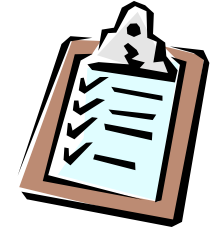


Recap (Previous Lecture)



- Introduction
 - Background
 - Basic Concepts of Environmental Services
 - Air Conditioning and Refrigeration
 - Video: Fundamentals of Air Conditioning (Heathrow Airport Terminal 4, London)

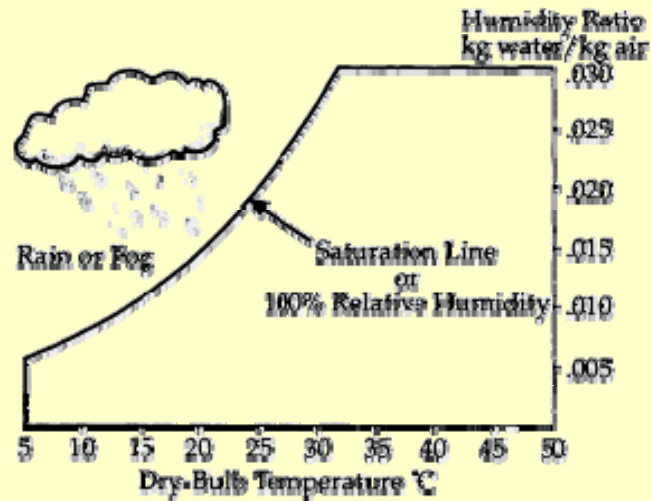
Test Your Understanding



- HVAC aims to control what functions?
 -
 -
 -
 -
 -
- What are the important HVAC design factors?
 -

MEBS6006 Environmental Services I

<http://www.hku.hk/bse/MEBS6006/>



Advanced Psychrometry



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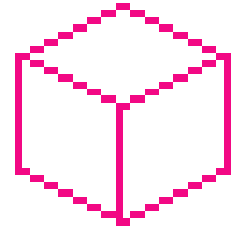
Contents



- Review of Basic Psychrometry*
 - Introduction to Psychrometry (Handout Chapter 1)
 - Psychrometric Processes (Handout Chapter 2)
- Practical Applications of Psychrometry
 - Characteristics and use of psychrometric charts
 - Software for psychrometric analysis
- Techniques of Psychrometric Analysis
 - Psychrometrics and Bioclimatic Analysis

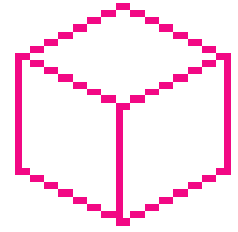
(* Printed handouts can be downloaded for self study)

Introduction to Psychrometry



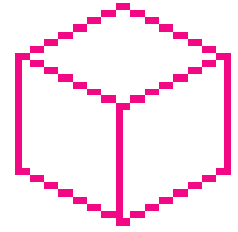
- Basics
 - The atmosphere
 - Water vapour
 - Saturated vapour pressure
- Also, Appendix - Thermodynamic Basics
 - Perfect gas laws
 - 1st law of thermodynamics
 - Conservation of energy

Introduction to Psychrometry



- Psychrometry
 - The study of atmospheric air and its associated water vapour
 - Dry air and moist air
- Dalton's law of partial pressures
- Standard atmospheric pressure = 101.325 kPa
- Saturated vapour pressure
 - Max. pressure of water vapour that can occur at any given temperature

Introduction to Psychrometry



- Psychrometric Chart (Theory)
 - Moisture content (g), or absolute humidity (w)
 - Relative humidity (rh or RH)
 - Percentage saturation (μ)
 - Wet-bulb temperature (t_{wb})
 - Specific volume (v)
- (See the illustration on psychrometric chart)

Can you read them from the chart?

Psychrometric Chart

Wet-bulb temperature

Enthalpy

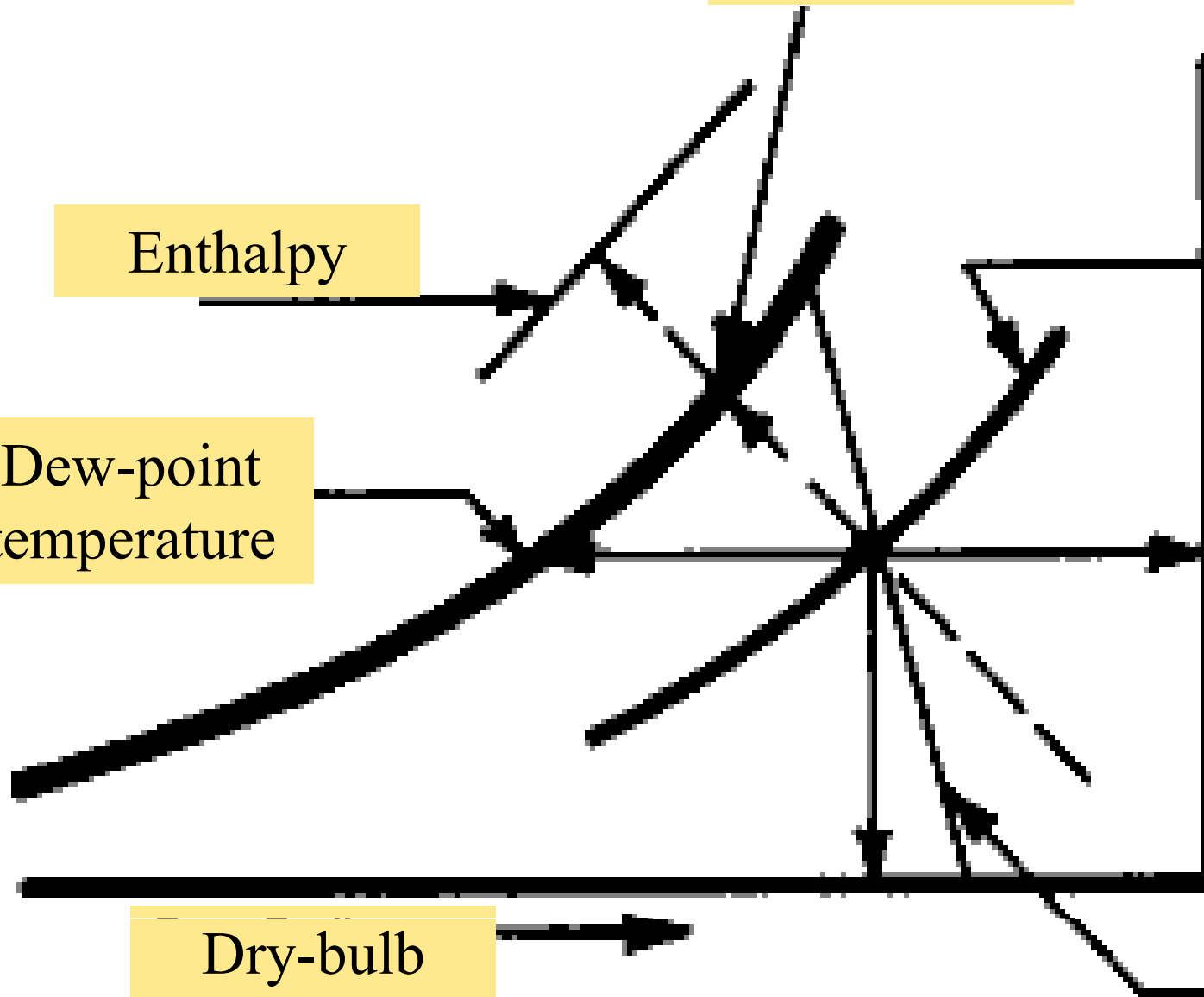
Relative humidity

Dew-point temperature

Humidity ratio

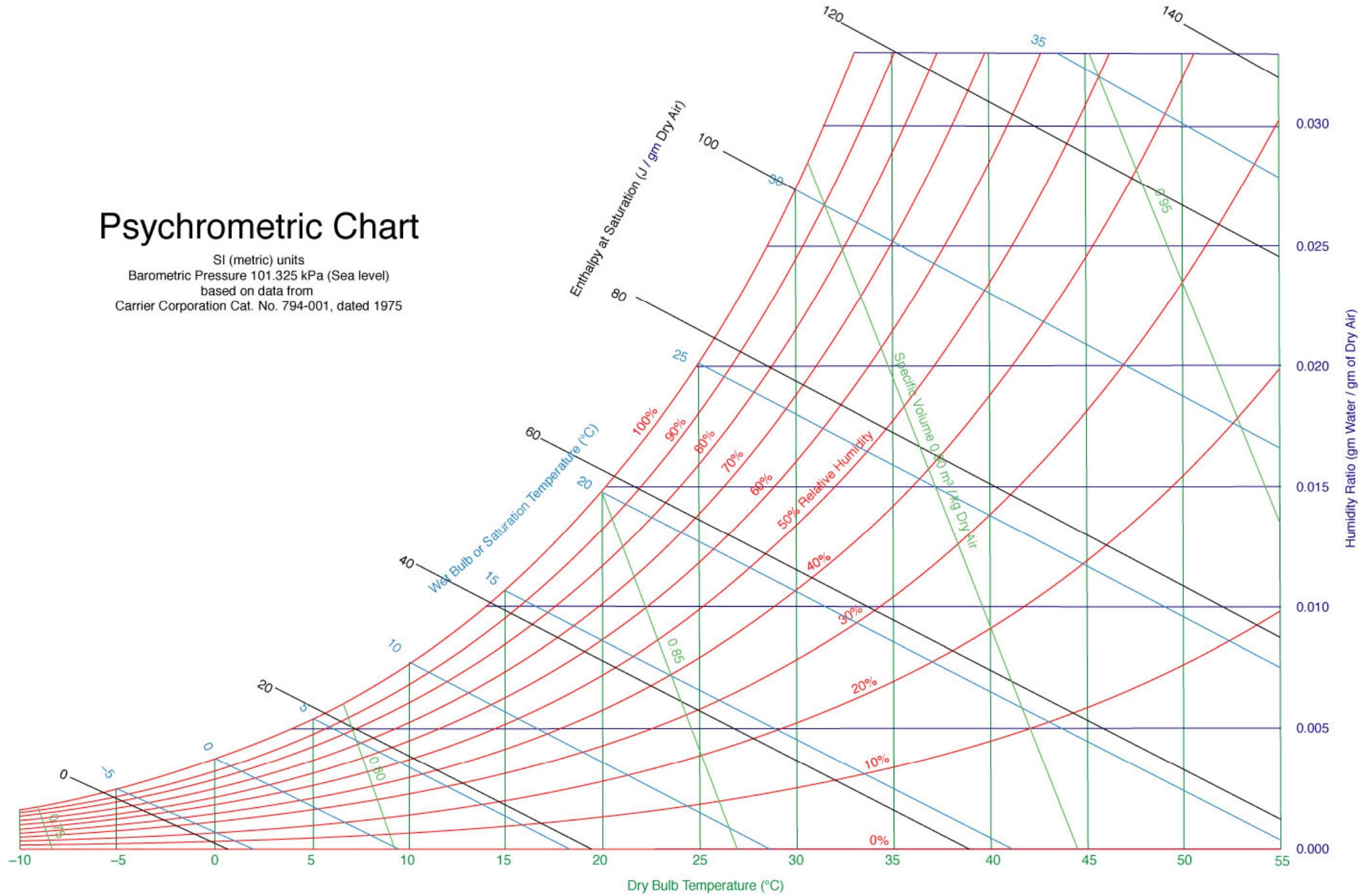
Dry-bulb temperature

Specific volume



Psychrometric Chart

SI (metric) units
Barometric Pressure 101.325 kPa (Sea level)
based on data from
Carrier Corporation Cat. No. 794-001, dated 1975



BAROMETRIC PRESSURE:

101.325 kPa

0 - 914 mt (0 - 3000 ft)

