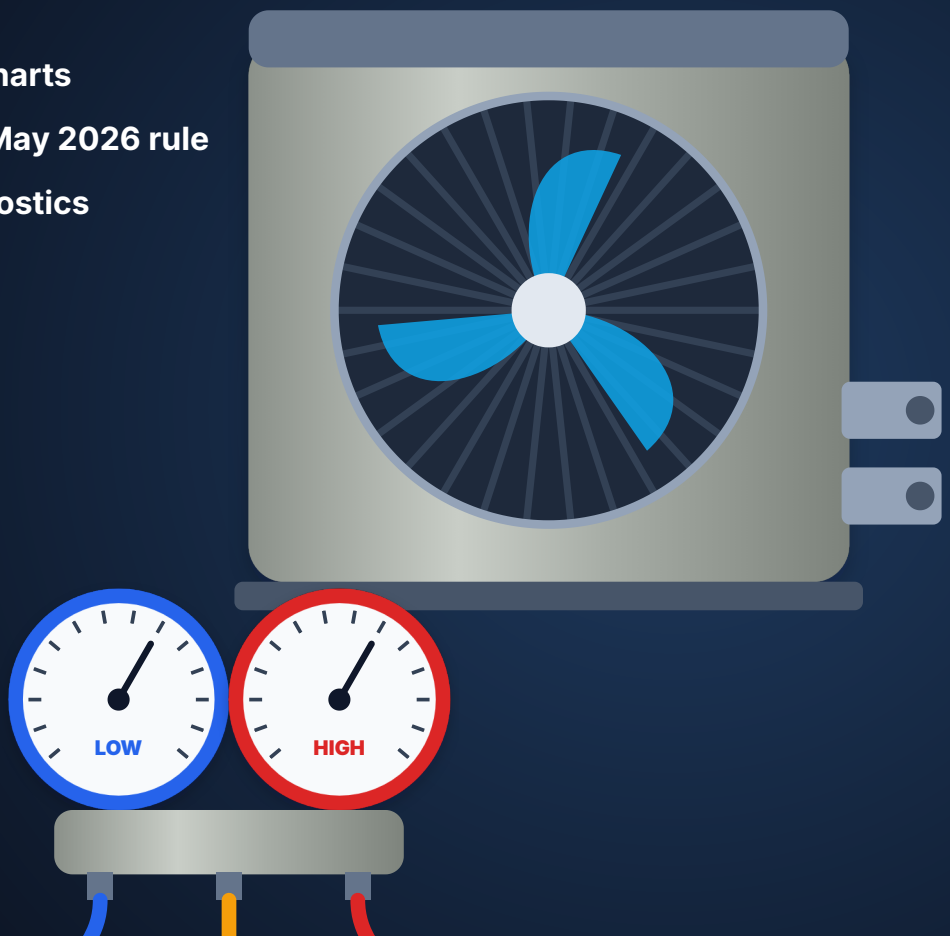
2026 A2L EDITION · R-454B · R-32

55 HVAC VISUAL CARDS

500 MICRONS

Charging, diagnostics, electrical & gas furnaces, updated for R-454B and R-32

- 55 visual field cards · 8 units
- Superheat, subcooling & PT charts
- A2L rules, updated for EPA's May 2026 rule
- Electrical & gas furnace diagnostics



Every value sourced from EPA, OSHA, AHRI, UL, manufacturer literature and named trade sources · EPA sources reviewed as of Nov 1, 2026

BEFORE YOU START

How to use this guide

01 **One card, one job.**

Each card covers one task or concept: a diagram, the key points, the most common mistake and a pro tip.

02 **Brand values are examples.**

When a card names a manufacturer (Carrier, Rheem, Lennox, Goodman, Copeland...), the number comes from that company's literature for a specific product. Other equipment can differ.

03 **The rating plate wins.**

Charging targets, test pressures, evacuation criteria, temperature rise, gas pressures and flame-signal specs must come from the unit in front of you.

04 **Sources on every card.**

The footnote lists the documents each card is built from. The full list is at the back.

⚠ IMPORTANT — READ BEFORE USE

This guide is a study and quick-reference aid for trained technicians. It does not replace manufacturer installation and service instructions, the equipment rating plate, local and national codes, or required training and certification (including EPA Section 608).

HVAC work involves high voltage, pressurized and flammable refrigerants, combustion and carbon monoxide. Work only within your training, license and certification, and follow OSHA and your employer's safety procedures.

Regulations change. The EPA rules summarized here are current as of November 2026; some are under legal challenge, and states can be stricter. Verify current requirements before relying on them.

The publisher has made every effort to verify each value against its source but cannot guarantee that it applies to your equipment or situation, and accepts no liability for its use.

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UNIT 1

Safety & Meters

Lockout, proving dead, and the meter habits that keep you alive on every call.

01 Lockout / Tagout Before You Touch

02 Live–Dead–Live: Prove It Dead

03 Meter Ratings: CAT II, III, IV

04 Volts, Ohms & Continuity with a DMM

05 Measuring Amps with a Clamp Meter

06 Capacitors Bite: Discharge First

Lockout / Tagout Before You Touch

OSHA's six steps, in order, every time you open a panel.

1. **Prepare for shutdown**
2. **Shut the equipment down**
3. **Isolate every energy source**
4. **Apply your lock / tag**
5. **Release stored energy**
6. **Verify zero energy**

1. OSHA 1910.147 requires these steps in this sequence.
2. A split system can have more than one power source: indoor unit, outdoor disconnect, sometimes a separate heat-strip circuit.
3. A thermostat or control board is NOT a disconnect. Push buttons, selector switches and interlocks cannot be the only means of de-energizing.
4. Stored energy includes charged capacitors.

COMMON MISTAKE

Turning the thermostat off and calling the unit "dead".

PRO TIP

Lock out at the disconnect, then prove it dead with a meter you just checked on a live source.

SOURCES OSHA 29 CFR 1910.147, Control of Hazardous Energy (Lockout/Tagout) · OSHA 29 CFR 1910.333, Selection and Use of Work Practices · Goodman/Daikin Service & Troubleshooting Manual RS6200006

Reference only — always follow the rating plate and installation instructions.

Live–Dead–Live: Prove It Dead

The three-point test that keeps a broken meter from fooling you.

1. **TEST a known live source**
2. **TEST the circuit you will work on**
3. **RE-TEST the known live source**

1. Treat every circuit as energized until you have tested it and found no voltage.
2. Test phase-to-phase AND phase-to-ground with a meter rated for that circuit.
3. OSHA makes the before-and-after meter check mandatory above 600 V; NFPA 70E applies it at every voltage. Do it on every job.

COMMON MISTAKE

Reading 0 V and trusting it without checking that the meter (or a blown fuse in it) actually works.

PRO TIP

Keep a proving unit or a known outlet nearby for the "live" checks.

SOURCES Fluke application notes: absence-of-voltage testing, measurement categories, DMM how-tos · OSHA 29 CFR 1910.333, Selection and Use of Work Practices

Meter Ratings: CAT II, III, IV

The category on your meter says where it is safe to use it.

CATEGORY	WHERE IT APPLIES (FLUKE)
CAT II	Receptacle-connected loads: appliances, portable tools, outlets
CAT III	Distribution: panels, feeders, polyphase motors, short branch circuits
CAT IV	Utility connection and any outdoor mains conductors, meters

1. Higher category = the meter is built to survive bigger transient spikes.
2. Fluke: choose a tool rated to the HIGHEST category and voltage where it could possibly be used.
3. Look for the CAT / voltage marking printed near the input jacks, and independent lab certification.
4. Inspect the meter and leads for damage before each use.

COMMON MISTAKE

Using a cheap CAT II meter inside a service panel or on an outdoor disconnect.

PRO TIP

For residential HVAC work, a CAT III 600 V meter (or CAT IV 600 V) is the practical minimum.

SOURCES Fluke application notes: absence-of-voltage testing, measurement categories, DMM how-tos

Volts, Ohms & Continuity with a DMM

The three readings you take on almost every service call.



- **RED lead → VΩ jack**
  Volts, ohms and continuity
- **BLACK lead → COM**
  Every measurement
- **A jack = amps only**
  Never measure volts with a lead here
- **Ohms & continuity**
  Power OFF · capacitors discharged · part isola

1. VOLTAGE: black lead in COM, red in V — never in the A jack. Connect black first, red second; remove red first. AC has no polarity.
2. RESISTANCE / CONTINUITY: power OFF first. Discharge any capacitor. Best: remove the part from the circuit so parallel paths do not distort the reading.
3. "OL" on the ohms scale means open (no path).

COMMON MISTAKE

Leaving the red lead in the amps jack and then measuring voltage — that is a dead short and can cause an arc flash.

PRO TIP

Unknown voltage? Start on the highest range.

SOURCES Fluke application notes: absence-of-voltage testing, measurement categories, DMM how-tos

Measuring Amps with a Clamp Meter

Amps tell you how hard a motor or compressor is working.



ONE conductor = real amps



Both legs = near 0 A

1. Set the dial to A AC, open the jaws and clamp ONE conductor only.
2. Two conductors carrying current in opposite directions cancel and read near zero.
3. Center the wire on the alignment marks and keep your fingers behind the tactile barrier.
4. Copeland: running amps should be within ±20% of the published performance data.

COMMON MISTAKE

Clamping the whole cable (both legs) and reading 0 A on a running motor.

PRO TIP

Compare amps with the nameplate RLA/FLA and the manufacturer's data, not with a guess.

SOURCES Fluke application notes: absence-of-voltage testing, measurement categories, DMM how-tos · Copeland (Emerson) Electrical Handbook

Capacitors Bite: Discharge First

A good capacitor can stay charged after power is removed.

1. **Lock out power** →
2. **Discharge through a resistor** →
3. **Verify 0 V with your meter** →
4. **Now handle or test it**

1. OSHA requires capacitors to be discharged before work where stored energy could hurt you.
2. Use a resistor, never a screwdriver dead short. Values differ by source: Fluke shows 20 kΩ / 5 W for 5 seconds; Goodman says 200–300 Ω.
3. Follow the equipment manufacturer, then always confirm 0 V with the meter.
4. Never run a compressor with a bulging, leaking or damaged capacitor (Copeland).

