

## Psychrometry



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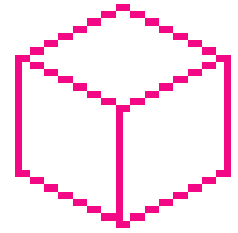
# Contents



- Atmosphere and water vapour
- Psychrometric chart (theory)
- The psychrometric equation
- Psychrometric software

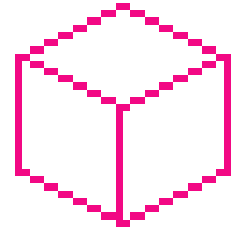
(\* Handouts with details can be downloaded from the course website:  
Chapter 1 – Introduction to Psychrometry.)

# Overview of the handouts



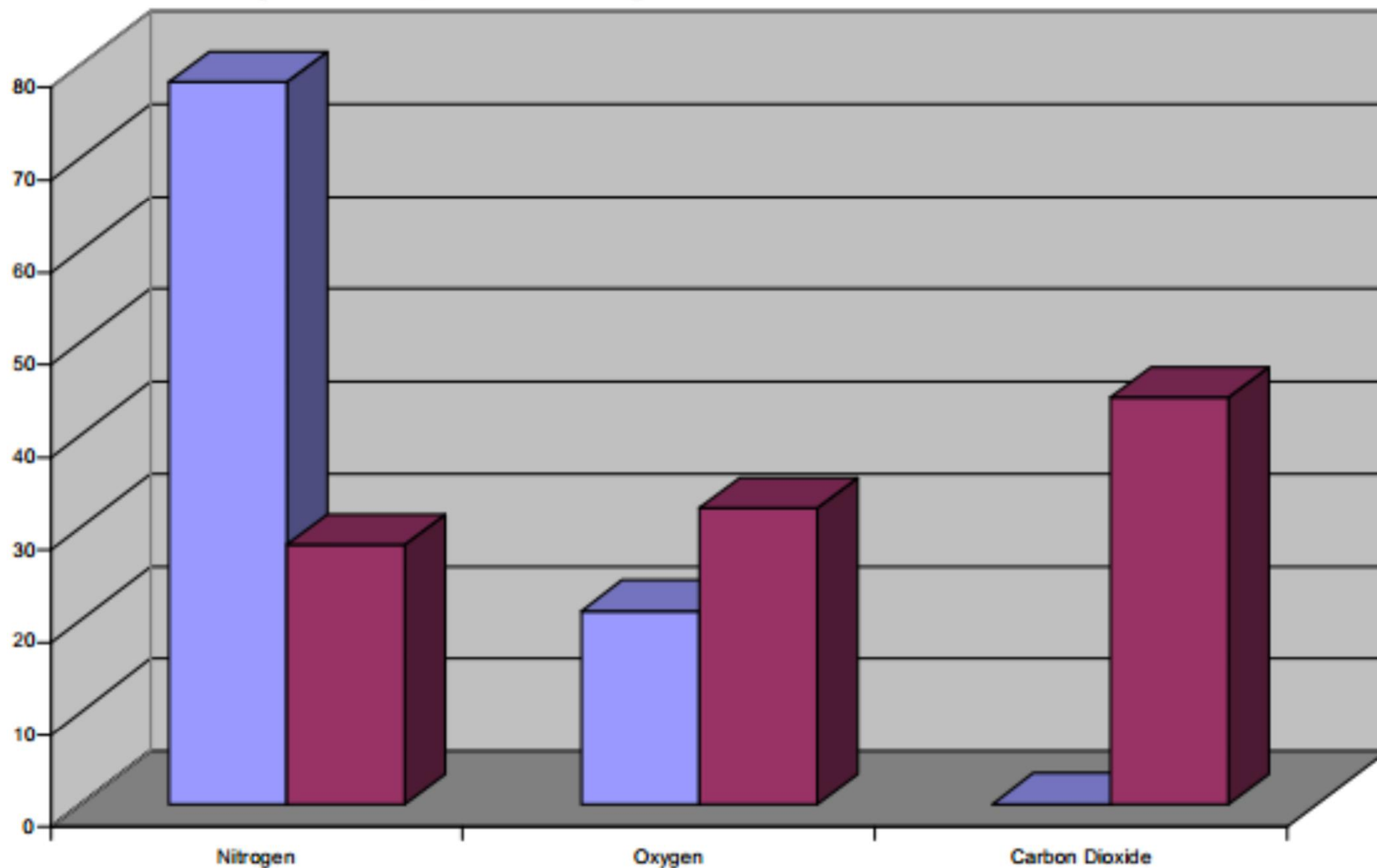
- Chapter 1 – Introduction to Psychrometry
  - Atmosphere and water vapour
  - Psychrometric chart (theory)
  - The psychrometric equation
  - Psychrometric chart (CIBSE)
  - Quick revision study guide (5 questions)
  - Chapter notes (footnotes)
- Appendix - Thermodynamic Basics
  - Perfect gas laws
  - 1st law of thermodynamics
  - Conservation of energy

# Atmosphere and water vapour



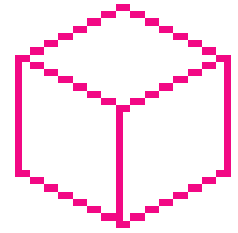
- Psychrometry (測濕學)
  - The measurement or study of the thermodynamic properties of **moist air**
    - The Greek term psuchron (ψυχρόν) meaning "cold" and metron (μέτρον) meaning "means of measurement"
  - Moist air properties: (water vapour + dry air)
    - Dalton's law of partial pressures ( $\text{Total} = P_A + P_B$ )
    - Standard atmospheric pressure = 101.325 kPa
    - Saturated vapour pressure: Max. pressure of water vapour that can occur at any given temperature

