

Module 2.1 — Electrical Safety, LOTO & Systematic Troubleshooting

Phase 2 begins. A seven-step troubleshooting method, the eight-step NFPA 70E lockout process with live-dead-live, arc flash labels and PPE, shock boundaries, and glove and tool checks.

Why this module. Installing work is done on circuits that have never been energized. Repair work is done on and around equipment that has been running, and that is where electricians get hurt. The Bureau of Labor Statistics counted 142 deaths from "exposure to electricity" in 2023 and 130 in 2024, and NIOSH reports that construction has more electrocutions than any other industry. This module teaches the routine that keeps you alive on repair work: a seven-step troubleshooting method, the eight-step NFPA 70E process for making equipment safe to touch, how to read an arc flash label and pick PPE, the shock boundaries, glove and tool checks, and the mistakes that put people in the hospital.

Part A — The Systematic Troubleshooting Method

THE SYSTEMATIC TROUBLESHOOTING METHOD

1. RECOGNIZE the symptom

what is actually wrong? get the real complaint



2. ELABORATE

ask questions, gather history, when/what changed



3. LIST probable causes

from most-likely / easiest-to-check first



4. LOCALIZE by testing

split the system, test, narrow it down (meter)



5. REPAIR & VERIFY

fix it — then confirm the whole system works

Work the steps IN ORDER. Guessing and swapping parts is slow, expensive, and dangerous.

Five steps, in order: recognize → elaborate → list probable causes → localize by testing → repair & verify.

The five boxes above are the short version. In the field the Navy construction electrician manuals (NAVEDTRA 14046, 14027 and 14026) break the same idea into seven working steps. Boxes 1 and 2 are steps 1 and 2 below. Box 3 and box 4 become steps 3, 4 and 5. Box 5 becomes steps 6 and 7.

Step by step: the seven-step field method

1. **Get the symptom.** Find out exactly what is wrong and what still works. NAVEDTRA 14046: "If a group of devices fails to operate, the fault is usually a defective circuit." When one device is dead and its neighbors work, the device itself is the usual suspect.
2. **Get the history.** Pull the drawings and any revision records (14046 calls them "System Revision Information"). Ask the customer what changed: new equipment, a storm, a remodel, a breaker that was reset. Ask whether the problem is constant or comes and goes.
3. **Look and check the source.** Use your eyes and nose first: burn marks, melted insulation, a tripped breaker, water in a box. NAVEDTRA 14027: "Check the power supply to see if it is on and if it is correct. Test all protective devices."
4. **Half-split.** Divide the circuit in the middle and test. NAVEDTRA 14046 says to open the circuit "about halfway between the control unit and the most distant" device, test, then move "about halfway between the present test point and the last test point." Each test throws away half of the circuit that could hold the fault.
5. **Isolate the part.** Test across switches and contacts. Across an open switch you read full line voltage. Across a closed switch you should read zero. NAVEDTRA 14026: "any voltage reading across the terminal of a closed switch indicates a fault." Use the ohmmeter only with power off: "a good wire checks 0 ohms; a faulty one, infinity."
6. **Repair and verify the whole system.** Fix the cause, then test everything the circuit serves, not only the device that was reported. NAVEDTRA 14046: "test the indicating circuit... If all devices operate properly, restore... to service."
7. **Document.** Tag every wire you lift. NAVEDTRA 14046: "Identification of wires removed from terminals during repair or testing is essential to ensure accurate reconnection." Write down the complaint, your readings, the cause, the part you replaced, and the final test. If you changed which breaker feeds what, fix the panel directory. NEC 2026 408.4(A) requires circuit descriptions that are "unlikely to result in confusion between circuits."

Worked example 1: half-splitting a 20-receptacle run

A ground fault trips a breaker that feeds 20 receptacles in a row. Testing every receptacle one at a time could take up to 20 tests. With power locked out and the meter on ohms, you split the run:

