ISLAND BREEZE TECHNICIAN CERTIFICATION PROGRAM

Airflow Diagnostics

MODULE D25 | DIAGNOSTICS | PREREQ D24

In D24 you learned the charge misdiagnosis triangle: low charge, a starving TXV, and low airflow all push suction pressure down, and only the full set of readings tells them apart. This module is the third corner of that triangle getting its own deep dive, because ignored airflow is one of the four failure patterns this whole track exists to kill. C12 taught you to measure airflow: drill two ports, read TESP, pull the fan table, get CFM. That tells you THAT the system is strangled. This module teaches you to find out WHERE. You will turn two test ports into four, split one TESP number into component pressure drops, and let the numbers point a finger at the filter, the coil, the blower wheel, or the ductwork before you ever open a panel on a hunch. A tech who can map static pressure does not guess at airflow problems. They read the map, walk straight to the restriction, fix it, and prove the fix with an after number.

Short Version

TESP from C12 tells you the system is sick; component pressure drops tell you where. Add two ports to the standard two (one upstream of the filter, one downstream of the coil) and every major component gets its own number: filter drop, coil drop, return side, supply side. Budget rule of thumb on a 0.5 in WC system: filter about 0.10, wet coil about 0.20 to 0.25 per its published data, return path about 0.10, supply ducts and registers about 0.10. Whichever component is spending double its budget is your restriction. A dirty evaporator coil gets convicted without pulling it: measured coil drop far above the manufacturer's published wet drop, a temperature split above 22 F, low suction with normal subcooling, and a flashlight on the air-entering face. A dirty blower wheel inverts the logic: dust-filled blade cups cannot grip air, so you get LOW airflow with LOW static, and a heavily loaded wheel can give up 20 to 30 percent of its CFM. Duct restrictions announce their side through the TESP split: return-heavy points at grilles, return runs, and the filter; supply-heavy points at the coil, crushed flex, and closed dampers. Under high static, a PSC blower droops and freezes coils; a constant airflow ECM holds CFM by eating watts until it overheats or dies young, so on ECM systems static and watt draw are the truth tellers. Low airflow mimics low charge on the gauges (D24), kills capacity, freezes coils, and floods compressors. Find it with numbers, fix it, re-measure, and document both readings.

Key Values

VALUE	NUMBER	WHAT IT MEANS
Design TESP recall (C12)	0.5 in WC	The budget most residential blowers were rated against. Everything below divides this budget.
Field trouble threshold (C12)	Above about 0.8 in WC	Strangled. The component map tells you where.

VALUE	NUMBER	WHAT IT MEANS
Filter budget	About 0.10 in WC, roughly 20 percent of TESP budget	A clean, properly sized filter. A 1 inch high-MERV pleat blows this budget on day one.
Wet coil drop, typical published	About 0.20 to 0.30 in WC	From the coil manufacturer's data. Measured drop far above published means a dirty or impacted coil.
Return path budget	About 0.10 in WC	Grille, return duct, and fittings, not counting the filter.
Supply path budget	About 0.10 in WC	Supply duct, registers, and fittings, downstream of the coil.
Dirty blower wheel CFM loss	Up to 20 to 30 percent	Dust-cupped blades stop gripping air. Signature: low airflow WITH low static.
Dirty coil temperature split	Above about 22 F	Slow air over a cold coil. Recall the healthy 18 to 22 F window from C12.
Low airflow refrigerant signature (D24)	Low suction, normal to high subcooling	Low charge drops subcooling. Low airflow does not. That one reading splits the triangle.
Constant airflow ECM limit	Commonly about 0.8 to 1.0 in WC	Above its limit the motor cannot hold target CFM, runs hot, and ages fast.
Nominal airflow recall (C12)	400 CFM per ton, 350 floor, 450 dry climate lean	The verdict scale for every CFM estimate in this module.
Wet coil penalty recall (C12)	0.05 to 0.10 in WC extra	Always map static in cooling with the coil wet, 15 minutes of runtime first.
Module demo anchors	0.90 TESP as found, 0.36 return path drop, 0.68 after repair	The worked example in this article and video v2: a crushed return flex convicted by the map.

Field Checklist

Airflow fault location on any system flagged by TESP or symptoms:

- [ ] Confirm the C12 baseline first: system in cooling 15 minutes, coil wet, standard two-port TESP, fan table CFM, per-ton verdict. If CFM is in the window, stop. No airflow fault to hunt.
- [ ] Read the TESP split: return magnitude versus supply magnitude. The heavy side is the hunting ground.
- [ ] Drill the third port upstream of the filter. Filter drop = reading after filter minus reading before filter (magnitudes). Compare to about 0.10 budget and the filter's own rating.
- [ ] Drill the fourth port downstream of the coil. Coil drop = supply-side reading at the coil inlet minus reading above the coil (magnitudes). Compare to the published wet coil drop.
- [ ] Whatever the four numbers leave unexplained belongs to the ducts on that side. Compare each side's duct number to about 0.10.

