ISLAND BREEZE TECHNICIAN CERTIFICATION PROGRAM

Package Units

MODULE C20 | CORE SYSTEMS | PREREQ C18, C19

It is 6:15 in the morning and you are standing on a flat gravel roof with the sun barely up, looking at a beige steel box the size of a chest freezer. There is no furnace closet in this house. No air handler in the attic. No line set running down the wall. Everything you learned in the split system modules, the compressor, both coils, the metering device, the blower, and in this case a complete gas furnace, lives inside that one cabinet. That is a package unit, and in Phoenix you will work on more of them than almost any market in the country.

This module teaches you what a package unit is, the three families it comes in, how it attaches to a building, what an economizer does and how it quietly wastes energy when it fails, how a crane puts one on a roof without hurting anybody, and how to move around a rooftop like a professional instead of a statistic.

Short Version

A package unit is a complete heating and cooling system in a single outdoor cabinet: compressor, condenser coil, evaporator coil, metering device, and blower all factory-installed, factory-charged, and factory-tested, with no field line set. The three families are gas/electric (gas heat section plus electric cooling), heat pump packs (a packaged version of everything from C19, reversing valve and all), and straight cool with optional electric heat strips. Packs mount on a roof curb (downflow, ducts drop through the roof inside the curb) or on a ground pad (horizontal duct connections). Commercial packs often carry an economizer, a damper assembly that cools the building with outdoor air when conditions allow; a failed economizer is one of the most common silent energy wasters in the trade. Units go up by crane, and the lift has rules, roles, and an exclusion zone you never stand inside. Treat the roof itself as a jobsite hazard, especially in a Phoenix summer.

Key Values

VALUE	NUMBER	WHY IT MATTERS
Nominal airflow	400 CFM per ton	Same airflow rule as splits; verify duct connections can deliver it
Cooling temperature split	18 to 22 F	Same health check as splits, measured at supply and return
Gas manifold pressure, natural gas	3.5 in WC	Gas/electric heat section, same as C18
Gas manifold pressure, LP	9 to 11 in WC	Conversion kits change orifices and pressure
Run capacitor tolerance	Replace beyond minus 6 percent of rated microfarads	Pack cabinets bake in the sun; capacitors die early here

VALUE	NUMBER	WHY IT MATTERS
Typical economizer dry bulb changeover	55 to 70 F outdoor, set per climate	Above the setpoint, dampers return to minimum position
Economizer minimum position	Set to deliver required ventilation air during occupied hours	Zero percent on an occupied commercial space is a code and IAQ failure
Condensate trap depth	Deeper than the blower's negative static pressure, commonly 2 to 3 inches	Pack evaporators sit on the negative side; an untrapped drain will not drain
Condensate slope	1/4 inch per foot	Same rule as every drain you will ever run
ENERGY STAR single package AC	SEER2 at least 15.2, EER2 at least 11.5	Label thresholds for packaged cooling
ENERGY STAR single package heat pump	SEER2 at least 15.2, EER2 at least 10.6, HSPF2 at least 7.2	Packaged HP thresholds run below split thresholds; packs give up some efficiency
R-410A package sell-through deadline	December 31, 2027	Packaged units got a longer A2L sell-through than splits
Crane near power lines	Keep at least 20 feet of clearance	Default rule for lines up to 350 kV; the operator manages it, you respect it
Ladder angle	4 to 1	One foot out for every four feet up, same F1 rule, used on every roof access

Field Checklist

Rooftop package unit arrival routine, phone-friendly:

- [ ] Ladder set 4 to 1, tied off or footed, extends 3 feet past the roof edge
- [ ] Tools and meter hauled in a bag or bucket on a line, not carried in your hands on the ladder
- [ ] Walk the roof path once before working; note skylights, soft spots, edges, and trip hazards
- [ ] Identify the family before opening anything: flue hood and gas line means gas/electric, reversing valve and defrost board means heat pump pack, neither means straight cool
- [ ] Confirm disconnect location and pull it before opening compressor or control panels
- [ ] Open panels in order: controls, blower/filter, heat section, compressor; bag the screws
- [ ] Check filter condition and economizer damper position on arrival, before changing anything
- [ ] Verify condensate trap is intact, primed, and the drain run actually slopes to its termination
- [ ] Check curb flashing and gasket line for daylight, ponding, or membrane damage; photograph it
- [ ] Note coil condition: dust mat on the condenser, fin damage from hail, UV-cracked wire insulation
- [ ] Measure supply and return temperatures at the unit; 18 to 22 F split in cooling

- [ ] Close every panel with every screw; an unscrewed panel becomes a sail in a monsoon gust

> **IB STANDARD**
>
> Roof work follows the ladder and roof protocol from F1 every time: 4 to 1 ladder angle, three points of contact, tie off the ladder, tools on a hand line, and no roof work alone during summer heat advisories. The 8-photo ServiceTitan close-out on any package unit job must include a curb and flashing photo and, on gas/electric units, a flue photo. If the curb or flue is not in the photo set, the job is not closed.

