

Legacy Systems Masterclass — Old Gear You'll Still Work On

The pre-1970 panels, fuses, wiring, services and hazards still energized in Birmingham commercial buildings: recognize them, meter them, judge them honestly, and respond step by step.

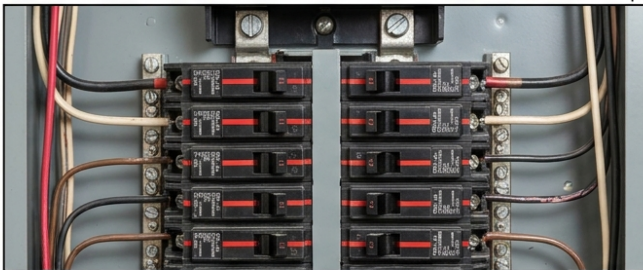
Why this masterclass, and why Birmingham especially. Birmingham boomed as a steel town from the 1870s. Its downtown commercial core is largely 1900s to 1950s, and its industrial and mill stock is older still; much of it is still standing and energized. Add Alabama's historic-rehab tax credits driving adaptive reuse, and you get modern tenants sitting on century-old wiring. A Birmingham-area commercial electrician routinely meets live gear from before 1970, often before 1960. This module is how you recognize it, judge the hazard honestly, and respond correctly. For each system it gives the field tells, the meter readings to expect, step-by-step procedures, and the NEC 2026 rule that applies (2023 number in parentheses where it moved).

One standing caveat: Alabama adopts the NEC on a lag and local amendments vary. Confirm the edition your AHJ enforces before quoting a section to an inspector.

Part A — Legacy Panels: Know Them on Sight

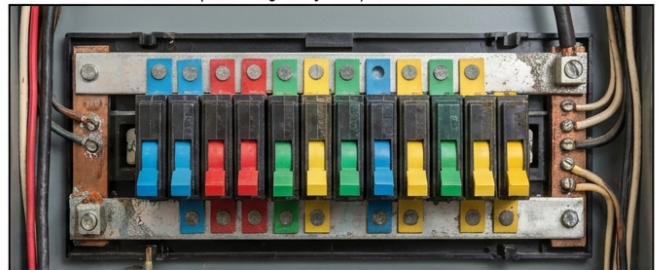
LEGACY PANELS — KNOW THEM ON SIGHT

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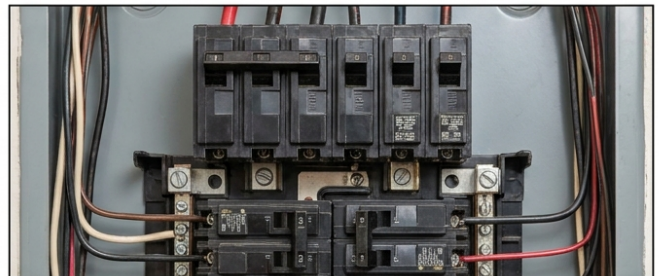
ZINSCO — multi-colored (blue/red/green/yellow) breaker handles on a flat aluminum bus



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PUSHMATIC / BULLDOG — push-BUTTON breakers, no toggle handles



SPLIT-BUS — up to six main breakers grouped at top, no single main

The four you must recognize instantly. The first two are defective-by-design; the second two are obsolete.

Panel	Recognize	Field response
FPE Stab-Lok	Label reads one of "Federal Electric, Federal Pacific Electric, Federal NOARC, Federal Pioneer, FPE, FPE-Stab-Lok, Stab-Lok"; black handles with a thin red center stripe	Replace the panel. The defect is the breaker-to-bus interface; swapping breakers does not fix it.
Zinsco / GTE-Sylvania	Multi-colored (blue, red, green, yellow) handles on a flat aluminum bus; blue-and-silver "Zinsco" label and an embossed "Magnetrip" label at the top	Replace the panel. Breakers arc and weld to the bus.
Pushmatic / Bulldog	Push-button breakers, no toggle handles ; often bolt-in, no main	Parts are obsolete and trips get sluggish with age. Replace when you are in there.
Split-bus	Up to six "main" breakers grouped at the top, no single main	No one-motion shutoff and the "lighting main" trap. Replace at the service upgrade (230.71).

Get the FPE story right. CPSC began investigating in June 1980 after Reliance Electric reported that many FPE breakers did not meet UL requirements, and "Commission testing confirmed that these breakers fail certain UL calibration test requirements." UL revoked the listing on many FPE breakers. But CPSC closed the investigation in 1983, citing cost against its budget, "without making a determination as to the safety of FPE circuit breakers," and with no recall. So do not tell a customer it was "recalled," and do not tell them it was "cleared"; neither happened. The widely quoted fire and death numbers are an independent researcher's estimate, not a government tally. The honest message: documented failure-to-trip defect, recommend replacement.

The split-bus "lighting main" trap. The breaker marked "main" often kills only the lower 120 V bus; the 240 V circuits stay live. People think the panel is dead when it isn't. Meter before you trust it.

What the 2026 code says about old panels

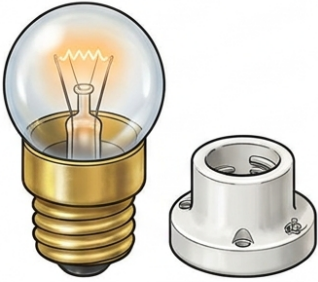
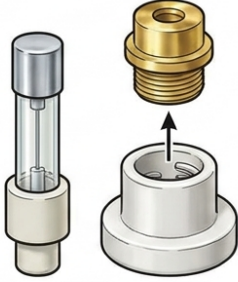
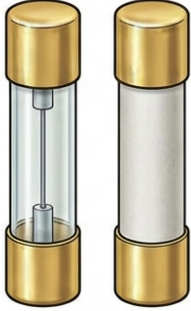
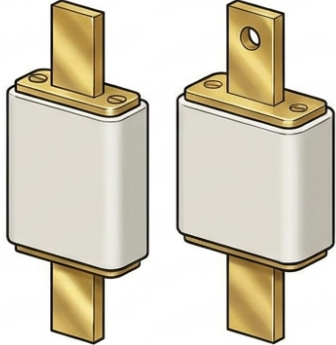
- **Split-bus stays until the service changes.** 230.71 allows one service disconnect, or two to six only in separate enclosures or compartments. The 230.71(B) Exception lets "Existing service equipment, installed in compliance with previous editions of this code that permitted multiple service disconnects in a single enclosure" keep up to six. When the service is replaced, the new gear must meet 230.71.
- **No "delta breakers" (408.36(C)).** "Delta breakers shall not be installed in panelboards." These are 3-pole breakers that fake a third phase from a two-phase bus in an old single-phase panel. Remove any you find.
- **No reconditioned panelboards (408.3(B), new in 2026).** "Reconditioned panelboards shall not be permitted." Switchboards and switchgear may be reconditioned (408.3(A)); panelboards may not.