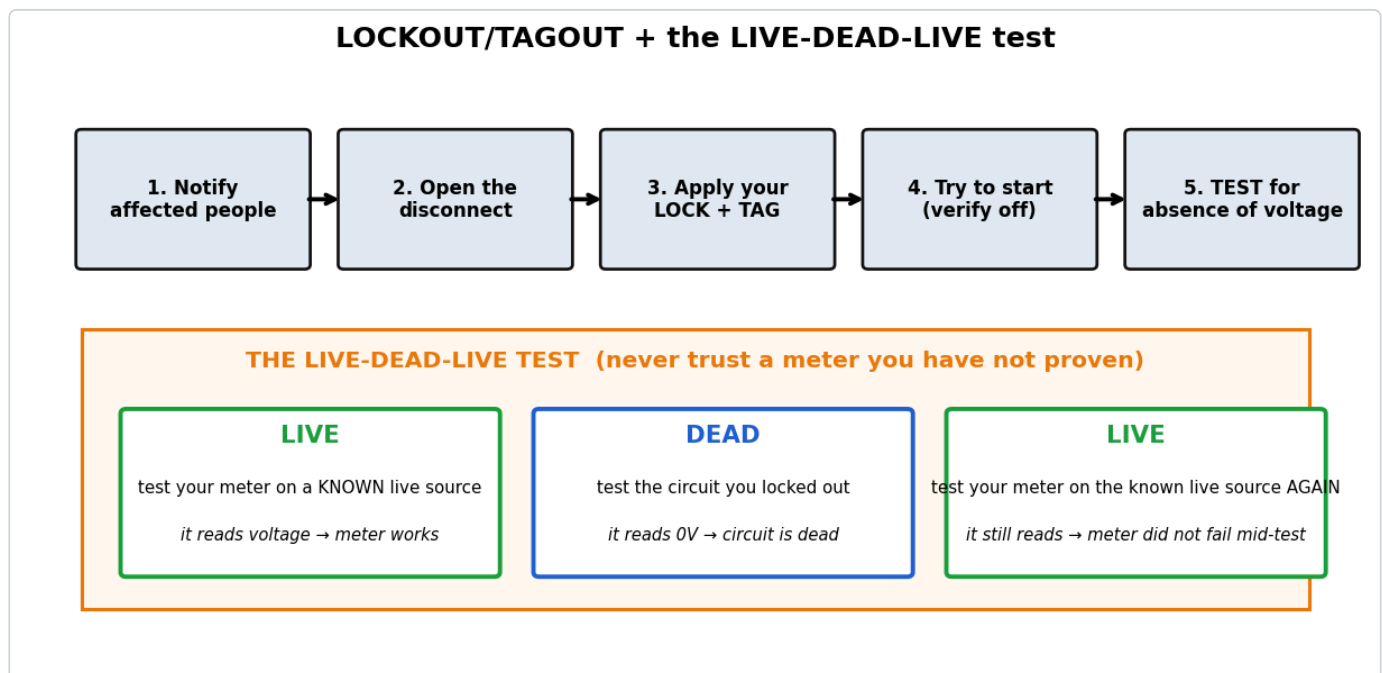
Test	Where you open the circuit	Result	What is left to search
1	At receptacle #10	Fault is beyond #10	#11 to #20
2	At #15 (halfway between #10 and #20)	Fault is before #15	#11 to #14
3	At #12	Fault is beyond #12	#13 to #14
4	At #13	Fault found at #13	Done

Four tests replace as many as twenty. The same idea works on a feeder with several panels, a control circuit with a chain of contacts, or a lighting run with a dozen fixtures.

Limits while troubleshooting

- Never put a jumper "across a power-consuming device, such as a contactor coil" (NAVEDTRA 14027). The jumper shorts the line.
- Testing and troubleshooting do not need an energized work permit, but they still need PPE (NFPA 70E 130.2(C)(1)).
- Only a qualified person does energized testing (70E 110.6(A)). A qualified person has the training to recognize and avoid the hazards of that equipment.
- Interlocks may be defeated only by a qualified person, and "only temporarily" while that person works on the equipment (OSHA 1910.333(c)(10)).

Part B — STEP-BY-STEP: Lockout/Tagout + Live-Dead-Live



The short version of LOTO with the live-dead-live test. The full NFPA 70E 120.6 process below has eight steps and adds sources, stored energy and grounding.