Full Breakdown

One cabinet, the whole machine

Recall the split system anatomy you already know: an outdoor unit with the compressor and condenser coil, an indoor unit with the evaporator coil and blower, and a field-installed line set carrying refrigerant between them. A package unit erases the split. The factory builds the entire refrigeration circuit, compressor, condenser coil, metering device, evaporator coil, plus the blower and the heat source, into one weatherproof cabinet, charges it, runs it, and ships it sealed.

That single fact changes your job in three ways:

1. **No line set.** Nobody brazed refrigerant lines on a rooftop in the wind. The circuit was assembled and leak-tested in a factory. Field refrigerant leaks on packs cluster at Schrader cores, service valves, and coils, not at field joints, because there are no field joints.
2. **The connections that remain are air, power, gas, and water.** A package install or changeout is ductwork, electrical, gas piping (on gas/electrics), condensate, and rigging. The refrigerant side mostly takes care of itself until something fails.
3. **Everything is outside.** The whole machine lives in the weather. Sun, rain, hail, and dust attack every component, including parts that would be protected indoors on a split system, like the blower motor, the control board, and the heat exchanger.

The trade calls these units packs, package units, packaged units, or, on commercial roofs, RTUs, which stands for rooftop units. Same machine, different slang.

The three families

Every pack you will ever touch belongs to one of three families, defined by how it heats.

Gas/electric packs. The workhorse. Cooling is the standard electric refrigeration cycle you know cold. Heating is a complete gas furnace section built into the cabinet: burners, igniter, flame sensor, induced draft motor, tubular heat exchanger, and a gas valve fed by a field-piped gas line, with combustion air drawn from outside and flue products leaving through a weather hood on the cabinet. Everything you learned in C18 about gas heat applies here, including manifold pressure at 3.5 inches WC on natural gas and 9 to 11 on LP, flame rectification, and the sacred rule that a cracked heat exchanger condemns the heat section. The differences are packaging: the heat exchanger sits downstream of the blower (the blower blows through it rather than pulling through it), and the flue terminates right at the cabinet instead of running up through a roof jack.

Heat pump packs. A packaged version of C19. Reversing valve, defrost board, defrost thermostat or sensor, and electric heat strips for supplemental and defrost-tempering heat, all in the one cabinet. In cooling, the unit runs exactly like a straight cool pack. In heating, the reversing valve sends hot discharge gas to the indoor coil and the outdoor coil becomes the evaporator. Everything you know about defrost cycles, the steam cloud that scares customers, and balance points carries over unchanged. One packaging note: because both coils share one cabinet, the nameplate and wiring diagram are your map for which coil is which; do not assume from position.

Straight cool with electric heat. Cooling only, with an optional electric resistance heat kit mounted in the supply air stream. Electrically this is the simplest family: no gas valve, no reversing valve, no defrost logic. In a mild Phoenix winter, resistance strips run few enough hours that plenty of buildings never justify anything more.

How to identify the family in ten seconds, before you open a panel: a gas line and a flue hood means gas/electric. No gas line, but a reversing valve visible through the compressor panel louvers or a defrost board on the diagram, means heat pump pack. Neither means straight cool, and the heat, if any, is strips.

> **PHOENIX FIELD NOTE**
>
> Phoenix is a package unit town. Decades of flat-roof and low-slope housing stock, block construction with no attic to spare, and mobile and manufactured home communities mean rooftop and ground-mount packs are everywhere. Some shops in other markets treat packs as a specialty. Here they are Tuesday. Learn this module like it is a core skill, because at Island Breeze it is.

Why package units exist

Packs win wherever a split system has nowhere to put its indoor half or no way to connect the two halves. The classic cases:

- **Mobile and manufactured homes.** There is no attic, no furnace closet sized for modern equipment, and the structure was often built around a packaged system from day one. Ground-mount packs beside the home, ducted into the belly duct, are the standard.
- **Flat-roof commercial.** Strip malls, offices, restaurants, shops. The roof is unused real estate, the ducts already terminate at the roof deck, and one curb-mounted RTU per zone keeps every noisy, serviceable component out of the rentable space.
- **Retrofit constraints.** Older flat-roof houses where the original gravity furnace or evaporative cooler footprint left no indoor mechanical space. A rooftop pack ducts straight into the existing ceiling plenum with no indoor demolition.
- **Serviceability and security.** Everything in one place, at one location, behind panels. No crawling an attic in August to reach the indoor half. The tradeoff is that the one place is a roof.

The efficiency tradeoff is real and worth knowing: a packaged unit gives up some efficiency to its split cousin because the whole machine, including the cold side, lives in the heat, and because compact cabinets constrain coil sizes. You can see it in the ENERGY STAR thresholds: a split heat pump must hit EER2 11.7 and HSPF2 7.8 for the label, while a packaged heat pump qualifies at EER2 10.6 and HSPF2 7.2. Same label, lower bar, because physics taxes the package.