- [ ] If TESP is LOW but airflow is also low: pull the blower compartment panel and put a flashlight on the wheel blades. Check for cupped dust, a slipping or wrong speed setting, and on PSC a weak run capacitor (D23).
- [ ] On a constant airflow ECM: read watts, not just CFM. High watts at normal airflow is hidden duct disease.
- [ ] Dirty coil suspected: confirm with at least two independent signs (coil drop versus published, temp split, suction plus subcooling behavior, visual on the air-entering face) before recommending a pull-and-clean.
- [ ] Walk the accessible duct: crushed or kinked flex, closed or partially closed dampers, blocked or undersized returns, furniture over grilles, disconnected runs dumping into the attic.
- [ ] Fix what you found, then re-measure TESP and re-read the fan table. The before and after CFM numbers are the proof, not the repair story.
- [ ] Cap every port with a plug and photograph port locations and the restriction itself.

IB STANDARD

An airflow diagnosis is not complete at "found it." It is complete when the work order shows the as-found static map, the component that broke its budget, the repair, and the after readings proving CFM came back into the window. Both number sets and the restriction photo go in ServiceTitan with the 8-photo close-out.

PHOENIX FIELD NOTE

Phoenix attics run 140 to 160 F all summer, and almost every duct system here is flex baking in that oven. Heat makes the outer jacket brittle, the liner stiff, and the duct easy to crush and slow to recover. Every monsoon dust storm reloads the filters and recoats the blower wheel. When you map static in this market, assume the return side and the attic flex are guilty until the numbers clear them.

Full Breakdown

From one number to a map

Recall the C12 picture: the blower has a fixed budget of pressure it can work against, 0.5 in WC on most residential equipment, and TESP is how much of that budget the installed system is actually spending. C12 ended at the verdict: TESP 0.82, fan table says 325 CFM per ton, system starved. D25 starts where that verdict stops, because "starved" is a symptom, not a diagnosis.

Here is the key idea of this entire module: TESP is a sum, and every component in the air path contributes its own piece. The filter spends some. The coil spends some. The return grille and return duct spend some. The supply duct and registers spend some. If you can measure each piece separately, the restriction identifies itself, because a restriction is just a component spending far more of the budget than it should. You stop asking "why is airflow low?" and start asking "which line item on this bill is wrong?"

The blood pressure analogy from C12 extends naturally. TESP is the blood pressure reading. Component pressure drops are the scan that finds the blocked artery. A doctor does not treat a blood pressure number by guessing which vessel is narrow, and you do not treat a 0.9 TESP by changing parts until the house cools.

One discipline before any mapping: run the C12 baseline first, completely. System in cooling 15 minutes so the coil is wet (a dry coil reads 0.05 to 0.10 low and lies to you), standard two ports, TESP, fan table, CFM per ton. If the per-ton number is inside the 350 to 450 window, there is no airflow fault to hunt and this module's tools stay in the bag. Diagnostics means measuring before believing, in both directions.

The four-port static map

The standard C12 ports give you two readings. Two more ports turn those readings into a component map. On the common Phoenix configuration, a gas furnace or air handler with the filter at the cabinet and a cased coil on the supply side, the four ports are:

1. **Port A, return duct upstream of the filter.** In the return drop or plenum before air reaches the filter. This reading is everything the return path costs: grille, return duct, and fittings, but not the filter.
2. **Port B, between the filter and the blower.** The standard C12 return port. Everything upstream including the filter.
3. **Port C, between the equipment outlet and the coil inlet.** The standard C12 supply port on a furnace with an external cased coil. Everything downstream including the coil.
4. **Port D, in the supply plenum above the coil.** Downstream of the coil. Everything downstream except the coil: supply duct, registers, fittings.

Same drilling rules as C12, and they matter more here because ports C and D bracket the coil: know what is behind the metal, map the coil and condensate pan locations through an open panel before the bit spins, use a drill stop, stay a couple of inches clear of takeoffs. Putting a 3/8 inch bit through an evaporator coil converts a diagnostic visit into a coil replacement.

The arithmetic, all signs dropped, magnitudes only:

- **Return path drop = Port A reading.** The air arrived at the grille at house pressure, so whatever Port A reads is what the return path spent getting it there.
- **Filter drop = Port B minus Port A.**
- **Coil drop = Port C minus Port D.**
- **Supply path drop = Port D reading.** Whatever pressure remains at D gets spent pushing air through the supply duct and out the registers.
- **Check: A + (B minus A) + (C minus D) + D = B + C = TESP.** The map must add back up to the total. If it does not, re-zero the manometer and re-read.

On an air handler where the coil lives inside the rated cabinet, the coil is internal (recall the C12 rule), so there is no port C location and the map is three ports: return path, filter, supply path, with the coil's contribution already inside the fan table. You can still measure across an internal coil for dirty-coil detection (next section), but it does not count against external static.

