

Contactors & Relays: Operation, Testing, Replacement

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 3 • Electrical for HVAC I • Appendix A Competency 19 — (contactor/relay half) **Class time:** ~4 hrs (1 video + 3 bench)

1. What you'll be able to do

- Explain the one idea both devices share: **a small coil closes a bigger switch** — and what separates a relay from a contactor (load size; pilot duty vs power duty).
- Test a contactor completely: **coil voltage present? coil resistance? contacts dropping voltage under load?** — the three questions that convict or acquit.
- Replace a condenser contactor start-to-finish, including the **one-leg-always-hot trap** of single-pole residential contactors.
- Test a general-purpose switching relay by energizing the coil and proving each contact set (NO closes, NC opens).
- Read contactor/relay failures in their physical evidence: pitted/welded contacts, ants, chattering, a hum with no pull-in.

2. Tools & materials

- Contactor pile: 1-pole and 2-pole residential 30/40 A, a definite-purpose 3-pole (commercial show), dead ones (welded shut, burnt coil, ant-packed — the Alabama classic)
- General purpose relays: 90-340 style SPDT, fan-center
- Training board, meters, the shop condenser

3. Watch first

Order	Video	Channel	Length	Why
1	HVAC Contactor Operation, Types, Ratings, Problems, Testing	AC Service Tech	16:06	The complete contactor story
2	HVAC Relays 101 3D	HVAC School	13:30	Coil + contacts, animated
3	Contactors Explained and Tested	AC Service Tech	5:58	Bench testing + power-up
4	How and When to Change a Contactor	HVAC School	13:15	The judgment call + the swap
5	How a Relay Works (90-340)	HVAC School	11:02	The universal switching relay
6	TOP 5 Contactor Troubleshooting Problems	AC Service Tech	7:05	Failure parade
7	Shorted Contactor Coils — an Emerging Issue	HVAC School	7:59	The transformer-killer from 3.4, found

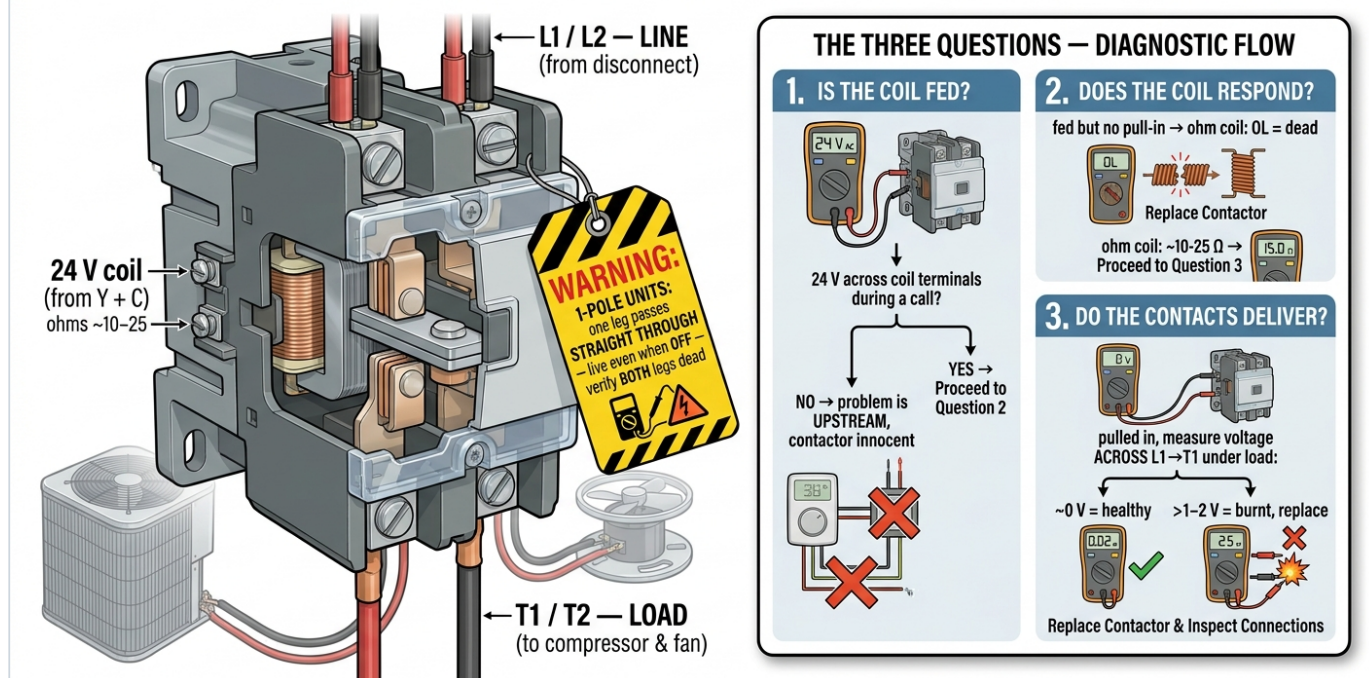
4. The idea

One idea, two sizes

Relay = small coil, small contacts (pilot duty — blower relays, fan centers, board relays).

Contactor = same idea built to carry motor/compressor current (power duty, 20–40+ A). Both are just Lesson 3.3's switch — moved by an electromagnet instead of a finger. The coil is a LOAD on the 24 V system (a rung in the ladder); the contacts are a SWITCH in the 240 V system. One device, citizen of both worlds — which is why it's where brain-vs-muscle diagnosis crosses over.