Step by step: identifying and reporting an old panel

1. Read the label from the dead-front with the trim on. Photograph the label, the breaker handles and any interior label.
2. Record the manufacturer, model, bus rating, voltage and the breaker types listed on the label. Any breaker not named on the label, and not UL Classified for that panel, is a defect to note.
3. Do not pull FPE or Zinsco breakers off the bus to look for damage. Home inspectors report that repeated removal scratches the bus plating further (field reports, not a published test). Look instead for scorch marks, melted handles and warm spots, using an infrared camera with the door closed if possible.
4. Write the finding in plain words. FPE: "documented failure-to-trip defect, recommend replacement." Zinsco: "bus-connection arcing reported by inspectors, recommend replacement." Never write "recalled."

Part B — Legacy Fuses: Get the Class Right

LEGACY FUSES — GET THE CLASS RIGHT

Edison-base plug fuse (screws in like a lightbulb — any amp fits any socket = over-fusing risk)	Type S rejection-base fuse + adapter (size-keyed, tamper-resistant)	Ferrule cartridge fuse (0-60A)	Knife-blade cartridge fuse (61-600A)
			
Edison-base plug fuse (screws in like a lightbulb — any amp fits any socket = over-fusing risk)	Type S rejection-base fuse + adapter (size-keyed, tamper-resistant)	Glass Ceramic Ferrule cartridge fuse (0-60A)	Knife-blade cartridge fuse (61-600A)

Plug fuses and cartridge fuses. The class and rating are load-bearing — this is where over-fusing and underrated gear hide.

- **Edison-base plug fuses** screw in on the same thread as a light bulb, so any amp fuse fits any socket. A 30 A fuse on a 15 A circuit is the classic over-fusing hazard. The tell: fuse amp rating higher than the conductor allows (for example 30 A on #14). Retrofit each socket with a **Type S** rejection adapter sized to the circuit (240.52–240.54).

- **Cartridge fuses:** ferrule type covers 0–60 A, knife-blade 61–600 A. One-time fuses nuisance-trip on motor inrush; motor circuits want dual-element time-delay fuses (Fusetron, Low-Peak) sized about 125–130% of FLA. Replace like-for-like by catalog number, not just amps.

The 2026 plug-fuse rules

Rule	Section
Plug fuses only on circuits "not exceeding 125 volts between conductors" or on a grounded-neutral system where "the line-to-neutral voltage does not exceed 150 volts." So no plug fuses on the 208 V high leg or on a 240 V delta with no neutral.	240.50(A)
Fuses 15 A and smaller have a hexagonal window or cap	240.50(C)
Edison-base fuses "shall be used only for replacements in existing installations where there is no evidence of overfusing or tampering"	240.51(B)
Edison-base fuseholders "shall be installed only where they are made to accept Type S fuses by the use of adapters"	240.52
Type S classes: "0 to 15 amperes, 16 to 20 amperes, and 21 to 30 amperes," not interchangeable with a lower class	240.53
Type S adapters accept only Type S fuses and are "nonremovable" once inserted	240.54

NFPA 70E-2024 110.9 adds: "Overcurrent protection of circuits and conductors shall not be modified, even on a temporary basis, beyond what is permitted by applicable portions of electrical codes." A penny behind a plug fuse or a 30 A fuse on #14 breaks this.

Step by step: Type S retrofit

1. Open the fused main or the upstream disconnect, lock it out, and test for absence of voltage (Part G).
2. Find the conductor size at each socket (read the jacket or use a strip gauge). Compare with 240.4(D): "14 AWG copper 15 amperes," "12 AWG copper 20 amperes."
3. Pick the adapter by the wire, not by the fuse that was in the socket: 15 A for #14, 20 A for #12, 30 A for #10.
4. Screw the adapter in fully. It locks and cannot be removed (240.54).
5. Install the matching Type S fuse. Use a time-delay Type S on motor or compressor circuits.
6. Write the circuit and adapter size in the panel directory.
7. If a socket shows heat damage, cracked porcelain or a loose shell, do not adapt it. Recommend replacing the fuse panel.

Class H is the commercial red flag. Eaton Bussmann's REN/RES renewable Class H fuses are "non-current limiting" and meant for use "where the available fault current is less than 10,000 amps." The one-time Class H(K) NON is also 10 kA at 250 V, while an LPN-RK Class RK1 is rated 300 kA. Modern commercial services often have far more than 10 kA available, and an H fuse facing more than its rating can rupture instead of clearing. Upgrade to **Class RK1 or J** in proper rejection holders (Part E). Bussmann has discontinued 70–600 A REN/RES and points to FRN-R (250 V) or FRS-R (600 V) Class RK5.

Renewable-link fuses have removable end caps and a replaceable link inside. Someone can drop a larger link into a body labeled for less. Open every renewable fuse and check the link rating against the label on the cap.

Part C — Legacy Wiring You'll Still Find

LEGACY WIRING YOU WILL STILL FIND

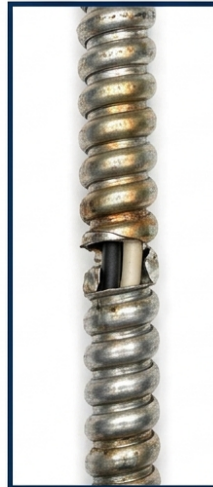
KNOB-AND-TUBE — single conductors on white ceramic knobs, ceramic tubes through joists, ungrounded



CLOTH / EARLY-RUBBER insulated conductors — woven fabric braid, cracking/embrittled



OLD BX armored cable — spiral steel armor, NO bonding strip



ALUMINUM branch wiring — Romex marked AL/ALUMINUM, oxidized terminations



All four are still energized in older Birmingham buildings — and all four are ungrounded or failing in characteristic ways.

Knob-and-tube (Article 394)

Single conductors on porcelain knobs and tubes, ungrounded. It was designed to shed heat in open air. Concealed K&T is permitted "(1) For extensions of existing installations" or "(2) Elsewhere by special permission" (394.10), but many local AHJs forbid extending it, so confirm locally. 394.12 prohibits it in commercial garages, theaters, motion picture studios, hazardous locations, and "(5) Hollow spaces of walls, ceilings, and attics where such spaces are insulated by loose, rolled, or foamed-in-place insulating material that envelops the conductors." Insulation

blown over K&T is the top fire hazard. Rules when it is still in service: 3 in. between conductors and 1 in. from the surface (394.19(A)); supports within 6 in. of each tap or splice and every 4½ ft (394.30(A)); "Splices shall be soldered unless approved splicing devices are used" (394.56).

