Mini-Split and Ductless Systems

MODULE A35 | ADVANCED SYSTEMS | PREREQ C17

A homeowner converts her garage into a home gym and has a wall-mounted mini-split installed in May. It cools beautifully for one summer. The next June it blows air that is barely cool, a tech tops it off, and it limps through the season. The June after that, same call, same top-off. On the third visit a different tech puts bubble solution on the flare nuts at the outdoor unit and finds a slow stream of bubbles crawling out of the 5/8 inch suction flare. The original installer tightened that nut by feel, cracked the flare cone, and built a leak into the system on day one. Three service calls, two illegal top-offs on a system nobody leak-searched, and a customer who now believes mini-splits are junk. The equipment was never the problem. Mini-splits have a reputation for losing charge, and that reputation was earned one hand-tightened flare at a time. This module is about installing and servicing ductless systems so well that the reputation never attaches to your work.

From C17 you know how to charge a system by weighing in the exact factory charge plus a line set adjustment, and from C16 you know how to make a flare and what the torque table is for. This module puts both skills inside the machine they were built for. You will learn the ductless equipment family, how single-zone and multi-zone systems move refrigerant, where indoor units belong on a wall, how line sets and flares and evacuation work on these systems, how the condensate gets out, why multi-zone systems confuse techs who learned on single splits, and how to clean and diagnose the heads hanging in living spaces all over this market.

Short Version

A mini-split is a split system with no ducts: a small inverter-driven outdoor unit connected by a refrigerant line set, power, and a communication wire to one or more indoor heads that condition the room they hang in. Indoor units come as wall-mounted heads, ceiling cassettes, floor consoles, and slim-duct concealed air handlers. Single-zone systems pair one outdoor unit with one head. Multi-zone systems feed two to eight heads from one outdoor unit through individual ports or a branch box, and they behave differently at part load: one small zone calling can force the system to its minimum capacity and beyond, and oversized heads short-cycle and wreck humidity control. Every mini-split is an inverter system by default, so A33 thinking applies: capacity varies continuously, and steady long runtimes are normal and good. Installation quality lives in five places: indoor unit placement (airflow throw, condensate gravity, serviceability), line set routing within the manufacturer length and lift tables, flare connections made fresh and torqued with a torque wrench to the table (10 to 14, 24 to 31, 36 to 45, and 45 to 60 ft-lb for 1/4, 3/8, 1/2, and 5/8), evacuation to 500 microns with a decay test through the service port before the holding charge is released, and a dedicated circuit with correctly polarized communication wiring. Condensate leaves by gravity at 1/4 inch per foot or by a condensate pump, and the pump is a wear item with known failure modes. Service work centers on filters, blower wheel and coil cleaning with a bib kit, and reading fault codes from blinking lights or the remote. New ductless equipment ships with R-32 or R-454B, so A31 cylinder and handling rules apply.

Key Values

ITEM	VALUE	WHY IT MATTERS
Flare torque, 1/4 inch	10 to 14 ft-lb	Liquid line on most heads. Under-torque seeps now, over-torque cracks later.
Flare torque, 3/8 inch	24 to 31 ft-lb	Suction on small heads, liquid on large ones.
Flare torque, 1/2 inch	36 to 45 ft-lb	Suction line on mid-size heads.
Flare torque, 5/8 inch	45 to 60 ft-lb	The big suction flare, the most common leak point in ductless work.
Manufacturer torque table	Wins every disagreement	The anchor values above are typical. The install manual for the unit on the job is the law.
Evacuation standard	500 microns with a decay test	Pulled through the suction service port before the holding charge is released.
Single-zone line set limits, typical	50 to 66 ft total length, 16 to 33 ft lift	Model-specific. Read the table in the install manual, never assume.
Multi-zone total piping, typical	Up to roughly 230 ft combined on large systems	Per-zone and total limits both apply, plus lift limits between outdoor unit and highest or lowest head.
Pre-charged line set allowance, typical	About 25 ft on many ductless systems	Beyond the allowance, add refrigerant per the manual's ounces-per-foot value, weighed on a scale per C17.
Indoor unit mounting height, wall head	About 6 to 7 ft minimum, per manual	The head needs room above the floor to throw air across the room and room above it to breathe.
Line set insulation	3/4 inch closed-cell minimum, both lines insulated separately	Both lines carry temperature on an inverter heat pump. UV-protected outdoors.
Condensate gravity slope	1/4 inch per foot, continuous	Any sag or rise makes a trap that fills, then overflows out of the head.
Communication wiring, typical	14 AWG 4-conductor stranded cable rated for the application	Two power legs, one communication conductor, ground. Polarity matters, splices fail.
Dedicated circuit, typical ductless sizes	15A (0.75 to 1.0 ton), 20A (1.5 to 2.0 ton), 25 to 30A (3.0 ton) at 208/230V	Sized to nameplate MCA and MOCP, never shared with other loads.
Disconnect	Weatherproof, within sight, within 50 ft (NEC 440.14)	Same rule as every condensing unit.
Outdoor unit clearances, typical	12 inch sides, 24 inch front, 18 inch rear	Per manual. Inverter boards live on airflow.

ITEM	VALUE	WHY IT MATTERS
Multi-zone connected capacity ratio	Commonly up to 130 percent of outdoor capacity	All heads cannot demand full output at once. The manual states the limit.
Southwest efficiency minimum, ductless	16 SEER2	Higher than the 14.3 SEER2 split-system floor.

Field Checklist

Run this on every ductless install before the holding charge is released, and on any "mini-split not cooling" call before condemning parts.

