ISLAND BREEZE TECHNICIAN CERTIFICATION PROGRAM

Recovery, Evacuation, and Deep Vacuum

MODULE C15 | CORE SYSTEMS | PREREQ C14

A three-year-old condenser in Goodyear gets a new compressor under warranty. Fourteen months later the new compressor is dead too. The manufacturer pulls an oil sample, finds acid, and denies the second claim. The homeowner pays full price for compressor number three, and the company that did the first swap eats the reputation damage. What killed compressor number two was not bad luck and not a bad part. It was the twenty minutes the first tech skipped: he recovered the charge, brazed in the new compressor, pulled a vacuum until his gauge "looked good," and charged the system with moisture still inside it. Moisture plus the oil in that system made acid, and acid ate the motor windings from the inside, slowly, invisibly, on a schedule.

This module is the craft that prevents that story. In C14 you learned the legal framework: what recovery is, what the EPA requires, how cylinders are handled, and why venting is a federal violation. Now you do the work. You will learn the four ways to move refrigerant out and when each wins, how to run a clean recovery from nameplate to labeled cylinder, what a micron is, how to build a rig that reaches deep vacuum in reasonable time, and how to run the decay test that proves tight and dry before refrigerant goes back in. The decay test is the heart of this module, because it is the only moment in the entire job where the system itself tells you the truth.

Short Version

Recovery and evacuation are two different jobs that happen to use vacuum. Recovery pulls the charge into a cylinder so it is never vented: vapor, liquid, or push-pull, chosen by charge size and access, under every C14 cylinder rule. Evacuation comes after the repair: a vacuum pump pulls the sealed system so deep that air is gone and any water inside boils away at job-site temperature. Depth is measured in microns of absolute pressure; the atmosphere is 760,000 microns and the target is 500 or below. The rig matters as much as the pump: valve cores out, large vacuum-rated hoses, no charging manifold in the path, micron gauge on the system side, never on the pump. Reaching 500 proves nothing by itself. Isolate the pump and watch the shape: a small rise that levels off below 1,000 means tight and dry, a steady climb that never levels means a leak, a climb that plateaus means moisture still boiling. Wet systems get triple evacuation with nitrogen sweeps. Every opened system gets the 500-micron pull and decay test. No exceptions.

Key Values

ITEM	VALUE	WHY IT MATTERS
Atmospheric pressure in microns	760,000 microns (760 mm Hg)	The micron scale is absolute pressure. Atmosphere is the starting line, 500 is the finish line. That ratio is why your compound gauge is useless down here.

ITEM	VALUE	WHY IT MATTERS
IB evacuation target	500 microns or below on every opened system	Deep enough that water boils off at any job-site temperature and air is effectively gone.
IB decay test	Isolate the pump at 500 or below, watch 10 minutes minimum, reading must level off below 1,000 microns	Pulling to 500 proves the pump works. The decay test proves the system is tight and dry. Only the decay test counts.
Moisture decay signature	Climbs after isolation, then plateaus, commonly in the 1,500 to 2,500 micron range	Water still in the system boils until its vapor pressure is reached, then stops. The plateau is the fingerprint.
Leak decay signature	Steady, straight climb that never levels off	Air keeps entering forever. There is no plateau on a leak.
Water boiling threshold at room temperature	Roughly 20,000 microns	Below this, water in a 70s F system boils into vapor the pump can remove. At 500 microns, water boils far below freezing.
Recovery level, R-22 class system under 200 lb	0 in Hg (atmospheric)	The C14 table in action. Most residential work lands here.
Recovery level, high-pressure system 200 lb or more	10 in Hg for R-22 class, 15 in Hg for other high-pressure refrigerants, with machines built after November 15, 1993	The 200 lb threshold changes the required depth.
Passive (system-dependent) recovery limit	Appliances holding 15 lb or less	Above that, an active recovery machine is mandatory.
Recovery cylinder fill limit	80 percent of capacity, verified by weight on a scale	Liquid expands with temperature. An overfilled cylinder is hydraulic failure waiting for a hot truck.
Nitrogen sweep pressure, triple evacuation	2 to 5 psig dry nitrogen, hold 10 to 15 minutes per sweep	Enough to carry moisture, never enough to stress the system or waste nitrogen.
Vacuum hose standard	1/2 inch or larger inside diameter, vacuum rated, as short as practical	Flow through a hose under vacuum collapses as diameter shrinks. A 1/4 inch charging hose strangles a good pump.
Hermetic compressor under deep vacuum	Never energize	Thin gas cannot insulate the motor terminals. The windings arc and the compressor is destroyed.

Field Checklist

Recovery phase:

- [ ] Nameplate read, refrigerant identified, machine and cylinder match it (A2L work uses the A2L machine and left-hand-thread cylinders, per C14)
- [ ] Recovery cylinder on the scale, scale zeroed on a hard level surface, starting weight recorded
- [ ] Cylinder has capacity for this charge without passing 80 percent
- [ ] Machine inlet filter drier in place and within its service life
- [ ] Hoses purged or low-loss fittings used, no air pushed into the cylinder
- [ ] Method chosen and stated: vapor, liquid first then vapor, or push-pull
- [ ] Recovery taken to the C14 table level for this appliance and machine date
- [ ] Several-minute wait after reaching level, watching for pressure rebound from refrigerant boiling out of the oil
- [ ] Machine self-purged into the cylinder before disconnect
- [ ] Cylinder labeled, final weight recorded, pounds recovered logged

Evacuation phase:

- [ ] Pump oil clear and at the fill line, changed if anything else
- [ ] Both Schrader valve cores removed with core removal tools
- [ ] Large-diameter vacuum-rated hoses, shortest workable length, charging manifold out of the path
- [ ] Micron gauge on the system side, far from the pump, upright, verified against atmosphere
- [ ] Gas ballast open for the early pull, closed for the deep pull
- [ ] Pull to 500 microns or below
- [ ] Decay test: pump isolated, 10 minutes minimum on the clock, result read against the three signatures
- [ ] Wet system or failed moisture decay: triple evacuation with nitrogen sweeps, then the final 500 and decay again
- [ ] Result photographed for the job record

> **IB STANDARD**
>
> Every opened system gets a 500-micron evacuation with a passing decay test before recharge. Not the systems that look clean, not the quick repairs, every opened system. The decay test result is photographed with the micron gauge readable in frame and the photo goes into the 8-photo ServiceTitan close-out for the job. A vacuum that was not decay-tested and documented did not happen.