# Principle Dry Atmospheric Gases



■ Molecular Weight    ■ % Atmosphere

# Psychrometric chart (theory)

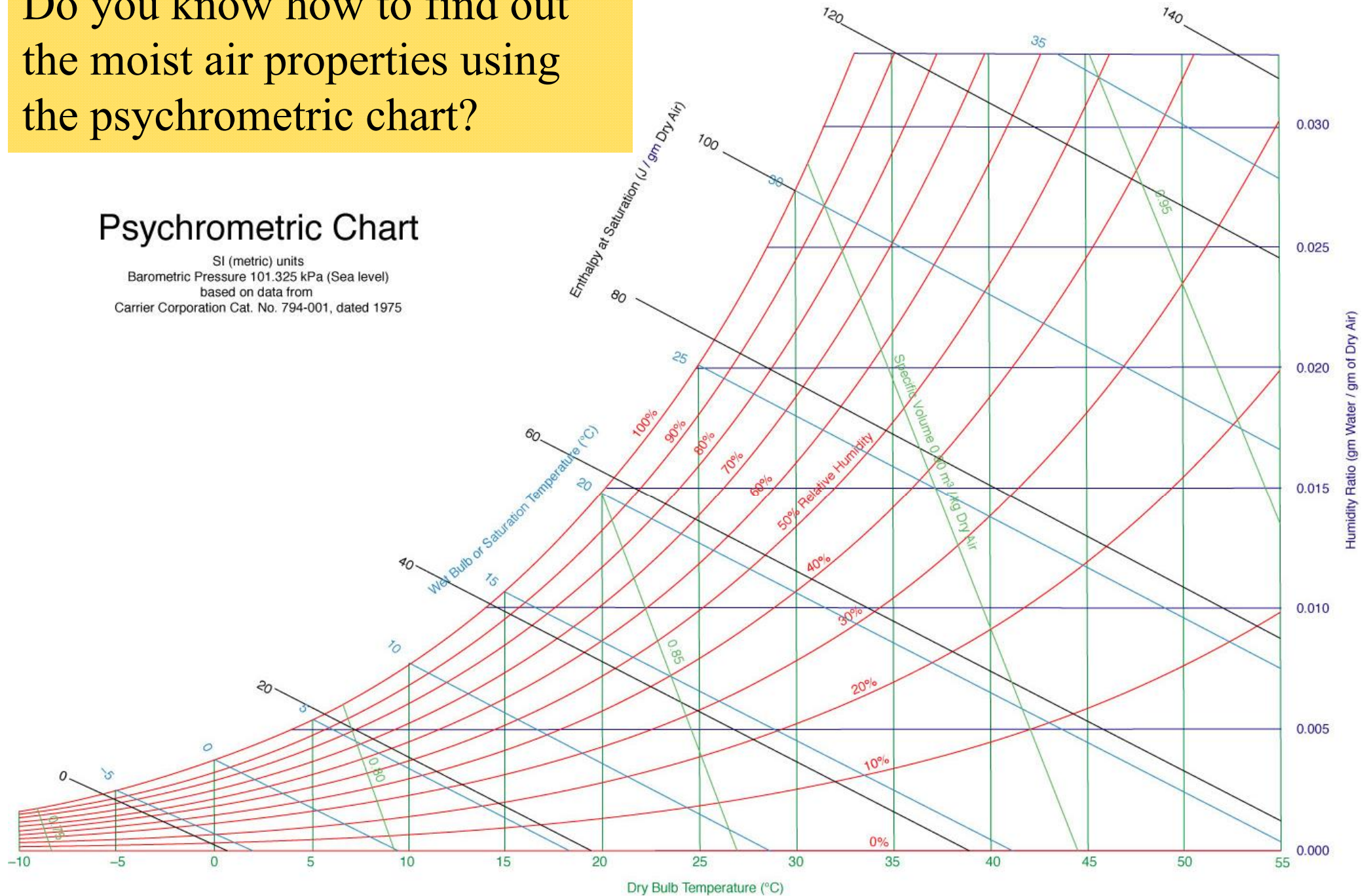


- Major parameters: (see handouts for details)
  - Moisture content ( $g$ ), or absolute humidity ( $w$ )
  - Relative humidity ( $rh$  or RH)
  - Percentage saturation ( $\mu$ )
  - Wet-bulb temperature ( $t_{wb}$ )
  - Dew-point temperature ( $t_{dp}$ )
  - Specific enthalpy ( $h$ )
  - Specific volume ( $v$ )
  - Density ( $\rho$ )

Do you know how to find out the moist air properties using the psychrometric chart?

## Psychrometric Chart

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



Can you read them from the chart?