Rooftop versus ground-mount, downflow versus horizontal

A pack connects to the building through exactly two air openings, supply and return. Where those openings point defines the installation style.

Downflow (rooftop on a curb). The supply and return openings face down through the bottom of the unit. The unit sits on a roof curb, and the duct connections drop straight through the roof inside the curb's perimeter. Conditioned air never sees weather; the curb encloses the penetration. This is the standard commercial arrangement and common on flat-roof homes.

Horizontal (rooftop or ground-mount). The supply and return openings face out one end or side of the cabinet. On a ground-mount, the unit sits on a level pad beside the building, usually a poured or prefab pad a few inches above grade for drainage, and ducts run horizontally through the wall or under the structure. This is the mobile home standard, with supply and return tying into the home's underbelly duct system. Horizontal rooftop installs exist too, with the unit on sleepers or a curb and ducts running across the roof into a penthouse or side penetration; every foot of duct exposed on a roof needs insulation and weatherproof cladding, and in our sun it needs them badly.

Many units convert between downflow and horizontal with factory panels, so read the install manual rather than assuming a unit only does one.

Two rules govern duct connections on any pack:

1. **Flexible connection at the unit.** A canvas or flexible collar between the unit and the rigid duct isolates vibration so the duct does not become a speaker broadcasting compressor hum into the building.
2. **Sealed and insulated, no exceptions.** A supply duct leaking into a 150 F roof cavity or radiating through bare metal on a roof deck throws away capacity before the air reaches a single register. The 400 CFM per ton you learned still has to arrive.

The roof curb and the curb adapter

A roof curb is a rectangular steel frame, typically 8 to 14 inches tall, anchored to the roof structure, leveled, and flashed into the roofing membrane by the roofer. Its job description has four lines:

- **Carry the weight.** The curb transfers the unit's weight, often 400 to 1,200 pounds on light commercial sizes, into the structure, not into the roofing material.
- **Seal the hole.** The supply and return penetrations live inside the curb's footprint, so the only weather barrier that matters is the curb-to-roof flashing and the gasket between the curb's top rail and the unit's base rails.
- **Gasket the unit.** A foam gasket tape goes on the curb rail before the set. The unit's weight compresses it into the air and water seal. Forget the gasket and the unit whistles, leaks air, and drips into the building on the first storm.
- **Keep the unit level and the condensate moving.** A level curb means coils drain and the condensate pan slopes the way the factory intended.

Division of labor, and it matters: the HVAC contractor sets the unit and owns the gasket and duct connections. The roofer owns the flashing and the membrane seal, and on most commercial roofs, letting anyone else cut or patch the membrane voids the roof warranty. When you find a leak at a curb, your finding may be real and the fix may still belong to a roofer. Document it, report it, do not freelance a tube of mastic onto somebody's warrantied membrane.

The curb adapter. Here is the retrofit problem: the existing curb was built for a unit made decades ago, and no current unit shares that footprint or duct opening layout. Tearing out the curb means roofing work, structural work, and interior work. The answer is a curb adapter: a custom transition frame that bolts to the existing curb, keeps the existing roof opening and duct drops, and presents a new top rail matched to the new unit's base and openings. Inside the adapter, sloped baffles redirect the airstreams from the old openings to the new ones.

Adapters are measured, ordered, and built per job: you supply the old curb's outside dimensions and duct opening locations and the new unit's model, and the fabricator does the rest. Two field truths about adapters:

1. **They are an airflow component, not just a spacer.** A short adapter that forces supply air through an abrupt offset adds static pressure exactly where you can least afford it. If the transition looks like a pinball machine inside, expect airflow complaints and check static once running.
2. **Gasket both joints.** Adapter to curb, and unit to adapter. Two rails, two gaskets, or you have built a two-story air leak.

> **PHOENIX FIELD NOTE**
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> Phoenix flat roofs are mostly foam or rolled membrane, and both punish sloppy curb work. Foam roofs get recoated every few years, and a curb that was flashed into the old coat sometimes gets buried sloppily by the next one; look for coating slopped over the gasket line. Membrane roofs pond near curbs that were set low. Photograph the curb perimeter on every visit, because the roof changes between your visits and the photo proves which trade touched it last.

Economizers: free cooling, real money

An economizer is a damper assembly bolted to the return side of a commercial pack that can cool the building with outdoor air instead of the compressor whenever outdoor air is cool enough to do the job. Offices, restaurants, and shops generate heat from people, lights, and equipment all year, so they often need cooling on a 58 F morning. Running a compressor to make 55 F supply air when 58 F air is sitting outside the damper is paying for something nature is giving away. That is the entire idea, and it is required by energy code on most new commercial equipment above a few tons.

The hardware. Two linked dampers driven by one actuator: an outdoor air damper and a return air damper, geared opposite each other, so as one opens the other closes. A hood with a bird screen and rain protection covers the outdoor intake. A barometric or powered relief damper lets the displaced building air escape. Sensors tell the logic when outdoor air qualifies. A small controller, factory or field installed, runs the show.