Full Breakdown

Recovery and evacuation are two different jobs

C14 gave you the legal definitions; here is the working distinction, because the EPA's own vocabulary blurs it. When the regulations say "evacuate the appliance," they mean recovery: pulling the refrigerant charge out to the required level so it is captured instead of vented. When a tech says "pull a vacuum," they mean dehydration: using a vacuum pump on an already-empty system to remove air and moisture before recharge. Recovery is about capturing refrigerant. Evacuation is about removing what is not refrigerant. Same fittings, same direction of pressure, completely different operations with different machines, different targets, and different ways to fail.

The order on a repair job is always the same: recover the charge, open the system and make the repair, pressure test with nitrogen (C16 covers brazing and pressure testing), evacuate to 500 microns, prove it with the decay test, then recharge. This module covers the first step and the last three.

The four recovery methods and when each wins

Every recovery moves refrigerant from the system into a recovery cylinder. The four methods differ in what does the pushing and what state the refrigerant is in when it moves.

Vapor recovery is the default. The recovery machine's inlet connects to the system (typically the suction port, or both ports through the manifold), the machine compresses the vapor, condenses it, and pushes liquid into the cylinder. As pressure in the system falls, liquid refrigerant left in the system boils to replace the vapor you remove, which is why vapor recovery gets slower and slower toward the end: the boiling refrigerant chills the system, and cold refrigerant makes less vapor pressure. Vapor recovery is the cleanest method, pulls the least oil out of the system, and is the right call for small charges, which on residential splits at 6 to 13 lb means most days.

Liquid recovery moves refrigerant as liquid directly through the machine. Connect to the liquid port, and the machine drinks liquid instead of vapor. It is much faster per pound because liquid is dense, and it drags system oil along with it, because oil dissolves in liquid refrigerant. That oil drag is a feature when the system had a compressor burnout and you want contaminated oil out, and a bookkeeping problem otherwise, because oil removed must be measured and replaced. Not every machine tolerates liquid; check the machine's rating, and feed liquid slowly enough that the machine does not slug. The standard play on a system with significant liquid is liquid first, then vapor to finish: remove liquid to speed recovery, then pull the vapor.

Push-pull is for big charges, as a working rule 15 lb of accessible liquid or more, meaning commercial equipment and large package units, not residential splits. The rigging is a loop: the machine's inlet connects to the cylinder's vapor port, its outlet to the system's vapor side. The machine PULLS vapor out of the cylinder and PUSHES it into the top of the system. That pressure difference shoves liquid refrigerant out of the system's liquid port through a third hose into the cylinder's liquid port. The refrigerant moving into the cylinder never passes through the machine at all; the machine is just a vapor pump creating the pressure difference. A sight glass in the liquid hose tells you when liquid stops flowing, and that is your signal to break the loop and finish with standard vapor recovery, because push-pull only moves liquid. Push-pull needs a real column of liquid to work: a system that cannot deliver solid liquid to the port, or a charge too small to sustain the loop, just churns vapor in a circle.

Passive recovery, also called system-dependent recovery, uses the system's own compressor or internal pressure to push the charge into a recovery container without a recovery machine. C14 covered the legal boundary and it bears repeating: passive recovery is only legal on appliances holding 15 lb of refrigerant or less. On split systems and package units, an active recovery machine is the law.

Choosing in the field takes five seconds once you know the logic: small charge, vapor. Meaningful liquid present and you want speed or the oil is contaminated, liquid first then vapor. Large charge with accessible liquid, push-pull then vapor. Tiny sealed appliance, passive is permitted.

Running the recovery: the C14 rules, now in motion

Knowing the cylinder rules and doing a clean recovery under a 110 F sun are different skills. Here is the sequence as it actually runs.

Read the nameplate first, every time. The nameplate refrigerant decides the machine, the cylinder, and the hoses. R-410A work uses the standard machine and recovery cylinders dedicated to R-410A. R-454B or R-32 work uses the A2L-rated machine, the flammable-rated cylinders with left-hand threads, and the dedicated A2L hose set, with the ventilation and ignition-source discipline from C14. If the pressures do not match the nameplate refrigerant's PT behavior, stop: a mixed charge goes to a dedicated mixed-recovery cylinder marked for destruction, never into your clean cylinder.

Set the cylinder on the scale before anything connects. Zero the scale on a hard, level surface, record the starting weight, and do the arithmetic now: cylinder water capacity, the 80 percent limit adjusted for the refrigerant you are recovering, minus what is already in the cylinder. If the expected charge does not fit, you need a second cylinder on the truck before you start, not a discovery at three-quarters through.

Connect with intention. Purge the air out of your hoses, or rely on properly maintained low-loss fittings, because every connection is a chance to push air into a cylinder, and air in the cylinder is a noncondensable. C14 taught the check: let the cylinder reach a steady temperature, compare its pressure to the PT chart value for that refrigerant, and a meaningfully high reading means the cylinder holds air and that refrigerant cannot be reused as-is.

Run the method you chose and watch two things: the scale, climbing toward your stop weight, and the machine, for signs of overheating. Take the system down to the C14 table level for the appliance: residential R-410A and R-22 class systems under 200 lb go to 0 in Hg, larger systems go to 10 or 15 in Hg depending on refrigerant class with post-November 15, 1993 machines, and a known leaky system stops at 0 psig so the system does not inhale air through its own leak.

