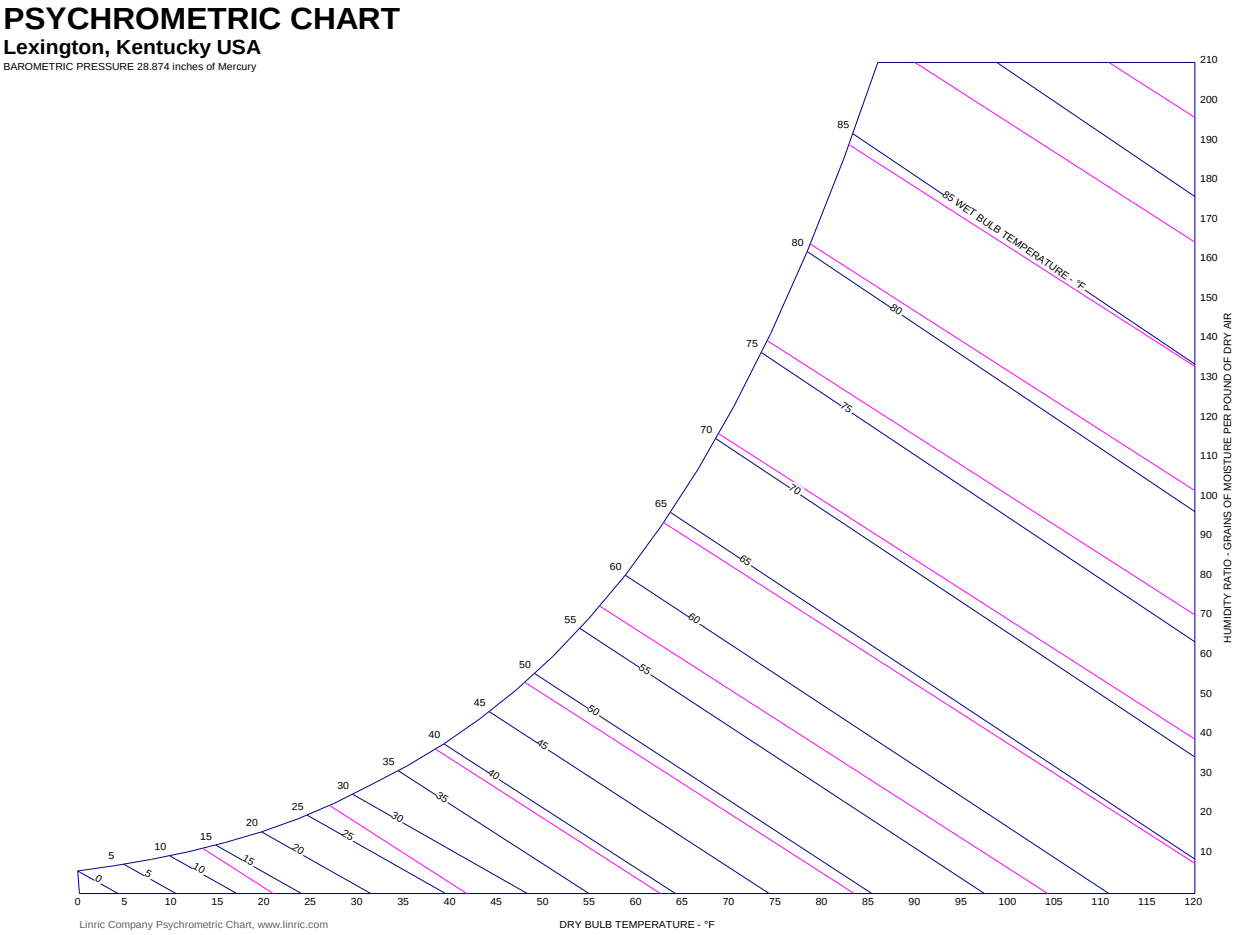
Constant Wet Bulb Temperature



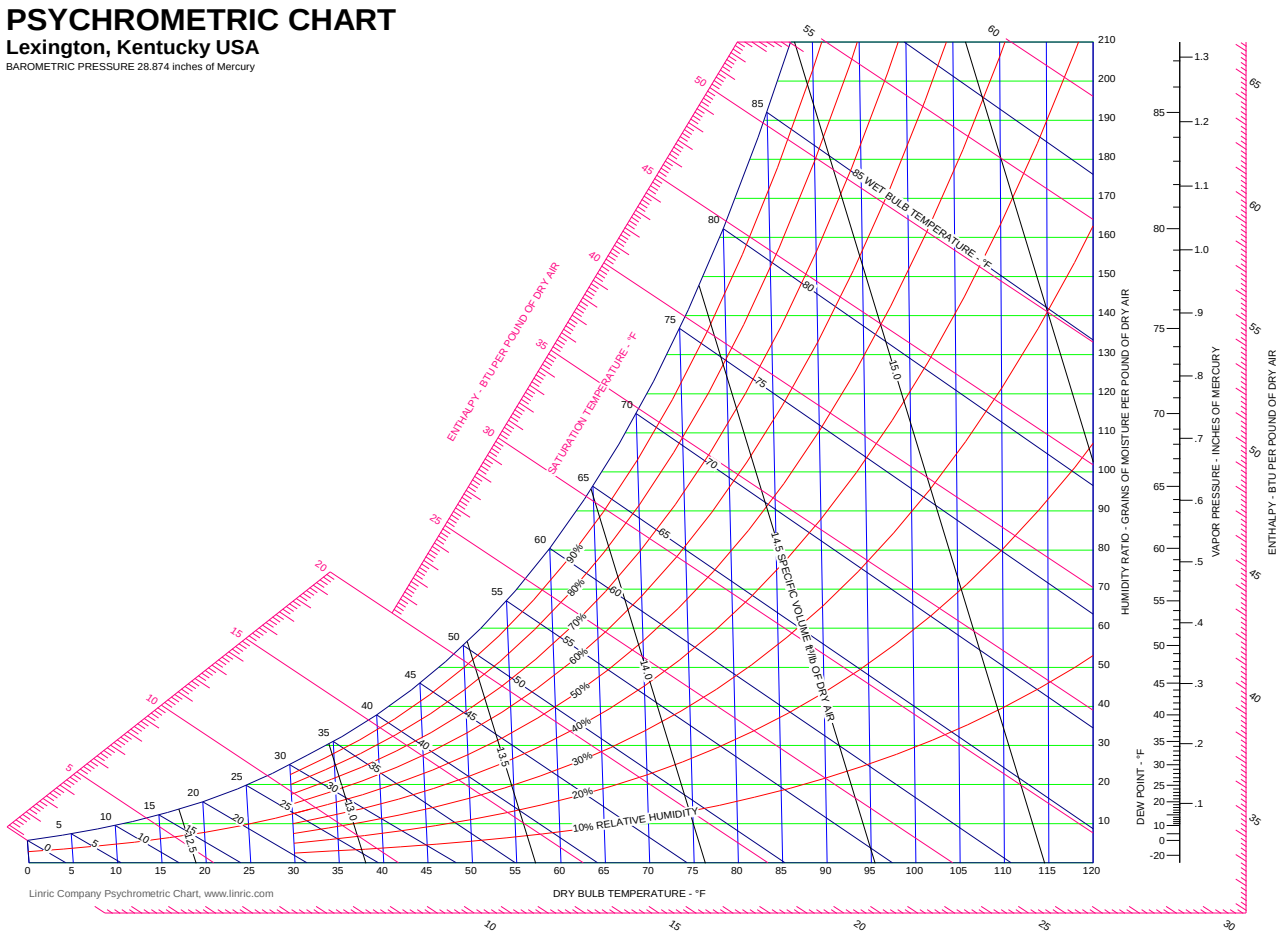
Constant Enthalpy



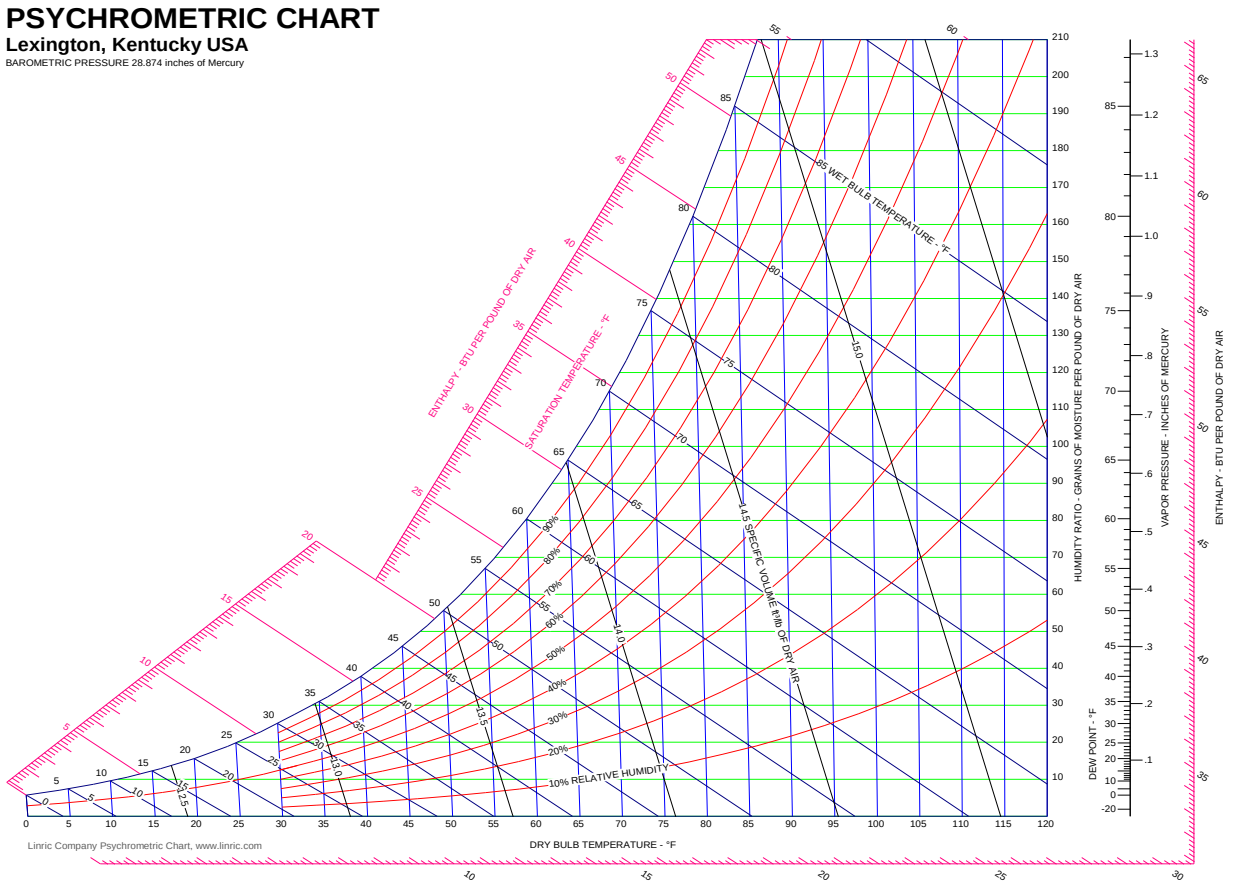
Constant Enthalpy and Web Bulb



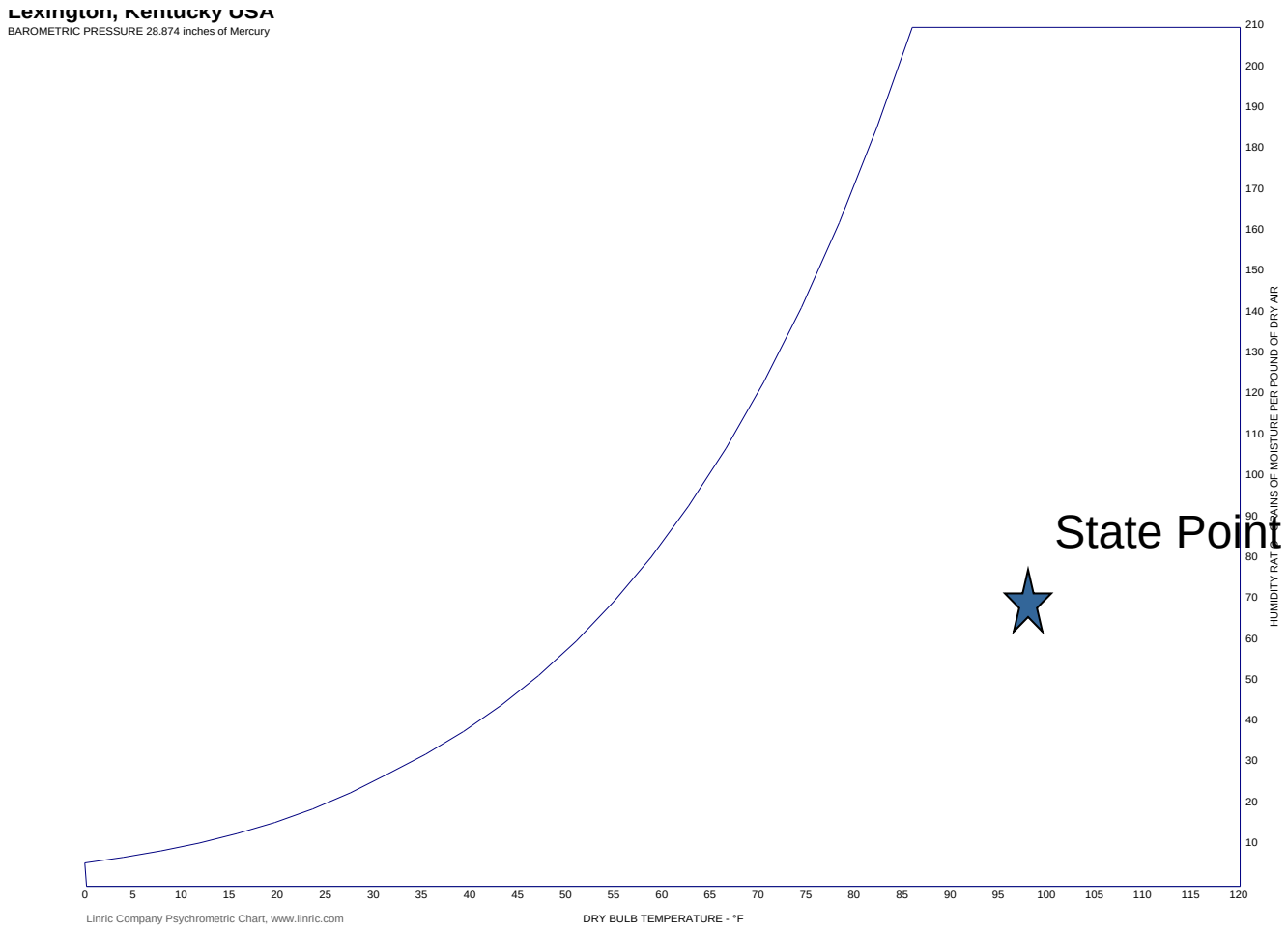
Typical Chart With Enthalpy Lines



Typical Chart Without Enthalpy Lines



State Point

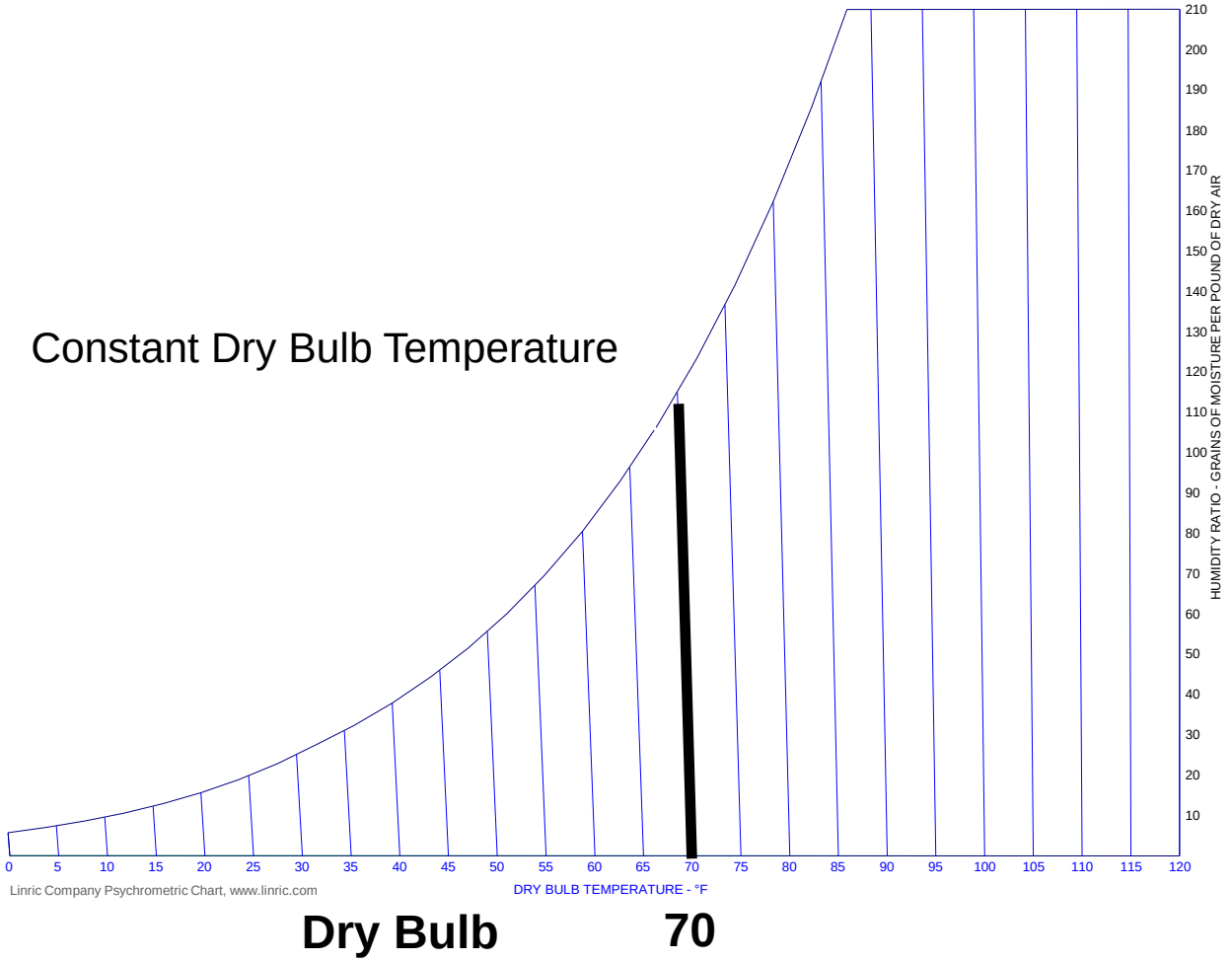

Lexington, Kentucky USA
BAROMETRIC PRESSURE 28.874 inches of Mercury
State Point
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
DRY BULB TEMPERATURE - °F