# Psychrometric Chart

Wet-bulb temperature

Enthalpy

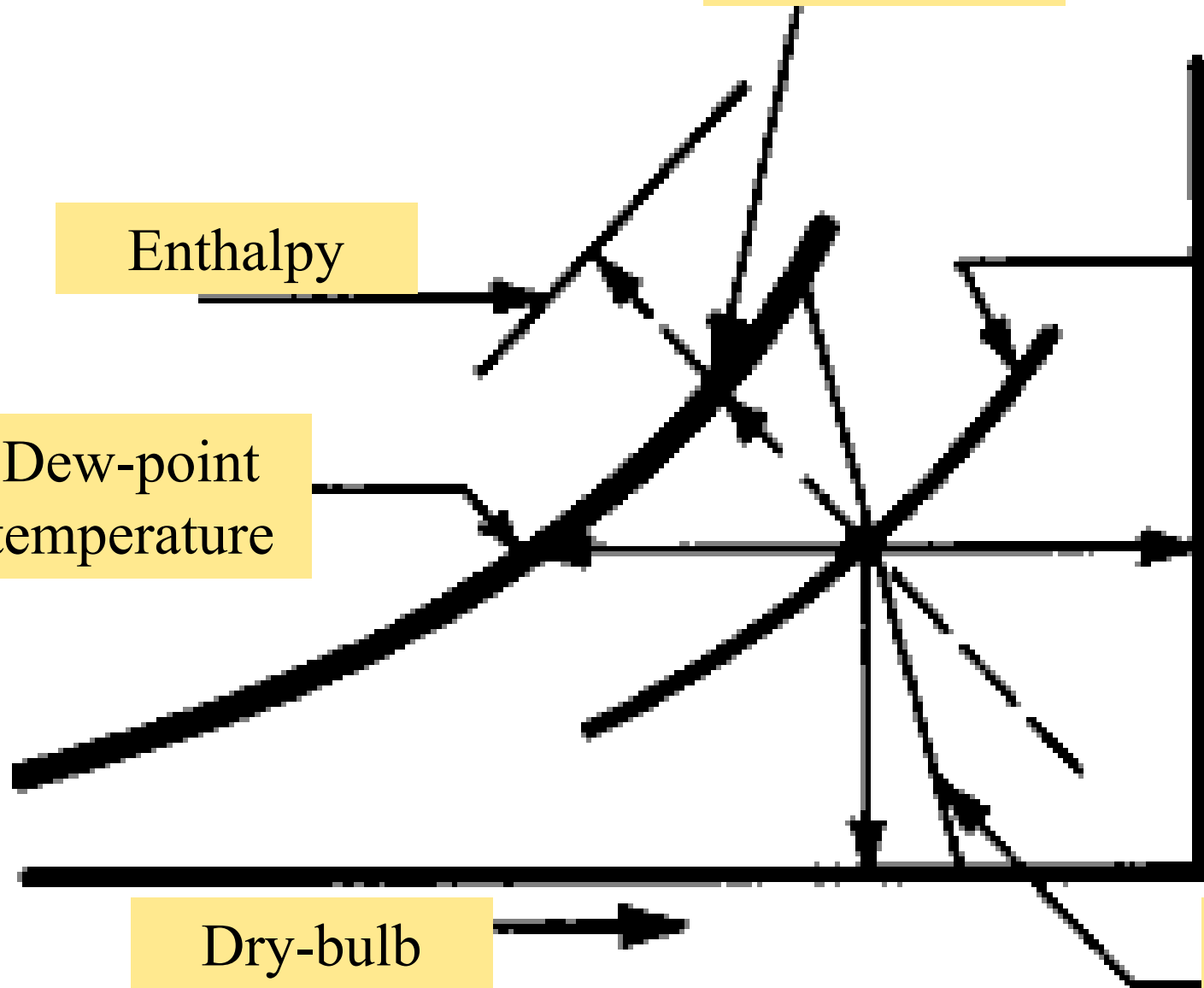
Relative humidity

Dew-point temperature

Humidity ratio

Dry-bulb temperature

Specific volume





# Measurement of moist air by sling psychrometer

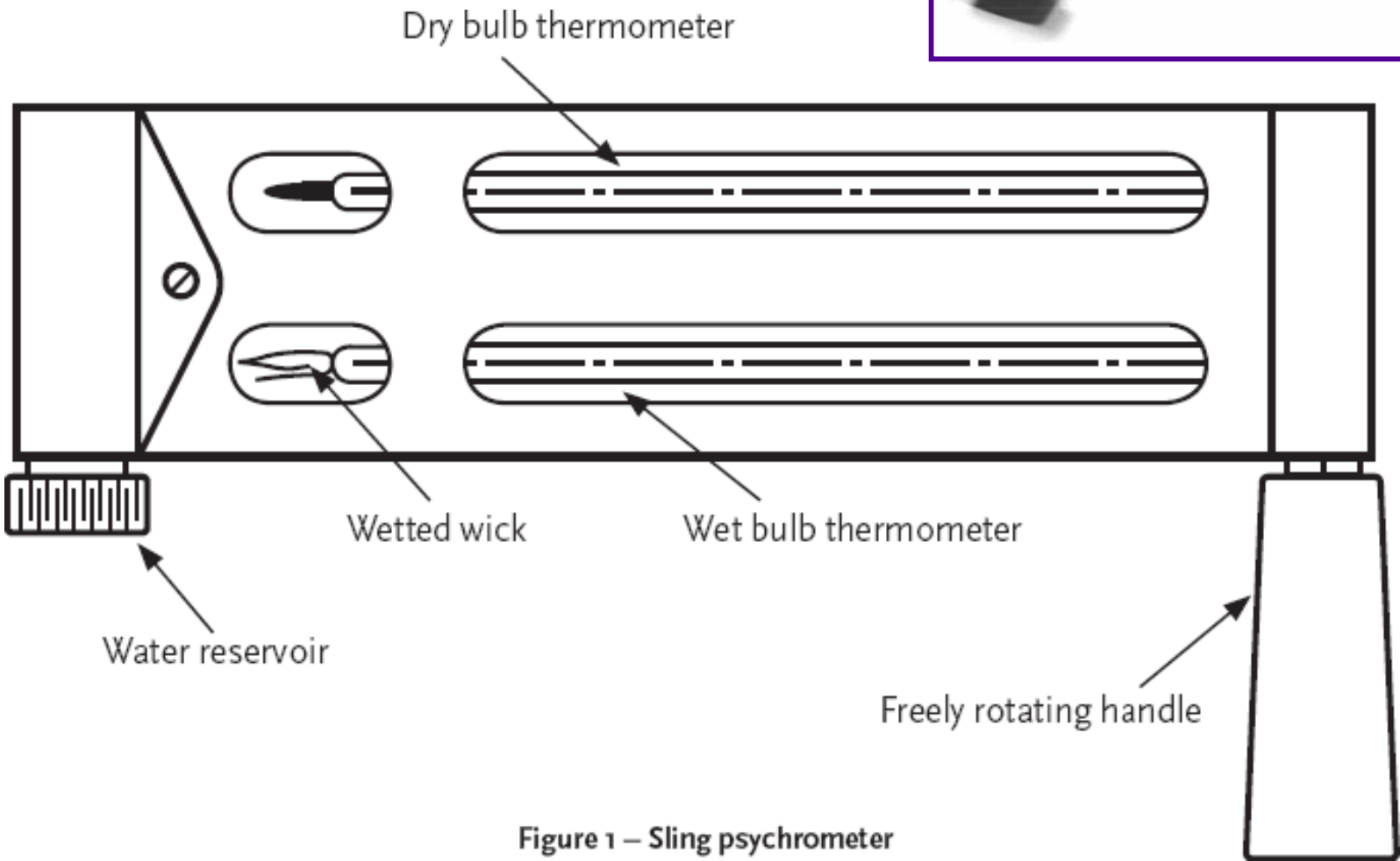
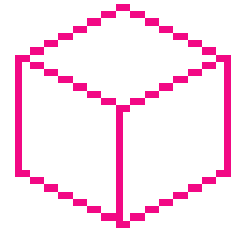


Figure 1 – Sling psychrometer

# Psychrometric chart (theory)



- Commonly used psychrometric charts
