ISLAND BREEZE TECHNICIAN CERTIFICATION PROGRAM

Electrical Diagnostics

MODULE D23 | DIAGNOSTICS | PREREQ D22

The scene: A tech rolls up on a no-cool, pops the condenser panel, and finds a dual run capacitor reading 29 microfarads on a 45 rated section. Easy call. New capacitor, unit fires up, cold air at the register, invoice signed, gone in forty minutes. Three weeks later the same address is back on the board, same complaint, and this time the brand new capacitor is dead too. What killed it? The same thing that killed the first one: a condenser fan motor with dragging bearings pulling 2.1 amps against a 1.5 amp nameplate, cooking every capacitor wired to it. The first tech replaced a part. He never made a diagnosis. This module exists so that tech is never you.

In D22 you learned the diagnostic funnel: symptoms first, system-level checks next, measurements before parts, and no component condemned without proof. This module aims that funnel at the electrical side of the system, where most of your calls actually live. You already know the components from F8 and you can read a ladder diagram from F9. Now you learn the part that separates a diagnostician from a parts swapper: finding not just the dead part, but the reason it died, and proving both with a meter.

Short Version

Bad capacitors cause about 21 percent of AC service calls, more than any other single part, and the industry's most common diagnostic failure is replacing them without asking what killed them. A capacitor is usually a symptom: heat, voltage events, a dragging motor, a pitted contactor, or blocked condenser airflow did the killing, and any of those will kill the replacement too. This module gives you the root cause discipline for capacitors, the full test sequence for PSC and ECM motors (windings, bearings, and amp draw against nameplate), the hopscotch method for finding the open in any series circuit by reading voltage across each switch, the 24V control circuit trace from transformer to coil and back, and the board-is-last rule: a control board is condemned only after every input is proven present and a commanded output is proven absent. The meter decides everything, and at Island Breeze the meter readings go in the job record as photos.

Key Values

ITEM	VALUE	NOTES
Capacitor failure share	About 21 percent of AC service calls (52 of 242 logged calls)	The number one part failure, and the number one misdiagnosis
Capacitor replace threshold	More than 6 percent below rated MFD	A 45 MFD section fails below 42.3; a 5 MFD section fails below 4.7

ITEM	VALUE	NOTES
Under load capacitor formula	MFD = (amps x 2652) / volts	Amps on the start winding wire, volts across the capacitor, 60 Hz power
Healthy 24V control voltage	24 to 29.5V	Do not condemn a transformer reading 27V
Voltage across a CLOSED switch	0V (effectively, millivolts)	A closed switch is a wire; it drops nothing
Voltage across the OPEN switch in a dead series circuit	Full source voltage (24V on the control circuit)	The open is the only break, so all the potential appears across it
Contactor drop under load	About 2V acceptable, more than 5V replace	Measured across each closed pole with the unit running
Contactor static contact resistance	Under 1 ohm pass, over 1 ohm replace	Power off, wires off
PSC winding pattern	C to R lowest, C to S higher, R to S equals the sum	OL on any pair is an open winding; continuity to case is a grounded motor
Motor amp verdict	Compare running amps to nameplate FLA (fan motors) or RLA (compressors)	At or above nameplate with a fresh capacitor means the motor is the root cause
ECM condemnation gate	Line voltage present, command signal present, shaft spins free	All three verified before the module is blamed
Board condemnation gate	All inputs proven present, commanded output proven absent	The board is last, always

FLA is full load amps, the maximum continuous current a motor is designed to draw. RLA is rated load amps, the compressor equivalent. Both live on the nameplate, and both are the standard you measure against.

Field Checklist

The electrical diagnostic sequence for a no-cool or no-heat call. Meter in hand, F1 and F7 safety rules in force: verify dead before touching, discharge every capacitor through a bleed resistor, one hand when probing live.

Before the panel comes off

1. Run the D22 intake: what does the customer report, when did it start, any storms or outages, any recent work.
2. Confirm the basics: thermostat calling, filter condition, breaker position, disconnect in place.

Capacitor (when the symptom points there: hum, click-buzz, fan not spinning)

1. Power off, verified dead, capacitor discharged through a bleed resistor.

2. Photograph the wiring, pull the wires, test each section on capacitance mode against its rating.
3. Apply the rule: more than 6 percent below rating fails.
4. THE DIAGNOSIS IS NOT DONE. Run the root cause screen before the panel goes back on: - Condenser coil: matted, blocked, or filthy raises cabinet heat. Look and document. - Fan motor: spin it by hand. Drag, grind, or wobble means bearings. - Contactor: inspect contacts, run the static resistance test, plan a drop test under load. - Voltage: ask about storms; look for a cluster pattern in the neighborhood. - Heat exposure: install orientation, afternoon sun, dead airflow corner.
5. Replace the capacitor, run the system, and take the closing amp readings: fan amps against nameplate FLA, compressor amps against RLA. High amps with a fresh capacitor means you found a symptom, not the cause. Keep diagnosing.