Linric Company Psychrometric Chart, www.linric.com

Reading a Psychrometric Chart Practice

State Point

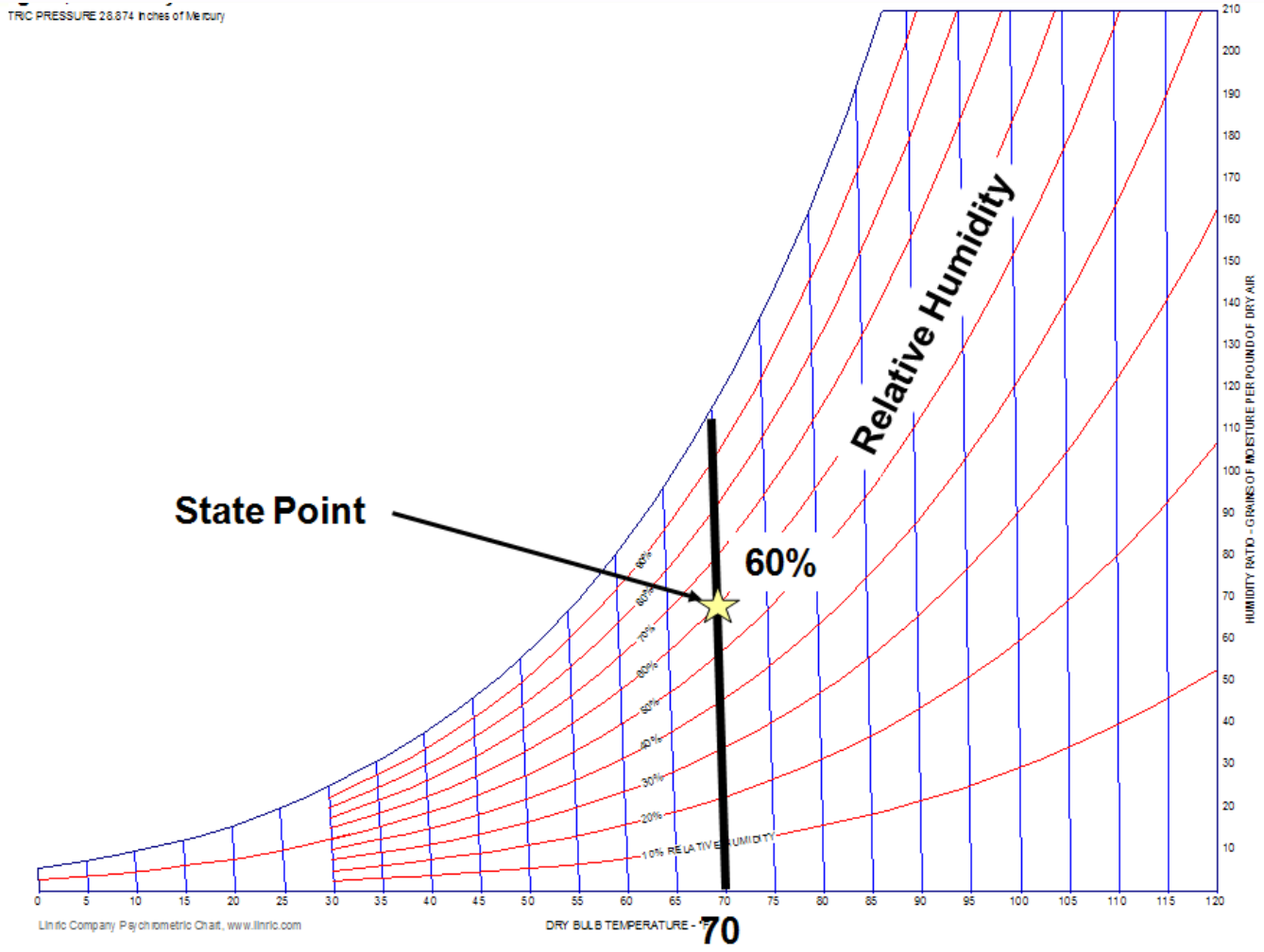
Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

State Point 70 F



Dry Bulb **70**

State Point 60%

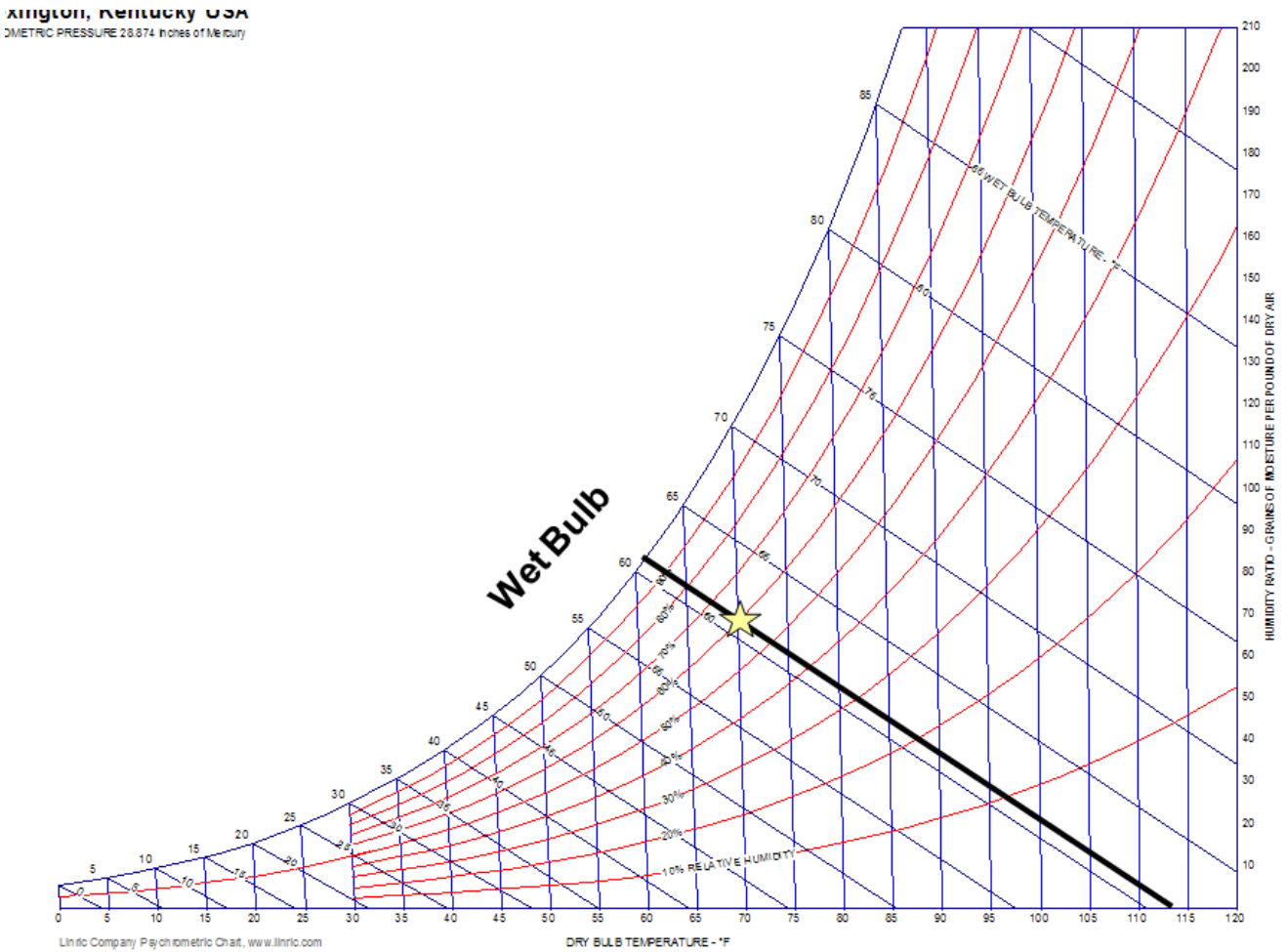


Wet-bulb

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

Wet-bulb temperature = ? F

Wet-bulb


ɔMETRIC PRESSURE 28.874 Inches of Mercury
Wet Bulb
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
10% RELATIVE HUMIDITY
Linric Company Psychrometric Chart, www.linric.com