.925

RELATIVE HUMIDITY

100% 80% 60% .950

90% 70% 50% 40%

WET .900

BULB 30

TEMPERATURE
IN °C

.875

25

.850

20

.825

15

SPECIFIC

VOLUME:

m³/kg .800

10

5

0

0

5

10

15

20

25

30

35

40

45

50

DRY BULB TEMPERATURE IN °C

28

24

20

16

12

8

4

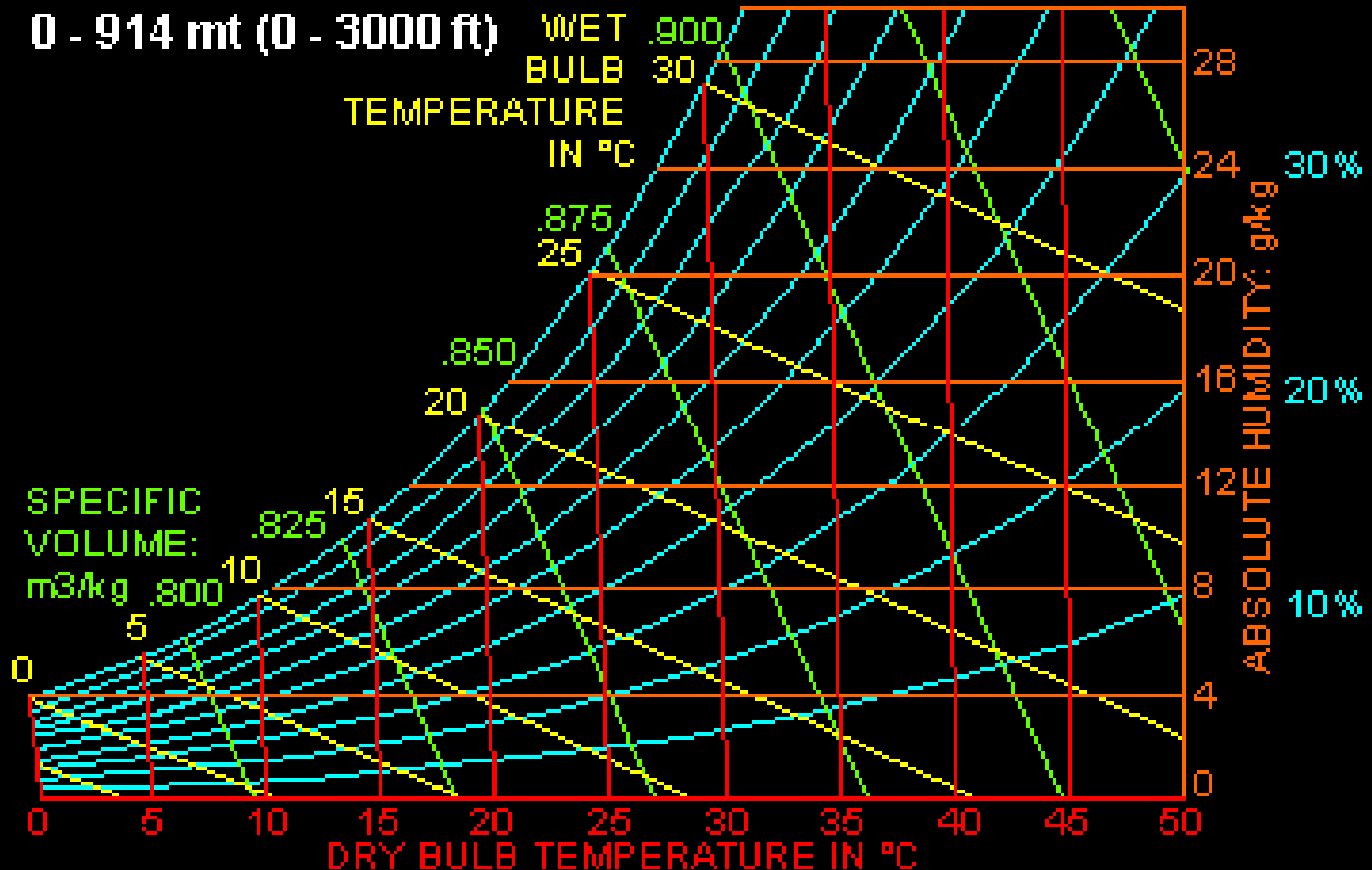
0

ABSOLUTE HUMIDITY: g/kg

30%

20%

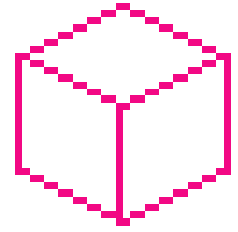
10%



Sling psychrometer

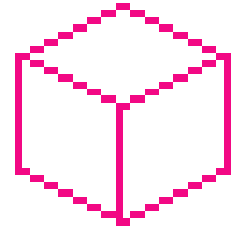


Introduction to Psychrometry



- The Psychrometric Equation
 - Dew-point temperature (t_{dp})
 - Specific enthalpy (h)
 - Specific volume (v)
 - Density (ρ)
- Do you know how to find out the moist air properties using the psychrometric chart?

Introduction to Psychrometry



- Commonly used psychrometric charts
 - ASHRAE psychrometric chart
 - CIBSE psychrometric chart
- Why are they slightly different?
- Can you find out the differences?



ASHRAE PSYCHROMETRIC CHART NO.1

NORMAL TEMPERATURE

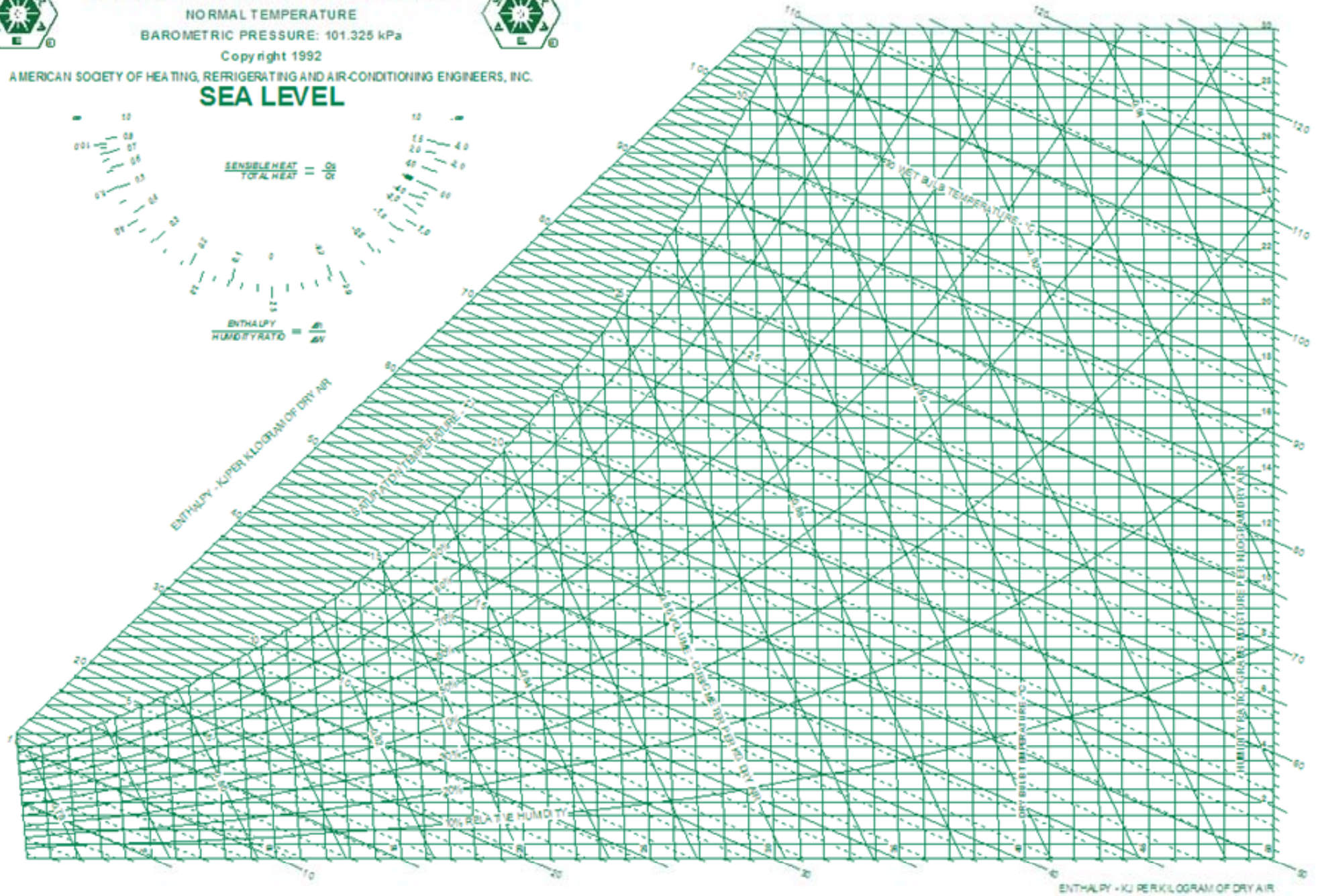
BAROMETRIC PRESSURE: 101.325 kPa

Copyright 1992

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.