When the equipment must be dead

NFPA 70E 110.2(B) requires an **electrically safe work condition** (ESWC) for anything at 50 V or more when you will be inside the limited approach boundary (Part D), or when your task raises the chance of an arc flash. An ESWC means the parts are disconnected, locked out, tested and proven dead, and grounded where needed. Energized work is allowed only under the listed exceptions:

Exception	What it covers	Example
De-energizing "introduces additional hazards or increased risk"	Shutting off creates a worse danger	Life support, fire alarms, ventilation for a hazardous location
De-energizing is "infeasible... due to equipment design or operational limitations"	The task can only be done live	Start-up checks and troubleshooting diagnostics that need voltage present
Under 50 V	No shock risk and no arc exposure	Low-voltage control and signal work

OSHA 1910.333(a)(1) says the same thing. Convenience is not on the list. A customer who does not want the lights to go out is not a reason to work hot.

Step by step: the NFPA 70E-2024 120.6 process (eight steps)

The 2024 edition moved this process from 120.5 to **120.6**. The steps "shall be performed in the order presented, if feasible."

Step	120.6 wording	What you do in the field
1	"Determine all possible sources of electrical supply... Check applicable up-to-date drawings, diagrams, and identification tags."	Look for a UPS, solar (PV) inverter, generator, second feeder, or control power fed from another panel
2	"After properly interrupting the load current, open the disconnecting device(s) for each source."	Stop the load with its own controls first, then open the disconnect
3	"Wherever possible, visually verify that all blades... are fully open or that drawout-type circuit breakers are withdrawn to the test or fully disconnected position."	Look through the switch viewing window; rack the breaker out
4	"Release stored electrical energy."	Drive and power-factor capacitors: wait the time on the label, then test
5	"Block or relieve stored nonelectrical energy..."	Discharge the closing springs on a power breaker
6	"Apply lockout/tagout devices in accordance with a documented and established procedure."	Your own lock and tag on every source
7	"...test each phase conductor or circuit part at each point of work... both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source."	Live-dead-live at every compartment you will touch

8	"Where the possibility of induced voltages or stored electrical energy exists, ground all circuit conductors and circuit parts before touching them."	Apply grounds rated for the available fault current; tie off extra cable
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- **Step 7, Exception 1:** a permanently mounted, listed absence-of-voltage tester may be used if it tests phase-to-phase and phase-to-ground at the point of work and checks itself.
- **Step 7, Exception 2:** noncontact (capacitive) testers are allowed only over 1000 V. A tick pen does not satisfy 120.6 at 208 V or 480 V.
- **Neutrals:** 70E-2024 adds a note that a neutral can still carry current after the phase conductors are opened, because other circuits may share it.

Step by step: live-dead-live on a 480Y/277 V panel

1. Inspect the meter, leads and probes before use (70E 110.6(D)). The meter must be rated for the circuit it is used on (110.6(B)).
2. Prove the meter on a known live source: a nearby energized 480 V circuit or a proving unit. It must read correctly.
3. At the point of work, read A-B, B-C, C-A, then A-G, B-G, C-G. If a neutral is present, also read each phase to neutral and neutral to ground. Every reading must be about 0 V.
4. Prove the meter again on the same known source. If it fails now, none of your "dead" readings count.
5. Repeat steps 2 through 4 at every compartment or box you will touch. Testing at the disconnect does not prove the work location is dead.

The second proof is required. 70E 110.6(E) and 120.6 step 7 both require checking the meter on a known source before and after. A meter that dies between readings shows 0 V on a live bus. Never work behind someone else's lock, and never remove a lock that is not yours.

OSHA 1910.333(b): the federal rule for electrical lockout

- (b)(2): the steps are followed "in the order... presented."
- (b)(2)(ii)(B): "Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means for deenergizing." A stop button, a contactor or a drive set to "off" is not a lockout point.
- (b)(2)(ii)(C) and (D): capacitors are discharged and stored mechanical energy is blocked.
- (b)(2)(iii): a lock and tag go on each disconnect. A tag without a lock needs "at least one additional safety measure."
- (b)(2)(iv)(A): a qualified person operates the controls "or otherwise verify that the equipment cannot be restarted." This is the **try-to-start**: push START and confirm nothing runs, then return the controls to off.
- (b)(2)(iv)(B): your test must detect "inadvertently induced voltage or unrelated voltage backfeed." That means voltage from a source you did not know about.

- (b)(2)(v): to re-energize, remove tools, jumpers and grounds; warn everyone to stay clear; each person removes only their own lock; then make a visual check before closing the disconnect.