Wet-bulb

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

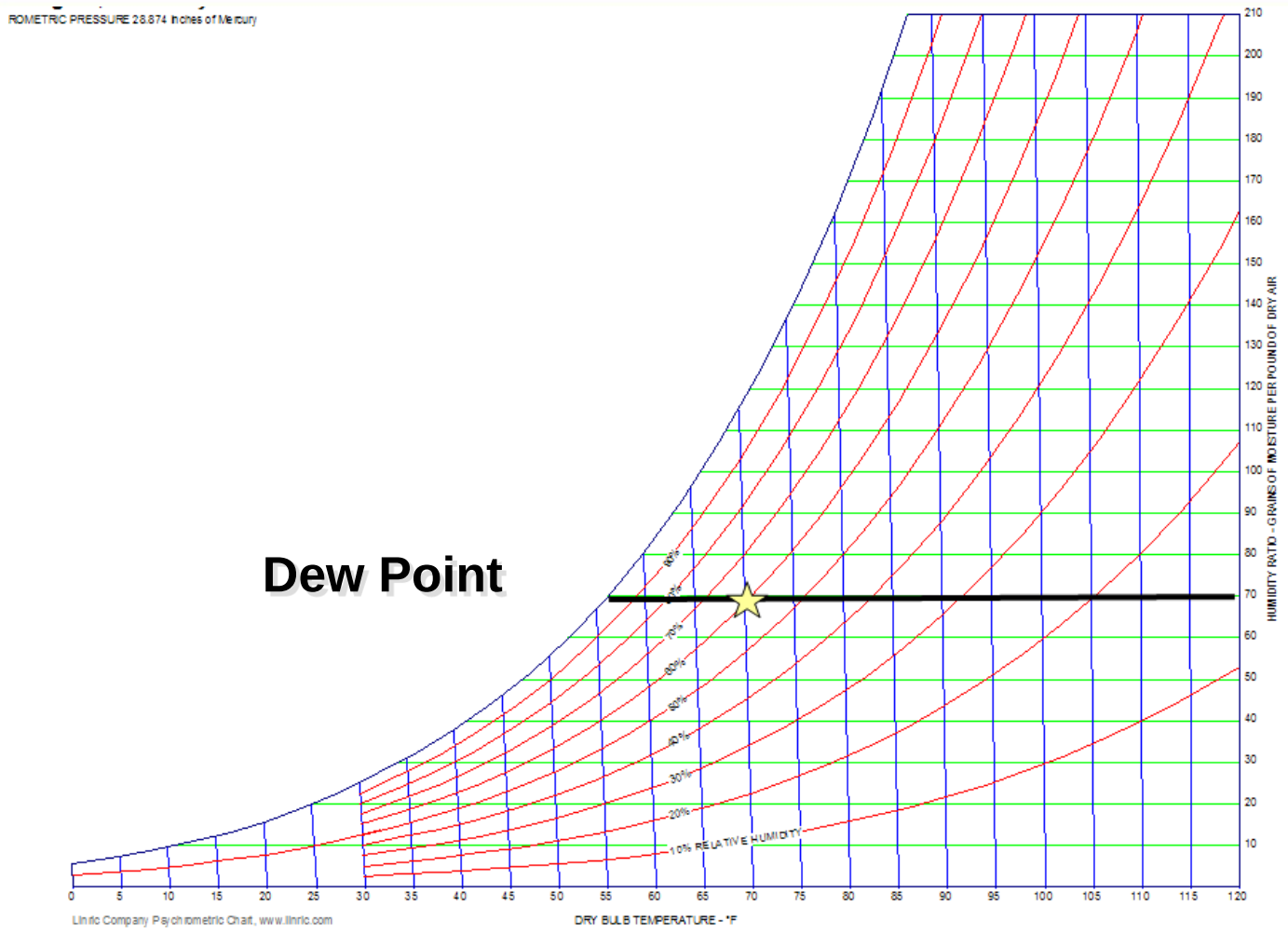
Wet-bulb temperature = 61 F

Dew Point

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

Dew point = ?

Dew Point


ROMETRIC PRESSURE 28.874 Inches of Mercury
Dew Point
90%
80%
70%
60%
50%
40%
30%
20%
10% RELATIVE HUMIDITY
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
DRY BULB TEMPERATURE - °F
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
Linric Company Psychrometric Chart, www.linric.com

Dew Point

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

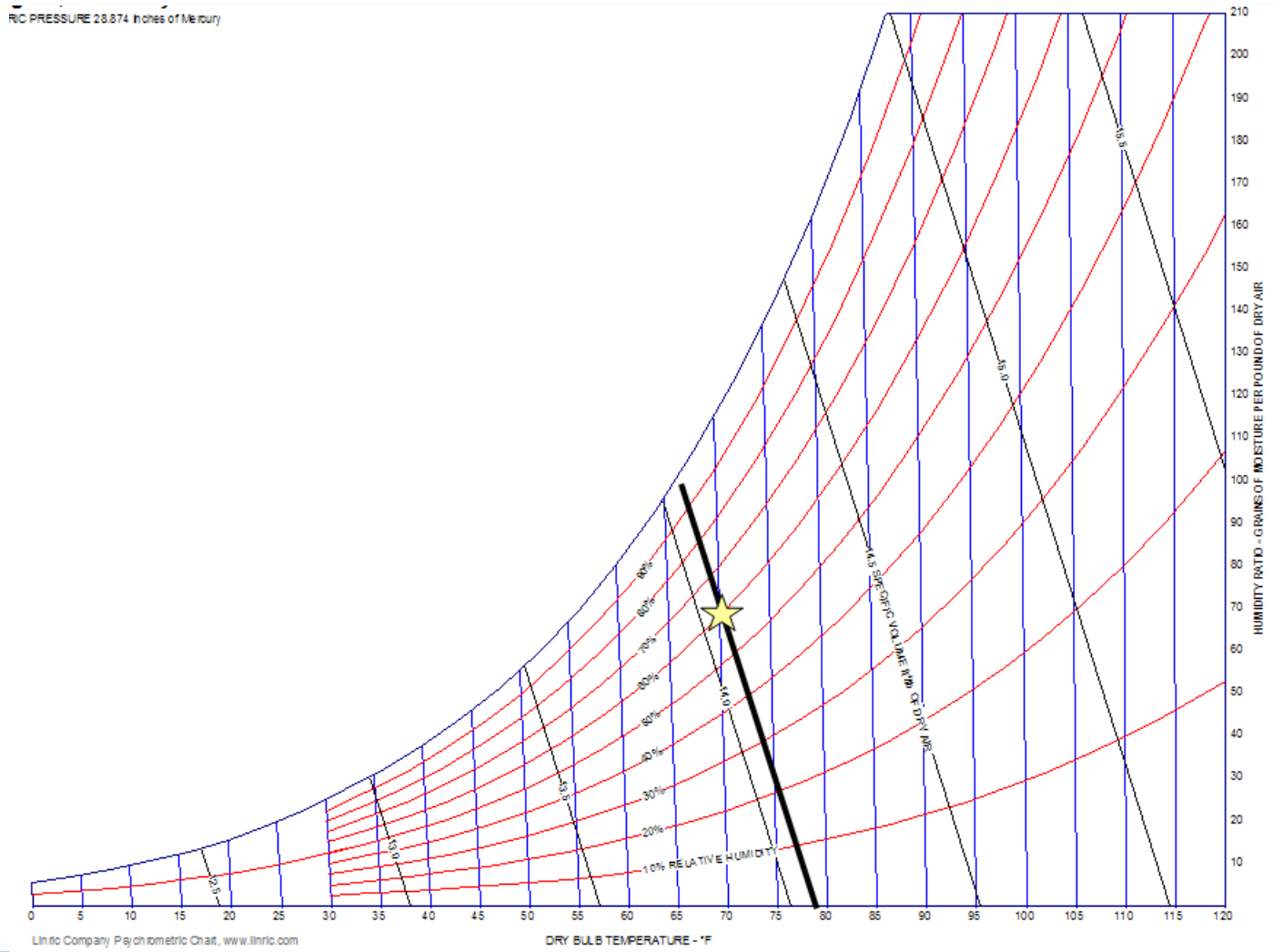
Dew point = 55.5 F

Specific Volume

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

Specific volume = ?

Specific Volume



Specific Volume

Sea Level Chart
Dry-bulb temperature = 70 F
Relative Humidity = 60%

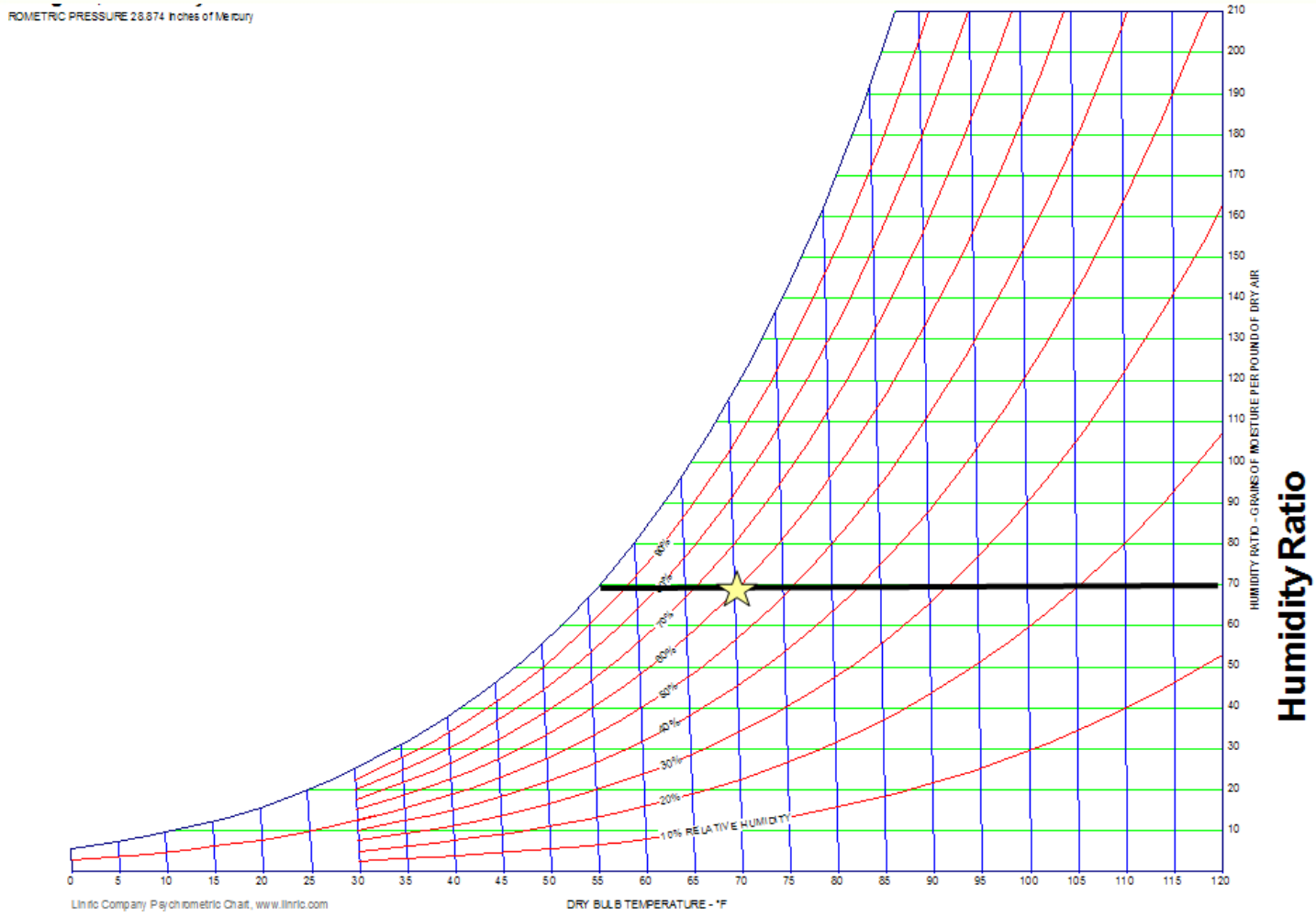
Specific volume = 13.6 ft3 / lb dry air

Humidity Ratio

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

Humidity ratio = ?

Humidity Ratio



Humidity Ratio

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

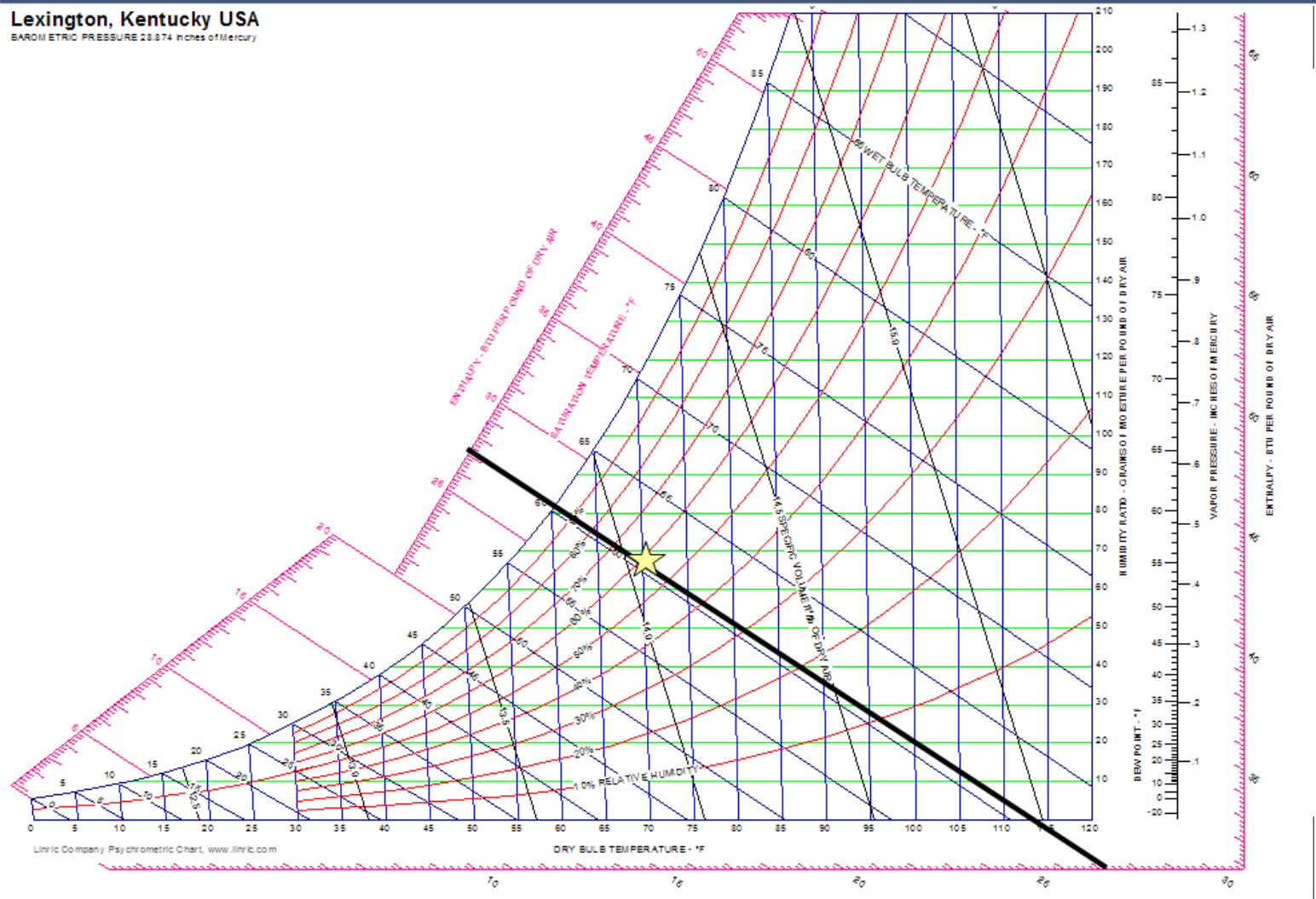
Humidity ratio = 0.0094 lb water / lb dry air
or
7000 grains = 1 lb water
7000 x 0.0094 = 65.8

Enthalpy

Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

Enthalpy = ?

