

Commissioning via Service Data (Hz, LEV Steps, Target SH)

YES Electric • Arc Workforce Academy HVAC Apprenticeship

Draft 1 (October 2026). This lesson is under review. Videos are made by other companies, not YES Electric; follow this lesson and your journeyman where they differ. Boxes marked "Shop photo coming" will get real photos from our shop in a later version.

Unit 9 • Ductless Mini-Splits • Job Function 18 • Appendix A Competency 49 (opens) — "Commission, test, and troubleshoot mini-split systems using manufacturer diagnostic procedures and error codes" **Class time:** ~6 hrs (1.5 video/discussion + 4.5 bench)

1. What you'll be able to do

By the end of this lesson you will be able to:

- Calculate a **weigh-in trim charge** from a unit's factory base charge, base line length, and per-foot charge factor — the primary charging method for inverter mini-splits.
- Correctly sequence charge release, weigh-in, and functional test — building directly on Lesson 9.2's install sequence steps 11–13.
- Access a unit's **service/test mode** and pull live operating data: compressor frequency (Hz), LEV (electronic expansion valve) step position, coil thermistor temperatures, and calculated superheat/subcooling.
- Explain why this service data — not a fixed gauge target — is the correct way to verify an inverter charge (the Lesson 9.1 idea, now put into practice).
- Record a complete commissioning baseline that makes this unit diagnosable by anyone who services it in the future.

2. Tools & materials

- Digital refrigerant scale (accurate to the manufacturer's stated precision, typically 0.1 oz / a few grams)
- Manifold gauges rated for the system's refrigerant, hoses with low-loss fittings
- Clamp meter, digital multimeter
- The shop unit's specific service manual (Hz/LEV/thermistor access varies by brand — do not assume one brand's procedure applies to another)

- Manufacturer or third-party commissioning tools where available in the shop: brand service apps (e.g., manufacturer diagnostic apps, SNET Pro-style tools), or a universal tool like MeasureQuick/EEVMate if the shop has one
- Commissioning record form / invoice template with fields for Hz, LEV steps, SH/SC, pressures, temps, amp draw

3. Watch first

Order	Video	Channel	Length	Why
1	Weighing in the Correct Amount of Refrigerant in a Mitsubishi Mini Split Unit!	AC Service Tech	9:10	The core weigh-in procedure this lesson is built around
2	Steps to Vacuum and Charge Refrigerant on a Mini Split Unit!	AC Service Tech	15:08	Full sequence from evacuation through charge, ties back to Lesson 9.2
3	Checking the Refrigerant Charge on a Running R-410A Inverter MINI SPLIT Unit!	AC Service Tech	12:28	Verifying a charge on a running inverter system — no fixed target, reading the actual behavior
4	Commissioning Samsung HVAC Units Like a PRO!	Taddy Digest	6:13	Brand-specific service-mode/ commissioning walkthrough
5	Cornerstones of Inverter-Based Equipment Commissioning with Chris Hughes and Adam Mufich	HVAC School	43:07	Re-watch from Lesson 9.1 with today's practical lens — the theory now has hands behind it
Reference	Ductless Mini-Split Single & Triple Evacuation Method! Step By Step & Opening Valves!	AC Service Tech	20:41	The valve-opening sequence for releasing factory charge, brand-general

4. The idea

The charging method: weigh-in first, service data confirms

Lesson 9.1 established that inverter systems don't hold to one fixed superheat/subcooling number the way Unit 5's fixed-speed charging lessons taught — the board is constantly modulating. That means **you cannot charge a mini-split by "adding refrigerant until the gauge hits a number."** The correct method is:

1. **Weigh in a calculated charge** based on the manufacturer's factory base charge plus a per-foot trim for any line length beyond the base allowance.
2. **Verify** the result using the unit's own service data — not by chasing a gauge number.