OSHA 1910.147: the general lockout program

1910.147 covers lockout for machines and equipment. Electrical shock exposure is handled by 1910.333, but a 1910.147 program is accepted for electrical work if it adds the 1910.333 try-to-start and backfeed test. The 1910.147 order is:

1. Notify affected employees before you start, and again before you re-energize ((c)(9)).
 2. Prepare: know "the type and magnitude of the energy, the hazards... and the method or means to control the energy" ((d)(1)).
 3. Shut down in an orderly way ((d)(2)).
 4. Isolate every energy source ((d)(3)).
 5. Apply locks and tags that hold the device in "safe" or "off" ((d)(4)).
 6. Relieve stored energy, and keep checking if it can build back up ((d)(5)).
 7. Verify isolation ((d)(6)).
 8. Release: inspect the area, make sure people are clear, the person who applied each device removes it, and notify affected employees ((e)).
- **Group lockout:** "Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox" ((f)(3)(ii)(D)). One authorized employee holds primary responsibility for the group.
 - **Shift change:** there must be an "orderly transfer... between off-going and oncoming employees" ((f)(4)). The oncoming worker's lock goes on before the off-going worker's lock comes off, so the equipment is never unprotected.
 - **Lock and tag devices** must be durable, standardized, substantial and identifiable to the person who applied them ((c)(5)(ii)).

Construction sites: OSHA 1926.416 and 1926.417

On construction work, employees are protected by "deenergizing the circuit and grounding it or by guarding it effectively by insulation" (1926.416(a)(1)). Fuses with energized terminals are handled with tools "insulated for the voltage" (1926.416(d)). De-energized equipment must be "rendered inoperative" with "tags attached at all points where such equipment or circuits can be energized" (1926.417(b)).

The job briefing: NFPA 70E 110.3(I)

Before the work starts, a qualified person writes a job safety plan (110.3(I)(1)). The 2024 edition requires it to contain:

1. A description of the job.
2. The hazards.

3. The shock risk assessment.
4. The arc flash risk assessment.
5. The work procedures and controls.
6. An **emergency response plan** (new in 2024).

The briefing covers the plan and any permit (110.3(I)(2)). If the scope changes, you re-plan and re-brief (110.3(I)(3)). In practice the briefing names the person in charge, every source and lock point, the boundaries and PPE, who calls 911, the site address to give the dispatcher, and where the AED is.

Worked example 2: locking out a rooftop unit fed from a 480 V panel

1. Brief the crew per 110.3(I). Note the site address and AED location.
2. Step 1: the drawings show the unit is fed from panel H2, and its control transformer is inside the unit. Check the drawings and labels for any second feed.
3. Step 2: turn the unit off at its thermostat or controller so the compressor and fans stop, then open the breaker in H2 and the disconnect at the unit.
4. Step 3: look through the disconnect window or at the blades to confirm they are open.
5. Steps 4 and 5: if the unit has a drive, wait the discharge time on its label.
6. Step 6: your lock and tag on the H2 breaker and the unit disconnect. Each crew member adds a lock.
7. Try-to-start per 1910.333(b)(2)(iv)(A): call for cooling; nothing should run. Return the control to off.
8. Step 7: live-dead-live at the disconnect load side and again inside the unit's control box.
9. Step 8: decide whether induced voltage or stored energy is possible. If it is, apply grounds before touching. Record the decision.
10. When the job is done, release per 1910.333(b)(2)(v).

Part C — Arc Flash & PPE (NFPA 70E)

ARC-FLASH PPE CATEGORIES (NFPA 70E)			
CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4
			
MIN. ARC RATING: 4 cal/cm ²	MIN. ARC RATING: 8 cal/cm ²	MIN. ARC RATING: 25 cal/cm ²	MIN. ARC RATING: 40 cal/cm ²

PPE categories rise with incident energy (cal/cm²). The equipment label tells you the category and boundary.

An **arc flash** is an explosion of heat and light when current jumps through the air between conductors. **Incident energy** is the heat that reaches your body, measured in calories per square centimeter (cal/cm²) at a set working distance. The **arc flash boundary** is the distance from the equipment inside which arc-rated PPE is required.

Reading the arc flash label (NEC 2026 110.16)

NEC 110.16 requires a field or factory label on service equipment, switchboards, switchgear, industrial control panels, meter sockets and motor control centers that are likely to be worked on while energized. It must meet 110.21(B) and show:

1. The nominal system voltage.
2. The arc flash boundary.
3. The available incident energy, or the required level of PPE.
4. The date the assessment was performed.