COMMON MISTAKE

Shorting terminals with a screwdriver — it causes a violent arc and can damage tools and the capacitor.

PRO TIP

Keep a purpose-made discharge tool with a built-in resistor in your bag.

SOURCES OSHA 29 CFR 1910.333, Selection and Use of Work Practices · Fluke application notes: absence-of-voltage testing, measurement categories, DMM how-tos · Goodman/Daikin Service & Troubleshooting Manual RS6200006 · Copeland (Emerson) Electrical Handbook

Reference only — always follow the rating plate and installation instructions.

UNIT 2

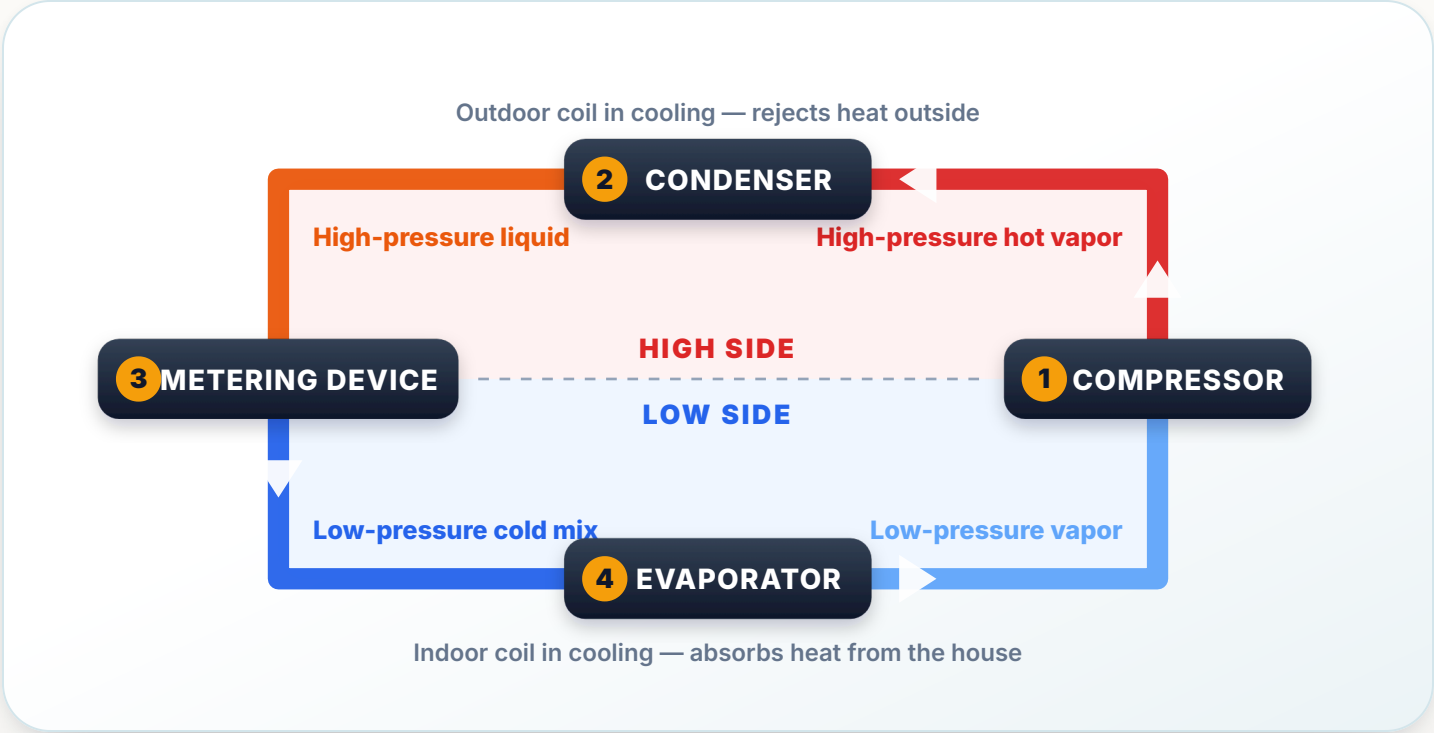
Refrigeration Basics

Pressure, temperature, superheat and subcooling — the language every diagnosis is written in.

07 The Refrigeration Cycle in 4 Steps
08 Pressure = Temperature (When Saturated)
09 Superheat & Subcooling Explained
10 Bubble Point vs Dew Point
11 PT Quick Reference (psig)
12 Refrigerant Oils: POE Is Thirsty

The Refrigeration Cycle in 4 Steps

Heat is not destroyed — it is moved from inside to outside.



1. COMPRESSOR: low-pressure vapor in, high-pressure hot vapor out.
2. CONDENSER (outdoor coil in cooling): the vapor rejects heat and condenses to liquid.
3. METERING DEVICE (piston, TXV or EXV): pressure drops and the liquid cools.
4. EVAPORATOR (indoor coil): the liquid boils, absorbing heat from the house air.

COMMON MISTAKE

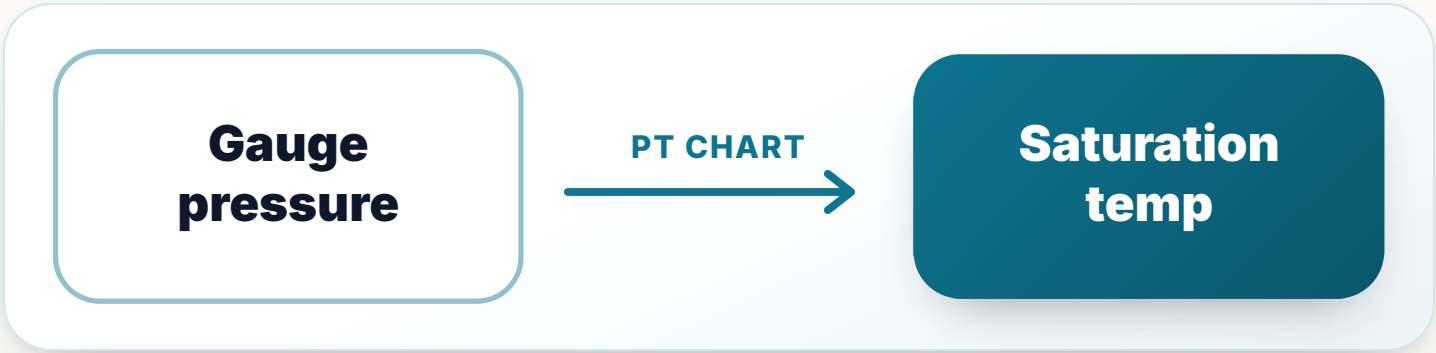
Thinking refrigerant "makes cold". It carries heat out; the air feels cold because heat left it.

PRO TIP

Every diagnosis starts by asking which of these four parts is not doing its job.

Pressure = Temperature (When Saturated)

Inside a coil where liquid and vapor coexist, pressure tells you temperature.



1. When refrigerant is boiling (evaporator) or condensing (condenser), it is saturated: its temperature is fixed by its pressure.
2. Example R-410A: 118.8 psig ≈ 40°F saturation; 318.5 psig ≈ 100°F (Arkema data).
3. Your gauges measure pressure. The PT chart (or your digital gauge) converts it into the saturation temperature.
4. Saturation temp is NOT the pipe temperature you measure — the difference between the two is superheat or subcooling.

COMMON MISTAKE

Reading the suction pressure and assuming the suction line must be that temperature.

PRO TIP

Always select the correct refrigerant on digital gauges before reading anything.

SOURCES Arkema Forane 410A / 22 Thermodynamic Properties and Americas PT wall chart · Rheem/Ruud (-)P17AY R-454B Installation Instructions

Superheat & Subcooling Explained

Two numbers that tell you how much refrigerant is where.

SUPERHEAT	**= Suction line temp − Evaporator saturation temp**
SUBCOOLING	**= Condenser saturation temp − Liquid line temp**

1. SUPERHEAT: how many degrees the vapor has warmed ABOVE boiling. Measured on the suction line.
2. SUBCOOLING: how many degrees the liquid has cooled BELOW condensing. Measured on the liquid line.
3. For blends with glide (R-454B), use the DEW point for superheat and the BUBBLE point for subcooling (Rheem states the bubble-point rule for subcooling).
4. Worked R-454B example: suction 118 psig → dew 45.1°F; suction line 55°F → SH ≈ 9.9°F.

COMMON MISTAKE

Subtracting in the wrong order and getting a negative number.

PRO TIP

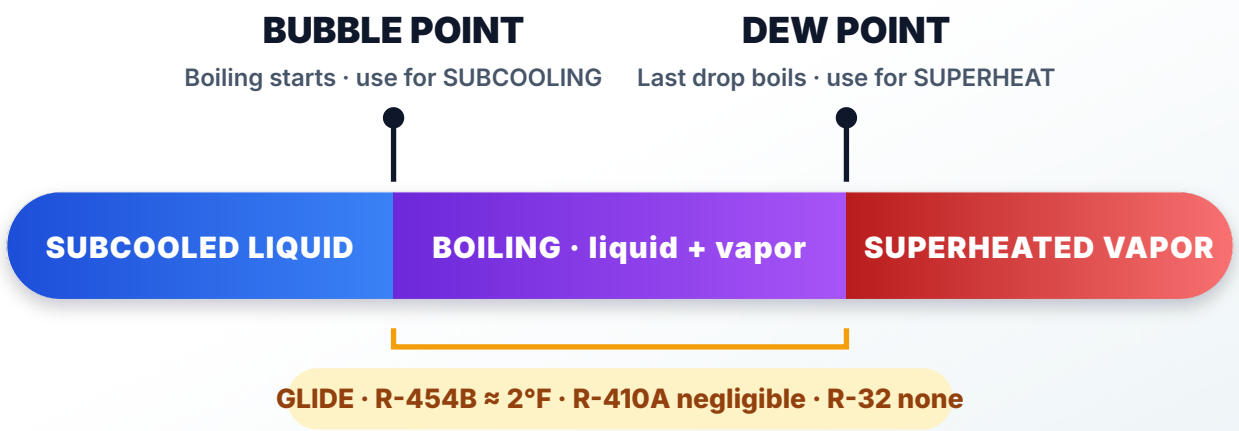
Near-zero superheat means liquid may be reaching the compressor — dangerous.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01 · Chemours, Opteon XL41 (R-454B) Temperature-Pressure Data, rev 07-23 · Parker Sporlan TEV Installation & Field Service, Tech Notice 10-11

 Reference only — always follow the rating plate and installation instructions.

