ISLAND BREEZE TECHNICIAN CERTIFICATION PROGRAM

Leak Detection Mastery

MODULE D27 | DIAGNOSTICS | PREREQ D24

A homeowner in Surprise gets a pound of R-410A added every May. First year, the tech checks superheat and subcooling, calls it low, and tops it off. Second year, same story, different tech, another pound. Third May the system limps into a 113 F afternoon, the compressor cuts out on thermal overload, and the family sleeps in a hotel. When somebody finally puts a detector on the evaporator coil, it screams at the first hairpin bend: formicary corrosion has been chewing tunnels through the copper for years, and three pounds of refrigerant went into the sky while two techs treated the symptom and billed for it. Both techs correctly confirmed low charge. They just stopped one step short of the actual question: where is it going?

D24 taught you to prove a system is truly low on charge instead of blaming the charge for what airflow or a TXV did. This module is what happens the moment that proof lands. Refrigerant does not evaporate into nothing and does not wear out; a confirmed low charge means a hole, and your job is to find it, prove it, and make a repair-or-replace call you can defend. You will learn the four tools of the hunt and the strict order they run in, why 80 percent of the leaks you will chase live in one component, why formicary corrosion kills coils young, and the one test that ends every argument: nitrogen, a gauge, a thermometer, and time.

Short Version

A confirmed low charge from D24 means the system has a hole, and a leak search before recharge is required, not optional. The hunt runs in a fixed order: locate with an electronic detector (heated diode or infrared, swept slow and low because refrigerant sinks), confirm the exact spot with bubble solution, then prove the verdict with a nitrogen standing pressure test: pressurize, record pressure and temperature, wait, and temperature-correct the final reading before calling it, because nitrogen pressure moves about 1 psi for every 3 F at typical test pressures. UV dye has a narrow lane and is the wrong answer more often than the truck stock suggests. Know where leaks live: 80 percent are in the A-coil, led by formicary corrosion, with braze joints, rub-outs, Schrader cores, and flare connections covering most of the rest. A found leak forces the repair-or-replace question, and on aging R-410A equipment that question now includes the A2L transition. EPA leak rate thresholds (30 percent industrial process, 20 percent commercial refrigeration, 10 percent comfort cooling) apply to appliances holding 50 lb or more, which makes them mostly a commercial rule; the old 35/15 numbers are pre-2019 legacy.

Key Values

ITEM	VALUE	WHY IT MATTERS
Where leaks live	80 percent of refrigerant leaks found in the A-coil (NIST TN 1648 plus a 242-call field dataset)	The statistic writes your search order. The evaporator coil is always stop one.

ITEM	VALUE	WHY IT MATTERS
Detector sensitivity class	0.1 oz per year or better, both heated diode and infrared	Sensitive enough to find a leak that takes years to empty a system. Trust the tool, control the conditions.
Sweep speed	1 to 2 inches per second, probe tip within 1/4 inch of the surface	Faster than this and the probe passes through the leak plume before the sensor responds.
Where to sweep on a joint	The underside	Refrigerant is heavier than air and falls. A leak on top of a pipe is found below the pipe.
Nitrogen standing test pressure	150 to 200 psig, never above the nameplate low-side test pressure rating	High enough to force a weep into showing itself, low enough to never stress the equipment.
Standing test duration	30 minutes minimum for a repair verification; overnight for a suspected slow weeper	Time is the test. A pinhole that loses an ounce a month needs hours to move a gauge.
Temperature correction	Expected P2 = (P1 + 14.7) x (T2 + 460) / (T1 + 460), minus 14.7. Rule of thumb: about 1 psi per 3 F at 150 psig	Nitrogen pressure tracks absolute temperature. An uncorrected morning reading fails tight systems and passes leakers.
Worked correction example	150 psig at 95 F reads 144 psig at 75 F: corrected expectation is 144.1 psig, system is TIGHT	The 6 psi "loss" was temperature, not a leak. Run the arithmetic before the verdict, every time.
Pressurizing gas	Dry nitrogen through a regulator, NEVER oxygen or compressed air	Oxygen or compressed air meeting refrigerant oil under pressure can detonate.
EPA leak rate thresholds (current)	30 percent industrial process refrigeration, 20 percent commercial refrigeration, 10 percent comfort cooling, annualized, for appliances holding 50 lb or more	The formal repair-trigger rule. Residential splits at 6 to 13 lb sit far below 50 lb, so this is mostly a commercial rule.
Legacy leak rates	35 percent (commercial and IPR) and 15 percent (comfort cooling)	Pre-2019 values. If you see them on an old exam or an old poster, flag them as history.
Typical residential split charge	6 to 13 lb	Below the 50 lb rule, but leak search before recharge is still required practice on every confirmed-low system.
A2L transition dates	New residential split manufacturing with R-410A stopped 1/1/2025; install cutoff 1/1/2026	The dates that make repair-or-replace on an old R-410A system a whole-system

ITEM	VALUE	WHY IT MATTERS
		conversation. Details in A31.