NFPA 70E 130.5(H) has the same list from the owner's side: voltage, arc flash boundary, and either incident energy with working distance, or PPE category, or minimum arc rating of clothing.

Two ways to choose PPE, never both

70E 130.5(F) allows the **incident energy analysis** method (an engineering study) or the **PPE category** method (tables), "either, but not both," on the same piece of equipment. If the label

gives incident energy, dress to that number. If it gives a category, use the category table. Table 130.5(C) lists tasks that need arc flash PPE, including racking breakers, inserting or removing MCC buckets, and working on exposed parts fed by a panelboard or MCC.

Table 130.7(C)(15)(a): the PPE category table (rows verified for 2024)

You may use this table only when the voltage, available fault current, clearing time of the upstream device, and working distance are all known and fall inside a row. If any value is outside the row, an incident energy analysis is required.

Equipment	Limits (18 in. working distance)	PPE category	Arc flash boundary
Panelboards and other equipment, 240 V and below	25 kA or less, cleared in 0.03 s (2 cycles) or less	1	19 in.
Panelboards and other equipment, over 240 V up to 600 V	25 kA or less, 0.03 s or less	2	3 ft
600 V motor control centers	65 kA or less, 0.03 s or less	2	5 ft

Other rows exist for longer clearing times and for switchgear. Read them from the printed 2024 table for the equipment in front of you. Switchboards and switchgear carry the highest energy in the building (Module 1.5B).

Worked example 3: using the table

- A 120/208 V panelboard with 25 kA available, fed by a breaker that clears in 2 cycles: row 1. PPE category 1, arc flash boundary 19 in.
- The same panel at 480 V: row 2. PPE category 2, arc flash boundary 3 ft.
- A 480 V panel labeled 40 kA available: 40 kA is over the 25 kA limit, so the table cannot be used. An incident energy analysis is required before anyone works on it energized.

Table 130.7(C)(15)(c): what each category wears

Category	Minimum arc rating	Main items
1	4 cal/cm ²	Arc-rated (AR) shirt and pants or coverall; AR face shield or hood; hard hat; safety glasses; ear inserts; leather, AR or rubber gloves with protectors
2	8 cal/cm ²	Category 1 items, but the face shield must be worn with an AR balaclava, or wear a hood; leather footwear
3	25 cal/cm ²	AR suit jacket, pants and hood; AR or rubber gloves with protectors
4	40 cal/cm ²	Category 3 items rated 40 cal/cm ²

- A hood is required above 12 cal/cm² (130.7(C)(10)(b)).
- Hearing protection is required anywhere inside the arc flash boundary (2024 130.7(C)(5)).
- Hard hats must be Class E or G. Class C has no electrical rating.

The energized electrical work permit (70E 130.2)

A permit is required for work inside the restricted approach boundary, or where your task raises the chance of an arc flash (130.2(A)). The permit must list (130.2(B)):

1. The circuit or equipment and its location.
2. A description of the work.
3. The justification for working energized (110.2(B)).
4. The safe work practices to be used.
5. The shock risk results: voltage, limited and restricted approach boundaries, and shock PPE.
6. The arc flash results: incident energy at the working distance or the PPE category, the PPE, and the arc flash boundary.
7. How unqualified persons will be kept out (130.8(O)).
8. Evidence that the job briefing was done (110.3(I)).
9. Approval signatures.

No permit is needed (but PPE still is) for testing, troubleshooting and measuring by a qualified person, or for thermography, visual inspection, access and housekeeping done outside the restricted approach boundary (130.2(C)).

Part D — Shock Approach Boundaries

Shock boundaries are distances from exposed live parts. The **limited approach boundary** is the line unqualified people may not cross without an escort. The **restricted approach boundary** is the line where shock risk is high enough that even a qualified person needs insulation or guarding. The column you use is **phase-to-phase voltage**.

Table 130.4(E)(a), alternating current (NFPA 70E-2024)

Phase-to-phase voltage	Limited approach, movable conductor	Limited approach, fixed part	Restricted approach
Under 50 V	Not specified	Not specified	Not specified
50 to 150 V	10 ft 0 in.	3 ft 6 in.	Avoid contact
151 to 750 V	10 ft 0 in.	3 ft 6 in.	1 ft 0 in.
751 V to 15 kV	10 ft 0 in.	5 ft 0 in.	2 ft 2 in.

