

Commercial Refrigeration Basics & Introduction to Diagnostic Graphs

7 Complete Modules for Beginners, Apprentices & New Starters · Individual Tuition: £29.00 (B2B Corporate Volume & Tailored Quotes Available via corporate@rda-academy.co.uk)

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Module 1: Laws of Thermodynamics, Sensible vs. Latent Heat & Pressure-Temperature

Duration: 18 Minutes · Target Competency: Master how heat moves from product load into refrigerant and out to ambient air.

1.1 Heat Transfer Fundamentals

Refrigeration does not create 'cold'—it removes heat from an enclosed retail display cabinet or coldroom and rejects that thermal energy outdoors. Heat always flows from a warmer substance to a cooler substance (Second Law of Thermodynamics).

1.2 Sensible Heat vs. Latent Heat of Vaporisation

Sensible heat causes a measurable temperature change on a probe or thermometer without changing state. Latent heat is the hidden energy absorbed or released during a phase change (liquid boiling to vapour in the evaporator, or vapour condensing to liquid in the condenser) at constant pressure and saturation temperature.

1.3 Pressure-Temperature (P-T) Saturation Relationship

Every refrigerant has a fixed boiling point for a given pressure. Raising pressure raises the saturation boiling temperature; lowering suction pressure lowers the boiling temperature inside the evaporator coil.

FIELD & BUREAU DIAGNOSTIC RULE: Always convert suction and discharge gauge pressures into Saturated Suction Temperature (SST) and Saturated Condensing Temperature (SCT) before calculating Superheat or Subcooling.

Thermodynamic Term	Physical Meaning	Where You See It on Telemetry
Sensible Heat	Temperature change you can measure with a probe	Air-On vs Air-Off split across a cabinet
Latent Heat	Phase-change boiling/condensing at constant pressure	Flooding zone inside the evaporator coil
Saturation Temp (SST/SCT)	Boiling/condensing point at measured pressure	Suction transducer converted via P-T chart

Module 2: The 4 Core Components of the Vapour-Compression Cycle

Duration: 22 Minutes · Target Competency: Trace refrigerant state, pressure, and temperature around the four quadrants of the loop.

2.1 The Evaporator (Low-Pressure Heat Absorber)

Cold, low-pressure liquid/vapour mixture enters the evaporator coil at around 25% flash gas / 75% liquid. As warm cabinet air passes over the fins, the refrigerant boils completely into a low-pressure superheated vapour.

2.2 The Compressor (Vapour Pump & Heart of the System)

Draws in low-pressure superheated suction vapour and compresses it into a high-pressure, high-temperature discharge vapour so that its saturation temperature is well above outdoor ambient air.

2.3 The Condenser & Receiver (Heat Rejection & Liquid Storage)

High-pressure discharge gas desuperheats, condenses into a saturated liquid, and subcools before entering the liquid receiver and filter-drier.

2.4 The Metering Device (Pressure Drop & Flow Control)

Creates the restriction between the high side and low side, dropping high-pressure subcooled liquid down to evaporator boiling pressure.

FIELD & BUREAU DIAGNOSTIC RULE: Compressors only pump vapour—never liquid! Liquid entering a compressor washes oil from bearings and breaks valves (liquid floodback/slugging).

Module 3: Compressors, Condensers & Subcooling Diagnostics

Duration: 20 Minutes · Target Competency: Calculate Subcooling and distinguish normal condenser operation from fouled coils or low charge.

3.1 Compressor Architectures

Commercial retail estates use hermetic scroll, semi-hermetic reciprocating, and inverter-driven variable-speed compressors. Capacity control matches mass flow to cabinet cooling load.

3.2 Calculating Subcooling

Subcooling = Saturated Condensing Temperature (SCT) minus Liquid Line Outlet Temperature. Healthy subcooling (typically 3 K to 6 K) proves a solid column of bubble-free liquid is arriving at the expansion valve.

3.3 High Condensing Pressure vs Low Subcooling

High SCT + normal/high subcooling points to poor condenser airflow (blocked coil, failed condenser fan) or overcharge. Low subcooling (< 1 K) accompanied by sight-glass bubbles points to refrigerant loss.

FIELD & BUREAU DIAGNOSTIC RULE: Subcooling = SCT - Liquid Line Temperature. If subcooling is near 0 K, flash gas is entering the expansion valve and starving the evaporator.