Field Checklist

- [ ] D24 confirmation in hand: low charge proven by superheat, subcooling, and pressures together, airflow and metering ruled out
- [ ] Detector matched to the refrigerant: standard HFC detector for R-410A, A2L-capable detector for R-454B or R-32 (per A31)
- [ ] Detector warmed up, zeroed in clean air AWAY from the equipment, fresh sensor or calibration check done
- [ ] Search order stated before starting: A-coil first, then service valves and Schrader cores, then line set ends and braze joints, then condenser coil
- [ ] Sweep slow and low: 1 to 2 inches per second, tip within 1/4 inch, underside of every joint
- [ ] Wind managed outdoors: body and equipment panels as windbreaks, or the search moved to the calm part of the day
- [ ] Every detector hit confirmed with bubble solution before it is called a leak
- [ ] Leak location photographed before any repair
- [ ] Repair path decided with the repair-or-replace logic, not by reflex
- [ ] After repair or on any ambiguous hunt: nitrogen standing pressure test, pressure AND temperature recorded at start and end
- [ ] Final reading temperature-corrected before the verdict is called
- [ ] Recovery and evacuation run per C15, brazing per C16, before recharge

> **IB STANDARD**
> No recharge without a leak search, on any system, ever. A confirmed low charge gets a documented hunt: the leak location photo (or the passing standing-test photo with start and end pressures and temperatures legible) goes into the 8-photo ServiceTitan close-out, and the job record states the method used, the location found, and the repair made. "Topped off, monitoring" is not a diagnosis and it is not an IB ticket.

Full Breakdown

Leak detection starts where D24 ends

Recall the D24 discipline in one sentence: a low-charge call is only real when superheat, subcooling, pressures, temperatures, and amps all agree, with airflow and the metering device ruled out. That confirmation is the ticket of admission to this module; skipping it is how techs spend an afternoon leak-hunting a system whose only problem is a dirty blower wheel.

Once the confirmation is real, the logic is short and unforgiving. Refrigerant is not a consumable. A sealed system holds its charge for the life of the equipment, and a system that is low has a hole. The EPA's position matches the physics: a leak search is required before recharging a leaking system. Adding refrigerant without finding the leak is not a repair; it rents the customer a few months of cooling while the same pound migrates to the atmosphere, and on a big enough appliance it is also a regulatory violation with your name on the ticket.

There is one more reason the search matters that has nothing to do with rules. The refrigerant still in the system is your best search asset. A charged, leaking system is actively pumping trace gas out of its own hole, which is exactly what an electronic detector is built to smell. Hunt first, while the system can still talk. Recover later.

The three jobs: locate, confirm, prove

Every leak tool on the truck does exactly one of three jobs, and most field frustration comes from asking a tool to do a job it was never built for.

Locate means narrowing a whole system down to a component, a joint, a few inches of tubing. This is the electronic detector's job, and only the electronic detector's job. It is fast, sensitive, and approximately honest about location.

Confirm means turning "the detector sounded here" into "the leak is THIS joint, and I can see it." That is bubble solution. A detector hit that has not been bubbled is a suspicion, not a finding.

Prove means demonstrating, with recorded numbers, that a system is tight, or that it is not. That is the nitrogen standing pressure test, and nothing else on the truck can do it. Detectors and bubbles find leaks; only the standing test can prove their absence.

The order is fixed: locate, confirm, prove. Run them out of order and each tool gets worse. Bubbling an entire system blind wastes an hour. Pressurizing with nitrogen before the electronic search throws away your trace gas, because an electronic detector cannot smell nitrogen at all.

Electronic detectors: heated diode and infrared

Two sensor technologies dominate, and a tech should know which one is in their hand, because they fail differently.

A **heated diode** detector pulls air across a ceramic element hot enough to break apart halogenated refrigerant molecules. The freed halogen ions change a current the instrument measures, and the alarm follows. Heated diode sensors are extremely sensitive, in the 0.1 oz per year class and often better. The costs: the sensing element is a consumable that degrades over roughly a hundred hours of use and dies faster when it eats a big slug of refrigerant, oil mist, or moisture. A heated diode that just took a direct hit at a gross leak goes partially blind for minutes, and one that has lived a hard year in the truck may be quietly half-deaf. It will also alarm on things that are not refrigerant: some cleaning chemicals, some adhesives, anything halogenated drifting through the work area.

An **infrared** detector instead draws the air sample through an optical cell and measures how much infrared light the refrigerant absorbs. Sensitivity is in the same 0.1 oz per year class, but the sensor lives roughly ten times longer, recovers from a big hit in seconds instead of minutes, and is far less interested in chemicals that are not refrigerant. Infrared instruments meter the sample against a reference, so where a heated diode in a refrigerant-fogged closet screams continuously, an infrared unit can still point at the strongest source.

Either technology does the job when it is maintained, warmed up, and zeroed in clean air before the hunt. One boundary to respect: detection on A2L refrigerants (R-454B, R-32) requires an A2L-capable instrument, and the handling rules around an opened A2L circuit are their own discipline. A31 owns that material; this module's technique transfers, the tooling does not automatically.

The sweep technique

The detector is only as good as the hand moving it, and the physics of the plume sets the rules.

Refrigerant leaking from a hole does not jet out and announce itself; it seeps, mixes, and, because the common refrigerants are all heavier than air, it falls. The plume below a leak is denser than the plume beside it, and there is almost no plume above it. So the probe works the UNDERSIDE of every joint, fitting, and tube, and on a vertical surface you start high and work down, because a leak above you has been raining refrigerant on everything below it and the first hit walking upward is pooled gas, not the source.