Enthalpy

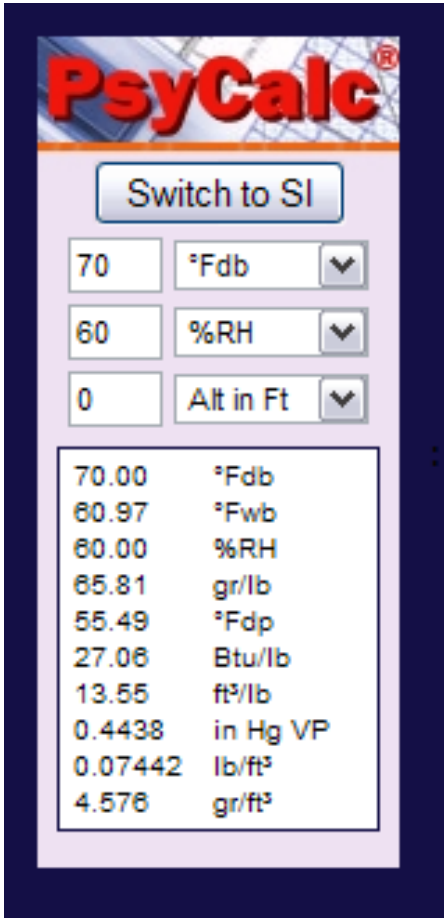

Lexington, Kentucky USA
BAROMETRIC PRESSURE 28.874 Inches of Mercury
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
WET BULB TEMPERATURE - °F
14.5 SPECIFIC VOLUME (ft³/lb OF DRY AIR)
100% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
VAPOR PRESSURE - INCHES OF MERCURY
DEW POINT - °F
ENTHALPY - BTU PER POUND OF DRY AIR
Linric Company Psychrometric Chart, www.linric.com

Enthalpy

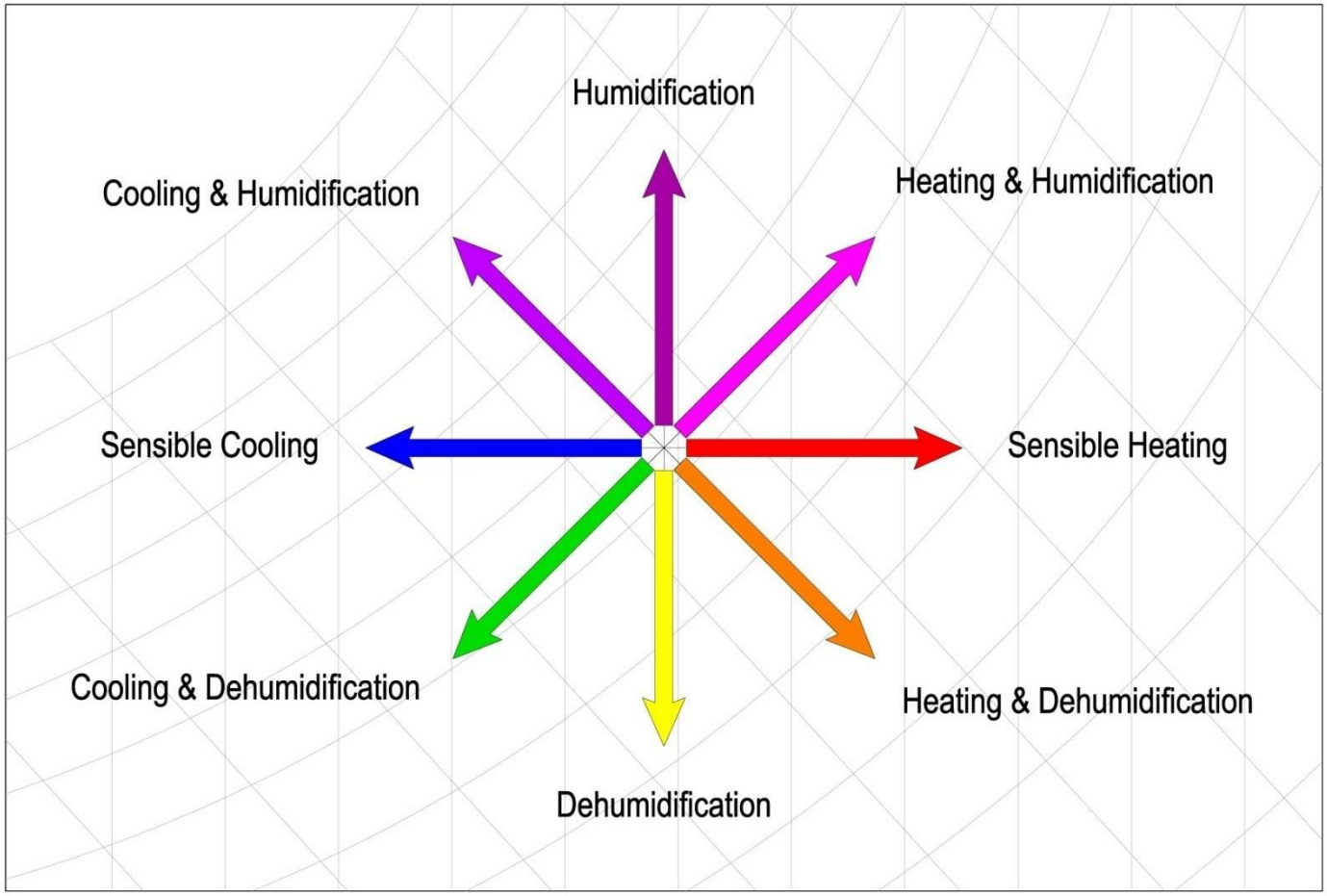
Sea Level Chart
Dry-bulb temperature = 70 F
Relative humidity = 60%

Enthalpy = 27.0 Btu / lb dry air

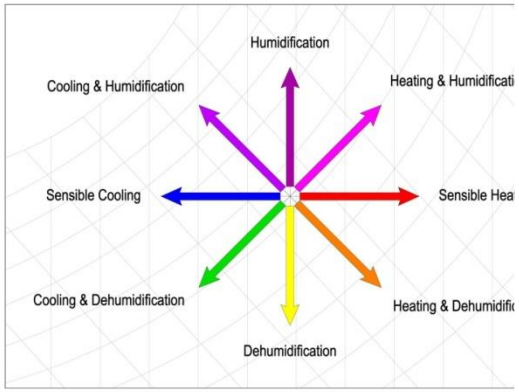
Calculating Air Property Values

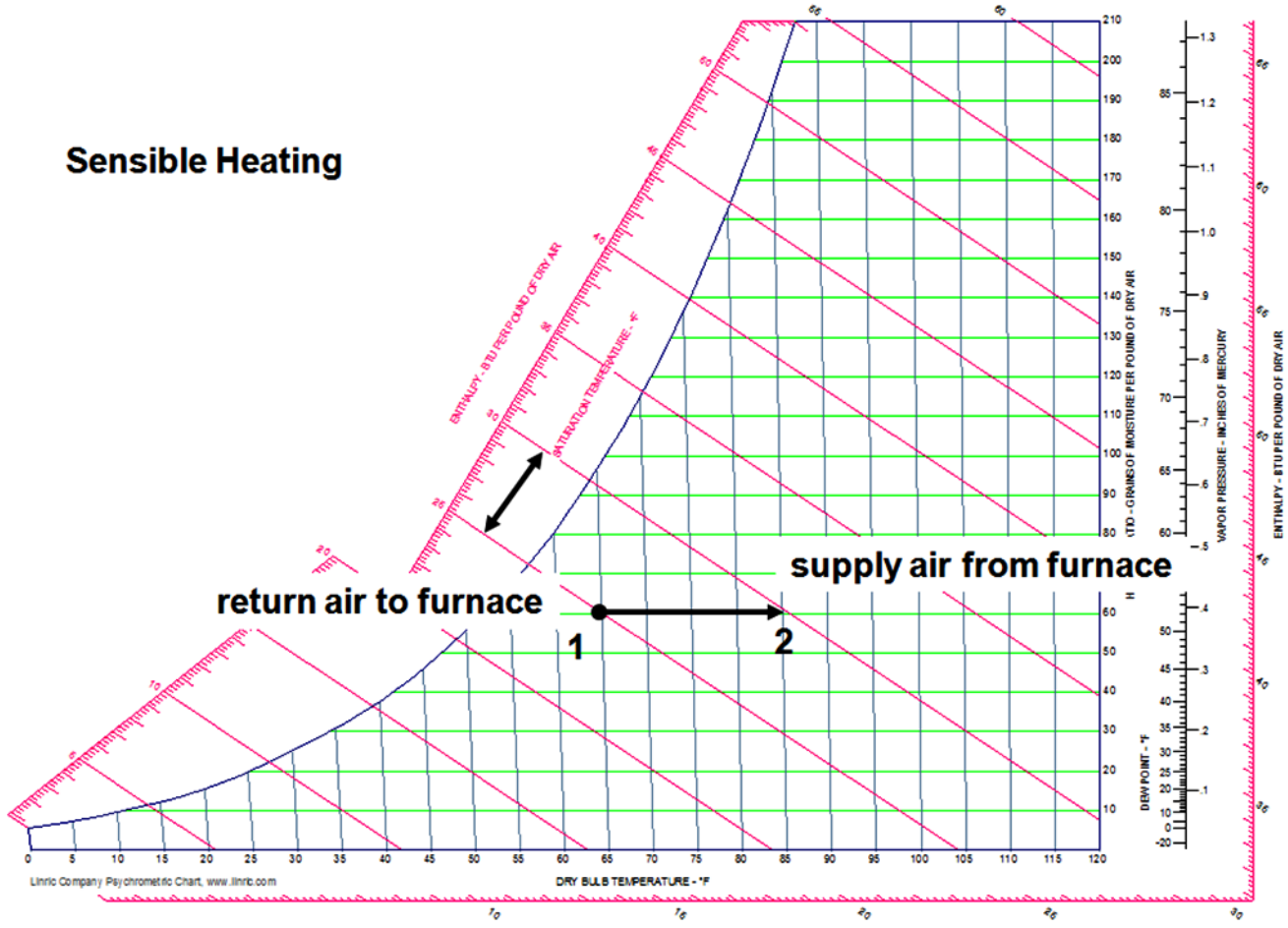


http://linricsoftw.web127.discountasp.net/webpsycalc.aspx

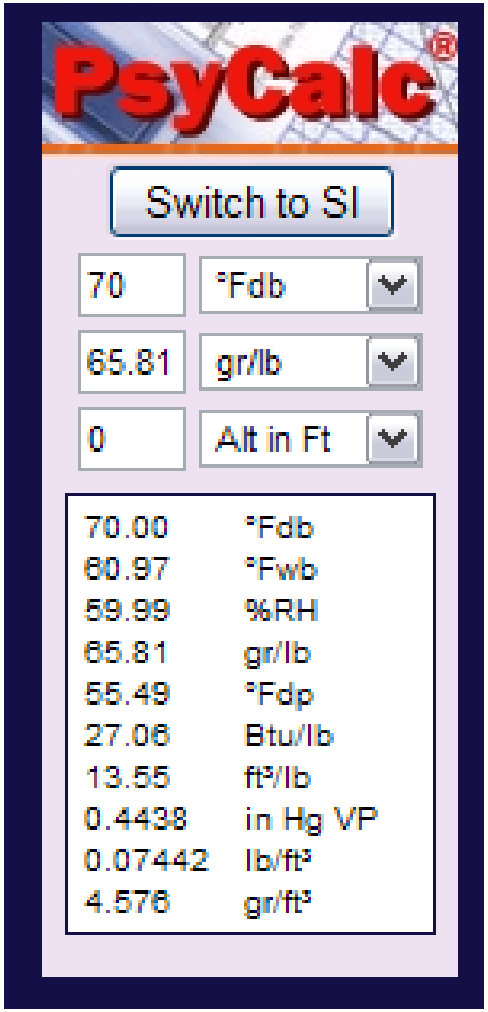

Humidification
Cooling & Humidification
Heating & Humidification
Sensible Cooling
Sensible Heating
Cooling & Dehumidification
Heating & Dehumidification
Dehumidification

Sensible Heating

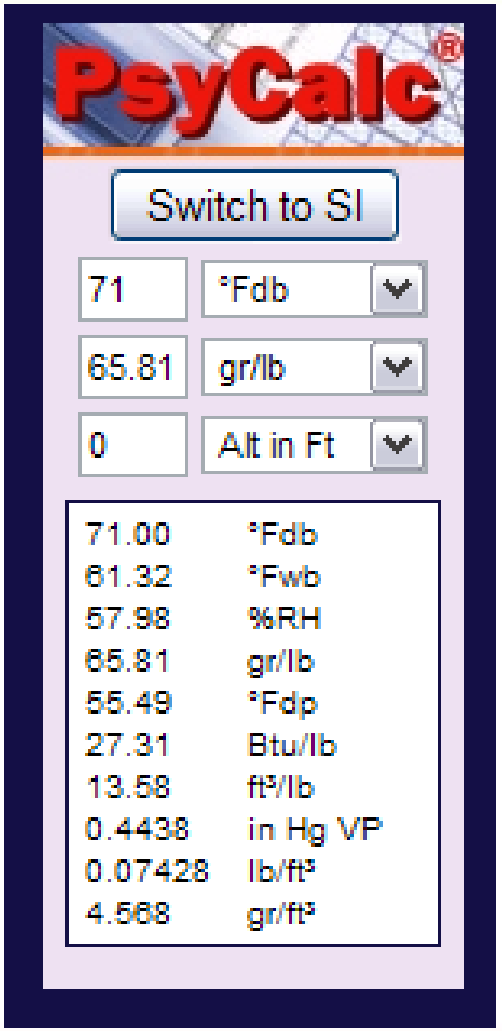




Raise Room Temperature 1 degree F
Constant Humidity Ratio



27.31 Btu/lb
27.06 Btu/lb
00.25 Btu/lb



Raise Room Temperature 1 degree F
Constant Humidity Ratio

Length (ft) x Width (ft) x Height (ft) = Volume (ft3)

