NFE 415: FOOD STORAGE ENGINEERING

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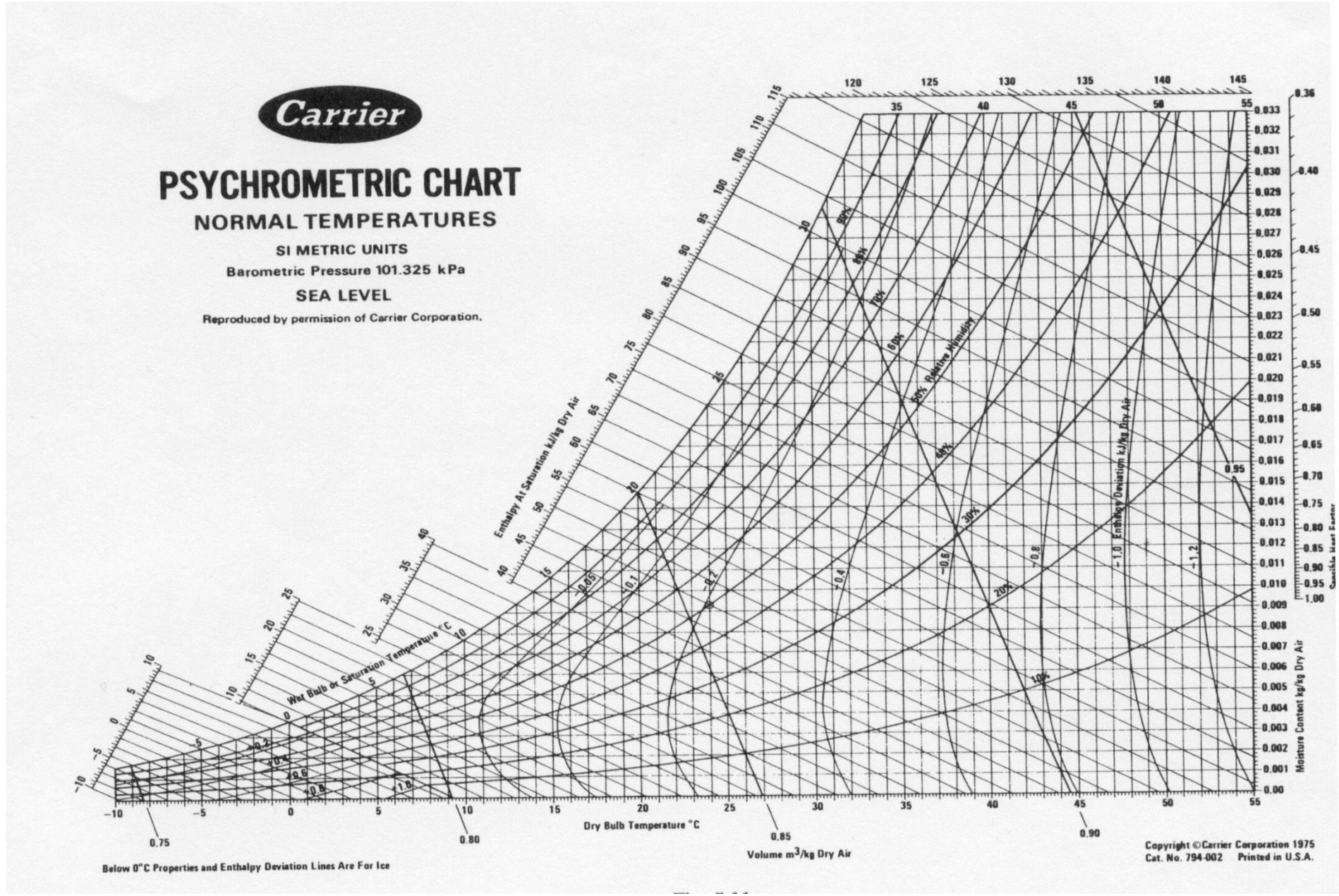
- Moist air flowing at 2 kg/s and a dry bulb temperature of 46C and wet bulb temperature of 20C mixes with another stream of moist air fl owing at 3 kg/s at 25C and relative humidity of 60%. Using a psychrometric chart, determine the (a) humidity ratio, (b) enthalpy, and (c) dry bulb temperature of the two streams mixed together.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PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL
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Wet Bulb or Saturation Temperature °C
Enthalpy At Saturation kJ/kg Dry Air
Relative Humidity
Enthalpy Deviation kJ/kg Dry Air
Moisture Content kg/kg Dry Air
Sensible Heat Factor
Dry Bulb Temperature °C
Volume m³/kg Dry Air
Below 0°C Properties and Enthalpy Deviation Lines Are For Ice
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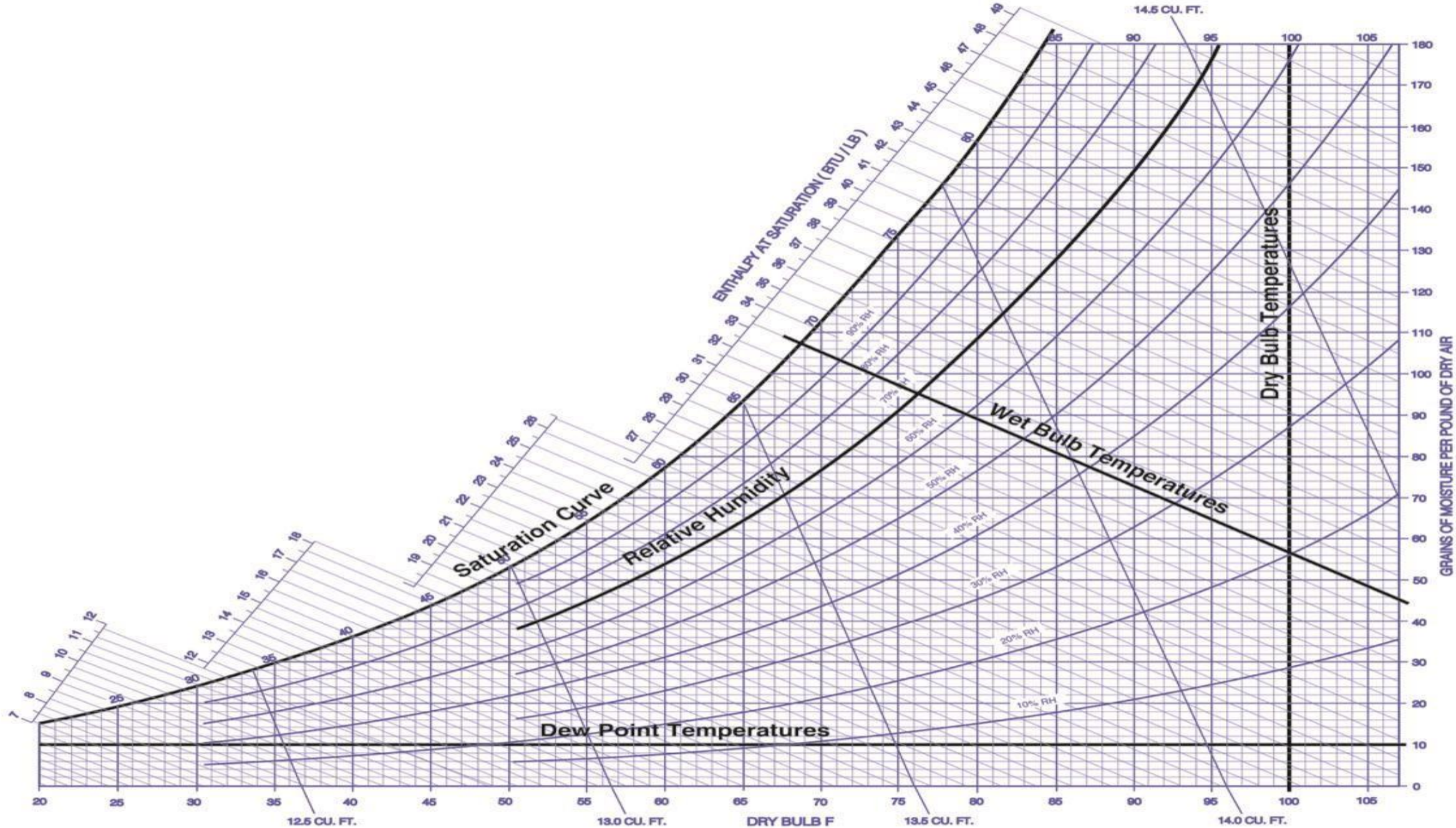

ENTHALPY AT SATURATION (BTU/LB)
Saturation Curve
Relative Humidity
Wet Bulb Temperatures
Dry Bulb Temperatures
Dew Point Temperatures
90% RH
80% RH
70% RH
60% RH
50% RH
40% RH
30% RH
20% RH
10% RH
14.5 CU. FT.
12.5 CU. FT.
13.0 CU. FT.
13.5 CU. FT.
14.0 CU. FT.
DRY BULB F
GRAINS OF MOISTURE PER POUND OF DRY AIR

TOPICS: AIR PROPERTY/ HUMIDITY

- Concept of Humidity
- Humidity.
- Relative Humidity.
- Identification of different parts of the chart
- Détermine air properties

CONCEPT OF HUMIDITY

- The water content in surrounding air is an important factor for the well-being of humans and animals.
- The level of comfort is determined by a combination of two factors: relative humidity and ambient temperature.
- Humidity is an important factor for operating certain equipment (e.g., high-impedance electronic circuits, electrostatic-sensitive components, high-voltage devices, fine mechanisms, etc.).
- Relative humidity near 50% at normal room temperature (20−25◦C).
- This may vary from as low as 38% for the Class clean rooms to 60% in hospital operating rooms

Concept of Humidity

- **Humidity can be measured by instruments called hygrometers.**
- Humidity can be measured by instruments called hygrometers.
- The first hygrometer was invented by Sir John Leslie (1766−1832).
- To detect moisture contents, a sensor in a hygrometer must be selective to water, and its internal properties should be modulated by the water concentration.
- Generally, sensors for moisture, humidity, and dew temperature can be capacitive, conductive, oscillating, or optical.

KEY THINGS:

- When designing an air conditioning system, the temperature and moisture content of the air to be conditioned, and the same properties of the air needed to produce the desired air conditioning effect.

HUMIDITY:

- Humidity: the amount of water vapor in the air. The maximum quantity of moisture that can be held in the air depends on air temperature.

RELATIVE HUMIDITY:

- The amount of water vapor in the air compared with the maximum amount of water vapor that the air can hold at a certain temperature.