Then wait. This is the step impatience deletes. Refrigerant dissolves in compressor oil, and after you reach the recovery level it boils back out of that oil slowly, raising system pressure again. Watch for several minutes. If pressure rebounds above the required level, recover again. Disconnect at first touch of the target and the refrigerant left in the oil becomes a venting violation when the system opens.

Finish clean: run the machine's self-purge cycle so the refrigerant inside the machine ends up in the cylinder instead of in the next system you touch, close everything, label the cylinder with refrigerant type, record the final weight, and log the pounds recovered.

IB STANDARD

Every recovery is logged in ServiceTitan on the job record: date, system, refrigerant type, and pounds recovered to 0.1 lb, plus the cylinder identification. The recovery cylinder log rides with the cylinder: date filled, refrigerant type, pounds, tech name, job ID. C14 told you incomplete cylinder logs are the most common EPA inspection finding; the fix is filling the log out at the truck before the cylinder goes back in the rack, not from memory on Friday.

PHOENIX FIELD NOTE

Recovery fights heat physics. The machine condenses vapor into the cylinder, and it can only condense if the cylinder is cooler than the machine's discharge. A recovery cylinder sitting in July sun climbs past 130 F, cylinder pressure soars, and recovery slows to nothing while the machine cooks. Shade the cylinder, wet a towel over it, or stand it in an ice-water bath on long pulls. If the machine thermal-overloads, it is not broken, it is hot: shade it, give it airflow, let it cool, restart. Plan recoveries for the morning when you can.

Why moisture is the enemy

Everything in this module's second half exists because of one chemical chain reaction.

Modern systems run POE oil (polyol ester, the synthetic oil R-410A and the A2Ls require). POE is hygroscopic, meaning it grabs water out of the air and holds it; an opened system with POE oil is actively drinking the humidity around it the entire time it sits open. When the system runs, that absorbed water meets heat at the compressor discharge, and water plus ester oil under heat runs a reaction called hydrolysis: the oil and water break each other down into acids.

The acids go to work on the system from the inside. They strip copper from the tubing and redeposit it on hot steel bearing surfaces, a failure called copper plating that tightens clearances until the compressor seizes. They attack the varnish insulation on the motor windings until the motor shorts. They react with oil to form sludge that plugs the metering device you learned about in C11. None of it is visible from outside, none of it shows on gauges until late, and all of it is permanent. The burnout arrives months later, on someone else's service call, with acid in the oil sample pointing straight back at the install or repair that let water in.

Liquid water does one more cheap trick: at the metering device, where refrigerant temperature can drop below 32 F, free water freezes. An ice crystal in an orifice intermittently chokes the system, producing flaky low-charge symptoms that come and go as the ice forms and melts. Techs have recovered, leak-searched, and recharged systems whose only problem was a droplet of water freezing in the valve.

Air left in a system is the lesser but real second enemy: it is a noncondensable, it stacks in the condenser raising head pressure and cutting capacity and efficiency, and the oxygen in it accelerates the acid chemistry. The filter drier you install at every repair catches residual moisture, and C14's rule stands: a drier polishes the last traces, it does not substitute for evacuation. Asked to absorb a sloppy evacuation, it saturates and quits.

Kill the water and the air before charging, and the whole chain never starts. That is evacuation's entire job.

What a micron is, and why the scale is so strange

Your compound gauge measures vacuum in inches of mercury, and its whole vacuum range, 0 to 30 in Hg, is one cramped arc of needle travel. The problem: the difference between a system at 29 in Hg and a system dry enough to charge is enormous, and the compound gauge cannot see it at all. Evacuation needed a finer unit, so the trade borrowed one from absolute pressure measurement.

A micron is one thousandth of a millimeter of mercury, measured up from perfect vacuum rather than down from atmospheric. Standard atmospheric pressure is 760 mm Hg, which makes the atmosphere 760,000 microns. A deep vacuum of 500 microns is 500 parts out of 760,000, about 0.07 percent of an atmosphere. That is the resolution evacuation demands: the last 0.1 percent of the air and all of the water live in territory your compound gauge displays as a single needle width. This is why the micron gauge from F2 exists, why it resolves single microns near the target, and why no evacuation is ever judged on a compound gauge.

The number 500 is not arbitrary. Water's boiling point depends on the pressure above it: 212 F at full atmosphere, and lower as pressure falls. Pull below roughly 20,000 microns and water boils at ordinary room temperature, turning to vapor the pump can carry away. Keep pulling to 500 and water boils at temperatures far below freezing, which means there is no job-site condition anywhere, from a 55 F crawlspace to a 115 F attic, where liquid water can keep hiding as liquid. At 500 microns with a holding decay test, the air is gone and the water has been boiled out and removed. That is the physical meaning of the standard.

One warning that belongs in your bones, recalled from C14 and repeated wherever vacuum is taught: never energize a hermetic compressor while the system is under deep vacuum. Gas at normal pressure insulates the motor terminals. Thin it to a few hundred microns and it stops insulating; the windings arc across the gap and the compressor is scrap in under a second. Evacuation is the one time the system is at its most electrically fragile. Pump down, decay test, break the vacuum with refrigerant charge, and only then run the machine.

Building the IB evacuation rig

A two-stage pump can reach 50 microns sitting on the truck shelf. Whether it can get a SYSTEM to 500 in a reasonable time is decided entirely by what you connect between the pump and the system. Vacuum flow is brutally unforgiving of restriction: at deep vacuum, the gas is so thin that flow through a small opening nearly stops, and every fitting in the path is a toll gate. The rig is the skill.

Valve cores come out. The Schrader valve core in each service port is the single worst restriction in the path, a pinhole the system must breathe through. The core removal tool (CRT) is a valved chamber that threads onto the port, extracts the core while holding the seal, and parks it: now the port is wide open to your hose, and the CRT's valve lets you isolate the system later without reinstalling the core under vacuum. One CRT on each service port, cores out, every evacuation. The CRT side port also gives you the proper home for the micron gauge.