Bubble Point vs Dew Point

Why R-454B has two pressures for every temperature.



Same pressure, left to right through the coil: a blend's temperature rises while it boils.

1. Zeotropic blends do not boil at one temperature. At a given pressure they start boiling at the BUBBLE point and finish at the DEW point.
2. The difference is called temperature glide. R-454B glide is about 2°F (Chemours states ~2.0°F).
3. R-410A is a near-azeotrope: bubble and dew differ by only ~0.3–1.1 psi, so glide is negligible.
4. R-32 is a single component: no glide at all.

COMMON MISTAKE

Using the bubble column to calculate superheat on R-454B — it overstates superheat by roughly the glide.

PRO TIP

Rule: DEW for the suction side (superheat), BUBBLE for the liquid side (subcooling).

SOURCES Chemours, Opteon XL41 (R-454B) Temperature-Pressure Data, rev 07-23 · Chemours, Opteon XL41 Product Information C-11001 · Arkema Forane 410A / 22 Thermodynamic Properties and Americas PT wall chart · Goodman/Daikin, R-32 Get the Facts brochure (06-25)

 Reference only — always follow the rating plate and installation instructions.

PT Quick Reference (psig)

Saturation pressures for the four refrigerants you will meet most.

°F	R-22	R-410A	R-454B BUBBLE / DEW	R-32
30	55.0	97.4	91.7 / 87.4	99.1
35	61.5	107.7	101.5 / 96.9	109.7
40	68.6	118.8	112.0 / 107.0	121.0
45	76.1	130.6	123.1 / 117.8	133.0
50	84.1	143.2	135.0 / 129.3	145.9
55	92.6	156.5	147.7 / 141.6	159.5
60	101.6	170.7	161.1 / 154.6	174.1
65	111.3	185.8	175.4 / 168.5	189.5
70	121.4	201.8	190.5 / 183.1	205.8
75	132.2	218.7	206.5 / 198.7	223.2
80	143.6	236.5	223.4 / 215.2	241.5
85	155.7	255.4	241.2 / 232.6	260.9
90	168.4	275.4	260.1 / 251.0	281.3
100	195.9	318.5	300.8 / 290.9	325.7
110	226.4	366.4	345.9 / 335.2	374.9
120	260.0	419.4	395.7 / 384.3	429.3
125	278.0	447.9	422.4 / 410.8	458.7

1. R-22 and R-410A: Arkema data (converted from psia; R-410A shown as liquid/bubble). R-454B: Chemours chart rev 07-23. R-32: Arkema wall chart.
2. Different charts can differ by 1–4 psi for R-454B. Use one chart consistently — ideally the one the equipment manufacturer specifies.

COMMON MISTAKE

Mixing PT charts from different sources in the same diagnosis.

PRO TIP

R-32 runs slightly higher pressure than R-410A; R-454B slightly lower.

SOURCES Arkema Forane 410A / 22 Thermodynamic Properties and Americas PT wall chart · Chemours, Opteon XL41 (R-454B) Temperature-Pressure Data, rev 07-23

Reference only — always follow the rating plate and installation instructions.

Refrigerant Oils: POE Is Thirsty

The oil type follows the refrigerant — and it absorbs water fast.

REFRIGERANT	OIL (PER MANUFACTURER)
R-22	Mineral oil (typical)
R-410A	POE
R-454B	POE (Rheem: POE only · Carrier: POE or PVE)
R-32	POE and/or PVE (Goodman/Daikin)

1. POE and PVE oils absorb moisture rapidly. Do not leave systems or oil containers open to the air.
2. Vacuum pumps will NOT remove moisture already absorbed into POE oil (Rheem, Carrier).
3. Store oil in its original sealed container — many plastics let moisture through.
4. Always use the oil named on the compressor or in the manual.

COMMON MISTAKE

Leaving a line set or compressor open overnight, then expecting the vacuum pump to dry it.

PRO TIP

Cap every open tube immediately and follow the manufacturer's filter-drier replacement rule.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Goodman/Daikin, R-32 Get the Facts brochure (06-25) · HVAC School (B. Orr), trade training articles (secondary source)

 Reference only — always follow the rating plate and installation instructions.

UNIT 3

The A2L Transition

R-454B, R-32 and EPA's May 2026 rule: what changed, what is legal, and how to work safely with A2Ls.

13 EPA 608: Certification & the Law
14 What Changed: The AIM Act Timeline
15 Safety Classes: A1, A2L, A2, A3
16 R-454B vs R-32 vs R-410A
17 Identify the Cylinder
18 A2L-Ready Tools & Gauges
19 Leak Sensors & Mitigation (RDS)
20 No Retrofit · No Mixing · Safe Jobsite

EPA 608: Certification & the Law

What every technician must know before touching refrigerant.

TYPE	COVERS
Type I	Small appliances
Type II	High / very high-pressure appliances (incl. residential AC)
Type III	Low-pressure appliances
Universal	All types

1. Since Jan 1, 2018, EPA Section 608 certification is required to buy HFC refrigerants for stationary AC and refrigeration.
2. Per EPA-approved certifying organizations (ESCO Institute; ACHR News, Sept 2026), exams using the current question bank can be given only through Jan 1, 2027; new candidates after that date take the revised exam. Existing 608 certifications remain valid — no retest required. (Not yet posted on epa.gov as of Nov 1, 2026.)
3. Intentional venting is prohibited. Exceptions are narrow: "de minimis" releases during good-faith recovery, plus a few EPA-exempt substitutes in specific appliances.
4. Civil penalty: up to $124,426 per day, per violation (inflation-adjusted, Jan 2025).

COMMON MISTAKE

Selling recovered refrigerant to another customer — it must go to an EPA-certified reclaimer first.

PRO TIP

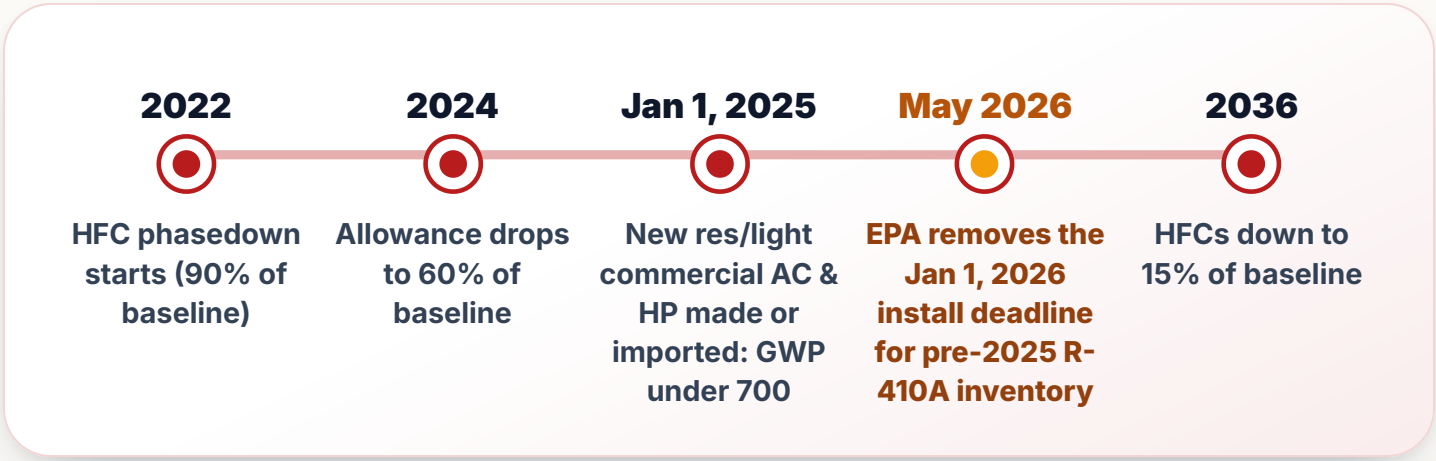
Keep your 608 card (or a photo) with you — supply houses ask for it.

SOURCES US EPA, Section 608 Technician Certification Requirements (epa.gov/section608) · US EPA, Technicians and Contractors: Frequent Questions · US EPA, Prohibition on Venting Refrigerants (epa.gov/section608) · 40 CFR 19.4, Civil Monetary Penalty Inflation Adjustment (Jan 8, 2025) · ACHR News, What You Need to Know About the New Section 608 Exam (Sept 2026); ACHR News, Washington State HFC rules still apply (2026)

Reference only — always follow the rating plate and installation instructions.

What Changed: The AIM Act Timeline

Why new residential systems now use R-454B or R-32.



1. R-410A has a GWP of 2,088 — above the 700 limit — so it cannot be used in NEWLY manufactured residential systems.
2. EPA's 2026 reconsideration rule (effective July 27, 2026) lets R-410A systems made or imported before Jan 1, 2025 be installed until supply runs out.
3. Existing R-410A systems can still be serviced. States can be stricter (e.g., New York kept the 2026 deadline; Washington State's HFC rules still apply).
4. Petitions for review pending in the D.C. Circuit (industry groups, NRDC, 18 states + DC). No stay reported by EPA as of Aug 13, 2026 — check epa.gov/hfcs for updates.

COMMON MISTAKE

Telling customers R-410A is "illegal now". Servicing existing systems is allowed.

PRO TIP

Expect R-410A supply and prices to tighten as the phasedown steps down.