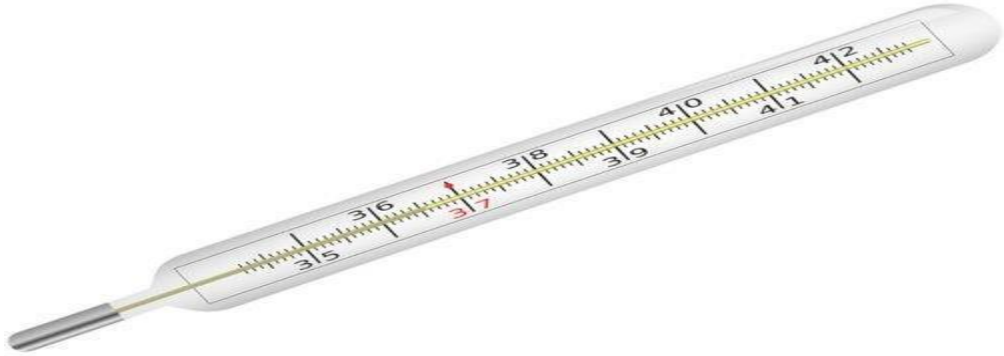
Formula :

$$\text{Relative humidity} = \frac{\text{Partial pressure of water vapor}}{\text{Saturation vapor pressure}} \times 100$$

- When air holds all of the water that it can at a given temperature, it is said to be saturated.
- Saturated air has a relative humidity of 100%

DRY-BULB TEMPERATURE

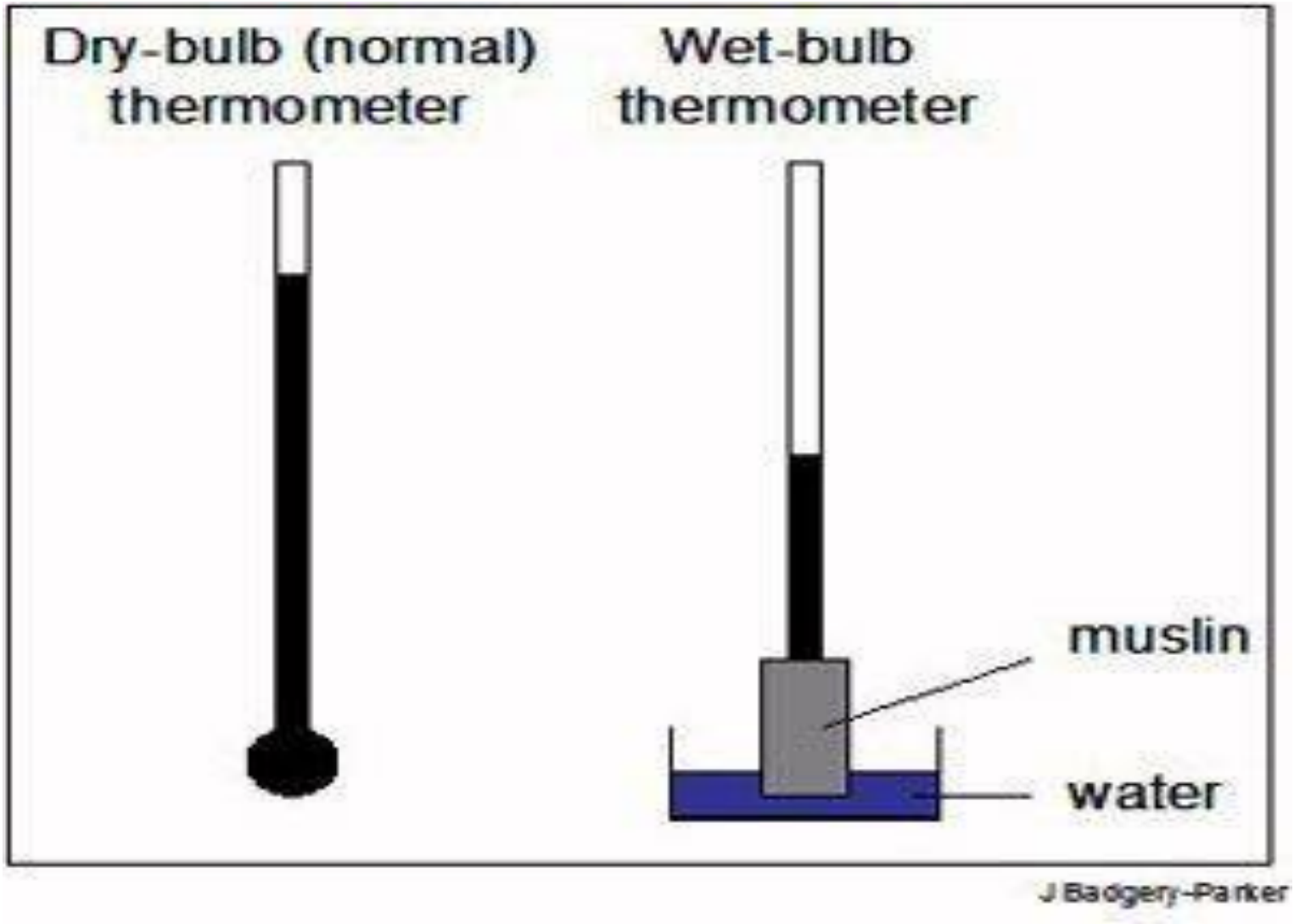
- The dry-bulb temperature is the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.
- The term dry-bulb is customarily added to temperature to distinguish it from wet-bulb and dew point temperature.



WET BULB TEMPERATURE

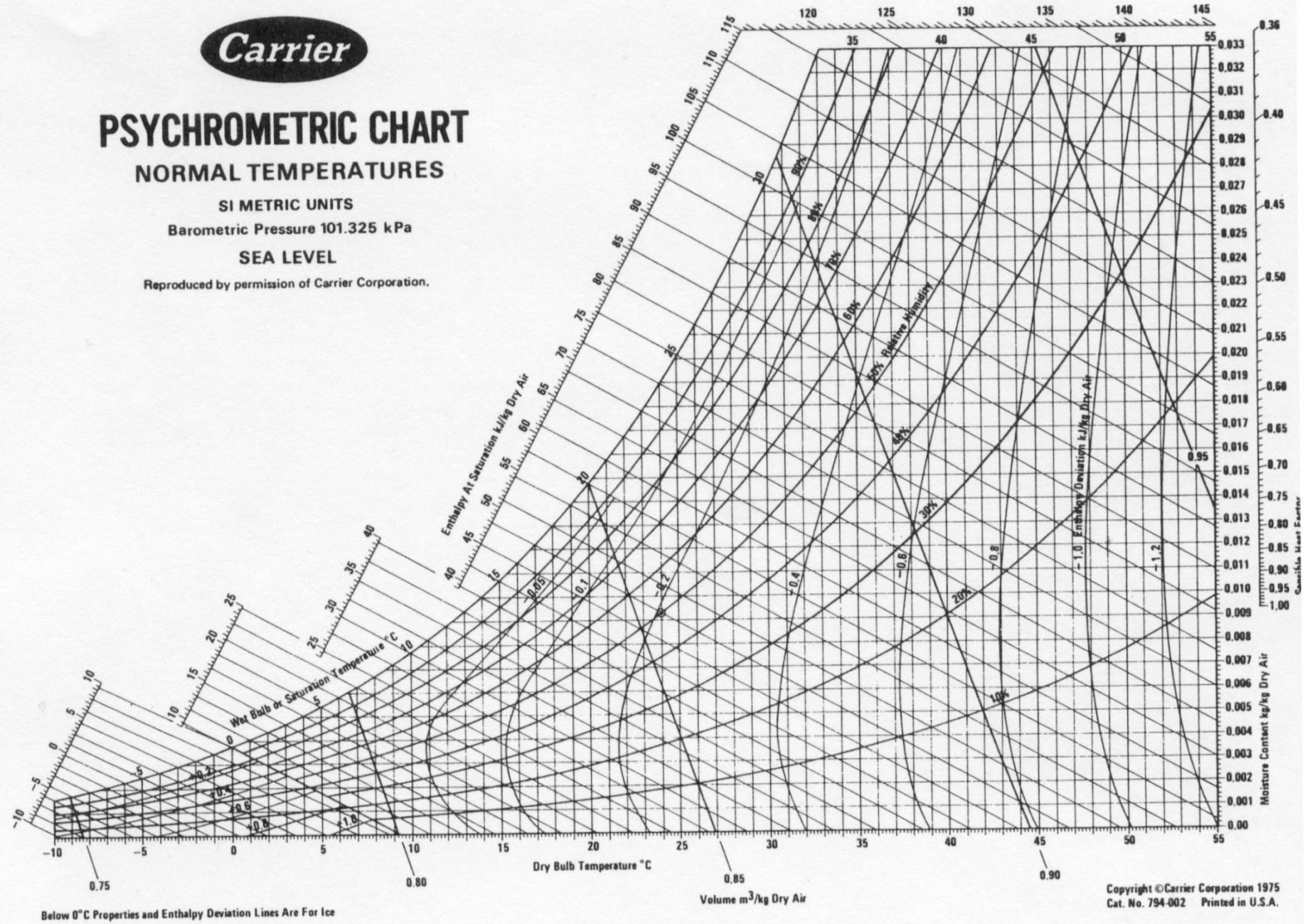
- Wet bulb temperature is the temperature recorded by thermometer when the bulb is enveloped by cotton wick saturated with water.
- The accuracy of a simple wet-bulb thermometer depends on how fast air passes over the bulb and how well the thermometer is shielded from the radiant temperature of its surroundings.

MEASUREMENT OF TEMPERATURE



WHAT IS THE DEWPOINT TEMPERATURE?