Volume (ft3) / Specific Volume (ft3/lb) = Mass of Air (lb)

Mass of Air (lb) x Enthalpy Change (Btu/lb) = Heat Input (Btu)

Bedroom

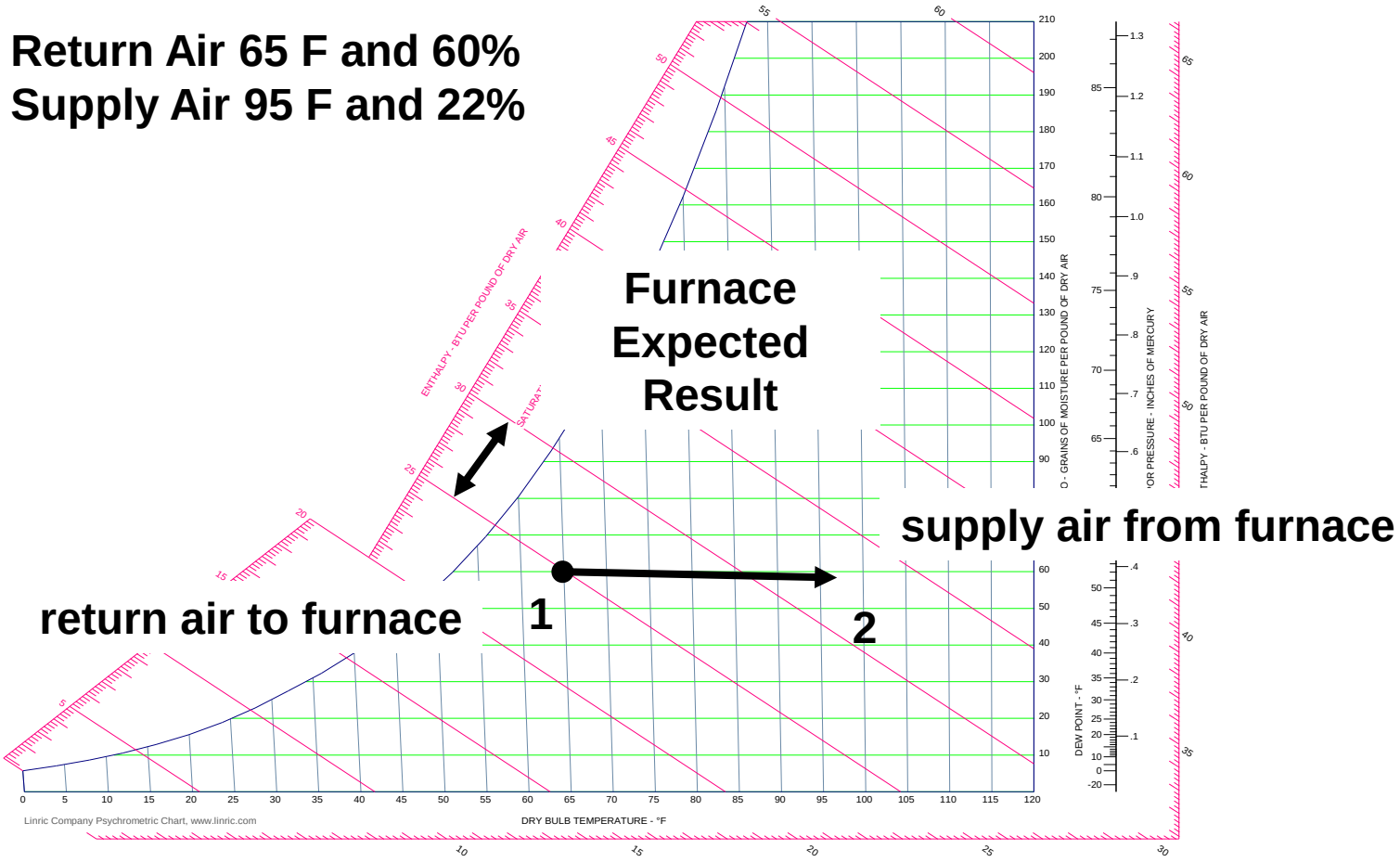
12 x 12 x 8 = 1152 ft3

1152 / 14.02 = 82.17 lb

82.17 x 0.25 = 20.54 Btu

Heating System Example

1) Return Air 65 F and 60%
2) Supply Air 95 F and 22%

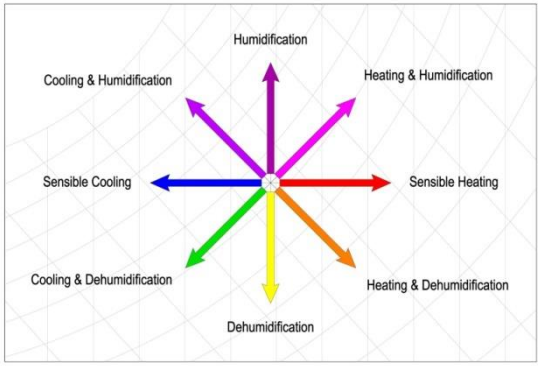


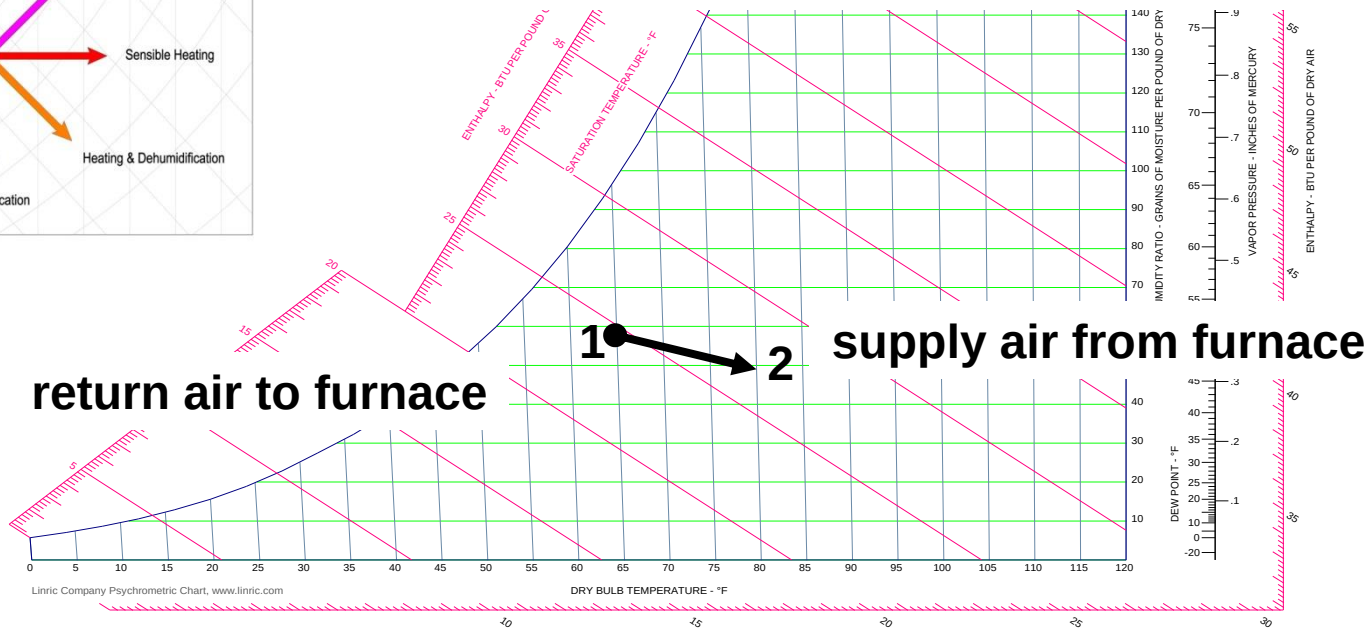
Heating System Example

1) Return 65 F and 60%
2) Supply 95 F and 18%

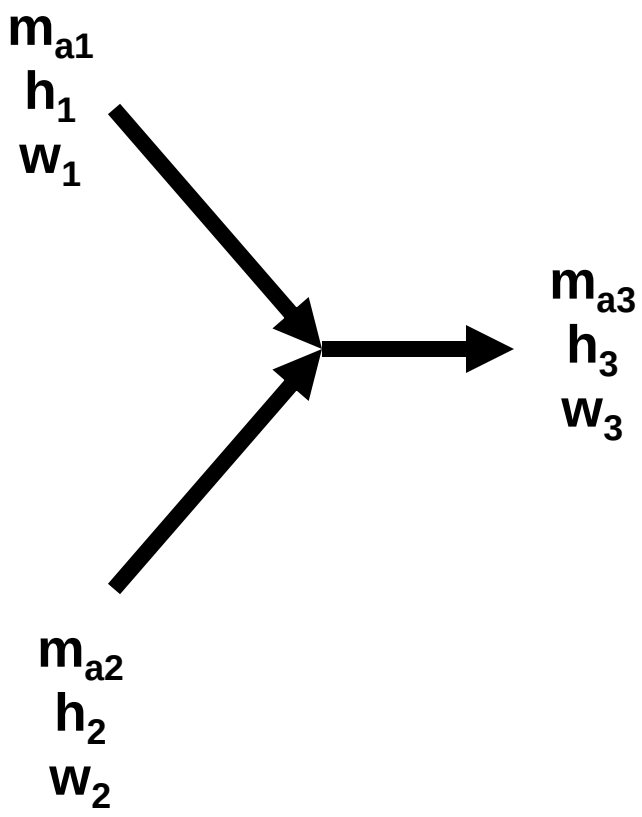
Measured Values

How is this possible?





Mixing Air Streams



Energy Balance

$$m_{a1}\ h_1 + m_{a2}\ h_2 = m_{a3}\ h_3$$

Mass Balance

$$m_{a1}\ w_1 + m_{a2}\ w_2 = m_{a3}\ w_3$$

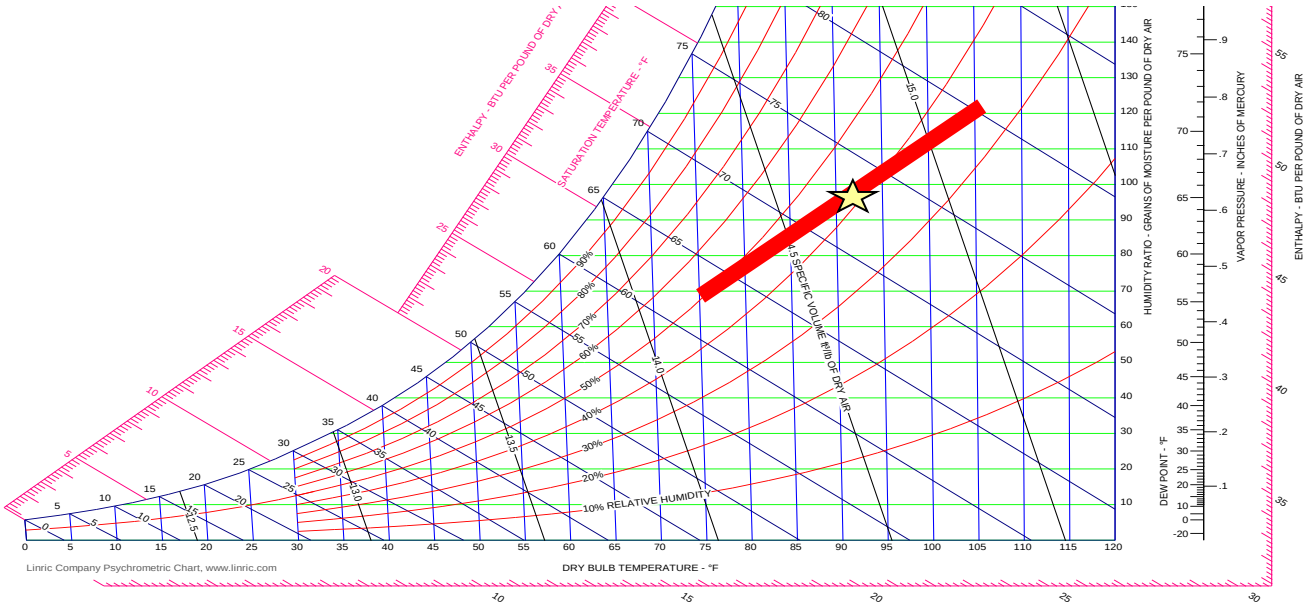
By Algebra

$$\frac{h_2 - h_3}{h_3 - h_1} = \frac{w_2 - w_3}{w_3 - w_1} = \frac{m_{a1}}{m_{a2}}$$

Mixing Air Streams

Resulting mixture lies on the line between the two state points.