The logic, in plain order:

1. **Is outdoor air suitable?** This is the changeover decision. A **dry bulb** changeover compares outdoor temperature to a setpoint, commonly somewhere from 55 to 70 F depending on climate: below the setpoint, outdoor air qualifies. An **enthalpy** changeover measures total heat content, temperature plus humidity, because muggy 62 F air can carry more total heat than dry 70 F air. Differential versions compare outdoor air against return air instead of a fixed point and pick whichever is better.

2. **If suitable and there is a call for cooling:** the actuator modulates the outdoor damper open, the return damper closed, and the unit cools with outdoor air, compressor off. If outdoor air alone cannot hold setpoint, the compressor stages in as the second stage, dampers still favoring outdoor air.
3. **If not suitable:** the outdoor damper sits at **minimum position**, a small fixed opening that exists for ventilation, not cooling. Occupied buildings are required to bring in fresh air for the people inside, and minimum position is how a pack meets that requirement during every occupied hour, summer included.

Dry bulb versus enthalpy, the field reality. Enthalpy is the theoretically smarter changeover, but the humidity element in an enthalpy sensor drifts and fails far more than a simple temperature sensor, and a drifted enthalpy sensor makes bad decisions invisibly. In a dry climate like ours, outdoor humidity almost never disqualifies cool air, so a plain dry bulb changeover is the right tool: simpler, cheaper, and harder to break. Enthalpy earns its keep in humid markets.

How they fail, and what it costs. Field studies of small commercial rooftops keep finding that a large share of installed economizers, often around half, are not working at all. Nobody notices, because a pack with a dead economizer still cools; it just cools expensively. Know the failure directions:

- **Failed closed** (seized actuator, snapped linkage, dead controller): no free cooling, so every cooling hour is compressor hour, and no minimum position ventilation, so the building slowly goes stale. The energy waste hides; the IAQ complaints eventually surface.
- **Failed open**: the worst one. In summer, the unit invites 110 F outdoor air into the return and then pays the compressor to fight it, hour after hour. Cooling energy use can climb by a third to a half, capacity falls exactly on the days the building needs it most, and in cold climates a stuck-open damper can freeze hydronic coils overnight. A stuck-open economizer in a Phoenix August is a unit running flat out and losing.
- **Bad sensor or drifted changeover**: the subtle one. The dampers move, the logic runs, and the decisions are wrong: economizing on hot air or refusing free cooling on cool mornings. This is why newer energy codes require economizer fault detection and diagnostics built into the controller; you will see FDD lights and fault codes on current commercial packs.

Your minimum check on every commercial pack visit: note damper position on arrival against what conditions say it should be, stroke the actuator through its range from the controller or by jumper, confirm the linkage actually moves both dampers, and verify a sane minimum position on an occupied building. Five minutes, and it catches the most expensive silent failure on the roof.

PHOENIX FIELD NOTE

Phoenix gives an economizer fewer useful hours than a mild coastal market, but the hours it does give are real: winter middays and shoulder-season mornings when offices and restaurants still need cooling. The bigger Phoenix story is failure exposure. Actuators and damper bushings live at 150 F plus under that hood, blade gaskets cook and curl, and monsoon dust packs the intake screen and hood. Check the screen when you check the coils; a mud-caked hood screen chokes minimum position ventilation even when everything else works.

Service access: the panel map

Manufacturers vary, but the language of a pack cabinet is consistent enough that you can walk up to any brand and predict the layout:

- **Control/electrical panel.** Usually the smallest panel, often nearest the unit's power entry. Contactor, capacitors, transformer, control board, terminal strips, and the wiring diagram glued to the panel's inner face. The diagram on the panel is the single most valuable document on the roof; photograph it before you touch anything.
- **Blower and filter section.** The largest access, into the return airstream. Blower assembly, filters in racks, and on downflow units a view down into the return duct drop. Filters on packs are inside the unit, not in the building; a pack with mystery airflow problems often just has filters nobody knew existed.
- **Heat section** (gas/electrics). Burner compartment with the gas valve, igniter, flame sensor, and inducer; the flue hood lives on the outside of this panel. Combustion happens behind this panel, so gas-side rules from C18 apply in full.
- **Compressor compartment.** Compressor, often the reversing valve on HP packs, and service ports. The condenser coil wraps one or more full sides of the cabinet around this compartment, with the condenser fan discharging out the top.
- **Evaporator/coil access.** Sometimes shared with the blower section, sometimes its own panel, giving you the indoor coil face, the metering device, and the condensate pan.

Discipline points that matter more on roofs than anywhere else: pull the disconnect before opening compressor or control panels, bag every screw, and never leave a panel resting loose on the roof. A gust takes a panel off a three-story roof exactly once before you learn this the expensive way; learn it here instead.

Crane sets: the most dangerous hour of the trade

Packs above ground level go up by crane, and a crane set compresses more risk into one hour than anything else you will do in this career. The machine is heavy, it is in the air, and there are people, a building, and often live power lines in the picture. The way the trade keeps this safe is the same way aviation does: roles, rules, and language agreed on before anything leaves the ground.

