



## Breakers Lab

**Program:** Electrician Technician

**Course:** EL140 Residential Applications

**Objectives:** Under the supervision of your instructor, you should be able to do the following:

- Identify the following on one or more circuit breakers(s) and fuse(s)
  - Number of Poles
  - Load Rating
  - Voltage Rating
  - Amperage Interruption Rating
- Properly install circuit breakers

**Lab Equipment:**

- Residential Lab Bays

**Required Tools:**

- 1 – Pencil
- 1 – Pair of Wire Strippers
- 1 – Pair of Diagonal Cutters
- 1 – Pair of Pliers
- 1 – Flathead Screwdriver

**Materials:**

- 1 – 15-amp single pole breaker
- 1 – 15-amp two pole breaker
- 3' – #14/2 AWG Nonmetallic wire
- 1 – Service panel

**Safety (PPE):**

- Safety glasses/goggles
- Hard hat

**Resources:** N/A

**Required Time:** 60 Minutes

**Shop Maintenance:**

- All work will cease 20 minutes prior to the end of class.
- All work areas must be cleaned.
- Tools and equipment must be cleaned and returned to the designated areas (cage, tool room, cabinets etc.)
- Any broken or missing tools must be reported immediately.
- Tools and equipment are students' responsibility



**Procedures:** *(Eye protection must always be worn)*

**Identifying a Breaker**

1. 15-amp single pole breaker – explain how to identify how many poles the breaker is/are and what the ratings means (voltage, load, and amperage interrupting)
2. 15-amp two pole breaker – explain how to identify how many poles the breaker is/are and what the ratings means (voltage, load and amperage interrupting)



**Determining Where to Install the Circuit Breaker**

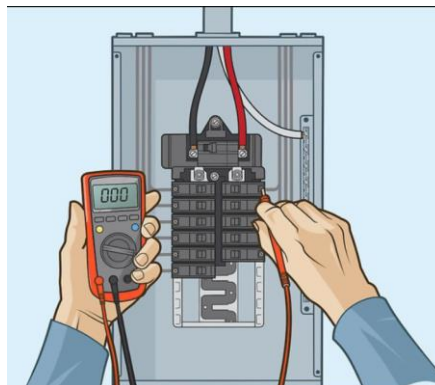
1. Turn off the power supply to the electrical panel. Locate the Service Disconnect or Main circuit breaker in the panel and set it to the "Off" position.
  - a. This circuit breaker is likely to have the largest amp value and will be located either at the top or bottom of the panel.



2. Inspect the circuit breaker arrangement for unused locations.
  - a. If the unused location has a knockout plate over it, you will have to eventually remove it before completing the installation process. For now, you simply need to identify a space where you can install the circuit breaker.
3. Remove the electrical panel cover.



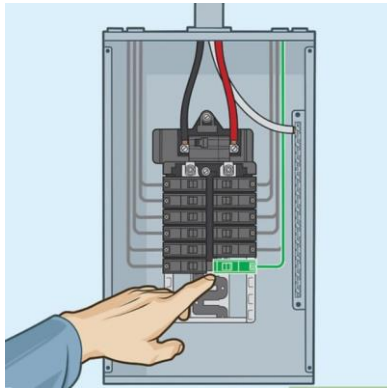
4. Test the panel to make sure the power is off.
  - a. Use a test light or meter set to check for the presence of power. Touch 1 probe to ground (the bar that has bare or green and white wires connected) or neutral (the bar that has just white, or just bare or green wires connected) and touch the other probe to the screw terminal of a circuit breaker that has a black, red, or blue insulated wire connected. If 120 (or more) volts are indicated, the panel is still being powered and will need to be turned off before proceeding.
  - b. Make sure your test light is set to the highest AC voltage range available (and is set at minimum to 120 volts).
  - c. If the Service Disconnect or Main circuit breaker is in this panel, it will always indicate power on the terminals that have cables connected. The output of the Main or Service Disconnect when located in the panel, connects to the bus bar. The bus bar should have no power present when this breaker is OFF. Testing at the Service Disconnect or Main circuit breaker is not recommended due to this "seemingly conflicting" information.
  - d. It is not safe to install a circuit breaker in an electrical panel that still has power flowing to it. Do not continue if power is present on a circuit breaker other than Service Disconnect or Main circuit breaker, until the power source has been shut off.



5. Find an unused space next to or between existing circuit breakers. The new circuit breaker you install will need to be placed next to a circuit breaker already in place. Carefully compare this location to the cover that was removed earlier to make sure it aligns with an unused location on the cover.