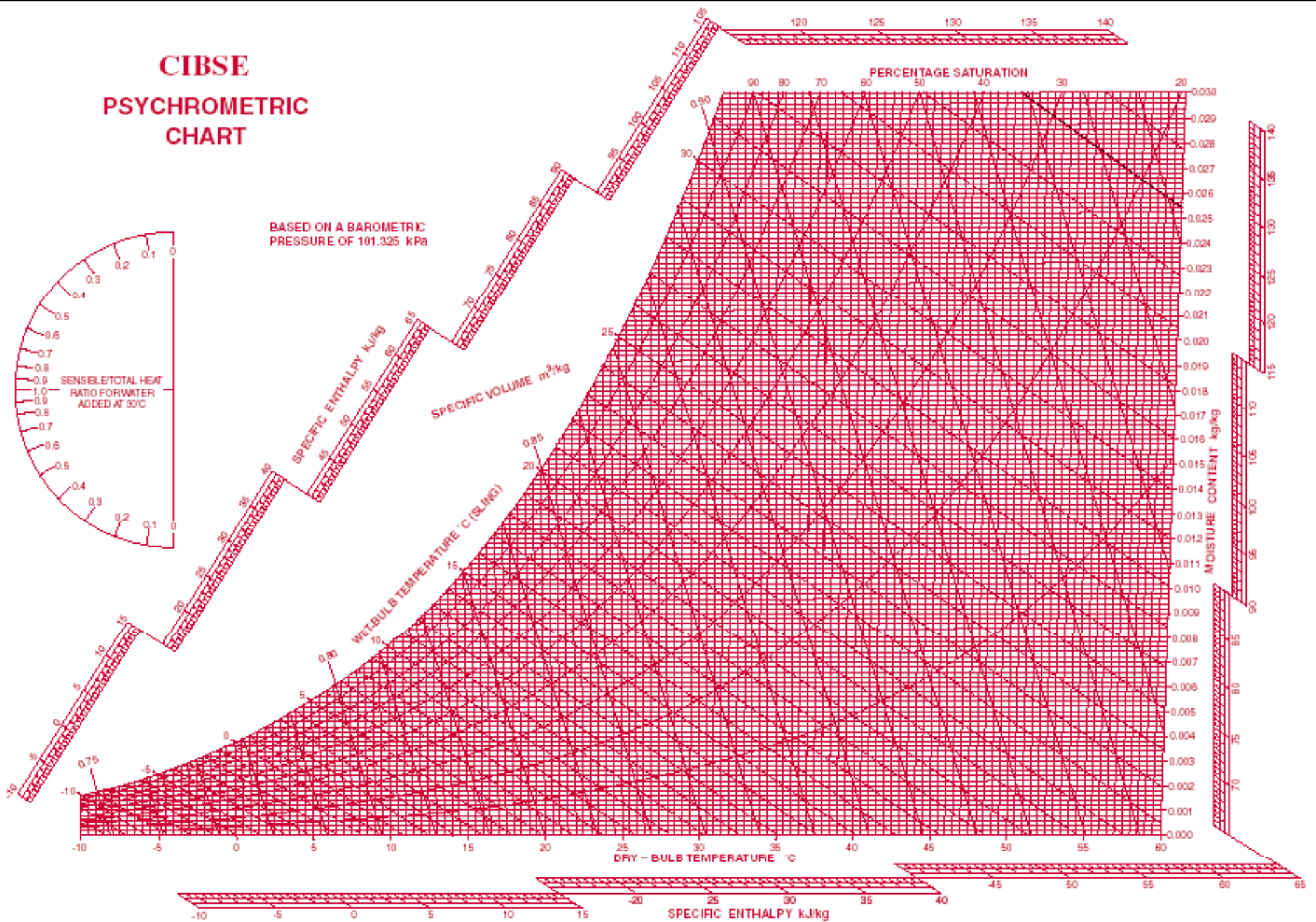
SEA LEVEL



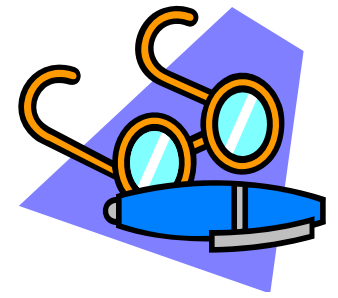
ENTHALPY - KJ PER KILOGRAM OF DRY AIR

CIBSE PSYCHROMETRIC CHART

BASED ON A BAROMETRIC
PRESSURE OF 101.325 kPa

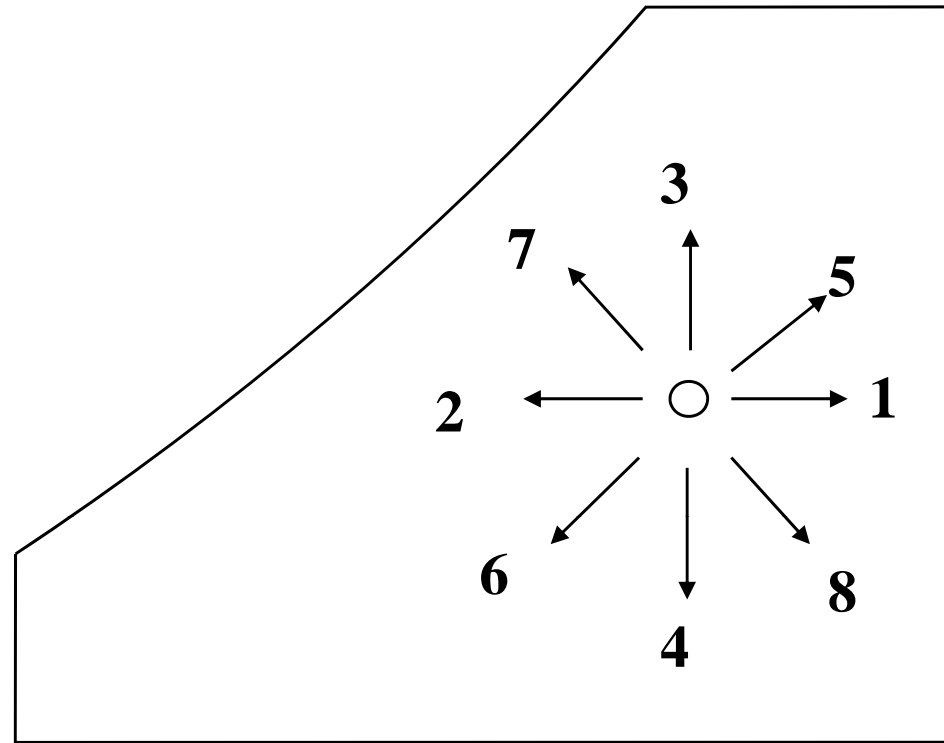


Psychrometric Processes



- Common processes:
 - Sensible cooling / sensible heating
 - Cooling and dehumidification / heating and humidification
 - Humidification / dehumidification
 - Evaporative cooling / chemical dehydration
- Typical devices:
 - Cooling/heating coils
 - Humidifiers / dehumidifiers