The roles:

- **The crane operator** owns the crane: its capacity chart, its setup and outriggers, the load radius math, and the final no-go call. If the operator says the lift does not happen, the lift does not happen, and no schedule pressure overrides that.
- **The signal person.** Exactly one person directs the crane at any moment, using standard hand signals or a dedicated radio channel agreed on beforehand. The single exception that everyone on site holds: **anyone** may give the emergency stop signal, and the operator obeys it from anyone.
- **The riggers** attach the load. Slings rated for the weight, attached to the manufacturer's designated lifting points or lugs, with spreader bars when the manual calls for them so the slings do not crush the cabinet's top edges. The rigging diagram in the install manual is not a suggestion.
- **You, the technician,** own the readiness of everything that is not the crane: weights confirmed from the nameplate and submittal before the crane was even ordered, curb gasketed, shipping bolts and packaging

removed, panels latched, the roof path and set area clear, tag lines on the unit to control spin, and the building's people kept out of the swing path.

The rules you personally live by on a lift:

- **Never under the load. Ever.** The exclusion zone is the load's full travel path plus the area it could reach if anything let go, and nobody enters it while the load is in the air. You guide the unit onto the curb with tag lines and fingertips at the rail from outside the footprint, never with your body beneath steel.
- **Know the basic signals even when you are not the signal person**, so you can read the lift: hoist is a raised forearm with the index finger up, moving in a small circle; lower is an arm extended down, finger down, circling; emergency stop is both arms extended, hands swinging horizontally.
- **Power lines end lifts.** Cranes keep at least 20 feet from energized lines as the default rule. Spotting the line is everyone's job; managing the distance is the operator's.
- **Wind ends lifts.** Gusts turn a flat-sided cabinet into a kite. The operator makes the call, and a postponed set is a Tuesday, not a failure.

When the unit settles onto the gasketed curb, the rigging comes off only when the operator releases it, and then the set becomes an installation: duct connections, power, gas, condensate, controls, startup.

> **IB STANDARD**
>
> Island Breeze technicians never ride a load, never rig outside the manufacturer's lifting points, and never stay on a roof inside the swing path during a set. Before any crane day, the lead on the job confirms unit weight, curb readiness, and the signal plan with the crane company, and the morning starts with a two-minute all-hands huddle naming the signal person out loud.

Condensate on a roof

The evaporator in a pack still wrings water out of the air, and that water still needs a managed exit. Three things change on a roof:

1. **The trap is not optional and its depth is not arbitrary.** Pack evaporators sit on the negative pressure side of the blower, which means the blower is actively sucking air up the drain line. An untrapped or shallow-trapped drain will not drain at all; it will hold water in the pan while the blower holds it there. The trap depth must exceed the blower's negative static, which in practice means a trap 2 to 3 inches deep, primed with water, every time.
2. **The termination is a code and roofing question.** Condensate must go somewhere deliberate: a roof drain, a scupper, a downspout, or a piped run to grade, per the local jurisdiction. Letting it dribble onto the membrane next to the unit breeds algae, stains the fascia, degrades foam coatings, and creates a pond that finds the one flaw in the flashing. Maintain the 1/4 inch per foot slope on every horizontal run, and remember PVC on a Phoenix roof needs UV protection or it turns to chalk.
3. **Overflow risk is different, not absent.** A clogged drain on an attic air handler floods a ceiling; on a roof it floods the roof, which sounds harmless until the pan rusts out, the water tracks down the duct drop inside the curb, and a ceiling tile two floors down turns brown. Check the pan, the trap, and the termination on every maintenance visit, and blow or vacuum the line during monsoon season when algae growth is fastest.