Mixing Two Equal Air Streams = the center of the line

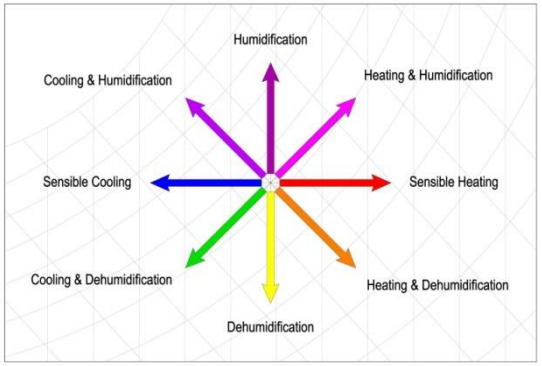


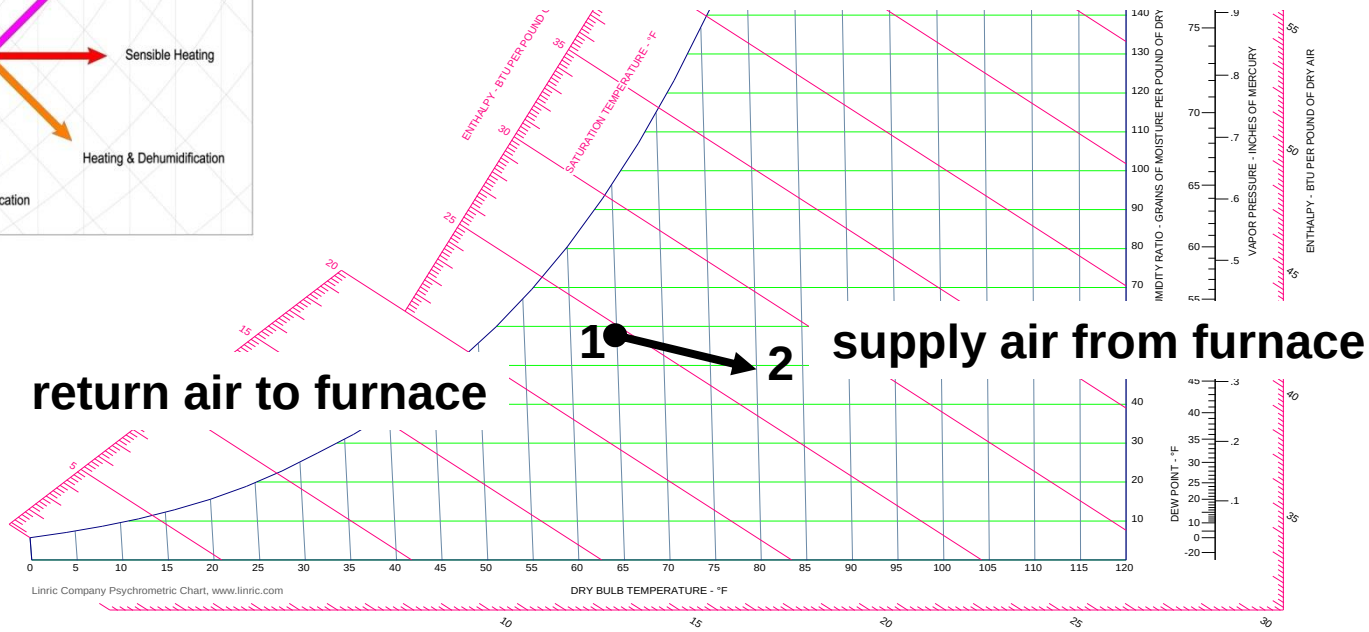
Heating System Example

1) Return 65 F and 60%
2) Supply 95 F and 18%

Measured Values

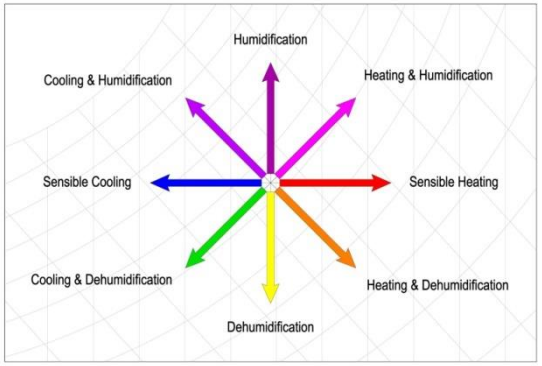
How is this possible?





Heating System Example

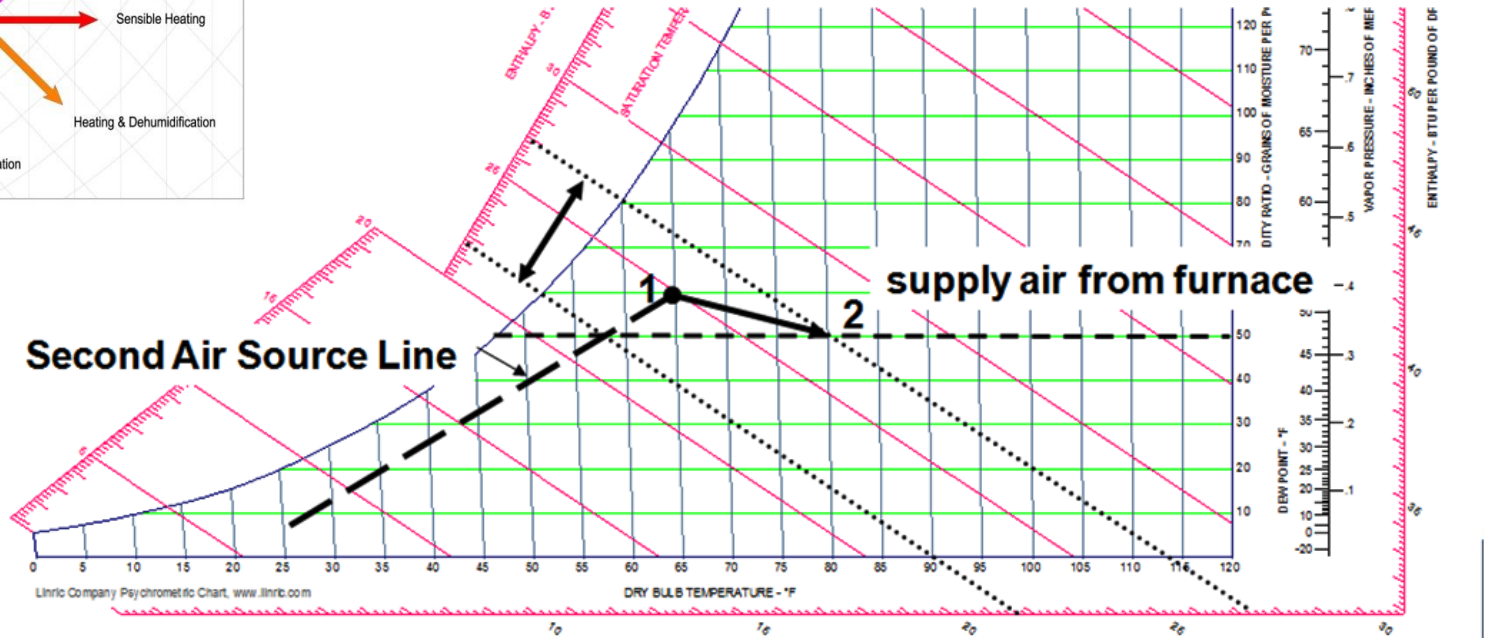
Sensible Heating



How is this possible?

- Heat output of furnace constant
- Furnace does not dehumidify
- Must have mixed a second air source

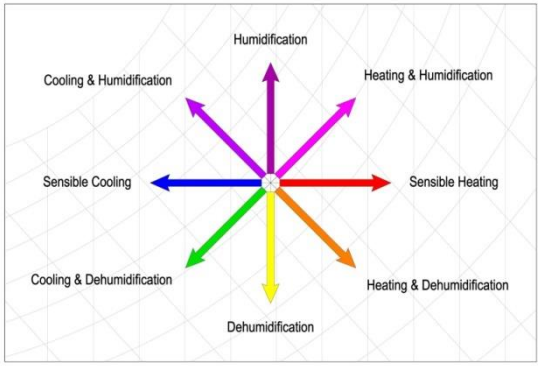
Temperature of second air source determines the % contribution

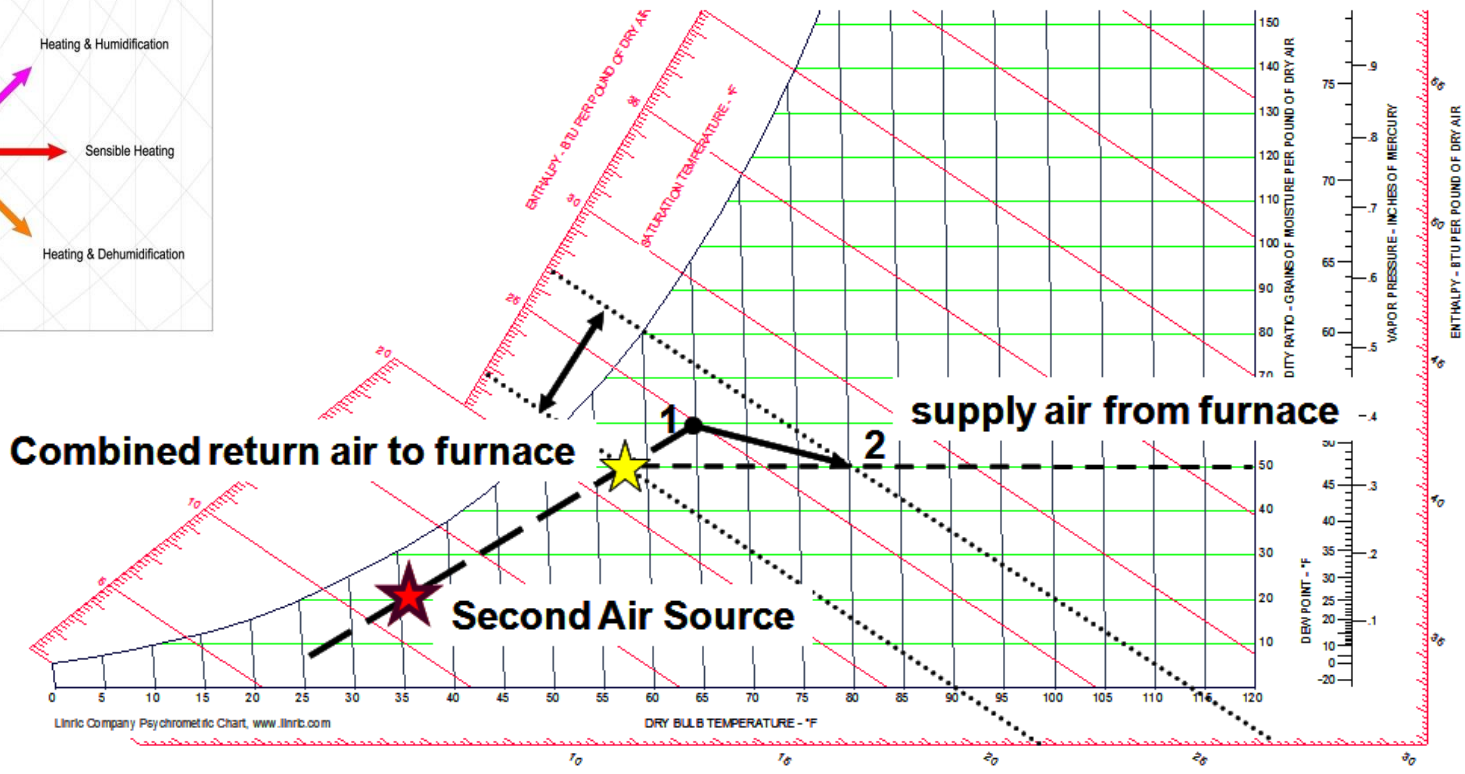


Heating System Example

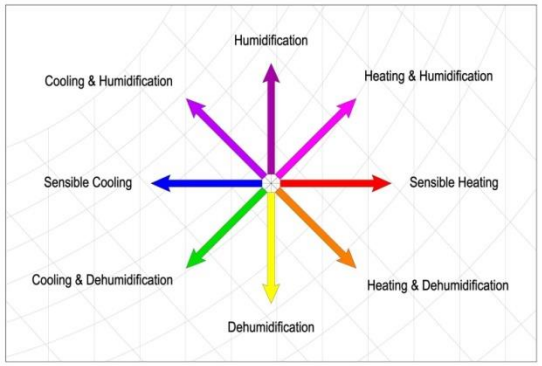
Second air source = 35 F and 85%

% duct leakage ~ 22%



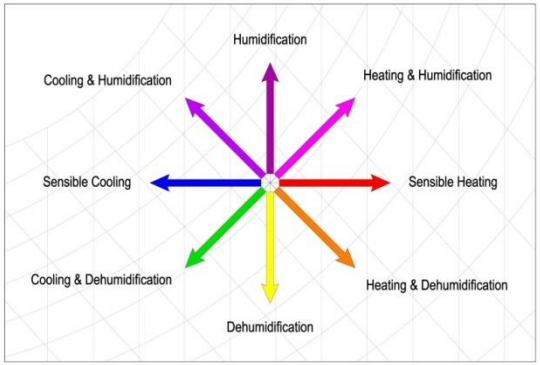


Cooling

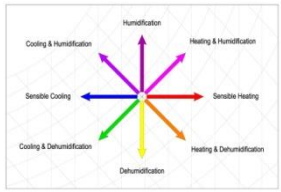

Humidification
Cooling & Humidification
Heating & Humidification
Sensible Cooling
Sensible Heating
Cooling & Dehumidification
Heating & Dehumidification
Dehumidification