Motor (PSC)

1. Power off. Spin test by hand: free and silent passes, drag or grind condemns the bearings, no meter needed.
2. Ohm the windings: C to R low, C to S higher, R to S the sum. OL on any pair is an open winding.
3. Windings to case: any continuity means a grounded motor, replace.
4. If the windings and bearings pass, test the capacitor before condemning anything.
5. Running: clamp the common wire and compare amps to nameplate FLA. Over nameplate is a failing motor or a downstream restriction making it work too hard.

Motor (ECM)

1. Verify line voltage at the motor connector (many ECMs hold line voltage constantly, so power off before unplugging anything).
2. Verify the command: 24V at the signal taps on constant torque motors, data connection intact on constant airflow motors.
3. Power off, spin the wheel: a seized bearing condemns the motor, not the module.
4. Only when power, command, and a free shaft are all proven does the module become the suspect.

24V control circuit (nothing runs, or one side runs and the other does not)

1. Transformer secondary: 24 to 29.5V across R and C proves the source.
2. Control fuse intact. A blown fuse means find the short before anything else.
3. Confirm the call leaves the thermostat: 24V on Y to C (cooling) at the equipment.
4. Hopscotch the chain: meter across each switch and safety in series. Closed switches read 0V. The open reads full control voltage. That device, or the splice next to it, is your fault.
5. Ask why the safety opened before you bypass or reset anything. A float switch full of water and a tripped high pressure switch are messengers, not faults.

Board (when an output never fires)

1. Read the LED status code against the legend on the panel door or wiring diagram.
2. Verify every input: line voltage, 24V at R and C, the call present at the board terminal, safety circuit closed, board fuse intact.

3. Command the output and measure at the board terminal: call present, inputs good, output dead at the terminal condemns the board. Output present but the load dead clears the board and moves you downstream.

IB STANDARD

Every electrical diagnosis at Island Breeze is documented with meter photos in ServiceTitan: the failed reading that proves the diagnosis (capacitor MFD, winding OL, voltage across the open switch, dead board output) and the closing reading that proves the repair (post-repair amp draw against nameplate, restored control voltage). A reading that is not photographed did not happen. This is what protects you on the callback that was not your fault.

Full Breakdown

The parts swapper and the diagnostician

D22 taught you that a diagnosis names the cause, not the casualty. Electrical work is where that distinction earns its money, because electrical failures come in chains. A pitted contactor chops voltage to a compressor; the compressor strains; its capacitor cooks. A blocked condenser coil overheats the cabinet; the capacitor inside cooks. A bearing-dragging fan motor over-amps for months; its capacitor cooks. Notice the pattern: the capacitor is the weakest link in several different chains, so it fails first and gets the blame, while the real fault keeps working on the replacement.

The industry-wide failure pattern this module attacks head-on: **replacing capacitors without root cause analysis.** Capacitors are about 21 percent of service calls. They are cheap, fast to swap, and the unit almost always starts afterward, which makes the swap feel like a win. It is a win exactly as often as the capacitor died of old age, and old age is only one suspect on a five suspect list.

Capacitor testing with the why attached

You learned the mechanics in F8: discharge through a bleed resistor, photograph the wiring, wires off, capacitance mode, each section against its rating, replace beyond minus 6 percent. You also learned the under load method for maintenance work: MFD = (amps x 2652) / volts, measured with the system running, which tests the part at real operating voltage instead of the meter's tiny test signal. That is the test. Here is the diagnosis.

A run capacitor is an oil filled can with a designed shell temperature limit, most commonly 70C, which is 158F. Everything that kills capacitors works by pushing the part past that limit or by hitting it with voltage it was not built for. Five suspects, in roughly the order you should check them:

1. Heat. The capacitor lives in the condenser's electrical compartment. Anything that raises compartment temperature shortens its life on a steep curve. A dirty or matted condenser coil is the big one: blocked heat rejection raises head pressure, the compressor works harder, and the whole cabinet runs hot. Check the coil on every capacitor call. It takes ten seconds and it is the most common root cause on the list.

2. Voltage events. Surges, spikes, and brownouts stress the dielectric, the insulating film inside the can. One lightning-season storm can produce a cluster of capacitor calls the next morning across one neighborhood. Ask the customer about storms and outages. A voltage-event failure has no equipment-side root cause to fix, but it still changes your work: you note it, you check the rest of the electrical system for collateral damage, and you do not go hunting for a mechanical cause that does not exist.