PHOENIX FIELD NOTE

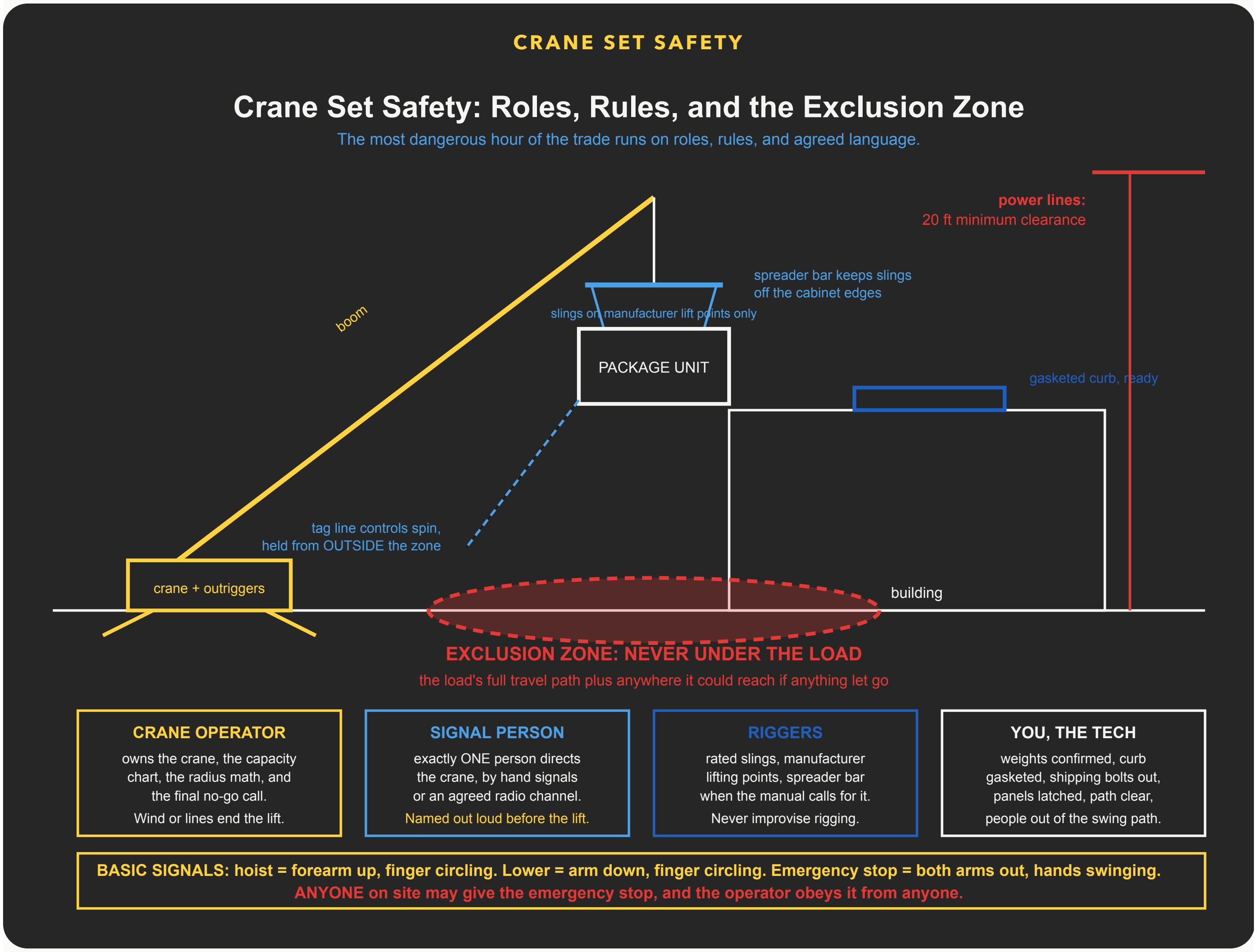
Summer on a Phoenix roof is its own hazard category, and packs put you there constantly. Roof deck surface temperatures run far above air temperature, radiating up at you while the sun works down. The F1 heat rules are not theory here: roof work scheduled for the early morning, a gallon of water minimum, and telling dispatch when your energy is dropping. The equipment ages the same way you do up there: sun-cooked wire insulation cracking at the first touch, run capacitors dying years early in 150 F plus cabinets (they are the single most common service call), hail-flattened condenser fins on the weather side, and a monsoon dust mat on the condenser coil that raises head pressure and cuts capacity. When you service a Phoenix pack, assume sun, hail, and dust have each taken their bite, and look for all three.

Common Mistakes

- **Treating a pack like a split with weird packaging.** The refrigeration circuit is the same, but the failure map is different: no line set leaks, but sun-killed capacitors, cooked wiring, dust-loaded condensers, and dead economizers instead. Diagnose the machine in front of you.
- **Missing the filters.** Pack filters live inside the unit on the roof, not in a hallway return grille. Buildings change hands, nobody tells the new owner, and the filters compost for years. Low airflow on a pack starts at the filter rack, every time.
- **Ignoring the economizer because cooling works.** A pack with a failed economizer still makes cold air, so the failure survives visit after visit. Stuck open wastes energy every hot hour; stuck closed starves the building of ventilation. Stroke the dampers on every commercial visit.
- **Skipping or shallow-trapping the condensate drain.** The negative-side drain physics get missed by techs who learned on furnaces with positive-side coils. No trap, no drainage, full pan, rusted cabinet floor.
- **Setting a unit on a dry curb.** No gasket, or a gasket laid crooked and gapped at the corners, means air leakage, whistling, and water intrusion that gets blamed on the roofer. Gasket the rail, lap the corners, set once.
- **Patching roof membrane yourself.** Your mastic on their warrantied membrane converts a roofing claim into your company's claim. Document the leak, photograph it, route it to the roofer.
- **Improvising rigging.** Slings around the cabinet because the lugs were inconvenient, no spreader bar because it was back at the shop, two people half-guiding a spinning unit from under it. Crane sets kill people in exactly these sentences. Rig per the manual, stay out from under, one signal person.
- **Treating the roof casually.** Walking backward near edges, leaving panels loose in the wind, soloing a summer roof with no water and no check-ins. The roof is part of the job hazard, not the commute to it.