Speed discipline: 1 to 2 inches per second, probe tip within 1/4 inch of the surface. The sensor needs dwell time in the plume; a probe waved at reading speed crosses a pinhole plume in a tenth of a second and the instrument never responds. When you get a hit, pull the probe away, let the instrument clear, and come back slowly from a different direction. The leak is at the point of strongest repeatable response, not at the point of first alarm.

Two conditions fool every detector ever made, and both are about air, not electronics. **Wind** dilutes and relocates the plume: outdoors at a condenser, a 5 mph breeze can carry the plume two feet downwind and hand you a confident hit on a joint that is perfectly tight. Block it with your body, a panel, or the open service door, or hunt the outdoor unit in the still part of the morning. **Pooling** is the opposite failure: in a dead-air space (cabinet bottom, condensate pan area, closet air handler), weeks of seepage accumulates into a fog and the detector alarms everywhere at once. The fix is patience: ventilate the space, let the pooled gas clear, and re-sweep. The pool drains away; the source keeps producing. The spot that lights the detector up again first is your leak.

The search order is statistical, not alphabetical, and the next sections explain why: evaporator coil first, then service valves and Schrader ports, then line set ends, braze joints, and contact points, then the condenser coil last.

Soap bubbles: the confirmation tool

Bubble solution is the oldest leak tool in the trade and it has exactly one modern job: confirmation. The detector says "somewhere in these six inches." The bubbles say "this joint, this side, right here," and they say it in a way you can photograph.

Use a commercial bubble solution rather than improvised dish soap; commercial mixes hold a film over a slow weep and foam into distinctive cauliflower clusters at a pinhole instead of sliding off the joint. Brush it generously on the suspect area and then do the hard part: wait. A gross leak bubbles instantly. A weeper that loses ounces a month can take two or three minutes to raise its first dome, and the tech who wipes the joint at thirty seconds just cleared the evidence. Watch the whole film, not just the center of your suspicion, and watch for the slow single bubble growing in place, the signature of a micro-leak.

What bubbles cannot do is search. Painting an entire system in solution and staring at it is slower than an electronic sweep, blind to leaks in places solution cannot cling, and useless on the hundreds of fin-buried tube inches inside a coil where you can see nothing. Locate first. Bubble second. Photograph third.

UV dye: the right tool less often than the truck stock suggests

UV dye rides along in the refrigerant and oil, escapes with them at the leak, and fluoresces under a UV lamp days or weeks later. That delay is the whole story: dye is a time-lapse tool in a trade that mostly needs answers today.

Where dye genuinely wins: the intermittent ghost leak that has defeated a competent electronic search, the system that only leaks under certain operating conditions (a joint that opens up only at full discharge pressure on a 110 F afternoon), and the multi-leak coil where you want a future tech to see every escape point at a glance. Inject the correct dose for the system's oil charge, run the system, and the next visit reads the evidence with the lamp.

The cautions are real. Dye is a contaminant by design: overdosing dilutes the oil, and any dye at all is forbidden under some manufacturers' warranty terms, so check before injecting. Dye in your hoses migrates into the next system you touch, and a system that glows from a previous tech's dye job hands you false finds forever: a glowing joint proves dye escaped there at some point, not that today's leak is there. And dye is flat-out wrong in three common situations: a system too low to run safely (dye needs runtime), a customer with no cooling who needs a fix today (dye needs days), and any hunt where the detector and bubbles have not been tried yet. Dye is the last resort that looks like a first move because it is easy. Resist it until it is actually the right call.

The nitrogen standing pressure test

Everything before this point finds leaks. The standing pressure test is the only method that can PROVE a verdict, in both directions: it proves a repaired system tight before you spend refrigerant on it, and it proves a "no leak found" system actually leaks when the electronic hunt came up dry. It is the gold standard because it removes the two weakest components from the measurement, the detector's sensor and the tech's optimism, leaving a sealed volume, a gauge, a thermometer, and time. That combination cannot be argued with.

The procedure, in full, because every step carries the verdict:

1. **Isolate and connect.** The refrigerant charge is recovered first (C15), or the section under test is isolated. Connect dry nitrogen through a regulator. Never oxygen, never compressed air: either one meeting refrigerant oil under pressure can detonate. This is the same nitrogen discipline C16 taught for brazing, with the same zero exceptions.
2. **Pressurize to 150 to 200 psig**, and never above the nameplate's low-side test pressure rating. The pressure has a job: a weep that hides at operating pressure gets forced into producing a findable flow. More is not better past the nameplate limit; the nameplate number is a ceiling, not a suggestion.
3. **Record the starting pressure AND the starting temperature**, on paper or in the job record, with the time. The temperature matters as much as the pressure, and the next section is why.
4. **Wait.** Thirty minutes minimum to verify a repair. Overnight for a suspected slow weeper the detector could not pin down. The arithmetic of small leaks is humbling: a leak that empties a 10 lb charge over two years moves about half an ounce a week, and a gauge needs real time to show that.

5. **Record the ending pressure and temperature**, temperature-correct the reading, and only then call the verdict. Corrected pressure held: tight. Corrected pressure fell: there is a hole, and now you bubble every joint at test pressure, where the leak is producing harder than it ever has, and find it.