Basic psychrometric processes



Process 0-1: Sensible heating

Process 0-2: Sensible cooling

Process 0-3: Humidifying

Process 0-4: Dehumidifying

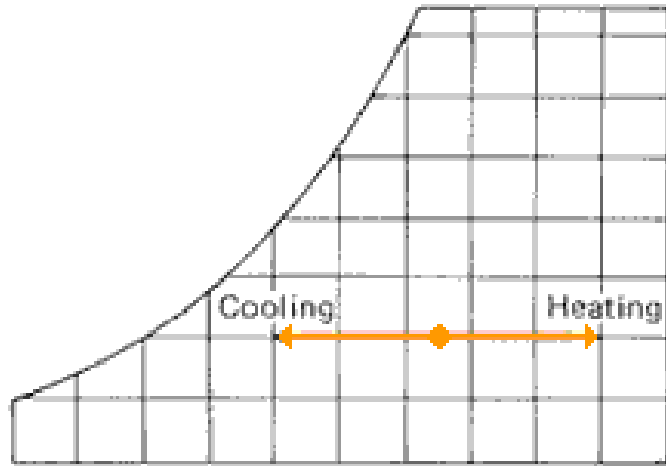
Process 0-5: Heating and humidifying

Process 0-6: Cooling and dehumidifying

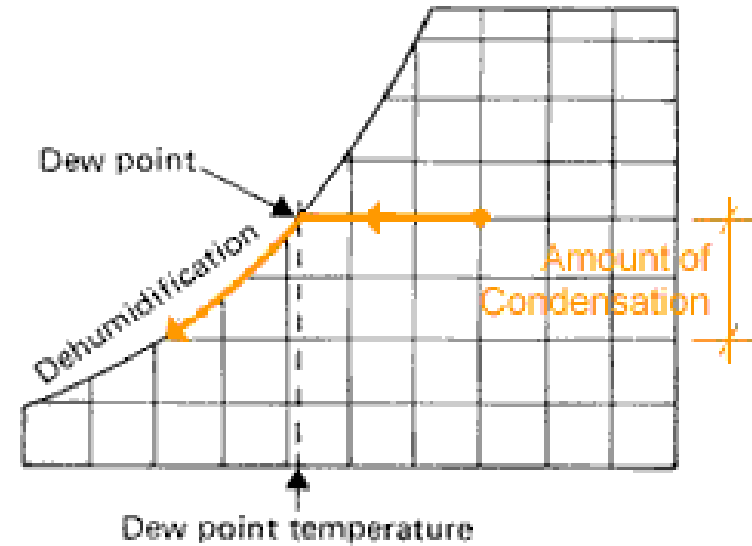
Process 0-7: Cooling and humidifying

Process 0-8: Heating and dehumidifying

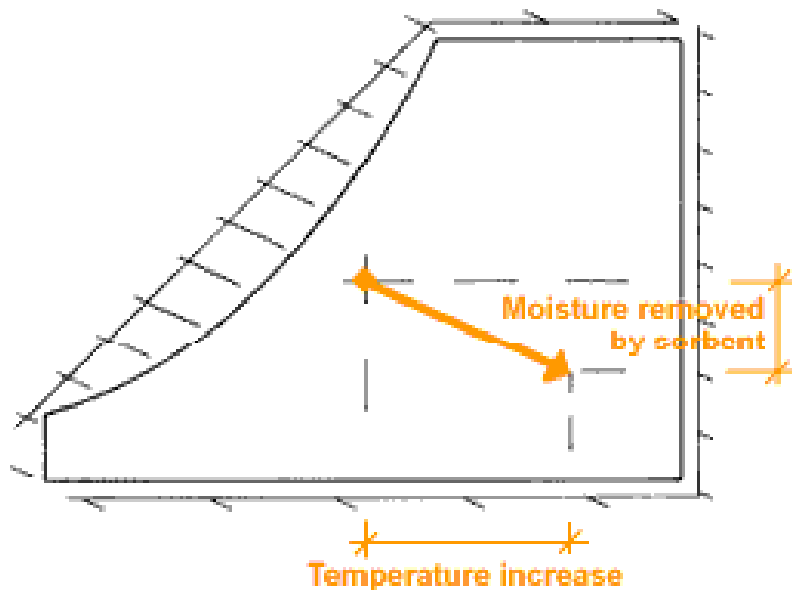
Psychrometric processes



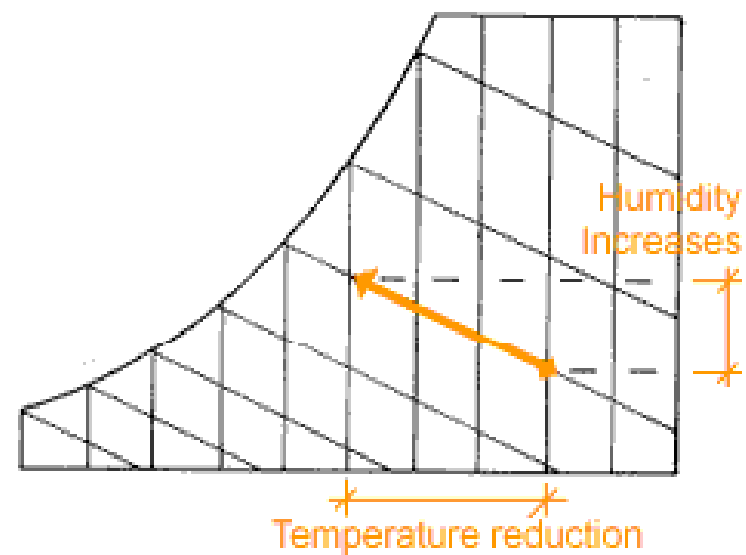
Sensible cooling/heating



Cooling and dehumidification

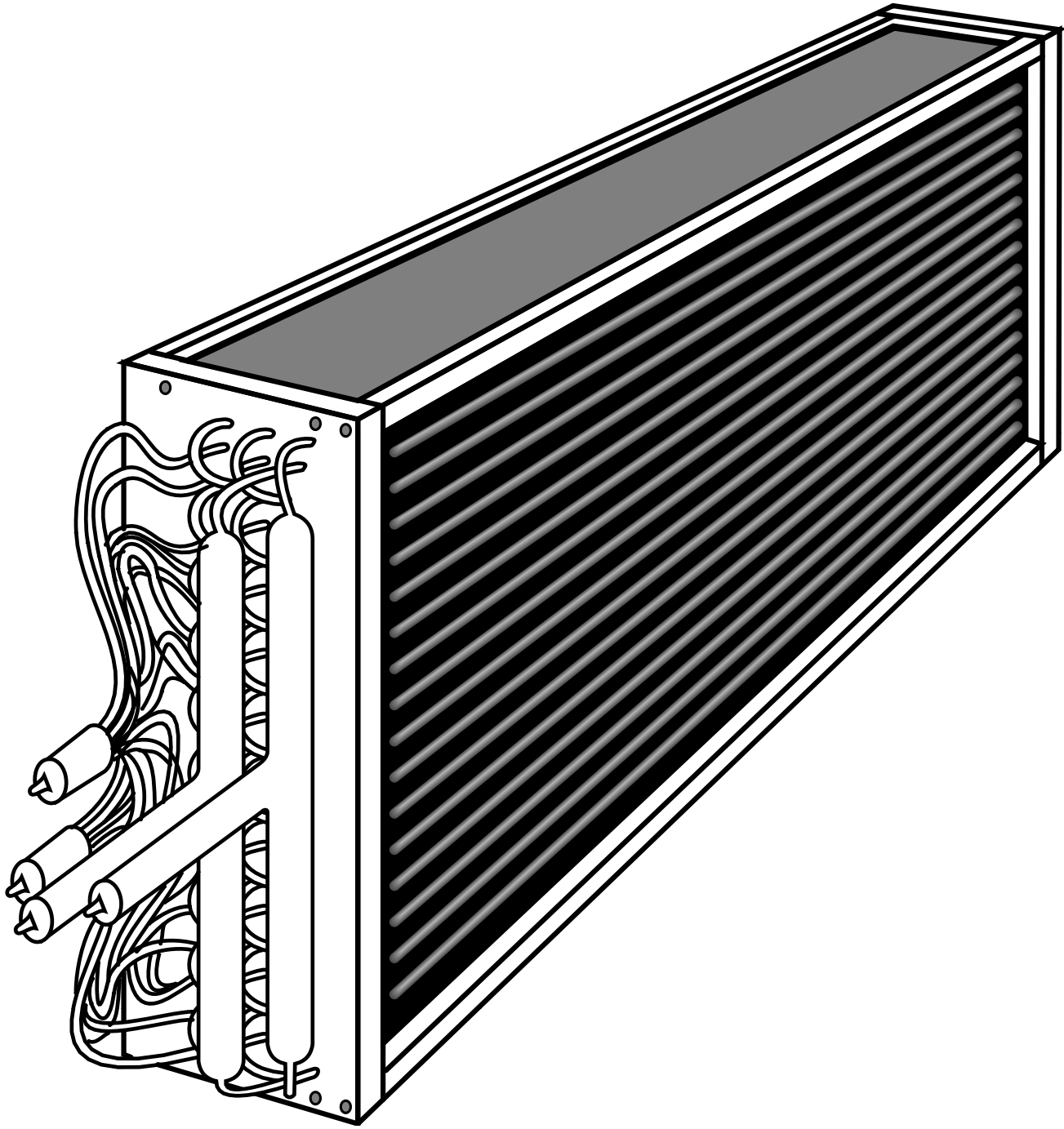


Adiabatic dehumidification

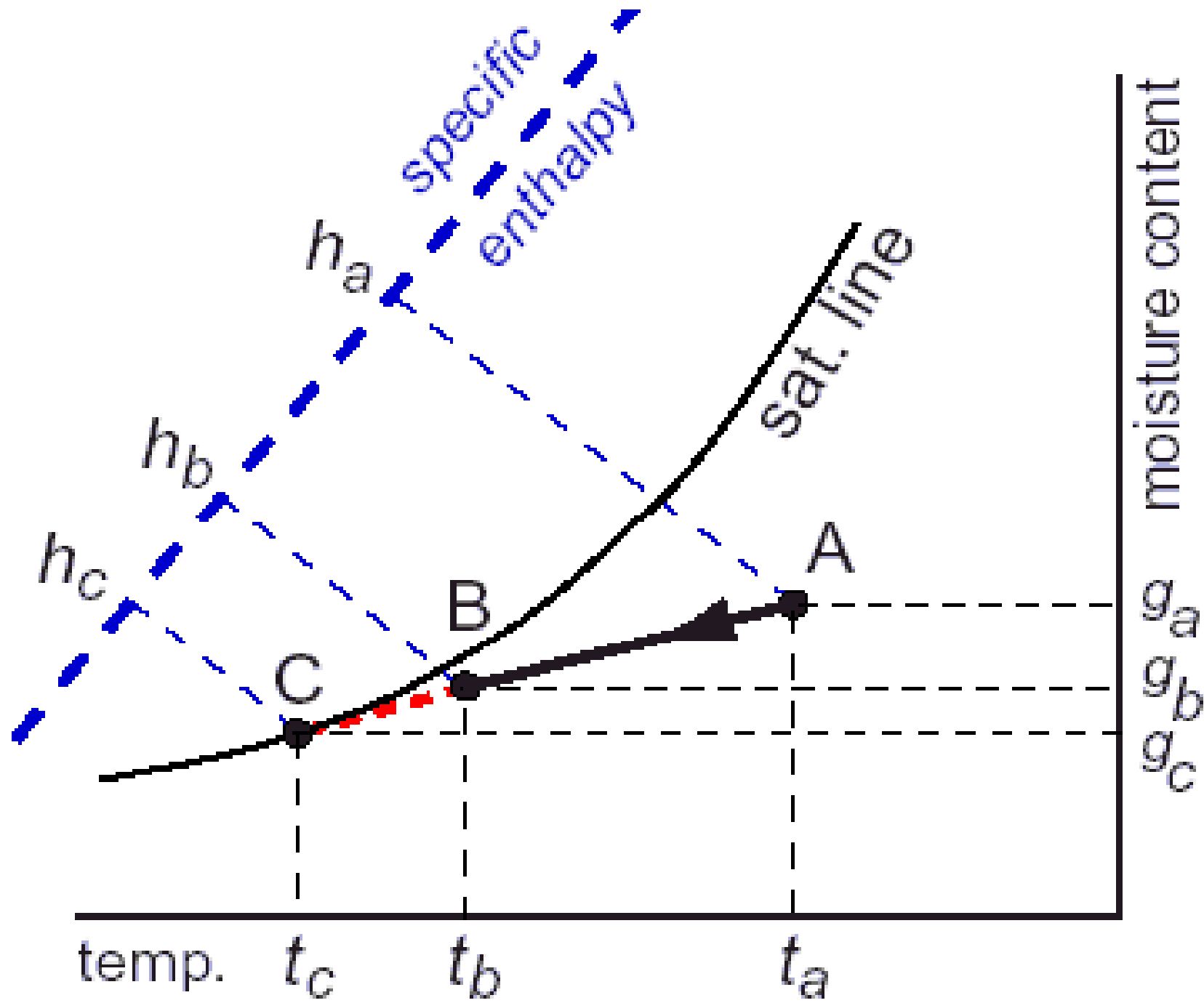


Evaporative cooling

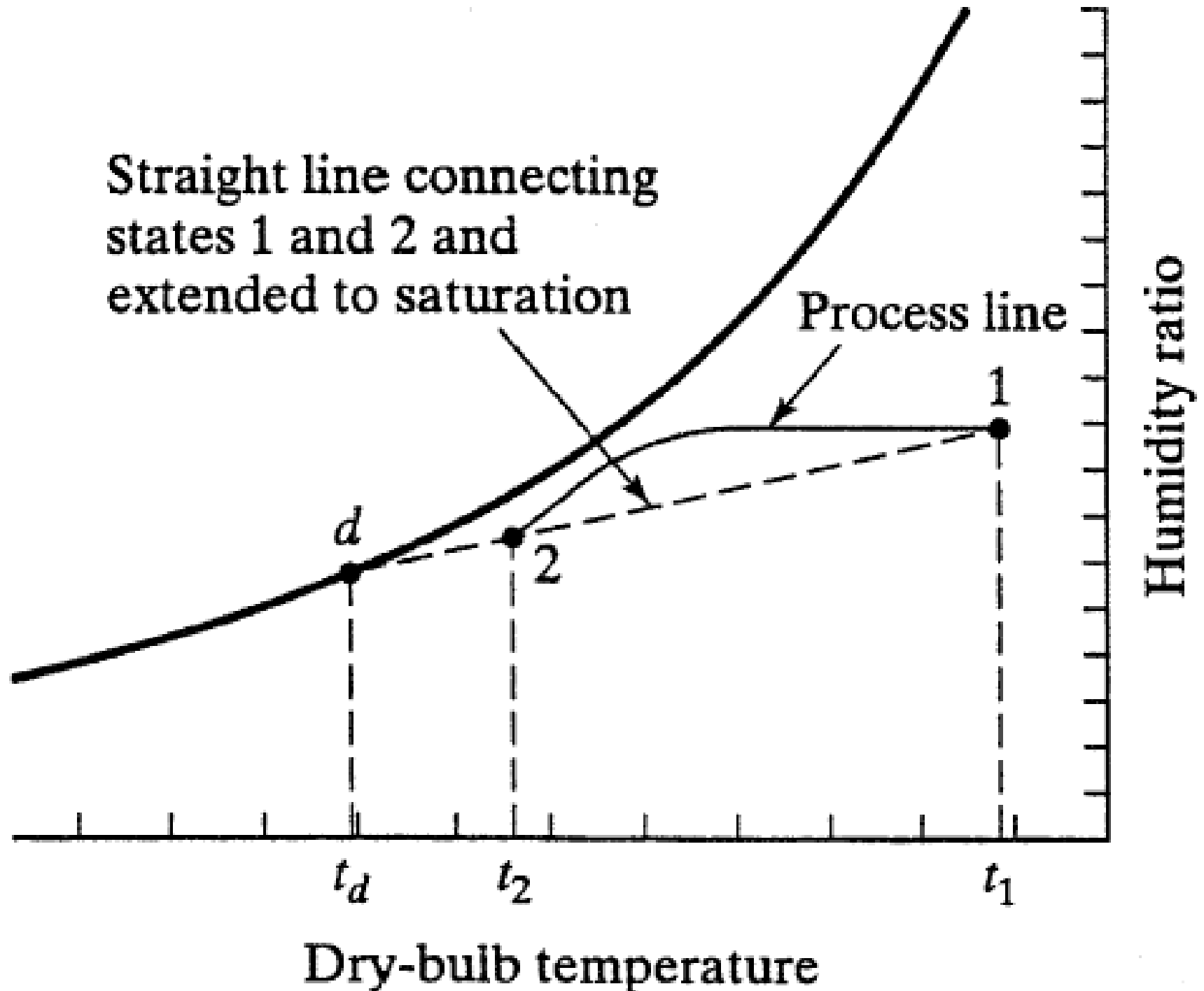
Cooling coil



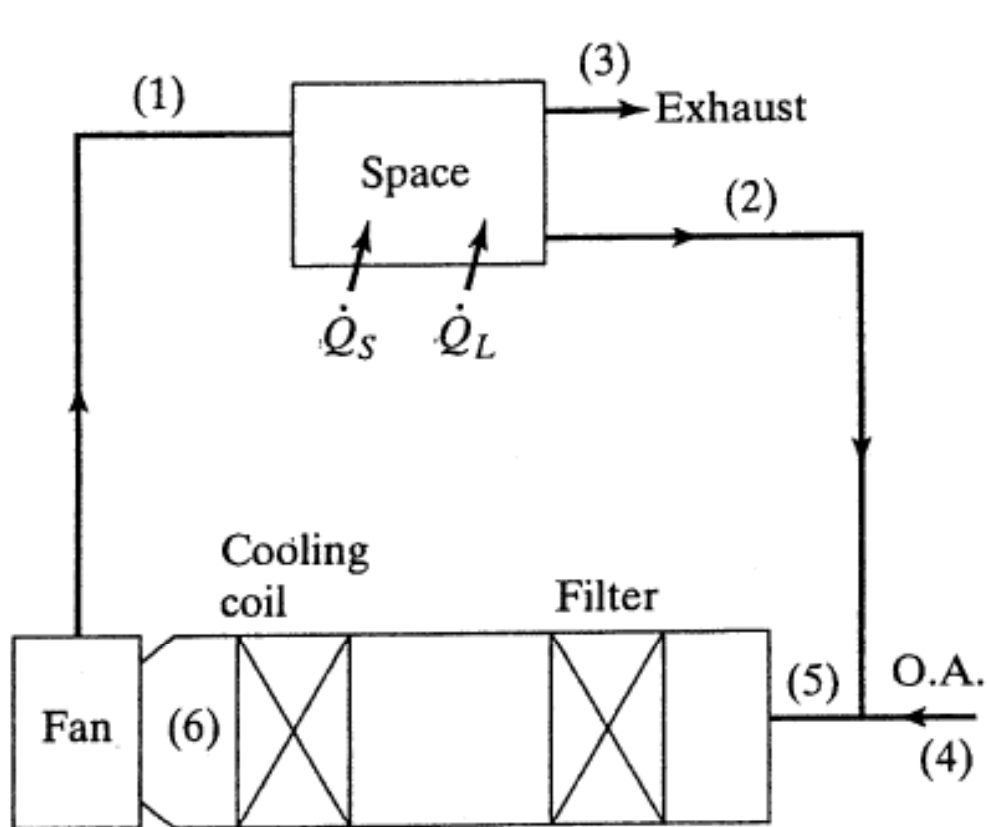
Cooling and dehumidification



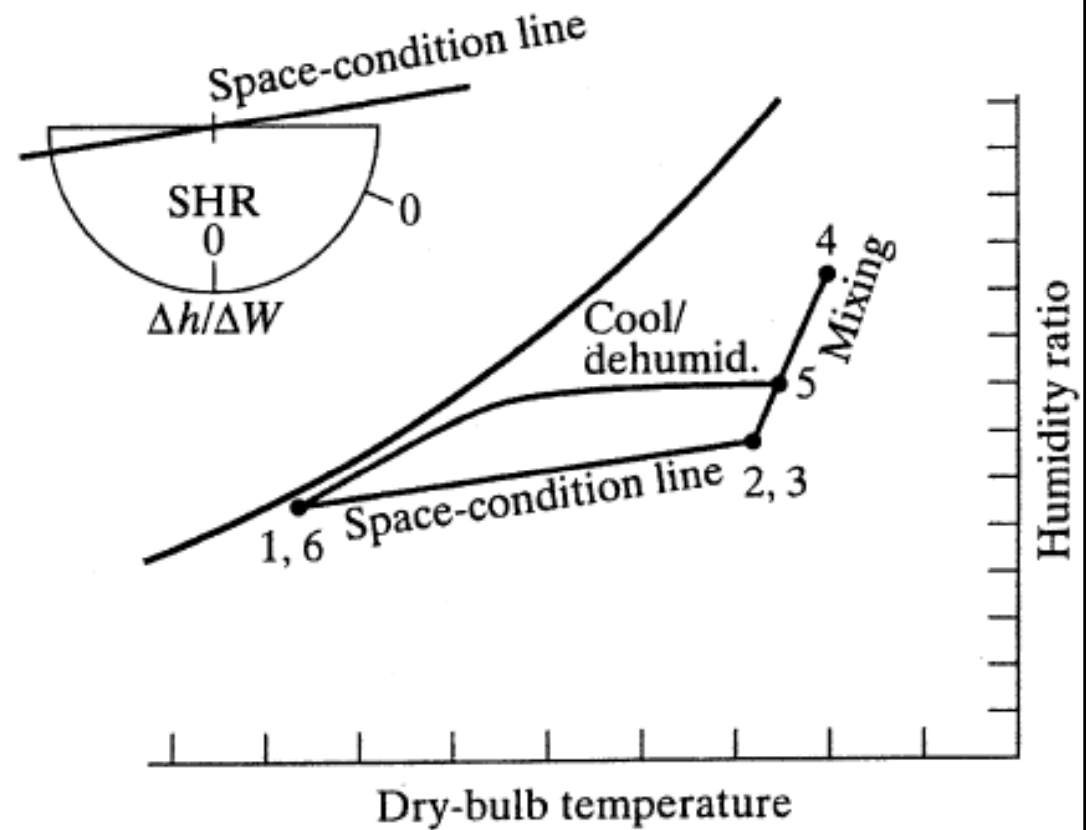
Cooling and dehumidification



Simple air conditioning cycle



(a)

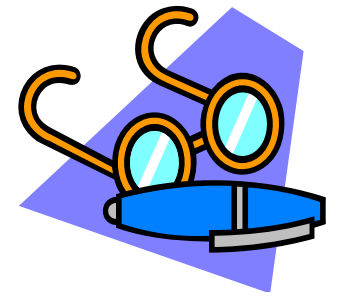


(b)

Can you draw such a cycle for Hong Kong summer conditions?