1. Trace the circuit from the fuse or breaker. Check insulation condition at a knob near the panel.
2. Look in attics and wall cavities for blown or batt insulation touching the conductors. If you find it, that is a 394.12(5) violation. Stop and report it.
3. Megger with a 500 V insulation tester, conductors disconnected at both ends, conductor to conductor and conductor to ground. There is no published NEC pass value for old K&T; record the readings in the existing-conditions report so they can be compared over time.
4. Never splice new cable onto K&T in a hidden location. Terminate in an accessible box, with the K&T entering through flexible nonmetallic loom (394.19(B)).

Cloth and early rubber insulation

The cloth is only a braid; the rubber underneath is the insulation, and it dries, cracks and crumbles. Old RHW and RHH (rubber with a braid) crack at bends near terminals. Bend a sample at the first few inches inside each box and panel. Crumbling rubber means replace the circuit. Old TW is 60°C only (Table 310.4(1)), so size it from the 60°C column (110.14(C)).

Old BX (pre-1959, no bonding strip)

The spiral armor was the only ground path, and it acts like a choke coil: too much impedance to trip a breaker reliably. Today's AC cable must have "an internal bonding strip" (320.100) and "provide an adequate path for fault current" (320.108). Old BX without the strip does neither. Do not rely on it as the EGC; run a wire-type EGC.

Aluminum branch wiring, 1965 to mid-1970s (CPSC Publication 516)

- "Homes built before 1965 are unlikely to have aluminum branch circuit wiring. Electrical cables installed between 1965 and the mid 1970s ... may contain aluminum wiring."
- Identify it by "Al" or "Aluminum" printed or embossed on the jacket every few feet; shine a flashlight at a low angle to read embossing. #12 aluminum on a 15 A circuit is typical. "CU-clad" or "Copper-clad" plus "Al" is copper-clad aluminum, which is "not covered by the repair recommendations."
- The Franklin Research survey CPSC cites found homes built before 1972 and wired with aluminum "55 times more likely to have one or more wire connections at outlets reach 'Fire Hazard Conditions'" (cover-plate screws at 300°F, sparks or charring).
- Permanent repairs CPSC accepts: (1) rewire with copper; (2) COPALUM crimp pigtailed installed with the dedicated tool by an authorized installer; (3) AlumiConn set-screw lug pigtailed where COPALUM is unavailable. CPSC notes AlumiConn is "too new to have developed a significant long-term safe performance history."

CO/ALR devices are not a CPSC-approved repair. CPSC says CO/ALR devices "have failed in laboratory tests when connected to aluminum wire typical of that installed in existing homes" and "must be considered, at best, an incomplete repair." CPSC allows CO/ALR devices and AL/CU twist-on pigtails only "as an emergency, temporary repair," and it "strongly recommends against" non-COPALUM crimp connectors. The NEC still permits CO/ALR-marked devices to terminate aluminum directly (406.10(1)), and devices not so marked may not be used on aluminum. Code-legal and CPSC's permanent repair are two different bars; tell the customer which one you are meeting.

Step by step: AlumiConn pigtail (one device)

1. De-energize, lock out and test for absence of voltage.
2. Pull the device.
3. Cut back damaged or oxidized aluminum to bright metal.
4. Insert the aluminum conductor and a new copper pigtail in separate ports of the AlumiConn.
5. Torque each set screw to the value printed on the AlumiConn package.
6. Land the copper pigtail on a standard device.
7. Repeat for every aluminum termination on the circuit, including splices in boxes, fixtures and appliance whips.

No equipment ground? NEC 2026 406.12(D)(2) (406.4(D)(2) in 2023)

Replacing a receptacle where no EGC exists in the box, you may use: (a) another non-grounding receptacle; (b) a **GFCI receptacle marked "No Equipment Ground,"** with its grounding terminal not connected to any downstream outlets; or (c) grounding-type receptacles fed through a GFCI, marked "GFCI Protected" and "No Equipment Ground," with the grounding terminals not connected between them. The GFCI gives shock protection but **does not create a ground**; equipment that needs an EGC (250.114) still needs one. Where an EGC exists or is added per 250.130(C), use grounding-type receptacles (406.12(D)(1)).

Step by step: adding an EGC to an old outlet (250.130(C))

1. Confirm the outlet has no EGC: plug-in tester first, then look in the box.
2. Pick the closest accessible connection point the code allows: (1) the grounding electrode system; (2) the grounding electrode conductor; (3) the EGC bar in the panel where the circuit starts; (4) the EGC of another circuit from the same panel; (5) on grounded systems, the grounded service conductor inside the service enclosure; (6) on ungrounded systems, the grounding bar in the service enclosure. Option (4) is usually the shortest run.
3. Size the EGC from Table 250.122 for the breaker or fuse on the circuit being grounded.
4. Protect it in raceway or a cable sheath where exposed to damage. Bond the box and the device yoke.

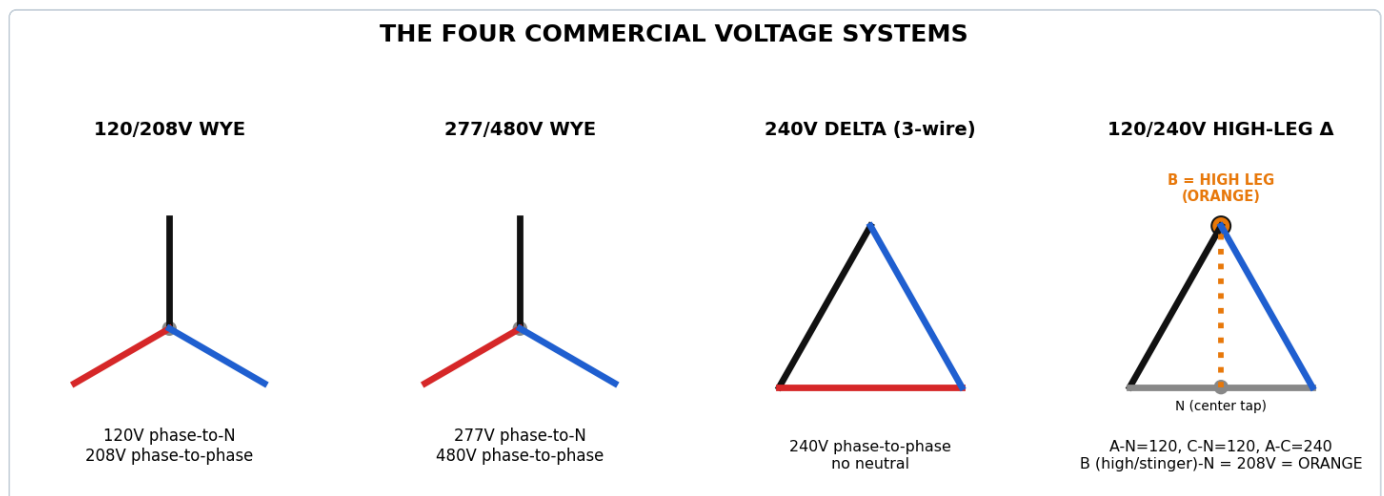
5. Test: the outlet tester shows correct wiring, and a GFCI tester or loop-impedance tester confirms the ground path works.