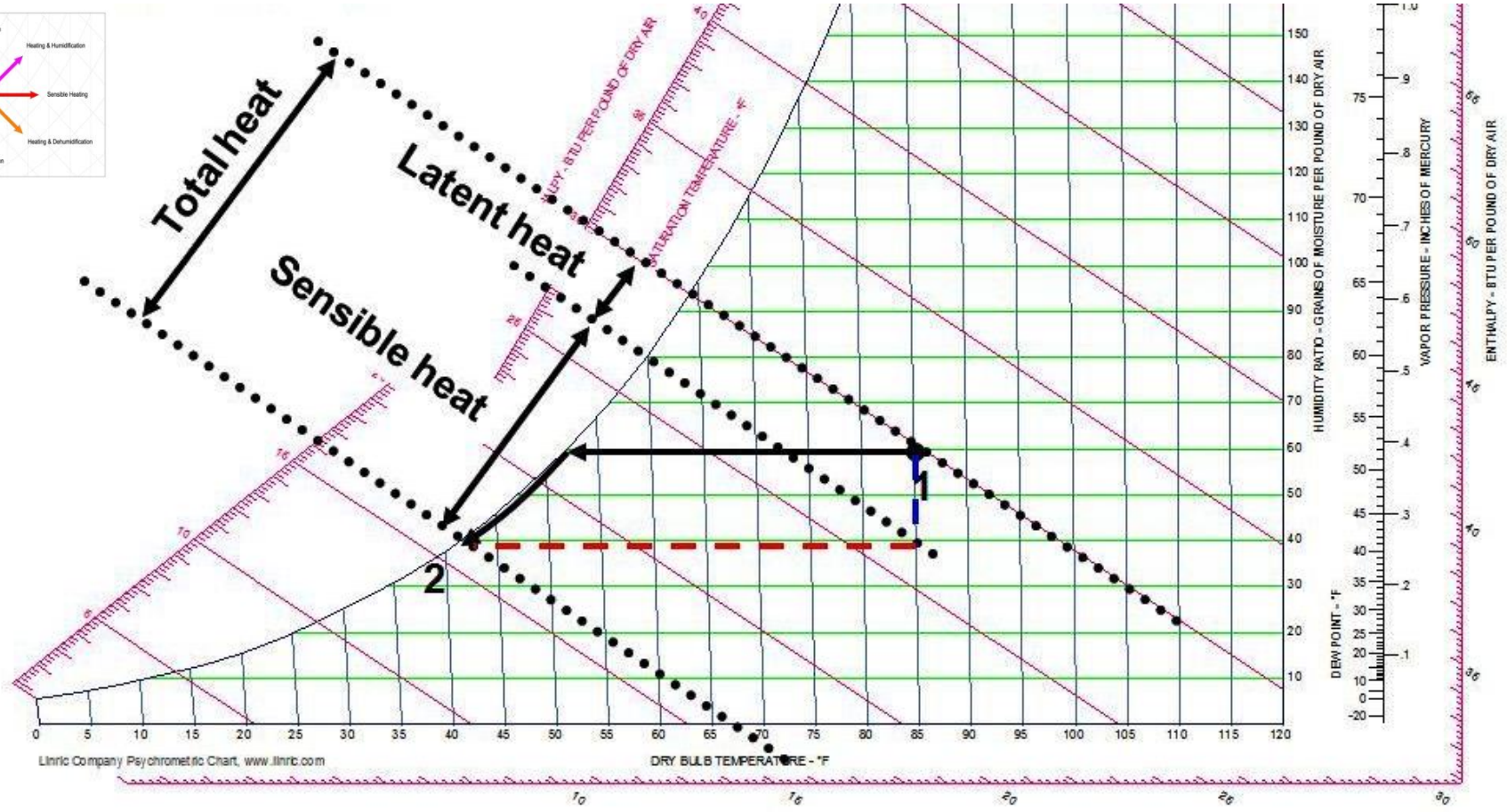
2
1
DRY BULB TEMPERATURE - °F
DEW POINT - °F
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF
VAPOR PRESSURE - INCHES OF MERCURY
ENTHALPY - BTU PER POUND OF DRY AIR
Linric Company Psychrometric Chart, www.linric.com

Cooling Systems



Cooling Systems





Solving the General Equations for Air Conditioning

Total Heat

$$q = (cfm)\ (4.5)\ (\Delta h)$$

$$q = Btuh$$

h = enthalpy, Btu per lb dry air

Sensible Heat

$$q = (cfm)\ (1.08)\ (\Delta t)$$

t = temperature F

Latent Heat

$$q = (cfm)\ (4840)\ (\Delta w)$$

w = humidity ratio, lb water per lb dry air

Solving the General Equations for Air Conditioning - Sources of Error

Sensible Heat

$$q\ (Btuh) = (cfm)\ (1.08)\ (\Delta t)$$

$$(\Delta t) = \frac{q\ (Btuh)}{(cfm)\ (1.08)}$$

cfm lower - (Δt) higher

cfm higher - (Δt) lower

q lower - (Δt) lower

q higher - (Δt) higher

Standard Operation of an Air Conditioner

12,000 Btuh / ton

400 cfm /ton

Sensible heat fraction = 0.70

Latent heat fraction = 0.30

Standard Operation of an Air Conditioner

Total Heat

$$q = (cfm)\ (4.5)\ (\Delta h)$$

$$12{,}000 = (400)\ (4.5)\ (\Delta h)$$

$$(\Delta h) = 27.3 \text{ Btu / lb dry air}$$

Sensible Heat

$$q = (cfm)\ (1.08)\ (\Delta t)$$

$$12{,}000\ (0.7) = (400)\ (1.08)\ (\Delta t)$$

$$(\Delta t) = 19 \text{ F}$$

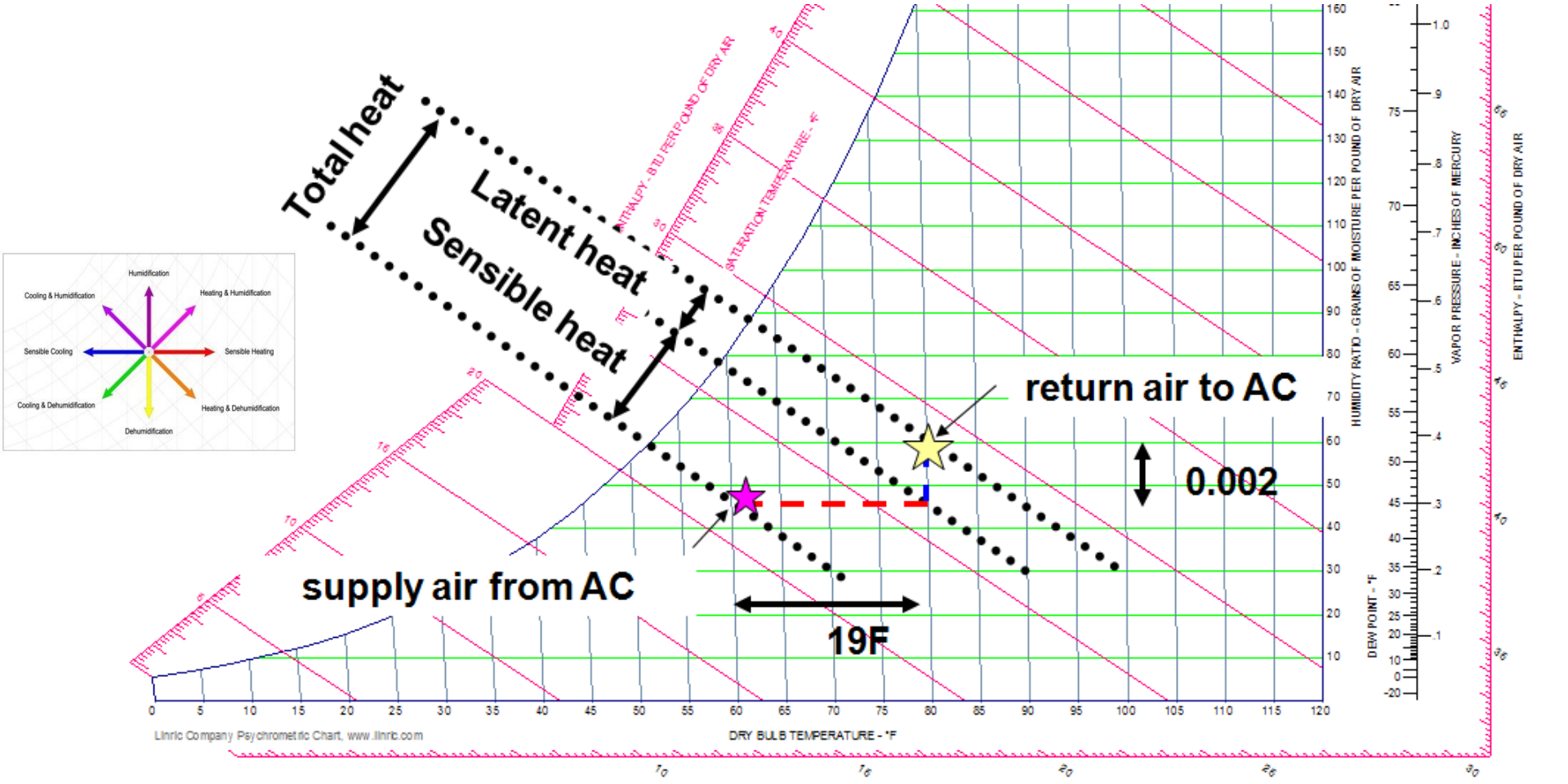
Latent Heat

$$q = (cfm)\ (4840)\ (\Delta w)$$

$$12{,}000\ (.3) = (400)\ (4840)\ (\Delta w)$$

$$(\Delta w) = 0.002 \text{ lb water / lb dry air}$$

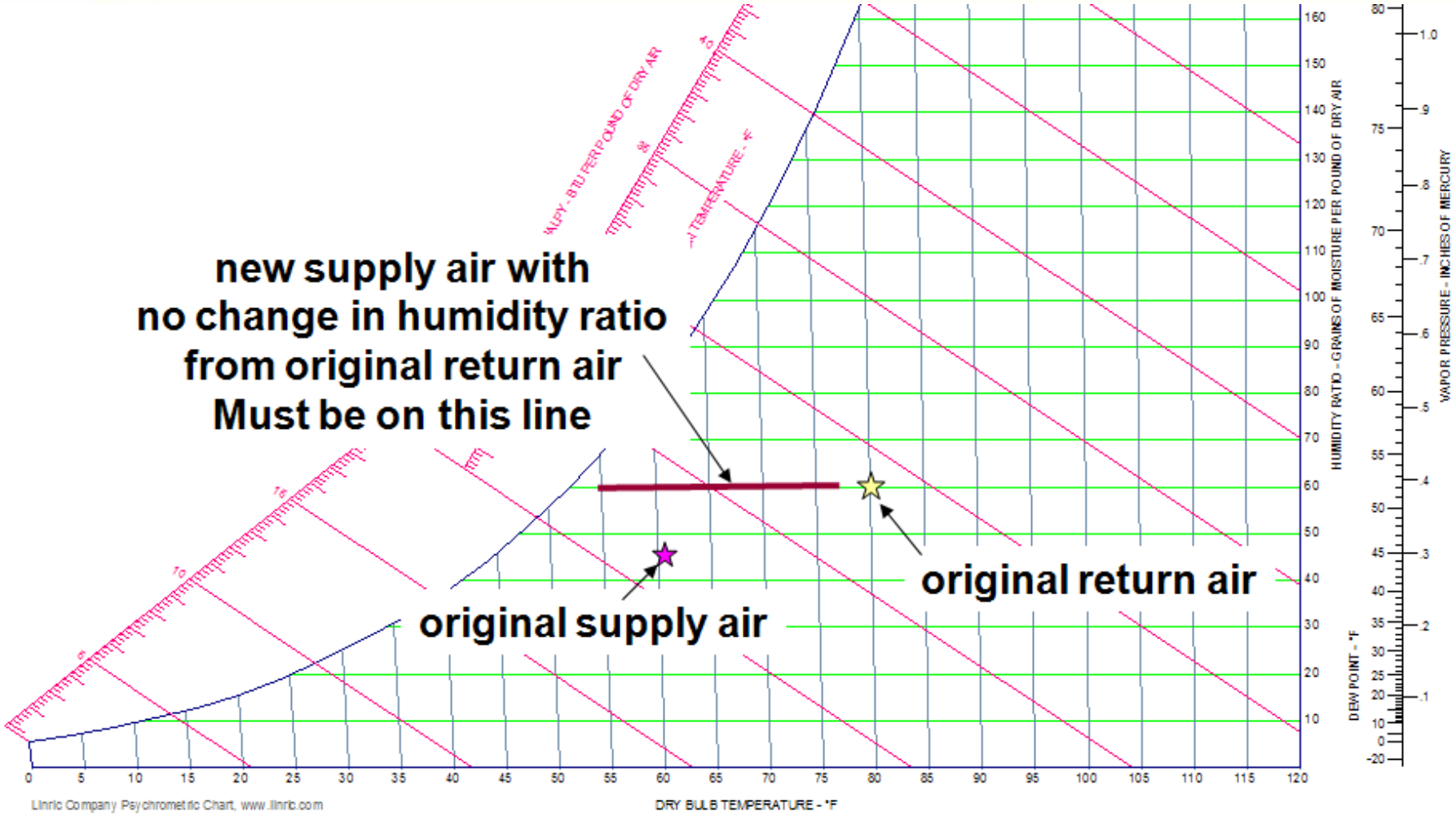
Standard Operation of an Air Conditioner