- [ ] Indoor unit level side to side, tipped per manual toward the drain side if specified, mounting plate lagged into studs or solid anchors
- [ ] Airflow throw path clear: no shelving, beams, or cabinets in front of the discharge, no return obstruction above
- [ ] Service clearance preserved: the cabinet front opens, filters slide out, a bib kit can hang
- [ ] Line set length and lift inside the manufacturer table, measured, not guessed
- [ ] No kinks, no flat ovals on bends, line set supported every 4 ft
- [ ] Both lines insulated separately, 3/4 inch minimum, insulation sealed at joints and UV-protected outdoors
- [ ] Every flare cut fresh, deburred face down, nut on first, cone inspected, oil on the cone back only, never the threads
- [ ] Every flare torqued with a torque wrench and backup wrench to the manufacturer table, value recorded
- [ ] Nitrogen pressure test held, then evacuation to 500 microns with a passing decay test through the service port
- [ ] Holding charge released only after the decay test passes, hex ports recapped and torqued
- [ ] Line set adjustment refrigerant weighed in per the manual if the run exceeds the pre-charge allowance
- [ ] Dedicated circuit at nameplate MCA/MOCP, weatherproof disconnect within sight
- [ ] Communication wiring continuous (no splices), correct polarity, terminal numbers matching end to end
- [ ] Condensate: continuous 1/4 inch per foot gravity slope verified with water poured at the head, or pump installed with safety switch wired to shut the system down
- [ ] Fault code chart photographed or saved from the install manual before leaving
- [ ] Owner shown how to remove and rinse the filters

IB STANDARD

Island Breeze installs RunTru ductless equipment, single-zone inverter heat pump condensers with matched wall-mount air handlers, purchased through our normal supply chain. The standards in this module are brand-neutral, but the torque tables, line set limits, and fault codes you will use day to day come out of the RunTru install manual, and a copy lives in the truck folder. Every ductless install gets the full IB close-out: 500-micron decay test, torque wrench on every flare with values in the job notes, and the 8-photo ServiceTitan documentation set.

Full Breakdown

What ductless means, and the indoor unit family

A mini-split is the split system you learned in C10 with the ductwork deleted. One outdoor unit holding the compressor and outdoor coil, one refrigerant line set, and an indoor unit that conditions air. The difference is where the indoor unit lives: instead of an air handler in a closet pushing air through ducts, the indoor unit hangs in the room itself and serves only that room. No ducts means no duct losses, which is a real advantage in this trade: a duct system in an unconditioned attic can give away 20 to 30 percent of the capacity you paid for before the air reaches a register. A ductless head gives away none.

The indoor units come in four shapes, and you will see all four:

Wall-mounted heads are the default: a long, low cabinet high on the wall with a tangential blower wheel (a long cylindrical wheel that spans the whole cabinet), a coil wrapped around it, washable mesh prefilters, and motorized louvers that aim the discharge. Cheapest, easiest to install, easiest to service.

Ceiling cassettes recess into the ceiling between joists and discharge in four directions from a square grille. They disappear visually and throw air evenly in a square room, but they need ceiling depth, a condensate lift pump is usually built in, and service means a ladder and a grille removal.

Floor consoles sit low on the wall like an old radiator cabinet. They fit under windows and in rooms with knee walls or full-glass walls where there is no high wall space. Airflow throw is weaker than a wall head, so placement matters more.

Slim-duct air handlers (also called concealed duct or ducted mini-splits) hide above a ceiling or in a soffit and feed two or three short duct runs. They are the answer when the customer refuses visible equipment, and they give up some efficiency to static pressure. They are still ductless-family equipment: inverter-driven, flare-connected, communicating with the outdoor unit.

All four connect to the outdoor unit the same way: liquid line, suction line, power, communication wire, and a condensate drain. Learn one, and the others are variations in sheet metal.

Inverter by default

Here is the single biggest mental shift from conventional splits. From A33 you know what an inverter system is: the drive rectifies incoming AC power, builds a DC bus, and synthesizes variable-frequency power so the compressor can run anywhere from a low simmer to full speed. On central equipment, inverter drives are a premium option. On mini-splits, there is no non-inverter version worth speaking of. Every modern ductless outdoor unit is an inverter heat pump, which means everything you learned about variable-capacity behavior applies to every ductless call.

The practical consequences: a mini-split running for hours at a whisper is healthy, not broken. Pressures float with compressor speed, so gauge readings without knowing the operating frequency are nearly meaningless, which is one more reason ductless charging is weigh-in per C17 and not gauge interpretation. Capacity ramps to match the load, so the system holds setpoint within a fraction of a degree instead of swinging two degrees like a single-stage system. And the electronics are the system: the outdoor board runs the compressor, the fan, and the electronic expansion valve, and it talks to the indoor board constantly. That is awareness level. When an inverter board fault takes you deeper, into DC bus measurements, IPM testing, or drive fault isolation, that work lives in A33 and you go there for it.

Single-zone vs multi-zone

A **single-zone** system is one outdoor unit and one indoor head. It is the simple, robust version: dedicated capacity, dedicated metering, no sharing. When each room can have its own outdoor unit, single-zone systems are almost always the better-performing choice.

A **multi-zone** system feeds two to eight indoor heads from one outdoor unit. Two architectures exist. On port-style systems, the outdoor unit has individual flare connection pairs, one liquid and one suction port per zone, and each head runs its own home-run line set back to the outdoor unit. On branch-box systems, one larger line set leaves the outdoor unit and lands on a branch box (a distribution manifold with electronic expansion valves and controls inside), and the individual head line sets fan out from the box. Branch boxes go where you can reach them, because they are serviceable components with electronics and metering inside, not buried junctions.