3. A dragging motor. Worn bearings make a motor fight its own shaft. The fight shows up as amp draw above nameplate, and the capacitor wired in series with the start winding absorbs that stress full time. This is the suspect that produces the classic three week callback. The screen is built into your closing routine: after every capacitor replacement, clamp the motor lead and compare to nameplate. A condenser fan pulling 2.1 amps against a 1.5 FLA killed your old capacitor and has already started on the new one. The honest repair on that call is motor and capacitor together.

4. A failing contactor. Pitted, burned contacts are a resistor in series with everything downstream. They chop and sag the voltage the motors receive, and motors fed low voltage draw high current, which loops back to suspect three. A chattering contactor (a coil fed weak 24V, or worn contact springs) is worse: every chatter is an arc and a current spike. Inspect the contact faces, run the static under 1 ohm test, and on the running system measure the drop across each closed pole. Around 2V is acceptable. More than 5V means the contactor is converting your customer's power into heat and it is part of your diagnosis.

5. Condenser airflow. A failing fan motor, a slowed fan from its own weak capacitor section, cottonwood fluff on the coil face, a fence built two feet from the discharge: anything that strangles airflow through the condenser raises compartment temperature and joins suspect one. Stand there and feel the discharge air while the unit runs. Weak discharge on a running fan is data.

Visual D23-1 maps the whole tree. The closing discipline that makes it real: **no capacitor replacement is complete without a post-repair amp reading compared to nameplate.** Healthy amps close the loop and prove old age or a voltage event. High amps reopen the call while you are still standing in front of the equipment instead of three weeks later.

PHOENIX FIELD NOTE

Phoenix runs the heat suspect at maximum difficulty. A condenser baking on a west wall hits internal compartment temperatures near the capacitor's 158F shell limit on an ordinary July afternoon, before any fault is added, and the first June heat wave produces a predictable spike of capacitor failures on marginal parts. Monsoon season stacks suspect two on top: storm transients produce next-morning capacitor clusters. The practical Phoenix rule: a capacitor reading minus 4 to minus 5 percent in spring will not survive to September. It is inside tolerance today and you cannot fail it on the rule, but you document the reading, photograph it, and tell the customer what the trend means, so the August failure is a scheduled visit instead of an emergency.

Motor diagnosis: windings, bearings, and the amp clamp

A motor can fail four ways: an open winding, a grounded winding, dead bearings, or a failed start component. The test sequence sorts them in minutes, and the order matters because the cheapest test comes first.

The spin test. Power off, verified dead. Spin the blade or blower wheel by hand. A healthy motor spins free, quiet, and coasts. Drag, grinding, a gritty feel, or shaft wobble you can feel side to side means the bearings are gone, the motor is condemned mechanically, and no electrical test can save it. This five second test also protects you from the classic ECM mistake, because a seized ECM looks electrically dead from the outside.

Winding checks. From F8: a PSC motor has a run winding and a start winding sharing a common terminal. Ohm the three pairs. Common to run reads lowest, common to start reads higher, run to start reads the sum of the other two. That arithmetic is your proof you have identified the terminals correctly. OL on any pair is an open winding: condemned. Then ohm each terminal to bare metal on the motor case: any continuity at all is a grounded winding: condemned. On standard meters a healthy motor reads OL to case. The deeper version of that test, measuring insulation resistance in megohms with a megohmmeter to catch windings that are failing but not yet failed, is the heart of compressor diagnosis and belongs to D26. Here, know that it exists and that ohms-to-case on a standard meter is the field screen, not the final word on a compressor.

Amp draw against nameplate. The clamp meter is the motor's lie detector. Every motor nameplate states FLA (or RLA on a compressor), and a running motor telling you its amps is telling you its health:

- **At or below nameplate:** working within design. Healthy.
- **Above nameplate:** the motor is fighting something. Bad bearings, a wrong or weak capacitor, low voltage, an overpitched replacement blade, or a load problem like a dirty blower wheel. Find which.
- **Locked rotor amps, then click, then silence, repeating:** the motor cannot start at all. It draws the huge inrush current, the internal overload heats and opens, the motor cools, the overload resets, and the cycle repeats. A hum-click cycle is this signature.
- **Well below nameplate on a PSC:** often a weak run capacitor letting the motor run inefficiently off one winding's worth of field. Check the capacitor.

PSC versus ECM: how they fail and how you test them. These two motor families fail differently, and applying PSC instincts to an ECM is how good modules get condemned.