And the budget to judge each number against, on a 0.5 in WC design system:

COMPONENT	HEALTHY BUDGET	BROKE THE BUDGET
Return path (grille + duct)	About 0.10 in WC	0.20 and above

COMPONENT	HEALTHY BUDGET	BROKE THE BUDGET
Filter (clean, properly sized)	About 0.10 in WC	0.25 and above, or double its own clean rating
Coil (wet)	Published, typically 0.20 to 0.30	Roughly 1.5 times published and above
Supply path (duct + registers)	About 0.10 in WC	0.20 and above

These are rules of thumb, not law. The coil's published wet pressure drop from the manufacturer's data sheet always beats the generic number, and a deep media filter cabinet may legitimately run below 0.10 while a code-minimum return may never have been capable of 0.10 on its best day. The budget's job is to make the outlier obvious, and it almost always does: a healthy map reads like 0.09, 0.11, 0.24, 0.10, and a guilty one reads like 0.36, 0.12, 0.24, 0.18. Nobody needs a committee to find the problem in that second list.

Worked example, the one Darrel runs in video v2. A 4 ton furnace-and-cased-coil system, complaint of weak cooling, high blower noise at the return. Baseline: Port B reads minus 0.48, Port C reads plus 0.42. TESP 0.90, well past the 0.8 trouble line, and the split is return-heavy: 0.48 of 0.90 is more than half the budget on the suction side. Map it: Port A reads minus 0.36, so the filter is only spending 0.48 minus 0.36 = 0.12, fine for its rating. The return path is spending 0.36 against a 0.10 budget. Smoking gun. Port D reads plus 0.18, so the coil drop is 0.42 minus 0.18 = 0.24 against a published 0.22 wet, healthy, and the supply path's 0.18 is elevated but not the story. The hunt is now one sentence: something between the return grille and the filter is strangling this system, and the filter is innocent.

> **PHOENIX FIELD NOTE**
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> In this market that sentence usually ends in the attic. The classic finds: a return flex run crushed flat where someone stored boxes on it or knelt on it servicing the unit, a kinked turn where the installer saved two feet of duct, and liner collapse in flex so heat-aged it slumps under its own insulation. Attic flex that has baked through fifteen Phoenix summers does not spring back. It stays crushed and waits for you.

Reading the budget: side dominance and what each pattern means

You will not always drill four ports. On a busy day, the two-port TESP split from C12 already narrows the hunt to one side of the blower, and the component map is how you finish the job on that side. The patterns to know cold:

Return-heavy split. The return magnitude dominates TESP. Suspects in order: loaded or over-restrictive filter (cheapest check in the trade, look at it), undersized return (one small grille feeding a 4 or 5 ton system, the signature Phoenix builder sin from C12), blocked grille (furniture, rugs, a closed door on a room with the only return), crushed or kinked return flex. Port A splits filter from return path in one reading.

Supply-heavy split. The supply magnitude dominates. Suspects: dirty or impacted coil, crushed or kinked supply flex, closed or partially closed dampers (manual balancing dampers at takeoffs get bumped, and registers get shut in unused rooms until the system chokes), undersized or flattened supply trunk. Port D splits coil from supply duct in one reading.

Both sides high. Usually a system-level cause: airflow set too high for the duct system (a 5 ton blower breathing through 3 ton ducts spends double budget everywhere), or a whole duct system that was never adequate. Map it, document it, fix what is fixable today, and flag the rest honestly.

TESP low but airflow low too. The inverted pattern, and the one that fools techs who learned "high static = bad" as the whole story. Resistance is not the problem; the blower is. Next two sections.

One physics note that saves confusion: pressure drops rise with airflow. The same duct spends more pressure when more air moves through it. Two consequences. First, always compare readings taken at the same blower setting. Second, when you remove a restriction, expect every OTHER component's drop to creep up, because the system is finally moving more air. In the worked example, fixing the return brings TESP from 0.90 down to 0.68, not to 0.5, partly because the supply side rose from 0.42 to 0.46 with the extra flow. The proof of the fix is never the TESP alone. It is the fan table CFM: 1,150 CFM at 0.90 as found, about 1,470 at 0.68 after, which is 287 per ton turned into 368 per ton on a 4 ton system. Starved to healthy, in numbers a customer and the next tech can both read.

> **IB STANDARD**
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> Side dominance gets stated on the work order in plain English ("0.36 of the 0.90 total is the return path") before any panel comes off. Writing the prediction down before the hunt is how you build diagnostic discipline, and how the next tech learns from your call instead of repeating it.

Convicting a dirty evaporator coil without pulling it

The evaporator coil is the one restriction you cannot just look at from the front. It hides inside a cased enclosure, its dirty face is usually the bottom one (air enters from below on an upflow system, so the entering face catches the dirt), and pulling a coil to inspect it is hours of work that needs justification. So you convict it the way D22 taught you to convict anything: independent lines of evidence that agree.

Evidence 1: coil pressure drop versus published. The C-to-D measurement from the map. Every coil manufacturer publishes wet pressure drop at rated airflow, typically 0.20 to 0.30 in WC for residential coils. Measured 0.45 against a published 0.25 is not subtle. One honesty check: low airflow itself reduces the measured drop (less flow, less drop), so a moderately dirty coil on a badly starved system can read closer to published than it deserves. If other components are also restricting, judge the coil after the easy restrictions are cleared, or weigh the next evidence lines more heavily.

Evidence 2: temperature split. Recall the healthy 18 to 22 F cooling split from C12. A split pushing past 22 F means air is crossing the coil too slowly and leaving too cold. With the filter verified clean and the blower verified healthy, a high split points at the coil itself or the ducts. Pair it with the map and the coil either clears or condemns itself.