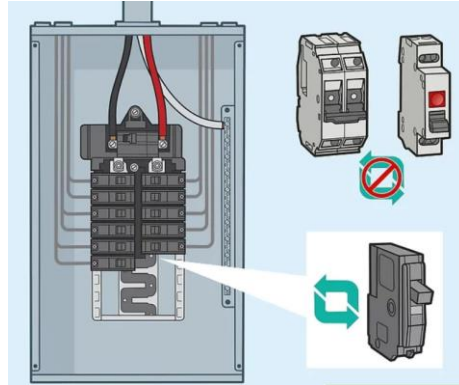


- a. It is important that the cover has provisions for exposing the new circuit breaker by removal of the knockout plate. If there is no plate to be removed, the circuit breaker will have to be in a different place on the panel.
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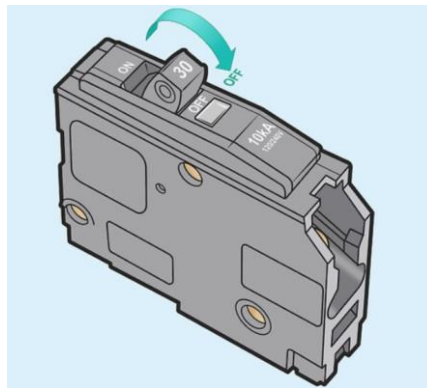


#### **Placing the Circuit Breaker in the Panel**

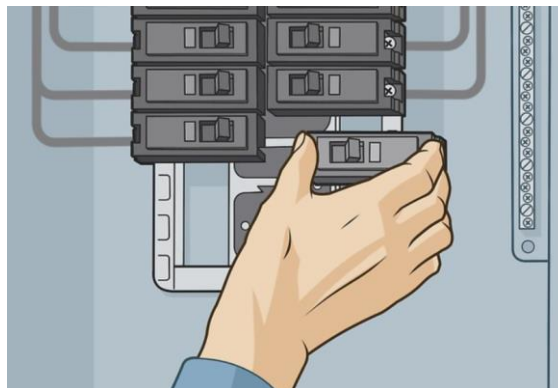
1. Make sure you have the correct circuit breaker. The panel label will list all the approved types of circuit breakers that can be installed in the panel. Deviating from the list is a code violation and voids any UL, FM or other listing services' approval. For maximum safety, use only those circuit breakers that are allowed to be installed in the panel.
  - a. Typically, the only breakers allowed to be installed are from the same manufacturer of the panel - even if other brand breakers are labeled as "fits (brand name here) panels".
  - b. The breaker should be of an ampacity that does not exceed the circuit conductor's rating. This is typically 15 amps for #14 copper, 20 amps for #12 copper and 30 amps for #10 copper conductors or wires. Consult the code book to determine sizes for other circuits.
  - c. The terminal size should be large enough for the wire to fit. The need to remove strands of wire to fit the terminal is an indication of an error somewhere along the



2. Set the circuit breaker handle to the OFF position. The circuit breaker has 3 positions: ON and OFF and a mid-position when TRIPPED. Push the handle towards the OFF position before installing the breaker to ensure your own safety during the installation process.

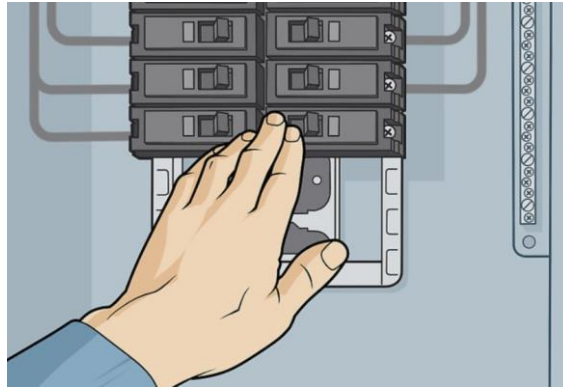


3. Align the circuit breaker with the bars in the panel. Tilt the circuit breaker so that the hold-on clip on the bottom of the breaker is attached to the plastic “grab” bar in the panel. Once attached, pivot the circuit breaker on the mechanical contact and roll towards the center of the panel - making sure the bus bar of the panel is still aligned with the slot or opening on the circuit breaker case.
  - a. You may have to apply pressure to the breaker for it to become attached to the plastic bar.



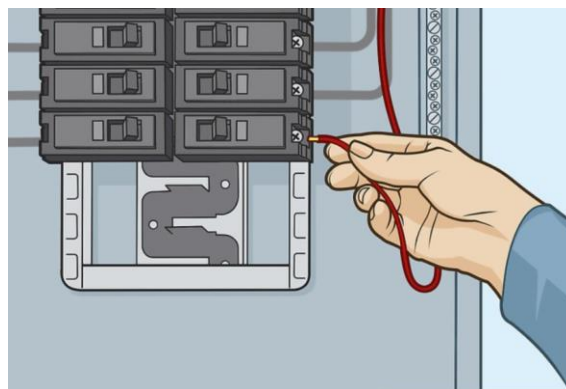


4. Firmly press on the circuit breaker to seat it onto the bus bar. Use your thumb to press firmly but gently on the circuit breaker until it snaps into place on the bus bar. You don't have to screw the breaker into place; it's held in place by spring clips and the panel cover.
  - a. While it will require firm, even pressure to be seated, it should not have to be forced.