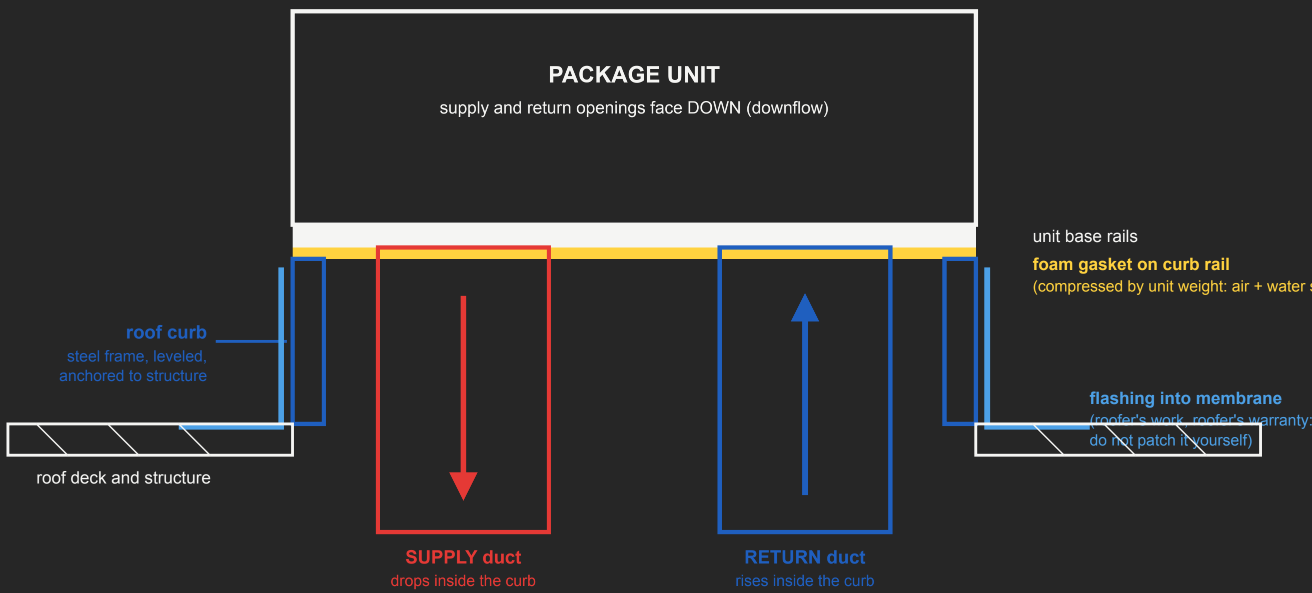
The pattern across every mistake: packs concentrate the entire system, and all of its risks, into one box in a harsh place. The techs who master them respect the box, the roof, and the crane in equal measure.

Module Visuals



Roof Curb and Downflow Duct Connections (Cross-Section)

The curb carries the weight, seals the hole, and keeps weather off the ducts.



Both penetrations live INSIDE the curb footprint, so conditioned air never sees weather.

RETROFIT: a custom CURB ADAPTER bridges an old curb to a new unit's footprint. Gasket BOTH rails. Watch added static.

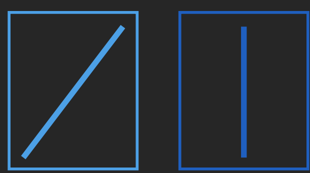
ECONOMIZER OPERATION

Economizer Operation: Damper Positions and Changeover Logic

Two linked dampers, one actuator: as outdoor air opens, return air closes.

MINIMUM POSITION

outdoor air too hot to help



OA damper cracked open | RA damper open

Ventilation only: occupied buildings are owed fresh air every hour

FREE COOLING

cool outdoor air qualifies, compressor off

OA damper modulating open | RA damper closing

Cooling with outdoor air instead of the compressor: free capacity

FAILED OPEN IN SUMMER

actuator dead, linkage broken, bad sensor

OA stuck open: 110 F air pours in | RA choked down

Compressor fights air it invited in: cooling energy up a third to a half

CHANGEOVER: is outdoor air suitable?

DRY BULB

temperature only, setpoint about 55 to 70 F
simple and tough: the right tool in a dry climate

ENTHALPY

total heat: temperature plus humidity
smarter in humid markets; sensors drift and fail

Differential versions compare outdoor air against return air and pick the better one