THE CONTACTOR — ANATOMY & THE THREE QUESTIONS



Residential contactor anatomy

- **Coil terminals** (side, small spades): 24 V from Y + C. Typical coil resistance ~10-25 Ω. OL = open coil = hum-free silence. Near-0 = shorted coil = the 3.4 transformer murderer.
- **L1/L2 line side** (from disconnect) — **T1/T2 load side** (to compressor/fan).
- **1-pole vs 2-pole:** the 1-pole breaks only ONE leg — **the other leg is live at the compressor terminals even when "off."** This trap is why the lockout ritual never skips verifying BOTH legs dead (3.2). 2-pole breaks both.
- **The shunt/bar** on 1-poles passes the unbroken leg straight through — not a defect, a design.

The three questions (diagnosis in order)

- 1. Is the coil being FED?** 24 V across the coil terminals during a call? - No → the problem is upstream (stat, safety chain, transformer — Unit 3/6 skills). The contactor is innocent.
- 2. Does the coil RESPOND?** Fed 24 V but no clunk/pull-in → ohm the coil (dead unit): OL = dead coil → replace. Hums but won't seat = debris/ants/burnt seat → replace (don't "clean and hope" on a compressor's lifeline).
- 3. Do the contacts DELIVER?** Pulled in: measure voltage ACROSS each contact set (L1→T1) under load. ~0 V = healthy. **More than ~1-2 V dropped = burnt/pitted contacts heating themselves** → replace. (Voltage-drop testing — Lesson 3.3's "switch that drops voltage is a bad switch," now applied to its most famous patient.)

And the reverse failure: **welded contacts** — unit runs with the stat OFF (compressor won't quit). Kill it at the disconnect; replace; ask what overloaded the contacts (short-cycling, low voltage from a weak cap era, undersized contactor).

Relays — same exam, more contact sets

The 90-340-style universal: coil (24 V) + SPDT contacts (1-NO, 3-NC, etc. labeled on the case). Test: ohm/continuity each set with coil dead, energize the coil from a transformer, watch every set flip. Fan centers = a relay + transformer in one box (the add-a-blower classic in old air handlers — returns in 6.x).

Why they fail

Contacts: every make/break under load draws an arc → pitting → resistance → heat → worse pitting (the death spiral; I^2R from 2.4). Coils: heat + voltage sag (a 19 V "24" from an overloaded transformer makes coils chatter and cook — 3.4 connection). And in Alabama: **ants**. Fire ants are drawn into contactors (it's the arc), pack the mechanism, jam the armature. You will see this monthly — it's a replace, plus a barrier granule perimeter, plus a customer conversation.

5. Bench procedure

1. **Anatomy + autopsy:** dead pile teardown — find the coil, contacts, springs; identify the failure on each body (welded, pitted, ant-packed, open coil by ohm).
2. **Three-questions drill (training board):** instructor rigs a fault per round — no coil feed / dead coil / burnt contacts (simulated with a resistor in series). Students run Q1→Q2→Q3 with narration, conviction must name the question that caught it.
3. **One-leg trap demo (instructor, live):** 1-pole contactor "off" — meter proves L2 STILL LIVE at the compressor terminal. Every student measures it. Every student says the rule out loud.
4. **Relay proving:** 90-340 on the bench — map all contacts dead, energize coil, re-map. Wire one to switch a lamp from a stat signal.
5. **Full contactor swap** on the shop condenser (locked out, verified): photo → label wires → swap → torque lugs → restore → watch pull-in → voltage-drop test the new contacts under load (~0 V — prove your own work).

Checkout: three-questions diagnosis on an unknown fault, unaided, with correct verdict + the one-leg trap stated; relay contact map performed correctly. **Comp 19 complete** (caps 3.5 + contactors/relays here) at mentor-guidance level.

6. Field gotchas

- **The contactor is guilty until Q1 proves otherwise — backwards.** Most "bad contactors" weren't fed (a safety opened the Y rung). Run the questions IN ORDER or you'll replace good parts into the same dead unit.
- **One-leg-always-hot** has bitten every tech who skipped the both-legs-dead check exactly once. Be the tech it never bites.
- **Voltage drop, not looks, convicts contacts.** Shiny contacts can drop 3 V; ugly ones can read 0.1. Measure.

- **Chattering = upstream voltage problem** (weak transformer, long undersized stat wire, shorted coil elsewhere) as often as a bad coil. A new contactor that still chatters tells you where to look next (3.4's VA budget).
- **Match coil voltage on replacements** (24 V residential; 120/240 coils exist for packaged/commercial — grabbing the wrong coil off the shelf = silent contactor).
- **Welded-shut is an emergency finding:** a compressor that can't shut off destroys itself or floods — don't leave the job with "I'll order one."

7. Competency link

- **Comp 19 — COMPLETED** (with 3.5). Field repetitions logged through Units 6–8.
- Three-questions structure = the template for every coil-driven device after: gas valves (7.6), reversing valve solenoids (8.6), zone dampers (10.15).

8. Check yourself

1. Relay vs contactor — what's actually different?
 2. The three questions, in order, with the meter move for each.
 3. Coil ohms: OL means? Near-0 means — and what did it kill (3.4)?
 4. Healthy contacts drop ___ V under load; replace at more than ___.
 5. The one-leg trap: which contactor type, what's live, when?
 6. Unit won't shut off with stat disconnected. Diagnosis? First action?
 7. Contactor hums, won't pull in. Two mechanical causes, one electrical?
 8. New contactor chatters. Three upstream suspects?
 9. Why are ants in the contactor an Alabama service staple, and what's the full fix?
 10. After a swap, what measurement proves the new part before you leave?
-

Arc Workforce Academy · YES Electric LLC Apprenticeship 2026-AL-141731 · Lesson 3.6 v1.0
(2026-06-10)