A PSC motor fails simply. The windings open or ground, the bearings wear, or its capacitor dies. The signature you will see weekly: the motor hums but will not start, and if you spin it (power off, then restore power, or with a stick through the grille on a fan rated for it) it takes off and runs. Nine times out of ten that is a dead run capacitor. The tenth time it is dying bearings that need just a push to break free, which is why the spin test and the post-repair amp check are both mandatory: the bearing-drag motor that barely starts today is the one that kills your new capacitor.

An ECM has no capacitor at all. It is a DC motor with an electronic module that rectifies incoming power and fires the windings under microprocessor control. It fails as electronics fail: the module dies from heat or moisture, a connector corrodes, or the command never arrives. The module is the expensive half, and the diagnostic trap from F8 is now a hard rule. Before any ECM module is condemned, three proofs:

1. **Line voltage at the motor.** Many ECMs receive constant line voltage and wait for a command. No line voltage means the problem is upstream: door switch, breaker, board relay.
2. **The command is present.** Constant torque motors (the X13 family) take 24V signals at numbered taps: prove 24V at the energized tap. Constant airflow motors take serial data from the board: prove the data

connection is intact and the board is commanding (a known-good test like the manufacturer's diagnostic tool, or the board's own blower-on command).

3. **The shaft spins free.** Power off, unplug the motor, spin the wheel. Seized bearings condemn the motor and clear the module.

Line power present, command present, shaft free, motor still dead: now the module is condemned, and you have the three proofs photographed. Visual D23-4 puts the PSC and ECM symptom paths side by side.

The hopscotch method: finding the open with voltage

Here is the most transferable skill in this module, and arguably in the whole diagnostics track. It rests on two F7 facts:

- A **closed switch is a wire.** Current flows through it and it drops essentially no voltage. Meter across a closed switch: 0V.
- An **open switch is the break.** In a series circuit with one open, all the source potential appears across that open, because the meter completes the circuit through the load. Meter across the open switch: full source voltage.

So in any dead series circuit, the fault announces itself: every good switch reads 0V across it, and the one open device reads the full 24V (or 240V on a line circuit). You hop the meter across each device down the rung of the ladder diagram, switch by switch, and the fault is the one that shows voltage. That is the hopscotch method. F9 taught you to read the rung on paper; hopscotch is how you walk it with a meter.

There are two ways to run it, and they are the same logic:

Across each device (the hopscotch proper). Both probes on the two terminals of one switch, then hop both probes to the next switch down the line. 0V, 0V, 0V, 24V: stop. The device showing 24V is open. This is the method of choice when the components are all in one panel in front of you.

Probe parked on common (the voltage walk). One probe stays on the transformer common, which on most equipment is bonded to the chassis, so the grounded frame itself works as your common point. The other probe walks the circuit point by point in circuit order. Every point upstream of the open reads 24V to common; every point downstream reads 0V. The fault sits between the last live point and the first dead one. This version is faster when the circuit spans distance, and it leaves one hand free, which is also the safer posture from F1.

Two practical notes that save real time. First, the open is not always a component. Wire nuts, spade terminals, and crimp connectors fail more often than the parts they connect, and a corroded splice reads exactly like an open switch. When the hopscotch lands between two components, the connection itself is the suspect, and an intermittent crimp that looks perfect to the eye and opens under vibration is a classic planted fault on training boards for a reason. Second, hopscotch requires the circuit to be energized and calling. A circuit with no source voltage at all sends you back a step: prove the transformer first.

One bonus read you already met in F8: voltage across an open switch also certifies everything else in the rung. If 24V appears across the open contacts, then the source, every other switch, the load, and the path back to common are all proven good in one reading, because that is the only way potential reaches your meter. One measurement, whole rung characterized. That is why diagnosticians love this method: it is not just fast, it is information dense.

Tracing the 24V control circuit

Now aim the hopscotch at the circuit you will trace most: the cooling call. From F9, the rung runs from the transformer's R side, through the thermostat, out the Y wire, through every safety in series, to the contactor coil, and back to C. In real equipment the chain looks like this:

Transformer secondary, R and C. The source. 24 to 29.5V across R and C proves it. Zero here means nothing downstream can work: check the control fuse (commonly 3A or 5A), and if the fuse is blown, your diagnosis is now find the short, not replace the fuse. A shorted thermostat wire stapled through its insulation, a rubbed-bare Y wire at the condenser, or a shorted coil will kill fuse after fuse until found.

The thermostat. Just a switch panel, per F8. Prove the call leaves it: 24V from Y to C with the stat calling cool. The classic shortcut when the stat is suspect: jumper R to Y at the equipment. Condenser starts, the field wiring and equipment are innocent and the stat or its wire is your fault. No start, the stat is innocent and the problem is downstream.