  - ASHRAE psychrometric chart
  - CIBSE psychrometric chart
  - Carrier psychrometric chart
  - Trane psychrometric chart
  - Mr. S K Wang (similar to Trane)
  - Mollier chart in Mainland China (濕空氣焓濕圖)
- You should learn how to read and use the psychrometric charts for HVAC design



# ASHRAE PSYCHROMETRIC CHART NO.1

NORMAL TEMPERATURE

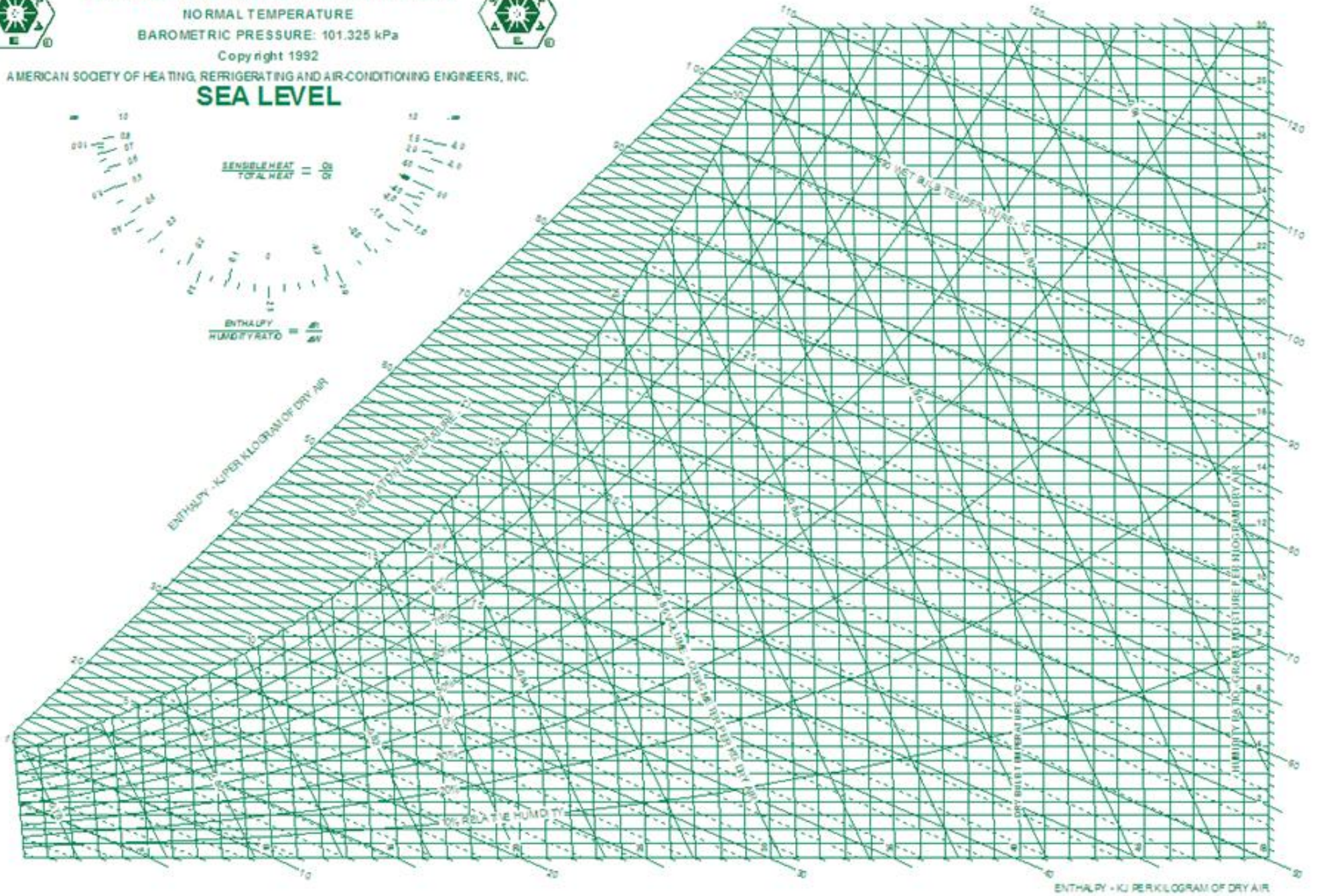
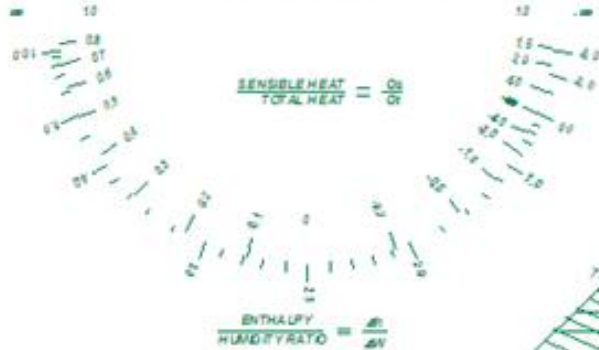
BAROMETRIC PRESSURE: 101.325 kPa