Evidence 3: suction and subcooling behavior, the D24 recall. A dirt-blanketed coil receives less heat, so less refrigerant boils, and suction pressure falls. On the gauges it impersonates low charge, which is exactly the misdiagnosis triangle. The discriminator you learned in D24: subcooling. Low charge starves the condenser too, so subcooling drops. An airflow problem leaves the condenser fully fed, so subcooling stays normal or runs slightly high. Low suction with healthy subcooling says the charge is fine and the evaporator is starving for air, not refrigerant.

Evidence 4: eyes on the entering face. There is almost always a visual path that does not require pulling the coil: through the blower compartment looking up at the coil's underside with a bright flashlight and an inspection mirror, through the TXV or coil access panel on the casing, or with a borescope snaked through an existing port or panel gap. You are looking at the AIR-ENTERING face, because that is where the mat forms. A coil can look clean from the top (leaving face) while wearing a quarter inch felt blanket underneath. While the panel is open, check the secondary signature: a coil shedding dirt into the condensate stream often shows a slimed or partially blocked drain pan.

IB rule: two independent lines of evidence minimum before recommending a coil cleaning, three before recommending a pull-and-clean. The pull-and-clean recommendation also rides on D27 logic, because the A-coil is where 80 percent of refrigerant leaks live, and a corroded coil that needs pulling for cleaning may be a coil conversation anyway.

PHOENIX FIELD NOTE

Phoenix coils load from two directions. Haboob season drives ultra-fine dust through filter bypass gaps and cheap fiberglass filters, and it sails straight into the coil. And every summer of 110 F plus runtimes means thousands of hours of air across that face per season, so a filter maintenance lapse here costs coil cleanliness faster than the same lapse anywhere else. When a homeowner says the system has run on gas station fiberglass filters since 2019, put the coil at the top of the suspect list before you drill a single port.

The dirty blower wheel: when low static is bad news

Every restriction so far raises static. The blower wheel is the fault that lowers it, and that inversion is the whole diagnostic.

A forward-curved blower wheel moves air with dozens of small cupped blades. Those cups are shaped to grip air and throw it outward. Dust does not just add weight to the wheel, it FILLS THE CUPS, turning each precisely shaped blade into a rounded lump that slips through the air instead of biting it. A heavily loaded wheel can give up 20 to 30 percent of its airflow while the motor spins at exactly the same RPM. The motor is fine. The wheel has gone bald.

The signature, and burn this in: **low airflow WITH low static.** A weak wheel cannot generate pressure, so both the return pull and the supply push read soft. A tech who only knows "high static = restriction" sees 0.45 in WC on a 0.5 system, calls the ducts healthy, and walks past the actual fault. The full logic table:

TESP	AIRFLOW (FAN TABLE OR TEMP RISE)	VERDICT
High	Low	Restriction. Map the components.
Low	Low	Blower problem: dirty wheel, wrong speed setting, weak motor.
Normal	Normal	Air side healthy. Back to the D24 triangle's other corners.

Important honesty note on that table: when the wheel is dirty, the fan table itself becomes a liar, because fan tables assume a clean wheel (the C12 caveat). At 0.45 in WC the table promises healthy CFM that a bald wheel is not delivering. So when the low-low pattern shows up, verify airflow by a method that does not trust the wheel: the temperature rise method from C12 on a furnace, or the temperature split plus delivered-air evidence in cooling. Then put eyes on the wheel: blower compartment open, flashlight raking across the blades. Clean blades show metal cups with crisp edges. Dirty blades show smooth gray crescents. If you can write your name in the cup of a blade, you found your CFM.

Two more blower-side checks while the panel is off, both D23 recalls: a PSC blower with a weak run capacitor runs slow and moves less air at normal static (test microfarads, replace beyond minus 6 percent of rating), and a blower set to the wrong speed tap or dip switch moves the wrong airflow at ANY static, which is why the fan table step always includes physically verifying the active setting.

Cleaning a wheel properly means pulling the blower assembly, and on most direct-drive units that is a routine job: mark wiring, drop the assembly, clean the wheel completely (a half-cleaned wheel is out of balance and worse than dirty), inspect the motor mounts, reassemble, then re-measure. Static comes UP after a wheel cleaning, and that is the rare case where rising static is the proof of success: the wheel can grip air again.

Duct restrictions: hunting on the right side

The map and the split have already told you which side to hunt. This section is what you are hunting for, in the order you will actually find it in this market.

Crushed and kinked flex. The number one find. Flex duct holds its rated airflow only when it is pulled tight, supported every few feet, and curved gently (C12). The failure modes: crushed where weight sat on it or a knee landed on it, kinked at sharp turns, sagged into a low spot between supports so it droops like a hammock and the liner accordions, and pinched where it squeezes through framing. A flex run crushed to half its diameter is catastrophically worse than half a duct, because pressure drop scales brutally as diameter shrinks. From six feet away in a dark attic it can look fine. Put a light down the run and your hand on it.