Calculating the trim charge

Every mini-split ships **pre-charged from the factory for a base line-set length** — commonly somewhere around 25 feet, but this varies by model and **MUST** be read from that specific unit's spec sheet or nameplate, never assumed. If your actual line-set length (measured in Lesson 9.2, Step 1) exceeds that base length, the manufacturer specifies a **charge factor per foot** (in ounces or grams per foot, specific to the liquid line diameter) that you add:

$$\text{Trim charge} = (\text{actual line length} - \text{base length}) \times \text{charge factor per foot}$$

Real worked example, pulled from an actual manufacturer install manual (an ICP/Carrier-family ductless system): a 9,000 BTU unit ships with a 2.65 lb factory charge good for lines up to 25 ft, with a charge factor of 0.16 oz/ft (cooling-only model). A second brand's 24,000 BTU single-zone unit, same 25 ft base allowance, uses a 0.161 oz/ft factor and shows the arithmetic right in the manual: **30 ft actual – 25 ft base = 5 ft over base. 5 ft × 0.161 oz/ft = 0.81 oz additional refrigerant.** Notice both real brands land in the same 0.16 oz/ft neighborhood for a small-line liquid run — but neither matches the other exactly, and a heat-pump version of the same ICP unit jumps to 0.22 oz/ft. **Pull the actual factor from the spec sheet or nameplate every time** — the two real examples above are close enough to sanity-check your math against, not close enough to substitute for the real number.

- If your line set is **UNDER** the base length, some manufacturers call for a charge **REDUCTION** (recovering a small amount) — check the spec sheet; don't assume shorter is always fine as-is.
- Weigh with the digital scale zeroed and the refrigerant tank/cylinder on the scale, add through the manifold's liquid-line port with the system in the correct state per manufacturer instructions (often with the unit calling for cooling in a forced test mode so it can actively draw the charge in).

TRIM CHARGE CALCULATION



REAL MANUFACTURER EXAMPLE:

30 ft actual – 25 ft base = 5 ft over base. 5 ft × 0.161 oz/ft = 0.81 oz trim charge to add.



Weigh in through the liquid line port, system in manufacturer-specified charging state

Releasing the factory charge — sequence matters, and there is no universal default

Before adding any trim charge, the factory charge already inside the outdoor unit has to be released into the line set and indoor coil by opening the service valves. **Do not memorize one order and apply it to every brand** — pulled install manuals across several major manufacturers show real disagreement on this point:

- Several brands simply say to fully open both the low-pressure (suction) and high-pressure (liquid) valves as one combined step, without specifying which goes first.
- At least one manufacturer is explicit that the **suction (low-pressure) line valve must open FIRST**, with a stated mechanical reason: opening the liquid line valve first, while the system is still in a deep vacuum, can pull oil into and clog the capillary tube on models that use one as part of the metering circuit. Opening suction first prevents that pressure differential from forming.

The lesson underneath the disagreement: **read the label on the service valve cover of the specific unit you're working on** — manufacturers print the sequence there for a reason, and guessing based on what you remember from a different brand's system is exactly how you'd trap charge or introduce a restriction on a unit whose design assumptions are different from the last one you serviced. Use the correct hex key size for the valve stem, and turn each valve fully open until it stops against the valve body (back-seated) — do not force it further once it stops.

Why "do not force it" is a real mechanical warning, not just caution

A mini-split service valve stem has a hard stop when it's fully back-seated — and that stop exists because the stem is held captive by an internal retaining ring (a split ring, similar in concept to a

snap ring). **Keep turning past that stop and you can pop the retaining ring, and the entire inner cylinder of the valve stem can come out — releasing the system's full charge uncontrolled, fast, and with the stem assembly potentially ejecting under pressure.** This isn't a hypothetical: it's a documented failure mode field techs are specifically warned about. The fix is simple and absolute: turn the hex wrench until you feel it stop, and stop. If the valve feels like it should open further, it doesn't — check that you have the correct wrench size and that you're turning the right direction before you ever consider applying more force.