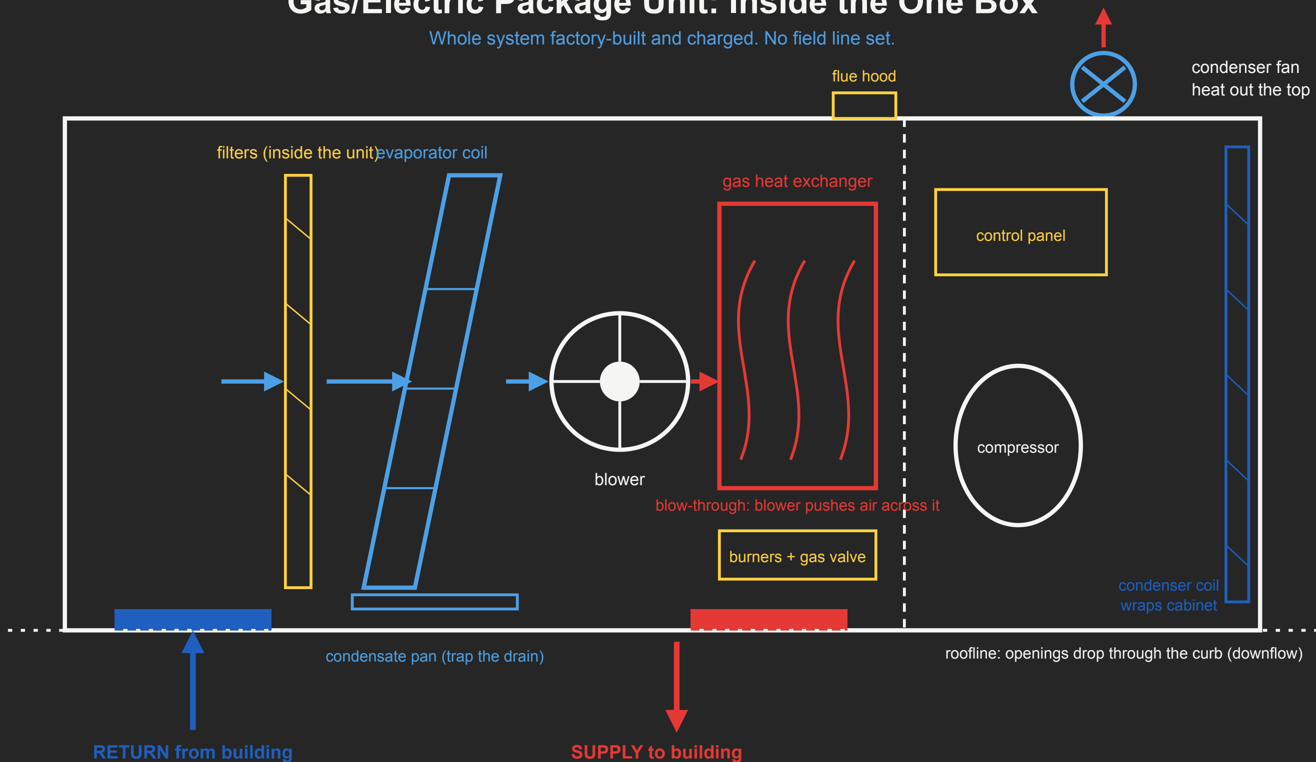
Field studies find about HALF of economizers not working. The unit still cools, so nobody notices.

Every commercial visit: note damper position, stroke the actuator, watch both dampers move, verify minimum position.

PACKAGE UNIT CUTAWAY

Gas/Electric Package Unit: Inside the One Box

Whole system factory-built and charged. No field line set.



Air path: return, filter, evaporator coil, blower, heat exchanger, supply. Compressor end rejects heat outdoors.

THREE PACK FAMILIES

The Three Package Unit Families

Sorted by how they heat. Cooling is the same refrigeration cycle in all three.

GAS / ELECTRIC	HEAT PUMP PACK	STRAIGHT COOL
HEAT complete gas furnace section: burners, heat exchanger, inducer (everything from C18 applies)	**HEAT** reversed refrigeration cycle: hot gas to the indoor coil (everything from C19 applies)	**HEAT** none, or optional electric resistance heat strips in the supply airstream
EXTRA PARTS gas valve, flame sensor, igniter, flue hood on the cabinet	**EXTRA PARTS** reversing valve, defrost board, strips for backup + defrost tempering	**EXTRA PARTS** heat kit with sequencers or contactors; simplest electrically
FIELD CONNECTIONS ducts, power, control, condensate, PLUS gas piping	**FIELD CONNECTIONS** ducts, power, control, condensate (no gas, no flue)	**FIELD CONNECTIONS** ducts, power, control, condensate (watch heat kit ampacity)
10-SECOND ID gas line + flue hood visible	**10-SECOND ID** no gas line; reversing valve and defrost board on the diagram	**10-SECOND ID** no gas line, no flue, no reversing valve
KEY NUMBERS manifold: 3.5 in WC natural gas, 9 to 11 in WC on LP	**KEY NUMBERS** ENERGY STAR package HP: SEER2 15.2, EER2 10.6, HSPF2 7.2	**KEY NUMBERS** ENERGY STAR package AC: SEER2 15.2, EER2 11.5
cracked heat exchanger condemns the heat section	**defrost steam clouds are normal, not smoke**	**fine for mild winters: strips run few hours here**

All three: one cabinet, factory-charged, no field line set. Connections are air, power, water, and sometimes gas.

R-410A packaged units: sell-through allowed until December 31, 2027 (longer than splits).