Closed and partially closed dampers. Manual balancing dampers live in takeoffs and branch runs, and their handles get bumped by storage, pest crews, cable installers, and gravity. A damper handle perpendicular to the duct is closed. Registers count too: homeowners shut registers in unused rooms to "save energy," and enough closed registers strangle the supply side and freeze coils. Check every accessible damper handle and every register before condemning hardware.

Undersized and blocked returns. The C12 Phoenix signature: one small return grille feeding a large system. You cannot resize a return in a diagnostic visit, but you can measure it (Port A tells you exactly what the return path costs), document it, and fix the blockable part: furniture against the grille, a filter jammed crooked into a too-small rack, a closed bedroom door with no return path. Adding return capacity is real work scoped per M38.

Disconnected and leaking runs. A supply run pulled off its takeoff dumps conditioned air into the attic, and the symptom pattern is sneaky: one room gets nothing, static may actually read slightly LOW on the supply side (air escaping is less resistance), and the attic near the disconnect is mysteriously comfortable. Walk the duct, look for the blowing insulation, feel for the breeze. Duct sealing and repair beyond reconnection gets scoped honestly, not patched with cloth duct tape that will be dead by August.

The boundary line for this module: you find, document, and fix restrictions on the system as built. Deciding what the duct system SHOULD have been, friction rates, effective lengths, and Manual D sizing, is M38 territory. When the map proves the ducts were never adequate (both sides chronically over budget with nothing crushed or closed), the honest verdict is "this duct system needs evaluation," with your static map attached as the evidence that starts that conversation.

PHOENIX FIELD NOTE

Treat every Phoenix attic crawl as a duct inspection you are already being paid for. The flex up there bakes at 140 to 160 F every summer, and heat-aged flex crushes easier, kinks sharper, and recovers never. The standard finds, in order: runs crushed by stored belongings near the hatch, kinks where short runs make hard turns off the plenum, liner separation in pre-2000 flex, and returns undersized from the day the builder installed them. Thirty seconds with a flashlight on every visit catches what gauges never will, and in this market the attic is guilty until proven innocent.

Filter loading: the fastest-moving number in the system

Quick recall from C12, because in diagnostics the filter is always suspect number one: every filter has a clean pressure drop set by its design (the ladder: fiberglass around 0.05 to 0.08, MERV 8 pleat 0.15 to 0.20, MERV 11 pleat 0.20 to 0.28, MERV 13 pleat 0.25 to 0.35 clean in a 1 inch rack, deep media 0.10 to 0.20), and dirt can double or triple that number. The filter is also the one component of TESP that changes without anyone telling you, which is why a system that measured healthy in March can be starved in August with no repair history in between.

What D25 adds to the C12 picture is the measurement: Port B minus Port A is the filter's actual, current cost, in numbers, while the system runs. No more squinting at a pleat deciding if it is "dirty enough." A filter spending 0.30 against a 0.10 budget is condemned by arithmetic. This is also how you catch the subtle case: a filter that LOOKS acceptable but is over-restrictive by design for this rack, the 1 inch MERV 13 trap, spending most of the budget the day it was installed.

PHOENIX FIELD NOTE

Phoenix dust loading runs on its own calendar. A filter rated for 90 days lasts 3 to 4 weeks in haboob season, and one good monsoon dust storm can visibly load a filter overnight. When mapping static between June and September, ask when the filter went in and what the sky has done since. A perfect static map taken the week after a filter change can be a strangled system five weeks later, which is exactly why the IB standard is a static reading on EVERY visit: the trend line catches what a single reading cannot.

PSC versus ECM under high static: two failure stories

C12 introduced the three blower personalities. Diagnostics cares about how each one fails when static climbs, because the same duct disease produces opposite symptoms on the two motor families.

PSC under high static: the loud failure. A PSC motor has no feedback. Static climbs, airflow droops hard, and every symptom downstream of low airflow arrives quickly: long runtimes, high temperature splits, low suction, frozen coils. The system FEELS broken, the customer calls, and the fault is findable because it is symptomatic. Diagnostically, PSC systems are honest: measure static, read the fan table, the droop is right there.

Constant airflow ECM under high static: the quiet failure. The motor is programmed to deliver target CFM and will spend whatever watts it takes, up to its limit, commonly somewhere around 0.8 to 1.0 in WC. Against a restriction it ramps RPM, draws more current, runs hotter, and delivers the programmed airflow anyway. The house feels fine. The temperature split checks out. Airflow measurements look healthy. Meanwhile the motor is running flat out against a duct system that should have been fixed years ago, and the failure arrives later as a dead motor module, thermal cutouts on brutal afternoons, or a motor that drops out of its target and lets the coil freeze on the hottest week of the year. The customer history reads "replaced blower motor twice in five years," and nobody ever measured the static that was killing them.

Diagnostic consequences, worth memorizing as a pair: on PSC systems, low airflow is the symptom you chase. On constant airflow ECM systems, high static and high watt draw are the symptoms, because the airflow will not tell on the ducts until the motor is already dying. When an ECM system shows a motor failure history, map the static BEFORE installing the replacement motor, because a new module installed against the same 1.0 in WC is a warranty claim with a countdown timer. And when a constant airflow ECM is tripping or cycling on protection during peak heat, treat it as a static problem until the map proves otherwise.