One practical note on the silent partner: nitrogen has no halogens, so an electronic detector cannot smell it. Under a nitrogen-only test your location tools are bubbles and your ears (a serious leak at 150 psig produces an audible hiss in a quiet room). That is why the electronic search happens BEFORE recovery while trace refrigerant is still present, and the nitrogen test happens after, as proof.

Temperature correction: the arithmetic that saves a misdiagnosis

A fixed mass of nitrogen in a fixed volume obeys one rule: its absolute pressure tracks its absolute temperature. Heat the system and pressure rises with no leak anywhere. Cool it and pressure falls with the system perfectly tight. Every overnight standing test crosses a temperature swing, in Phoenix a big one, and the tech who ignores it will fail tight systems in the morning chill and pass leaking systems in the afternoon heat.

The correction uses absolute units: absolute pressure is gauge plus 14.7, absolute temperature is Fahrenheit plus 460. The expected ending pressure is:

Expected $P2 = (P1 + 14.7) \times (T2 + 460) / (T1 + 460)$, then subtract 14.7 to get back to gauge.

Worked example, the one to memorize: you pressurize to 150 psig at 95 F in the evening and come back to 144 psig at 75 F the next morning. Six psi gone, leak, right? Run it: $(150 + 14.7) \times (75 + 460) / (95 + 460) = 164.7 \times 535 / 555 = 158.8$ psia, minus 14.7 is 144.1 psig. The expected reading IS 144. The system lost six psi to a cool night, not a hole, and it is tight. Now reverse the trap: a system that reads the SAME 150 psig after warming 20 F overnight has lost the six psi that warming should have added, and it leaks, even though the gauge never moved.

The field rule of thumb with no calculator handy: at a 150 psig test, expect about 1 psi of change per 3 F of temperature change, in the same direction. Anything beyond that is a leak talking. Read the temperature where the bulk of the system volume sits, and use the same spot for both readings; a test that starts against attic metal and ends against a morning breeze is comparing two different thermometers.

IB STANDARD

A standing pressure test that was not written down did not happen. The job record gets four numbers minimum: starting psig, starting temperature, ending psig, ending temperature, with times, plus the corrected verdict stated in one line. The gauge photo at start and at end, with the thermometer readable in at least one frame, rides in the ServiceTitan close-out.

Where leaks live

A leak hunt without a map treats every inch of the system as equally suspect, and the data says the system is nothing like equal. The NIST TN 1648 fault analysis combined with a 242-service-call field dataset puts 80 percent of refrigerant leaks in the A-coil, the evaporator. Not the condenser baking outside, not the line set: the indoor coil. That number writes your search order: the detector goes to the evaporator first on every hunt, and a tech who starts anywhere else is searching the 20 percent by habit.

Inside the A-coil, the hit list in order: the hairpin U-bends at the ends of the slab, where manufacturing stress and vibration concentrate; the distributor and its capillary tubes, a cluster of small braze joints feeding the circuits; the suction header brazes; and the lower third of the coil generally, where condensate keeps the copper wet and the corrosion chemistry of the next section does its work. Sweep the condensate pan area too, but remember pooling: heavier-than-air refrigerant from a leak anywhere on the coil drains downhill and collects at the pan, so a pan hit means "leak above here somewhere," not "leak in the pan."

The other 20 percent, in rough field order:

Schrader cores. The spring-loaded valve cores in the service ports are the cheapest part in the system and one of the most common leakers: a grain of debris on the seat, a worn seal, a core left a quarter-turn loose after the last gauge-up. Always sweep the ports, and always check that the previous tech's caps are present and snug; a capped port with a good o-ring is the backup the core should never need but often does.

Braze joints. Every factory and field braze is a candidate, and field joints lead: a joint brazed without nitrogen flowing (C16) carries internal oxide scale and pinhole risk from the day it cooled. Voids and flux inclusions weep under vibration years later.

Rub-outs. Copper is soft, and a line set that touches anything (stucco, a joist edge, another tube, service-valve sheet metal) saws itself open over ten thousand hours of compressor vibration. The wear shows as a bright polished flat before it ever opens; finding rub THROUGH should make you look for rub STARTING everywhere else along the run.

Flare connections. Mechanical flare joints seal copper against brass by torque alone, and they loosen with thermal cycling and vibration. On ducted residential splits you meet them mostly at metering devices and accessories, but flares are the standard line set connection on mini-splits, which makes every mini-split tie-in a flare-leak candidate for life: a mini-split with confirmed low charge gets its four flare nuts swept and bubbled before anything else. Full mini-split coverage, including flare make-up and torque practice, lives in A35.

PHOENIX FIELD NOTE

Attic coils here live a harder life than the textbook imagines: 140 to 155 F attic air half the year, then monsoon humidity loading the coil with condensate for weeks, then bone-dry winter. That thermal cycling works every braze and hairpin, and the condensate-plus-dust paste that builds on the lower slab holds moisture against the copper exactly where formicary chemistry wants it. When you sweep an attic A-coil in August, give the detector a minute to acclimate to the heat, keep the sensor tip out of standing condensate, and budget your own body for the attic clock from F1.