Verifying the valve core itself doesn't leak

Anywhere you've removed a Schrader-style valve core (to speed up evacuation — see below — or to access a port), reinstalling it is not automatically leak-tight. After threading the core back in with a valve-core installation tool, **test the core's seal directly**: thread on a service cap that has a small pre-drilled test hole in its top, apply bubble solution to that hole, and watch for a full minute. A bubble forming means the core itself is seeping and needs to be reseated or replaced — found now, on the bench essentially, instead of as a slow leak discovered on a callback months later.

Protecting your evacuation tools from contamination

If you're isolating a micron gauge from the vacuum pump with its own valve (rather than reading straight through the pump's own gauge), a clean way to do it: thread a second valve-core-removal tool inline just ahead of the micron gauge, in the closed position, so the gauge's sensor is only exposed to the system once you deliberately open it. This keeps refrigerant oil and system debris away from the gauge's sensing element during pump-down, which protects its accuracy over the life of the tool — a \$200+ micron gauge that's been fouled with oil reads wrong long before it fails outright, and a wrong reading here undermines the whole commissioning record.

Getting into service/test mode

Every major brand provides a way to force the unit into a diagnostic or test mode that reveals live operating data instead of just running normally. **How you get there is different for every brand** — common patterns include:

- A physical button combination or DIP switch/jumper on the outdoor board ("test pins" or "forced operation" mode)
- A code entered on the wired controller's service menu
- A sequence on the wireless remote (often documented in the install/service manual, not the owner's manual)
- A manufacturer app or service tool connected via Bluetooth/USB/cloud (brand ecosystem-specific)

Look it up for the specific unit you're on — every time. Guessing at a service-mode sequence risks putting the unit into an unintended forced-operation state (e.g., forced defrost or a factory test that isn't what you meant to trigger).

Reading the data that matters

Once in service/test mode (or sometimes even during normal operation via the wired controller's monitor screen), pull:

Data point	What it tells you
Compressor frequency (Hz)	How hard the board is currently driving the compressor — context for every other number, since a system at 30 Hz and a system at 90 Hz will show different "normal" pressures and temps
LEV (EEV) step position	How far open the electronic expansion valve is (often expressed as a step count out of a max, e.g., 0–480 steps) — tells you if the board is metering normally or hunting/maxed out
Coil thermistor temperatures (indoor coil, outdoor coil, sometimes discharge/suction)	The board's own sensor readings — often more trustworthy than a clamp-on gauge/temp reading because it's what the board itself is actually using to make decisions
Calculated superheat/subcooling	Some service tools/apps compute this live from the thermistor and pressure data — compare against the manufacturer's target chart for the current Hz/conditions, NOT a single fixed number

The verification logic: at the Hz the compressor is currently running, does the reported SH/SC fall within the manufacturer's expected range for that operating point? That's a real answer. "Is subcooling at 12°?" without knowing the Hz is not a real question on this equipment.

SERVICE MODE DATA READOUT

COMPRESSOR FREQUENCY ... 62 Hz

LEV STEP POSITION ... 210 / 480

INDOOR COIL TEMP ... 48F OUTDOOR COIL TEMP ... 96F

CALCULATED SUPERHEAT ... 9F SUBCOOLING ... 11F

**Compare SH/SC against the manufacturer chart
for THIS Hz — not a single fixed target.**

Why "3°F superheat" can be a perfectly healthy reading

If Unit 5's fixed-speed training is still your instinct, a superheat reading of 3–4°F will look alarming — on a fixed-orifice or TXV system that low usually means liquid is about to slug the

compressor. **On a healthy mini-split it can be completely normal.** Most inverter outdoor units have an **accumulator tank** ahead of the compressor that catches and meters any stray liquid before it reaches the compressor's suction port — the same protective role Lesson 1.1's suction-line discussion foreshadowed, just engineered directly into the unit instead of left to line design. That protection is exactly why these systems can be run, safely and by design, at superheat values that would be a red flag anywhere else in this program. Don't "fix" a low superheat reading on a mini-split before confirming it's actually a problem — compare it against the manufacturer's chart for that Hz, the same rule as every other reading on this equipment.