A note on the middle child: constant torque ECMs droop less than PSC but they do droop, and they do not report watts to you conveniently. Treat them like efficient PSCs diagnostically: static plus fan table.

Estimating CFM: the recall and the verdict scale

Every verdict in this module ends in CFM per ton, so the three C12 methods stay in the toolkit, each with its diagnostic role:

Static plus fan table is the daily driver on PSC and constant torque motors: measured TESP into the manufacturer's blower table at the verified speed setting, interpolate, divide by tonnage. Its blind spots are the dirty wheel (the table assumes a clean one) and constant airflow ECMs (airflow is programmed, not static-dependent, so on those the table logic inverts and static tells you how hard the motor works instead).

Temperature rise is the cross-check that trusts no fan table and no wheel: on a gas furnace, CFM = output divided by (1.08 x measured rise), output being input times efficiency. It is heating-only, but it is the method that catches the dirty wheel lying to the fan table, and when Methods 1 and 2 disagree badly, that disagreement IS a finding: something (usually the wheel, the speed setting, or the nameplate assumption) is wrong, and you find out which.

Anemometer comparisons never produce totals (plus or minus 20 percent at registers, per C12), but they answer the duct-hunting questions the other methods cannot: which branch went dead, which room collapsed versus last visit, what changed at this register after the damper was opened. In a restriction hunt, a quick register-by-register sweep often localizes a supply-side fault to one branch in five minutes.

The verdict scale never changes: 400 CFM per ton is the anchor, 350 is the floor, dry-climate setups lean toward 450. Below the floor, the system cannot be judged on refrigerant and the restriction hunt is the job. That sentence is the bridge to everything D24 taught and the next section makes it permanent.

The chain: what ignored airflow actually costs

Failure pattern 3 is not "the house is warm." It is a chain, and every link is something you have now measured:

1. **A restriction forms.** A filter loads, a flex run gets crushed, a coil mats over, a wheel goes bald. Silent, gradual, invisible from the thermostat.
2. **CFM falls.** PSC and constant torque systems droop. Constant airflow ECMs hide it and start burning themselves instead.

3. **Capacity falls with it.** The F3 formula runs the math: BTU/h = 1.08 x CFM x split. Less air, less delivered cooling, longer runtimes, higher bills, a system that "runs all day and never catches up" in July.
4. **The gauges start lying.** Less heat reaches the coil, suction falls, and the system impersonates low charge: the D24 triangle. Subcooling stays healthy, but only the tech who checks it knows.
5. **The wrong tech adds refrigerant.** Now the system is overcharged AND starved. The complaint survives, plus a new problem that someone will later "fix" by removing refrigerant, and the actual restriction is still there.
6. **The coil freezes.** Slow air over a too-cold coil ices, ice blocks more air, more ice forms. The customer reports warm air and a frozen line.
7. **The compressor pays.** Ice melts into floodback, liquid refrigerant slugs toward a compressor designed for vapor, oil washes out, and on the worst calls the suction pressure has spent weeks below the Copeland 55 psig cooling floor. Compressors condemned for "age" die of airflow more often than anyone writes down.

Break the chain at link 1 or 2 and it costs a filter, a cleaning, or a flex repair. Break it at link 7 and it costs a compressor, and somewhere in the job history there is a static reading that was never taken. That is failure pattern 3, and the four-port map is how it dies: every "low charge" complaint gets its airflow proven first, every restriction gets found by number, and every fix gets an after-reading. The two minutes of measuring you learned in C12, plus the ten minutes of mapping you learned here, is the cheapest compressor warranty in the trade.

> **IB STANDARD**
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> No refrigerant-side repair gets recommended on any system whose airflow has not been verified that visit, and no airflow repair closes without an after-measurement proving the CFM recovered. Both rules exist because of link 5 and link 7 in this chain, and both are checked in callbacks review.

Common Mistakes

1. **Stopping at TESP.** "Static is high" is a symptom, not a finding. The cost: parts-cannon repairs on the wrong component while the real restriction stays. Map the components; let the budget convict.
2. **Treating low static as good news without checking airflow.** Low TESP with low airflow is a blower wheel or speed problem hiding behind a "healthy" number. The fan table also lies here, because it assumes a clean wheel. Cross-check with temperature rise or the split.
3. **Condemning a coil on one reading.** A high coil drop alone can be a measurement issue, and a starved system can mask a dirty coil's drop. Two independent lines of evidence to clean, three to pull. Anything less is guessing with expensive consequences.
4. **Forgetting that pressure drops rise with airflow.** Fixing a restriction raises everyone else's numbers, and a tech who expects TESP to fall to 0.5 declares the repair a failure when it lands at 0.68. The proof of a fix is the CFM, not the TESP.
5. **Reading the fan table at an assumed blower setting.** Wrong speed tap or dip switch means every CFM number downstream is fiction. Physically verify the active setting, every time, on every map.