Three numbers govern every multi-zone design, and all three come from the manufacturer's tables:

1. **Per-zone line length and lift limits**, head by head.
2. **Total combined piping limit**, all zones added together, commonly in the neighborhood of 230 feet on larger systems.
3. **Connected capacity ratio**: the sum of the indoor heads' rated capacity divided by the outdoor unit's rated capacity, commonly allowed up to about 130 percent. The system is allowed to be oversold on connected heads because the engineering assumption is that all zones never call at full demand simultaneously. That assumption is also the source of the one honest limitation of multi-zone equipment: on the rare day every zone calls hard at once, the outdoor unit delivers its rated capacity and no more, and every zone gets a proportional share. The manual states the simultaneous operation limit. Read it before promising performance.

Single-zone line set limits are model-specific, typically 50 to 66 feet of total length with allowable vertical lift between 16 and 33 feet, and some larger single-zone systems allow up to 100 feet. None of those typical numbers belongs in your head as a fact about the unit in front of you. The number that matters is printed in the install manual for that model, and exceeding it costs capacity, oil return, and eventually the compressor.

Indoor unit placement: the decision that lasts twenty years

A wall head placement is a three-question test, and the install passes only if all three pass.

Airflow throw. The head discharges a flat ribbon of air that needs to travel across the room. Put it where the throw covers the occupied space: on the long wall throwing down the room's length, not in a corner firing into a wall four feet away. Keep furniture, beams, ceiling fans, and shelving out of the discharge path. The return is the top of the unit, so the head also needs the manual's clearance from the ceiling, typically a few inches minimum, to breathe.

Condensate gravity. The drain pan under the indoor coil drains from one end of the cabinet, and the drain line needs continuous fall from that point to wherever it terminates. Decide the drain route before the mounting plate goes on the wall. A head placed on an interior wall with no gravity path has just bought the customer a condensate pump and its maintenance for life. A head placed on an exterior wall with the drain falling away through the wall penetration drains free forever.

Serviceability. Someone, possibly you, will hang a bib kit on this head and pressure-wash the coil and blower wheel. The cabinet front must open fully, the filters must slide out without hitting a cabinet or ceiling, and there should be room to work from a ladder. A head tucked into a soffit pocket that cannot open is a head that never gets cleaned.

Mount the plate level (or with the slight tilt toward the drain end if the manual specifies one), lagged into studs or rated anchors. A loose head vibrates, and vibration works on flares.

> **PHOENIX FIELD NOTE**
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> In this market the mini-split heartland is the garage conversion, the casita, and the bonus room over the garage. These spaces share three brutal traits: high solar load, marginal insulation, and air full of dust because the garage door opens twenty times a day or the casita sits off a gravel drive. Phoenix sizing runs hotter than national rules of thumb: where national guidance says 18 to 20 BTU per square foot, this climate needs 20 to 22 on north exposures, 25 to 30 on south and west, 30 to 35 for garage conversions, and 35 plus for glass-walled sunrooms, confirmed by Manual J at the 112 F design temperature. And the dust is not a footnote: a wall head in a converted garage loads its blower wheel with dust bonded by coil moisture in one season, which is why the cleaning section of this module is not optional knowledge here.

Line sets: routing, lengths, and lifts

The line set is the same two copper lines from C10, sized smaller: commonly 1/4 inch liquid with 3/8 or 1/2 inch suction on small heads, and 5/8 suction on larger ones. The manual lists required line sizes per model, and substituting sizes because the truck has them is not an option on inverter equipment, where the metering algorithm assumes the designed line volume.

Routing rules: support every 4 feet, no kinks, and large-radius bends made with a bender or by careful hand-forming on soft copper. A flattened bend is a permanent restriction. Where the line set runs down an exterior wall, line-hide channel protects the insulation from sun and weed trimmers. Both lines get insulated separately with 3/4 inch closed-cell minimum, because on an inverter heat pump both lines carry meaningful temperature in one mode or the other, and bare or sun-rotted insulation costs capacity all summer.

Length and lift live in the manufacturer table, and three entries matter: maximum total length, maximum lift when the outdoor unit is below the head, and maximum lift when the outdoor unit is above. Long lifts move oil against gravity, and the manual may require traps or specific routing on tall runs. Most ductless systems ship pre-charged for a stated line set length, commonly around 25 feet. Beyond the allowance, the manual gives an ounces-per-foot adder for the liquid line size, and that refrigerant goes in by weight on a scale, exactly the C17 weigh-in discipline with a smaller per-foot number than the 3/8 inch central-split value. Measure the line set, do the arithmetic, record it.

There is also a minimum length on many models, often around 10 feet. A condenser sitting directly behind the wall from the head with three feet of pipe can hurt oil management and transmit compressor pulse into the head. Coil the spare length in flat horizontal loops if the manual permits it, or route the long way.

The flare: the number one leak point in ductless work

Every field connection on a mini-split is a flare: two at the head, two at the outdoor unit, four more per zone at a branch box. No brazing, no flame, fully serviceable, and absolutely unforgiving of sloppy technique. Industry experience and our own callback history agree: the flare connection is where mini-splits leak, and almost every flare leak was built by the installer.

The making of a flare is C16 knowledge: cut square, deburr facing down, nut on first, clamp at the specified proud height, run the eccentric flaring cone down with steady force, inspect for even width, smooth face, no cracks or scoring. Recall it, practice it, and add the ductless-specific layer:

Always cut and re-flare. Factory flares on a new line set get inspected, and any flare that has been tightened once and opened gets cut off and remade. Copper work-hardens. A re-used flare is a gamble with the whole charge as the stake.

Oil the cone, never the threads. A drop of the system's refrigerant oil on the back of the flare cone helps it seat and rotate without galling. The threads stay dry. Oil on the threads changes the friction the torque spec assumes, so a "correctly torqued" oiled thread is actually over-torqued.