Hoses are vacuum hoses. Standard 1/4 inch charging hoses strangle the pump and leak besides: their rubber walls and gasketed ends are built to hold pressure in, not vacuum out, and they seep and outgas at deep vacuum. The rig uses dedicated vacuum-rated hoses, 1/2 inch inside diameter or larger, as short as practical. The difference is not subtle. Moving from a 1/4 inch six-foot charging hose to a 1/2 inch three-foot vacuum hose can cut evacuation time by most of an hour on an average system.

The charging manifold gets bypassed. Your manifold is a refrigerant tool, not a vacuum tool: small internal bores, multiple hand-wheel seals, and gaskets at every port, each one a restriction and a potential seep. The vacuum path runs from the CRTs through vacuum hoses directly to the pump, or through a purpose-built vacuum manifold (a tee or tree with vacuum-rated seals). The charging manifold's job comes later, when refrigerant moves.

The micron gauge reads the system, not the pump. While the pump runs, there is a pressure gradient along the whole path: deepest vacuum at the pump's intake, shallowest inside the system where the moisture is. A gauge mounted at the pump reads the best number anywhere in the rig and tells you nothing about the equipment you are drying. Mount the gauge on the side port of the CRT farthest from the pump, so the vacuum must travel through the entire system to reach it. Mount it upright so pump oil mist cannot migrate into the sensor. When the gauge at the far CRT reads 500, the SYSTEM is at 500. When a gauge on the pump reads 500, the pump is at 500 and the system could be at 5,000.

The complete IB rig, then: core removal tools on both service ports with cores extracted, micron gauge upright on the far CRT's side port, large-bore vacuum hose from the near CRT (or both CRTs on bigger systems) running short and direct to the pump, charging manifold nowhere in the path.

> **PHOENIX FIELD NOTE**
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> Heat changes vacuum work in three ways, two friendly and one liar. Friendly: hot systems evacuate faster, because warm water boils off at a higher vapor pressure, and a 130 F attic coil gives up its moisture quicker than a 60 F one. Friendly: you will rarely fight the cold-coil stall that slows winter evacuations elsewhere. The liar: hose permeation. Rubber hose walls get more permeable as they heat, and at 115 F a charging hose in the vacuum path seeps air inward and outgasses plasticizer fast enough to put a floor under your vacuum or fake a leak-shaped rise during the decay test. In summer attics, vacuum-rated hoses are not a preference, they are the difference between a decay test you can read and one that lies. Keep the micron gauge head out of direct sun, and keep the pump in shade with airflow: pump oil thins as it overheats and the pump loses depth.

Pump care: oil and the gas ballast

The vacuum pump is the muscle, and its oil is the seal. Inside a rotary vane pump, a film of oil is what actually closes the gap between the spinning vanes and the housing; the pump can only pull as deep as that oil film is clean. Every system you evacuate sends its boiled-off moisture through the pump, and some of that moisture condenses into the oil. Wet oil turns milky, loses its sealing ability, and the pump's ultimate vacuum collapses. A pump with milky oil will run all afternoon, sound perfect, and never get the system below 1,500 microns, and the tech will hunt a leak that does not exist. F2 planted the rule and it stands: look at the sight glass before every evacuation, and change the oil if it is anything other than clear and at the line. On a wet job, change it mid-job without ceremony. Oil changes are the cheapest insurance in this trade.

The gas ballast is the small valve on the pump that most techs have never opened and should be using on every pull. Open, it bleeds a little dry air into the pump's second stage, which keeps the moisture passing through the pump hot enough to stay vapor and get exhausted instead of condensing into the oil. The cost is depth: with the ballast open the pump cannot reach its deepest vacuum. The technique is two-phase: ballast open for the early pull while the bulk of the moisture moves through the pump, closed for the deep pull to 500.

Early and wet, ballast open. Deep and dry, ballast closed. Your oil stays clear several times longer and the pump keeps its depth.

Two-stage pumps are the standard for the same reason they were in F2: the second stage pulls on the first stage's exhaust, reaching depths a single-stage pump cannot. Size the pump to the work, roughly 4 to 6 CFM for residential splits; bigger is not automatically better, because the hoses and ports, not the pump, are the bottleneck on small systems.

The IB 500-micron standard and the decay test

Here is the heart of the module. Reaching 500 microns proves your pump and rig work. It does not prove the system is tight, and it does not prove the system is dry, because the pump is actively winning an argument that ends the moment you switch it off. The decay test asks the only question that matters: with the pump out of the conversation, what does the system do on its own?

The procedure: pull the system to 500 microns or below. Close the CRT valve (or the rig's isolation valve) so the system is sealed off from the pump and hoses, with the micron gauge inside the isolated section. Start a timer. Watch for 10 minutes minimum. Every isolated system rises a little at first as pressure equalizes through the system's internal restrictions; what you are reading is the shape of the rise. There are three shapes, and they are the three possible verdicts.

Tight and dry: the reading rises slightly and levels off flat, holding below 1,000 microns through the full watch. The small rise is residual vapor equalizing; the flat line afterward is a system with nothing left to say. This is a pass. Charge it.

Leak: the reading climbs steadily and never levels off, because the atmosphere outside is infinite and it keeps coming. No amount of additional pumping fixes a leak: more pump time just holds the line down until you stop again. Check your own rig first, every fitting, the CRT seals, the gauge connection, because the most common vacuum leak is the rig, not the system. Then nitrogen pressure test the system and search.

Moisture: the reading climbs, fast at first, then bends over and plateaus, typically in the 1,500 to 2,500 micron range. Remaining liquid water boils into the vacuum, raising pressure until it reaches water's vapor pressure at the system's temperature, then stops. The plateau IS water announcing itself. The system does not leak, it is wet. Single-pass pumping will eventually dry it, but the colder and wetter the system, the slower the boil. The right tool for a wet verdict is the next section.