SOURCES US EPA, Technology Transitions rules (88 FR, Oct 2023; 2023-28500) and TT Reconsideration Final Rule fact sheet (May 2026) · US EPA, Frequent Questions on the Phasedown of HFCs · US EPA, Technology Transitions GWP Reference Table · Petitions for review in the D.C. Circuit (AHRI et al., June 2026; Massachusetts et al., July 2026), as reported by ACHR News · ACHR News, What You Need to Know About the New Section 608 Exam (Sept 2026); ACHR News, Washington State HFC rules still apply (2026)

Reference only — always follow the rating plate and installation instructions.

Safety Classes: A1, A2L, A2, A3

The ASHRAE 34 code on every cylinder, decoded.

	FLAMMABILITY ↓	A · LOWER TOXICITY	B · HIGHER TOXICITY
3	Higher flammability	A3 Hydrocarbons	B3
2	Flammable	A2	B2
2L	Lower flammability · burning velocity ≤ 10 cm/s	A2L R-32 · R-454B · R-1234yf	B2L
1	No flame propagation	A1 R-22 · R-410A	B1

1. LETTER = toxicity. A = lower toxicity, B = higher toxicity.
2. NUMBER = flammability. 1 = no flame propagation. 2L = lower flammability, slow burning velocity (10 cm/s or less). 2 = flammable. 3 = higher flammability (e.g., hydrocarbons).
3. R-410A and R-22 are A1. R-32, R-454B and R-1234yf are A2L.
4. A2L is hard to ignite and burns slowly, but it CAN burn: treat ignition sources seriously.

COMMON MISTAKE

Thinking "mildly flammable" means "not flammable".

PRO TIP

Read the safety class on the cylinder label, not just the color.

SOURCES AHRI Safe Refrigerant Transition Task Force, Low-GWP Refrigerants FAQs · ASHRAE/UNEP Factsheet: Refrigerant Designations and Safety Classifications · Honeywell Solstice 454B Technical Data Sheet

Reference only — always follow the rating plate and installation instructions.

R-454B vs R-32 vs R-410A

Same job, different chemistry.

	R-410A	R-454B	R-32
Safety class	A1	A2L	A2L
Makeup	R-32 / R-125 50/50	R-32 / R-1234yf 68.9/31.1	Single component
GWP (EPA list)	2,088	466 (AR4)	675
Glide	Negligible	~2°F	None
Pressure vs R-410A	—	Slightly lower	Slightly higher
Oil	POE	POE (PVE per Carrier)	POE and/or PVE
Charge as	Liquid	Liquid only	Liquid or vapor

1. R-454B is a blend: always charge it as liquid so the mixture stays correct.
2. R-32 is a single refrigerant: Goodman/Daikin state it can be topped off as liquid or gas without changing composition.
3. Neither can be used to convert an R-410A system.

COMMON MISTAKE

Assuming R-454B pressures are identical to R-410A and using an R-410A chart.

PRO TIP

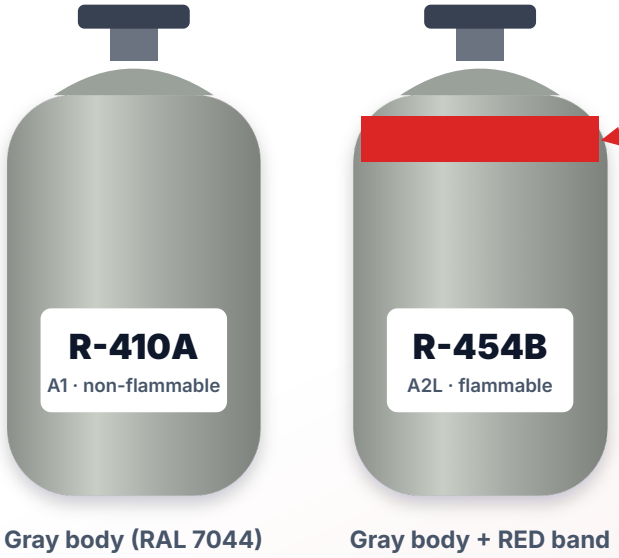
Lower GWP: R-454B is about 78% below R-410A (Chemours).

SOURCES US EPA, Technology Transitions GWP Reference Table · Chemours, Opteon XL41 Product Information C-11001 · Goodman/Daikin, R-32 Get the Facts brochure (06-25) · Rheem/Ruud (-)P17AY R-454B Installation Instructions · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B

Reference only — always follow the rating plate and installation instructions.

Identify the Cylinder

Gray body, red band = flammable. Read the label anyway.



Gray body (RAL 7044)

Gray body + RED band

RED BAND
Flammable refrigerant (A2L, A2, A3)

VALVE
Most A2L: left-hand thread + reclosing relief valve

LABEL
Always read it — color is never the only ID

1. AHRI Guideline N (voluntary, widely followed): containers since Jan 1, 2020 should be light green-gray (RAL 7044). Older colored cylinders may still be around.
2. A RED band on the shoulder or top marks flammable refrigerants such as A2Ls.
3. Most A2L cylinders use a LEFT-hand-thread valve (same size as the right-hand 1/4" SAE A1 valve) and a reclosing relief valve. Check the valve before connecting.
4. Guideline N says color should never be the only way to identify a refrigerant — read the label.

COMMON MISTAKE

Grabbing a cylinder by color alone in a dark truck.

PRO TIP

Use hoses and adapters made for the A2L valve; never force a fitting.

SOURCES AHRI Guideline N-2017, Assignment of Refrigerant Container Colors · Arkema Forane, The difference between A2L and A1 cylinders

A2L-Ready Tools & Gauges

What your kit must handle on R-454B jobs (Rheem/Carrier specs).

ITEM	REQUIREMENT (MANUFACTURER MANUALS)
Manifold gauges	High side 800 psig · low side 250 psig (550 retard)
Hoses	Rated 800 psig service
Recovery cylinder	DOT 4BA400 / 4BW400 (400 psig service), marked for flammable refrigerant
Filter drier	Working pressure 600 psig or more
Recovery machine	Certified for flammable / A2L refrigerants
Vacuum pump	A2L-rated (AHRI)

1. Powered equipment that handles refrigerant should be rated for A2L.
2. AHRI notes that non-sparking HAND tools are not required for A2Ls.
3. Do not use R-410A TXVs on R-454B equipment (Rheem).
4. Ground cylinders and keep hoses short.

COMMON MISTAKE

Recovering R-454B with an old machine that is not listed for flammable refrigerants.

PRO TIP

Check the label on your recovery machine and vacuum pump before the first A2L job.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · AHRI, A2L Refrigerants Best Practices (V1.0) · AHRI Safe Refrigerant Transition Task Force, Low-GWP Refrigerants FAQs · Copeland E360, Safety Best Practices for Servicing A2L Refrigerants

Leak Sensors & Mitigation (RDS)

Many A2L systems ship with a refrigerant detection system.



1. UL rule of thumb: an RDS is needed above about 4 lb of charge for most equipment (2 lb for non-fixed factory-sealed units). Trane: ducted systems over 3.91 lb need one.
2. Typical mitigation: indoor blower ON, compressor OFF, zone dampers fully open, electric heat and other ignition sources de-energized, extra ventilation if required.
3. Sensors self-test and are designed fail-safe (AHRI).
4. Installers must follow the manual for sensor location, wiring and mitigation setup.

COMMON MISTAKE

Unplugging a "nuisance" sensor. It is a required safety device.

PRO TIP

Note the sensor location and wiring on the startup sheet.

SOURCES UL Solutions, Inspecting Refrigerant Detection Systems in HVAC Equipment · Trane, Refrigerant Leak Detection Systems (REFR-SLB008-EN) · AHRI Safe Refrigerant Transition Task Force, Low-GWP Refrigerants FAQs

Reference only — always follow the rating plate and installation instructions.

No Retrofit · No Mixing · Safe Jobsite

The three rules that keep A2L work legal and safe.

1. **Never convert R-410A or R-22 equipment to an A2L**
2. **Never mix refrigerants**
3. **Control ignition sources and ventilate**

1. EPA SNAP Rule 23 lists R-454B and R-32 only for NEW equipment designed for them — never as retrofits.
2. Before work: evaluate the area for ignition sources and flammable vapors, ventilate, keep exits clear (AHRI).
3. Recover with A2L-rated equipment into a DOT recovery cylinder marked for flammable (A2L) refrigerant; do not exceed the fill weight. Never put A2L and A1 refrigerant in the same cylinder.
4. Opening a charged A2L circuit: recover (A2L-rated machine), purge with nitrogen, evacuate (Carrier: to 1,500 microns), break with nitrogen, vent pump exhaust away from ignition sources — then cut or braze.

COMMON MISTAKE

Leak-checking with a flame or working with a torch near an open A2L circuit.

PRO TIP

Copeland recommends continuous leak monitoring while you work.

SOURCES US EPA, SNAP Final Rule 23, 86 FR 24444 (May 6, 2021) · AHRI, A2L Refrigerants Best Practices (V1.0) · Copeland E360, Safety Best Practices for Servicing A2L Refrigerants · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)P17AY R-454B Installation Instructions

Reference only — always follow the rating plate and installation instructions.

UNIT 4

Installation Procedures

Brazing, pressure testing, deep vacuum and weigh-in — the install steps callbacks come from.

21 Brazing with Flowing Nitrogen
22 Nitrogen Pressure Test
23 Deep Vacuum to 500 Microns
24 Micron Gauge Placement & Decay Test
25 Triple Evacuation (Alternative Method)
26 Weigh-In for Line Set Length
27 Charging Blends as Liquid

Brazing with Flowing Nitrogen

Nitrogen keeps oxide scale from forming inside the pipe.

1. **Remove Schrader cores**
2. **Flow nitrogen through the line**
3. **Wrap valves & drier with a wet cloth**
4. **Braze, keep nitrogen flowing**
5. **Let it cool, then reinstall cores**

1. Rheem: when using a torch, nitrogen MUST flow while brazing.
2. Lennox: flow regulated nitrogen at 1–2 psig in the liquid port and out the vapor port (vapor core removed).
3. Uniweld (tool maker): purge at 20+ SCFH, then reduce to 3–5 SCFH while brazing.
4. Never use oxygen or compressed air.

