# B-03

# ELECTRICIAN TRAINING

## SKILL DEVELOPMENT GUIDE

**Duty B: Power Distribution (600V and below)**
**B-03: Troubleshoot 480V System**

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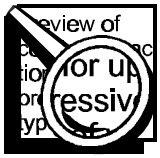


## Task Preview

Troubleshoot 480V System

The 480V distribution system powers the plant from the substation. When some part of the system fails, anything from one machine or light to the whole plant goes down. The Electrician must be able to diagnose the problem and isolate the component failure efficiently to quickly restore power. The Electrician must also be able to diagnose the conditions that caused the problem and recommend corrections to prevent recurrence.

How your skills will be checked

The Skill Check will require you to troubleshoot a problem in a 480V power distribution system. All tools, materials, and resources will be available. The Evaluator will verify that your demonstration meets the skill objective by observing or measuring each task standard. You must demonstrate safe work practices during the Skill Check. Contact your Evaluator when you are ready for the Skill Check.

## Skill Objective

Given a problem in a 480V power distribution system, troubleshoot the system to identify the component at fault and the conditions that caused the problem.

Task Standards

1. Power is restored to all circuits quickly.

2. All safety requirements are demonstrated.

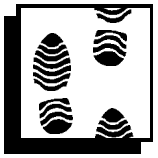
## What You Will Need

This section contains the safety information, tools, and resources you will need before you can troubleshoot a 480V system.


- ☐ Follow all Caterpillar facility safety standards when performing this task.
- ☐ Lock out and tag the power disconnect supplying a section of distribution equipment before testing the section for ground and line faults.
- ☐ Appropriate Electrician's gloves are required when working on live circuits of 50V or more.
- ☐ A ladder or manlift and harness is necessary to work on overhead distribution equipment.

- ☐ Electrician's pouch, with wiggy and DVM


- ☐ prints of power distribution equipment
- ☐ persons who may have been present and / or involved when the system problem occurred



## Task Steps

Troubleshoot 480V System

1. Investigate the symptoms.

   - ☐ Determine the specific loads, drops, and areas where a power outage, lost phase, or other 480V power distribution problem has been reported.
   - ☐ Measure voltage between each phase and ground, and between each phase pair at the affected load, or at one of the loads in the affected area.
   - ☐ Determine when the problem occurred, if possible, and what equipment the 480V distribution system was powering at the time.

2. Identify the cause of the symptoms. In most cases, the cause will be a tripped circuit breaker or a blown fuse.

   - ☐ Lockout and tagout the disconnect.
   - ☐ If there is no voltage to ground on any phase and no voltage between any phase pair, a circuit breaker is tripped.
     a. If only one load is affected, the circuit breaker / disconnect supplying that load is tripped.
     b. If all the loads supplied through a load control center are dead, the load control center main breaker is tripped.
     c. If a whole area is affected, the substation circuit breaker is tripped.
   - ☐ If voltage between two phases is normal, but voltage between either of those phases and the third phase is zero or low, a fuse is blown.
     a. If only the load or loads supplied by one drop are affected, one of the bus plug fuses that supply the drop is blown.
     b. If all the drops supplied by one or more bus ducts are affected, one of the fuses in the distribution bus duct(s) that supplies the bus duct(s) is blown.
   - ☐ If necessary, obtain prints of the affected parts of the distribution system. Use the prints to map out the affected drops, bus ducts, or area.

- ☐ If prints are not available, visually trace the feeders. Many bus ducts are labeled; signs on them identify the distribution bus duct(s) and substation supplying them.

3. Test the cause of the symptoms.

   - ☐ Find and inspect the circuit breaker or fuse identified in step 2.

Caution: Do not reset any tripped breaker or replace any blown fuse until the problem that caused it to open has been corrected.

Do not try to defeat interlocks on fused disconnects. If you suspect a fuse is blown, set the disconnect to OFF before opening the cabinet. In general, test a fuse by measuring the resistance through it rather than the voltage across it.

4. Determine why the breaker tripped or the fuse blew.

   - ☐ Blown fuses and tripped circuit breakers are occasionally the result of a problem with the circuit breaker, fuse, or associated equipment. More often, breakers trip and fuses blow because of a ground fault, a line fault, or an overcurrent condition.