Water-pipe-only grounding

Old buildings often have the grounding electrode conductor clamped to interior copper 20–40 ft from where the water line enters, and no ground rod. A metal underground water pipe electrode must "be supplemented by an additional electrode" (250.53(D)(2)). Interior water pipe more than 5 ft from the point of entrance may not be used to interconnect electrodes, except in commercial or industrial buildings with qualified maintenance (250.68(C)(1)). Note it on the report and add the supplemental electrode when the service is worked on.

Part D — Legacy Service / Distribution Configurations

Older commercial and industrial services often aren't the 208Y/120 or 480Y/277 wye you're used to. **Meter every leg to ground before you energize or land a 120 V circuit.** These systems give voltage-to-ground readings that fool wye-trained techs.



From the 3-Phase Masterclass — the high-leg delta (right) is the legacy trap: B phase reads 208V to neutral and must be ORANGE.

Readings to expect (nominal)

System	L-L	A-G	B-G	C-G	N-G	Note
208Y/120 wye	208	120	120	120	0	Baseline for comparison
120/240 high-leg delta	240	120	208 (high leg)	120	0	$120 \times \sqrt{3} = 207.8$ V. Pre-1975 gear may have the high leg on C
240 V ungrounded delta, healthy	240	≈ 139	≈ 139	≈ 139	—	Capacitive reference only; readings float
480 V ungrounded delta, healthy	480	≈ 277	≈ 277	≈ 277	—	Ground-detector lamps glow equal
480 V ungrounded delta, solid fault on A	480	≈ 0	480	480	—	Now accidentally corner-grounded
480 V corner-grounded delta (B grounded)	480	480	0	480	—	Grounded phase is the identified conductor
120/240 single-phase 3-wire	240	120	120	—	0	

Use a low-impedance meter on ungrounded systems. A high-impedance digital meter reads capacitive coupling on an ungrounded system, and field reports describe readings near 1,000 V to ground on an unloaded 480 V ungrounded secondary. Electricians on these systems say phase-to-ground readings with a high-impedance meter are "all but meaningless" (Mike Holt forum, anecdotal). Use the LoZ function or read the ground detector itself.

The systems

- **240 V 3-wire delta:** three hots, no neutral; motor loads only. Any 120 V load needs a transformer. Plug fuses are not permitted on it (240.50(A)).
- **120/240 V high-leg ("stinger") delta:** A-N and C-N are 120 V, but B-N is about 208 V. Land a 120 V load on it and you smoke the equipment.
- **Corner-grounded delta:** one phase is intentionally grounded, and the other two read full line voltage to ground.
- **Open delta (two transformers):** often a high-leg system. Two identical transformers deliver 86.6% of the sum of their ratings (57.7% of a closed bank of three). Two 50 kVA units give $0.866 \times 100 = 86.6$ kVA.
- **Ungrounded systems:** watch for three ground-detector lamps (Part D procedure below).

High-leg delta: rules and steps

- 110.15: on a 4-wire delta "where the midpoint of one phase winding is grounded, only the conductor or busbar having the higher phase voltage to ground shall be durably and permanently marked orange."

- 408.10(E)(1) (408.3(E)(1) in 2023): "The B phase shall be that phase having the higher voltage to ground on 3-phase, 4-wire, delta-connected systems." Other arrangements are allowed for additions to existing installations if marked.
- 408.10(F)(1) (408.3(F)(1) in 2023): the panel "shall be marked as follows: CAUTION ___ PHASE HAS ___ VOLTS TO GROUND," on a 110.21(B) label at a readily accessible location on the front.
- "Prior to 1975, the high-leg conductor was required to terminate on the 'C' phase of panelboards and switchboards" (Mike Holt, EC&M, 2013). Utility meter sockets may also put the high leg on C; confirm with the utility's service manual.

1. Meter every bus to neutral before landing anything.
2. Mark the 208 V bus or conductor orange at every termination.
3. Apply the 408.10(F)(1) caution label.
4. When replacing a pre-1975 panel, find which phase the high leg is on now and re-land it on B in the new panel.
5. Never land a 1-pole 120 V breaker on the high-leg bus.

Corner-grounded delta: rules and steps

250.20(D) is now impedance-grounded systems; it is no longer the corner-grounded rule. The 2026 rules for corner-grounded delta are:

Rule	Section
On a multiphase system with one grounded phase, the conductor to be grounded is a phase conductor	250.26(4)
Straight-rated breakers (240 V, 480 V) only. "A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked 1 Φ -3 Φ "	240.85(A)
Slash-rated breakers (120/240 V, 480Y/277 V) only on solidly grounded circuits where no conductor exceeds the lower voltage to ground. Never on corner-grounded delta.	240.85(B)
No OCPD in series with the grounded conductor unless it opens all conductors at once, or for motor overloads under 430.36	240.22
Where fuses provide motor overload protection, a fuse goes in each ungrounded conductor "and also in the grounded conductor if the supply system is 3-wire, 3-phase ac with one conductor grounded"	430.36
SPDs may not go on "ungrounded systems, impedance grounded systems, or corner grounded delta systems unless listed specifically for use on these systems"	242.12(2)

1. Meter all three phases to ground. One reads 0 V. Identify that phase at every panel and disconnect.
2. Check every 2-pole breaker on a 3-phase corner-grounded circuit for the 1 Φ -3 Φ marking, and check that every breaker is straight-rated.

3. Look for fuses in the grounded phase. 430.36 requires one for fused motor overload protection; for other circuits a solid neutral link replaces it. Confirm with the engineer before changing anything.
4. Use only SPDs listed for corner-grounded systems.
5. Check drive and SPD manuals: equipment rated for 277 V to ground sees 480 V to ground on two phases here.

