

The Sequence of Operation: the Diagnostic Backbone

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 7 • Gas Furnaces & Straight AC • Appendix A Comp 27 (the core) Class time: ~4 hrs
(1 video + 3 watch-and-narrate bench)

1. What you'll be able to do

- Recite the **gas furnace sequence of operation** from a cold call to steady heat — every step, every actor, every proof — and recite it backwards through shutdown.
- **Watch a furnace fire and narrate it live**, matching each sound/light to the step ("inducer... switch proved — there's the igniter glow... valve open, light-off... sense current's holding... blower delay... blower").
- Use the sequence as a **diagnostic address system**: any failure = the FIRST step that didn't happen; everything after it is innocent-by-sequence (6.6's logic question, furnace edition).
- Time the steps against spec (prepurge seconds, igniter warm-up, flame-proving window, blower delay) and spot a step that's present-but-wrong (slow glow = dying igniter).
- Hold the whole of 7.3–7.5 as a map: each upcoming lesson is one or two steps of THIS sequence, zoomed in.

2. Tools & materials

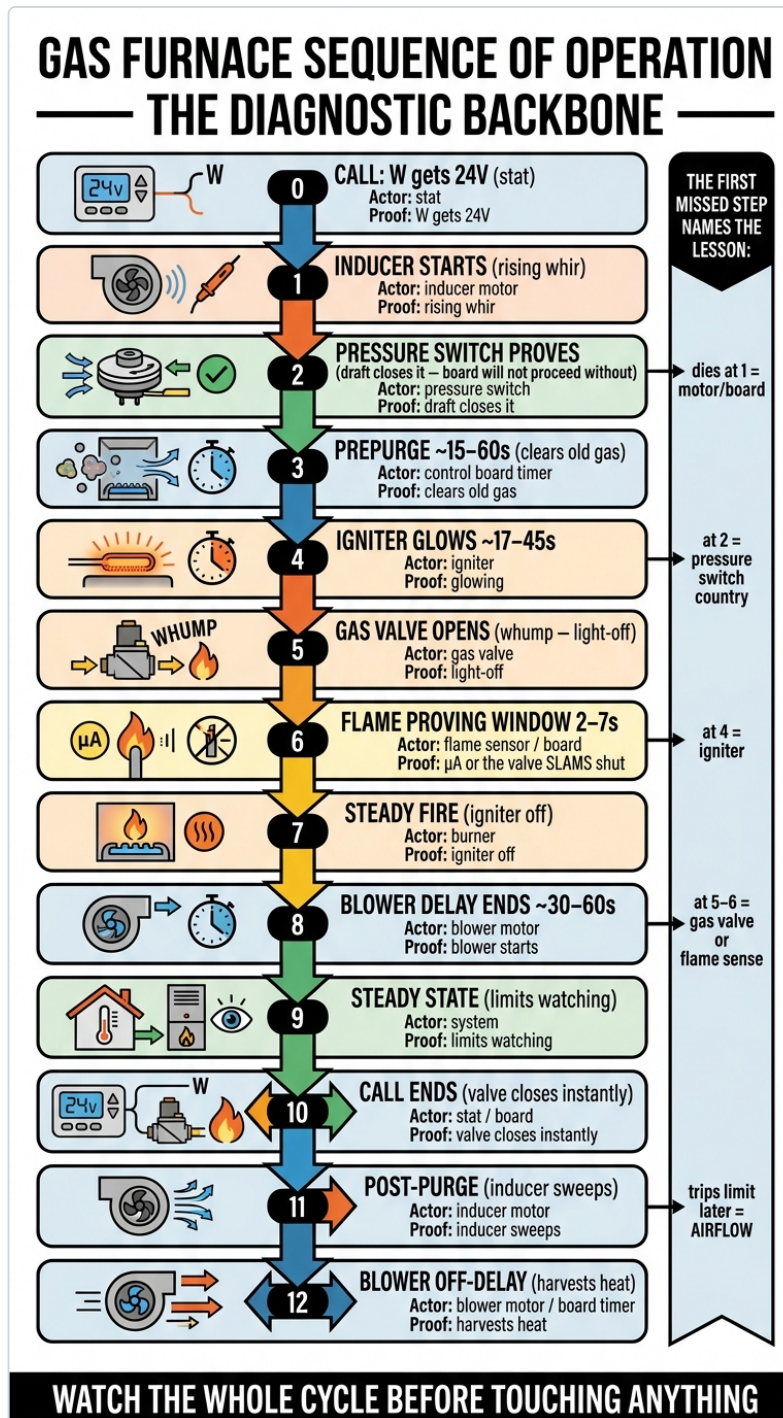
- The live donor furnaces (80 + 90) with doors off and the door-switch held (instructor-supervised — the watching lesson)
- Stopwatches; the sequence narration card (ours); flashlights angled at igniter + burners
- The board's LED legend (7.1/6.6)

3. Watch first

Order	Video	Channel	Length	Why
1	Gas Furnace Sequence of Operation	AC Service Tech	3:24	The steps, tight
2	Why the Sequence Is Important — Troubleshooting	AC Service Tech	7:35	The diagnostic frame
3	HVAC Furnace Sequence of Operation	HVAC School	41:45	The deep version with variations

4. The idea

The sequence (single-stage HSI, the reference standard)