- The dewpoint temperature is the temperature at which the air can no longer "hold" all of the water vapor which is mixed with it, and some of the water vapor must condense into liquid water.
- The dew point is always lower than (or equal to) the air temperature.
- At this point where the dew point temperature equals the air temperature, the relative humidity is 100%.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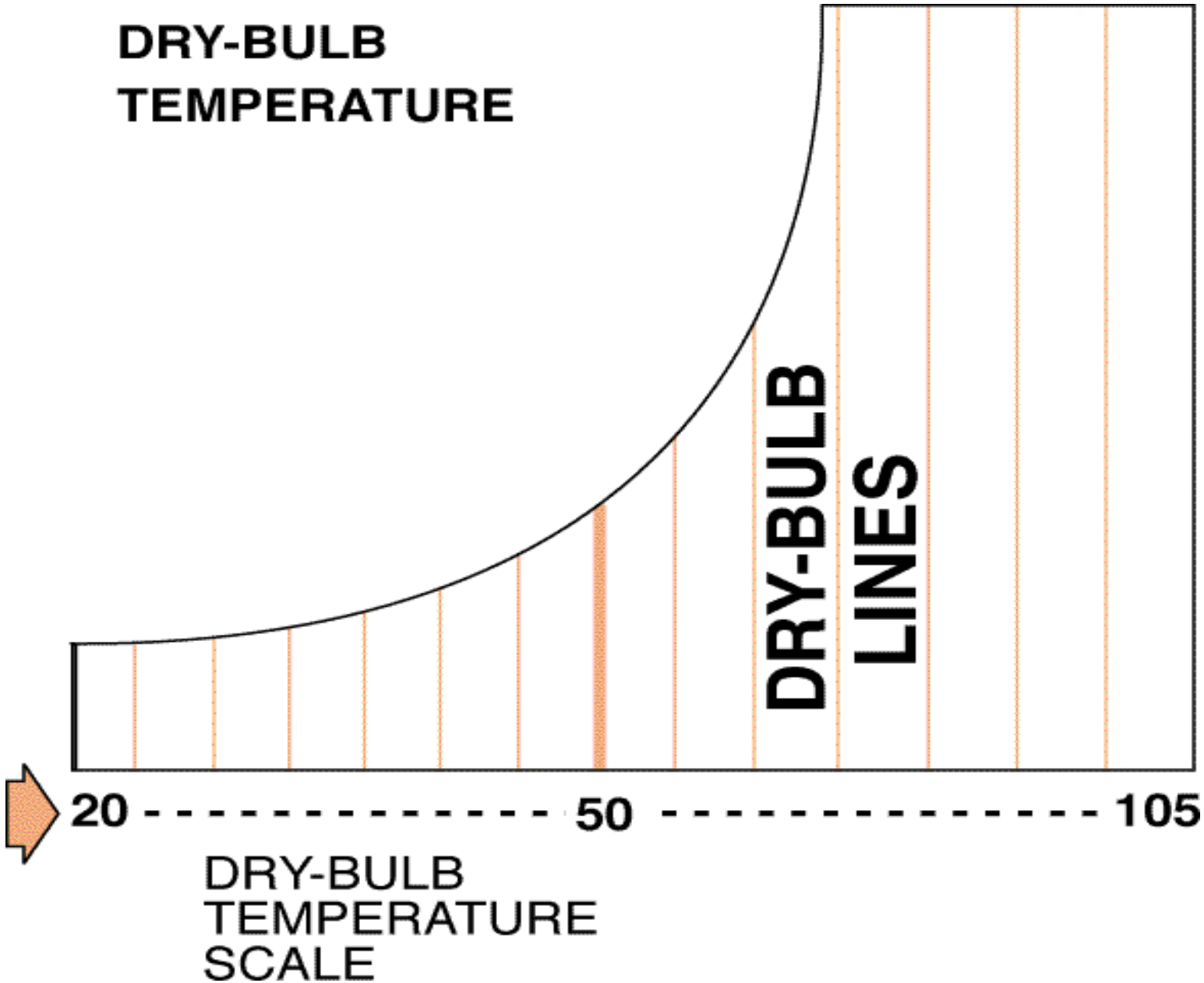
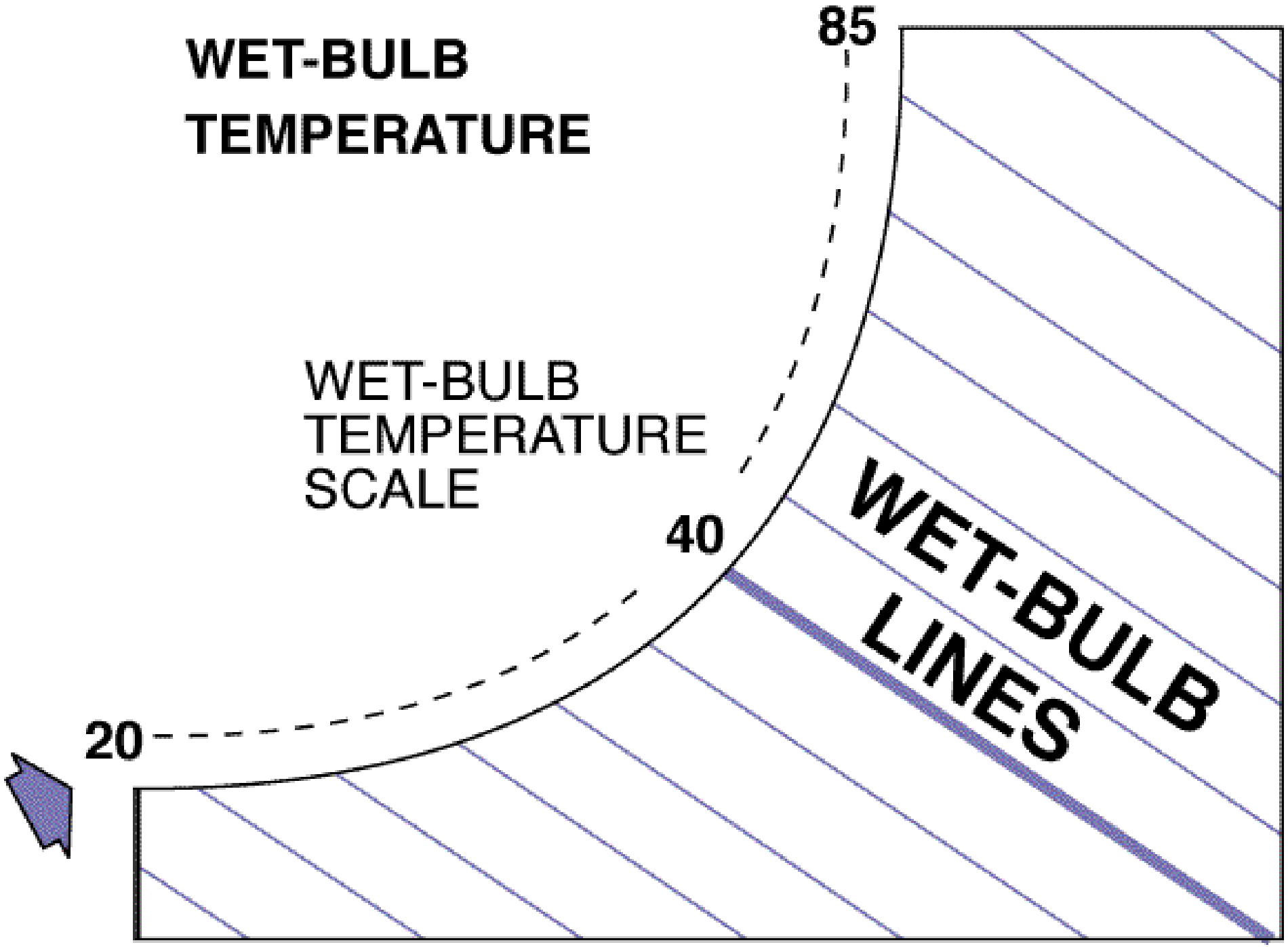
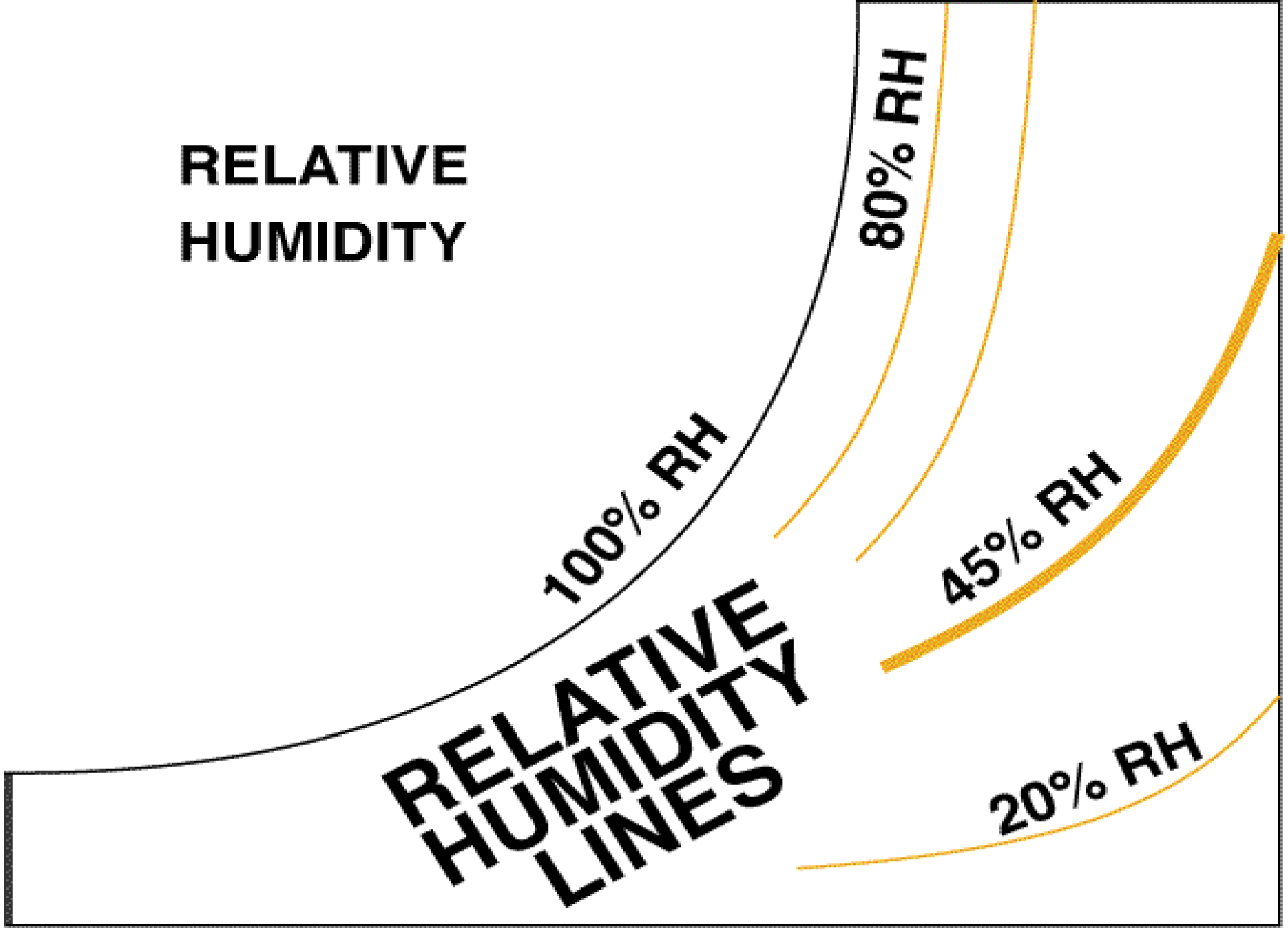
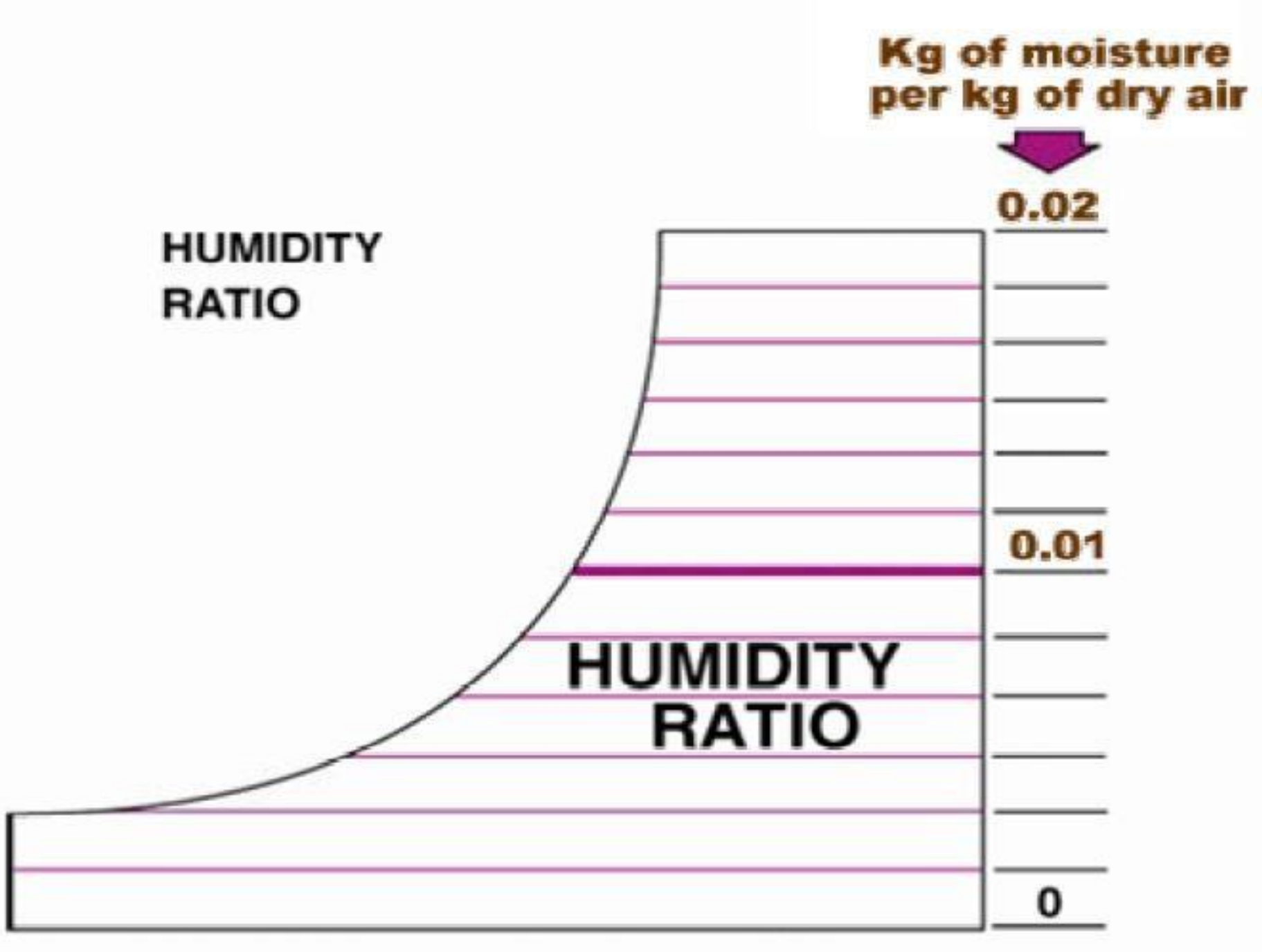
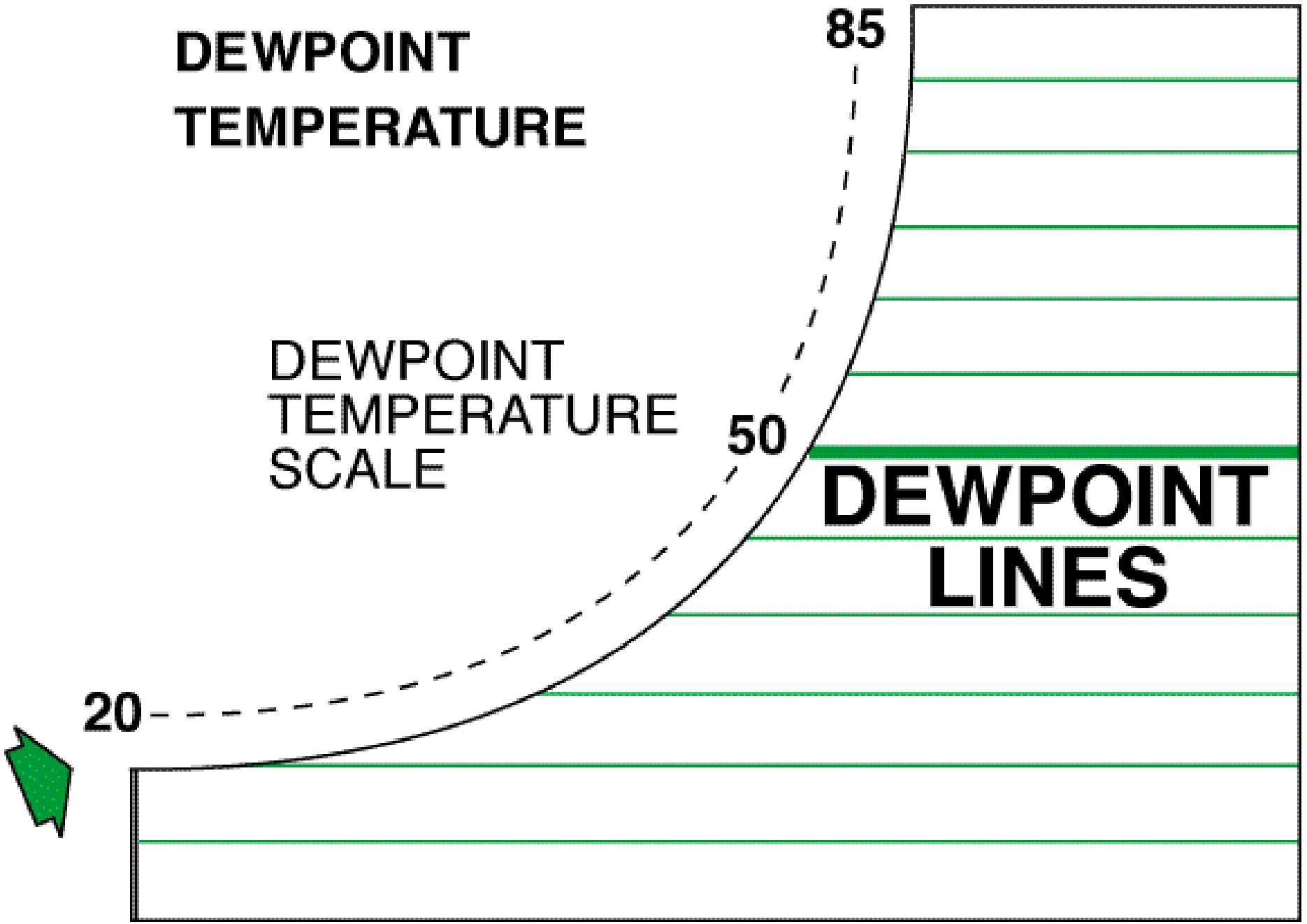
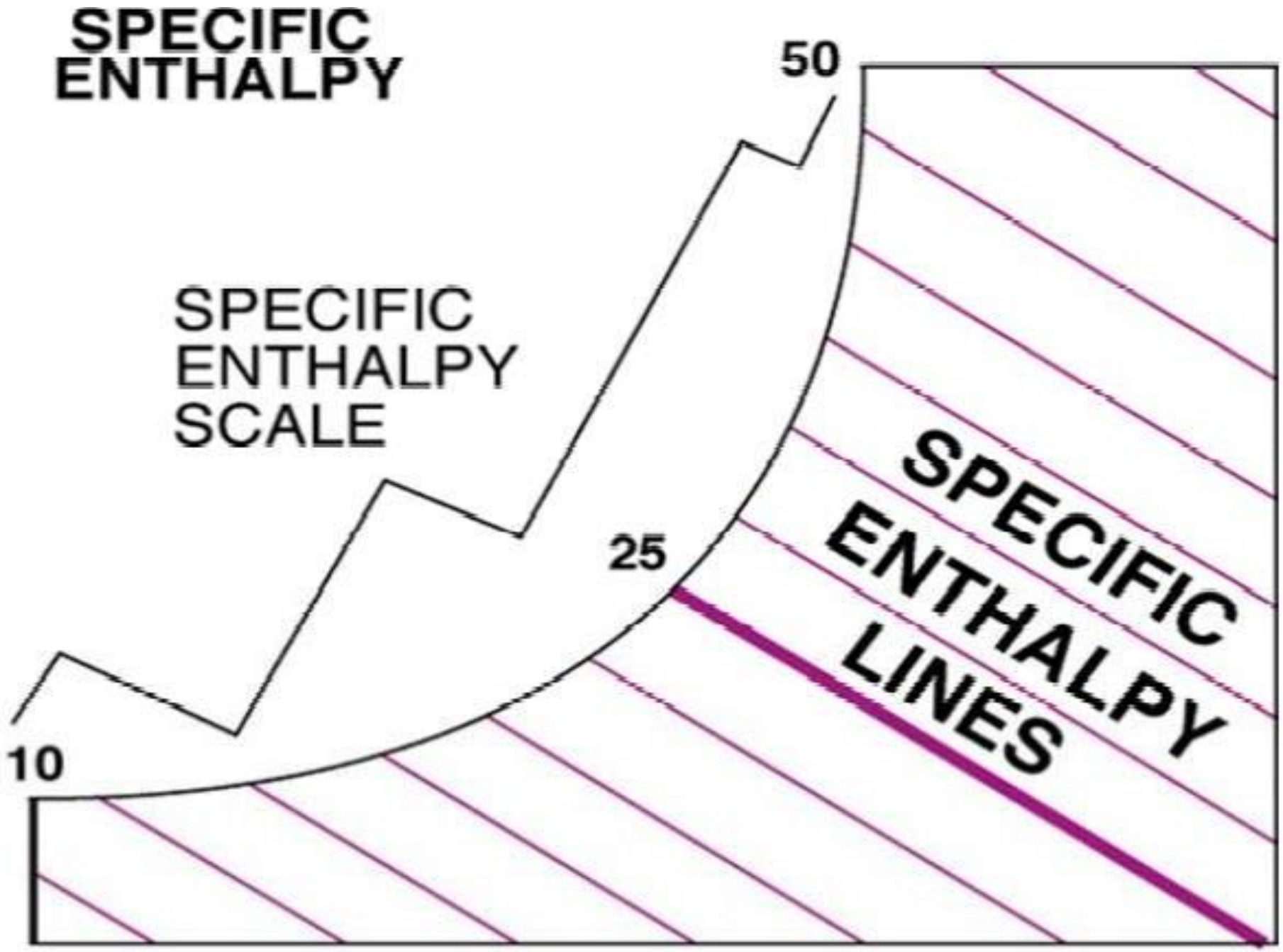

