PROFESSIONAL ENGINEERING WORKBOOK & DATABASE

PEWDB

HOW TO READ AND USE A PSYCHROMETRIC CHART

HVAC / FCU / AHU / ERV Engineering Guide

Purpose
Provide a practical, engineering-focused method for reading psychrometric charts, plotting air states, interpreting HVAC process lines, analyzing cooling/dehumidification, finding apparatus dew point (ADP), estimating bypass factor, and analyzing mixed air.

Prepared for PEWDB - Psychrometric Chart Module
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1. What a Psychrometric Chart Represents

A psychrometric chart is a graphical representation of the thermodynamic properties of moist air. HVAC and refrigeration engineers use it to see, on one diagram, how temperature, moisture and energy change as air is heated, cooled, humidified, dehumidified or mixed with another airstream.

The chart is especially useful because a single air state can be described by multiple properties. Once two independent psychrometric properties are known at a specified pressure, the remaining properties can be determined graphically or calculated.

- Typical engineering uses include:
  - Cooling-coil and heating-coil analysis
  - Fan-coil unit (FCU) performance
  - Air-handling unit (AHU) processes
  - ERV/HRV outdoor-air treatment
  - Comfort and dehumidification analysis
  - Ventilation-air mixing
  - Condensate estimation
  - Sensible heat ratio (SHR) evaluation
  - Humidifier and evaporative-cooling analysis

2. Select the Correct Chart First

Psychrometric properties depend on barometric pressure. Therefore, the first step is to use a chart or calculation basis appropriate for the site pressure or altitude. ASHRAE publishes charts for sea level and several altitude conditions, and psychrometric properties may also be calculated directly at the actual barometric pressure.

$$\text{Standard sea-level pressure: } P \approx 14.696 \text{ psia} \approx 101.325 \text{ kPa}$$

Engineering rule

Do not assume a sea-level chart is valid for a high-altitude project. Pressure changes affect humidity ratio, specific volume, enthalpy and airflow/mass-flow relationships.

3. Main Chart Properties and Line Families

Property	Symbol	How it appears	Engineering meaning
Dry-bulb temperature	DBT / Tdb	Approximately vertical lines	Ordinary air temperature
Humidity ratio	W	Horizontal lines	Mass of water vapor per mass of dry air
Relative humidity	RH	Curved lines	Moisture relative to saturation at the same temperature
Saturation	100% RH	Upper-left curved boundary	Air is saturated; additional cooling can cause condensation
Wet-bulb temperature	WBT / Twb	Diagonal line family	Moist-air property closely associated with evaporative

			cooling
Enthalpy	h	Diagonal line family / edge scale	Total moist-air energy per mass of dry air
Specific volume	v	Diagonal line family	Volume occupied per mass of dry air
Dew point	Tdp	Read by moving horizontally to saturation	Temperature where condensation begins at the existing moisture content

3.1 Dry-Bulb Temperature

Dry-bulb temperature is the ordinary air temperature measured by a conventional temperature sensor that is not intentionally wetted. On a standard psychrometric chart, moving right means warmer air; moving left means colder air.

3.2 Humidity Ratio

Humidity ratio is the mass of water vapor divided by the mass of dry air. It is commonly expressed as lb water/lb dry air, grains/lb dry air, or kg water/kg dry air.

$$W = m_{water\ vapor} / m_{dry\ air}$$

Horizontal movement on the chart keeps humidity ratio constant. Vertical movement changes the moisture content.

3.3 Relative Humidity

Relative humidity is shown by curved lines. The outer saturation curve is 100% RH. Relative humidity is not the same as humidity ratio: sensible heating can lower RH even when no water is removed because the saturation capacity increases as temperature rises.

4. How to Locate an Air State

At a known pressure, locate a state using two independent properties. A common field/design combination is dry-bulb temperature and relative humidity.