PHOENIX FIELD NOTE

Out at the condenser, our sun is its own leak mechanism. UV cooks the line set insulation to powder in a few years on exposed runs, and bare suction copper then sweats, drips, and rubs in the clamp points while the unprotected vapor line bakes. A leak hunt that finds crumbled insulation should treat every clamp, penetration, and contact point on that run as a rub-out candidate, and the repair ticket should include UV-rated insulation so the next tech is not hunting the same run in three years.

Formicary corrosion: the coil killer

The 80 percent statistic has a chemistry engine behind it: formicary corrosion, from the Latin for ant nest, because that is what it looks like under a microscope: branching tunnels eating through the tube wall from the surface inward, an ant colony carved in copper.

The recipe takes four ingredients, all common: copper, oxygen, moisture, and an organic acid, either formic or acetic. The first three are simply what an evaporator coil IS: copper tube, air, and a permanent film of condensate. The fourth comes from the house. Formaldehyde off-gassing from particleboard, plywood, cabinetry, and carpet adhesives oxidizes into formic acid. Acetic acid comes from vinegar-based cleaners, curing silicone sealants, and some wood products. Household chemistry in general feeds the pool: cleaning sprays, air fresheners, paints, cosmetics, any volatile organic compounds that drift to the return, cross the coil, and dissolve into the condensate film. The coil sits in the home's entire airborne chemical diet, wet, 24 hours a day.

The attack is unlike ordinary corrosion in three ways that matter in the field. First, it is nearly invisible from outside: the surface pits are smaller than a human hair, no green crust, no obvious damage, just a coil that loses charge. Second, it tunnels rather than thins, so a wall 99 percent intact by weight can be perforated in a dozen places. Third, it is fast: formicary coils fail at 2 to 10 years old, routinely inside the equipment's expected life, which is why "the coil is only four years old, it cannot be leaking" is a sentence experience deletes from your vocabulary.

The field signatures: a confirmed slow leak on a young coil with no visible damage; detector hits spread across the slab instead of concentrated at one joint; a coil that holds a dry shop pressure test but leaks in service, because some tunnels open and close with thermal expansion; and repeat low-charge calls at the same address with a previous coil repair on record. The diagnostic implication changes your repair thinking: formicary corrosion is a condition of the whole coil, not a defect at one point. The pinhole you found is the tunnel that broke through first. More are coming. Patching one formicary pinhole on a corroded slab is soldering a screen door.

> **PHOENIX FIELD NOTE**
>
> Phoenix housing is a formicary greenhouse. Tight, energy-efficient construction holds VOC concentrations high, long cooling seasons keep the coil wet with condensate eight months a year, and new-build off-gassing (cabinets, flooring adhesive, paint) peaks in exactly the years the first coil is young. Expect formicary failures here on coils younger than the national pattern, expect clusters in newer subdivisions, and when a four-year-old coil in a two-year-old kitchen remodel comes up leaking, you already know the likely story before the detector is warm.

Repair or replace: thinking past the pinhole

A located, confirmed leak forces a decision, and the decision tree is technical. (What anything costs, and how options are presented to the customer, is deliberately outside this course's scope.)

Serviceable leaks get repaired. A loose or fouled Schrader core is a core replacement with the proper tool. A weeping flare gets remade: cut, re-flared, torqued to spec. An accessible braze joint or a rubbed-through line section gets repaired with the full C16 discipline, nitrogen flowing, then proven with the standing pressure test, then recovered, evacuated, and recharged per C15 and C17. These repairs restore the system to its design integrity and the system's age barely enters the decision.

Coil-body leaks force the bigger question. A leak in the evaporator slab itself, especially with formicary signatures, is not a joint problem, it is a component condition. The honest repair unit is the coil. And the moment the coil is the unit, the system's age and refrigerant enter the picture, because of the transition running through the industry right now: new residential split equipment using R-410A stopped being manufactured 1/1/2025, with installation of the remaining inventory cut off 1/1/2026. New equipment runs A2L refrigerants, A2L equipment is never retrofitted from or mixed with R-410A, and the rules for working on it are a separate discipline (A31 owns all of it).

So the technical decision factors for a leaking coil on an aging R-410A system stack up: system age against its expected life (12 to 15 years in this climate); whether matched R-410A coils remain available; the condition of the rest of the system, because a 13-year-old compressor inherits all the risk after a new coil goes in; whether the leak history suggests one event or a corroding coil whose replacement will live in the same VOC environment; and the long-term phasedown of the refrigerant supply itself. No single factor makes the call. Together they decide whether the right repair unit is the coil or the system, and your job as the diagnostic tech is to establish the facts so the decision is made on evidence: location, cause, extent, and proof.

What is never the right call, on any system of any age: adding refrigerant to a confirmed leaker without a search, a finding, and a decision. That is the Surprise story from the top of this module, and you now know everything wrong with it.

EPA leak rate thresholds

The formal federal machinery around leaking equipment applies to appliances holding 50 lb of refrigerant or more, and it works on the annualized leak rate: the percentage of the full charge an appliance loses per year, calculated when refrigerant is added. The current trigger thresholds, in force since 2019:

- **30 percent** annualized for industrial process refrigeration
- **20 percent** annualized for commercial refrigeration
- **10 percent** annualized for comfort cooling and all other appliances

Cross the threshold and the owner is into mandatory territory: repair within the required window, verification, and records. If you ever see **35 percent and 15 percent** on a chart, a practice exam, or a laminated card in an old service binder, those are the pre-2019 legacy values and they are wrong today; flag them, do not learn them.