The sealant debate, settled factually. Thread sealants and assembly compounds marketed for flares exist, and techs argue about them. The facts: the flare seals metal to metal at the cone, never at the threads, so thread sealant does not seal anything on a properly made flare. Some manufacturers explicitly permit a specific oil on the flare seat, some prohibit any compound anywhere, and the install manual for the unit on the job is the ruling document. What a sealant absolutely cannot do is rescue a cracked, scored, or under-height flare, and using it that way converts a visible day-one leak into a hidden month-six leak. IB practice follows the manual: oil the cone back when permitted, nothing on the threads, and never use any compound as a repair for a flare that should be remade.

Torque wrench, every flare, both ends. The anchor values: 10 to 14 ft-lb for 1/4 inch, 24 to 31 for 3/8, 36 to 45 for 1/2, and 45 to 60 for 5/8, confirmed against the manufacturer table, applied with a torque wrench and crowfoot adapter while a backup wrench holds the fitting body so the line never twists. Under-torqued flares seep immediately. Over-torqued flares deform the cone, work-harden, and crack weeks later, after the day-one leak check passed. "Tight plus a grunt" is how the trade built the mini-split leak reputation, and the torque wrench is how we refuse to participate.

After torque, leak-test before insulating: nitrogen pressure test per the manual, bubble solution on every flare.

IB STANDARD

Torque wrench on every flare is not a guideline, it is the standard, and it has a paper trail: the torque value used goes in the job notes and the finished connection gets photographed as part of the 8-photo close-out. Any flare that is cracked, scored, galled, or has been over-tightened gets cut off and remade. Flares are free. Refrigerant, callbacks, and the customer's trust are not.

Evacuation through the service port

Mini-split outdoor units ship holding their full refrigerant charge behind closed service valves. The line set and the indoor coil ship full of air and whatever humidity the day offers. Your job is to make the field piping as clean and dry as the factory side before the two ever meet, and the standard does not change because the equipment is small.

The sequence: pressure-test the field piping with nitrogen per the manual and confirm it holds. Release the nitrogen, then connect the vacuum rig to the single service port on the suction line service valve. Use the C15 rig discipline scaled to one port: large-bore hose, core removal tool so the Schrader core is out of the flow path, micron gauge at the system side of the rig, not at the pump. Pull to 500 microns or below, then valve off and run the decay test: a rise that stabilizes means moisture still boiling off, keep pulling; a continuous rise means a leak, and the flares are suspects one through four.

Only after the decay test passes do the service valves open: hex key, both valves, full open, caps back on and snugged. That moment releases the factory charge into the field piping and it is irreversible without a recovery machine, which is exactly why the decay test comes first. If the line set exceeded the pre-charge allowance, weigh in the adder now per C17.

IB STANDARD

500 microns with a passing decay test, on every opened ductless system, verified through the service port with the core removed, before the holding charge is released. The system being small does not shrink the standard. A mini-split evacuated to "the pump ran a while" is a moisture-contaminated inverter system with an electronic expansion valve waiting to ice and stick.

Electrical: one circuit, one cable, one disconnect

Ductless electrical is simple and rigid. The outdoor unit gets a **dedicated circuit** sized to the nameplate MCA and MOCP, typically 15 amps for 0.75 to 1.0 ton, 20 amps for 1.5 to 2.0 tons, and 25 to 30 amps at 3 tons, at 208/230 volts. Dedicated means dedicated: no garage freezer, no sprinkler controller sharing the breaker. A weatherproof **disconnect** mounts within sight of the outdoor unit and within 50 feet, per NEC 440.14, exactly like every condensing unit you have worked on.

On most ductless systems, the indoor unit does not get its own circuit. Power and control run from the outdoor unit to the indoor unit on one cable, typically 14 AWG 4-conductor stranded cable rated for the purpose: two power conductors, one **communication** conductor, and ground. That communication conductor carries a digital signal, the constant conversation between the outdoor board and the indoor board: setpoints, sensor readings, compressor commands, fault flags. Three rules keep it alive:

Polarity and terminal order. Terminal 1 lands on terminal 1, 2 on 2, 3 on 3, ground on ground, at both ends. The communication signal is referenced to the power legs, and swapping any pair scrambles the conversation. The classic result is a system that powers up and then throws a communication fault, or runs and drops out randomly.

Continuous cable, no splices. A wire nut splice in a comm line is a future intermittent fault with a corrosion timer attached. One continuous run, outdoor terminal block to indoor terminal block.

Separation from noise. Stranded cable, and on long runs or runs near other wiring, shielded cable with the shield grounded at one end only. Communication wire pulled through the same hole and zip-tied tight to a 240-volt feeder for thirty feet can pick up enough induced noise to corrupt the signal. Give it a few inches of separation or shielding.

Condensate: gravity first, pumps when you must

A ductless head in cooling produces the same condensate physics as any evaporator, with one twist: the pan and drain are inside a cabinet hanging on a finished wall over the customer's floor, television, or bed. There is no secondary pan and no emergency drain under a wall head. The drain either works or the wall gets wet.

Gravity is plan A. Continuous 1/4 inch per foot fall from the pan fitting to the termination, no sags, no humps, insulated where it passes through unconditioned space. Most wall heads drain out the back through the same wall penetration as the line set. The test is not visual: pour water into the pan (or pull the drain hose and pour through it) and watch it run out at the termination. A drain that gurgles, hesitates, or backflows fails.