Example: 80°F DB and 50% RH

1. Locate 80°F on the dry-bulb scale.

2. Move upward along the 80°F dry-bulb line.

3. Find the 50% RH curve.

4. Mark the intersection as the air state.

5. From that point, read or calculate humidity ratio, dew point, wet bulb, enthalpy and specific volume.

5. Dew Point - A Critical HVAC Reading

Dew point is obtained graphically by moving horizontally left from the air-state point until reaching the 100% RH saturation curve. Horizontal movement holds humidity ratio constant, so this represents sensible

cooling with no moisture removal. The saturation-curve temperature at that intersection is the dew-point temperature.

Why it matters

If a cooling-coil surface is below the entering-air dew point, condensation can occur. This is the basic psychrometric reason a cooling coil can provide latent cooling and dehumidification.

6. How to Interpret Process Directions

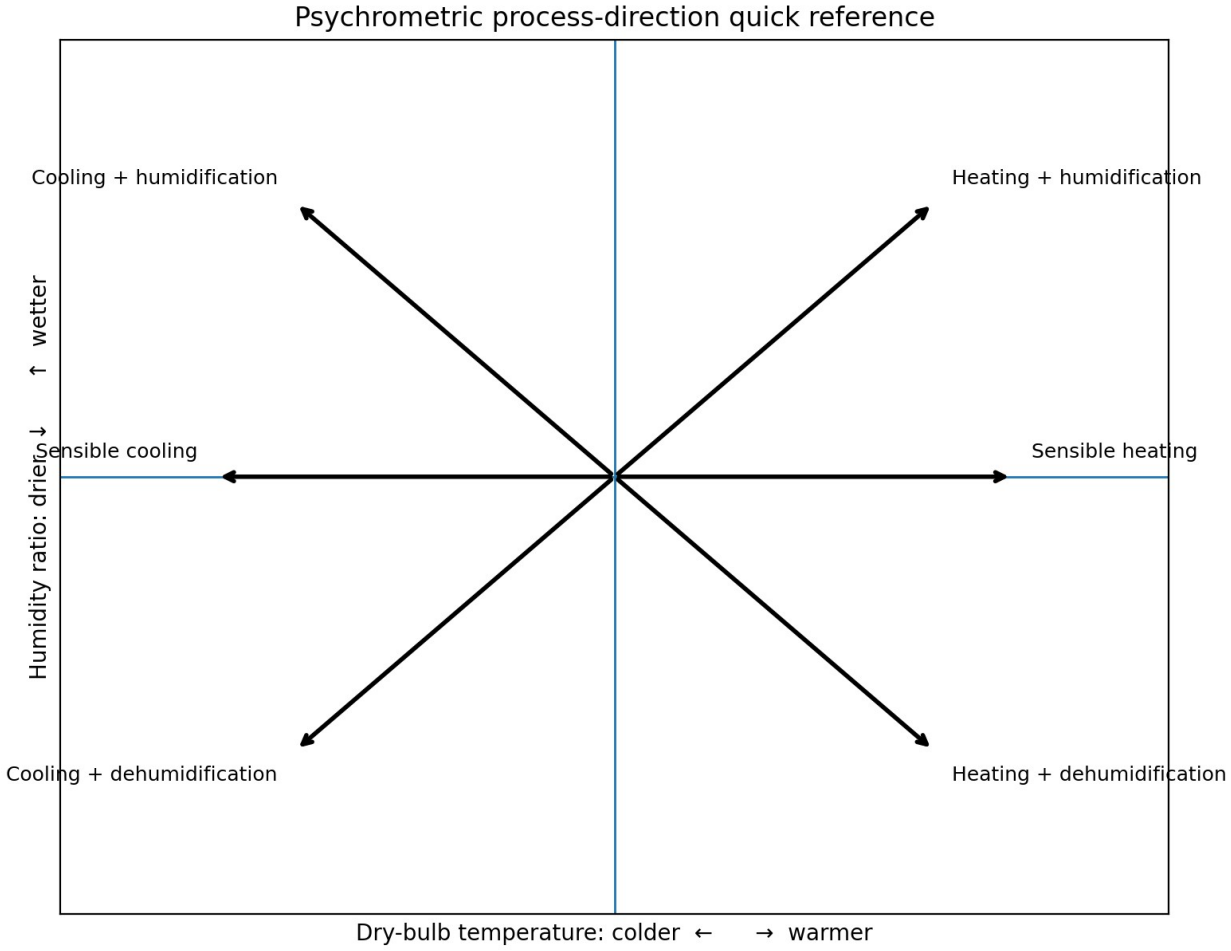


Figure 1. Original PEWDB process-direction reference.