The discipline that makes the test honest: do not shortcut the watch. A leak and a moisture rise look identical for the first ninety seconds. The signature is in whether it levels, and that takes the full 10 minutes to read. And run the test on every opened system, because the test costs ten minutes and the failure it catches costs a compressor.

IB STANDARD

The IB evacuation standard is a single sentence every tech can recite: pull to 500 microns or below, isolate, and pass a 10-minute decay test holding under 1,000 microns, on every opened system, no exceptions. The passing decay reading is photographed with the gauge legible and the photo is part of the 8-photo ServiceTitan close-out. "It pulled down fine" is not a record. The photo is the record, and it is also the tech's protection: when a compressor dies of acid two owners later, the tech with a documented decay test is covered.

Triple evacuation: the wet-system protocol

Some systems show up wet and you know it before the pump starts: a system that sat open for days waiting on parts, a coil replaced during monsoon humidity, a compressor burnout, rain or wash water in the line set, or a moisture plateau on the decay test you just ran. Single-pass evacuation can dry a wet system the way a shop vac can drain a pool: technically, eventually. Triple evacuation does it in a fraction of the time by bringing in a carrier.

The protocol is three pulls separated by two nitrogen sweeps:

1. **First pull:** evacuate to roughly 1,500 to 5,000 microns. No need to fight for 500 yet; this pass removes the bulk of the air and the easy moisture.
2. **First sweep:** break the vacuum with dry nitrogen to a slight positive pressure, 2 to 5 psig, and hold 10 to 15 minutes. Dry nitrogen is a sponge: it diffuses through the system, absorbs water vapor from surfaces and pockets the vacuum could not reach efficiently, and holds it in suspension. Then release the nitrogen, gently, carrying its moisture load out with it.
3. **Second pull:** evacuate to the same intermediate depth. The system is dramatically drier already.
4. **Second sweep:** nitrogen again, 2 to 5 psig, another 10 to 15 minute hold, release.
5. **Final pull:** evacuate to 500 microns or below and run the full decay test. The final pass faces only traces and gets deep fast.

The third evacuation is not exempt from proof: the decay test on the final pull is the same test with the same pass bar. Triple evacuation changes how you get to dry. It never changes what dry means.

Why nitrogen instead of just pumping longer: deep in the thousands of microns, water evaporates slowly into near-nothing, and the pump spends hours hauling thin traffic. Nitrogen at positive pressure puts molecules back in the system that bump into water, absorb it, and then leave in bulk when you release the charge. Each sweep is a freight run. The vacuum passes in between just clear the road.

One connection to C16 worth planting now: the nitrogen for sweeps is the same dry nitrogen you flow while brazing and pressurize with for leak testing, always through a regulator, never oxygen or compressed air, which can detonate when they meet refrigerant oil.

Common evacuation lies

Every failed evacuation in the field traces back to a small set of self-deceptions. Learn them as a list, because you will meet every one of them.

"The gauge on the pump reads 400." The classic. The gauge reads the pump's local vacuum while the system three hose-lengths away sits at several thousand microns, wet. Any vacuum reading taken at the pump is a reading of the pump.

"It pulled to 500, we're done." No decay test, no verdict. A running pump holds a leaky system at 500 indefinitely; the reading is the pump winning, not the system passing. Isolate and watch or you know nothing.

"It held for a minute." All three signatures look the same for the first stretch of the watch. The 10-minute watch is the minimum that separates them.

"The pump is huge, it'll power through." A 10 CFM pump breathing through a Schrader core and a 1/4 inch charging hose performs like a much smaller pump. Restriction, not pump size, sets the pace on residential work. Cores out, big hoses, short runs.

"The oil is fine, I changed it last month." The oil is wet after one wet job. The sight glass takes five seconds and it is the only opinion that counts.

"It's a brand new system, it's clean inside." New equipment ships with a dry nitrogen holding charge, and the line set you just brazed was open to the air the whole install, in a trade where POE oil drinks humidity. New installs get the same 500 and decay as the oldest repair. There is no clean-enough exemption.

"The decay rose to 900, that's a fail." Read the shape, not just the number. A rise that levels off flat below 1,000 is the definition of a pass; the residual equalization rise is normal. The fail is the line that keeps climbing or the plateau that parks high.