Working space: for ungrounded circuits, Article 100 defines voltage to ground as "the greatest voltage between the given conductor and any other conductor of the circuit." On a 480 V ungrounded or corner-grounded delta, use the 151–600 V column of Table 110.26(A)(1).

Ungrounded systems: ground detectors and the fault hunt

- Ungrounded systems from 120 to 1000 V "shall have ground detectors installed on the system" (250.21(B)(1)), connected as close as practicable to where the system gets its supply.
- They must be labeled "Caution: Ungrounded System Operating — ___ Volts Between Conductors" at the source or first disconnect (250.21(C)), and the panel marked the same way (408.10(F)(2); 408.3(F)(2) in 2023).
- Older detectors use "7½-watt indicator lights ... connected to the lines through 18,000-ohm resistors"; the lamp on a grounded phase "stops glowing, thus identifying the faulted phase" (IAEI). Normally all three glow dim and equal. One dark lamp means a first ground fault already exists.

A first ground fault is a countdown. IAEI explains that a second ground fault on a different phase becomes a phase-to-phase fault through conduit, couplings and enclosures. If the two faults are far apart, the path has high impedance and "a great deal of heat along with arcing and sparking is produced." Find and clear the first fault the same day.

IAEI's method: "The first step is to open the feeders one at a time and observe the ground detection indicator. After finding the feeder with the ground fault, branch circuits are disconnected, one at a time, until the offending circuit is located."

1. Confirm the indication. Press the lamp test, then measure each phase to ground with a LoZ meter at the detector. Record the readings and time.
2. Get the owner's permission and a shutdown order. Every feeder you open drops production loads.
3. Open feeders one at a time and watch the detector. When the dark lamp comes back to equal brightness, the fault is on the feeder you just opened.
4. Re-close that feeder and open its branch circuits one at a time the same way.
5. With the faulted circuit isolated and locked out, megger the conductors and the motor. Common causes are a motor winding shorted to the frame, a nicked conductor at a conduit entry, and water in a junction box.
6. Repair, megger again, re-energize, and confirm all three lamps are equal.

Part E — The Silent Killer: Available Fault Current vs. AIC

THE SILENT KILLER: available fault current creeps ABOVE old gear ratings

WHEN INSTALLED (decades ago)

TODAY



Old gear was right at install, but the utility quietly RAISES available fault current over the years. When it exceeds the device AIC, a fault can make the breaker/fuse RUPTURE or EXPLODE instead of clearing.

FIELD: pull a current fault-current letter from Alabama Power; compare to every AIC/SCCR nameplate (NEC 110.9 / 110.10 / 110.24).

Gear correctly rated decades ago can be dangerously underrated today, because the utility quietly raises the available fault current over the years.

Never assume the original interrupting rating is still adequate. Get a current available-fault-current letter from **Alabama Power** and compare it to the AIC and SCCR nameplates of the service gear and every downstream device. 110.9 requires an interrupting rating "at least equal to the available fault current at the line terminals of the equipment." 110.10 requires OCPDs and short-circuit current ratings "selected and coordinated with the available fault current." Panelboards and switchboards need an SCCR "not less than the available fault current" (408.6).

- Non-dwelling service equipment must be marked with the available fault current and "the date the fault-current calculation was performed" (110.24(A)). After changes that affect fault current, "the available fault current shall be verified or recalculated" and the marking updated (110.24(B)).
- Series ratings (240.86): existing installations may use a series combination selected, stamped and documented by a professional engineer and field-marked (240.86(A)); otherwise only tested combinations marked on the equipment (240.86(B)). Not allowed where connected motors between the two devices total more than 1% of the lower-rated breaker's interrupting rating (240.86(C)).

Worked example: is a 10 kA fuse safe on this service? (Bussmann point-to-point method)

Transformer: 500 kVA, 240 V three-phase delta, 4.0 %Z (impedance from the nameplate; assumed here).

Step	Math	Result
Full-load amps = $kVA \times 1000 \div (V \times 1.732)$	$500,000 \div (240 \times 1.732)$	1,203 A
Multiplier = $100 \div \%Z$	$100 \div 4.0$	25
Fault current = FLA $\times$ multiplier	$1,203 \times 25$	30,075 A
Worst case: $\%Z \times 0.9$ (UL 1561 $\pm 10\%$ tolerance)	$\%Z$ 3.6, multiplier 27.8	About 33,400 A at the transformer terminals

A Class H fuse or a 10 kA breaker on this service faces about 3 times its interrupting rating before any conductor impedance is subtracted.

1. Request a fault-current letter from the utility for the service address.
2. Read the AIC of the main and every branch device, and the panel SCCR.
3. Any device below the letter value fails 110.9, and it also fails the NFPA 70E normal-operation test (Part G).
4. Do not operate it under load.
5. Report it. Fixes are new gear, current-limiting fuses with an engineered series rating under 240.86(A), or replacement.

Part F — Hazmat: Recognize & STOP

Your job with these is **recognize, isolate, document, call the specialist**. You do not abate. Disturbing them is a health hazard and a federal liability.

HAZMAT IN LEGACY GEAR — RECOGNIZE & STOP (don't abate it yourself)

PCB OIL TRANSFORMER / CAPACITOR	SEE: Pre-1979 OIL-filled; nameplate says Askarel / Pyranol / Inerteen / Aroclor DO: Don't drain/cut. Report; licensed PCB contractor (40 CFR 761).
PCB FLUORESCENT BALLAST	SEE: Pre-1979 T12 magnetic ballast, no "No PCBs" mark; tar-like ooze DO: Leaks cleaned ≤ 24 hr; PCB waste handler. Pitch LED retrofit.
ASBESTOS	SEE: Arc chutes, transite/millboard panels, AVA/cloth wire (pre-~1980 gear) DO: Never dry-brush or air-blow. Test first; licensed abatement (OSHA 1926.1101).
LEAD	SEE: Lead-sheathed cable, lead paint/solder (pre-1978) DO: No dry grinding/torching uncontrolled; OSHA 1926.62 controls.

Your job is to RECOGNIZE → ISOLATE → DOCUMENT → CALL the specialist. Disturbing these creates a health hazard AND federal liability.

PCB transformers and ballasts, asbestos, and lead — identify and stop. None of these are yours to cut, drain, or scrape.