Pumps are plan B, for interior walls, ceiling cassettes (most have a lift pump built in), and basements. A condensate pump is a small reservoir, a float switch, and a motor pushing water up small-bore tubing to a gravity point. It is a wear item, and its failure modes are worth knowing cold:

1. **Stuck float**: slime or debris jams the float down (pump never starts, reservoir overflows) or up (pump runs dry until the motor dies).
2. **Check valve failure**: water in the lift tube drains back after every cycle, so the pump short-cycles itself to death.
3. **Tubing problems**: kinked, crushed, or slime-blocked discharge tubing dead-heads the pump.
4. **Lost prime or airlock** on some designs after service.
5. **Electrical**: the pump dies of old age, or was never wired to its safety switch.

That last item is the one that floods homes. Every condensate pump has a safety switch output that must be wired to shut the system down (or at least kill cooling) when the reservoir hits high level. A pump installed without the safety wired is a flood with a delay timer. Test the whole chain at install and at every maintenance: pour water until the pump runs, keep pouring until the safety trips, confirm the system stops.

PHOENIX FIELD NOTE

Two local realities make ductless condensate a maintenance item, not an install-and-forget detail. First, dust: the dust load that shortens blower and capacitor life also washes off the indoor coil into the pan, where it becomes sediment that feeds blockages. Second, heat plus biology: in summer, the warm pan of a head in a garage gym or casita grows slime at a rate that surprises techs from milder climates, and a drain that was clear in April can choke by the first July monsoon humidity spike. Treat every ductless maintenance as a drain service: flush the drain, clean the pan, and on pumped systems open the reservoir and clean the float. The same monsoon season that drives our central-system drain calls drives the ductless ones, except the ductless overflow lands on drywall instead of in an emergency pan.

Multi-zone behaviors that confuse techs

Multi-zone systems generate a class of service calls where nothing is broken. Knowing these behaviors keeps you from condemning healthy equipment and tells you when the real problem is the design.

One zone calling. The outdoor unit has a minimum capacity, the floor of its inverter range. When a single small head calls, say a 9,000 BTU bedroom head on a 36,000 BTU outdoor unit, the demanded load can sit below the outdoor minimum. The system responds by cycling the compressor, or by routing a little refrigerant through non-calling heads to absorb the excess. That is why a head that is switched off can blow slightly cool air or why its coil sweats while another zone runs: small refrigerant bleed through idle heads is designed behavior on many systems, not a stuck valve. Verify against the service manual before condemning an expansion valve.

All zones calling. Connected capacity commonly exceeds outdoor capacity by design (up to that 130 percent ratio). When everything calls hard simultaneously, every zone gets a proportional share of rated output and the rooms with the worst loads lose. A homeowner complaint of "the back bedroom never keeps up, but only on the hottest afternoons when the whole house is running" is the connected-capacity math showing itself, not a refrigerant problem.

Refrigerant distribution. Each zone is metered by its own electronic expansion valve, in the head or in the branch box, commanded by the control system. There is no manifold of fixed orifices to clean. Distribution faults are control and valve faults, diagnosed through fault codes and service-mode data, not through gauges on the shared circuit.

Mode conflict. Most multi-zone systems (other than true heat-recovery equipment) heat or cool, never both at once. The first zone to call sets the mode, and a zone calling for the opposite mode waits, throwing a standby indication that customers report as a dead head in the den.

Why oversizing zones wrecks humidity. Here is the one that matters most in design conversations. A correctly sized head runs long, low, and steady, and its cold coil spends hours condensing moisture. An oversized head satisfies the thermostat in minutes and shuts down, and the moisture still sitting on its coil evaporates right back into the room air. The room reads 74 degrees and feels clammy. Oversizing is worse on multi-zone equipment because the outdoor minimum is shared: a system of all-oversized heads spends its life cycling at the bottom of its range, short on runtime in every room at once. The fix is in the Manual J, not in the service call. Size heads to the room load, resist the temptation to round every bedroom up to the next head size, and on multi-zone designs respect that the smallest available head is often 6,000 or 9,000 BTU, which is already oversized for a small bedroom. Sometimes the honest answer is one slim-duct unit serving three small rooms instead of three wall heads.

Service and cleaning: the work that keeps heads healthy

A ductless head lives in the room with the people, the pets, the cooking aerosols, and the dust, with a washable prefilter as its only defense. The mesh prefilter stops lint and hair. Fine dust passes through, hits the wet coil, and sticks, and what the coil misses lands on the blower wheel. Every blade of a tangential wheel carrying a ridge of bonded dust is a blade with ruined geometry, and the wheel quietly loses airflow over a year or two. The complaint arrives as "it doesn't cool like it used to," with a musty smell on startup as the bonus symptom, because that dust blanket on a wet coil grows biology.

Filter habits for owners. Teach the customer at the install: pop the front cover, slide out the prefilters, rinse them in the sink, air-dry, reinstall. Monthly in a bedroom, every two weeks in a garage gym or a home with shedding pets. This is the single highest-value habit in ductless ownership and it costs nothing.

The bib kit job. Deep cleaning a wall head in place is a standard service, and the bib kit is the tool: a fitted plastic bib that wraps the head and funnels wash water down into a bucket. The sequence: kill power at the disconnect, remove filters, louvers, and the cabinet front per the service manual, protect or remove the control board and motor connections as the manual directs, hang the bib, and wash the coil and blower wheel with low-pressure rinse and a coil cleaner approved for occupied spaces. Rotate the wheel and work it until rinse water runs clean: the wheel is the job, the coil is the warm-up. Flush the drain pan and drain line as part of the same service, dry, reassemble, restore power, and run it. A head cleaned this way comes back with airflow the customer can feel from across the room.

Fault code access. Ductless systems self-report. The indoor unit signals faults by a pattern of blinking LEDs (count the blinks, look up the code), and most brands expose detailed codes through the wireless remote held near the head in a service mode, or through the outdoor board's LEDs. The code chart lives in the install or service manual, photograph it onto your phone at the install, and start every ductless diagnostic by reading the code before touching a tool. A blink code is the indoor board telling you which conversation failed.