COMMON MISTAKE

Brazing with no nitrogen: the black scale it leaves clogs screens, TXVs and EXVs later.

PRO TIP

Use a nitrogen flow meter instead of guessing from the regulator.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01 · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · HVAC School (B. Orr), trade training articles (secondary source)

Nitrogen Pressure Test

Prove the joints before you pull a vacuum.

1. **Regulated dry nitrogen only**
2. **Pressurize line set & coil**
3. **Never exceed the rating-plate test pressure**
4. **Isolate and watch the gauge**
5. **Soap-test any joint that drops**

1. Carrier R-454B: about 200 psi, not above the Low Side Test Pressure, and it must NOT drop for 1 hour.
2. Rheem R-454B (e.g., (-)D16AY/D18AY): up to 500 psig — always per the unit's installation instructions. Isolate at least 15 min.
3. Lennox 13HPX (R-410A): 150 psig.
4. The values differ — the unit's own instructions and rating plate are the rule.

COMMON MISTAKE

Using compressed air or oxygen — it can cause an explosion with oil and refrigerant.

PRO TIP

Note the start pressure and ambient temperature; temperature swings change the reading.

SOURCES Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)D16AY/D18AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01

Deep Vacuum to 500 Microns

Remove air and moisture before charging.



1. Carrier, Rheem and Lennox all call for evacuation to 500 microns.
2. Connect the pump to both high and low sides with the largest connections available (Rheem).
3. JB Industries: before the job the pump should pull 50 microns on the gauge, or change the oil. Use short, large-diameter vacuum-rated hoses.
4. Never use the system compressor as a vacuum pump. If you must break a vacuum before the final pull-down (repairs, triple evacuation), use dry nitrogen — never air.

COMMON MISTAKE

Pulling a vacuum through standard charging hoses with cores installed — slow and misleading.

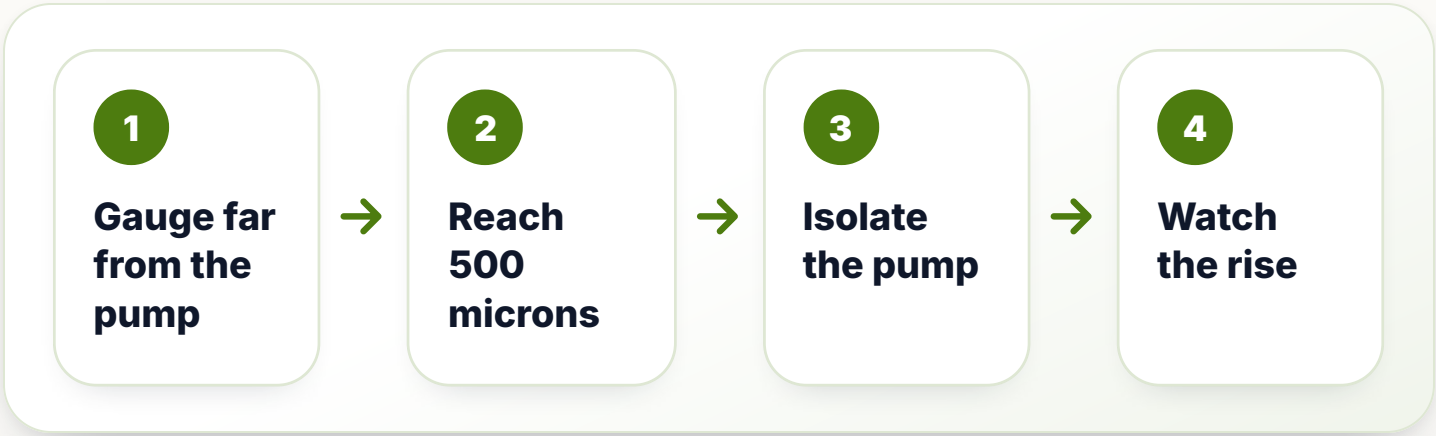
PRO TIP

Remove Schrader cores with a core-removal tool to speed up evacuation.

SOURCES Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01 · JB Industries, Deep Vacuum Principles and Application

Micron Gauge Placement & Decay Test

Where you read the vacuum matters as much as the number.



1. Appion: connect the gauge as far from the pump as possible — one end of a system can read 1,000 microns while the other is at 10,000.
2. Decay criteria differ by manufacturer: Carrier R-454B — no rise above 1,500 microns in 10 min; Rheem — hold 500 or less for 15 min; Lennox — no rise above 500 in 20 min.
3. A rise that keeps climbing toward atmosphere = leak. A rise that levels off = moisture still boiling off.
4. Keep the gauge upright so oil does not reach the sensor.

COMMON MISTAKE

Reading the micron gauge at the pump and calling the system "done".

PRO TIP

Follow the decay test in the installed unit's manual and record the result.

SOURCES Appion, AV760 Vacuum Gauge Placement Quick Start Guide · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01

Triple Evacuation (Alternative Method)

Used when a deep single vacuum is hard to reach.

1. **Pull a vacuum**
2. **Break with dry nitrogen**
3. **Let it stand**
4. **Repeat, then final vacuum**

1. Carrier lists triple evacuation as an alternative to the 500-micron deep vacuum method.
2. Example (Carrier ductless manual): evacuate, then add nitrogen to about 2 psig, let stand 10 minutes, repeat.
3. Lennox example: evacuate to 23,000 microns, break with nitrogen, release, then evacuate to 500 microns and decay-test.
4. Between evacuations, break the vacuum with dry nitrogen, never with air. After the final vacuum and decay test, open the service valves or charge refrigerant as the manual directs.

COMMON MISTAKE

Skipping the final decay test after a triple evacuation.

PRO TIP

Nitrogen "sweeps" help most on wet or contaminated systems.

SOURCES Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Lennox Merit 13HPX Installation Instructions 506727-01

Weigh-In for Line Set Length

Factory charge covers a standard line length. Adjust for the rest.

LIQUID LINE OD	RHEEM R-454B (OZ PER FT)
1/4"	0.3
5/16"	0.4
3/8"	0.6
1/2"	1.2

1. Carrier: factory charge covers 15 ft; adjust 0.6 oz per ft of 3/8" liquid line above or below 15 ft. Example: 40 ft → 25 × 0.6 = +15 oz.
2. Rheem: factory charge covers 15 ft of 3/8" line (9 oz). Adjustment = (oz/ft for your size × total length) − 9 oz. Example: 75 ft of 1/2" = (1.2 × 75) − 9 = +81 oz.
3. Rheem: add 6 oz for a field-installed filter drier.
4. Weigh-in is a STARTING point; final charge is set by subcooling or superheat.

COMMON MISTAKE

Charging by "feel" on a long line set instead of weighing in first.

PRO TIP

Long lines (Carrier: over 80 ft, or more than 20 ft lift) need the long-line guideline.

SOURCES Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)P17AY R-454B Installation Instructions

Charging Blends as Liquid

R-454B and R-410A must leave the cylinder as liquid.

1. **Invert cylinder (or use dip tube)**
2. **Meter liquid through a restrictor**
3. **Feed slowly into suction**
4. **Wait 15 min, then check**

1. Rheem: adding R-454B as vapor can change the blend proportions — add it in LIQUID form only.
2. Carrier: use a commercial metering device in the hose when charging liquid into the suction line with the compressor running; add no more than 0.5 lb per minute, then stabilize 15 minutes.
3. R-32 (single component) can be added as liquid or vapor (Goodman/Daikin).
4. Top-off after leaks: sources disagree for R-454B — follow the equipment manufacturer.

COMMON MISTAKE

Dumping liquid straight into the suction port — it can slug and damage the compressor.

PRO TIP

Use a scale for every ounce in and out, and write it on the service record.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Goodman/Daikin, R-32 Get the Facts brochure (06-25) · Chemours, Opteon XL41 Product Information C-11001

Reference only — always follow the rating plate and installation instructions.

UNIT 5

Charging & Airflow

Picking the right method, measuring in the right place, and getting airflow right first.

28 Which Charging Method?

29 Superheat Method (Piston Systems)

30 Subcooling Method (TXV / EXV)

31 Where to Measure

32 Airflow: 400 CFM per Ton & Delta T

33 Static Pressure & Furnace Temperature Rise

Which Charging Method?

The metering device decides.

PISTON / FIXED ORIFICE	TXV / EXV
Charge by SUPERHEAT	**Charge by SUBCOOLING**
Target from indoor WB + outdoor DB chart	Target on the rating plate or in the manual

1. Carrier/Bryant: "For TXV, use subcooling method. For piston, use superheat method."
2. Check airflow first: charging a system with low airflow gives wrong results.
3. Charging conditions matter: Bryant — outdoor 70–100°F, indoor 70–80°F, run 15 min first. Rheem — final charge by subcooling at 55°F outdoor and above.
4. Out of range? Weigh in the charge and come back when conditions allow.

COMMON MISTAKE

Charging a TXV system by superheat — the TXV holds superheat steady and hides the charge level.

PRO TIP

Identify the metering device before connecting gauges.

SOURCES Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01

Superheat Method (Piston Systems)

Find the target, measure the actual, adjust.

OUTDOOR DB / INDOOR WB	TARGET SH (°F)
75°F / 62°F	15
80°F / 66°F	18
85°F / 64°F	11
85°F / 70°F	22
95°F / 66°F	10
100°F / 72°F	20

1. Measure indoor entering-air WET bulb and outdoor DRY bulb.
2. Read the target superheat from the unit's chart (sample values above: legacy Bryant table — use YOUR unit's chart).
3. Actual SH = suction line temp − saturation (dew) temp at suction pressure, measured at the suction service valve.
4. SH too high → add refrigerant. SH too low → recover refrigerant.

COMMON MISTAKE

Using dry bulb indoors instead of wet bulb.

PRO TIP

A dash in the chart means "do not charge by superheat" at those conditions.

SOURCES Bryant split-system superheat charging table (legacy label) · HVAC School (B. Orr), trade training articles (secondary source)

Reference only — always follow the rating plate and installation instructions.

Subcooling Method (TXV / EXV)

The target is printed on the unit — there is no universal "10°F".