Copyright 1992

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



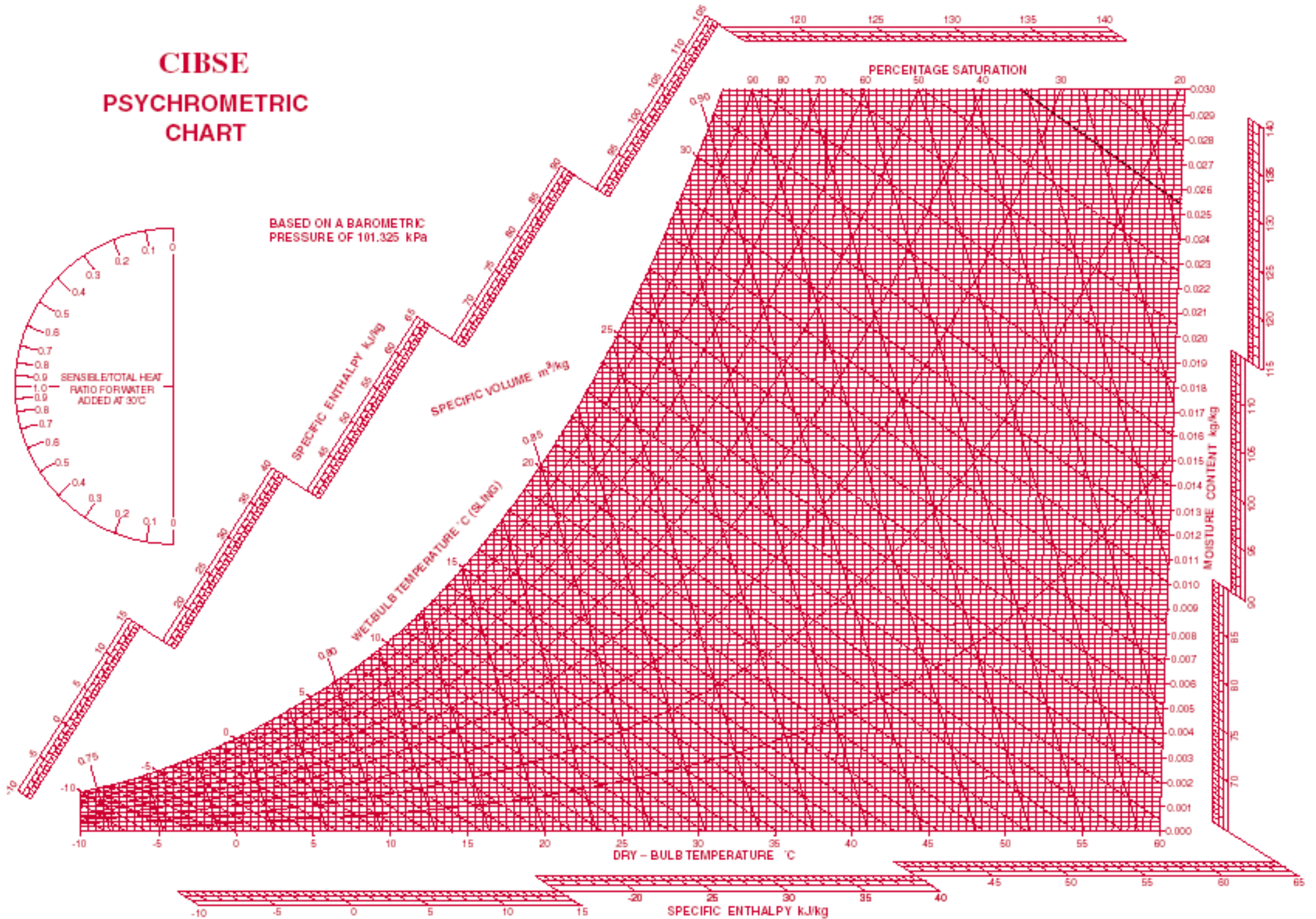
## SEA LEVEL



ENTHALPY - KJ PER KILOGRAM OF DRY AIR

# CIBSE PSYCHROMETRIC CHART

BASED ON A BAROMETRIC  
PRESSURE OF 101.325 kPa

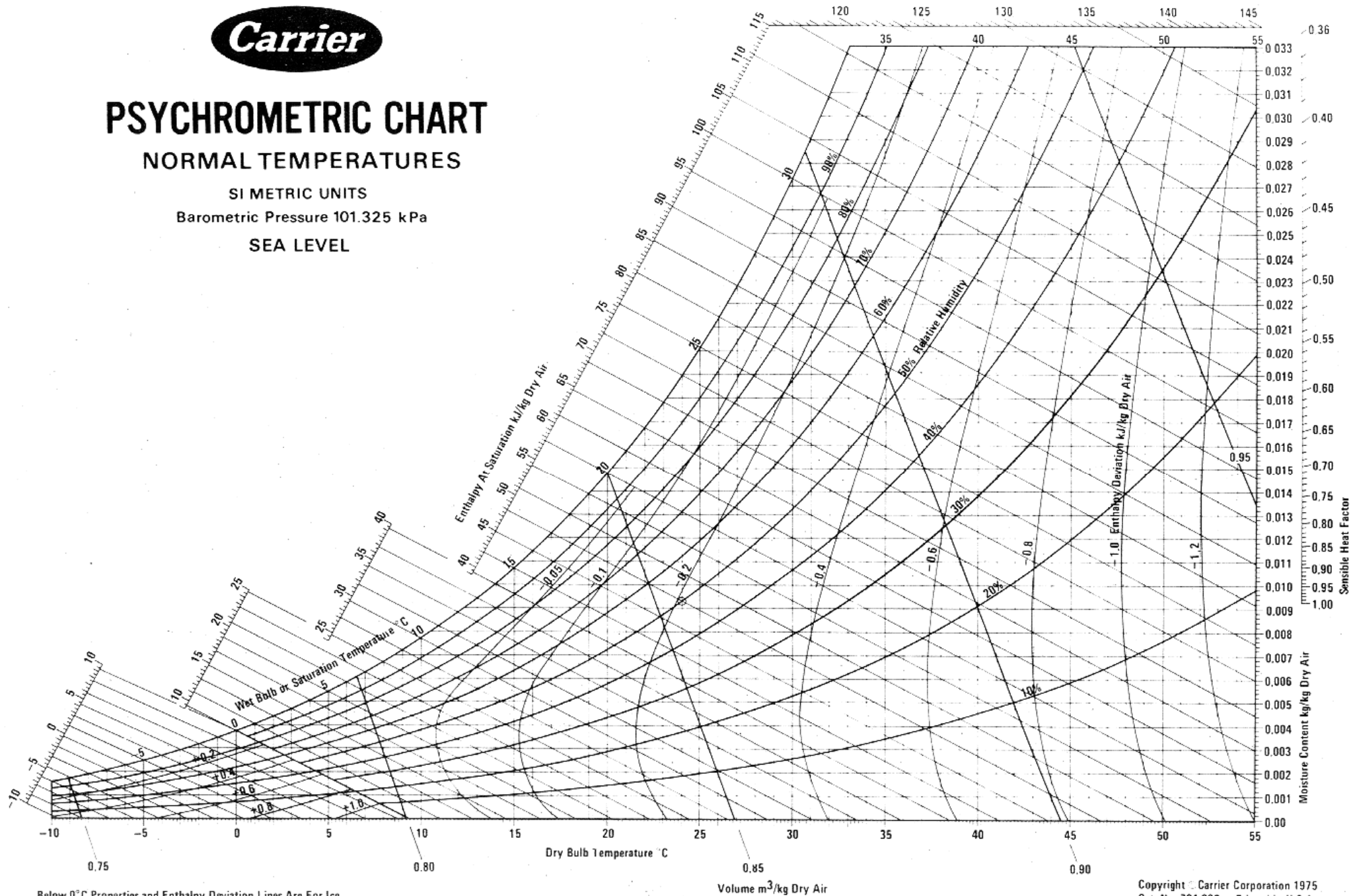




# PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS  
Barometric Pressure 101.325 kPa  
SEA LEVEL



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

Volume m<sup>3</sup>/kg Dry Air

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

Reproduced courtesy of Carrier Corporation

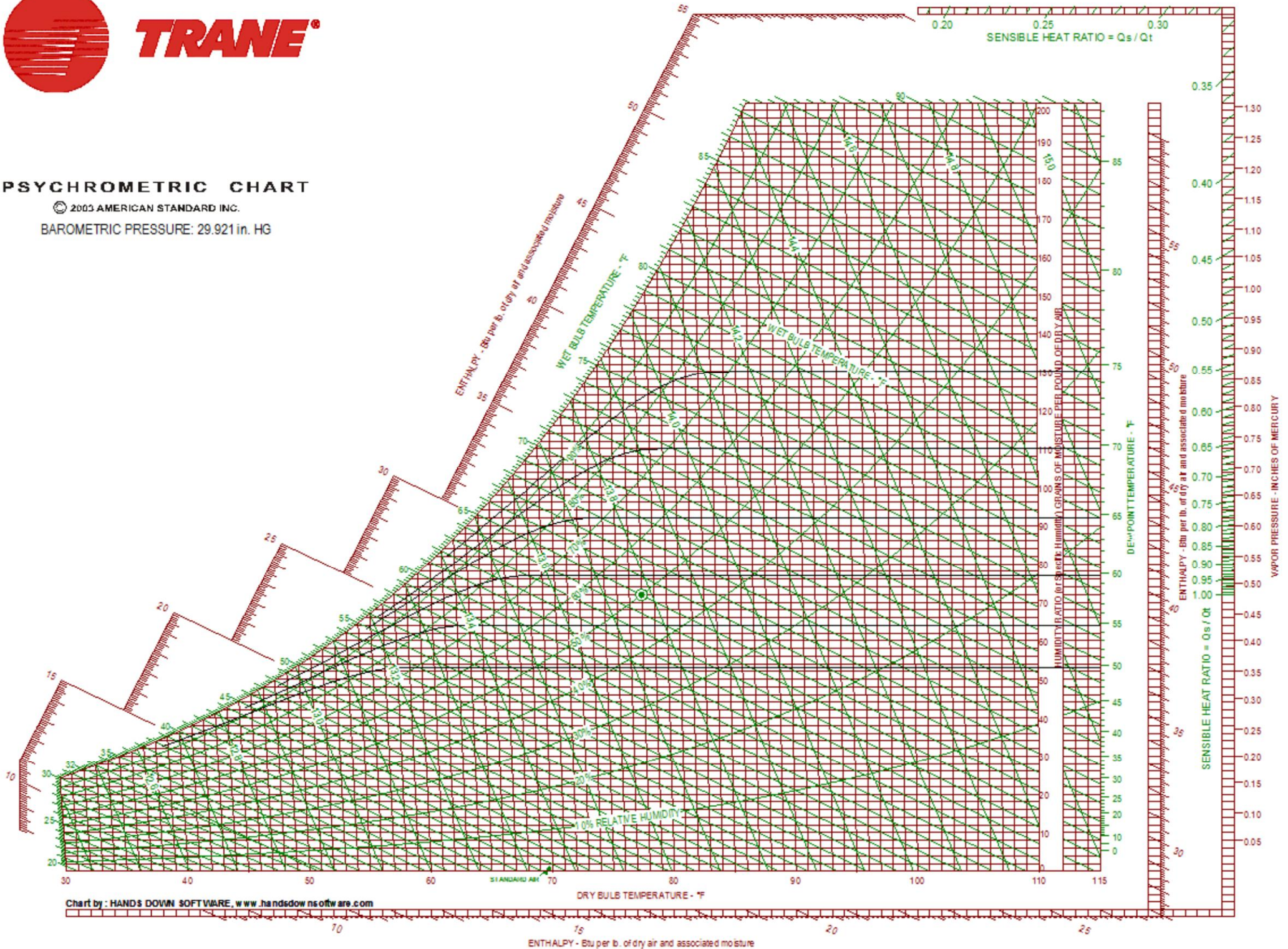


# TRANE®

## PSYCHROMETRIC CHART

© 2005 AMERICAN STANDARD INC.