The safety chain. Between Y and the contactor coil, equipment manufacturers and installers wire safeties in series: the float switch in the drain pan circuit, the low pressure switch, the high pressure switch, sometimes a compressor protection timer. Any one of them opening kills the call silently. This is where the hopscotch earns its living: across each safety in turn, 0V is closed and innocent, 24V is your open.

The coil and the path home. 24V arriving at the contactor coil with no pull-in points at the coil itself (ohm it: OL is an open coil) or at the return path on the C side. Do not forget the return: a broken C splice reads as a dead circuit even though Y-side voltage walks all the way to the coil. The full trace is visual D23-3.

And the rule that makes this diagnostics rather than parts roulette: **a tripped safety is a messenger.** The float switch opened because the drain is plugged. The high pressure switch opened because the condenser fan died or the coil is blocked. The low pressure switch opened because the charge leaked out. Finding the open safety is the midpoint of the diagnosis, not the end. You may jumper a safety briefly, meter in hand, as a test to confirm the rest of the circuit, and never as a repair. The repair is whatever made the messenger speak, and on the refrigerant-side messengers, D24 picks up the story.

Board diagnosis: the board is last

The control board is the most expensive electrical part in the air handler or furnace and the least understood, which makes it the most wrongly condemned. The board-is-last rule exists because a board has many inputs and a few outputs, and a missing input perfectly imitates a dead board.

Start with the LED. Most boards carry a status LED that flashes coded patterns: steady on, steady off, a counted blink sequence like three flashes then pause. The legend lives on the panel door sticker or the wiring diagram. The code is the board telling you what it sees: a pressure switch stuck open, a limit trip, a flame fault, lockout from too many retries. Read it first and write it down, because some codes clear when power cycles, and the furnace-specific meanings (flame sensing, pressure switch logic, ignition retries) get their full treatment in D28. A board with no LED lit at all is not necessarily dead: it may simply have no power, which is an input problem.

Verify the inputs. Before the board is even a suspect, prove everything it needs is arriving:

1. **Line voltage** at the board's power connections.
2. **24V** at R and C on the board terminal strip, which also proves the transformer and control fuse.

3. **The board's own fuse**, the small automotive-style blade fuse on many boards. Blown means find the short, same rule as always.
4. **The call**: 24V at the board's Y, G, or W terminal with the thermostat calling. The call has to arrive before the board can act on it.
5. **The safety inputs**: door switch closed, rollout and limit circuit closed, float switch closed. An open safety input commands the board to refuse, and a refusing board is an obedient board, not a dead one.

Then, and only then, test the output. With every input proven, command the function and measure at the board's output terminal. Cooling call present, board should close its fan relay: measure line voltage at the blower output terminals. Output dead at the terminal with all inputs alive: the board has failed, condemned with proof. Output alive at the terminal but the load not running: the board is innocent and your fault is downstream in the wiring, the motor, or its capacitor.

That is the whole rule. **Inputs proven present, commanded output proven absent, then the board is condemned. Anything less is a guess wearing a diagnosis costume.** Visual D23-5 is the flowchart. Two field habits seal it: photograph the LED code before power cycling, and when you do condemn a board, note which output failed and what the inputs read, because the supply house warranty desk and the next tech both need that story.

> **IB STANDARD**
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> Board condemnations at Island Breeze require the full proof set photographed in ServiceTitan before the part is ordered: the LED code as found, 24V present at R and C, the call present at the terminal, and the dead output measurement. Boards are expensive, frequently misdiagnosed, and usually nonreturnable once installed. The photo set is the difference between a warranty claim that pays and one that bounces, and it is the standard whether the board is two hundred dollars or two thousand.

Where this module hands off

Three pointers so you know where the track goes next. Compressor winding diagnosis beyond the basic ohm screen, megohm insulation testing, and the discipline of not condemning healthy compressors is D26. Furnace-specific electrical, flame sensors, pressure switch logic, and ignition sequences is D28, where the board LED codes you met here get their full furnace vocabulary. And every refrigerant-side cause behind a tripped pressure switch is D24, which starts on the other side of exactly the safeties you traced today.

Common Mistakes

1. **Replacing the capacitor and driving away.** The defining failure pattern of residential service. One in five calls is a capacitor, and a meaningful share of those capacitors were killed by heat, a dragging motor, a pitted contactor, or blocked airflow that is still there when you leave. The post-repair amp reading against nameplate is the screen, and skipping it converts a five week callback into a certainty. Cost: the callback is free for the customer and expensive for you.
2. **Condemning the board because nothing else was obvious.** The board is guilty only when every input is proven present and a commanded output is proven absent. Most condemned boards were innocent boards

missing an input: a blown blade fuse, an open door switch, a call that never arrived. Cost: hundreds of dollars of nonreturnable part, and the real fault still in the system.

