

Furnace Anatomy: 80% vs 90%+, Every Part Named

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 (begins) Class time: ~4 hrs (1.5 video + 2.5 panels-off bench)

1. What you'll be able to do

- Walk a furnace top to bottom with the panels off and **name every part and its job**: inducer, pressure switch(es), igniter, burners/orifices, gas valve, flame sensor, heat exchanger(s), limits & rollouts, blower, the IFC (6.6's patient).
- Split the world at **80% vs 90%+ (condensing)**: one heat exchanger + metal flue vs two heat exchangers + PVC + condensate — and READ a furnace's family from ten feet (flue material is the tell).
- Trace BOTH airstreams and never mix them: **combustion air path** (in through the burner box, out the flue) vs **house air path** (return → blower → over the exchanger → supply) — separated by the heat exchanger wall, which is the entire safety story of gas heat.
- Identify orientation/types: upflow, downflow, horizontal; single-stage vs two-stage vs modulating valves & boards (the staging preview).
- State what condensing buys (the extra ~15% lives in the flue gas's water vapor) and what it costs (acidic condensate, drains, PVC rules — 7.5/7.8).

2. Tools & materials

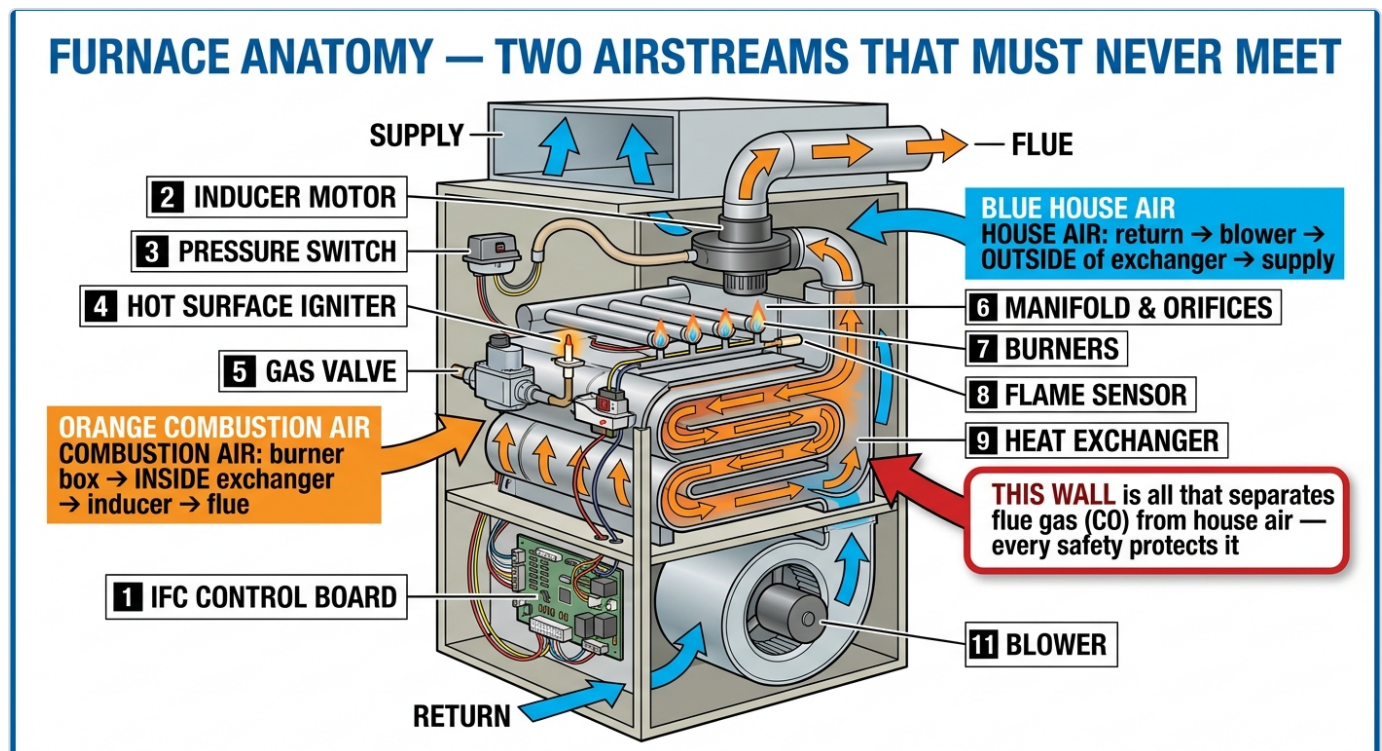
- Donor furnaces: one 80% (B-vent), one 90%+ (PVC, secondary exchanger visible) — panels off, tagged-out
- Parts wall additions: gas valves (single/2-stage), HSI + spark igniters, flame rods, pressure switches, limits/rollouts, an orifice spud set, a cut-open heat exchanger (our most important prop — source one from a changeout)
- Flashlights, inspection mirrors