5. Identify the causes of a blown fuse or tripped breaker.

   - ☐ Inspect the equipment. Look for:

     a. loose, corroded, or overheated-appearing terminals and conductors;

     b. overheated, cracked, or missing insulation;

     c. charred or burned insulators or cases on molded case circuit breakers;

     d. loose, corroded, or overheated-appearing fuse clips;

     e. loose, corroded, or overheated-appearing bus stabs on circuit breakers (large breakers will have to be racked out for this inspection).

Note: Circuit breakers that have interrupted fault current too many times may overheat and trip on less than their rated current.

- ☐ If all equipment appears to be in serviceable condition, check for a ground fault - a low-resistance path that allows high current between one phase and ground.
    a. Shut off, lock out and tag power (if necessary).
    b. Measure the resistance between each phase and ground on the load side of the blown fuse or tripped circuit breaker. A reading of less than 1 megohm between any phase and ground indicates a ground fault.
    c. Open (one at a time) every disconnect on the load side of the blown fuse or tripped circuit breaker while monitoring phase-to-ground resistance. When the low resistance disappears after opening a disconnect, the ground fault is in a component (conductor, bus, disconnect equipment, or load) on the load side of that disconnect.
    d. Close all other disconnects, reset the tripped circuit breaker or replace the blown fuse and restore power to the rest of the distribution system.
    e. Find the ground fault in the isolated part of the system by a similar procedure: disconnect sections or components until the low resistance to ground disappears.
    f. Correct the ground fault before restoring power to the disconnected circuits.
- ☐ If all phases read high to ground, check for a line fault - a low-resistance path that allows high current between two phases.
    a. Open load control contactors or switches to disconnect all loads on the load side of the blown fuse or tripped circuit breaker.
    b. Disconnect all transformer windings that are normally connected between phases on the load side of the blown fuse or tripped circuit breaker.
    c. Measure the resistance between each pair of phases. A reading of less than 1 megohm between any phase pair indicates a line fault.

d. Open (one at a time) very disconnect on the load side of the blown fuse or tripped circuit breaker while monitoring phase-to-phase resistance. When the low resistance disappears after opening a disconnect, the line fault is in a component (conductor, bus, or disconnect equipment) on the load side of that disconnect.

e. Close all other disconnects, reset the tripped circuit breaker, or replace the blown fuse and restore power to the rest of the distribution system.

f. Find the line fault in the isolated part of the system by a similar procedure: disconnect sections or components until the low resistance disappears.

g. Correct the line fault before restoring power to the disconnected circuits.

Note: Any line-to-ground or line-to-line reading lower than 1 megohm indicates an insulation problem. Recheck the resistance with a megohmmeter. The high voltage a megohmmeter applies can reveal arc paths that could carry fault current.

☐ If there are no ground or line faults, check for an overcurrent condition — a load problem that results in load current higher than the fuse or circuit breaker rating.

a. If the open circuit breaker or fuse supplies one load, the overcurrent was caused by problems such as an overloaded motor or a line-to-ground or line-to-line short in the windings of a motor or transformer.

Note: Individual motors are protected by overload breakers that trip when motor current is too high for too long. The circuit breakers and fuses supplying motors are sized to carry full load current and starting current. Thus, if a circuit breaker or fuse supplying a single motor opens on startup, a ground fault or line fault in the motor or in the conductors to it, rather than an overloaded motor, is probably the cause.

Note: Power distribution systems are designed to handle all expected loads. However, sometimes the designer underestimates, or additional loads are added to an existing system beyond the capacity of the original circuit breakers or fuses.