Module 4: Metering Devices, Evaporators & Superheat Mastery

Duration: 20 Minutes · Target Competency: Calculate Total & Evaporator Superheat and compare TEVs against stepper EEVs.

4.1 Capillary Tubes, TEVs, and Electronic Expansion Valves (EEVs)

Thermostatic Expansion Valves (TEVs) use a sensing bulb and equaliser line to modulate flow mechanically. Modern supermarket cases use stepper or pulse-width Electronic Expansion Valves (AKV/EEV) driven by an electronic controller measuring suction pressure and coil outlet temperature.

4.2 Calculating Evaporator Superheat

Superheat = Evaporator Outlet (Suction) Temperature minus Saturated Suction Temperature (SST). Healthy cabinet evaporator superheat is typically 5 K to 8 K.

4.3 High Superheat vs Low Superheat

High Superheat (> 12–15 K) with high EEV opening means the coil is starved of refrigerant. Low Superheat (< 3 K) means unboiled liquid is spilling out of the evaporator toward the compressor.

FIELD & BUREAU DIAGNOSTIC RULE: Superheat = Suction Pipe Temp - SST. High superheat = starved evaporator; Low superheat = flooded evaporator.

Module 5: Commercial Refrigerants, F-Gas Safety, A2L & R744 (CO₂) Intro

Duration: 15 Minutes · Target Competency: Identify HFC/HFO blends, A2L flammability classes, and why R744 (CO₂) operates at high pressure.

5.1 GWP Phase-Down & Refrigerant Families

Legacy HFCs (R404A) have been replaced by lower-GWP blends (R448A, R449A), mildly flammable A2Ls (R454C, R455A), hydrocarbons (R290 propane in integral cabinets), and natural R744 (CO₂) in supermarket packs.

5.2 Temperature Glide in Zeotropic Blends

400-series blends (such as R448A/R449A) have a temperature glide of 4–5 K across phase change: always use Dew Point for superheat calculations and Bubble Point for subcooling calculations.

5.3 Introduction to R744 (CO₂)

CO₂ operates at pressures 3 to 5 times higher than HFCs, with a low critical temperature of 31.1°C (73.8 bar), requiring dedicated high-pressure pipework and safety relief valves.

FIELD & BUREAU DIAGNOSTIC RULE: Never charge a 400-series zeotropic blend as a vapour from the cylinder—always charge as a liquid to prevent fractionation.

Module 6: Defrost Systems, Airflow Curtains & Basic Cabinet Fault-Finding

Duration: 15 Minutes · Target Competency: Understand electric, off-cycle, and hot-gas defrosts plus the cabinet honeycombs/air curtain.

6.1 Why Evaporators Ice Up

Moisture from store air condenses and freezes onto fins running below 0°C. Scheduled defrosts melt this frost and drain it away before ice bridges the fins and blocks airflow.

6.2 Off-Cycle vs Electric vs Hot-Gas Defrost

Chillers (+1°C to +4°C) often use off-cycle defrost (fans run while liquid solenoid closes). Freezers (-18°C to -22°C) require electric heater elements or hot-gas injection with fans switched OFF during heating.

6.3 Air Curtain Integrity

Damaged honeycomb grilles, blocked return-air grilles, or over-stacked stock break the invisible air curtain, spilling cold air onto the aisle and pulling warm, humid store air straight into the coil.

FIELD & BUREAU DIAGNOSTIC RULE: Before blaming the refrigeration pack, always check that stock is loaded below the load-limit line and the return-air grille is unobstructed.

Module 7: Introduction to Refrigeration Diagnostics & Reading Telemetry Graphs

Duration: 25 Minutes · Target Competency: Read a 24-hour bureau telemetry graph, distinguish Air-On vs Air-Off, spot normal defrost spikes, and run probe sanity checks.

7.1 Anatomy of a 24-Hour Bureau Telemetry Graph

Every modern supermarket cabinet and coldroom logs temperatures, valve percentages, and digital states (Refrigeration ON, Defrost Active, Door Switch, Fan State) every 1 to 5 minutes. Learning to read the 24-hour trace turns guesswork into forensic certainty.

7.2 Spotting Air-Off vs Air-On & The Healthy Sawtooth

Air-Off (discharge air leaving the honeycomb) is always the coldest trace in a running case and responds immediately when the valve opens or closes. Air-On (return air entering the base grille) is 3°C to 5°C warmer because it has absorbed heat from the cabinet envelope and store air. A healthy thermostatic cabinet produces a regular, rhythmic sawtooth between cut-in and cut-out.