Communication fault diagnosis. The most common ductless electrical fault class is the communication fault: indoor and outdoor boards no longer talking. Work it in order. First, power-cycle once at the disconnect, because boards do occasionally need a reboot after a utility flicker, and note whether the fault returns. Second, verify line voltage at the outdoor terminals and at the indoor terminals, because a comm fault code often really means a power problem on the leg feeding one board. Third, inspect the terminal connections at both ends against the wiring diagram: terminal numbers matching, conductors seated, no green corrosion. Fourth, check for the installer sins: a splice in the run, swapped conductors, or comm wire bundled with a noisy feeder. Fifth, measure the communication line per the service manual: on many systems a healthy comm line shows a fluctuating DC voltage as packets move, and a flatlined or rail-stuck reading points at a board. Only after wiring is proven does the diagnosis become a board, and the service manual's board-test procedure makes that call, not a guess. Lightning season fills this category: a surge that kills nothing outright can still take out one board's communication driver, leaving a system that powers up perfectly and cannot talk.

When a mini-split is the right tool

Ductless equipment wins when the load is separate from the house's duct system, when there is no duct path, or when one space needs its own schedule and setpoint:

- **Additions and garage conversions**: the existing central system was never sized for the new load, and extending ducts both robs the house and usually violates the duct design. A dedicated ductless head solves the load where it lives.
- **Casitas and detached spaces**: no duct path exists, and a small ductless heat pump is purpose-built for a one-room building.
- **Server and equipment rooms**: cooling load runs 24/7/365 including all winter, completely out of phase with house comfort. A dedicated single-zone unit runs independently and keeps the central system out of a job it is wrong for.
- **Rooms the central system cannot reach**: the bonus room over the garage, the converted attic, the sunroom with three glass walls.

Where ductless is the wrong tool: as a patch for a central system problem. A bedroom that will not cool because the duct is crushed needs a duct repair, not a head on the wall. Diagnose the system before changing the architecture.

The refrigerant note: ductless leads the A2L transition

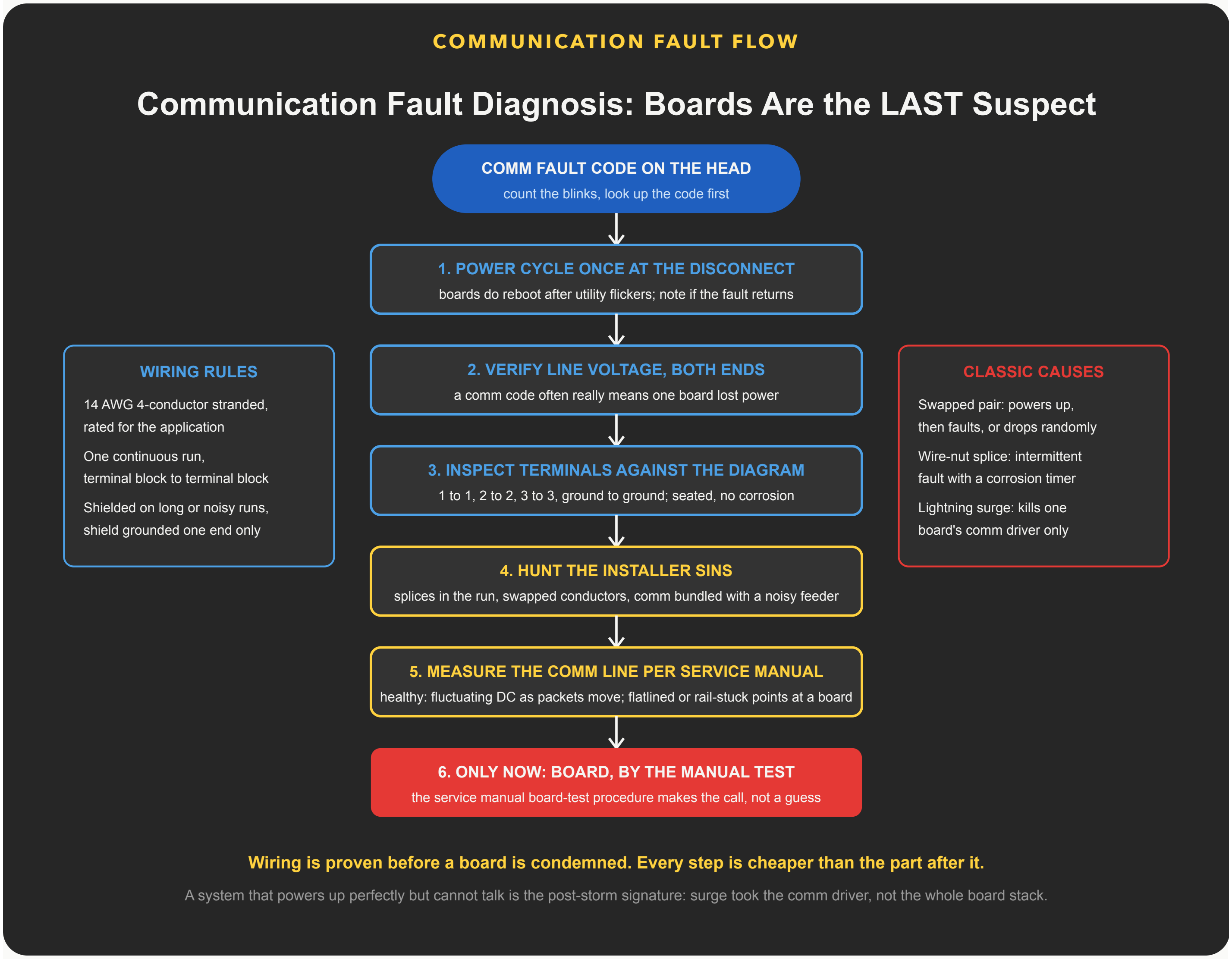
New ductless equipment ships with A2L refrigerants: R-32 in many brands, R-454B in others, and the transition hit ductless earlier than central splits in much of the market. Everything in A31 applies in full: left-hand threads and red-banded cylinders, A2L-rated recovery equipment and hoses, sensor and ignition-source rules, and zero tolerance for mixing refrigerants or topping an R-410A system with an A2L. The flare-and-torque, evacuate-and-decay disciplines in this module do not change with the refrigerant. The cylinder handling, leak response, and hot-work boundaries do, and A31 owns them. Before connecting anything to a ductless system, read the nameplate refrigerant, then pick up the matching hoses and cylinder.