Note: Because loads are not part of the 480V distribution system, troubleshooting overcurrent conditions in individual loads is not part of this task. However, an overcurrent condition caused by too many loads on full at once is a distribution system problem. An Electrician must be able to recognize such a situation. Many substation circuit breakers, and some modern circuit breakers intended for high-current individual loads, have indicators on them that flag the causes of the trip. If the long time overload indicator is set when such a breaker trips, the Electrician would know to look for conditions where too many loads were on simultaneously.

b. With all system disconnects open on the load side of the blown fuse or tripped circuit breaker, reset the breaker, or replace the fuse and restore power.

c. Close each disconnect individually, while monitoring current at the circuit breaker or fuse that opened. Current should remain zero, except when a closed disconnect energized a transformer primary winding; the magnetization current in such windings should be very small.

d. Turn loads on one at a time. Verify that the current each load draws is normal. If total current approaches the rating of the fuse or circuit breaker, notify the appropriate personnel that the distribution system needs to be upgraded or reconfigured.

e. If total current is within the rating of the fuse or circuit breaker, prepare to monitor the current at the fuse or circuit breaker for an extended period to identify an intermittent ground fault, line fault, or overcurrent condition. Also monitor the fuse or circuit breaker for overheating.

## Concept Check

Troubleshoot 480V System

Answer the following questions to check your understanding of how to troubleshoot a 480V system. Circle the correct answer in each question. Then compare your responses with the answers at the end of the Skill Check. Some of the questions may have more than one correct answer. If you have difficulty answering a question, review the Skill Development Guide or ask your Trainer for assistance.

1. The first step in troubleshooting a 480V system is to:

    a. measure the incoming voltage and current.

    b. check the phase imbalance.

    c. identify the loads, drops, or areas where power is out.

    d. inspect all fuses and circuit breakers in the affected area.

2. If voltage is zero or low to one phase of a three phase system:

    a. a fuse is probably blown.

    b. a circuit breaker has tripped.

    c. the connection to ground on that phase is open.

    d. that phase is overloaded.

3. When you find a blown fuse or tripped circuit breaker, the next step is to:

    a. replace the blown fuse or reset the tripped breaker.

    b. test the blown fuse or tripped breaker.

    c. disconnect power to the blown fuse or tripped breaker.

    d. determine why the fuse blew or the breaker tripped.

4. A ground fault is:

    a. A high resistance between all phases and ground.
    b. An open circuit to ground.
    c. A low resistance to ground on one phase.
    d. The current that flows after a fuse blows or a breaker trips.

5. To isolate a line fault:

    a. Open circuits until the low line-to-line resistance disappears.
    b. Close circuits until a fuse blows or a circuit breaker trips.
    c. Check for abnormally high current into each circuit.
    d. Use a megohmmeter to look for high resistance.

6. To identify the cause of a long time overcurrent condition:

    a. Disable the overload devices protecting individual loads.
    b. Measure current to each load powered through a fuse or breaker.
    c. Measure the total current on the supply side of a fuse or breaker.
    d. Use a current probe to measure the current at each load.

Answers: (1. c 2. a 3. c 4. c 5. a 6. b, d)

## Next Step

If you are ready to demonstrate the task now, ask your Evaluator or Trainer to schedule the Skill Check. However, if you need to practice some of the steps first, continue to the next section.

## Practice

The following practice will help prepare you for the Skill Check. Ask your Trainer to set up the practice for you. After you complete a practice, ask your Trainer to check your work.

Practice 1:

List the appropriate steps to respond to a problem specified by your Trainer in a 480V distribution system.

_____

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Practice Objective 1:

Your proposed steps must:

- ☐ be safe to perform
- ☐ not damage any equipment
- ☐ positively identify the responsible component with the fewest possible steps

Practice 2:

Determine if a problem simulated by your trainer in a 480V distribution system is due to a blown fuse or a tripped circuit breaker.

Practice Objective 2:

You must be able to state whether a fuse has blown or a circuit breaker has tripped. You must also be able to explain your reasoning.

Practice 3:

Use system prints to identify a blown fuse or tripped circuit breaker responsible for a problem simulated by your Trainer in a 480V distribution system. Find the identified fuse or breaker and demonstrate that it is open.

Practice Objective 3:

You must identify and find the correct fuse or breaker.

Practice 4:

Test a section of a 480V distribution system for an overcurrent condition.

Practice Objective 4:

You must be able to state whether the current in the section is too high for the overcurrent devices (fuses or circuit breakers) protecting the section.

## Next Step

Continue to practice until you are ready for the Skill Check. When you are ready to demonstrate the task, ask your Evaluator or Trainer to schedule the Skill Check.