Worked example 4. A 208 V panel and a 480 V panel both fall in the 151 to 750 V row, because 208 V is the phase-to-phase voltage. For both, the limited approach boundary to a fixed part is 3 ft 6 in. and the restricted approach boundary is 1 ft.

- Unqualified persons stay outside the limited approach boundary unless a qualified person advises them and "continuously escort[s]" them. They never cross the restricted boundary (130.4(F)).

- A qualified person crosses the restricted boundary only when insulated or guarded. Rubber gloves protect only for the parts you are working on with them (130.4(G)).
- The arc flash boundary is a separate distance and can be much larger. At 480 V switchgear it can reach 20 ft.

Working space (NEC 2026 110.26)

Working space in front of equipment must be "provided and maintained." For 151 to 600 V to ground (a 277/480 V system), Table 110.26(A)(1) requires 3 ft of depth for Condition 1 (live parts on one side, no live or grounded parts on the other), 3 ft 6 in. for Condition 2 (grounded parts on the other side), and 4 ft for Condition 3 (live parts on both sides). For 0 to 150 V to ground (a 120/208 V system), all three conditions require 3 ft. The NEC counts "concrete, brick, or tile walls" as grounded, so a panel facing a block wall is Condition 2. Equipment doors that open into the space must still leave 24 in. for you to get out.

Part E — Rubber Gloves, Insulated Tools and Meters

Step by step: the daily rubber glove check (OSHA 1910.137)

1. Read the test date stamped on the glove. Gloves are tested "before first issue and every 6 months thereafter" (Table I-5). Sleeves are tested every 12 months. Do not use a glove past its test date.
2. Check the class against the voltage. Class 00 is rated for 500 V ac maximum use. Class 0 is rated for 1,000 V ac, which covers 480 V (Table I-4).
3. Inspect "before each day's use" ((c)(2)(ii)) and after anything that could have damaged them.
4. Give them an air test: trap air inside the glove and check for leaks. OSHA: "Insulating gloves shall be given an air test."
5. Reject the glove for holes, cuts, ozone checking (fine surface cracks), embedded objects, or swelling, softening, hardening or stickiness ((c)(2)(iii)).
6. Put on leather protectors over the rubber gloves ((c)(2)(vii)). A glove used without protectors must be retested before reuse.

Insulated tools (OSHA 1910.335)

- Use "insulated tools or handling equipment if the tools... might make contact" with exposed energized parts ((a)(2)(i)).
- Use insulated fuse pullers for fuses ((a)(2)(i)(A)).
- Use signs, nonconductive barricades, or an attendant to keep others out of the area ((b)).
- Take off rings, watches and other conductive jewelry (1910.333(c)(8)).
- Inspect tool insulation for nicks and cuts before use, and take damaged tools out of service.

Meters

Your meter must be "rated for circuits and equipment where they are utilized" (70E 110.6(B)). Leads, probes and cables are inspected before each use (110.6(D)). Module 2.2 covers how to choose and use each instrument.

Part F — Ladders and Lifts Near Energized Equipment

- Use ladders with nonconductive siderails near exposed energized equipment (OSHA 1926.1053(b)(12) and 1910.333(c)(7)).
- Set the ladder at a 1-to-4 angle: for every 4 ft of working length, the foot goes 1 ft out. A 16 ft working length puts the foot 4 ft from the wall ((b)(5)(i)).
- Do not stand on the top step of a stepladder ((b)(13)).
- Tag a damaged ladder "Do Not Use" and take it out of service ((b)(16)).
- Boom lifts (1926.453(b)(2)): test the controls each day before use, never put a ladder or plank in the basket to gain height, and clip your lanyard to the boom or basket.

Part G — Common Mistakes

Mistake	The rule it breaks
Not proving the meter before and after the test	70E 110.6(E), 120.6 step 7
Locking the wrong breaker because the panel directory is wrong	120.6 step 1; NEC 408.4(A), 110.22(A). Testing at the point of work catches it
Using a stop button, contactor or drive "off" as isolation	OSHA 1910.333(b)(2)(ii)(B)
Missing a second source: UPS output, PV inverter, generator, second feeder, or control power from another panel	1910.333(b)(2)(iv)(B) "unrelated voltage backfeed"; NEC 705.10, 230.4(E); 70E neutral note
Using a noncontact pen to prove 208 V or 480 V dead	120.6 step 7, Exception 2
Testing phase-to-ground only. On an ungrounded or corner-grounded system, a live phase can read 0 V to ground	120.6 step 7 requires phase-to-phase and phase-to-ground
Testing at the disconnect, not at the work	120.6 step 7 "at each point of work"
Removing someone else's lock, or a gap in locks at shift change	1910.147(e)(3), (f)(4)
Jumpering across a coil to "test" a circuit	NAVEDTRA 14027: never jumper a power-consuming device