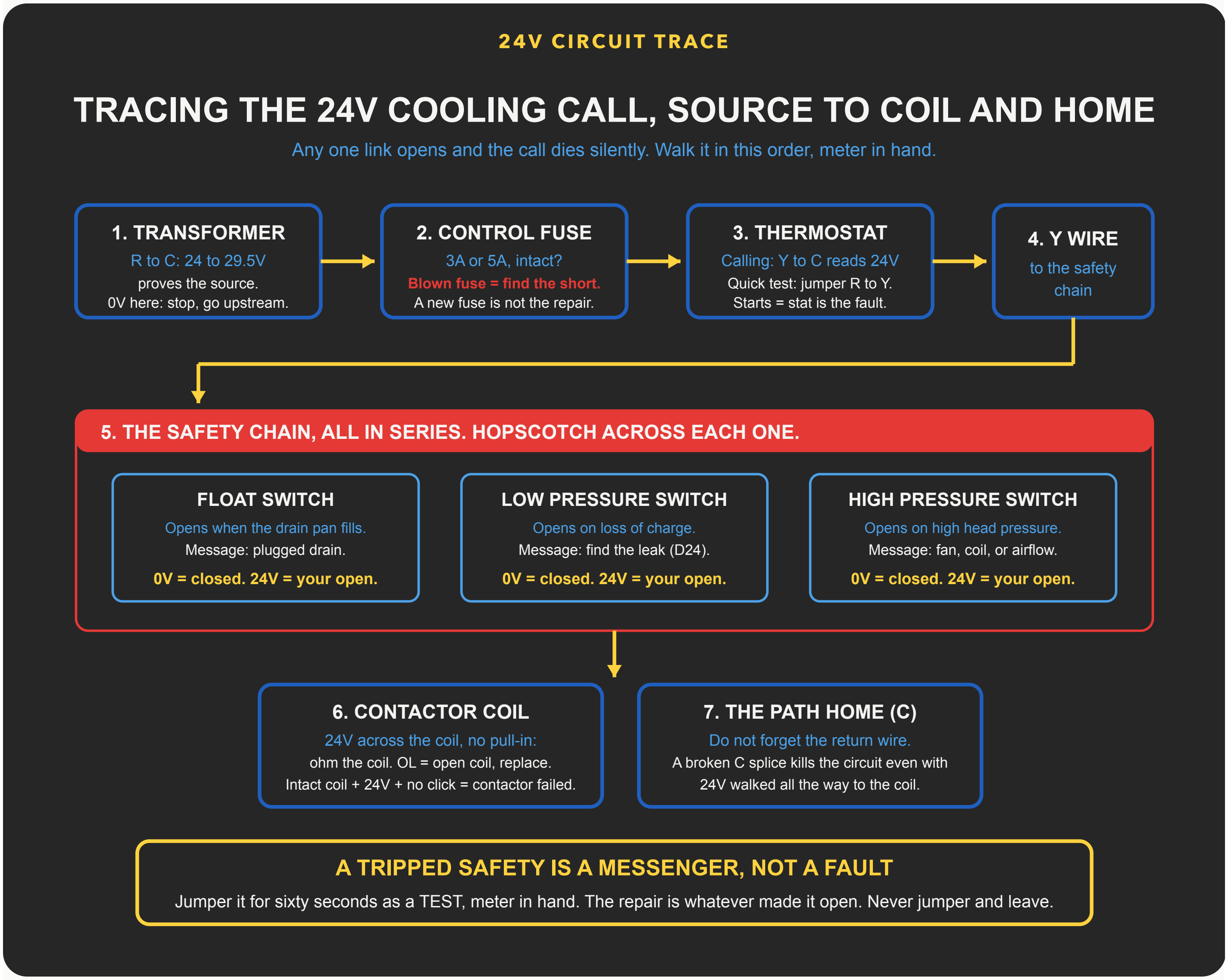
3. **Condemning an ECM module without the three proofs.** Line voltage, command signal, free shaft. A seized bearing or a dead data wire imitates a dead module perfectly. Cost: the most expensive motor part on the truck, wasted.
4. **Bypassing a safety as a repair.** Jumping a pressure switch or float switch to get it running silences a messenger and ships the real fault to the customer, and on a high pressure switch it can ship them a dead compressor. A jumper is a sixty second test with you standing there, never a fix.
5. **Hopscotching a circuit nobody proved was energized.** Voltage-across-the-switch logic only works when the source is live and the call is present. Prove the transformer and the call first or the whole walk reads 0V and tells you nothing.
6. **Forgetting that splices fail more than parts.** When the open lands between two components, the wire nut, spade, or crimp is the suspect. Tug-test connections; an intermittent crimp looks perfect and opens under vibration.
7. **Trusting the click.** Relays and contactors can click and still not conduct through burned contacts, and a board can click a relay closed onto a dead trace. The click is a clue. The meter reading through the contacts is the proof.
8. **Reading amps and never comparing them.** An amp number without the nameplate next to it is trivia. The diagnosis lives in the comparison: measured against FLA or RLA, every time, photographed.