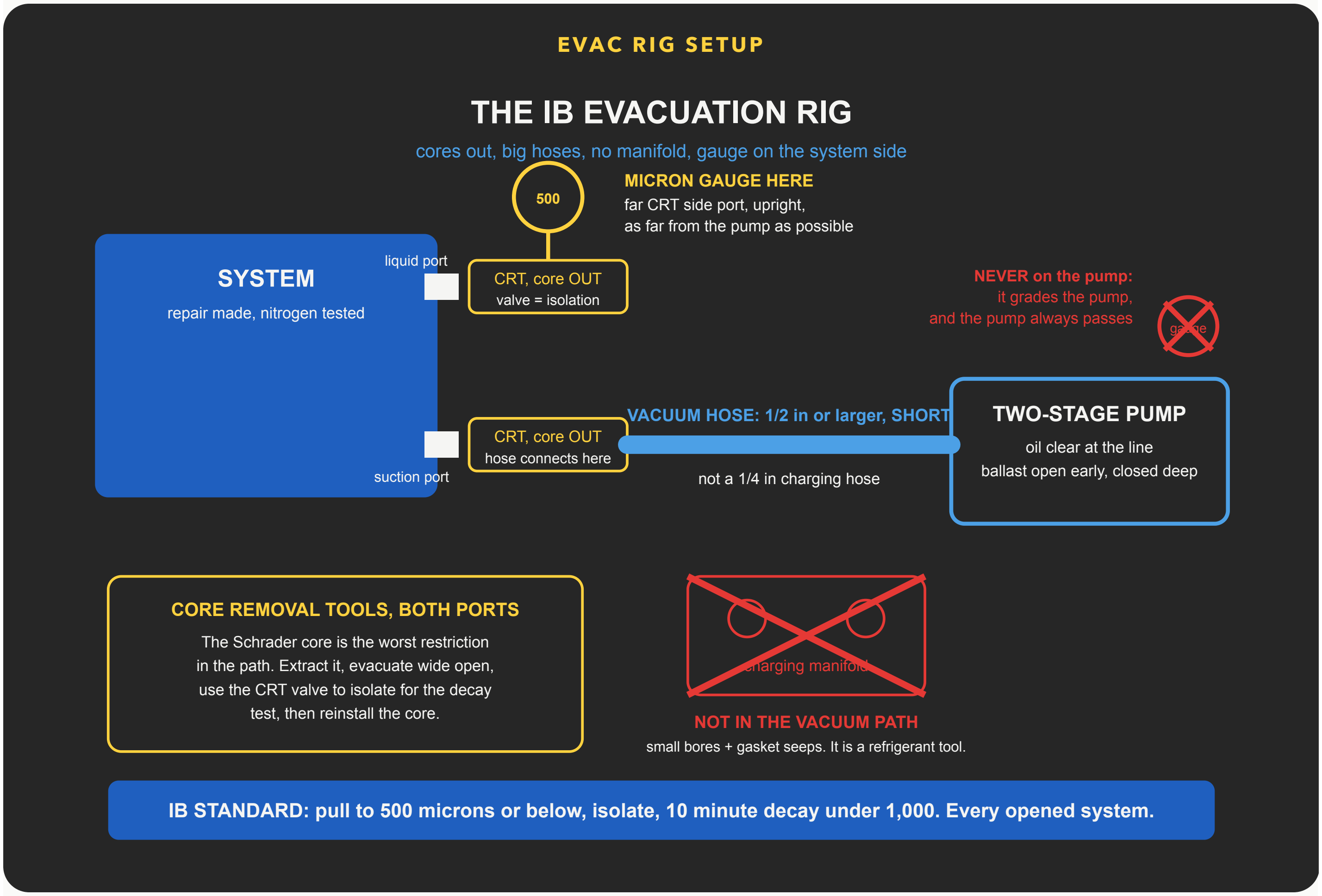
"We're losing the light, charge it and the filter drier will catch the rest." The drier polishes traces; it cannot absorb a failed evacuation, and when it saturates, the water is back in circulation. The decay test costs ten minutes. Compressor number two from the top of this article costs a customer relationship and a warranty fight.

Common Mistakes

1. Mounting the micron gauge at the pump. You are grading the pump, and the pump always passes. System side, far CRT, upright, every time.
2. Pulling vacuum through the Schrader cores. The core is the worst restriction in the entire path and turns a 45-minute evacuation into a half-day. Cores out with CRTs, no exceptions.
3. Skipping the decay test because the pull-down looked strong. A running pump masks both leaks and moisture. The only proof is what the isolated system does for 10 minutes on its own.
4. Calling a moisture plateau a leak, or a leak a moisture problem. The plateau levels off, the leak never does. Misread it one way and you hunt a leak that does not exist; misread it the other and you charge a wet system.
5. Evacuating with milky or unchecked pump oil, then blaming the system when 1,500 microns becomes a floor. Sight glass before every pull, change without hesitation, ballast open early to keep it clean longer.
6. Leaving the charging manifold in the vacuum path. Small bores and gasketed seals make it a restriction and a seep at once. Vacuum hoses run CRT to pump, manifold stays in the bag until charging.
7. Disconnecting recovery at first touch of the target level. Refrigerant boils back out of the compressor oil for several minutes; leave early and the rebound becomes vented refrigerant when the system opens.

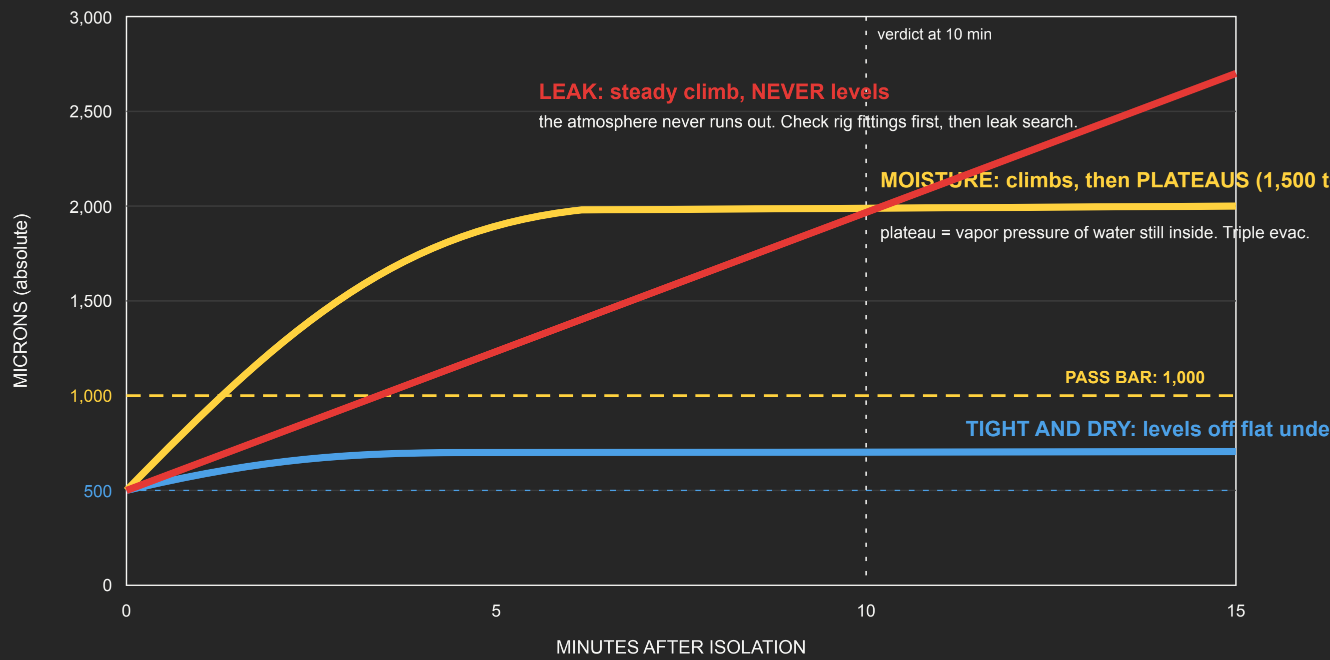
8. Recovering into a cylinder without the scale and the 80 percent arithmetic done first. Discovering mid-pull that the cylinder cannot take the charge forces bad choices at the worst time. The overfilled cylinder is the one that ruptures in a hot truck.
9. Energizing a hermetic compressor under deep vacuum, even briefly, even "just to check." Thin gas cannot insulate the terminals; the windings arc and the compressor is destroyed. Vacuum is broken with charge before the machine ever runs.
10. Treating a new install as exempt. The line set was open all day, the POE oil has been drinking humidity since the caps came off, and the factory holding charge left when you cut the stubs. New equipment earns the same 500-micron pull and decay test as everything else.