6. **Trusting comfort on a constant airflow ECM.** The house feels fine because the motor is paying the duct system's debt in watts and heat. Static and watt draw are the truth. Replacing a dead ECM module without mapping static installs the next failure.
7. **Walking past the attic.** In this market the duct evidence is overhead and free to look at. A tech who maps static perfectly but never puts a flashlight on the flex misses the crushed run that explains the whole map.
8. **Fixing it and leaving without re-measuring.** A repair without an after-number is a story, not a diagnosis. It also poisons the equipment's static history, because the next tech cannot tell what your repair actually changed.

What Is Next

D26 takes the last link of the chain, the compressor, and teaches you to test it properly so that compressors killed by airflow stop getting condemned as mysteries and healthy ones stop getting replaced. D27 sends you hunting leaks with the same evidence-stacking discipline you used on the dirty coil. And when you reach M38, the question flips from "what is wrong with these ducts" to "what should these ducts have been," with Manual D, friction rates, and retrofit design. Your static maps from the field are the raw material that module builds on.

DARREL FIELD WISDOM (to be recorded)

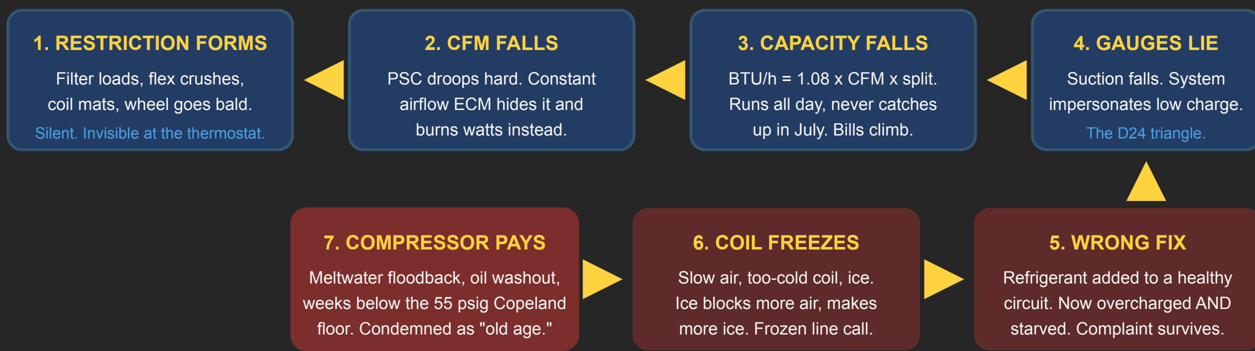
1. Walk us through the worst duct sin you have ever found in a Phoenix attic: what the static numbers said before you went up, what you actually found, and what the homeowner had been told by other companies before you.
2. Out of all the "system is low on charge" calls you have run over the years, how many turned out to be airflow when you actually measured? Tell the story of the one that taught you to check air first.
3. How do you decide a dirty blower wheel is worth pulling on a busy summer day when the system is technically still cooling? What does the customer conversation sound like?
4. Monsoon season: how fast have you actually seen a filter and a coil load up after a big dust storm, and what does that do to your maintenance route in August?
5. Tell the story of a compressor you condemned, or almost condemned, that turned out to be an airflow kill. What would the static map have shown if someone had drawn it a year earlier?

Module Visuals

AIRFLOW SYMPTOM CHAIN

D25: The Airflow Symptom Chain

Failure pattern 3: every link is measurable, and the last one costs a compressor



BREAK THE CHAIN EARLY

Broken at link 1 or 2: costs a filter, a wheel cleaning, or a flex repair.
Broken at link 7: costs a compressor, and the job history is missing a static reading.

The discriminator at link 4: low suction with NORMAL subcooling = air problem, not charge.
Temperature split above 22 F tells the same story from the air side.

RULE 1

No refrigerant repair on a system whose airflow was not verified that visit.

Kills link 5.

RULE 2

No airflow repair closes without an after-reading proving the CFM recovered.

Kills the repeat visit.

BLOWER FAULT TREE

D25: The Blower Fault Tree

Static AND airflow together. Either number alone can lie.

Measure TESP + verify airflow
fan table / temp rise / split evidence

HIGH TESP + LOW CFM
RESTRICTION

Next move: the four-port map

- Filter drop = B minus A
- Coil drop = C minus D vs published
- Return path = A, supply path = D
- **Double its budget = the restriction**

LOW TESP + LOW CFM
BLOWER PROBLEM

Next move: open the blower door

- Dirty wheel: dust-cupped blades lose up to 20 to 30 percent of CFM
- Wrong speed tap or dip switch (verify!)
- Weak PSC run capacitor (D23 test)

NORMAL TESP + NORMAL CFM
AIR SIDE HEALTHY

Next move: back to D24

Airflow corner of the triangle is cleared. Judge charge and metering device with superheat, subcooling, pressures, amps, all read together.

WARNING: a dirty wheel makes the fan table lie

Fan tables assume a clean wheel. In the low-low branch, verify airflow by temperature rise or split evidence, then put a flashlight on the blade cups.