Code labels that help you find every source

- **NEC 2026 110.22(A):** each disconnect is marked for its purpose. In other than dwellings, the marking includes "identification and location of the circuit source."
- **NEC 2026 230.4(E) (230.2(E) in 2023):** where a building is supplied by more than one service, or any combination of branch circuits, feeders and services, "a permanent plaque or directory shall be installed at each service disconnect location" showing all the other supplies and the area each one serves.
- **NEC 2026 705.10:** where solar, generators or other power sources are connected, a plaque shows the "location of each power source disconnecting means."
- **NEC 2026 110.25:** a disconnect that must be lockable locks in the open position, and the locking provision must "remain in place with or without the lock installed."

NEC 2026 Checkpoints (2023 number in parentheses where it moved)

- **110.16** arc flash label: voltage, arc flash boundary, incident energy or PPE, date (2023 split this into (A) and (B)).
- **110.22(A)** disconnect identification • **110.25** lockable disconnects • **110.26** working space, Table 110.26(A)(1).
- **230.4(E)** plaque at each service disconnect for multiple supplies (230.2(E)) • **705.10** power source plaque.
- **408.4(A)** panel circuit directory.
- NFPA 70E-2024: **110.2** ESWC, **110.3(I)** job planning and briefing (110.5(I) in 2021), **110.6** test instruments, **120.6** ESWC process (120.5 in 2021), **130.2** permits, **130.4** shock boundaries, **130.5** arc flash assessment, **130.7** PPE.
- OSHA: **1910.137** gloves, **1910.147** lockout, **1910.333** electrical work practices, **1910.335** insulated tools, **1926.416/417** construction, **1926.453** lifts, **1926.1053** ladders.

Hands-On Field Exercise

- Run a job briefing per 70E 110.3(I) for a branch-circuit repair, including the emergency response plan: who calls 911, the site address, and the AED location.
- Perform a full lockout on a branch circuit or rooftop unit using all eight 120.6 steps, with a try-to-start before step 7. Narrate each step out loud.
- Do live-dead-live correctly on a three-phase panel: all six phase readings plus neutral readings, meter proved before and after.
- Put your personal lock on a group lockbox, then do a shift-change handoff with another crew member without leaving a gap.
- Read an arc flash label. State the voltage, arc flash boundary, incident energy or category, and the date. Pick the PPE.
- Find the limited and restricted approach boundaries for a 208 V panel and a 480 V panel.
- Do the daily glove check: test date, class, visual inspection, air test, protectors.

- Walk a dead-receptacle fault through the seven-step method using half-splitting, and fill out the documentation.

Sources used in this module (public documents)

- NFPA 70, National Electrical Code 2026, and NFPA 70E, Standard for Electrical Safety in the Workplace 2024 (free read-only access): [nfpa.org](https://www.nfpa.org)
- NFPA 70E-2024 section excerpts, ElectricalLicenseRenewal.com: electricallicenser renewal.com
- Electrical Association, 2024 NFPA 70E Safety Training presentation: electricalassociation.com
- Brainfiller, "2024 NFPA 70E: Major Changes": brainfiller.com; Electrical Safety Publications, "Updates to the 2024 edition of NFPA 70E": electricalsafety pub.com
- OSHA 29 CFR 1910.137, 1910.147, 1910.333, 1910.335, 1926.416, 1926.417, 1926.453, 1926.1053: [osha.gov](https://www.osha.gov)
- NAVEDTRA 14026 Construction Electrician Basic, 14027 Construction Electrician Intermediate, and 14046 Construction Electrician Advanced (U.S. Navy training manuals).
- Bureau of Labor Statistics, Census of Fatal Occupational Injuries, Table 2: [bls.gov](https://www.bls.gov)
- NIOSH Electrical Safety: [cdc.gov/niosh](https://www.cdc.gov/niosh)

Next: Module 2.2 — Diagnostic Test Instruments.