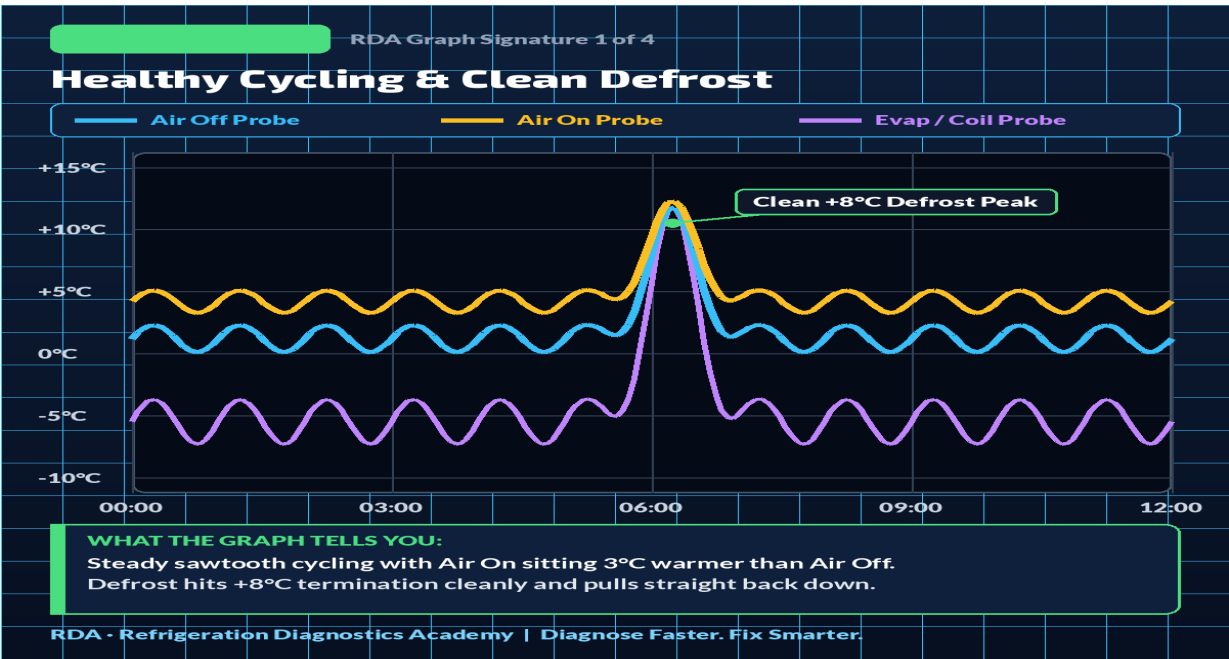
7.3 Recognising Normal Defrost Peaks vs Genuine Warming Faults

Every 4 to 6 hours, a scheduled defrost creates a sharp, temporary upward spike in Air-Off and Evaporator Coil temperature lasting 20 to 35 minutes. If the trace pulls rapidly back down to setpoint immediately after defrost termination, the cabinet is healthy! Only when the trace fails to recover after defrost—or drifts steadily upward between defrosts—is there an active fault.

7.4 Beginner Probe Sanity Checks

If a single probe jumps instantaneously by 20°C in one sample or flatlines at -40°C / +99°C while all other probes remain normal, suspect a failed thermistor or loose wiring termination rather than a refrigeration failure.

FIELD & BUREAU DIAGNOSTIC RULE: Compare Air-Off, Air-On, and Evaporator Coil Temp during a defrost cycle: if Evaporator Temp rises cleanly to termination (+8°C to +12°C) and pulls back down within 25 minutes, airflow and refrigeration capacity are healthy.



Telemetry Trace	Healthy Chiller Signature	Beginner Warning Sign
Air-Off Probe	Coldest trace; crisp sawtooth between +1°C and +3°C	Drifts above Air-On or flatlines during cooling

Air-On Probe	Tracks 3°C to 5°C above Air-Off	Converges with Air-Off (0.5°C split = iced coil/fan out)
Defrost Peak	Sharp 25-min spike every 6 hrs with rapid pulse	Stuck at termination time limit with slow recovery
EEV / AKV Valve %	Modulates smoothly between 25% and 75%	Pinned at 100% continuously (starvation/icing)