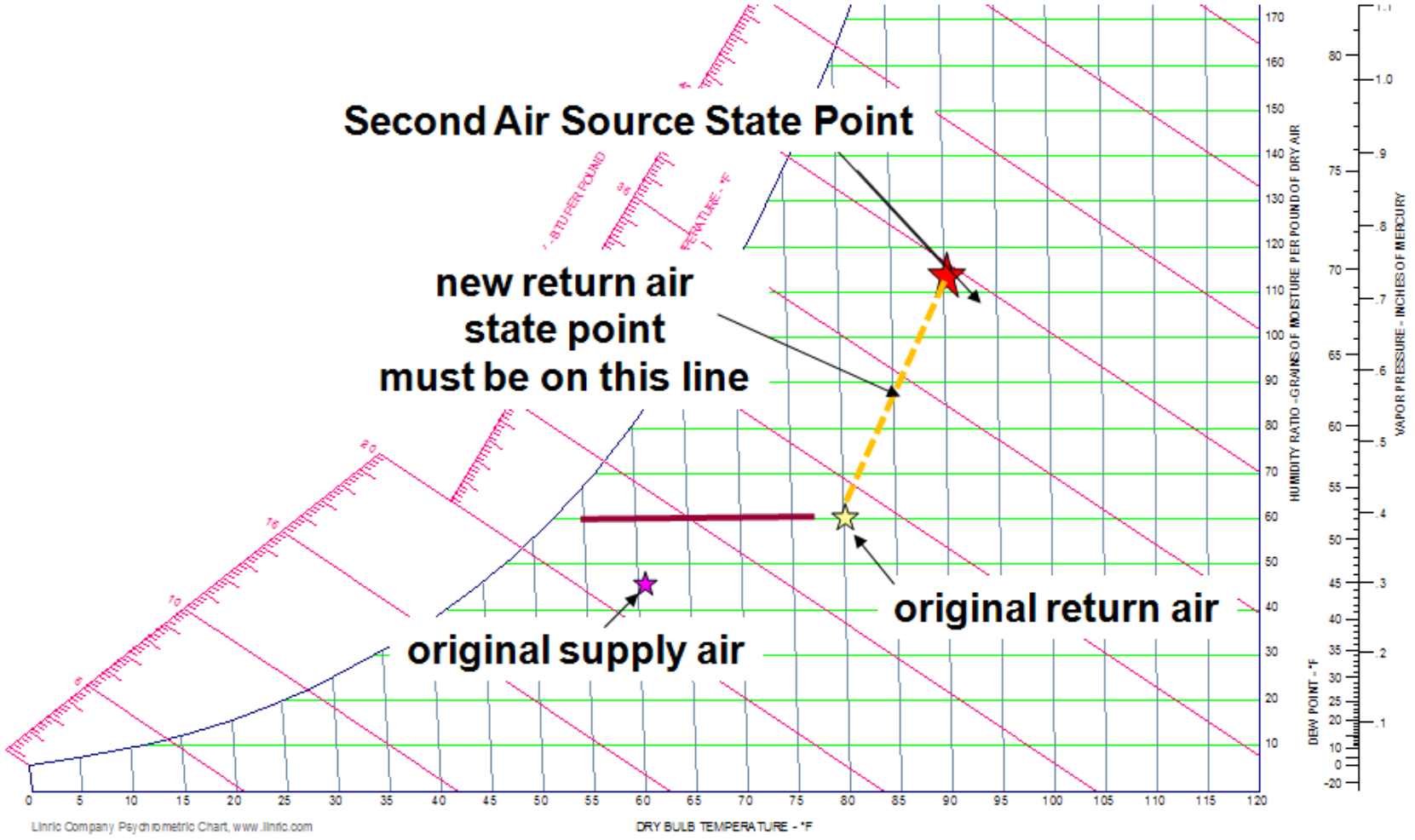
Operation of an Air Conditioner

What if humidity ratio of return air equals the humidity ratio of the supply air?

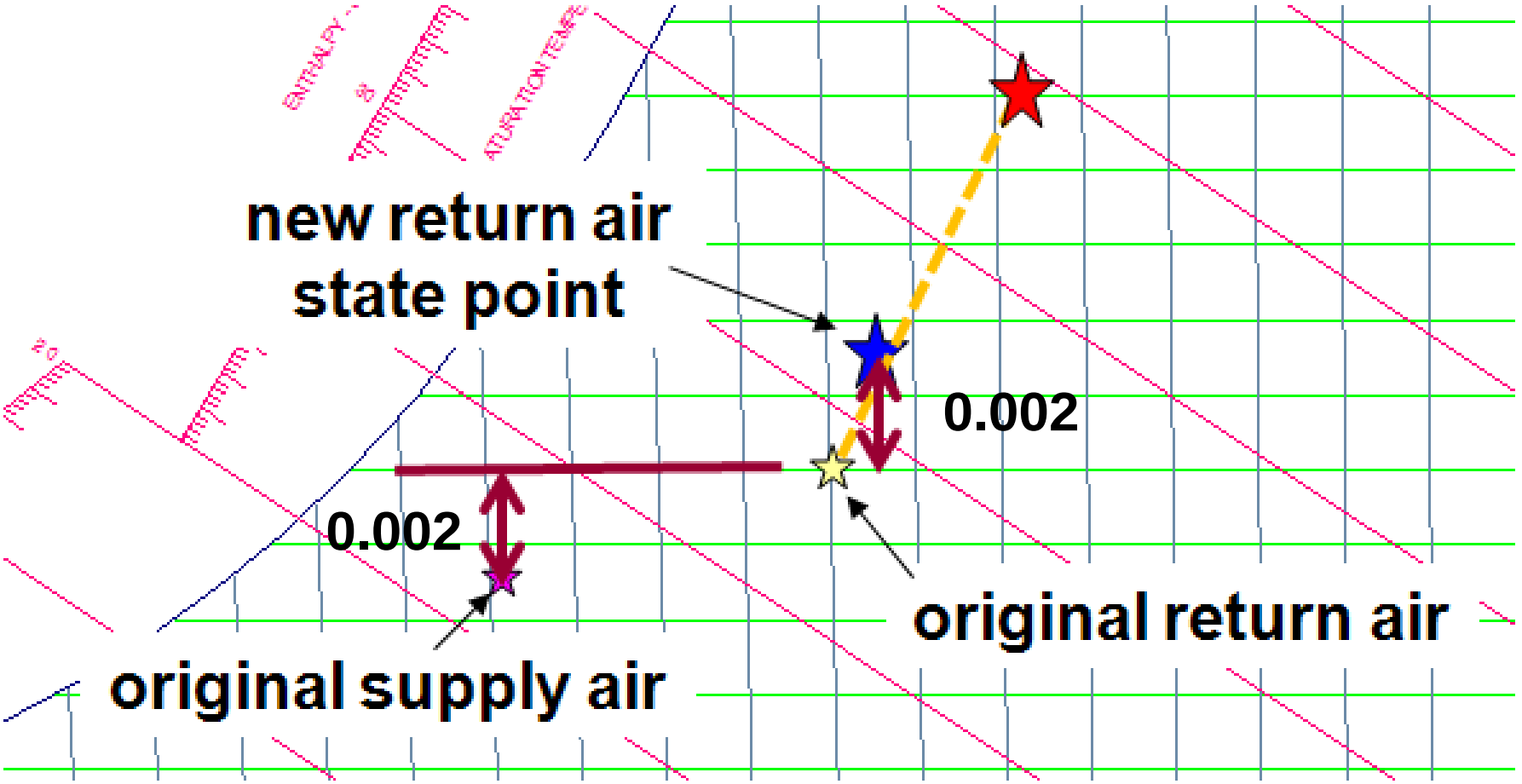
Air Conditioner Example



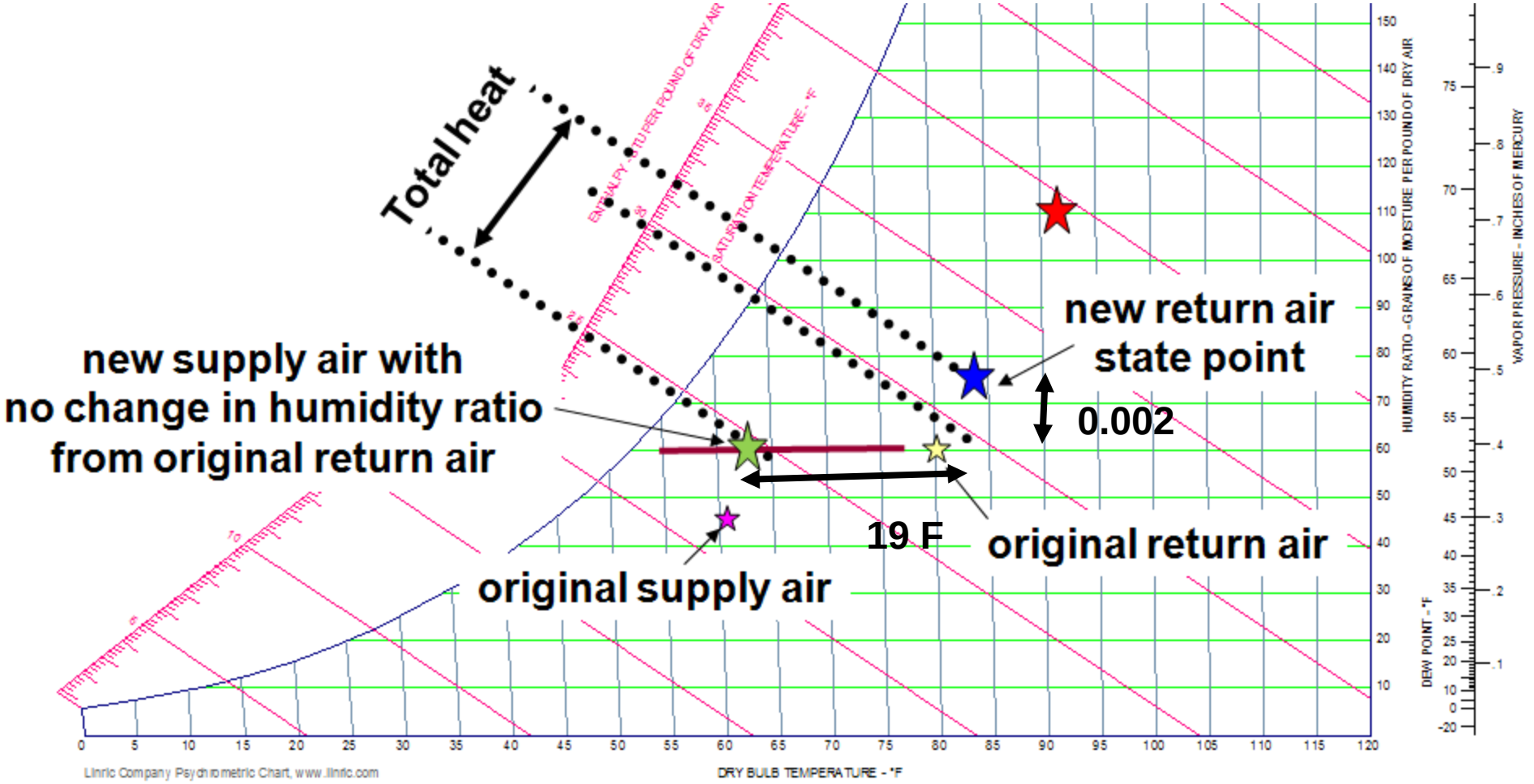
Air Conditioner Example



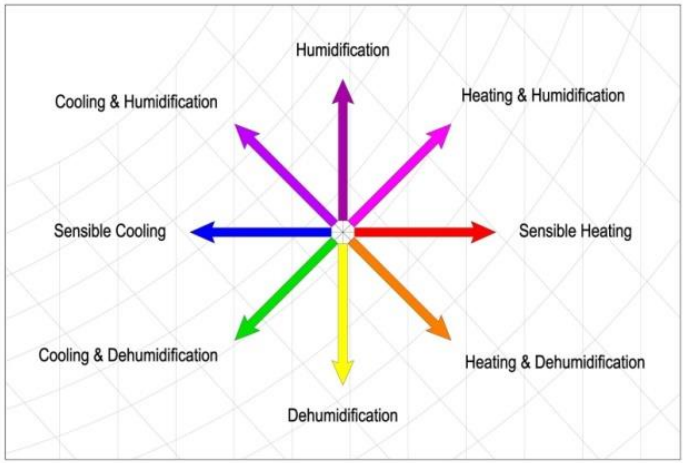
Air Conditioner Example



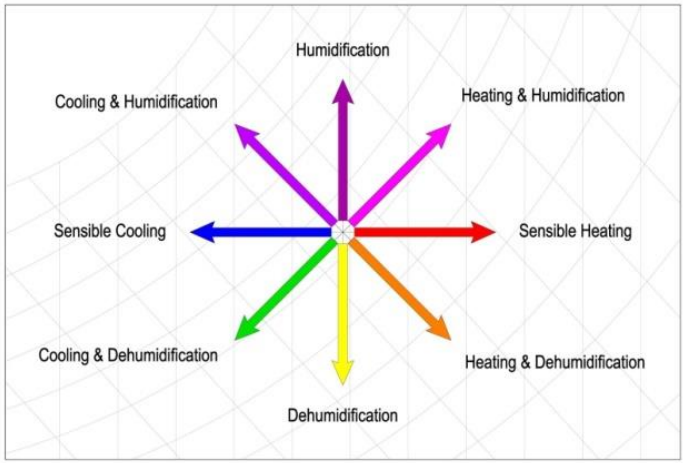
Air Conditioner Example



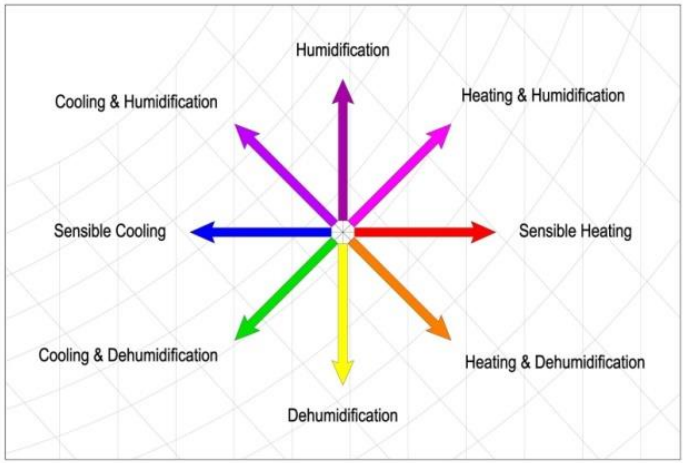
Evaporative Cooling



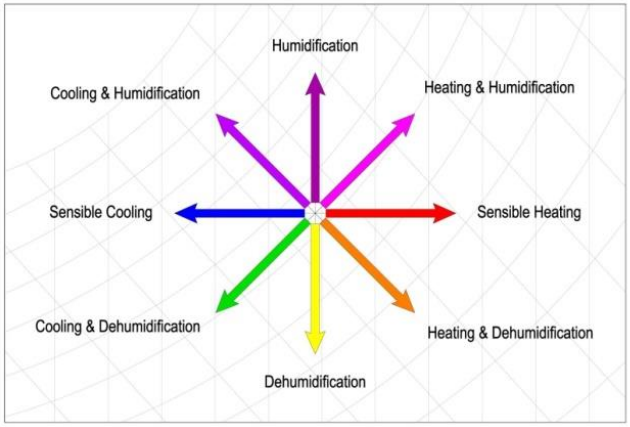
Annual Hourly Outside Air Conditions – Lexington KY



Human Comfort Zones



Annual Hourly Outside Air Conditions – Phoenix, AZ



Crawl Space Conditions Example

Annual Hourly Outside Air Conditions – Lexington KY