The scope note that keeps this in perspective: a typical residential split holds 6 to 13 lb, nowhere near 50, so the leak-rate thresholds are mostly a commercial rule. You will meet covered appliances on light commercial and larger rooftop work, where the calculation, the clock, and the records are real obligations. On the residential side the law is thinner but the craft standard is not: leak search before recharge, every confirmed-low system, documented. The threshold rule tells you when the federal clock starts. It never tells you that a smaller leak is acceptable.

Common Mistakes

1. Recharging a confirmed-low system without a leak search. It treats the symptom, vents refrigerant on a schedule, and books the same failure for next season with your name on the previous ticket.
2. Starting the electronic sweep anywhere but the A-coil. Eighty percent of the leaks are in one component; a tech who starts at the condenser because it is easier to reach is searching the long odds first, every time.
3. Sweeping too fast, or over the top of joints. The plume is below the leak and the sensor needs dwell time. 1 to 2 inches per second, 1/4 inch off the surface, underside first, or the detector walks right past the hole.
4. Calling a detector hit a leak without bubble confirmation. Wind-blown plumes, pooled gas, and chemical false positives all sound exactly like leaks. The bubble cluster you can photograph is the finding; the beep is the hint.
5. Trusting an electronic detector in pooled, dead air. In a closet or cabinet bottom the whole space alarms. Ventilate, let the pool drain, re-sweep, and believe the spot that lights up first.
6. Reading a standing pressure test without temperature correction. An uncorrected overnight test fails tight systems on cool mornings and passes leakers on warm ones. Four numbers and one line of arithmetic, before any verdict, always.
7. Pressure testing with anything but dry nitrogen through a regulator. Oxygen or compressed air meeting refrigerant oil under pressure can detonate. There is no hurry that justifies it.
8. Patching one pinhole on a formicary coil and calling it repaired. Formicary corrosion is a whole-coil condition; the first tunnel through is a forecast, not the problem. Diagnose the coil, not the hole.
9. Reaching for UV dye first because it is easy. Dye needs runtime and days, contaminates oil and equipment, can collide with warranty terms, and answers next visit's question instead of today's. It is a specialist tool for ghosts, not an opening move.
10. Treating the old 35/15 leak-rate numbers as current, or applying the 50 lb rule's thresholds as permission below 50 lb. The current numbers are 30/20/10 for appliances at 50 lb and up, and below that line the standard is professional, not statistical: find the leak.

DARREL FIELD WISDOM (to be recorded)

1. What is the weirdest place you have ever found a leak, the one that broke your search pattern, and what did it teach you about where to look when the usual spots come up clean?
2. Walk through your detector history: what do you carry now, heated diode or infrared, what did you carry before, and what made you switch or stay? What is your warm-up and zeroing ritual before you trust it?
3. A homeowner says "the other company just adds a pound every spring, can you just do that?" Walk through how you explain what that pound is actually doing, where it is going, and what finding the leak changes for their equipment.
4. Tell the story of a formicary coil that fooled you or almost fooled you: how young was it, what did it look like, and what tipped you off that it was the coil and not a joint?
5. When a standing pressure test and your gut disagree, which one have you learned to trust, and what is the longest you have ever let nitrogen sit on a system before calling it tight?

Module Visuals

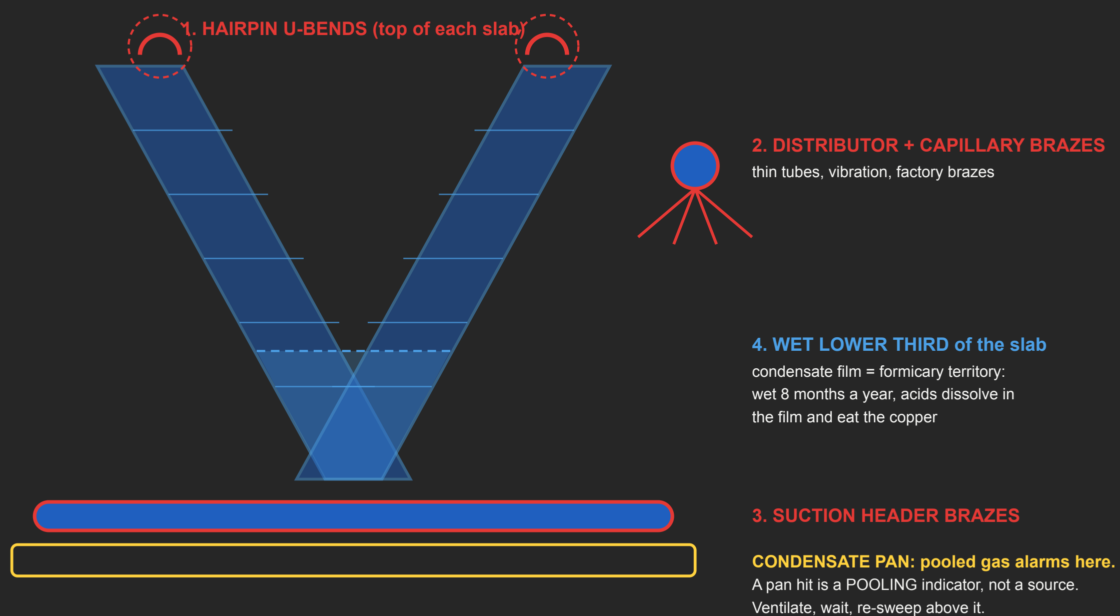
ACOIL LEAK ZONES

D27: Where Leaks Live, the A-Coil Map

The hunt has a map. Start where the leaks are, not where the access is easy.