DRY-BULB
TEMPERATURE
DRY-BULB
LINES
20
50
105
DRY-BULB
TEMPERATURE
SCALE

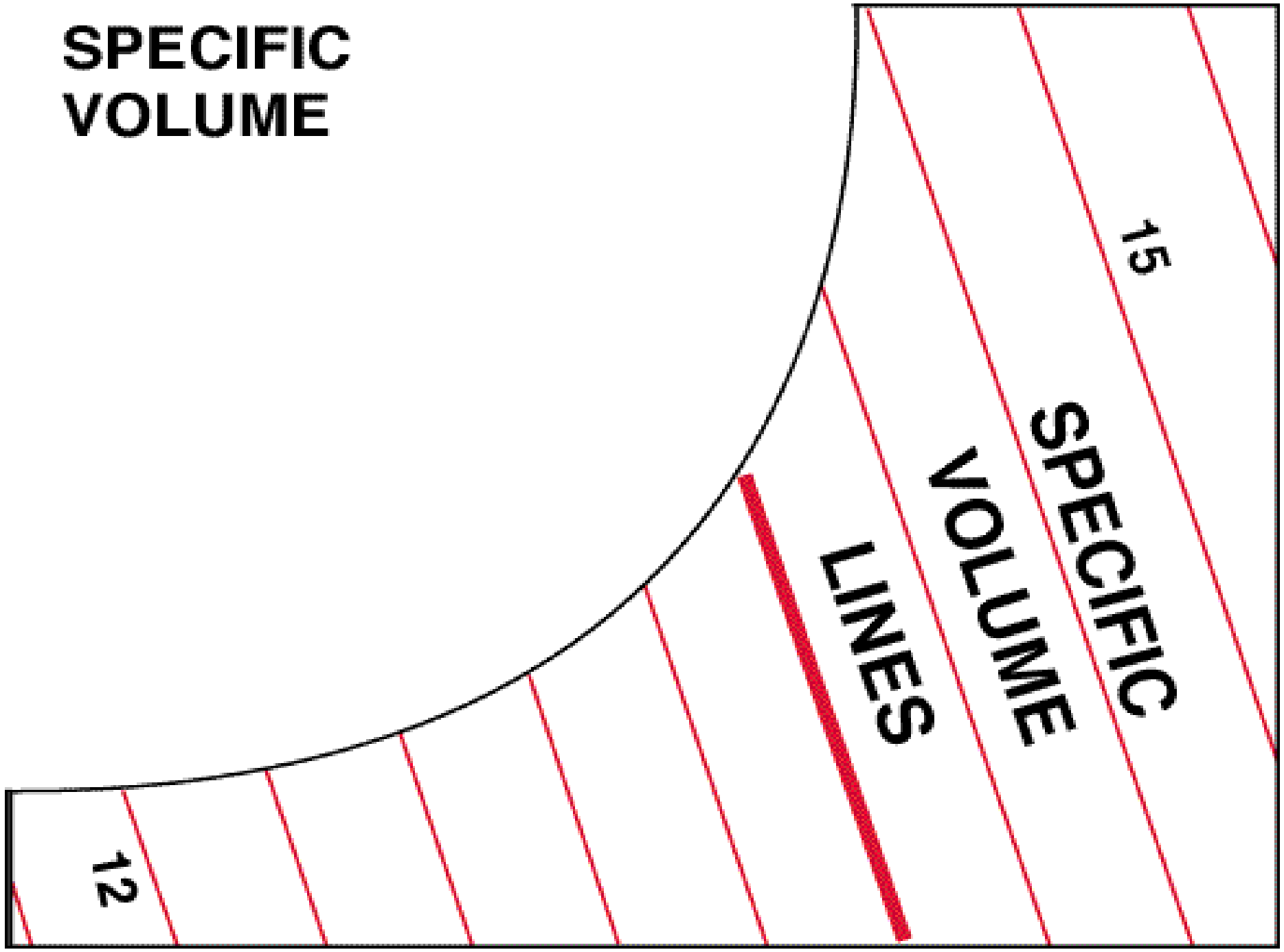

WET-BULB
TEMPERATURE
WET-BULB
TEMPERATURE
SCALE
85
40
20
WET-BULB
LINES


RELATIVE HUMIDITY
100% RH
80% RH
45% RH
20% RH
RELATIVE HUMIDITY LINES

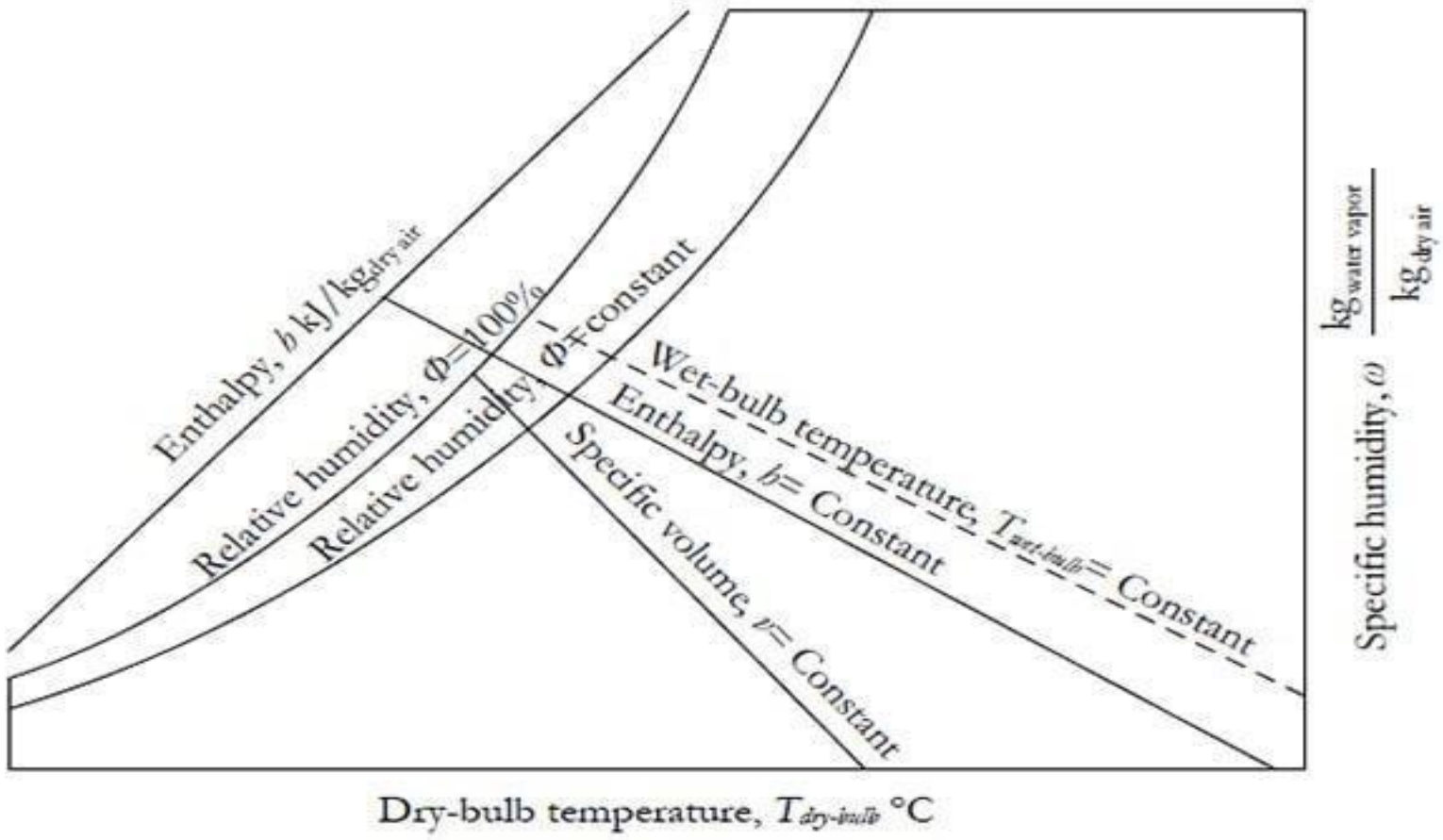

Kg of moisture
per kg of dry air
0.02
HUMIDITY
RATIO
0.01
HUMIDITY
RATIO
0


DEWPOINT
TEMPERATURE
85
DEWPOINT
TEMPERATURE
SCALE
50
DEWPOINT
LINES
20

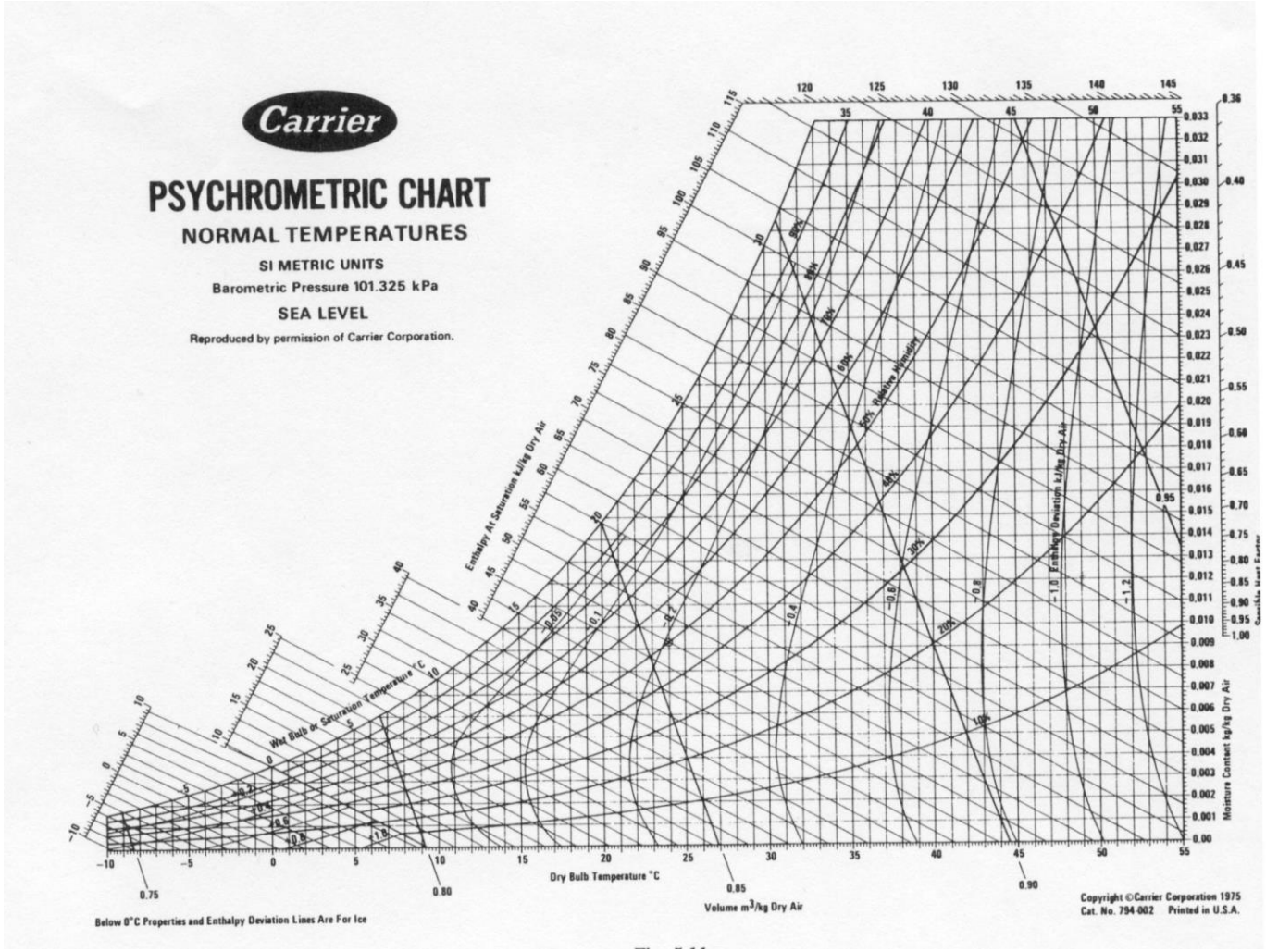