3. Watch first

Order	Video	Channel	Length	Why
1	Gas Furnace Parts and Functions — Operation Explained	AC Service Tech	18:46	The tour
2	Explaining Furnace Basics to Your Apprentice	AC Service Tech	17:49	The 80 vs 90 split, taught plain
3	Gas Furnace Overview	ACST x HVAC School	34:39	Both instructors, full depth
4	5 Parts That MUST Be Cleaned	AC Service Tech	3:34	Maintenance hooks
Reference	Gas Furnace Training Class	AC Service Tech	1:20:49	The long-form for review week

4. The idea

The two airstreams (the safety frame everything hangs on)



A furnace is two air systems that must NEVER meet:

- **Combustion side:** air + gas burn IN the heat exchanger tubes/clamshells; the inducer pulls the flame's exhaust through and out the flue. Everything on this side is the "fire circuit": burners, orifices, igniter, flame sensor, exchanger interior, inducer, flue.
- **House side:** the blower pushes return air ACROSS the exchanger's outside surface and on to the supply. House air touches only the exchanger's OUTER skin.

The heat exchanger wall is the only thing separating flue gas (with its CO) from the home's air. Every safety on the unit exists to protect that separation or react to its failure — which is why exchanger inspection (7.8) is a solemn job and why "cracked heat exchanger" is the phrase that red-tags furnaces.

The cast, in firing order (7.2 will make this a sequence)

1. **IFC board** (6.6) — the conductor.
2. **Inducer motor** — runs FIRST, creates draft, proves it through the...
3. **Pressure switch(es)** — NC-logic prove-it devices (3.3): "draft exists, safe to light."
4. **Igniter** — HSI (hot surface, glows) or intermittent spark.
5. **Gas valve** — 24 V operated (3.6's three questions apply), single/2-stage/modulating; feeds the...
6. **Manifold & orifices** — the metering jewelry (LP vs NG lives here — 7.7).
7. **Burners** — flame spreads across; at the end of the row sits the...
8. **Flame sensor** — a rod proving fire exists via flame rectification (7.4's whole lesson).
9. **Heat exchanger** — primary (all units); + **secondary** (condensing — pulls the latent heat out of the exhaust water vapor; 1.5's latent lesson, running backwards!).
10. **Limits & rollouts** — the temperature police: high limit (overheat = airflow problem, 7.9), rollout switches (flame escaping the box = RED FLAG, manual reset, never jumper).
11. **Blower** (6.1/6.2) — runs LAST on a delay (harvest the exchanger's heat without blowing cold first).

80% vs 90%+ — the family split

	80% (Category I)	90%+ (Category IV, condensing)
Exchangers	primary only	primary + secondary (stainless/coated — acid country)
Flue	metal B-vent , buoyant draft assist	PVC , pressurized by the inducer
Exhaust temp	hot (~300–400°F)	cool (~100°F) — cool enough for plastic, wet enough to drip
Condensate	none (by design — must stay ABOVE dew point or it rusts out)	yes — acidic (trap, drain, neutralizer; 7.5's lockout source)
The missing 15%	up the flue as hot, dry exhaust	harvested from water vapor (latent!) into the house
Tell at the curb	metal flue through the roof	white PVC out the sidewall

Why 80s must stay 80: run an 80% cool enough to condense and the acid eats a heat exchanger not built for it — efficiency "tweaks" that over-harvest are exchanger murder. The category system (full venting rules in 7.5) is about WHERE the dew point happens.