Same ducts, opposite symptoms

PSC: droops, freezes, LOUD failure
ECM: holds CFM, eats watts, QUIET death

THE CONSTANT AIRFLOW ECM BRANCH: airflow looks fine, watts tell the truth

Programmed CFM held by ramping RPM against static, up to about 0.8 to 1.0 in WC. House feels fine, motor runs hot, trips on brutal afternoons, dies young. Repeat motor failures = map the static FIRST.

A new ECM module installed against the same 1.0 in WC is the next failure on a countdown.

DIRTY COIL DETECTION

D25: Convicting a Dirty Coil Without Pulling It

Independent lines of evidence that agree. Two to clean, three to pull.

1 COIL DROP vs PUBLISHED

Map ports C and D bracket the coil.
Published wet drop: typically 0.20 to 0.30 in WC.

Measured 0.45 vs published 0.25 = guilty

Caveat: a starved system reads low. Clear easy restrictions first, then judge the coil.

2 TEMPERATURE SPLIT

Healthy cooling split: 18 to 22 F (C12).

Split above 22 F = air too slow over the coil

With the filter verified clean and the blower healthy, a high split points at coil or ducts.

3 SUCTION + SUBCOOLING (D24)

Blanketed coil receives less heat: suction falls, gauges impersonate low charge.

Low suction + NORMAL subcooling = air problem

Low charge drops subcooling. Low airflow does not.
That one reading splits the misdiagnosis triangle.

4 EYES ON THE ENTERING FACE

Dirt mats on the AIR-ENTERING face: the underside on an upflow system. The top can look clean.

Paths: blower compartment + mirror, TXV or coil access panel, borescope. No coil pull needed.

Bonus sign: slimed or blocked condensate pan.

THE VERDICT RULE

2 lines of evidence: recommend cleaning. 3 lines: pull-and-clean.

One reading alone is a guess. Stack evidence like D22 taught you.

DUCT RESTRICTION HUNT

D25: The Duct Restriction Hunt

The TESP split picks the side. The walk finds the fault.

READ THE TESP SPLIT

Which side of the blower dominates?

RETURN-HEAVY: hunt the suction side

1. **Filter** loaded, over-restrictive, or jammed crooked
2. **Undersized return** one small grille, big system
3. **Blocked grille** furniture, rugs, closed bedroom doors
4. **Crushed return flex** storage, knee strikes, kinks

Port A splits filter from return path in one reading:
filter = B minus A, return path = A alone.

Return faults strangle the WHOLE system (C12).

SUPPLY-HEAVY: hunt the pressure side

1. **Dirty coil** confirm with the evidence stack
2. **Crushed or kinked supply flex**
3. **Closed dampers** handle perpendicular = closed
4. **Shut registers** "saving energy" until the coil freezes

Port D splits coil from supply duct in one reading:
coil = C minus D, supply path = D alone.

Anemometer sweep localizes a dead branch fast.

BOTH SIDES HIGH, nothing crushed?

Ducts may never have been adequate. Document the map, fix the fixable, scope duct evaluation (M38).

DISCONNECTED RUN: the sneaky one

One dead room, supply static slightly LOW, attic oddly comfortable. Walk the duct, find the breeze.

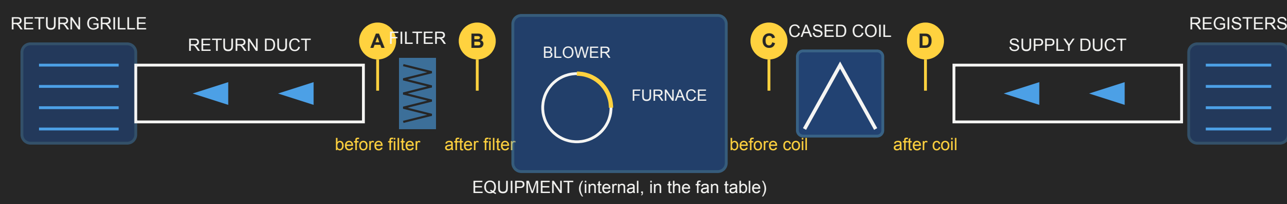
PHOENIX REALITY: attic flex bakes at 140 to 160 F and crushed flex stays crushed

Standard finds: runs crushed by storage near the hatch, kinks at hard turns off the plenum, heat-aged liner collapse, returns undersized since the builder. The attic is guilty until proven innocent.

STATIC PRESSURE DIAGNOSTIC MAP

D25: The Four-Port Static Map

Two ports tell you THAT. Four ports tell you WHERE.



The arithmetic (magnitudes, signs dropped)

RETURN PATH	FILTER	COIL (wet)	SUPPLY PATH
= Port A	= B minus A	= C minus D	= Port D
budget about 0.10	budget about 0.10	vs published, 0.20 to 0.30	budget about 0.10

Worked example: 4 ton system, TESP 0.90 in WC (B 0.48 + C 0.42)

Return 0.36	Filter 0.12	Coil 0.24	Supply 0.18
3.6x budget: GUILTY	fair for its rating	published 0.22: clean	elevated, not the story

Check: 0.36 + 0.12 + 0.24 + 0.18 = 0.90. The map must add back to the TESP.

The component spending double its budget is the restriction.

Coil inside the rated cabinet (air handler)? Then the coil is internal: three ports, no Port C.