Process	Dry-bulb temperature	Humidity ratio	Direction
Sensible heating	Increases	Constant	Right →
Sensible cooling	Decreases	Constant	Left ←
Heating + humidification	Increases	Increases	Up-right ↗️
Cooling + humidification	Decreases	Increases	Up-left ↖️
Cooling + dehumidification	Decreases	Decreases	Down-left ↙️
Heating + dehumidification	Increases	Decreases	Down-right ↘️

6.1 Sensible Heating and Cooling

If moisture content does not change, the humidity ratio stays constant and the process is horizontal. Sensible heating moves right; sensible cooling moves left.

6.2 Cooling and Dehumidification

When a cooling surface is below the air dew point, both dry-bulb temperature and humidity ratio can decrease. The process therefore moves down and left. This is the characteristic cooling-coil process used in comfort cooling and dehumidification.

7. Worked Cooling-Coil Example

The following example is illustrative and is intended to teach chart interpretation. It is not a universal coil design condition.

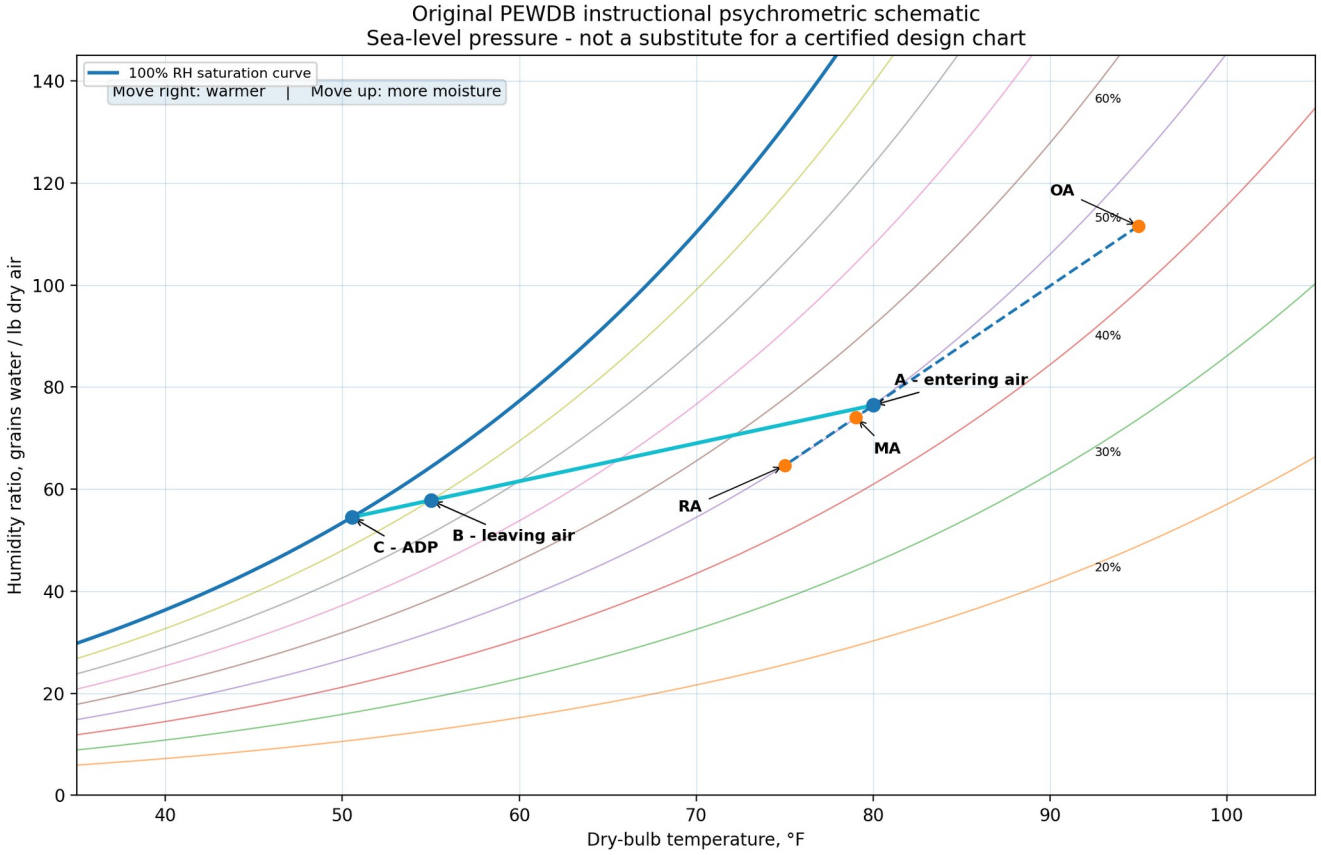


Figure 2. Original PEWDB psychrometric schematic with cooling-coil and mixed-air examples.

Point A - Entering air

Dry bulb = 80°F; RH = 50%. Approximate calculated values at sea-level pressure: W = 0.01092 lb/lb dry air = 76.5 grains/lb, h = 31.18 Btu/lb dry air, dew point ≈ 59.7°F.

Point B - Leaving air

Dry bulb = 55°F; RH = 90%. Approximate calculated values: W = 0.00826 lb/lb dry air = 57.8 grains/lb, h = 22.17 Btu/lb dry air, dew point ≈ 52.1°F.

Connect A to B. The line moves down-left, so the coil is removing both sensible heat and moisture. The horizontal component represents sensible cooling; the downward component represents latent cooling/dehumidification.

$$Q_{total} = Q_{sensible} + Q_{latent}$$

8. Apparatus Dew Point and Bypass Factor