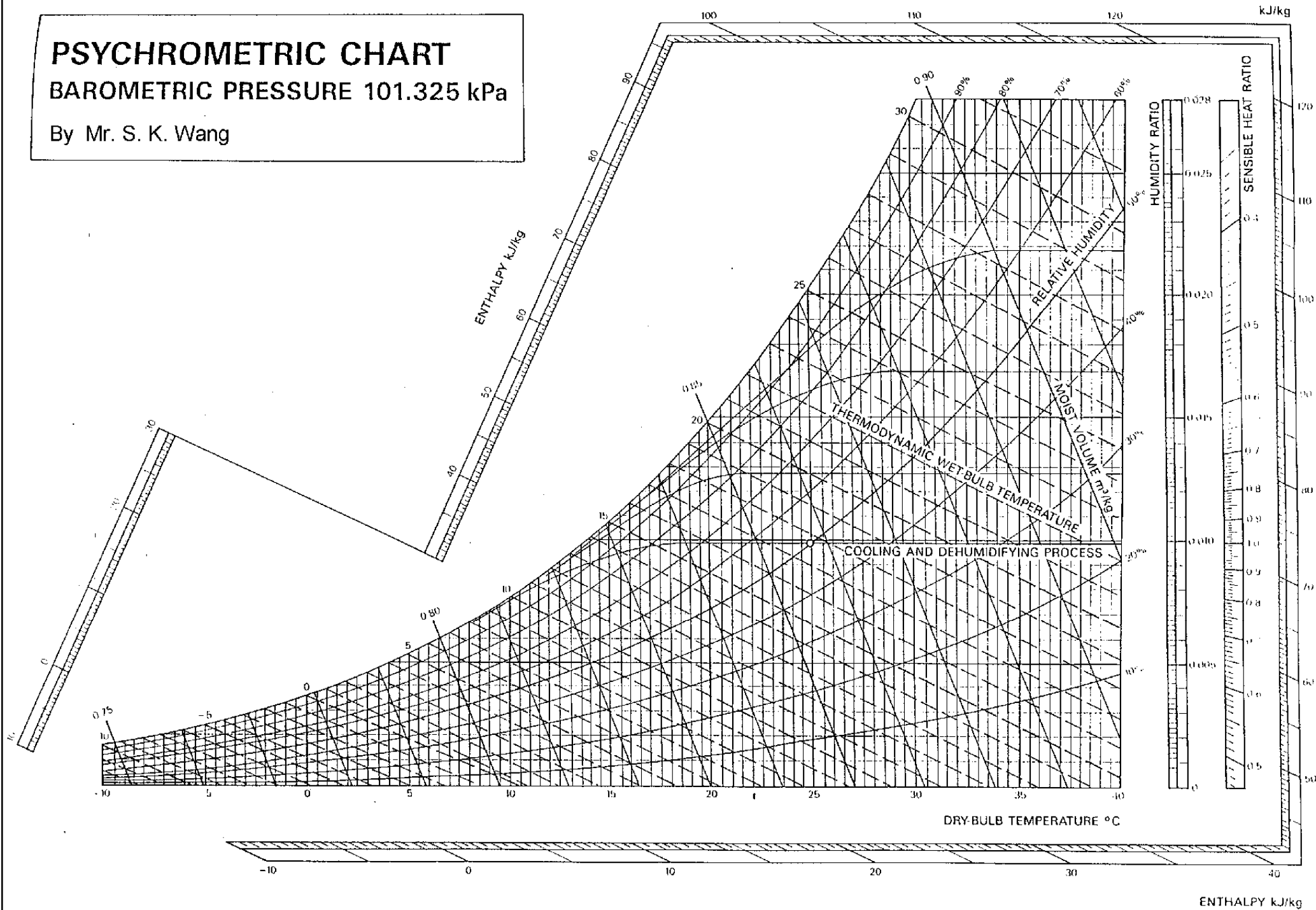
BAROMETRIC PRESSURE: 29.921 in. HG

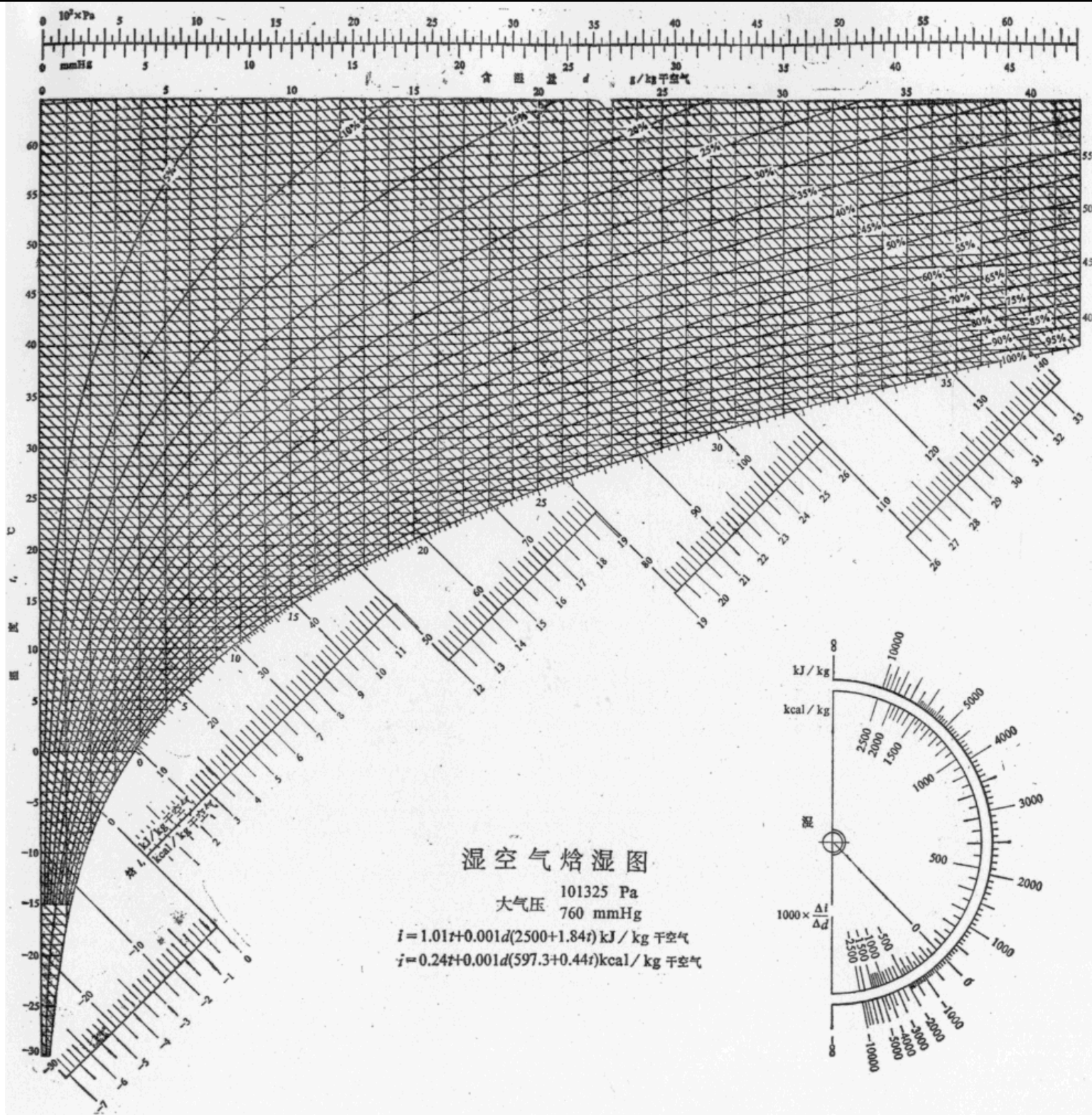


# PSYCHROMETRIC CHART

BAROMETRIC PRESSURE 101.325 kPa

By Mr. S. K. Wang





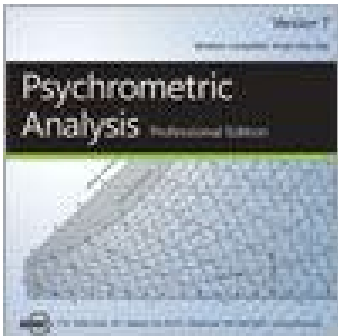
Mollier  
chart style



# Psychrometric software



- ASHRAE Psychrometric Analysis CD-ROM (2012, 2007, 2002) [AV 697 P97]
  - The program allows the user to plot typical psychrometric processes and perform the corresponding energy calculations
    - The program produces near-exact replications of the charts and can output a listing of points and processes in a tabular report with calculated properties and energy values for each. It includes a presentation of the ASHRAE climate data presented in the 2009 ASHRAE Handbook - Fundamentals



# Psychrometric software



- Psychrometric analysis software:
  - ArchiSci Software - PSYCHWIN
    - <http://arch.hku.hk/teaching/archisci/archisci.zip>
  - Psychrometric Chart (PSY) software
    - <http://www.vector.co.jp/soft/win95/business/se288946.html>
  - Daikin's Psychrometrics tool
    - [http://me.hku.hk/bse/MEBS6006/Psychrometric diagram viewer V210 tcm24-133157.zip](http://me.hku.hk/bse/MEBS6006/Psychrometric%20diagram%20viewer%20V210%20tcm24-133157.zip)
- Free Online Psychrometric Chart
  - <http://www.flycarpet.net/en/PsyOnline>

# Free Online Psychrometric Chart <http://www.flycarpet.net/en/PsyOnline>

www.flycarpet.net/en/PsyOnline

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Free Online Psychrometric Chart World's first online, and only! A convenient, precise and powerful psychrometric chart & calculator tool for HVAC engineers.