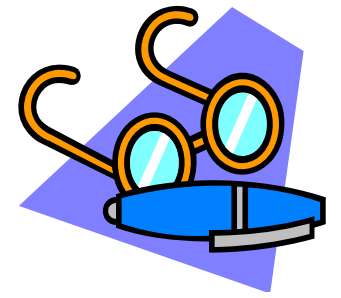
- Outdoor: DBT = 33 °C; WBT = 28 °C; flow = 20% of supply air
- Indoor: DBT = 25 °C; %RH = 50%
- Air leaving cooling coil: DBT = 13 °C; %RH = 95%

Psychrometric Processes



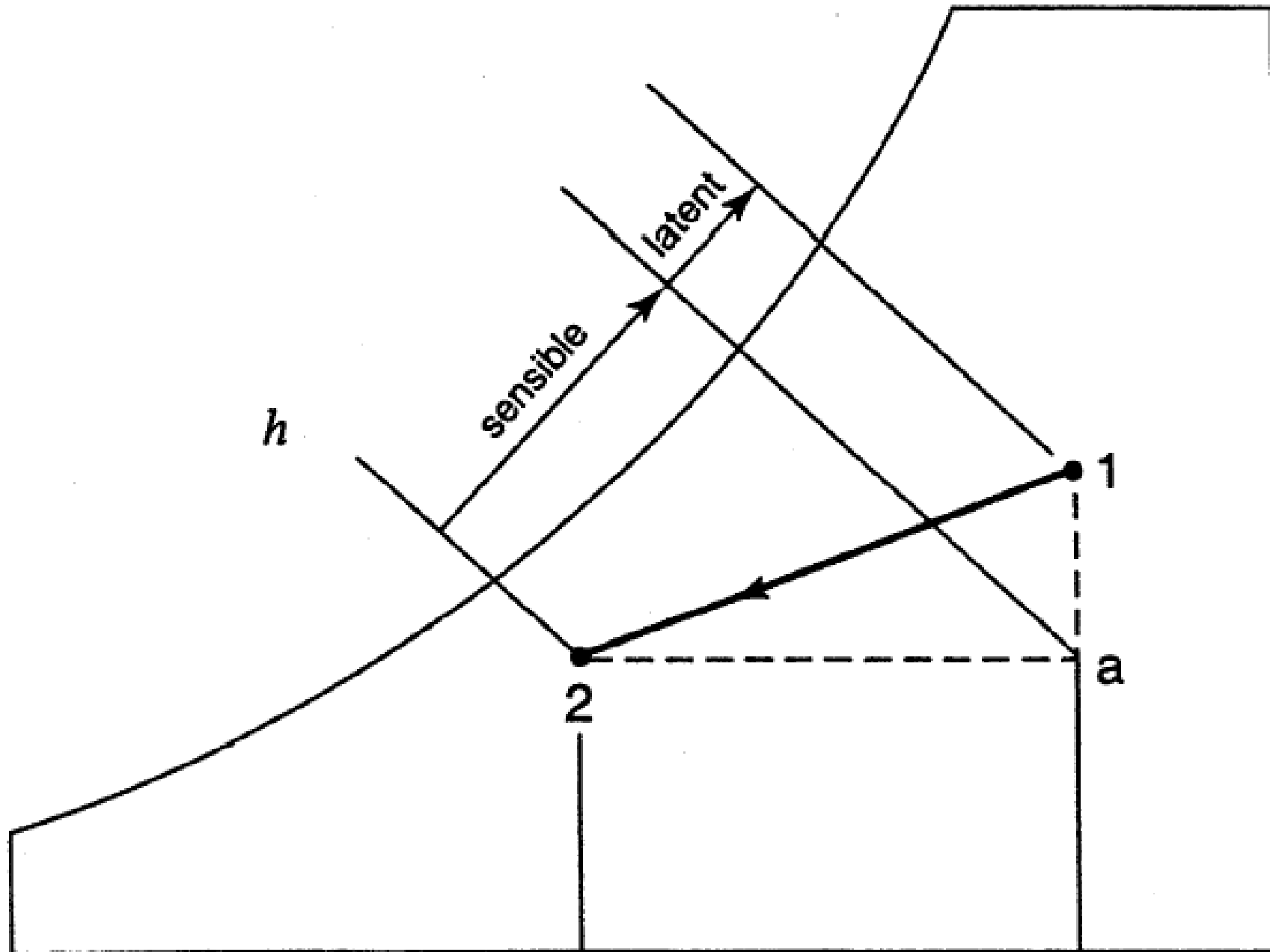
- Sensible heating coils
- Cooling coils
- Humidifiers
- Water spray types
- Steam humidifier
- Room psychrometric process
- Mixing air streams

Psychrometric Processes



- Calculations:
 - Sensible heat ratio (SHR)
 - Space cooling load
 - Cooling coil's load/capacity
 - Humidification capacity
 - Mixing processes
 - Principles of heat balance & conservation of mass

Sensible and latent cooling loads



Practical Use of Psych. Chart



- Examples of psychrometric charts
 - ASHRAE
 - CIBSE
 - Carrier
 - Mr. S K Wang (similar to Trane)
 - The chart used in Mainland China (upside down)
- Do you know how to construct these charts?



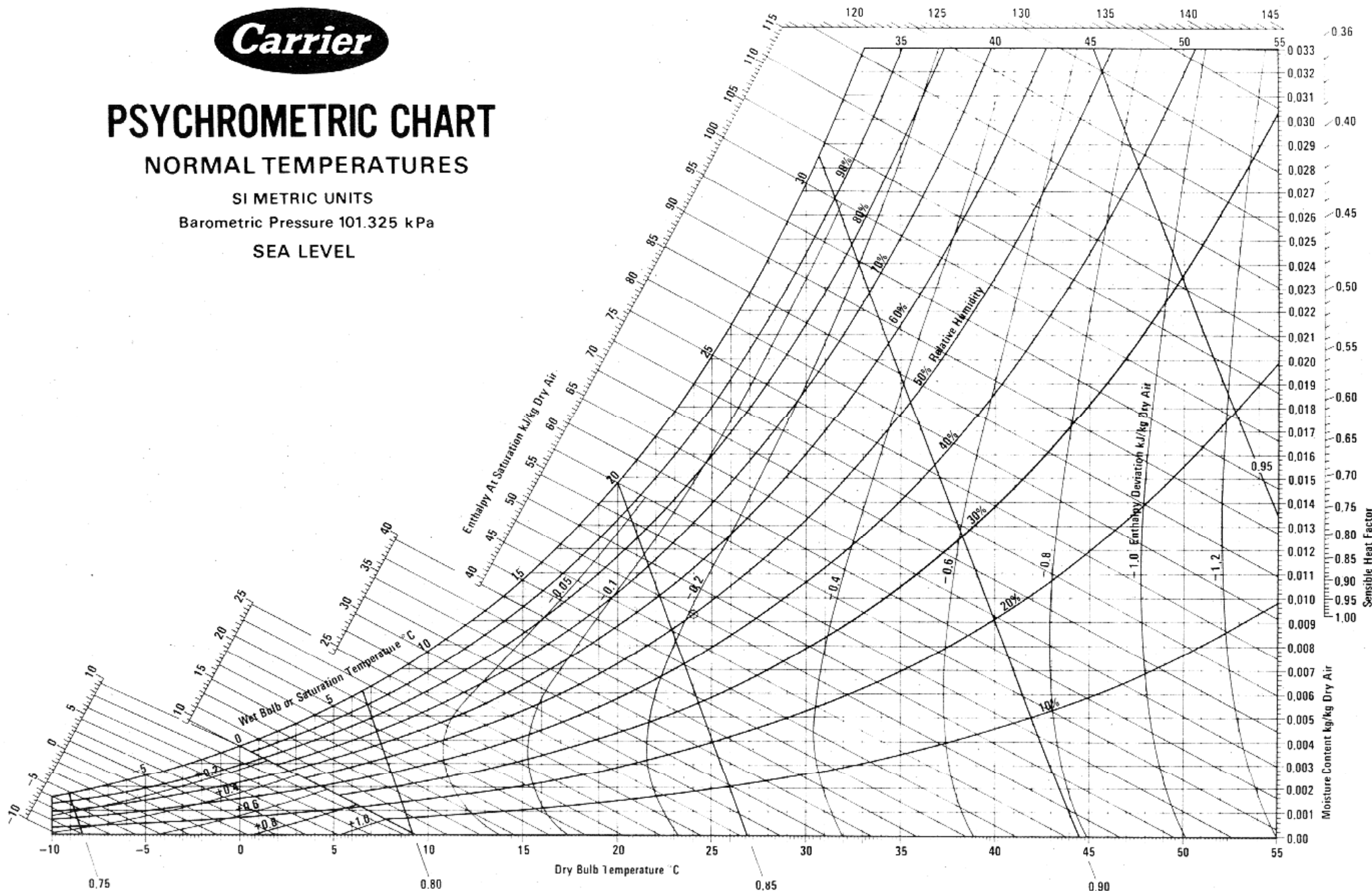
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 101.325 kPa

SEA LEVEL



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

Volume m³/kg Dry Air

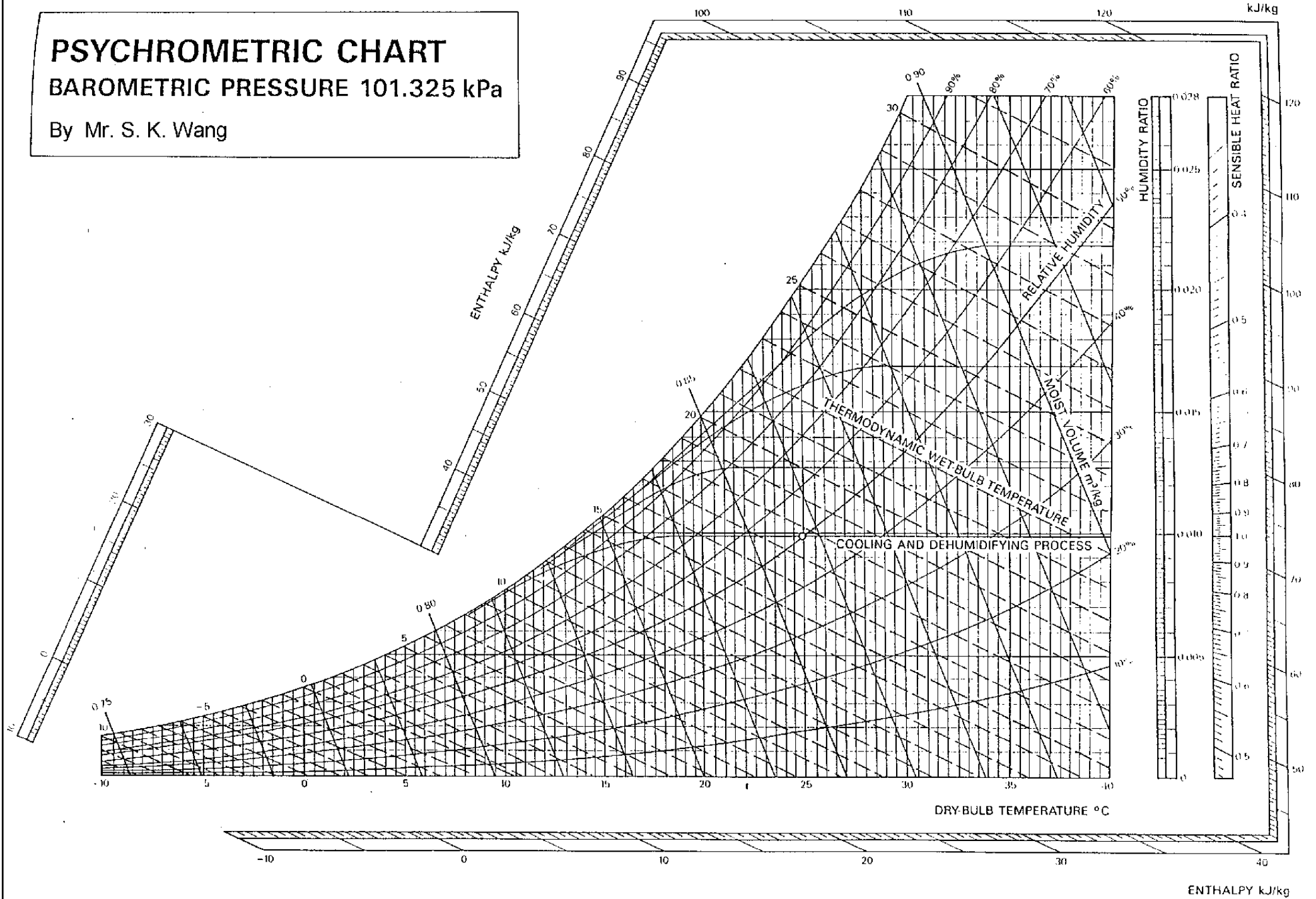
Copyright © Carrier Corporation 1975
Cat. No. 794-002 Printed in U.S.A.