SPECIFIC ENTHALPY
50
SPECIFIC ENTHALPY SCALE
25
10
SPECIFIC ENTHALPY LINES


SPECIFIC
VOLUME
15
SPECIFIC
VOLUME
LINES
12

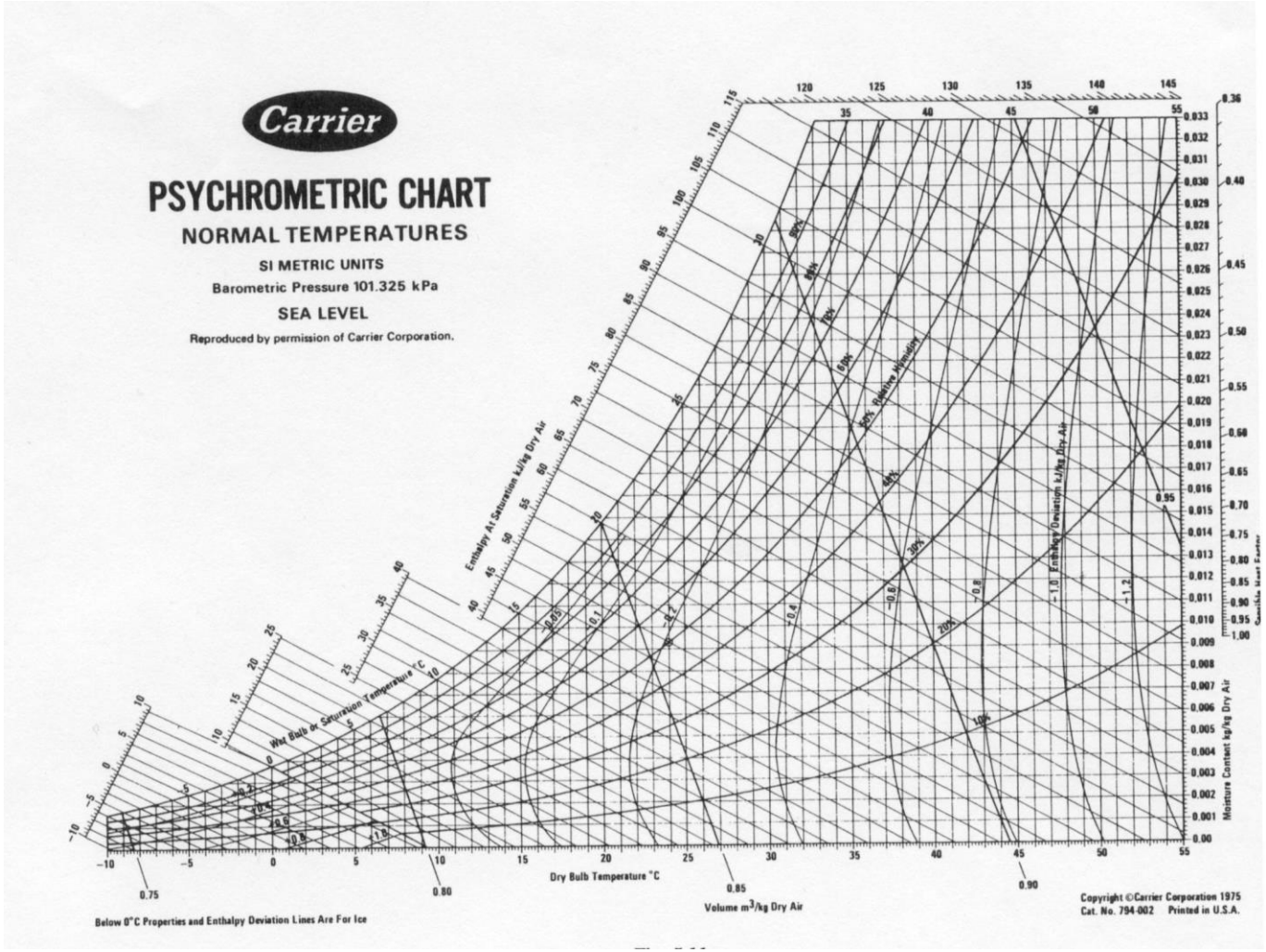
PUT ALL TOGETHER



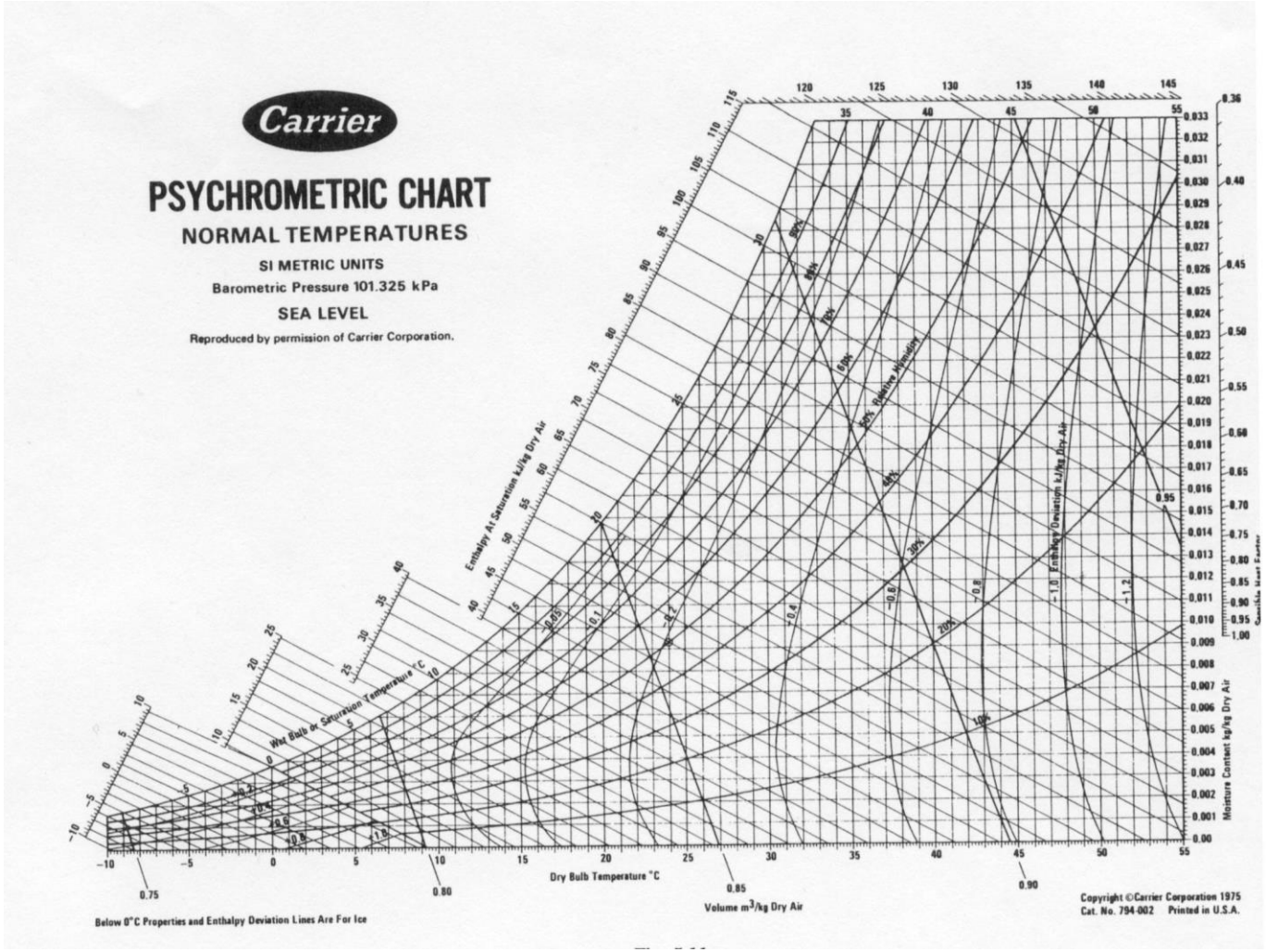
Air Heating Process



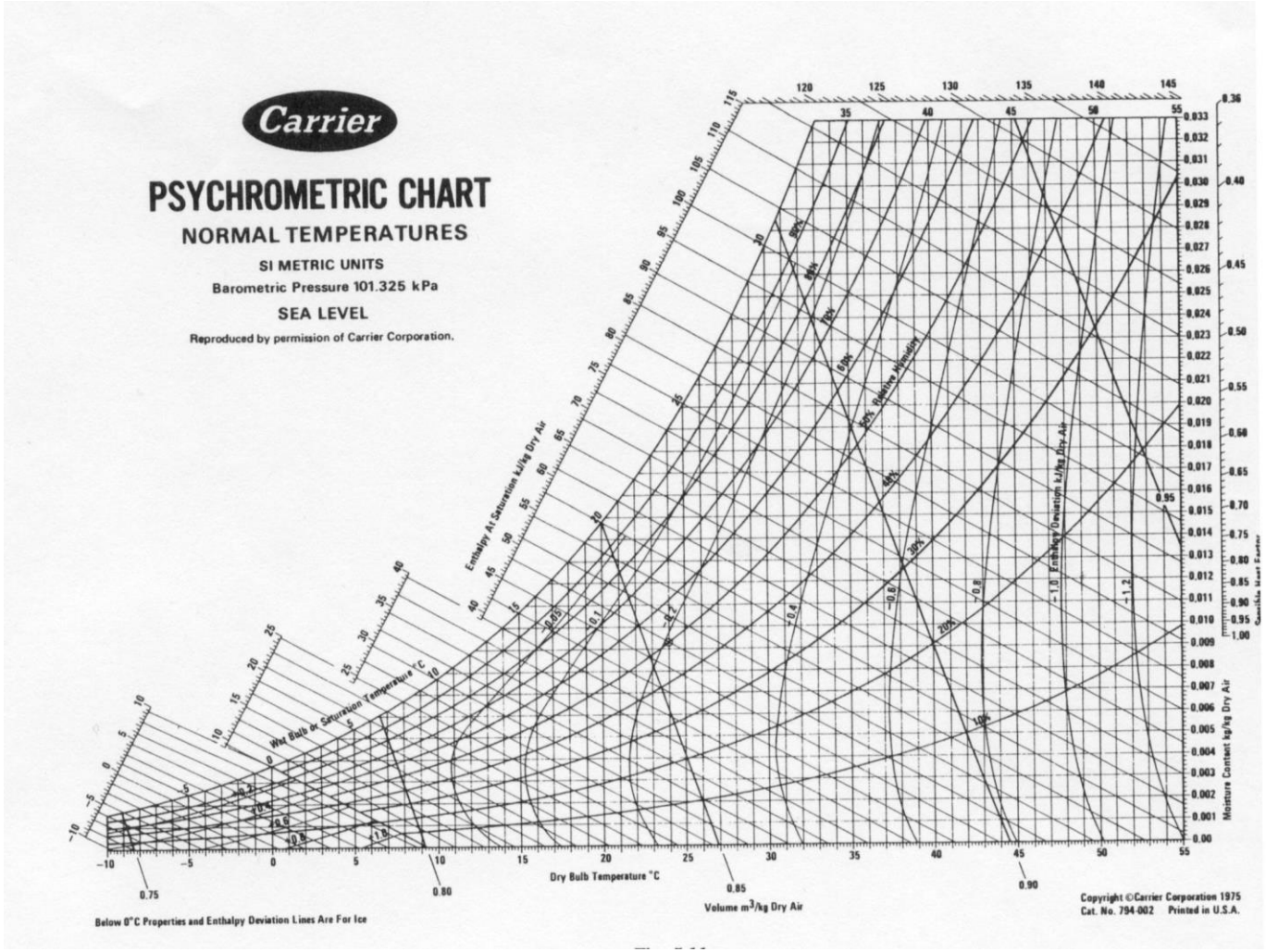
Air Cooling Process



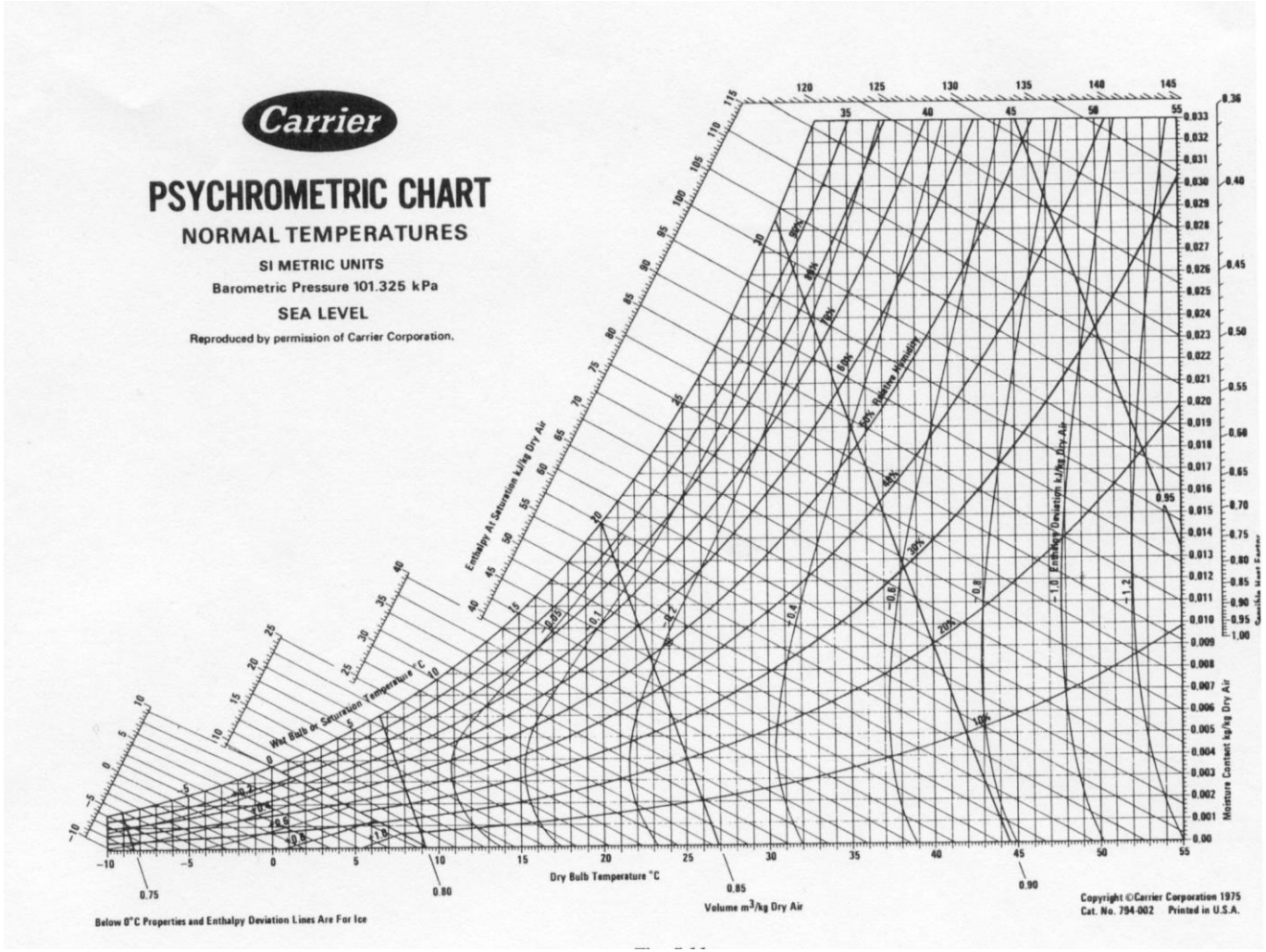
Air Heating Process



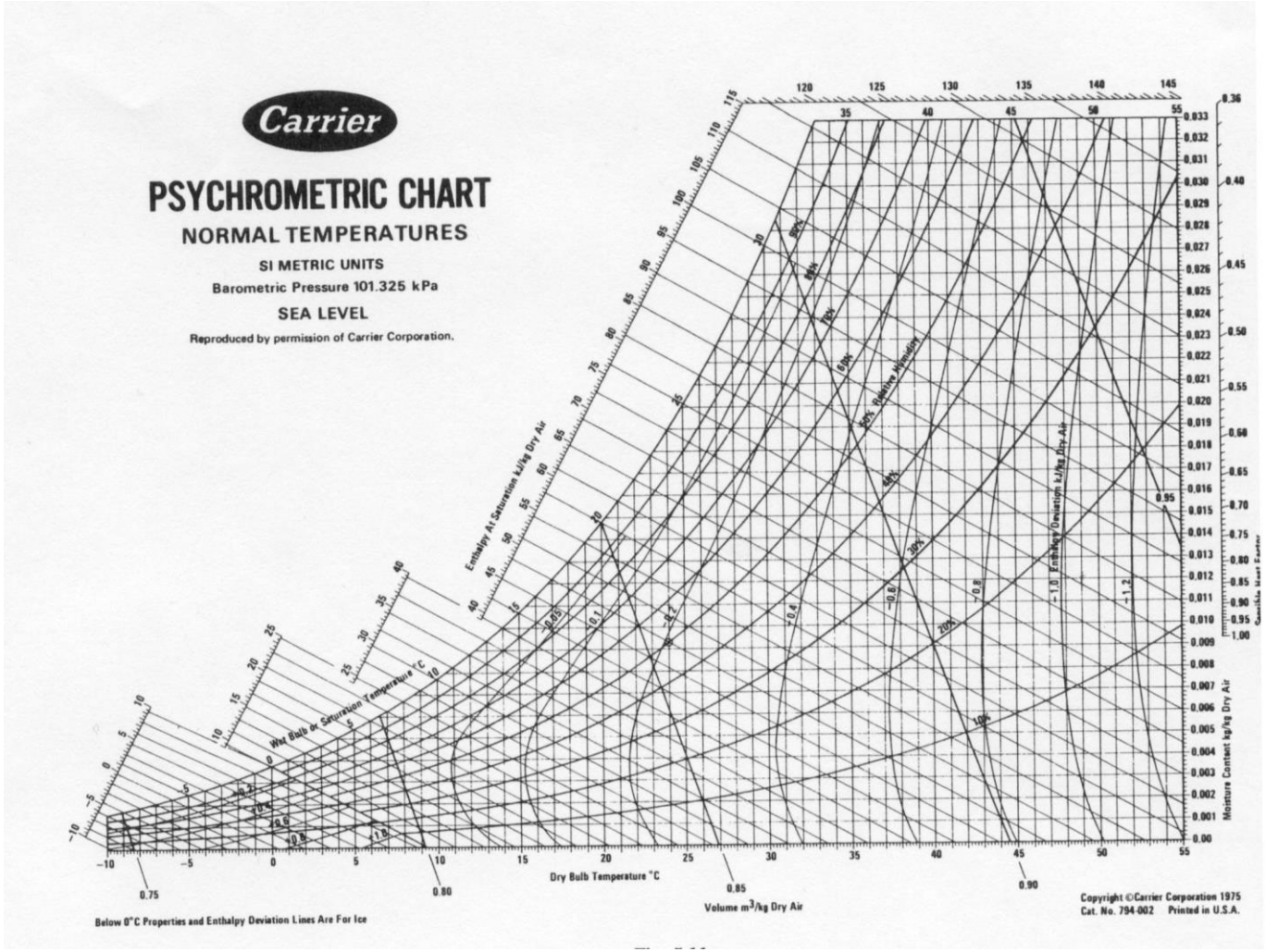
Air Humidification Process

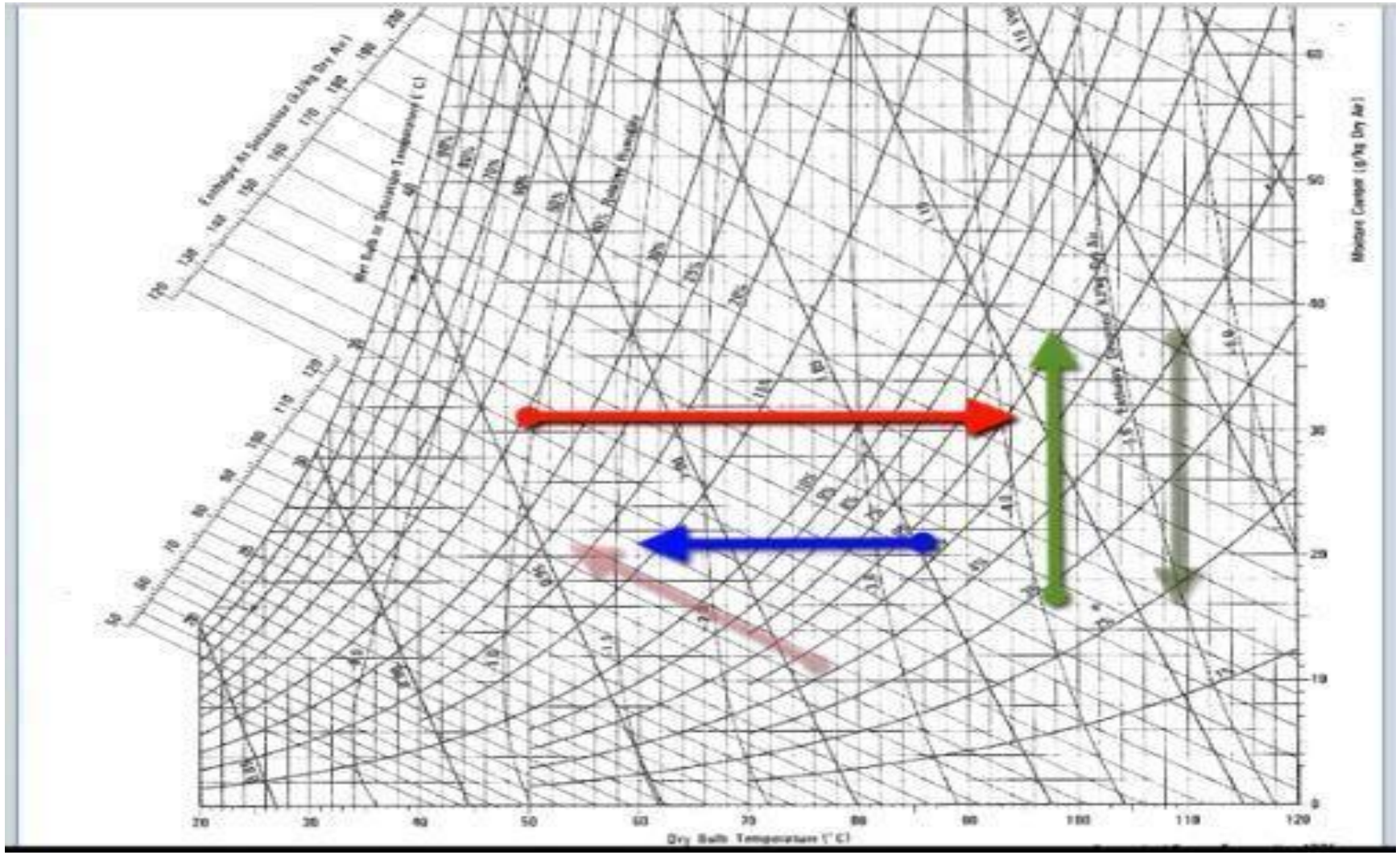