Extend the A-B cooling/dehumidification process line until it intersects the 100% RH saturation curve. That intersection is Point C, the apparatus dew point (ADP). ASHRAE defines ADP as the effective coil surface temperature associated with a dehumidifying process.

For the illustrative A-B example, the straight-line intersection is approximately:

$$ADP \approx 50.5°F$$

A commonly used dry-bulb bypass-factor relationship is:

$$BF = (T_{leaving} - T_{ADP}) / (T_{entering} - T_{ADP})$$

$$\text{Contact Factor, } CF = 1 - BF$$

Using 80°F entering, 55°F leaving and 50.5°F ADP: BF ≈ 0.15 and CF ≈ 0.85. This is an illustrative psychrometric estimate; final coil performance must be based on manufacturer coil data, airflow, geometry, rows, fin spacing, fluid/refrigerant conditions and test data.

9. Condensate and Cooling-Capacity Calculations

9.1 Moisture removal / condensate

$$\dot{m}_{condensate} = \dot{m}_{dry_air} \times (W_{entering} - W_{leaving})$$

Example for 1,000 cfm at the entering state above: estimated dry-air mass flow ≈ 72.2 lb/min. With ΔW ≈ 0.00266 lb/lb, condensate ≈ 11.5 lb/h, or about 1.38 gal/h of liquid water. Actual drain load varies with operating condition and should include appropriate design allowance.

9.2 Total cooling from enthalpy

$$\dot{Q}_{total} = \dot{m}_{dry_air} \times (h_{entering} - h_{leaving})$$

For the same illustrative 1,000 cfm condition, the enthalpy difference gives approximately 39,000 Btu/h, or about 3.25 refrigeration tons. This example demonstrates why coil duty cannot be judged from dry-bulb temperature reduction alone.

10. Mixed-Air Analysis

A common AHU process is adiabatic mixing of outdoor air and return air. On a psychrometric chart, the resulting mixed-air state lies on the straight line connecting the two inlet air states. Its position on that line is determined by the dry-air mass-flow ratio.