Common Mistakes

1. **Tightening flares by feel.** The number one cause of the ductless leak reputation. Under-tight seeps now, over-tight cracks after the leak check passed. Torque wrench, backup wrench, manufacturer table, every flare, both ends.
2. **Reusing a flare that has been opened.** Work-hardened copper does not reseal reliably. Cut it off, re-flare, re-torque. Two minutes of work against a full charge of refrigerant.
3. **Releasing the holding charge before the decay test passes.** Once the hex valves open, the factory charge is in the field piping, and every shortcut taken on evacuation is sealed inside an inverter system with an electronic expansion valve. Decay test first, valves second, no exceptions.
4. **Skipping the line set adjustment.** A 50-foot run on a system pre-charged for 25 feet is undercharged from day one, and on an inverter system the symptom is vague: weak capacity on hot days, long runtimes, no hard failure. Measure, calculate, weigh it in, record it.

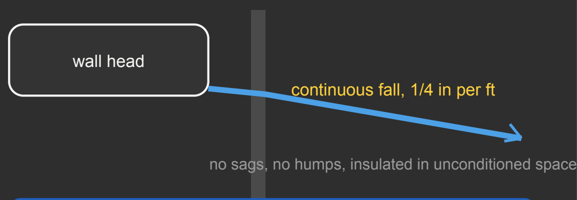
5. **Hanging the head where the furniture wants it instead of where the air and water want it.** A head with blocked throw short-cycles its own thermostat with its own cold discharge. A head with no gravity drain path commits the customer to a pump forever. Placement is engineering, not decorating.
6. **Splicing or mis-landing the communication cable.** Swapped conductors and wire-nut splices create the intermittent comm faults that burn hours. One continuous cable, terminal numbers matched at both ends.
7. **Installing a condensate pump without wiring the safety switch.** The pump will eventually fail, every pump does, and the safety switch is the only thing standing between that failure and a flooded wall. Wire it, then pour water until it trips to prove it.
8. **Condemning a multi-zone expansion valve because an off head sweats or blows cool.** Refrigerant bleed through idle heads at low load is designed behavior on many systems. Read the service manual before condemning parts that are doing their job.
9. **Oversizing heads to be safe.** Oversized ductless heads short-cycle, dehumidify poorly, and on multi-zone systems drag the whole circuit to the bottom of its range. Size to the Manual J, and consider a slim-duct unit when rooms are smaller than the smallest head.
10. **Cleaning the filters and calling the head clean.** The prefilter catches lint; the coil and blower wheel catch everything else, and the wheel is where capacity quietly dies. A head that has run for years in a dusty space needs the bib kit job, not a filter rinse.

Module Visuals



Condensate Management: Gravity First, Pumps When You Must

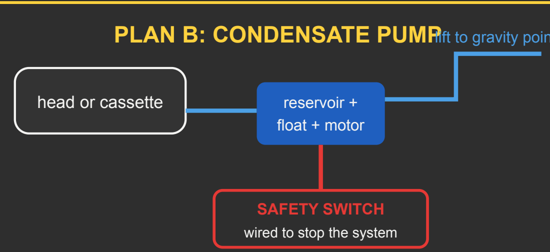
PLAN A: GRAVITY



THE TEST IS POURED WATER, NOT A GLANCE

pour into the pan, watch it run out at the termination

PLAN B: CONDENSATE PUMP



A pump without its safety switch wired is a flood with a delay timer. Pour until it trips.

PUMP FAILURE MODES, KNOW THEM COLD

1. Stuck float: jammed down, pump never starts, overflow. Jammed up, pump runs dry until the motor dies.
2. Check valve fails: lift tube drains back every cycle, pump short-cycles itself to death.
3. Tubing kinked, crushed, or slime-blocked: dead-headed pump.
4. Lost prime or airlock after service, on some designs.
5. Electrical: motor dies of age, or safety was never wired.

DESERT REALITY

Dust off the coil becomes pan sediment that feeds blockages.

Summer heat grows slime fast: clear in April can choke by the first monsoon humidity spike.

Every maintenance = drain service: flush drain, clean pan, open the pump reservoir, clean the float.

No emergency pan under a wall head.

The drain either works or the wall gets wet. There is no secondary pan on a wall head.

Flare and Torque Discipline: The #1 Leak Point on Earth

MAKING THE FLARE (C16 RECALL)

1. Cut square, light passes with the cutter
   no hacksaw, no crushing the tube
2. Deburr with the tube facing DOWN
   chips in the line end up in an EEV
3. **NUT ON FIRST, open end facing the work**
   the step that has embarrassed every tech alive
4. Flare, then INSPECT the cone
   even width, smooth shiny face, no cracks or scoring

Bad flare? Cut it off and remake it. Flares are free. Refrigerant is not.