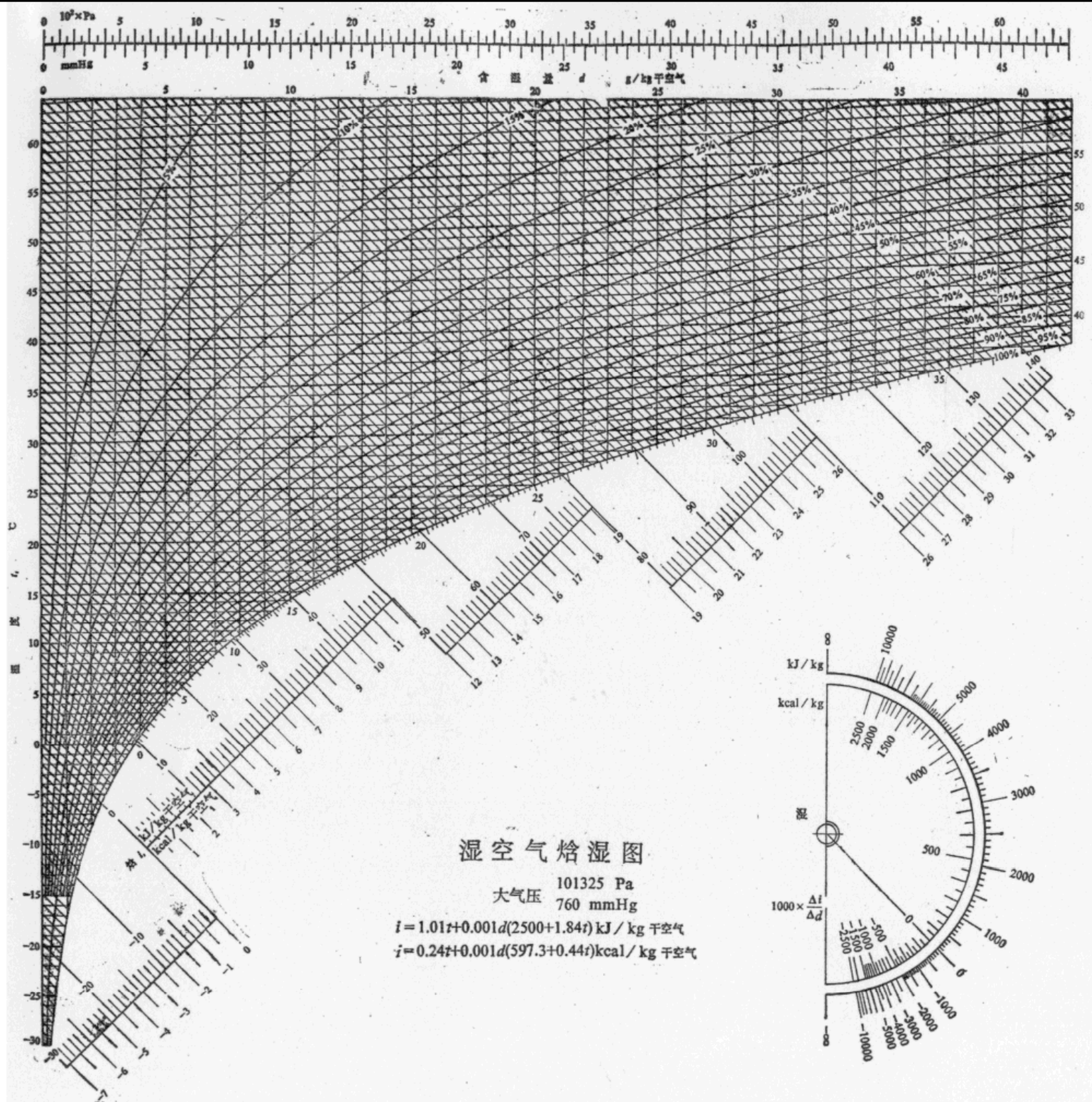
Reproduced courtesy of Carrier Corporation

PSYCHROMETRIC CHART

BAROMETRIC PRESSURE 101.325 kPa

By Mr. S. K. Wang



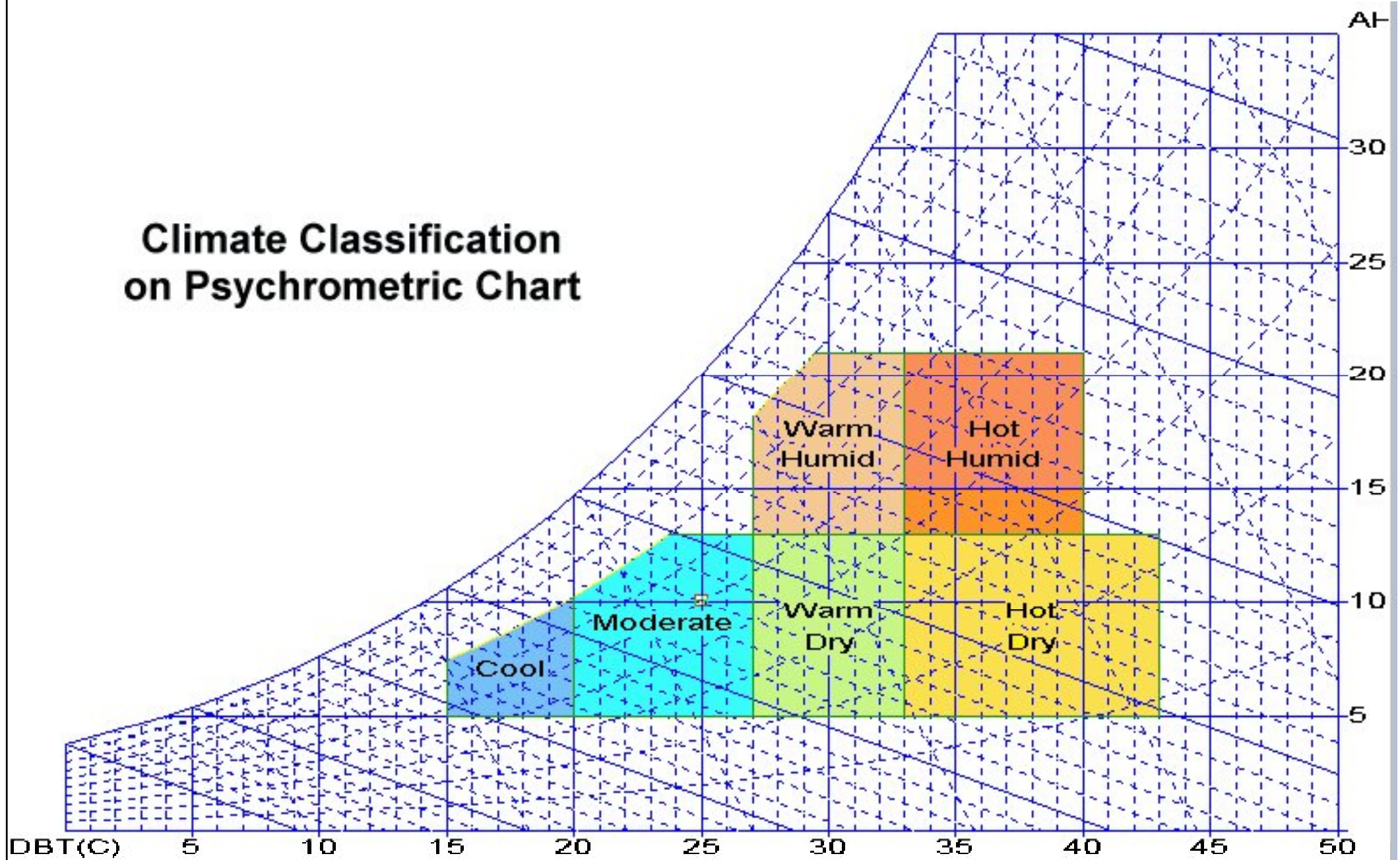


Psychrometric Software

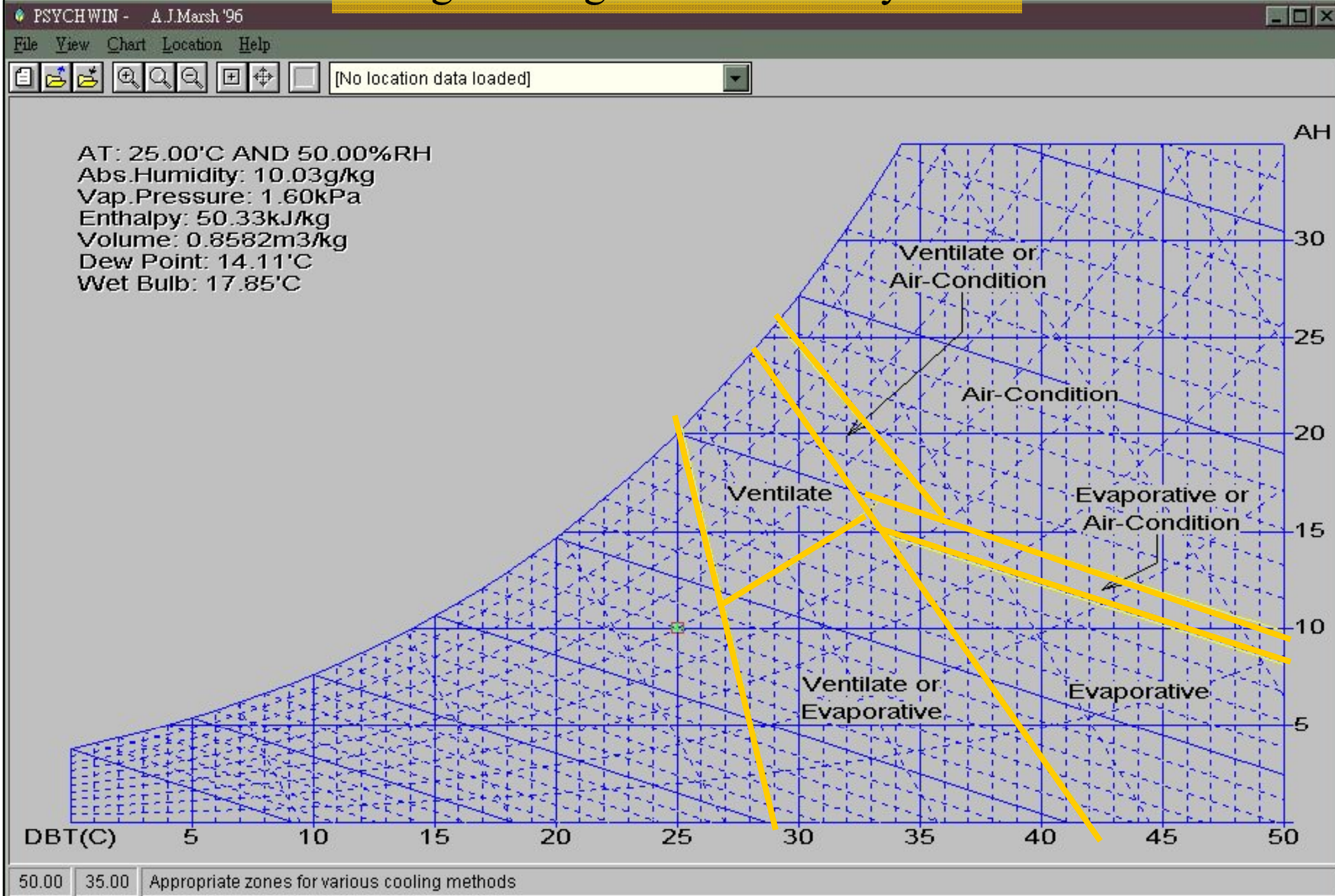


- ASHRAE Psychrometric Analysis CD-ROM (2002) [AV 697 P97]
- ArchiSci Software - PSYCHWIN (an evaluation version can be downloaded)
- Psychrometric Chart (PSY) software (Free for download)