PCB ballasts and capacitors (EPA, 40 CFR 761)

- "FLBs manufactured before July 1, 1979, may contain PCBs." Non-PCB ballasts made from July 1, 1979 to July 1, 1998 "must be labeled 'No PCBs.'" "If an FLB is not labeled 'No PCBs,' it is best to assume it contains PCBs unless it is known to be manufactured after 1979."
 - "Only the T12 magnetic FLBs (not T8 or T5 FLBs) may contain PCBs."
 - A capacitor made before July 2, 1979 with unknown concentration is assumed to contain 500 ppm or more PCBs (40 CFR 761.2(a)(4)).
 - "The entire lighting fixture does not need special handling and disposal as long as the ballast ... is not leaking." A leaking spill "must be cleaned up within 24 hours" (40 CFR 761.125(c)(1)), and that cleanup is regulated work.
 - EPA "does not recommend opening the FLBs just to sample the potting material."
1. De-energize and lock out.
 2. Open the fixture and read the ballast label without cutting anything.
 3. "No PCBs" on the label: normal ballast disposal. No label, and pre-1979 or unknown: treat as PCB.
 4. Leaking (tar or oil on the fixture): stop, do not touch it with bare hands, and notify the owner.
 5. Intact PCB ballasts go in a lined drum supplied by the owner's disposal vendor, kept apart from other waste. Out-of-service PCB ballasts go to an approved disposal facility within nine months (40 CFR 761.65(a)(1)).
 6. Record the count and location.

Asbestos (OSHA 1926.1101)

- Presumed asbestos-containing material (PACM) is "Thermal system insulation and surfacing material found in buildings constructed no later than 1980."
- Drilling or cutting through sprayed fireproofing or an asbestos ceiling to run conduit is Class III work: "Repair and maintenance operations, where 'ACM' ... is likely to be disturbed." Contact without disturbing is Class IV.
- Building owners "shall identify TSI and sprayed or troweled on surfacing materials in buildings as asbestos-containing" unless tested and shown otherwise (1926.1101(k)(1)).
- In electrical gear built before 1981, treat arc chutes, cement-board panel backs and barriers, cloth wire insulation in high-temperature fixtures and flash guards as suspect until sampled (common suspects, not an official list).
- Ask the owner for the asbestos survey before work in a pre-1981 building. Never dry-brush or air-blow a panel. Stop and report if suspect material is damaged.

Lead

Lead-sheathed cable and lead-based paint on old conduit and enclosures are the electrician's lead exposures (OSHA 1926.62). Lead wiping of paper-insulated lead-covered (PILC) cable joints has been replaced by other methods because of "Occupational Health & Safety problems with handling lead and associated fumes."

Mercury vapor, T12 and the reconditioned-lighting ban

- "Mercury vapor lamp ballasts, other than specialty application mercury vapor lamp ballasts, shall not be manufactured or imported after January 1, 2008" (10 CFR 431.286).
- The DOE 2009 lamps rule set standards for fluorescent lamps made on or after July 14, 2012, which removed most T12 lamps from production.
- NEC 2026 410.3(B) bans installing reconditioned luminaires, lampholders, ballasts, LED drivers, lamps and retrofit kits. A failed mercury vapor or T12 magnetic ballast can only be replaced with new stock, and new mercury vapor ballasts are no longer made. Replace the fixture or install a listed LED retrofit kit.

Part G — Code Gaps Under the Modern NEC

Legacy installs routinely violate today's rules. Each item below is independently citable and a real safety issue.

- **Working clearance (110.26, Table 110.26(A)(1)):** 0–150 V to ground, 3 ft for all three conditions; 151–600 V, 3 ft, 3½ ft and 4 ft for Conditions 1, 2 and 3. Also 30 in. wide and 6½ ft headroom, with the dedicated space above kept clear. Legacy panels are often crammed in closets or behind storage.
- **Labels:** arc-flash label (110.16) for equipment "likely to require examination, adjustment, servicing, or maintenance while energized," the available-fault-current label (110.24), and a circuit directory (408.4(A)) plus a source-of-supply label (408.4(B)) that is permanent and "not handwritten." Legacy gear almost never has these.
- **Guarding (110.27):** live parts at 50–1000 V must be guarded "by approved enclosures" or kept in a room accessible only to qualified persons. Open-frame starters, drum switches and knife switches in an unlocked room fail this.

Energized work on old gear (NFPA 70E-2024)

Operating a breaker or switch is "normal operation" under 70E 110.2 Exception No. 1 only when all seven conditions are met: "(1) The equipment is properly installed. (2) The equipment is properly maintained. (3) The equipment is rated for the available fault current. (4) The equipment is used in accordance with instructions included in the listing and labeling and ... manufacturer's instructions. (5) The equipment doors are closed and secured. (6) All equipment covers are in place and secured. (7) There is no evidence of impending failure." Impending failure means signs such as "arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or water damage." For legacy gear, condition (3) fails whenever Part E shows the AIC is below the available fault current, and condition (2) fails when there is no maintenance record.

Step by step: unlabeled old gear

1. Treat it as energized and unknown. No label means no voltage, boundary or PPE data.

2. Get the fault-current letter and any arc-flash study. Without both, an engineer's incident energy analysis is needed before energized work.
3. Inspect from outside the restricted approach boundary: infrared camera through the closed door or an IR window; listen and smell for arcing; look for the impending-failure signs.
4. Operate disconnects from the side, face turned away, in the PPE the assessment specifies. If any of the seven conditions fails, de-energize upstream instead.
5. Establish an electrically safe work condition (NFPA 70E 120.6; 120.5 in the 2021 edition): identify all sources (old buildings often have a second service or tie switches nobody remembers), open, verify a visible break where possible, lock out, and test for absence of voltage with a meter checked on a known source before and after.
6. Oil circuit breakers and oil switches: Army TM 5-682 says "An open oil circuit breaker is not acceptable" as an isolation point. If one must be used, "the line-side leads must be removed from the breaker bushings and the breaker must be mechanically blocked open, locked-out, and tagged," followed by a voltage test and protective grounds. Oil may contain PCBs; test before draining (40 CFR 761).