R-454B LIQUID PSIG (CARRIER)	REQUIRED LIQUID-LINE TEMP AT 6°F SC	AT 10°F SC	AT 14°F SC
318 psig	98°F	94°F	90°F

1. Read the target subcooling on the rating plate / manual (Carrier tolerance ±3°F).
2. Measure liquid pressure at the liquid service valve and liquid line temperature near it (Rheem: within 6 in of the unit).
3. SC = condenser saturation (bubble) temp − liquid line temp.
4. SC too low → add. SC too high → recover. Adjust slowly and wait 15 min.

COMMON MISTAKE

Assuming 10°F on every unit — Lennox targets range from 4°F to 23°F depending on the coil match.

PRO TIP

Carrier R-454B table (above): liquid line WARMER than required → add charge; COOLER → recover.

SOURCES Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01

Where to Measure

Put the probes and hoses in the right spots.

1. **Suction pressure: suction (large) service port**
2. **Suction temp: suction line at the service valve**
3. **Liquid pressure: liquid (small) service valve**
4. **Liquid temp: liquid line near the service valve**

1. Clean the pipe and use a calibrated clamp-on probe or insulated thermocouple (Rheem).
2. Insulate the probe from ambient air and sun for an accurate reading.
3. Let the system run at least 15 minutes before taking final readings.
4. Sporlan (TXV superheat): measure suction pressure at the bulb location for best accuracy.

COMMON MISTAKE

Reading the liquid line temperature in direct sun or right after a rain shower.

PRO TIP

Use the same probe type every time so readings are comparable.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · Lennox Merit 13HPX Installation Instructions 506727-01 · Parker Sporlan TEV Installation & Field Service, Tech Notice 10-11

Reference only — always follow the rating plate and installation instructions.

Airflow: 400 CFM per Ton & Delta T

Check the air side before blaming the refrigerant.

RETURN DB / WB	TARGET DROP (LENNOX)
80°F / 67°F	18°F
76°F / 62°F	20°F
72°F / 64°F	15°F

1. Rheem: airflow should be approximately 400 CFM per ton.
2. Lennox method: read the target temperature drop from return dry bulb and wet bulb; measured drop within ±3°F is OK.
3. Drop HIGHER than target → increase airflow. Drop LOWER than target → decrease airflow (Lennox).
4. The common "15–20°F split" is only a rule of thumb (ACCA).

COMMON MISTAKE

Using one fixed delta T for every house and every humidity level.

PRO TIP

Dirty filter and closed registers are the cheapest fixes — check them first.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Lennox Merit 13HPX Installation Instructions 506727-01 · ACCA HVAC Blog (secondary source)

Static Pressure & Furnace Temperature Rise

Two numbers printed on the nameplate.

TEMP RISE	**= Supply air temp − Return air temp**
RULE	**Must be within the nameplate range**

1. Most conventional ducted split systems are rated (DOE Appendix M1, SEER2) at 0.50 in. w.c. external static. Low-static, mid-static, mobile-home and high-velocity systems use other values. It is a rating condition, not a field maximum.
2. Goodman: external static pressure should not exceed the value on the rating plate.
3. Example Goodman GME8 temperature-rise ranges: 20–50°F, 30–60°F, 35–65°F depending on model.
4. Goodman: decrease blower speed to INCREASE temperature rise. Wrong rise can cause condensing or overheating of the heat exchanger.

COMMON MISTAKE

Leaving a high-efficiency furnace on a blower speed that puts the rise outside the nameplate range.

PRO TIP

Measure rise after the furnace has run long enough for supply temperature to stabilize.

SOURCES US DOE, 10 CFR 430 Subpart B, Appendix M1 (via AHRI/DOE term sheet) · Goodman GME8 furnace specification sheet · Goodman *MES80 / *MVC96 gas furnace installation manuals · Lennox G50DF gas furnace installation instructions

 Reference only — always follow the rating plate and installation instructions.

UNIT 6

Refrigerant Diagnostics

Read four numbers, find the fault: charge, restrictions, metering devices and compressors.

34 The Diagnostic Matrix

35 Undercharge (Leak)

36 Overcharge

37 Liquid-Line Restriction

38 TXV Underfeeding vs Overfeeding

39 Dirty Condenser, Low Airflow & Air in the System

40 Inefficient Compressor

The Diagnostic Matrix

Four readings point to the problem (Rheem cooling troubleshooting table).

PROBLEM	HEAD	SUCTION	SH	SC
Overcharge	High	High	Low	High
Undercharge	Low	Low	High	Low
Liquid restriction	Low	Low	High	High
Low indoor airflow	Low	Low	Low	Low
Dirty outdoor coil	High	High	Low	Low
Low outdoor ambient	Low	Low	High	High
Inefficient compressor*	Low	High	High	High

* Inefficient compressor: Rheem; values vary by source, see card 40.

1. Source: Rheem R-454B variable-speed unit (EXV). Other sources differ on some rows — signatures depend on the metering device and unit design.
2. Always verify airflow and coil cleanliness before adjusting charge.

COMMON MISTAKE

Adding refrigerant because suction pressure is low — low airflow also lowers suction pressure.

PRO TIP

Write all four readings down before deciding anything.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · HVAC School (B. Orr), trade training articles (secondary source)

Undercharge (Leak)

Not enough refrigerant to fill the coils.

Suction	Head	Superheat	Subcooling
↓ LOW	↓ LOW	↑ HIGH	↓ LOW

1. Typical signature (Rheem, HVAC School): low suction, low head, high superheat, low subcooling.
2. A low charge means a leak: find and repair it before recharging.
3. Leak repair is required by EPA for larger systems (15 lb+ of an HFC with GWP above 53, under the 2024 ER&R rule, from 2026), but residential and light commercial AC/HP are excluded. Good practice is still to fix the leak.
4. Venting refrigerant is illegal (EPA Section 608).

COMMON MISTAKE

"Topping off" every summer without finding the leak.

PRO TIP

Use an electronic leak detector rated for the refrigerant, then confirm with bubbles.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · HVAC School (B. Orr), trade training articles (secondary source) · US EPA, Emissions Reduction & Reclamation (ER&R) Fact Sheet, Sept 2024 · US EPA, Prohibition on Venting Refrigerants (epa.gov/section608)

 Reference only — always follow the rating plate and installation instructions.

Overcharge

Too much refrigerant backs up liquid in the condenser.

Suction	Head	Superheat	Subcooling
↑ HIGH	↑ HIGH	↓ LOW	↑ HIGH

1. Typical signature (Rheem): high head, high suction, low superheat, high subcooling.
2. Risk: high head pressure and amps; on piston systems, possible liquid floodback.
3. Correct it by recovering refrigerant into a recovery cylinder — never by venting.
4. Re-check after 15 minutes of stable operation.

COMMON MISTAKE

Confusing overcharge with a dirty condenser: both raise head pressure. Check subcooling and the coil.

PRO TIP

Clean the condenser before deciding the unit is overcharged.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · Carrier/Bryant installation instructions (235S, 26VNA1), R-454B · US EPA, Prohibition on Venting Refrigerants (epa.gov/section608)

Liquid-Line Restriction

Usually a plugged filter drier or kinked line.

Suction	Head	Superheat	Subcooling
↓ LOW	↓ LOW	↑ HIGH	↑ HIGH

1. Typical signature (Rheem): low head, low suction, high superheat, HIGH subcooling.
2. High subcooling separates a restriction from an undercharge (which has low subcooling).
3. Look for a temperature drop across the filter drier or frost at the restriction point.
4. Rheem: liquid-line pressure drop should not exceed 50 psig.

COMMON MISTAKE

Adding refrigerant to a restricted system — it makes subcooling and head worse.

PRO TIP

Feel or measure both sides of the drier: a noticeable temperature drop points to the restriction.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · HVAC School (B. Orr), trade training articles (secondary source)

TXV Underfeeding vs Overfeeding

When the metering device is the problem.

UNDERFEEDING	OVERFEEDING
Superheat too high	**Superheat low**
Suction pressure lower than normal	Suction normal or higher; liquid may return

1. Sporlan: moisture freezing in the port is the most common TEV trouble.
2. Check first: correct charge (subcooling OK), bulb clamped tight and insulated, external equalizer connected.
3. ACHR News (B. Orr): normal evaporator-outlet superheat is about 6–14°F on AC. Above 14°F with proper subcooling suggests underfeeding.
4. Rheem lists normal superheat as 5–15°F on its EXV unit.

COMMON MISTAKE

Replacing a TXV when the real problem was a loose bulb strap.

PRO TIP

Underfeeding + high subcooling + normal airflow → suspect the valve or a restriction ahead of it.

SOURCES Parker Sporlan TEV Installation & Field Service, Tech Notice 10-11 · Rheem/Ruud (-)P17AY R-454B Installation Instructions · HVAC School (B. Orr), trade training articles (secondary source)

Reference only — always follow the rating plate and installation instructions.

Dirty Condenser, Low Airflow & Air in the System

Three look-alikes that are not charge problems.

DIRTY CONDENSER	LOW INDOOR AIRFLOW	NON-CONDENSABLES
Head & suction HIGH	**Suction LOW, SH LOW (piston; a TXV may hold SH near normal)**	**Head HIGH, fluctuating**
Clean coil, check fan	Filter, blower, ducts	Recover, evacuate, recharge

1. Rheem: high head with high or normal suction → dirty outdoor coil, overcharge, outdoor fan not running, or air/non-condensables.
2. Low indoor airflow lowers suction pressure and superheat; coil saturation below 32°F will eventually freeze the coil (HVAC School).
3. Non-condensables (air) come from poor evacuation. The fix is recovery, deep evacuation and a weighed charge.

COMMON MISTAKE

Recovering refrigerant from a unit whose only problem is a dirty condenser.

PRO TIP

Check the outdoor fan and coil, then the filter and blower, before touching the charge.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · HVAC School (B. Orr), trade training articles (secondary source)

Inefficient Compressor

The compressor runs but does not pump well.