TORQUE TABLE: WRENCH, NOT FEEL

FLARE SIZE	TORQUE (ft-lb)
1/4 in	10 to 14
3/8 in	24 to 31
1/2 in	36 to 45
5/8 in	45 to 60

The torque table in the unit's manual overrides these anchors.

Torque wrench + crowfoot on the nut, backup wrench on the fitting body.

THE OIL RULE

One drop of refrigerant oil on the BACK of the flare cone. Never on the threads.

Oiled threads change the friction the torque number assumes: spec on the wrench becomes over-torque at the flare. No thread sealant or dope, ever.

UNDER-TORQUE

Flare never fully seats on the cone.
Seeps now: fails the bubble test on day one
if you actually run the bubble test.

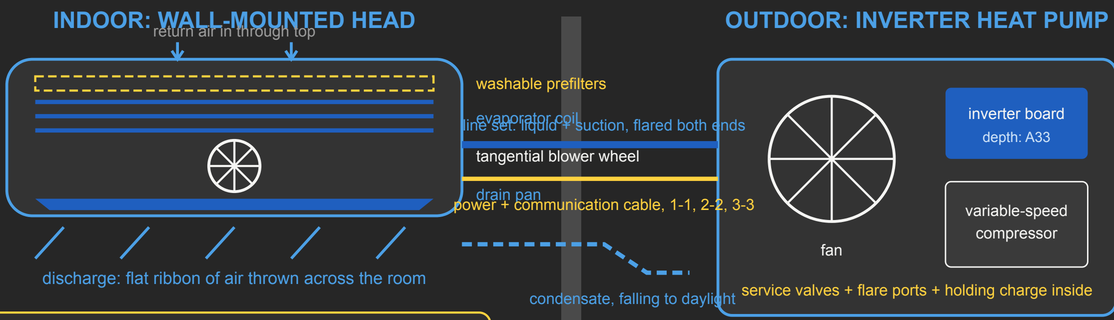
OVER-TORQUE

Work-hardens and cracks the flare face.
Passes day one, leaks in a month: the
slow callback nobody connects to the install.

IB rule: torque wrench on every flare, value in the job notes, photo in the close-out. Reused flares get cut off and remade.

MINI SPLIT ANATOMY

Mini-Split Anatomy: One Room, No Ducts



PLACEMENT: THREE-QUESTION TEST

1. Airflow throw clear across the occupied space
2. Condensate gravity path, 1/4 in per ft fall
3. Serviceable: cover opens, bib kit can hang

THE INDOOR FAMILY

wall head | cassette | floor console | slim duct

same connections on all four: liquid, suction, power + comm, drain

exterior wall

RULES AT THE OUTDOOR UNIT

Dedicated circuit at nameplate MCA / MOCP

Disconnect within sight, within 50 ft (NEC 440.14)

Clearances per manual: 12 in sides, 24 front, 18 rear

Line set inside the manual length and lift table

Both lines insulated separately, 3/4 in minimum

Every flare torqued to the table, wrench, not feel

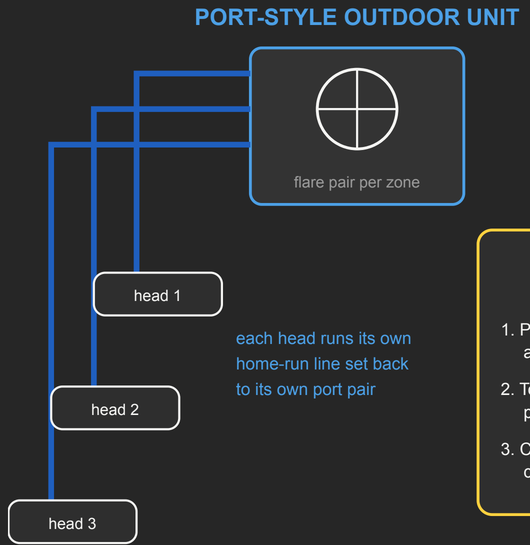
500 microns + decay test before valves open

New ductless ships R-32 / R-454B: A31 rules apply

Every mini-split is an inverter system. Long, low, steady runtimes are healthy.

No ducts means no duct losses, and no second chances on the four field flares.

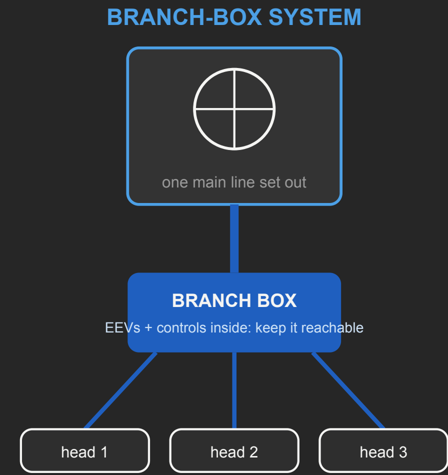
Multi-Zone Piping: Two Architectures, Three Limits



THREE LIMITS

all from the manual

1. Per-zone length and lift, per head
2. Total combined piping (~230 ft typ.)
3. Connected ratio, commonly to 130%



BEHAVIORS THAT FOOL TECHS: NOTHING IS BROKEN

One small zone calling
Demand below outdoor minimum: system cycles or bleeds refrigerant through idle heads. An off head sweating can be designed behavior.

All zones calling hard
Connected heads exceed outdoor capacity by design. Worst afternoon: every zone gets a share, the hottest room loses. Math, not refrigerant.

Oversized heads
Satisfy fast, shut down, coil moisture re-evaporates into the room: 74 degrees and clammy. Fix is in the Manual J, not a part.

Mode conflict: first zone to call sets heat or cool; opposite-mode zones wait in standby. Heat-recovery systems are the exception.