Climate Classification on Psychrometric Chart

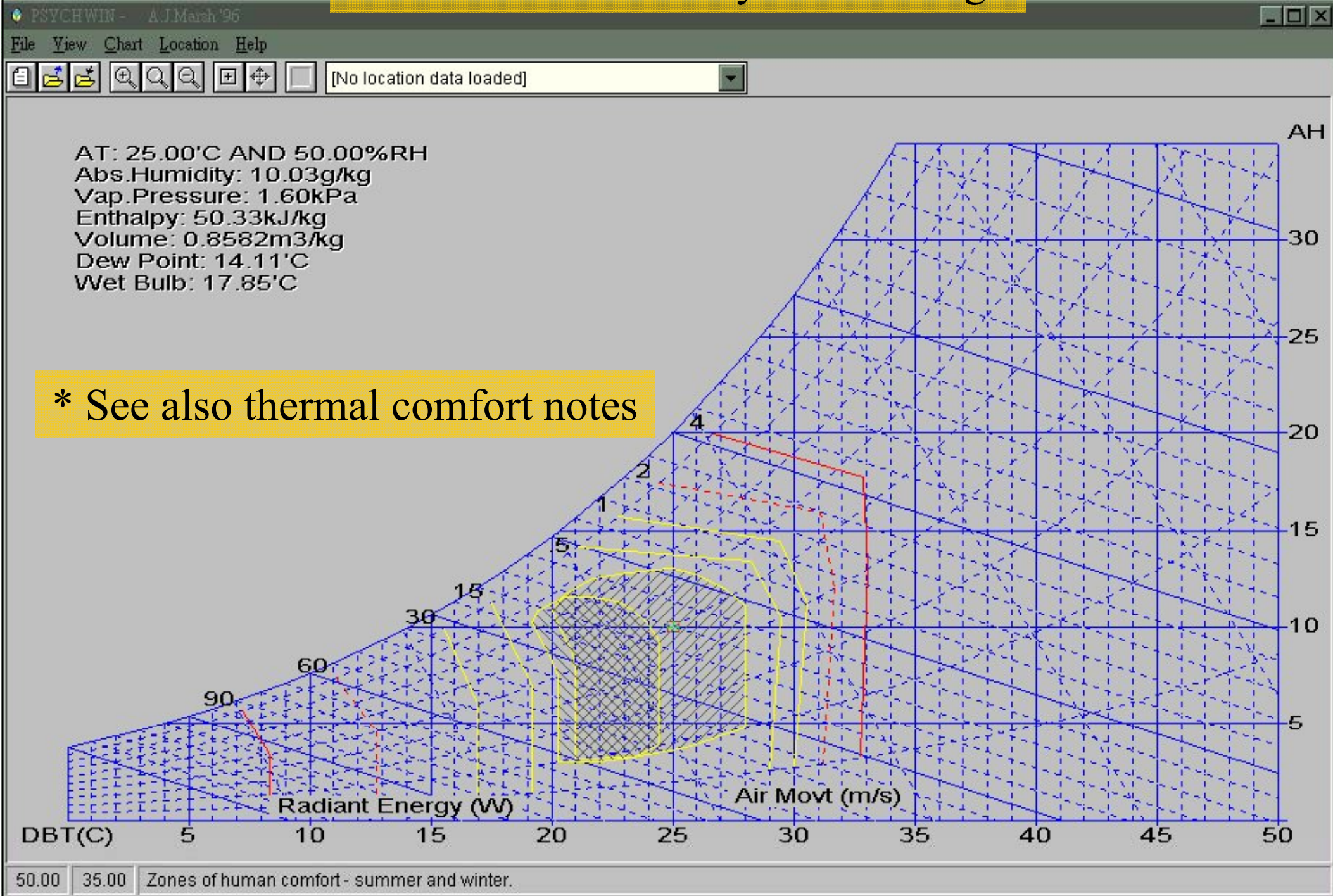


Design strategies for HVAC systems

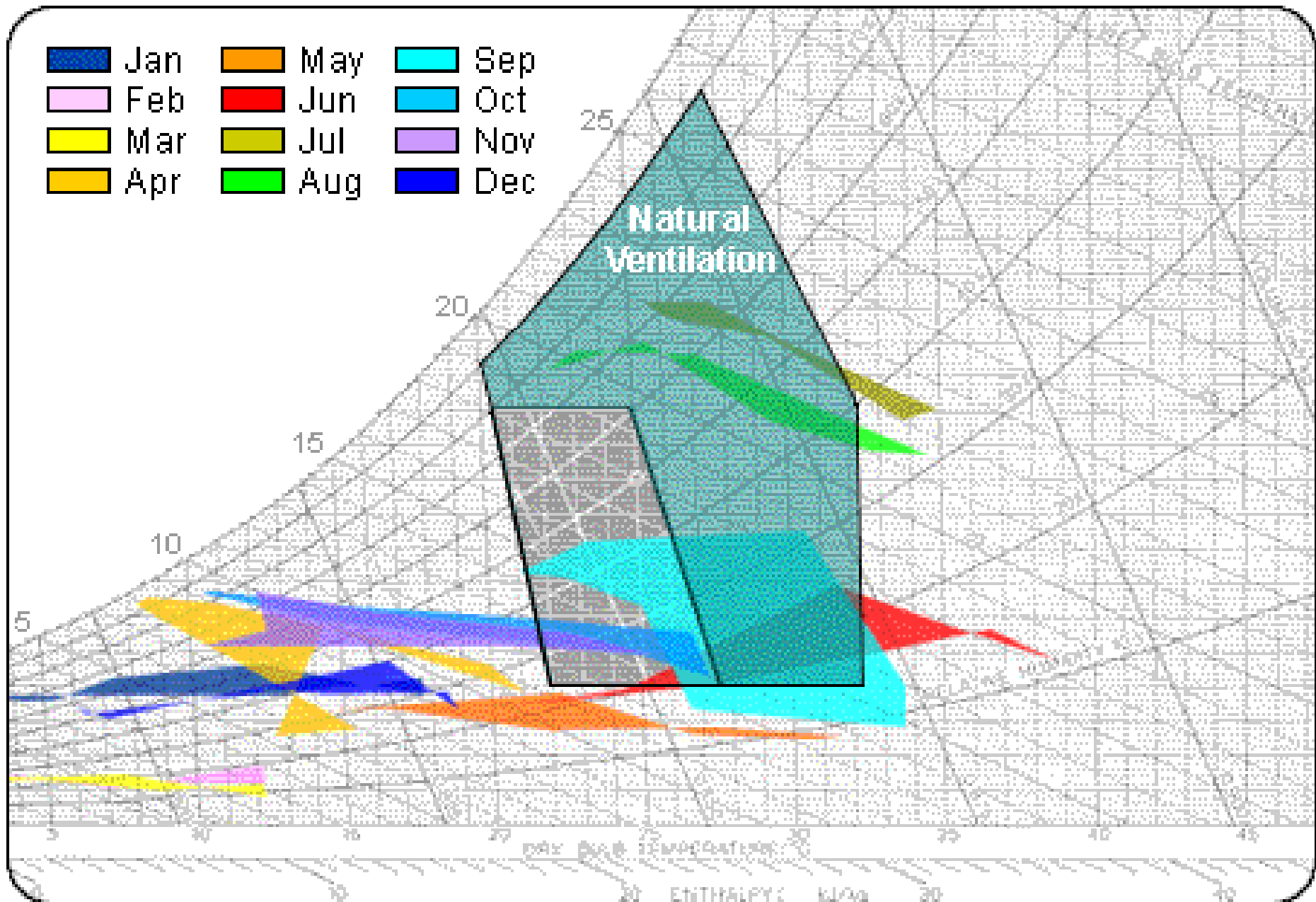


(Source: ArchiSci Software - PSYCHWIN)

Thermal comfort analysis and design



Analysis of external climate



Psychrometric Analysis



- Psychrometrics and Bioclimatic Analysis for Hong Kong

<http://arch.hku.hk/~cmhui/teach/65156-7e.htm>

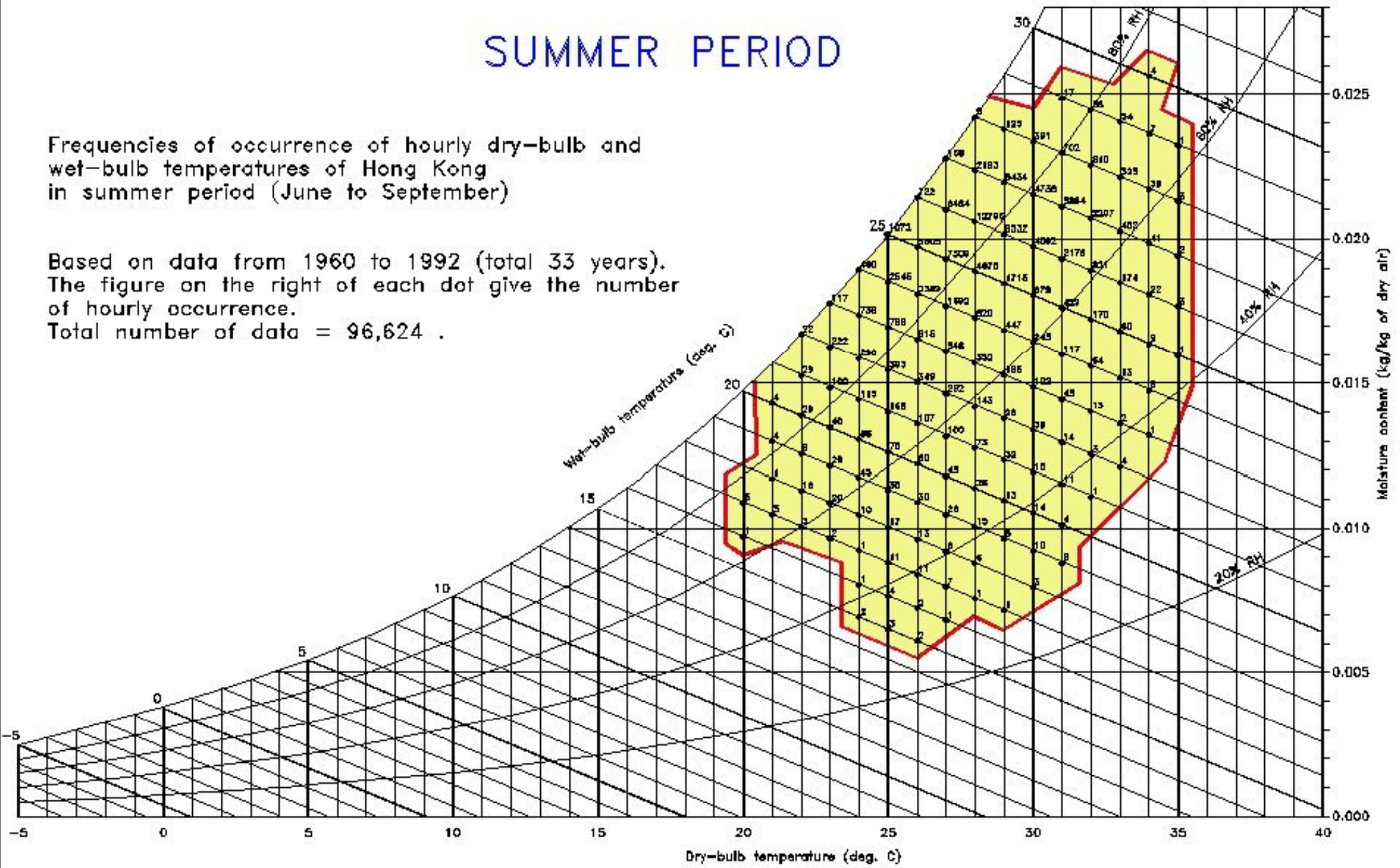
- Cooling strategies
- Thermal comfort zones
- Frequency distribution on psychrometric charts

Analysis of weather conditions in Hong Kong

SUMMER PERIOD

Frequencies of occurrence of hourly dry-bulb and wet-bulb temperatures of Hong Kong in summer period (June to September)

Based on data from 1960 to 1992 (total 33 years).
 The figure on the right of each dot give the number of hourly occurrence.
 Total number of data = 96,624 .