Suction	Head	Superheat	Subcooling
↑ HIGH	↓ LOW	? VARIES	? VARIES

1. Sources agree on the pressures: HIGH suction and LOW head pressure (trade guidance: amps typically low for the conditions).
2. Sources DISAGREE on superheat and subcooling: Rheem's table lists both high; HVAC School lists both low. Rely on the pressures and amps.
3. Before condemning it: confirm charge, airflow, voltage within ±10% of nameplate, and amps vs manufacturer data (Copeland).
4. On heat pumps, a leaking reversing valve can look similar (see card 49).

COMMON MISTAKE

Condemning a compressor without checking voltage and the run capacitor.

PRO TIP

Compare compression ratio and amps with the manufacturer's performance data.

SOURCES Rheem/Ruud (-)P17AY R-454B Installation Instructions · HVAC School (B. Orr), trade training articles (secondary source) · Copeland (Emerson) Electrical Handbook · Goodman/Daikin Service & Troubleshooting Manual RS6200006

Reference only — always follow the rating plate and installation instructions.

UNIT 7

Electrical Components

Thermostats, 24 V controls, contactors, capacitors and compressor windings.

41 Thermostat Terminals
42 The 24 V Control Circuit
43 Contactor Checks
44 Testing a Run Capacitor
45 Dual Capacitors & Replacement Rules
46 Compressor Windings: C, S, R
47 Ground Test & Internal Overload
48 Start Components & Hard-Start Kits

Thermostat Terminals

What each letter does (Honeywell definitions).

R / RH	24 VAC (heating transformer)
RC	24 VAC (cooling transformer)
C	Common
Y / Y2	Compressor stage 1 / 2
G	Fan
W / W2	Heat stage 1 / 2
O/B	Heat pump reversing valve
E / AUX	Emergency / auxiliary heat

1. Honeywell: "There is no standard for which color wire controls each function." Identify wires by the terminal they land on, not by color.
2. Single-transformer systems usually jumper R and RC; dual-transformer systems keep them separate — check the wiring.
3. Label every wire before removing an old thermostat.

COMMON MISTAKE

Matching wires by color between the old and new thermostat.

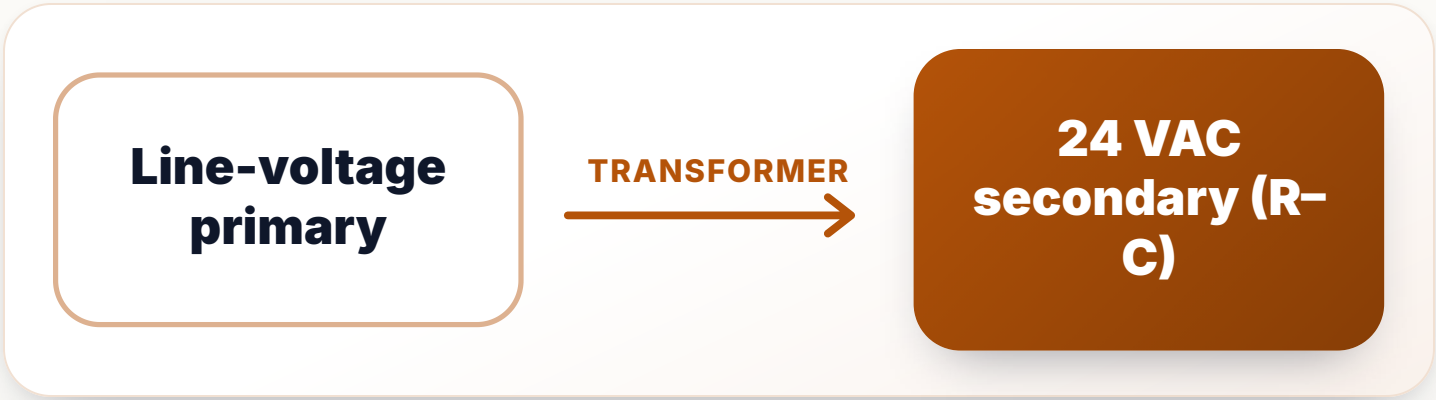
PRO TIP

Take a photo of the old terminal block before you touch anything.

SOURCES Honeywell Home thermostat wiring support and TH6320 installation guide

The 24 V Control Circuit

Low voltage tells the high-voltage parts what to do.



1. Air handlers (Goodman): 208/240 V primary to 24 V secondary. Most gas furnaces: 120 V primary. Check the transformer label, then measure 24 V between R and C.
2. Thermostat closes R to Y → contactor coil pulls in → compressor and outdoor fan start.
3. No 24 V? Check the transformer, the low-voltage fuse on the board, door switches and safeties in series.
4. Some systems use line-voltage coils — check the diagram.

COMMON MISTAKE

Shorting R to C with a meter probe and blowing the board's low-voltage fuse (rating varies; check the board).

PRO TIP

Check for 24 V across each safety in the circuit: full voltage across a switch means that switch is open.

SOURCES Goodman/Daikin Service & Troubleshooting Manual RS6200006 · ACCA HVAC Blog (secondary source)

Contactor Checks

The switch that starts the outdoor unit.

1. **24 V at the coil? (call for cooling)** →
2. **Coil pulls in?** →
3. **Voltage across closed contacts ≈ 0 V?** →
4. **Contacts pitted or burned?**

1. Goodman: when the coil is energized it pulls the normally open contacts closed; springs reopen them when de-energized.
2. Most outdoor contactors use a 24 V coil (some are line voltage).
3. A closed, healthy contact should show essentially no voltage across it under load. A reading between 0 and full voltage means bad contacts (ACCA).
4. Pitted contacts come from arcing and cause heat and voltage drop.

COMMON MISTAKE

Pushing the contactor in by hand to "test" the unit — exposed high voltage.

PRO TIP

Replace pitted contactors; filing contacts is a temporary patch at best.

SOURCES Goodman/Daikin Service & Troubleshooting Manual RS6200006 · ACCA HVAC Blog (secondary source)

 Reference only — always follow the rating plate and installation instructions.

Testing a Run Capacitor

Bench test or under-load test.

BENCH	**Discharge · remove · meter on µF**
UNDER LOAD	**µF = (Start-winding amps × 2,652) ÷ Volts across cap**

1. Bench (Goodman, Fluke): discharge, disconnect, set the DMM to capacitance and compare with the printed µF.
2. Under load (Goodman): amps on the wire from HERM to the compressor start terminal × 2,652, divided by the voltage between HERM and C. Constant is for 60 Hz.
3. Compare with the TOLERANCE PRINTED on the capacitor (Genteq and Totaline list ±6%).
4. Example: 5.8 A × 2,652 ÷ 385 V ≈ 40 µF.
5. The under-load test is LIVE: CAT III-rated meter and clamp, proper PPE, hands clear of terminals.

COMMON MISTAKE

Reading µF in capacitance mode with the capacitor still wired in — other parts in the circuit distort the reading.

PRO TIP

Weak capacitor = higher amps and hard starting. Test it on every maintenance visit.

SOURCES Goodman/Daikin Service & Troubleshooting Manual RS6200006 · Fluke application notes: absence-of-voltage testing, measurement categories, DMM how-tos · Genteq motor run capacitor data sheet

 Reference only — always follow the rating plate and installation instructions.

Dual Capacitors & Replacement Rules

One can, two capacitors: compressor and fan.

C	Common (line side)
HERM	Compressor start winding
FAN	Condenser fan motor

1. Match the µF exactly and match or EXCEED the voltage rating (e.g., 440 V can replace 370 V).
2. Copeland: on a 230 V motor, the voltage across a run capacitor can reach about 400 V — that is why the rating is higher than line voltage.
3. Copeland: run capacitors must not see more than 10% above their rated voltage.
4. Two equal capacitors in series give half the capacitance.

COMMON MISTAKE

Replacing a 440 V capacitor with a 370 V one.

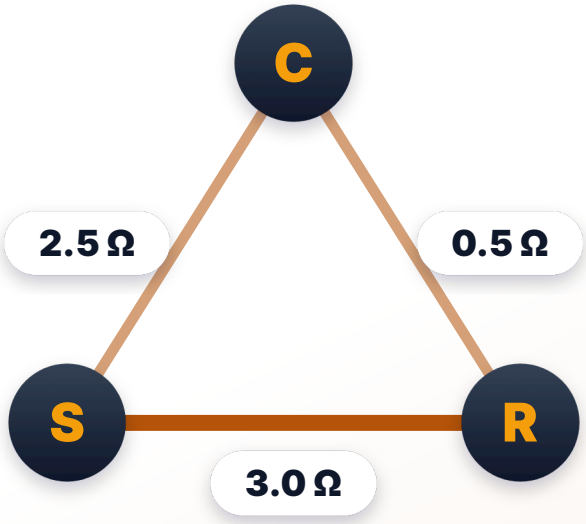
PRO TIP

Write the µF and voltage on your phone before removing the old capacitor.

SOURCES Copeland (Emerson) Electrical Handbook · Goodman/Daikin Service & Troubleshooting Manual RS6200006

Compressor Windings: C, S, R

Three terminals, three readings, one rule.



- **C** Common
- **S** Start
- **R** Run

THE RULE

C–S + C–R = S–R

Example values · use the compressor's data

1. Power off, remove all terminal wires, use a low-range digital ohmmeter (readings are often fractions of an ohm).
2. Start winding (C–S) has higher resistance than the run winding (C–R). S–R is the highest: C–S + C–R ≈ S–R.
3. Copeland: readings should be within ±10% of the published resistance.
4. Example: C–S 2.5 Ω + C–R 0.5 Ω = S–R 3.0 Ω.

COMMON MISTAKE

Measuring with the wires still connected — the capacitor and other parts change the readings.

PRO TIP

Identify the terminals from the readings: the pair with the highest resistance is S–R; the remaining terminal is C.

SOURCES Copeland (Emerson) Electrical Handbook · Goodman/Daikin Service & Troubleshooting Manual RS6200006 · ACCA HVAC Blog (secondary source)

Reference only — always follow the rating plate and installation instructions.

Ground Test & Internal Overload

Two quick checks before you condemn a compressor.