Next module: D24, Refrigerant Circuit Diagnostics, where the pressure switches you traced today become the entry point to the charge misdiagnosis triangle: low charge, TXV, or airflow.

DARREL FIELD WISDOM (to be recorded)

1. Tell the story of a capacitor call you got behind another company where the cap had been replaced two or three times and nobody asked why. What was actually killing them, and how fast did you find it?
2. Walk through your personal contactor inspection habit: what you look at first when the panel comes off, what pitting tells you versus what bugs tell you, and the worst contact set you have ever pulled out of a Phoenix condenser.
3. Describe the board you almost condemned. What input turned out to be missing, what made you check one more thing before writing it up, and what would the wrong call have cost?
4. When you hopscotch a 24V circuit, where do you put your first probe and why? Talk through one real call where the open turned out to be a splice or a crimp instead of a component.
5. June versus February in Phoenix: how does your electrical diagnosis change in the heat, and what do you tell a customer whose capacitor reads minus 5 percent in May?

Module Visuals



BOARD DIAGNOSIS FLOW

BOARD DIAGNOSIS: THE BOARD IS LAST

The most expensive part in the cabinet and the most wrongly condemned. A missing input imitates a dead board perfectly.

STEP 1: READ THE LED CODE

Legend on the panel door or wiring diagram.

Photograph it BEFORE power cycling. Codes clear.

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STEP 2: VERIFY EVERY INPUT BEFORE THE BOARD IS EVEN A SUSPECT

- **1. LINE VOLTAGE** — at the board power connections
- **2. 24V AT R AND C** — proves transformer + control fuse
- **3. BOARD FUSE INTACT** — **Blown = find the short first**
- **4. THE CALL ARRIVES** — 24V at Y, G, or W terminal, calling
- **5. SAFETIES CLOSED** — door switch, limits, float, rollouts
- **A REFUSING BOARD IS OBEDIENT, NOT DEAD**

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STEP 3: COMMAND THE OUTPUT, MEASURE AT THE TERMINAL

Call present, inputs proven. Does the board send voltage out of its own output terminal when commanded?

OUTPUT DEAD AT THE TERMINAL

with every input alive:

BOARD CONDEMNED, WITH PROOF.

OUTPUT ALIVE, LOAD STILL DEAD

Board is innocent. Move downstream: wiring, motor, capacitor.

Inputs proven present + commanded output proven absent = condemned. Anything less is a guess. Furnace codes in depth: D28.

CAPACITOR ROOT CAUSE TREE

THE DEAD CAPACITOR IS A SYMPTOM. FIND THE KILLER.

About 21 percent of AC service calls. Replace beyond minus 6 percent of rated MFD, then run this tree before the panel goes back on.

CAPACITOR FAILED
Proven with the meter. Diagnosis NOT done.

WHAT KILLED IT?

1. HEAT

Dirty or matted condenser coil cooks the cabinet. Shell limit is about 158F.

CHECK: Coil condition, sun exposure, cabinet location

2. VOLTAGE

Storm surges, spikes, and brownouts stress the dielectric. Fails cluster after storms.

CHECK: Ask about storms, outages, neighbors with the same call

3. DRAGGING MOTOR

Worn bearings pull amps over nameplate and stress the cap full time. The classic 3 week callback.

CHECK: Spin test by hand, amps vs FLA / RLA

4. CONTACTOR

Pitted contacts chop and sag the voltage. Low voltage = high amps. Chatter arcs.

CHECK: Inspect faces, static under 1 ohm, drop 2V ok, over 5V fail

5. COND. AIRFLOW

Slow fan, blocked coil face, fences or debris strangling the condenser. Loops back to heat.