Module Visuals

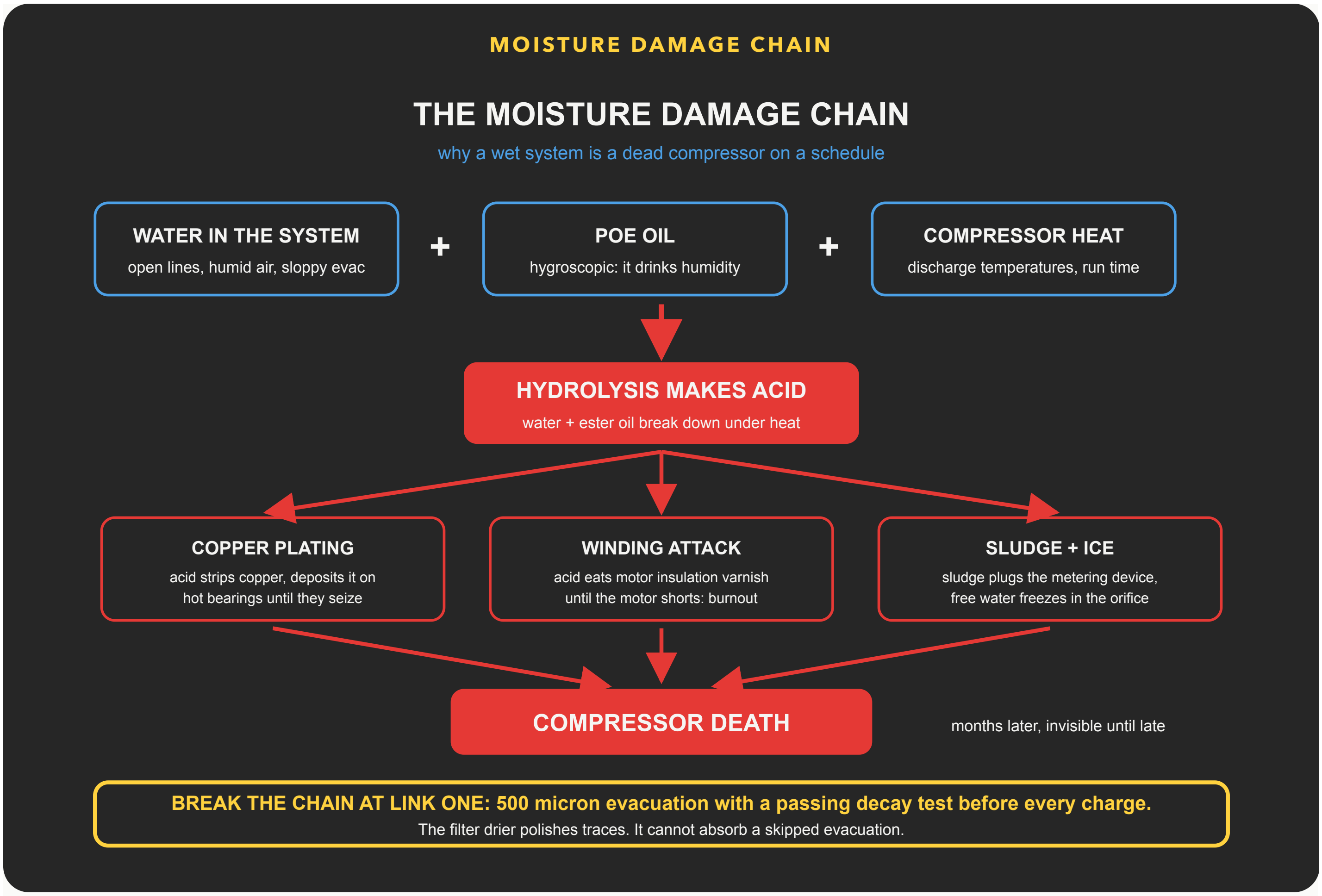


THE DECAY TEST: THREE SIGNATURES

pump isolated at 500 microns, then watch the shape for 10 minutes

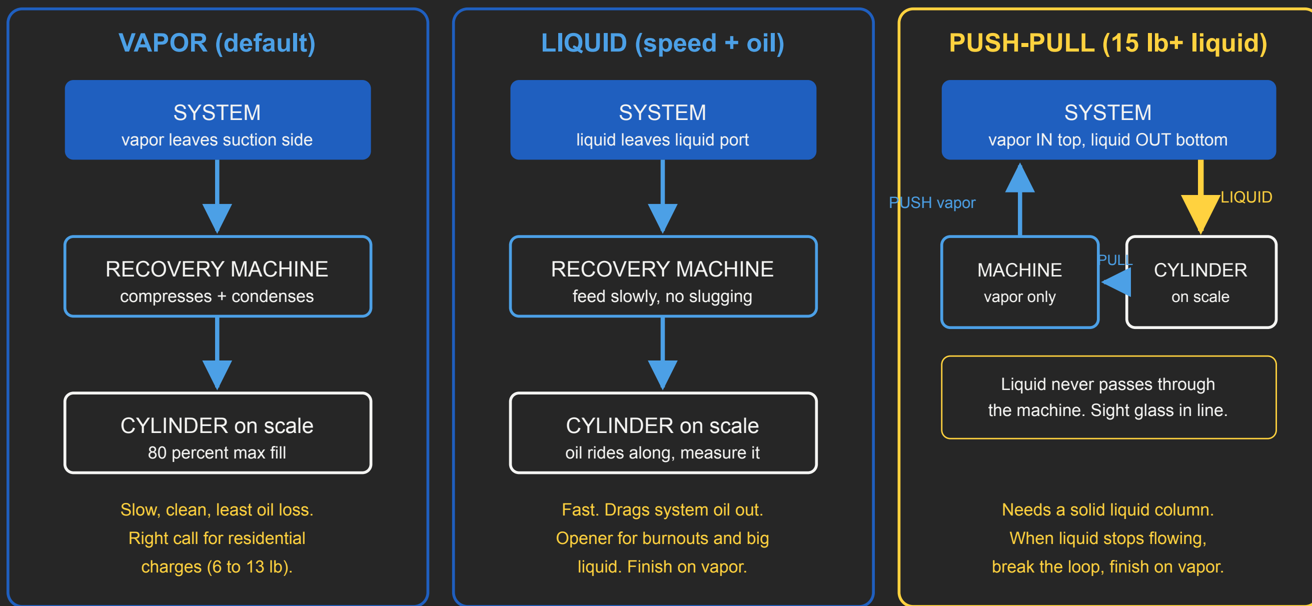


Read the SHAPE, not just the number. Leak and moisture look identical for the first 90 seconds.


MOISTURE DAMAGE CHAIN
THE MOISTURE DAMAGE CHAIN
why a wet system is a dead compressor on a schedule
WATER IN THE SYSTEM
open lines, humid air, sloppy evac
+
POE OIL
hygroscopic: it drinks humidity
+
COMPRESSOR HEAT
discharge temperatures, run time
HYDROLYSIS MAKES ACID
water + ester oil break down under heat
COPPER PLATING
acid strips copper, deposits it on hot bearings until they seize
WINDING ATTACK
acid eats motor insulation varnish until the motor shorts: burnout
SLUDGE + ICE
sludge plugs the metering device, free water freezes in the orifice
COMPRESSOR DEATH
months later, invisible until late
BREAK THE CHAIN AT LINK ONE: 500 micron evacuation with a passing decay test before every charge.
The filter drier polishes traces. It cannot absorb a skipped evacuation.