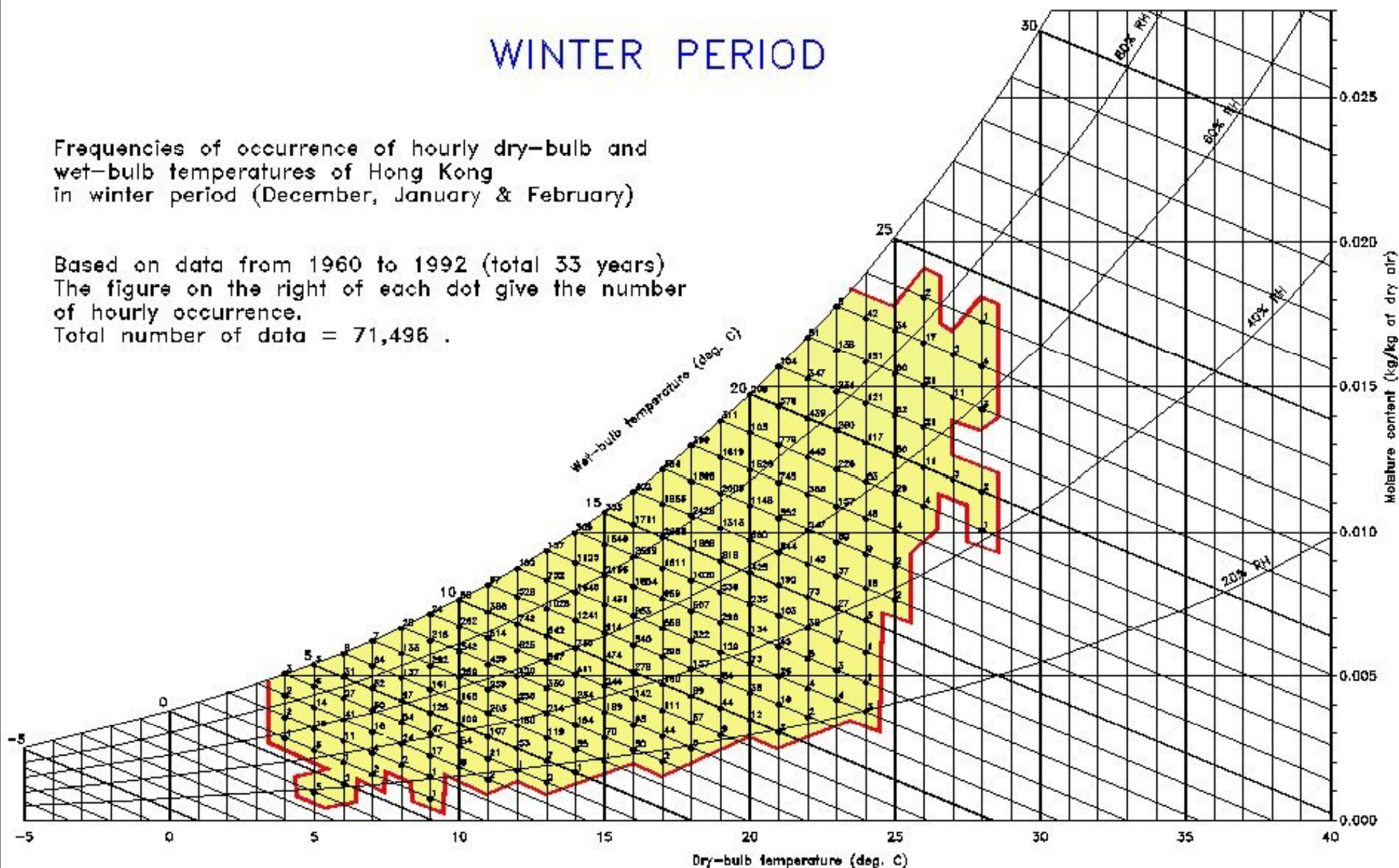


Analysis of weather conditions in Hong Kong

WINTER PERIOD

Frequencies of occurrence of hourly dry-bulb and wet-bulb temperatures of Hong Kong in winter period (December, January & February)

Based on data from 1960 to 1992 (total 33 years)
The figure on the right of each dot give the number of hourly occurrence.
Total number of data = 71,496 .

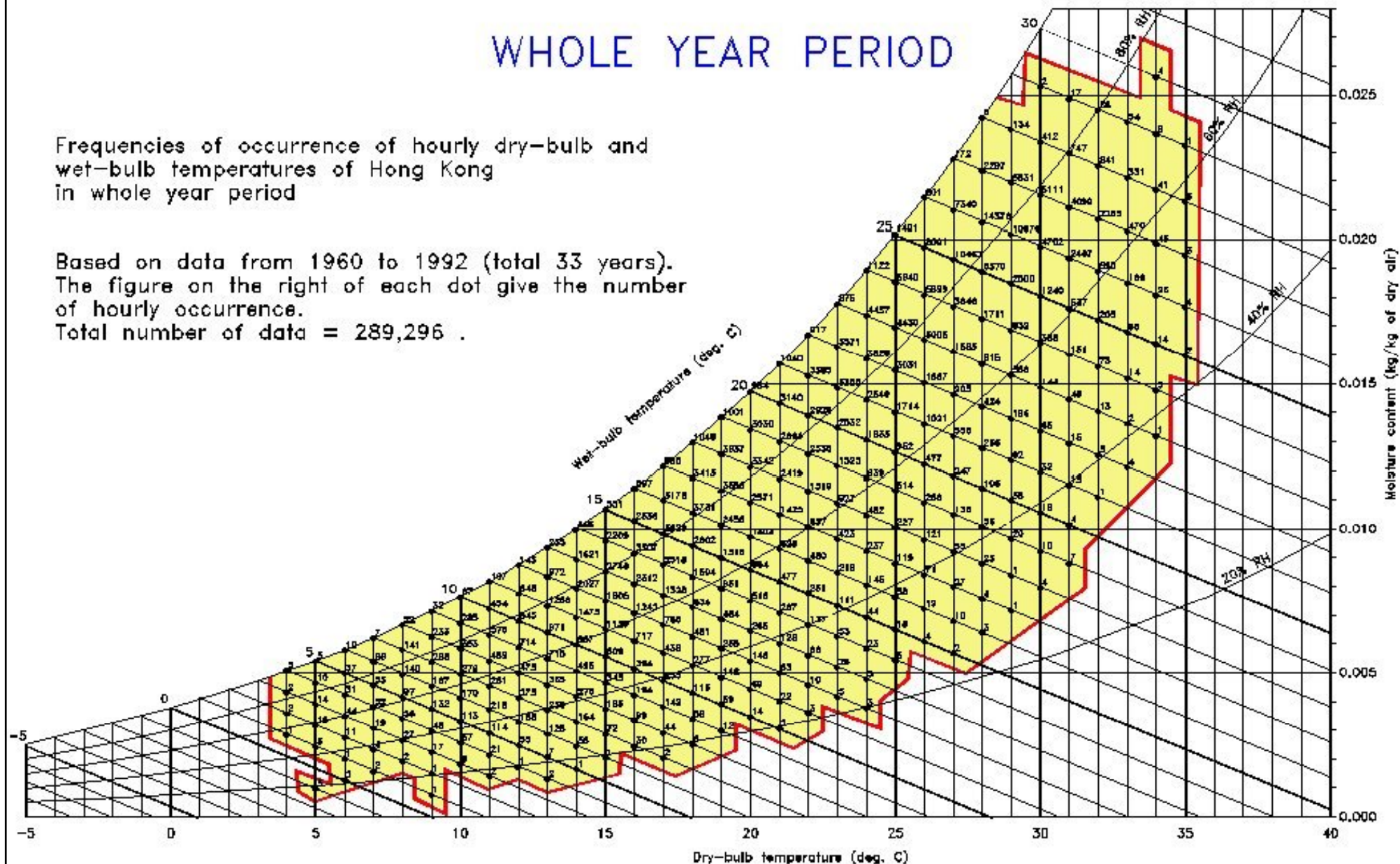


Analysis of weather conditions in Hong Kong

WHOLE YEAR PERIOD

Frequencies of occurrence of hourly dry-bulb and wet-bulb temperatures of Hong Kong in whole year period

Based on data from 1960 to 1992 (total 33 years).
The figure on the right of each dot give the number of hourly occurrence.
Total number of data = 289,296 .



Analysis of weather conditions in Hong Kong



ASHRAE PSYCHROMETRIC CHART NO.1

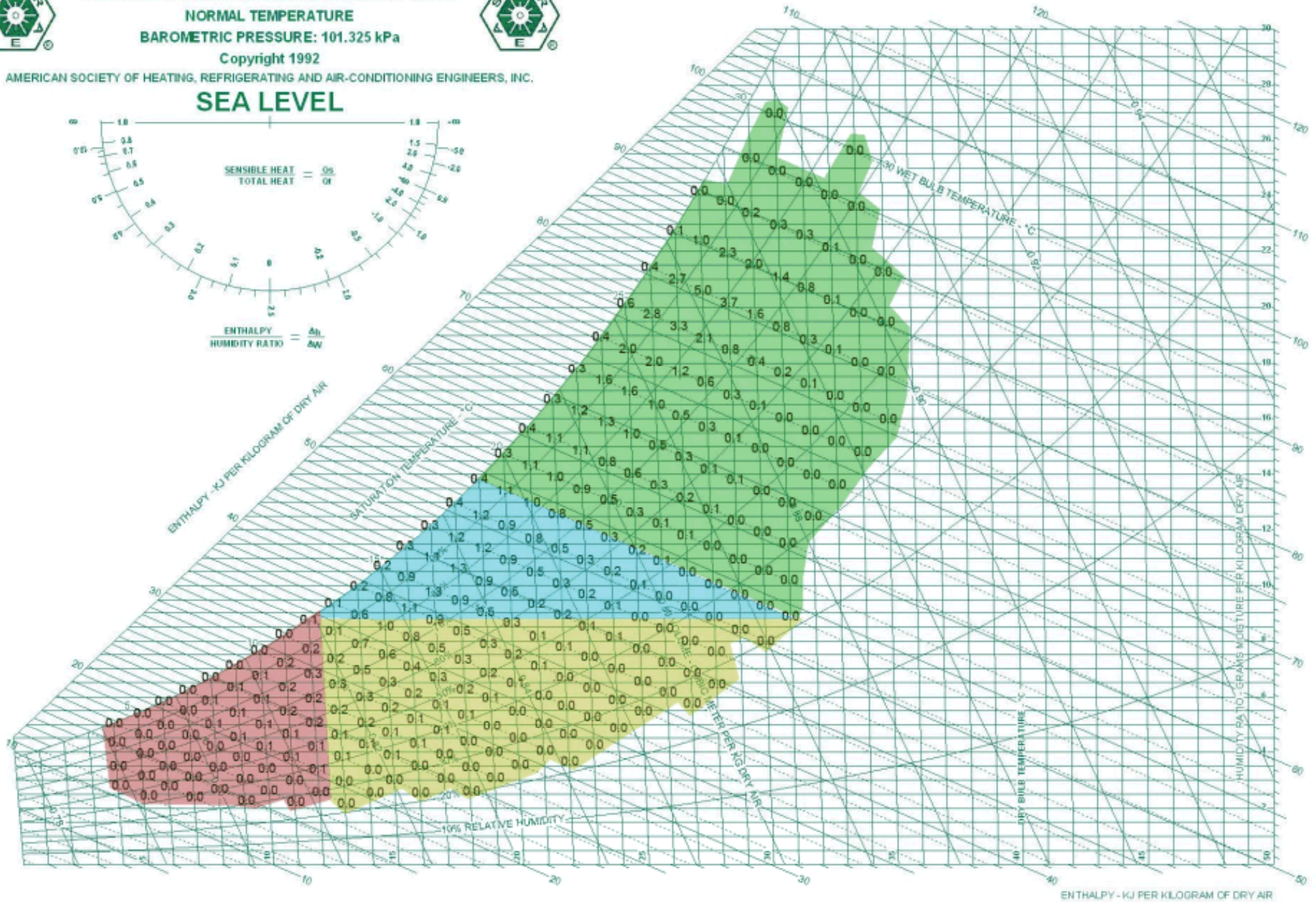
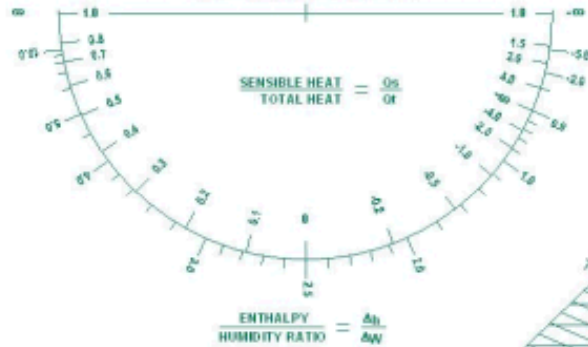
NORMAL TEMPERATURE

BAROMETRIC PRESSURE: 101.325 kPa

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SEA LEVEL



* The number represents the possibility of occurrence.

Analysis of HVAC operation strategy

Four Regions of Operation Schemes

For year-round operation of HVAC system in Hong Kong

Based on data from 1960 to 1992 (total 33 years).

Total number of data = 289,296 .