Orientations & staging (fast)

Upflow (basement/closet classic), downflow (supply below — mobile/slab patterns), horizontal (attic/crawl — Alabama's favorite, with the secondary-pan rules from Pass 2). Staging: single-stage (all-or-nothing), two-stage (low fire most hours = quieter, steadier — board + valve coordinate), modulating (continuum, communicating controls). Staging changes the DIAGNOSIS (a "weak flame" might be low fire doing its job — 7.6).

5. Bench procedure

1. **The naming walk:** both donor furnaces, panels off — every student walks the full cast in firing order, touching each part. Twice. The second walk is timed and graded.
2. **Two-airstream tracing:** yarn + tape: students physically route the combustion path (burner box → exchanger → inducer → flue) and the house path (return → blower → exchanger exterior → supply) with different colors. The "where could they ever meet?" question lands at the exchanger wall.
3. **The cut-open exchanger:** pass it around: see the tube/clamshell interior (fire side soot patterns), the exterior (house side), the bends where cracks live (7.8 preview).
4. **80 vs 90 comparative:** side by side — find the secondary exchanger, the condensate trap, the PVC vs B-vent, the pressure-switch hose differences. Build the comparison table from observation, then check against the printed one.
5. **Parts wall ID round:** valves, igniters, rods, switches, orifices — name + job + which lesson tests it.
6. **Orientation field trip:** photos of attic horizontals (ours, from jobs) — spot the secondary pan, the service platform (3.8/Pass-2 install rules foreshadowed).

Checkout: unaided full naming walk in firing order on the 90% + the two-airstream narration + five parts-wall IDs. **Comp 27 opens.**

6. Field gotchas

- **The flue material tells you the family before the door's off** — and warns you what's inside (condensate trap on 90s = the 7.5 lockout suspect list changes).
- **Rollout switches are manual-reset for a reason:** flame came OUT of the box once. Resetting without finding why (blocked exchanger? venting?) is handing the fire a second chance. NEVER jumper (the program's permanent rule).
- **Horizontal attic furnaces** hide their secondary pans under insulation — find the pan AND its float (11.4) on every attic call.
- **Two-stage misdiagnosis:** low fire isn't "weak burners." Check what stage the board is calling before condemning anything (7.6).
- **The blower delay is engineered** (heat-up + cool-down harvests) — customers who hear "it keeps running after it's off" get an explanation, not a "repair."

- **Don't store anything against the burner compartment** (homeowner habit) — the combustion air path starves and the cast misbehaves in confusing ways (7.5's combustion air math).

7. Competency link

- **Comp 27 begins** (completes across 7.2–7.9; Comp 28 = 7.8).
- The firing-order cast IS 7.2's sequence; the airstream frame is 7.8's inspection logic and the CO conversation's foundation.

8. Check yourself

1. The two airstreams — route each, and name the one wall between them.
2. The cast in firing order, all eleven.
3. 80 vs 90: exchangers, flue material & why, condensate, where the extra efficiency comes from (use 1.5's word).
4. Why must an 80% never condense?
5. Which two safeties are the "temperature police," what does each watch, and which one is manual-reset + why?
6. Why does the blower start late and stop late?
7. What's cool enough about Category IV exhaust that PVC is legal?
8. Horizontal attic install: two things you locate before any service.
9. The inducer runs before anything else — for whom is it providing evidence, and through what device?
10. From the curb: white PVC sidewall vs metal roof flue — what do you already know about each system's service points?

Arc Workforce Academy · YES Electric LLC Apprenticeship 2026-AL-141731 · Lesson 7.1 v1.0 (2026-06-10)