Part H — Old Cable and Conduit Types

Cable or raceway	2026 status	Field note
TW	Table 310.4(1): "Moisture-resistant thermoplastic," 60°C, dry and wet	60°C column only; old PVC goes brittle
RHW / RHH	RHW 75°C dry and wet; RHH 90°C dry and damp	Rubber with a braid; cracks at bends near terminals
Cloth braid over rubber	Not a current type	Bend a sample at the box; crumbling means replace the circuit
BX without bonding strip	Does not meet 320.100/320.108	Run a wire-type EGC
Lead-sheathed / PILC (usually medium voltage)	Not in Chapter 3	Splice with listed transition joints; MV splicing is for qualified MV splicers only
Black enamel conduit	300.8(A)(1) (300.6(A)(1) in 2023): enamel-only ferrous raceway "shall not be used outdoors or in wet locations"	Dry indoor use only
Old flex (Greenfield)	250.118: flex as the EGC only with listed fittings, 20 A or less for $\frac{3}{8}$ – $\frac{1}{2}$ in., total length 6 ft or less	Longer runs with no EGC need a wire-type EGC

Part I — Old Controls, Distribution and Low-Voltage Systems

- **Old bus duct.** NEMA BU 1.1 says "contact manufacturer before re-torquing joint bolts," "Do not remove plating from aluminum parts in joints," check insulation resistance before re-energizing and keep "a permanent record," "Never attempt to defeat rejection mechanisms" in plug units, and do an IR scan after re-energizing. 368.3(B) bans reconditioned Mylar-wrapped and powder-coated busway.
- **DC motors and elevator motor-generator sets.** Losing the shunt field while armature voltage is applied drives a DC motor's speed up toward runaway. A field-failure relay contact in series with the main contactor seal-in drops the motor on field loss. "Never jumper its contacts in service."
- **GE RR7/RR9 remote-control relays.** Small round relays mounted in a ½ in. knockout: mechanically latching, with a split 24 V coil, red lead ON and black lead OFF, plus a yellow pilot lead on the RR9. They run on 24–29 VAC rectified with a 50 ms minimum pulse, are rated 20 A tungsten at 125 VAC and 30 A ballast at 277 VAC, and take "#14-10 AWG ... copper wire only." "Do NOT use these relays to switch DC loads." The RR7PBP is listed as discontinued. Troubleshoot in this order: 24 V rectified at the transformer, pulse ON at the relay leads, listen for the click, then check the load side with the relay latched.
- **Old fire alarm.** Two-wire smoke detectors work only on panels that list them as compatible. Bosch: "Two-wire smoke detectors that are not listed as compatible should not be used," and different makers' detectors "may not be mixed on the same circuit." Do not replace a legacy detector with a "close" model; match the panel's compatibility list or hand it to the fire alarm contractor.
- **Maintenance condition (NFPA 70B-2023).** 70B is now a standard with mandatory language. Equipment that "has missed the last two successive maintenance cycles" is Condition 3, with most tasks every 12 months and IR thermography every 6 months. Most legacy gear with no records lands in Condition 3.

Part J — Sourcing Obsolete Breakers: the 2026 Reconditioned Rules

Article 100 defines reconditioned equipment as equipment "restored to operating conditions," and says it "is frequently referred to as rebuilt, refurbished, or remanufactured." Replacing listed equipment one-for-one is not reconditioning. Where reconditioned equipment is allowed, 110.21(A)(2) requires it to be marked with the reconditioner's name, the date and "reconditioned," and "The original listing mark shall be removed or made permanently illegible." Many articles now say outright what may and may not be reconditioned:

Section	Reconditioned permitted	Reconditioned prohibited
210.3	—	GFCI and AFCI equipment
240.3	Low-voltage power circuit breakers; electromechanical protective relays and CTs	(B)(1) ground-fault protection equipment; (B)(2) GFCIs; (B)(3) low-voltage fuseholders and nonrenewable fuses; (B)(4) molded-case circuit breakers ; (B)(5) power-breaker electronic trip units
242.3	—	SPDs and surge arresters
404.3	Knife switches; butt-contact switches; bolted-pressure switches	Electronic lighting controls that are not wiring devices; molded-case switches
408.3	Switchboards and switchgear	Panelboards
410.3	—	Luminaires, lampholders, ballasts, LED drivers, lamps, retrofit kits
430.3	Motors, reconditioned per the manufacturer or national standards (ANSI/EASA AR100)	—
368.3	—	Mylar-wrapped and powder-coated busway

No "refurbished" molded-case breakers. A rebuilt or refurbished MCCB from a surplus dealer cannot be installed (240.3(B)(4)). Your options are: (1) a new OEM breaker of the original type; (2) the manufacturer's designated replacement (for example, Schneider FAQ FA233980 replaces obsolete KA36100-KA36250 I-Line breakers with HGA36100 through JGA36250, rated 18 kA at 600 V, 35 kA at 480 V and 65 kA at 240 V); (3) a UL Classified replacement breaker listed for that panel (Eaton limits its classified breakers to "panelboards rated 225 amperes," 120/240 V applications, and available short-circuit current that "cannot exceed 10 kilo-amperes"); or (4) replace the panel.

Part K — Repair or Replace?

1. Is the equipment rated for the available fault current (110.9, 408.6; 70E 110.2 Exc. 1(3))? If not, swapping parts cannot bring it into compliance. Replace it, or have the engineer apply a 240.86(A) series rating.
2. Is it a known defect family (FPE Stab-Lok, Zinsco)? If yes, recommend replacement.
3. Are new or OEM-designated parts available? Reconditioned MCCBs, panelboards, GFCIs, fuseholders and ballasts are prohibited (Part J).
4. What does the 70B condition assessment say? Condition 3, missed maintenance cycles and repeated repairs support replacement.
5. Is the work a service change? Existing six-disconnect gear may stay only until the service is replaced (230.71(B) Exception).

Documenting existing conditions (walk-through report)

1. Photograph every nameplate: manufacturer, catalog number, voltage, ampacity, AIC or SCCR, date code.
2. Meter every bus to ground and to neutral; record readings in the Part D table format.
3. Note the ground-detector lamp state and whether the 250.21(C) and 408.10(F) labels are present.
4. Record the utility fault-current letter value and its date (110.24).
5. List each defect with its code section.
6. Record IR scan results with the load at the time of the scan.
7. Flag hazmat items (ballast labels, suspect asbestos, lead sheath) without disturbing them.
8. Note the AHJ's adopted NEC edition.