Basic Process Cycle 1 Cycle 2 Setting Display 简体中文

Click on chart for air properties

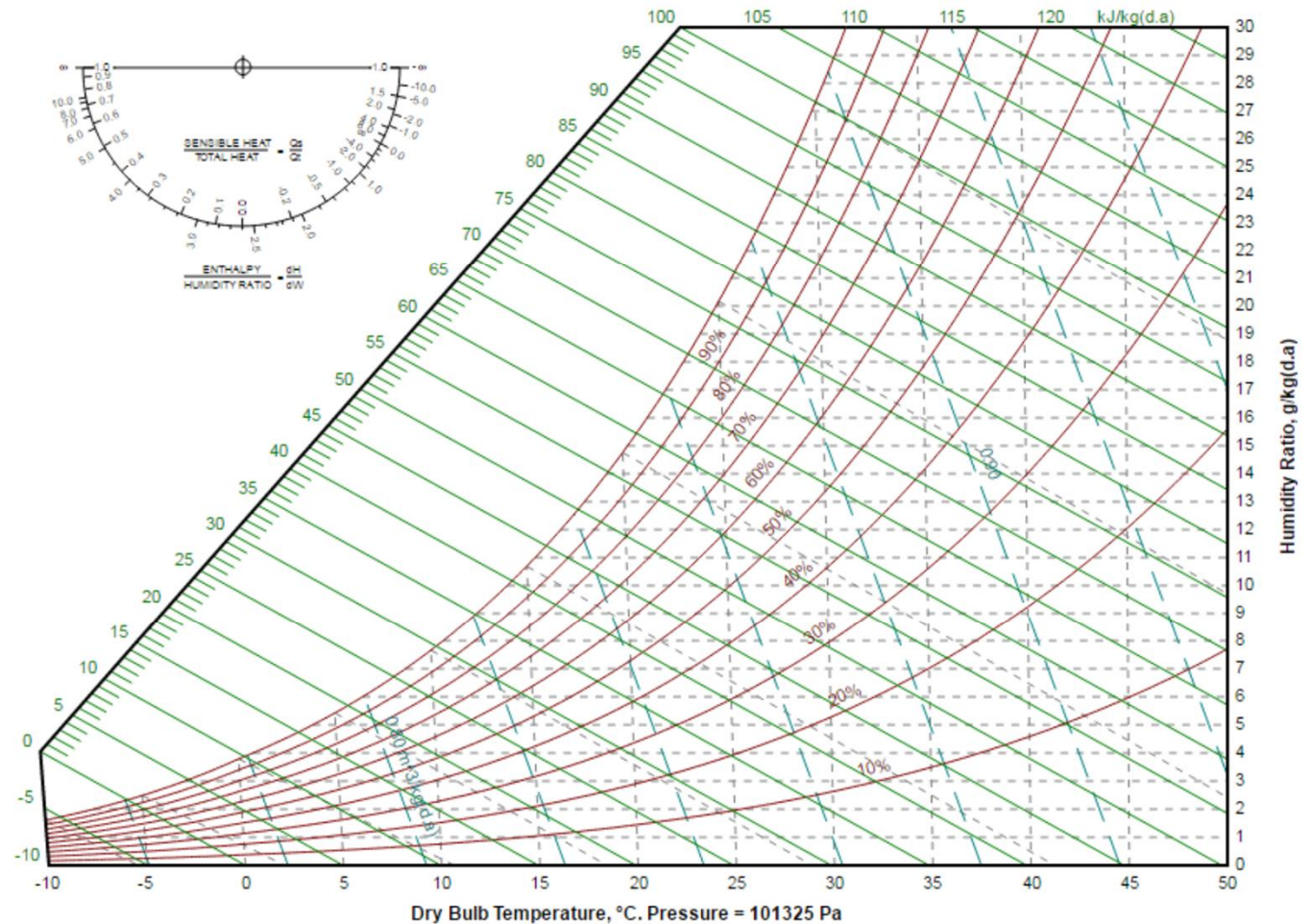
Or input data for air properties

T.Dry, °C 25

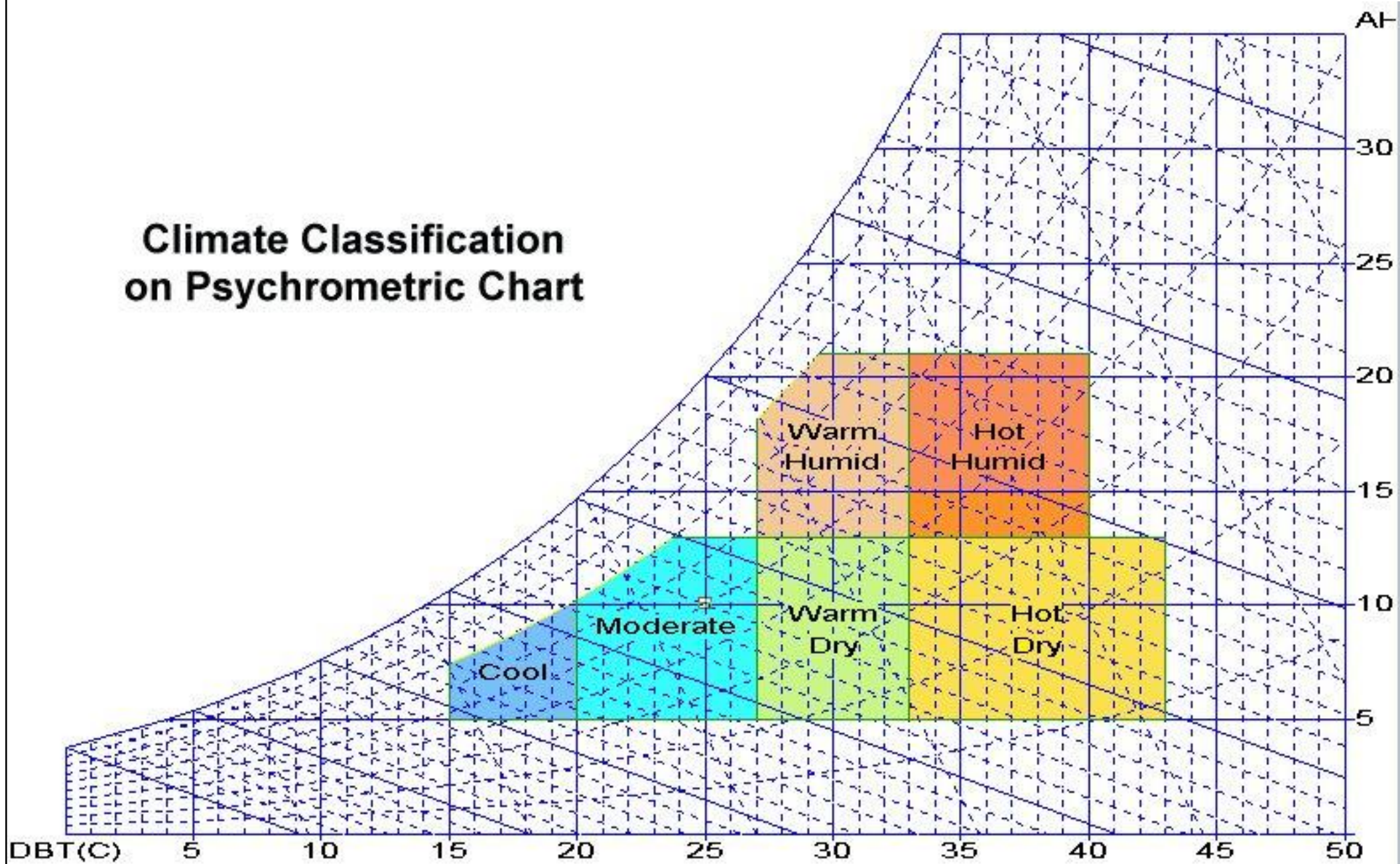
Rel.Humid, % 50

Quantity	Value	Units
P.Ambient		Pa
T.Dry.Bulb		°C
Humid.Ratio		g/kg(d.a)
Rel.Humid		%
T.Wet.Bulb		°C
T.Dew		°C
T.Saturation		°C
Enthalpy		kJ/kg(d.a)
P.Vapour		Pa
P.Sat.Vapour		Pa
Spec.Heat		kJ/(kg.K)

Stop and Play. We have a free small game for you: Survive Broken. Click to start play.