A real, checkable delta-T target for verification

Alongside SH/SC, a simple return-air-to-supply-air temperature split is a fast, non-invasive health check: **mini-splits typically run a 25-30°F delta-T, commonly landing right around 28°F** — noticeably higher than the ~20°F rule of thumb you learned for standard split systems in Unit 7. Run the unit at full stage (not idling at low Hz) before you take this reading, since a system loafing at low speed won't show its real number. A ductless system running full-speed with only a 20°F split is a system with a real problem — that's YOUR unit's fixed-speed-era target, not this one's.

The non-invasive-first philosophy — because these systems barely hold any charge

A mini-split's total factory charge is small — commonly just a couple of pounds. That has a direct consequence for how you approach a maintenance call: **don't reflexively hook up gauges every visit.** Every time you connect a hose set, a small amount of refrigerant is lost to the hose volume and connection process — trivial on a 10 lb residential system, meaningful on a 2 lb mini-split repeated over several service visits a year. The discipline:

1. **Check first, without connecting anything:** run the unit at full stage and read the delta-T (above). A healthy split with no customer complaint is a system you leave alone.
2. **Only escalate to gauges on a real red flag:** a warm suction line, ice forming on the liquid/expansion line specifically (not the suction line — a different signature than a standard split system's classic freeze-up), or an audible sloshing/gurgling sound at the indoor unit are all real indicators of a charge problem worth investigating further.
3. **When you do need to weigh in, minimize hose-volume loss.** A full hose set can hold several ounces of refrigerant — significant against a 2 lb total charge. Use the shortest hose you have (a 4-6 ft hose beats a 6 ft coil-up set), ideally with a probe/ball-valve setup: purge and bleed the hose first, zero the scale, then open the ball valve so only what crosses that point counts against the system — not what's sitting in the hose itself.

Recording the baseline — the gift you give the next tech

Commissioning isn't done when the number looks right once — it's done when it's **written down**. Record, on the invoice or commissioning form:

- Hz at a stable test-mode operating point

- LEV step position
- Suction and discharge (or liquid) pressures and line temps
- Calculated SH/SC and the Hz they were read at
- Indoor and outdoor ambient temperature at time of commissioning
- Compressor amp draw
- Any fault codes present or cleared during startup

This baseline is what turns Lesson 9.7's fault diagnosis from a guessing game into a comparison. A tech who shows up in year 4 with a vague complaint and this baseline on file has a real diagnostic starting point; a tech with nothing has to build the whole picture from scratch under pressure with an unhappy customer watching.

5. Bench procedure

Continuing directly from the Lesson 9.2/9.3/9.4/9.5 mock install — pressure test and evacuation already complete.

1. **Pull the real numbers.** From the shop unit's spec sheet, record: base charge, base line length, charge factor per foot, and this specific unit's actual measured line length (from your Lesson 9.2 notes).
2. **Calculate the trim charge** by hand, show the arithmetic, have your partner independently check it.
3. **Release the factory charge** per the sequence printed on the unit's service valve label — narrate each step (which valve, which direction, how you confirmed fully open by feel, stopping the instant it stops — no forcing). If a valve core was pulled earlier in the job, reinstall it now and verify its seal with the pre-drilled test cap + bubble solution before moving on.
4. **Weigh in the calculated trim charge** using the digital scale, through the correct port, with the system in the state the manufacturer specifies for charging (often a forced cooling test mode).
5. **Enter service/test mode** per this specific unit's documented procedure — look it up, don't guess.
6. **Record the live data set:** Hz, LEV steps, thermistor temps, calculated SH/SC, at a stable operating point. Compare against the manufacturer's chart or app for that Hz.
7. **Run the full functional test:** cooling, heating (if heat pump), fan-only — confirm normal operation with no fault codes across all modes tested.
8. **Complete the commissioning record** with every field from §4's baseline list, as if handing this job file to a stranger who'll service it in five years.

Checkout (graded, pass/redo): Student independently calculates a trim charge from given spec-sheet numbers, correctly sequences charge release and weigh-in, accesses service mode on the shop unit, and produces a complete, correctly-filled commissioning record. This opens Competency 49.