80 PERCENT OF REFRIGERANT LEAKS: THE A-COIL

THE OTHER 20 PERCENT



Other 20: Schrader cores in service ports, field braze joints, rub-outs (copper vibrating against anything), and flare connections, the mini-split signature joint (full mini-split coverage in A35).

DETECTION METHODS MATRIX

D27: Leak Detection Methods, What Each Tool Is For

Every tool does exactly one job. Run them in order: LOCATE, then CONFIRM, then PROVE.

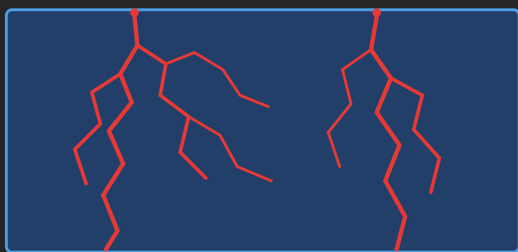
METHOD	WHERE IT WINS	WHERE IT FAILS	ITS ONE JOB
ELECTRONIC DETECTOR Heated diode: hyper-sensitive, consumable sensor, chemical false alarms. Infrared: long sensor life, fast recovery. Both: 0.1 oz/yr class	Narrowing a whole system to a joint or a few inches of tube, fast, while the charge is still in the system feeding it trace gas. Sweep 1 to 2 in/sec, tip within 1/4 inch, UNDERSIDE of joints.	Wind relocates the plume two feet downwind of the hole. Pooled gas in dead air alarms everywhere at once. Cannot smell nitrogen at all. A hit is a suspicion until it is bubbled. Never call a beep a leak.	LOCATE
SOAP BUBBLES Commercial solution, brushed generously on the suspect spot. Cheap, visual, photographable.	Turning a detector hit into a finding: THIS joint, THIS side. Pinpointing at nitrogen test pressure, when the detector is blind to the nitrogen.	Searching: painting a whole system is slow and blind inside fin packs. Impatience: a slow weeper needs 2 to 3 minutes to raise a dome. Wipe at 30 seconds = evidence gone.	CONFIRM
UV DYE Dye rides the oil, escapes at the leak, fluoresces under a UV lamp days or weeks later.	Ghost leaks that beat a good electronic search. Intermittent leaks that only open at certain pressures. Mapping a multi-leak coil for the record.	Needs runtime and DAYS. Wrong on a system too low to run, or a no-cool call that needs an answer today. Contaminates oil and tools. Old dye = false finds. Check warranty terms.	TIME-LAPSE last resort, not first
NITROGEN STANDING PRESSURE TEST Dry nitrogen, regulator, 150 to 200 psig, gauge, thermometer, and time.	The only PROOF in the toolbox, both directions: proves a repair tight before refrigerant goes in, proves a hidden leak exists when the electronic hunt came up dry. 30 min minimum; overnight for weepers.	Uncorrected readings: pressure moves about 1 psi per 3 F at 150 psig with no leak anywhere. Correct first. NEVER oxygen or compressed air: detonation risk against refrigerant oil. Never exceed nameplate rating.	PROVE

THE FIXED ORDER: locate with the detector while the charge is in, confirm with bubbles, prove with nitrogen.
Pressurize before the sweep and you throw away your trace gas: a detector cannot smell nitrogen.

D27: Formicary Corrosion, the Coil Killer

Ant-nest tunnels eaten through copper by household acids. Invisible outside, perforated inside.

COPPER TUBE WALL, CUTAWAY



Like an ant nest: one tiny entry, a maze inside, and it NEVER digs alone. Multiple colonies per coil.

THE FOUR-INGREDIENT RECIPE

COPPER
thin-wall coil tubing

OXYGEN
always present in air

MOISTURE
condensate film on a working coil

ORGANIC ACID
the ingredient the HOUSE supplies

WHERE THE ACID COMES FROM

FORMIC acid: formaldehyde off-gassing from particleboard, new cabinets, laminate flooring, and carpet adhesive

ACETIC acid: vinegar-based cleaners and curing silicone sealants

Also: paints, air fresheners, cosmetics, disinfectants

WHAT IT DOES

Pinholes too small to see, scattered across the slab. Coils fail YOUNG: 2 to 10 years, not 15.

Tunnels never come alone: fix one pinhole and the next one opens in weeks.

A formicary leak is a WHOLE-COIL CONDITION, not a point defect. The coil is the repair unit.

FIELD SIGNATURES

Young coil losing charge yearly. Detector hits the coil body, not a joint. Multiple weak hits across the slab.

Gray-green or blue-gray pitting under a loupe. New construction, remodel, or heavy cleaner use in the home.

NITROGEN STANDING PRESSURE

D27: Nitrogen Standing Pressure Test, the Gold Standard

Pressurize, record, wait, temperature-correct. Only then call the verdict.