#	Step	Actor	Proof / time
0	Call: W gets 24 V	stat (6.3)	board LED wakes
1	Inducer starts	board → inducer	rising whir
2	Pressure switch closes	draft pulls the switch CLOSED	board hears "draft proven" — won't proceed without it
3	Prepurge	board waits (~15-60 s)	clears any gas from the last attempt — patience by design
4	Igniter energizes	board → HSI	orange glow building ~17-45 s (or spark clicking)
5	Gas valve opens	board → 24 V to valve	soft whump — light-off across the burners
6	Flame proving window	flame sensor → board (μA — 7.4)	~2-7 seconds to prove or the valve SLAMS shut
7	Steady fire	valve held open by continuous proof	igniter off; flame blue and tight
8	Blower delay ends	board timer/temp (~30-60 s)	house air starts moving warm
9	Steady state	all hold	limits watching (7.9's temp rise)
10	Call ends: W drops	stat	valve closes instantly, flame dies
11	Post-purge	inducer runs on (~15-30 s)	sweeps the exchanger
12	Blower off-delay	(~60-180 s)	harvests remaining heat (7.1's "engineered delay")

Retries & lockouts: no flame proof → board re-tries (typically 3 attempts with purges) → **lockout** (LED code; 1-hour auto-reset or power-cycle). Mid-cycle flame loss → instant valve close → re-try. Pressure switch opening mid-fire → valve closes NOW (the drafting failed — 7.5's wind/vent stories).

Why the sequence IS the diagnosis

Every step is a checkpoint with a proof. The furnace can only die at a checkpoint, and the FIRST missed checkpoint names the lesson:

- Dies at 1 (no inducer) → motor/board (6.2/6.6).
- Dies at 2 (inducer runs, never proves) → **pressure switch country** (7.5: switch, hose, drain, vent).
- Dies at 4 (no glow) → igniter circuit (7.3).
- Dies at 5-6 (glow, no light-off / lights & drops) → gas valve/pressure (7.6) or **flame sense** (7.4).
- Runs then trips limit → airflow (7.9).

That's lesson 7.11's whole capstone tree — planted today. **Watch first, touch second:** a full observed cycle (90 seconds) localizes the fault before a single meter lead lands; it's the cheapest diagnostic instrument you own.

Variations to recognize (not master yet)

Two-stage (low-fire light-off, board steps up), spark/intermittent-pilot (clicks instead of glow — 7.3), older standing-pilot (thermocouple world — museum piece but Alabama attics keep museums), modulating/communicating (the sequence lives in software; the LED becomes a screen). The reference sequence is the skeleton key — variations decorate it.

5. Bench procedure

1. **Narrated cycles (the heart):** instructor fires the 90% — full class narrates together against the card, twice. Then EACH student narrates a cycle solo, naming steps as they happen. Stopwatch on: prepurge, glow time, proving window, blower delay — logged vs the manual's spec.
2. **The backwards drill:** narrate shutdown (10→12) — the post-purge and off-delay get named (and the "it keeps running" customer myth dies — 7.1).
3. **Spot-the-step rounds:** instructor rigs ONE fault per round (stat wire off = dies at 0; pressure hose pulled = dies at 2; igniter unplugged = dies at 4; flame rod unplugged = lights-and-drops at 6): class calls the dying step FROM OBSERVATION ONLY — no meters allowed this lesson. The verdict format: "died at step , **that's lesson 7.'s** territory."
4. **The 80% comparison cycle:** same narration on the 80 — hear/see the differences (hotter flue, no condensate gurgle).
5. **Lockout & recovery:** let the rigged no-flame attempt run to lockout: count the retries, read the code, recover correctly (power cycle vs wait — per the legend).
6. **Timing forensics:** the "slow glow" igniter (our aging demo HSI): present-but-wrong steps get caught by the stopwatch (32 s to dull orange = 7.3's patient next week).

Checkout: one solo narrated full cycle (steps + times) + three spot-the-step rounds correct with the right lesson-address. **Comp 27's backbone laid.**

6. Field gotchas

- **Watch the WHOLE cycle before touching anything** — techs who start pulling wires mid-sequence create second faults and erase the evidence.
- **The door switch** (3.1, forever): holding it closed to observe = deliberate, instructor-style, documented. Tape is for boxes, not safety switches — and never leave it bypassed.
- **Three faults share the "no heat" complaint;** the sequence splits them in one observed cycle. Dispatch notes that say WHERE it dies cut repair time in half — write them.
- **Retries hide intermittents:** a furnace that proves on attempt 3 every cold morning "works" — the stopwatch + sense-current trend (7.4) catch the decay before the lockout call.

- **Post-purge ≠ malfunction; off-delay ≠ malfunction.** Two customer-education moments per maintenance visit.
- **Two-stage furnaces idle at low** — supply air "feels cooler" by design; check the staging call before "weak heat" goes on a ticket.

7. Competency link

- **Comp 27 core** — the spine that 7.3 (ignition), 7.4 (flame sense), 7.5 (pressure/vent), 7.6 (gas), 7.9 (limits/airflow), and 7.11 (capstone tree) all hang from.
- The watch-first discipline =, made muscle.

8. Check yourself

1. The full sequence 0–12, with each step's proof.
 2. What two things does prepurge protect against?
 3. The proving window: how long, and what happens at timeout? After three timeouts?
 4. Inducer runs forever, nothing else happens. Step? Suspect family? Lesson?
 5. Glows beautifully, no whump. Step? Two suspects?
 6. Lights, runs 4 seconds, dies, retries. Step? The famous lesson it points to?
 7. Why does mid-fire pressure-switch opening close the valve instantly?
 8. What does a 32-second crawl to dull orange tell you that "it glows" misses?
 9. Why narrate before metering — give the two reasons (evidence preservation + localization).
 10. Write the dispatch note for: cycle observed, dies after glow with no light-off, three retries to lockout, code 33.
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