CHECK: Feel discharge air, walk the clearances

THE CLOSING SCREEN: POST-REPAIR AMPS VS NAMEPLATE

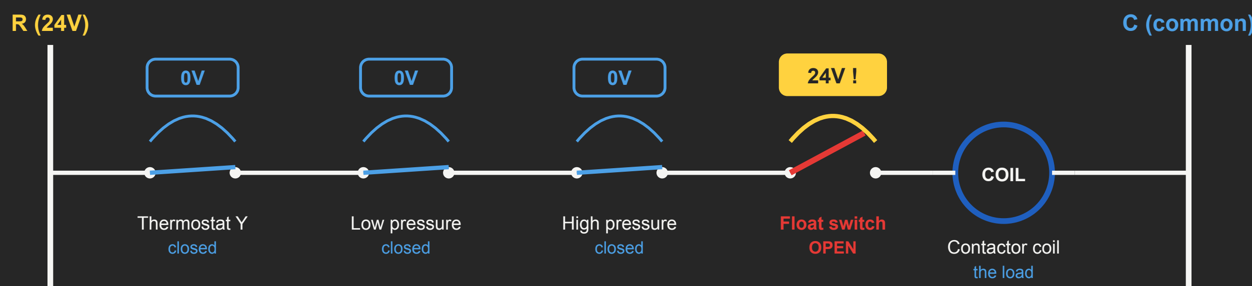
New capacitor in, system running, clamp every motor it serves. At or below FLA / RLA closes the loop.

AMPS HEALTHY: loop closed.
Old age or voltage event. Document and close.

AMPS OVER NAMEPLATE: keep diagnosing.
You found a symptom. The killer is still in the system.

THE HOPSCOTCH METHOD: VOLTAGE FINDS THE OPEN

A closed switch is a wire: 0V across it. The one open in a dead series circuit wears the full source voltage.



BONUS: 24V across the open certifies the rest of the rung.
Source, other switches, load, and path home all proven in one reading.

FULL VOLTAGE ACROSS ONE DEVICE
= that device is your open. Stop hopping.

VARIANT: PROBE PARKED ON COMMON (the voltage walk)

One probe stays on transformer common (chassis ground on most equipment). The other walks the circuit in order.

Every point upstream of the open reads 24V to common. Every point downstream reads 0V.

The fault lives between the last live point and the first dead one.

Faster across distance, and one-handed, which is the safer posture. Same logic, same answer.

FINE PRINT: the circuit must be powered and calling. Prove the source first.

And when the open lands between two components, suspect the splice: wire nuts, spades, and crimps fail more often than parts.

Works on any series circuit: 24V control today, 240V line circuits with the same logic and more respect.

MOTOR FAULT MATRIX: PSC VS ECM

Same symptoms, different machines, different tests. Cheapest test first: spin it by hand.

SYMPTOM	PSC (windings + run cap)	ECM (motor + module)
Hums, will not start (starts if you spin it, power cycled first)	**9 of 10: dead run capacitor.** Test the cap: more than 6 percent low fails. The 10th: dragging bearings that killed it. Spin test + post-repair amps catch that one.	No capacitor exists. A humming or twitching ECM is a module or bearing problem. Power off, spin the wheel: seized = motor. Free shaft = run the three-proof gate below.
Completely dead (no hum, no motion)	Prove voltage is arriving first (contactor, relay, board output). Then ohm the windings: **C-R low, C-S higher, R-S = the sum.** **OL on any pair = open winding. Replace.**	**Three proofs before blaming the module:** 1. Line voltage at the motor connector 2. Command present (24V tap or board data) 3. Shaft spins free with power off **All three pass + still dead = module.**
Trips breaker or cycles on overload	Hum-click-silence cycle = locked rotor inrush, overload opens, cools, repeats. **Winding to case continuity = grounded.** Instant breaker re-trip points at a ground.	Module faults can trip its internal protection. Check for a board fault code, moisture in the module, and a free shaft before condemning. Bearing drag overworks the module too.
Runs, but slow, hot, or over nameplate amps	**Clamp it: amps vs nameplate FLA / RLA.** Over: bearings, weak or wrong cap, low voltage (check contactor drop), dirty wheel. Well under on a PSC: suspect a weak cap.	Constant airflow ECMs ramp UP against restrictions: high watts often means a dirty filter, blocked coil, or crushed duct, not a motor fault. Fix the airflow (D25).
Grinding, squealing, or wobble	**Bearings. Condemned by feel, no meter.** A dragging motor is a capacitor killer: replace motor AND capacitor together.	**Bearings condemn the motor, not the module.** A seized ECM looks electrically dead from outside. The spin test protects your wallet.

EVERY VERDICT NEEDS A NUMBER: ohms, amps vs nameplate, or volts. Compressor megohm testing: module D26.

Winding screen on a standard meter: OL to case passes. Continuity to case = grounded = replace.