Illustrative states: Outdoor air OA = 95°F, 45% RH; Return air RA = 75°F, 50% RH. If the mixture is 20% OA and 80% RA by dry-air mass, the mixed state is approximately 79.0°F with W ≈ 74.0 grains/lb dry air.

$$W_M = (m_{OA}\, W_{OA} + m_{RA}\, W_{RA}) / (m_{OA} + m_{RA})$$

$$h_M = (m_{OA} h_{OA} + m_{RA} h_{RA}) / (m_{OA} + m_{RA})$$

This is particularly important for ventilation systems and ERVs because outdoor-air treatment changes the mixed-air load seen by the downstream cooling coil.

11. FCU, AHU and ERV Applications

Application	How the psychrometric chart helps
FCU	Use entering/leaving air states to estimate sensible/latent capacity, SHR, condensate, ADP and coil effectiveness.
AHU	Plot outdoor air, return air, mixed air, cooling-coil leaving air, heating/reheat, humidification and supply-air states.
ERV	Compare outdoor air before/after the energy recovery core and quantify sensible and latent transfer before downstream conditioning.
Load calculation	Use room/design states with supply-air conditions to understand required sensible and latent treatment.
Commissioning	Compare measured DB/RH states against expected process lines to identify insufficient dehumidification, excessive bypass, reheat or mixing issues.

12. Common Mistakes

- Using the wrong pressure/altitude basis.
- Confusing relative humidity with humidity ratio.
- Assuming a horizontal cooling process always dehumidifies. It does not until the process reaches the dew point / a surface below the dew point.
- Reading enthalpy or wet-bulb lines from the wrong scale.
- Assuming leaving air from a real cooling coil is exactly saturated.
- Treating an ADP/bypass-factor estimate as a substitute for certified coil-selection data.
- Mixing air streams by volumetric percentage without checking density/specific-volume effects when precision matters.
- Using psychrometric results without considering fan heat, duct heat gain, leakage, condensate re-evaporation or measurement uncertainty.

13. Recommended PEWDB Interactive Psychrometric Module

The final PEWDB Psychrometric Chart module should go beyond a static reference page. Recommended functions:

- Plot one or more state points from DB + RH, DB + WB, DB + DP, or other valid property pairs.
- Automatically calculate RH, W, WB, DP, enthalpy, specific volume and vapor pressure.
- Connect points with process lines and classify the process direction.
- Calculate sensible, latent and total heat change; SHR; moisture removal/addition; condensate rate.
- Estimate ADP, bypass factor and contact factor for valid cooling/dehumidification processes.
- Plot OA → ERV leaving OA → RA → MA → coil leaving → supply → room/return sequences.
- Support I-P and SI units and user-defined altitude/barometric pressure.
- Provide formula trace, assumptions, validation warnings and source references.

- Export an engineering report containing state-point tables and the plotted chart.

14. References and Source Notes

Primary authoritative references used for this instructional module:

- ASHRAE Handbook - Fundamentals (2025), Chapter 1: Psychrometrics. ASHRAE Handbook Online. https://handbook.ashrae.org/Handbooks/F25/IP/F25_Ch01/F25_Ch01_ip.aspx
- ASHRAE Handbook - Fundamentals (2025), Chapter 1: Psychrometrics, SI edition. https://handbook.ashrae.org/Handbooks/F25/SI/F25_Ch01/F25_Ch01_si.aspx
- ASHRAE Terminology: Apparatus dew point and bypass factor. https://terminology.ashrae.org/?term=apparatus+dew+point
- ASHRAE Psychrometrics resources and Psychrometric Chart App. https://www.ashrae.org/technical-resources/bookstore/psychrometrics
- ASHRAE Fundamentals of Psychrometrics training overview. https://www.ashrae.org/professional-development/self-directed-learning-group-learning-texts/fundamentals-of-psychrometrics
- ASHRAE Handbook - HVAC Systems/Equipment, Air-Cooling and Dehumidifying Coils, for cooling/dehumidification behavior and coil-surface/dew-point considerations.

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The diagrams in this guide are original PEWDB instructional graphics. They are not reproductions of ASHRAE psychrometric charts. ASHRAE is cited as the principal technical source for psychrometric definitions and methods.

Calculation note: numerical examples in this guide are approximate and intended for engineering instruction. Final project design should use verified psychrometric calculations at the actual pressure and certified equipment-selection data where applicable.