GROUNDED	OVERLOAD OPEN
Any reading from a terminal to the shell	**R–S has continuity, C–R and C–S open**
Compressor is defective (Goodman)	Let it cool 3–4 hours, retest

1. Goodman: test from each lead to a clean, unpainted tube on the highest resistance scale. It should read infinity.
2. Goodman: the internal line-break overload opens the common circuit on single-phase units; allow at least 3–4 hours to cool and reset.
3. Copeland: megohm readings are for tracking a trend over time, not a single pass/fail.
4. Never megger or hi-pot a compressor while the system is in a vacuum (Copeland).
5. Keep the terminal cover on: a damaged hermetic terminal can be expelled and its contents can ignite (Goodman).

COMMON MISTAKE

Condemning a hot compressor with an open overload that only needed to cool.

PRO TIP

Reset a breaker or replace a fuse only ONE time before investigating (Goodman).

SOURCES Goodman/Daikin Service & Troubleshooting Manual RS6200006 · Copeland (Emerson) Electrical Handbook

Reference only — always follow the rating plate and installation instructions.

Start Components & Hard-Start Kits

Help for compressors that struggle to start.

RUN CAPACITOR	START CAPACITOR
In circuit the whole time	**Intermittent duty only**
Metallized film, low µF	Electrolytic, high µF, removed by relay

1. Copeland: PSC compressors need equalized pressures to start; with PSC starting problems a hard-start kit is recommended.
2. Goodman (scroll units): in most cases hard-start components are not required; only kits approved by Amana or Copeland should be used.
3. Start capacitors must not see more than 30% above their rated voltage (Copeland).
4. A potential relay drops the start capacitor out as the motor reaches speed.

COMMON MISTAKE

Adding a hard-start kit to hide low voltage or a failing compressor.

PRO TIP

Measure voltage at the compressor during start-up before adding start assist.

SOURCES Copeland (Emerson) Electrical Handbook · Goodman/Daikin Service & Troubleshooting Manual RS6200006

UNIT 8

Heat Pumps & Gas Furnaces

Reversing valves, defrost, backup heat, and gas furnace sequence, flame and pressure checks.

49 Reversing Valve: O vs B

50 The Defrost Cycle

51 Aux Heat, Emergency Heat & Balance Point

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55 Furnace Safeties, Flash Codes & CO

Reversing Valve: O vs B

The four-way valve that turns a heat pump around.

O TERMINAL	B TERMINAL
Energizes valve in COOLING	**Energizes valve in HEATING**
Most brands (Goodman confirmed)	Some brands (e.g., Rheem/Ruud, per trade sources)

1. Set the thermostat's changeover option to O or B to match the unit (Honeywell installer setting).
2. Goodman check: with 24 V at the solenoid, lifting the coil should give a click from the pilot plunger. No click = stuck.
3. Goodman: the center tube is always the suction line and should be cold. Internal leak: suction-line temperature difference should not exceed about 4°F.
4. Some reversing valve coils are line voltage — check the diagram.

COMMON MISTAKE

Heat pump blowing cold air in heat mode because the thermostat is set to O on a B system.

PRO TIP

Check the outdoor unit's wiring diagram for O or B before setting the thermostat.

SOURCES Goodman/Daikin Service & Troubleshooting Manual RS6200006 · Honeywell Home thermostat wiring support and TH6320 installation guide · HVAC School (B. Orr), trade training articles (secondary source)

Reference only — always follow the rating plate and installation instructions.

The Defrost Cycle

How a heat pump melts ice off the outdoor coil.

1. Coil cold + run time (or sensed ice)
2. Outdoor fan OFF
3. Reversing valve shifts to cooling
4. Aux heat ON indoors
5. Coil warms → defrost ends

1. Time-temperature (Goodman): selectable 30, 60 or 90 min intervals; the sensor closes at about 31°F; defrost ends when it opens (about 75°F on that part) or a 10-minute override.
2. Demand defrost (White-Rodgers 47D40): senses performance loss from ice; termination selectable 50–80°F; max defrost 14 min.
3. Termination temperatures are brand-specific (Trane control: 47°F as shipped). Use the unit's data.
4. Steam from the outdoor unit in winter is normal during defrost.

COMMON MISTAKE

Calling a normal defrost "a broken heat pump blowing cold".

PRO TIP

Most boards have test pins or a jumper to force defrost — see the manual.

SOURCES Goodman/Daikin Service & Troubleshooting Manual RS6200006 · White-Rodgers 47D40-801 demand defrost control instructions · Trane Demand Defrost Control Checkout (CN 9092Y00)

 Reference only — always follow the rating plate and installation instructions.

Aux Heat, Emergency Heat & Balance Point

When the heat pump needs help.

AUX HEAT	EMERGENCY HEAT
Backup heat runs WITH the compressor	**Compressor OFF, only backup heat**
Automatic, to hold setpoint	Manual, for a failed heat pump

1. Honeywell: Aux heat helps the first-stage compressor and can run at the same time; in Em Ht the compressor does not run.
2. Balance point: the outdoor temperature where heat pump output equals the home's heat loss.
3. Electric strip heat has a COP of 1.0 — the heat pump should carry the load whenever it can.
4. Outdoor thermostats can lock out strip heat above a set temperature (Goodman).

COMMON MISTAKE

Leaving a customer's system in Emergency Heat all winter — very high electric bills.

PRO TIP

Explain the difference to the homeowner; it prevents call-backs.

SOURCES Honeywell Home thermostat wiring support and TH6320 installation guide · Goodman/Daikin Service & Troubleshooting Manual RS6200006 · HVAC School (B. Orr), trade training articles (secondary source)

 Reference only — always follow the rating plate and installation instructions.

Gas Furnace Sequence of Operation

Induced draft, hot-surface ignition — the order is universal, the timings are not.

1. **Call for heat (R–W)**
2. **Inducer starts (pre-purge)**
3. **Pressure switch closes**
4. **Igniter warms up**
5. **Gas valve opens**
6. **Flame proven by sensor**
7. **Blower on after delay**

1. Example timings — Goodman *MES80: 15 s pre-purge, then igniter warm-up, 30 s blower-on delay. Lennox G50DF: 15 s pre-purge, 20 s igniter warm-up, 45 s fan-on. White-Rodgers 50M56: 30 s pre-purge.
2. Shutdown: gas valve closes, inducer post-purges, blower runs its off-delay.
3. Goodman: lockout after three failed ignition attempts; auto-reset after one hour.

COMMON MISTAKE

Assuming timings from one brand apply to another.

PRO TIP

Watch one full cycle and note where it stops — that is where the problem is.

SOURCES Goodman *MES80 / *MVC96 gas furnace installation manuals · Lennox G50DF gas furnace installation instructions · White-Rodgers 50M56U-843 universal HSI control instructions

Reference only — always follow the rating plate and installation instructions.

Flame Sensor & Flame Rectification

The furnace proves flame with a tiny DC current.

MANUFACTURER / CONTROL	FLAME SIGNAL SPEC
Goodman *MES80	1 to 3 µA (should be)
White-Rodgers 50M56U	Minimum 1 µA DC
Lennox G50DF	Low below 0.31 µA · drop-out 0.24 µA

1. Measure with a DC microammeter in series with the flame sensor lead.
2. Specs vary widely — always use the furnace's own value.
3. Goodman: clean the sensor with steel wool; a coating acts as an insulator.
4. Goodman: proper line polarity is required; rapid LED flash can mean reversed polarity.

COMMON MISTAKE

Replacing the control board when the flame sensor just needed cleaning or a good ground.

PRO TIP

Low microamps after cleaning? Check the burner ground and polarity.

SOURCES Goodman *MES80 / *MVC96 gas furnace installation manuals · White-Rodgers 50M56U-843 universal HSI control instructions · Lennox G50DF gas furnace installation instructions

Gas Pressure & Burner Check

Typical values — confirm on the rating plate.

	NATURAL GAS	LP / PROPANE
Manifold (Lennox G50DF)	3.5" w.c.	10.0" w.c.
Manifold (Goodman *MES80)	3.2–3.8" w.c.	9.7–10.3" w.c.
Inlet minimum (Goodman)	4.5" w.c.	11.0" w.c.
Inlet maximum (Goodman)	10.0" w.c.	13.0" w.c.

1. Two-stage furnaces have separate low-fire settings (e.g., Goodman *MVC96 low fire NG nominal 1.9" w.c.).
2. Clocking the meter (Goodman): input Btu/h = (heating value × 3,600) ÷ seconds per cubic foot. Do not exceed the rating plate input.
3. Goodman: flames should be stable, soft and blue; dust may cause orange tips, but they must not be yellow, lift off or impinge on the heat exchanger.

COMMON MISTAKE

Setting manifold pressure without checking inlet pressure first.

PRO TIP

Use a manometer that reads inches of water column — not a refrigerant or psi gauge. Reinstall the tap plug and bubble-test it before leaving.

SOURCES Lennox G50DF gas furnace installation instructions · Goodman *MES80 / *MVC96 gas furnace installation manuals

Furnace Safeties, Flash Codes & CO

Every safety is there for a reason — find out why it opened.

SAFETY	WHAT IT GUARDS AGAINST
Pressure switch	Proves inducer / venting before ignition
Primary limit (auto reset)	Overheating from low airflow
Rollout switch (manual reset)	Flames not drawn into the heat exchanger
Flame sensor	Gas flowing with no flame

1. LED flash codes are brand- and control-specific: read the chart on the furnace door.
2. Lennox: if a rollout switch trips, check combustion air before resetting.
3. Carbon monoxide is odorless, colorless and toxic (EPA). CPSC recommends CO alarms on each level and outside sleeping areas, and an annual professional inspection.
4. Never jumper a safety to keep a furnace running.

COMMON MISTAKE

Resetting a rollout switch repeatedly without finding the cause.

PRO TIP

Carry a CO analyzer and test combustion on every heating call.

SOURCES Goodman *MES80 / *MVC96 gas furnace installation manuals · Lennox G50DF gas furnace installation instructions · US EPA, Carbon Monoxide's Impact on Indoor Air Quality; US CPSC CO safety guidance

 Reference only — always follow the rating plate and installation instructions.

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