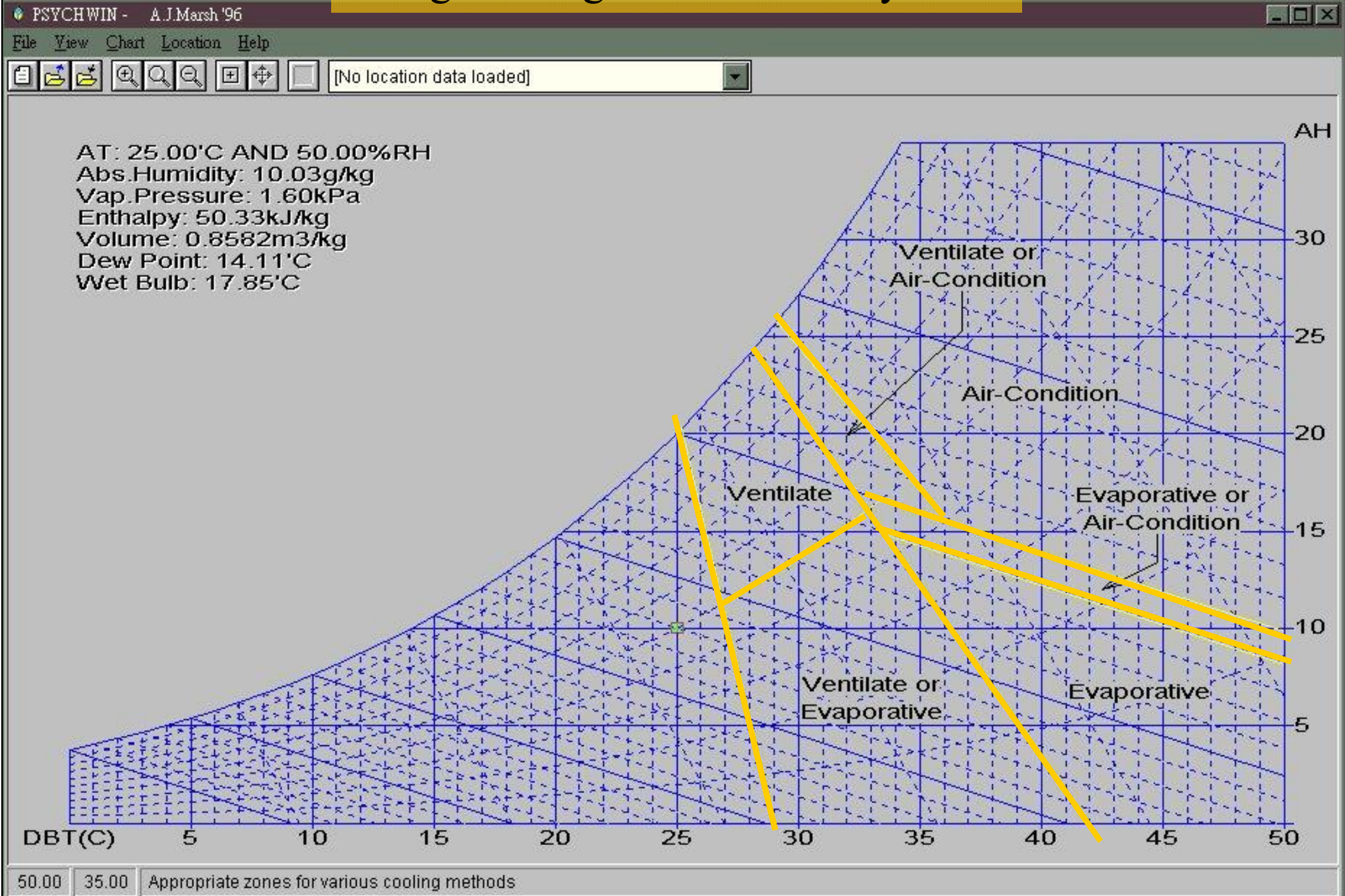


# Climate Classification on Psychrometric Chart



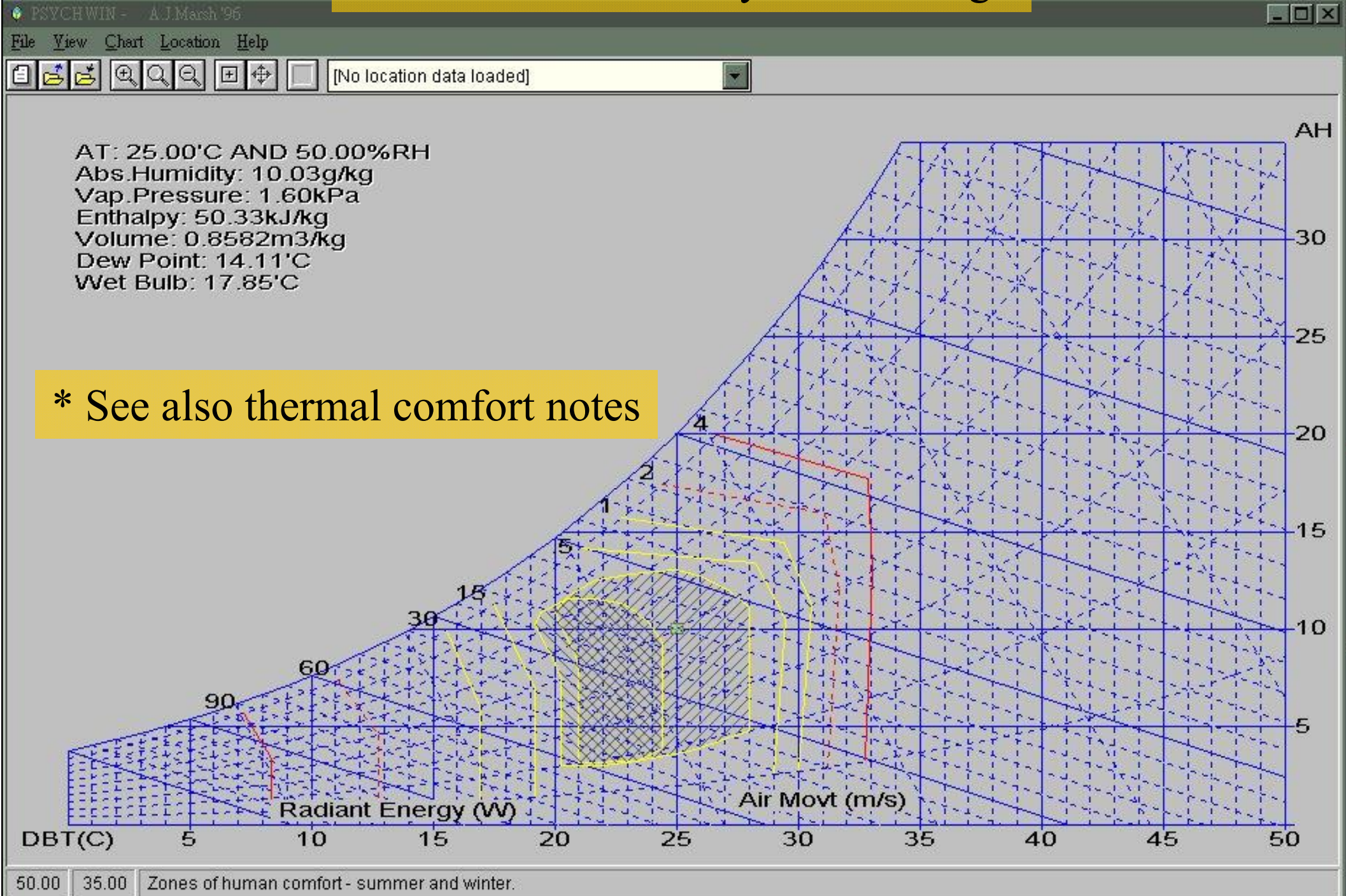
(Source: ArchiSci Software - PSYCHWIN)

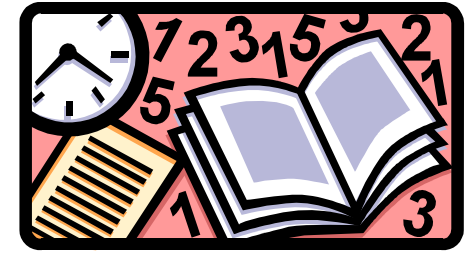
# Design strategies for HVAC systems



(Source: ArchiSci Software - PSYCHWIN)

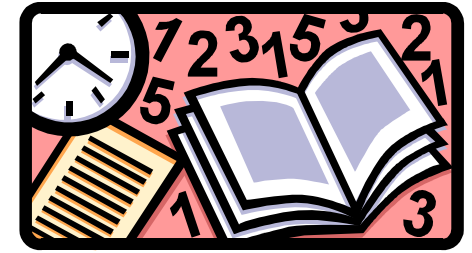
# Thermal comfort analysis and design





# Further Reading

- Air Conditioning: Psychrometrics (pages 1 to 4)
  - [http://www.arca53.dsl.pipex.com/index\\_files/psy1.htm](http://www.arca53.dsl.pipex.com/index_files/psy1.htm)
- CIBSE Journal CPD Programme:
  - <http://www.cibsejournal.com/cpd/>
  - The properties of air (Apr 2009)
  - Applying the psychrometric relationships (Aug 2009)
- NPTEL E-learning course -- Refrigeration and Air Conditioning <http://nptel.ac.in/courses/112105129/>
  - Lesson 27 Psychrometry <http://nptel.ac.in/courses/112105129/27>



# References

- ASHRAE Psychrometrics Tools
  - [www.ashrae.org/resources--publications/bookstore/psychrometrics](http://www.ashrae.org/resources--publications/bookstore/psychrometrics)
  - Psychrometric Chart App (on iPad)
    - ASHRAE HVAC Psychrometric Chart App (8:11)  
<http://www.youtube.com/watch?v=VFFqkBHDqPk>
  - Psychrometric Analysis CD, Version 7 (2012)
  - Understanding Psychrometrics, 3rd ed. (2013)