Field Identification Table

What you see	What it probably is	What to do
Black handles with a thin red stripe, "Stab-Lok"	FPE panel	Do not reseal breakers; recommend replacement
Multicolored handles, "Magnetrip" embossed at the top	Zinsco / GTE-Sylvania	Recommend replacement; avoid repeated breaker removal
Push-button breakers, no toggle	Pushmatic / Bulldog	Parts obsolete; plan replacement
Up to six "main" breakers at the top of one panel	Split-bus	Meter both buses; allowed by 230.71(B) Exc. until the service changes
3-pole breaker in an old single-phase panel	Delta breaker	Remove (408.36(C))
Screw-in fuses, round window	Edison-base plug fuses	Check wire size; Type S adapters (240.52-240.54)
Cartridge fuses with removable end caps	Class H renewable	Check link vs. cap rating; 10 kA only; upgrade to RK1 or J
Three small lamps marked A-B-C on the switchboard, one dark	Ungrounded delta with an existing ground fault	Run the feeder-by-feeder hunt today
One phase reads 0 V to ground, others 480 V	Corner-grounded delta (or a faulted ungrounded system)	Straight-rated breakers only; 1 Φ -3 Φ 2-poles; listed SPDs
One bus reads 208 V to neutral, others 120 V	High-leg delta	Orange marking, 408.10(F)(1) label, no 120 V loads on it
Porcelain knobs and tubes in the attic	Knob-and-tube	Check for insulation contact (394.12(5)); megger and document
"AL" or "ALUMINUM" on the cable jacket, #12 on 15 A	1965-mid-70s aluminum branch wiring	CPSC: COPALUM, AlumiConn, or rewire
Spiral armor cable, no thin strip inside	Old BX without a bonding strip	Add a wire-type EGC
Black-painted (not galvanized) rigid conduit	Enamel conduit	Dry indoor use only (300.8(A)(1))
T12 fixture, ballast with no "No PCBs" label	Possible PCB ballast	Stop; treat as PCB; EPA disposal
Large HID fixture with an "MV" or H-series lamp	Mercury vapor	No new MV ballasts since 2008; replace the fixture
Small round relays in a ½ in. KO with red, black, blue (and yellow) leads	GE RR7/RR9	24 V rectified pulse control; no DC loads
Oil-filled switch or breaker tank	Oil switch or oil circuit breaker	Not an isolation point (TM 5-682); oil may contain PCBs

Cement-board backing, cloth wire in fixtures, built before 1981	Possible asbestos	Do not disturb; owner survey per 1926.1101(k)
Lead-covered cable entering switchgear	PILC (often medium voltage)	Qualified MV splicer; lead exposure controls
Motor-generator set in an elevator machine room	DC elevator drive	Never jumper the field-failure relay
"Refurbished" breaker in a surplus box	Reconditioned MCCB	Do not install (240.3(B)(4))

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

- **230.71** service disconnects, existing split-bus exception • **408.36(C)** no delta breakers • **408.3(B)** no reconditioned panelboards (new) • **240.3(B)** no reconditioned MCCBs, GFCIs, fuseholders (new) • **410.3(B)** no reconditioned luminaires, ballasts, drivers, lamps (new) • **110.20, 110.21(A)(2)** reconditioned marking.
- **240.50-240.54** plug fuses and Type S • **240.4(D)** small conductors • **110.9, 110.10, 110.24, 408.6** interrupting rating, SCCR and fault-current marking • **240.86** series ratings.
- **394.10, 394.12, 394.19, 394.30, 394.56** knob-and-tube • **320.100, 320.108** AC bonding strip • **406.10(1)** CO/ALR • **406.12(D)(2)** (406.4(D)(2)) ungrounded-receptacle replacement • **250.130(C)** EGC retrofit • **250.53(D)(2), 250.68(C)(1)** water-pipe electrodes.
- **110.15** high-leg orange • **408.10(E)/(F)** (408.3(E)/(F)) high-leg on B and caution labels • **250.21** ungrounded systems and ground detectors • **250.26(4), 240.85(A)/(B), 240.22, 430.36, 242.12(2)** corner-grounded delta. 250.20(D) is now impedance-grounded systems.
- **110.16, 110.26, 110.27, 408.4** arc-flash label, working space, guarding, directory • **300.8(A)(1)** (300.6(A)(1)) enamel conduit • **250.118** flex as EGC • **368.3** busway.
- Other standards: NFPA 70E-2024 110.2 Exc. 1, 110.9, 120.6 • NFPA 70B-2023 • OSHA 1926.1101 (asbestos), 1926.62 (lead) • 40 CFR 761 (PCBs) • 10 CFR 431.286 (mercury vapor ballasts).

Field Red-Flag Checklist (older commercial)

- FPE red-stripe or Zinsco colored handles: recommend **panel replacement** and expect insurance friction.
- Edison-base plug fuses, or any fuse larger than the conductor allows: over-fused; Type S adapters or replace.
- **Class H** fuses on a commercial service: likely underrated for the available fault current; go to RK1 or J.
- Pull an **Alabama Power fault-current letter** and compare it to every AIC and SCCR nameplate.
- **Meter every leg to ground** before landing 120 V (high-leg, corner-grounded, ungrounded).

- A 2-pole breaker with no 1 Φ –3 Φ marking on a 3-phase corner-grounded circuit, or a slash-rated breaker on any delta: 240.85 violation; replace with straight-rated.
- A fuse in the grounded phase of a corner-grounded system is allowed only for fused motor overload (430.36). Ask the engineer before removing it.
- One dark ground-detector lamp: an existing ground fault. Start the feeder-by-feeder hunt the same day.
- Pre-1975 high-leg panel: the high leg may be on C. Re-land it on B in the replacement (408.10(E)(1)).
- Two-wire, K&T, or a broken ground path: add an EGC (250.130(C)) or use a GFCI marked "No Equipment Ground" (406.12(D)(2)).
- Aluminum branch wiring on CO/ALR devices only: code-legal but, per CPSC, at best an incomplete repair.
- Pre-1981 gear: **get the asbestos survey** before any disturbance; never dry-brush or air-blow a panel.
- Pre-1979 oil transformer or T12 ballast with no "No PCBs" label: treat as **PCB**; stop and call.
- "Refurbished" molded-case breaker, GFCI or panelboard: prohibited (240.3(B), 408.3(B)).

Hands-On Field Exercise

- Walk an older building with a lead and fill out the existing-conditions report: nameplates, meter readings, labels, defects and code sections.
- Identify FPE, Zinsco, Pushmatic and split-bus panels from photos and write the one-line finding for each.
- Do a Type S retrofit on a plug-fuse board in the shop, choosing each adapter by wire size.
- Fill in the expected readings for a 120/240 high-leg delta and a 480 V corner-grounded delta, then meter a real one and compare.
- Talk through the feeder-by-feeder ground-fault hunt on a one-line drawing of an ungrounded plant.
- Work the point-to-point fault-current example for a 750 kVA, 480 V transformer at 5.75 %Z and compare it with a 22 kA panel.
- Open a T12 fixture (locked out) and read the ballast label; decide PCB or not.

Sources used in this module (public documents)

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- U.S. Army TM 5-682, Facilities Engineering: Electrical Facilities Safety.
- GE TLC RR-series relay data sheet. Bosch FPD-7024 smoke detector compatibility list: [boschsecurity.com](https://www.boschsecurity.com)
- Power and Cables, "Lead Wiping Cables": [powerandcables.com](https://www.powerandcables.com)
- Encyclopedia of Alabama and REV Birmingham (building stock); Alabama Power Rules and Regulations (fault-current letters).

Next: none. This bonus masterclass is the last module in the program.