1 PRESSURIZE

Dry nitrogen through a regulator. 150 to 200 psig, never above the nameplate test pressure rating.

NEVER oxygen or shop air.

2 RECORD

Starting pressure AND starting temperature, with the time. Bubble your own rig connections first.

A reading without a temp is half a number.

3 WAIT

30 minutes minimum to verify a repair. Overnight for a suspected slow weeper.

A half-ounce-a-week leak needs hours to move a gauge.

4 CORRECT

Record end pressure and end temperature. Run the correction math. THEN call tight or leaking.

Expected P2 = (P1 + 14.7) x (T2 + 460) / (T1 + 460), then subtract 14.7

Absolute pressure = gauge + 14.7 psi. Absolute temperature = Fahrenheit + 460.

Field rule of thumb at 150 psig: about 1 psi of change per 3 F of temperature change.

WORKED EXAMPLE: THE OVERNIGHT TRAP

Evening: 150 psig at 95 F. Morning: 144 psig at 75 F.
Six psi gone. Leak? Run it:

(150 + 14.7) x (75 + 460) / (95 + 460)
= 164.7 x 535 / 555 = 158.8 psia = 144.1 psig

Expected reading IS 144. Verdict: TIGHT.
The cool night took the six psi, not a hole.

THE REVERSE TRAP

Same system warms 20 F overnight and the gauge still reads exactly 150 psig in the afternoon.

Warming should have ADDED about 6 psi.
The pressure that warming should have created escaped through a hole instead.

Verdict: LEAKING, and the gauge never moved.

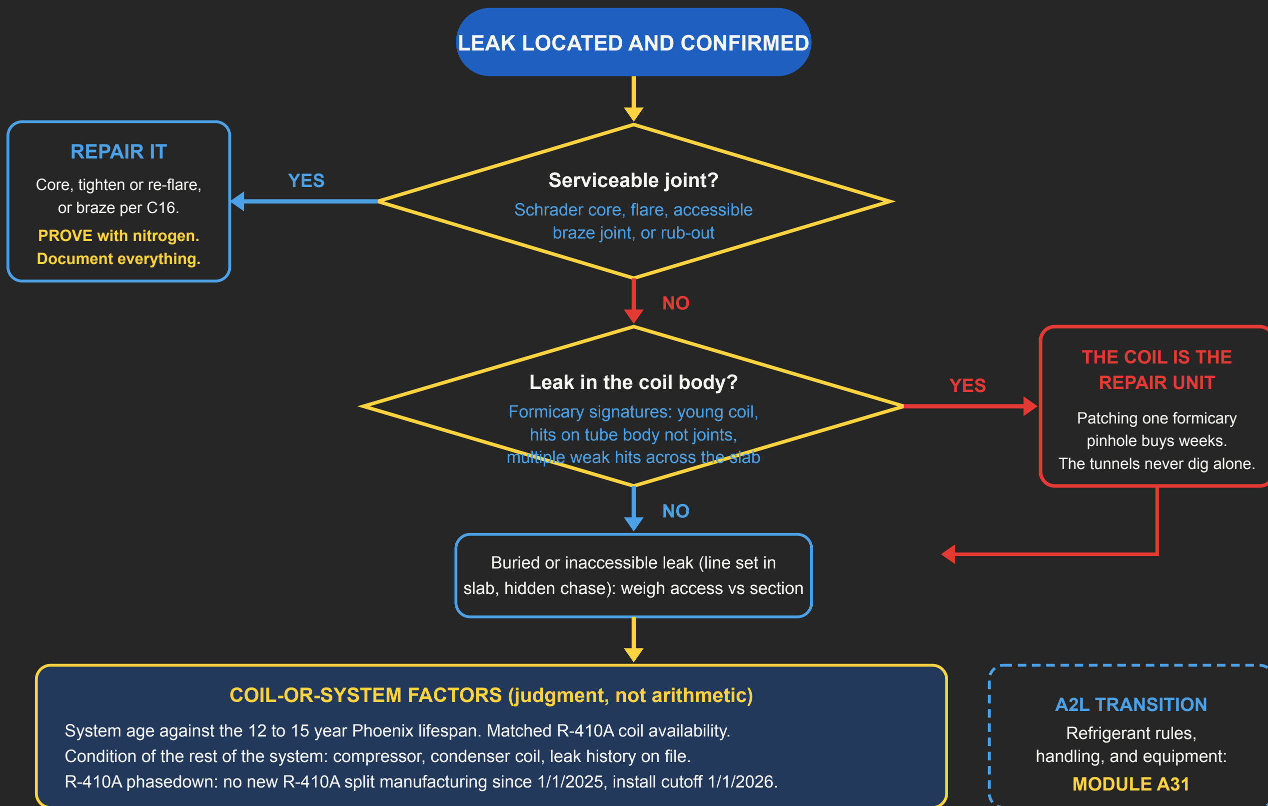
Job record minimum: start psig, start temp, end psig, end temp, times, and the corrected verdict in one line.

A standing test that was not written down did not happen.

REPAIR VS REPLACE FLOW

D27: Repair or Replace, Thinking Past the Pinhole

The leak location decides the repair unit. The system age decides the conversation.



Every path ends the same way: nitrogen proof before refrigerant, and the finding documented in the job record.