Air Dehumidification Process



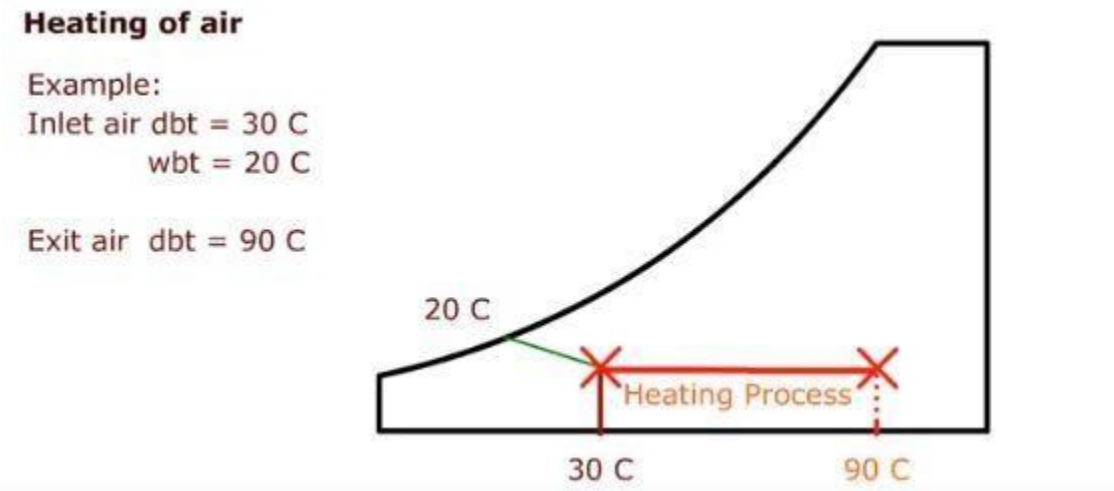
ADIABATIC SATURATION PROCESS




Dry Bulb Temperature (°C)
Moisture Content (g/kg Dry Air)

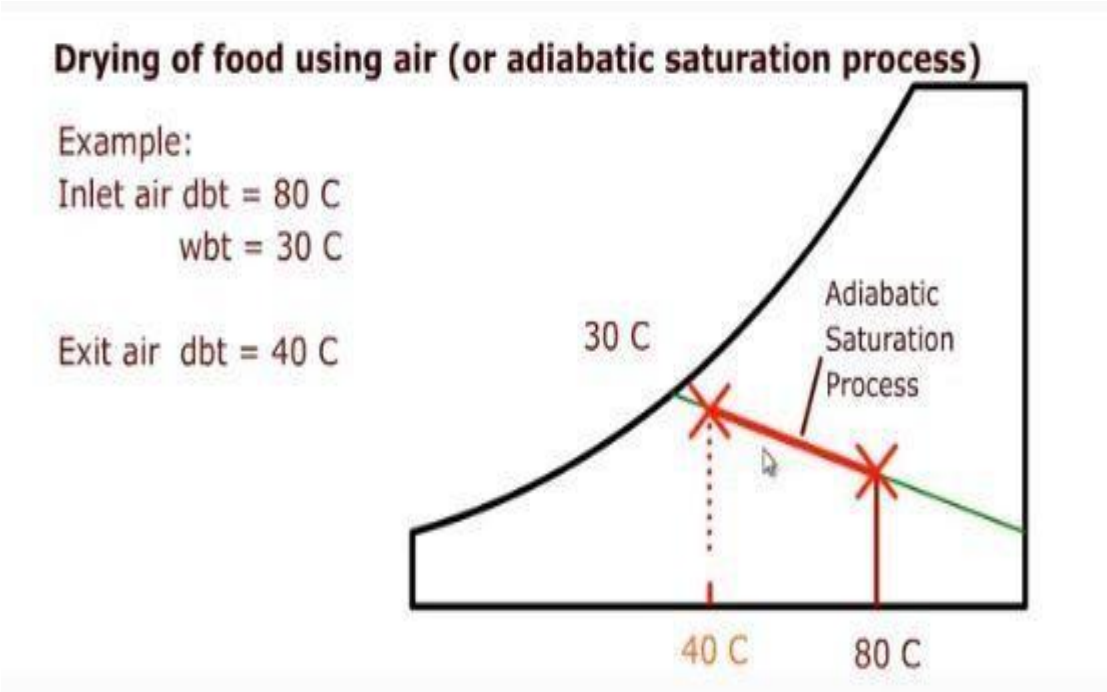
PROBLEM

- Inlet air temperature is 30 C and wet bulb temperature is 20C. Air is heated to 90 C and what would be other parameter.



PROBLEM 2:

- Inlet air temperature is 30 C and wet bulb temperature is 20C. Air is heated to 90 C and what would be other parameter.