5. Connect the circuit wiring to the electrical panel. After making sure the circuit breaker is still in the OFF position, connect the white neutral wire and the black hot wire to the breaker. Loosen the screw over the breaker's connection terminal, insert the wires into the appropriate terminal locations, then tighten the screw until snug.
  - a. Your circuit breaker should have a label that indicates where to insert the neutral and hot wires.
  - b. If you're installing a double pole breaker, you'll connect it to both the black and red wires. Just make sure you're using a switch that's designed to be used as a double breaker.

**Note** that there's no need to bend the end of the wire into a hook; it just needs to be straightly inserted into the connection terminal.



### Finishing and Testing the Installation

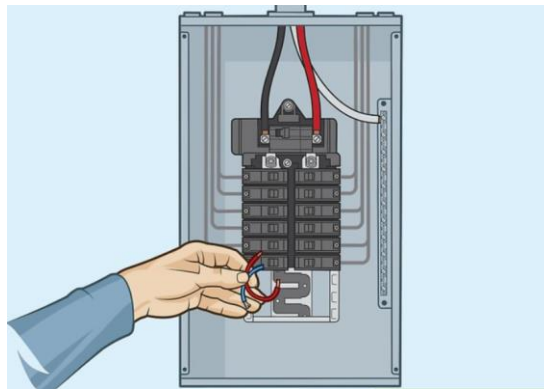


1. Remove knockout plates from your cover as needed. Bring the cover up to the panel to compare the new circuit breaker location to the cover openings. Use a pair of pliers to remove any knockout plates on the cover location where the circuit breaker will be located.

- a. To remove the knockout plate, simply grip with the pliers and move the metal back and forth until it comes away.



2. Clean all foreign objects out of the panel and reinstall the cover. Remove any tools, wire scraps, or other foreign objects that could cause a short circuit from the interior of the panel. Then, place the cover on the panel to check that the circuit breaker has fully been seated at both contact points and fits through the cover. Finally, screw the cover onto the panel.



3. Turn on the main breaker and test your new circuit breaker. Standing to the side of the panel, restore power to the panel by setting the Service Disconnect or Main to "On" and then set the new circuit breaker to "On". Check for correct operation of the new circuit (light, outlet, etc.) with a test light or meter.

- a. Clear any short circuit before attempting a reset if circuit breaker instantly trips.



4. Label the circuit breaker. Locate the panel's circuit directory on the inside of the panel door. Determine the circuit breaker location (or "circuit number") and write a description of the circuit (load type such as "refrigerator" or a location such as "living room") in the space provided. Be sure to edit the directory if any circuits were moved to install the new circuit.



### Warnings

- Voltage levels as little as 50 volts can be lethal under the right conditions. Most residential electrical systems are 2 to 5 times this value. Shut off power whenever working on circuits and never proceed if unsure or uncomfortable performing the steps above.
- Always stand to the side of an electrical panel when turning circuit breakers "on". The amount of energy being transferred is directly proportional to the amperage value rating on the circuit breaker. While a single pole 15- or 20-amp short circuit would not cause catastrophic damage, a double pole 100- or 200-amp short circuit certainly could. Standing off to the side takes a person (though not completely) "out of harm's way".
- Never install a circuit breaker into a panel for which it was not designed. Many circuit breakers will physically fit into different panels, however only those identified on the panel's label are approved for use. Using improper circuit breakers causes forfeiture of UL, Factory Mutual and all other "listings". Use of unlisted devices is a code violation and in extreme cases, may result in denial of a claim to the insurance company in the event of a loss.





- Prior to using any tester or meter, be sure it works by first checking on a known live circuit. If the device fails to indicate properly, do not use it until repaired or replaced.
- In the US, 120/240 systems (the type most often found in a residence or dwelling) use a color code for wiring; Black, Red, Blue "hot wires" and White neutral wires. In addition to 120/240-volt systems that appear in residences, many commercial and industrial settings also have 277/480 systems. These higher voltage systems use distinct colors scheme to immediately alert the electrician of the higher voltage panel. The color scheme used for these systems is Brown, Orange, Yellow (think "BOY") "hot wires" and Gray neutral wires. Be sure new wiring is installed correctly.