6. Field gotchas

- **Charging "until the gauge looks right" on an inverter system is a rookie mistake carried over from Unit 5 habits** — the weigh-in + service-data method is the only reliable approach here, every time.
- **Assuming a base line length or charge factor instead of reading the spec sheet** turns a precise calculation into a guess — the numbers are printed for a reason, use them.
- **Guessing at a service-mode entry sequence** can accidentally trigger the wrong forced-operation state — look up the correct sequence per brand and model.
- **Reading SH/SC without noting the Hz it was measured at** produces a number that means nothing on its own — always pair them.
- **Skipping the written commissioning record "because the unit's running fine"** is exactly how a future diagnostic call turns into hours of guesswork instead of minutes of comparison.
- **Confusing a factory-forced test mode with normal operation** — data pulled in test mode may run the compressor at a fixed test frequency, not real-world modulation; know which state you're reading before you interpret the numbers.
- **Forcing a service valve stem past its stop "because it feels like it should open more"** can pop the internal retaining ring and release the full charge uncontrolled — stop the instant the wrench stops turning, every time, no exceptions.
- **Skipping the valve-core leak test after reinstalling one** leaves a slow leak undiscovered at the exact point you just had open — thirty seconds with a test cap and bubble solution catches it while you're still standing there.
- **"Fixing" a low superheat reading on a healthy mini-split** because it looks wrong by fixed-speed standards is a real rookie mistake — verify against the manufacturer's chart before you touch anything.
- **Grading a mini-split's temp split against the standard-split ~20°F rule** will make a perfectly healthy 28°F-delta-T system look broken, or vice versa — use the right target for the equipment in front of you.
- **Hooking up gauges on every routine maintenance visit** slowly bleeds down a system that barely holds any charge to begin with — check delta-T first, escalate only on a real red flag.

7. Competency link

- **Competency 49 (opens)** — "commission, test, and troubleshoot mini-split systems using manufacturer diagnostic procedures" begins here with the commissioning half; troubleshooting/fault codes complete it in Lesson 9.7.
- Directly extends Lesson 9.2's install-sequence steps 11–13 (charge, functional test, commission/record) into full procedural depth.
- Built entirely on Lesson 9.1's core idea (no fixed target, read the board's own data) — this is that theory lesson made into hands.

8. Check yourself

1. Write the trim charge formula from memory and explain each term.
2. Why is charging "until the gauge hits a familiar number" the wrong method on an inverter mini-split?
3. What determines the correct order for opening the outdoor unit's service valves, and where do you find it?
4. Name the four pieces of service data this lesson says to pull, and what each one tells you.
5. Why is a superheat/subcooling reading meaningless without also knowing the compressor's Hz at that moment?
6. What are three different ways a brand might let you enter service/test mode?
7. List at least six fields that belong on a complete commissioning record.
8. A unit's actual line-set length is 10 feet SHORTER than the factory base length. What should you check before assuming no charge adjustment is needed?
9. Why might data pulled while the unit is in a forced test mode look different from data pulled during normal operation?
10. A future tech, five years from now, opens this unit's file and finds a complete commissioning record from today. What specifically does that let them do that they couldn't do without it?
11. What physically happens inside a service valve if you force the stem past its back-seated stop, and why is that dangerous?
12. After reinstalling a valve core, how do you verify it doesn't leak, and why not just trust that it's fine?
13. Why isolate a micron gauge with its own valve-core-removal tool instead of reading straight off the vacuum pump's gauge?
14. Why can a mini-split run a healthy 3–4°F superheat when that same reading would signal a serious problem on a Unit 5 fixed-orifice system?
15. What's the typical delta-T target for a mini-split running full stage, and how does it compare to a standard split system's target?
16. Describe the non-invasive-first check sequence for a maintenance call, and name the three red flags that justify hooking up gauges.
17. Why does hose length/volume matter more when weighing in a mini-split's charge than a standard residential split system's charge?