EXAMPLE

- Given: T = 25°C, Tw =20°C
- Required:

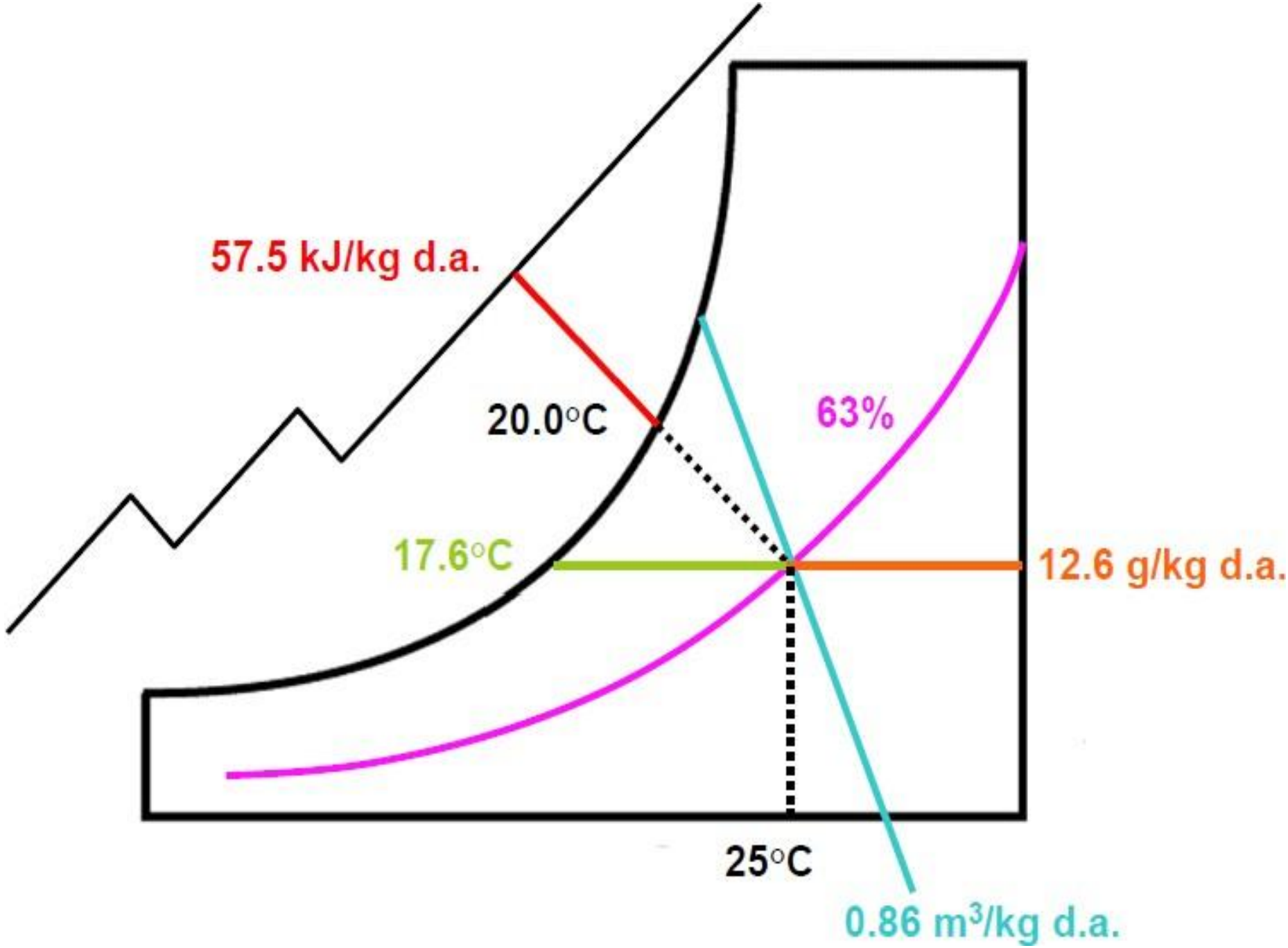
(a) RH

(b) Tdp

(c) HR

(d) v

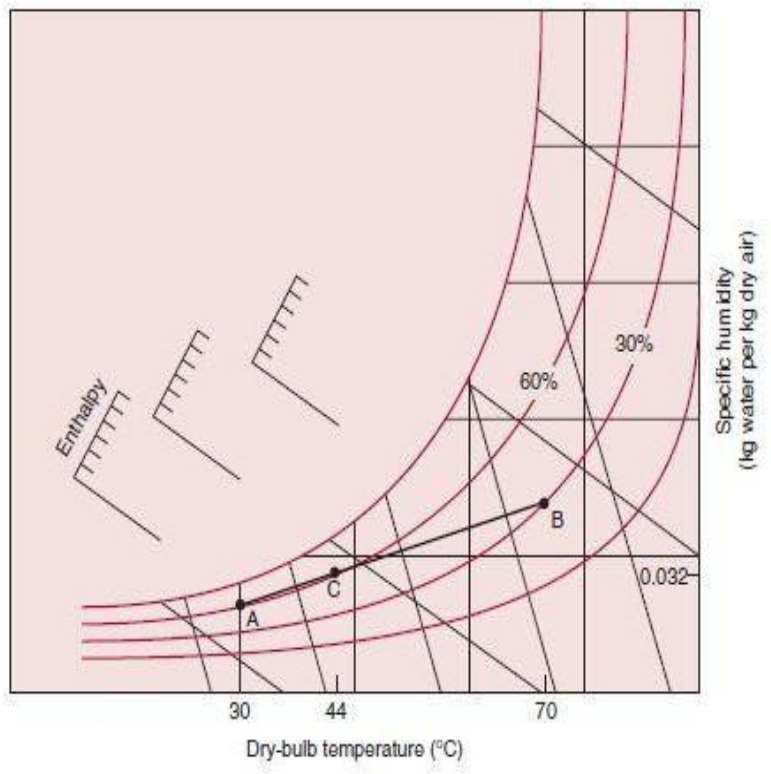
(e) h


57.5 kJ/kg d.a.
20.0°C
63%
17.6°C
12.6 g/kg d.a.
25°C
0.86 m³/kg d.a.

9.6: CALCULATE THE RATE OF THERMAL ENERGY REQUIRED TO HEAT 10 M3/ S OF OUTSIDE AIR AT 30C DRY BULB TEMPERATURE AND 80% RELATIVE HUMIDITY TO A DRY BULB TEMPERATURE OF 80C.

- *Using the psychrometric chart, we find at 30C dry bulb temperature and 80% relative humidity,*
  - *the enthalpy H 1=85.2 kJ/kg dry air,*
  - *humidity ratio W1=0.0215 kg water/kg dry air, and*
  - *specific volume V 1 =0.89 m 3 /kg dry air.*
- *At the end of the heating process,*
  - *the dry bulb temperature is = 80C*
  - *a humidity ratio of=0.0215 kg water/kg dry air. The remaining values are read from the chart as follows: enthalpy H_2=140 kJ/kg dry air; relative humidity φ_2=7%.*
- ***2.** Using Equation (9.23), q=(volume/sp. v)* x *(H2 − H1)= 615.7kj/s = 615.7kW*

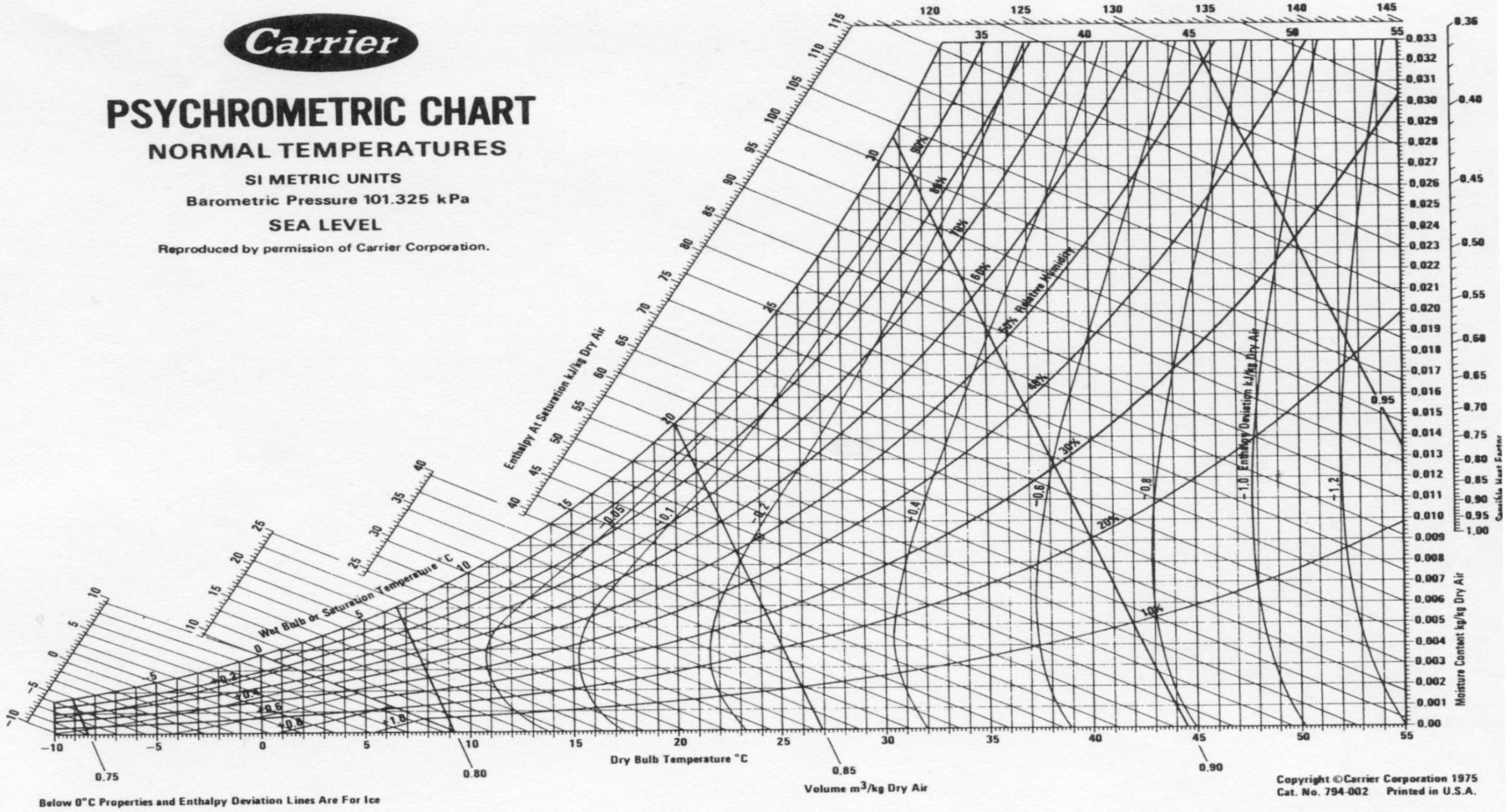
EXAMPLE 9.7 : IN EFFORTS TO CONSERVE ENERGY, A FOOD DRYER IS BEING MODIFIED TO REUSE PART OF THE EXHAUST AIR ALONG WITH AMBIENT AIR. THE EXHAUST AIRFLOW OF 10 M3/S AT 70C AND 30% RELATIVE HUMIDITY IS MIXED WITH 20 M3/S OF AMBIENT AIR AT 30C AND 60% RELATIVE HUMIDITY. USING THE PSYCHROMETRIC CHART, DETERMINE THE DRY BULB TEMPERATURE AND HUMIDITY RATIO OF THE MIXED AIR.



Example 9.8: Heated air at 50C and relative humidity is used to dry rice in a bin dryer. The air exits the bin under saturated conditions. Determine the amount of water removed per kg of dry air.

10%

- *Locate point A on the psychrometric chart,*
- *Read humidity ratio 0.0078 kg water/kg dry air.*
- *Follow the constant enthalpy line to the saturation curve.*
  - *At point B, read the humidity ratio 0.019 kg water/kg dry air.*
- *The amount of moisture removed from rice = 0.019 – 0.0078 0.0112 kg water/kg dry air.*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