RECOVERY METHODS MAP

RECOVERY METHODS: VAPOR vs LIQUID vs PUSH-PULL



PASSIVE (system-dependent) RECOVERY: legal ONLY on appliances holding 15 lb or less

Splits and package units always use an active machine. Nameplate decides machine, cylinder, and hoses (A2L = A2L kit).

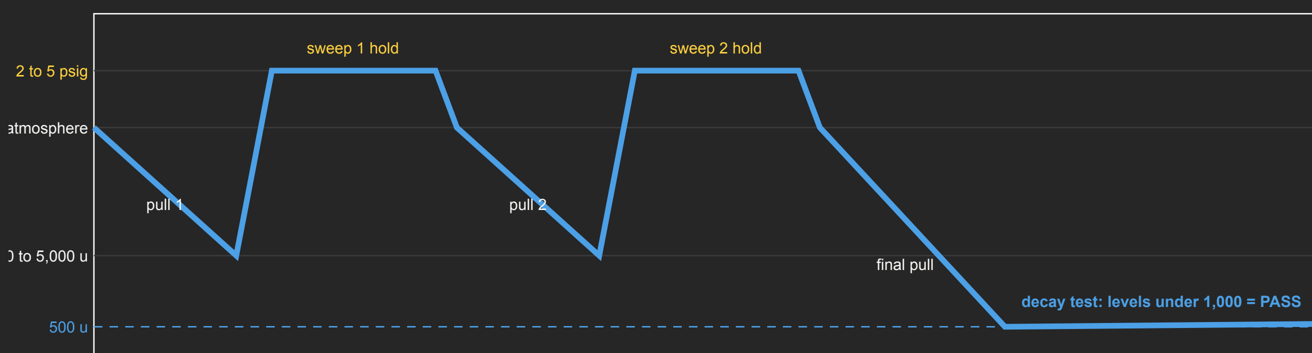
TRIPLE EVAC SEQUENCE

TRIPLE EVACUATION: THE WET-SYSTEM PROTOCOL

dry nitrogen is the sponge, the vacuum passes just clear the road

1. PULL — to 1,500 to 5,000 microns: bulk air and easy moisture →
2. N2 SWEEP — dry nitrogen to 2 to 5 psig, hold 10 to 15 min, release →
3. PULL AGAIN — same intermediate depth, dramatically drier already →
4. N2 SWEEP — second sweep, same pressure, same hold, release →
5. FINAL PULL — to 500 or below + full 10 min decay test

WHAT THE PRESSURE TRACE LOOKS LIKE



WHEN: system sat open, monsoon-season coil swap, compressor burnout, water in the line set, or a moisture plateau on the decay test.

Triple evac changes how you get to dry. It never changes what dry means: 500 and a passing decay.