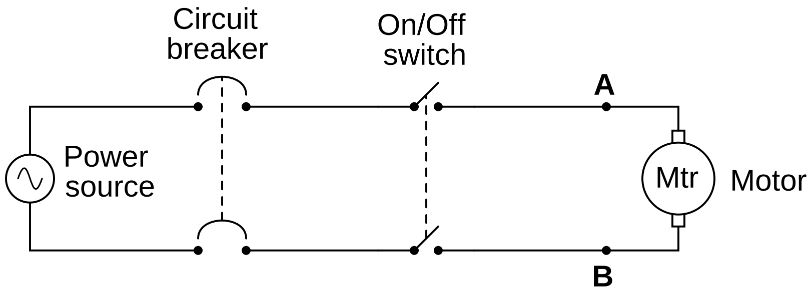
Lock-out / Tag-out

Resources and methods for learning about these subjects (list a few here, in preparation for your research):

Question 1

In this motor control circuit, how would you ensure that there is no danger of electric shock prior to touching either of the motor terminals (shown as points **A** and **B** in the schematic diagram)? Describe both the action required to secure the power, and the means by which you would check for the presence of hazardous voltage at the motor:



file 00566

Answer 1

Follow these steps:

1. Open the circuit breaker.
2. Lock the circuit breaker in its "open" position so no one can close it.
3. Try to start the motor by turning the On/Off switch "on".
4. Leave the On/Off switch in the "off" position.
5. Test for hazardous voltage (both AC and DC) between A and B, between A and ground, and between B and ground.

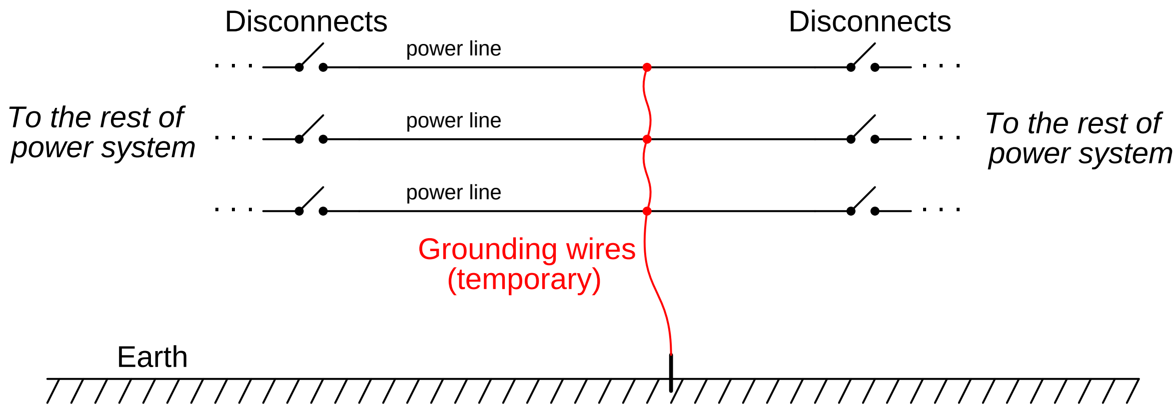
Notes 1

For each of the steps given in the answer, discuss the rationale with your students. *Why* is it important we do each one of those steps, in the order shown? How many voltage checks must we do with the voltmeter, total?

Also, be sure to ask your students how they would know whether or not their voltmeter was functioning properly prior to using it to check for the presence of hazardous voltage. What types of faults in the meter could cause it to not indicate voltage when there really was voltage?

Question 2

Linemen working on high-voltage conductors do not simply rely on open disconnect switches to isolate sections of power lines from sources of electricity during maintenance. They also attach "grounding" cables from line to line, and then to earth ground like this:



Explain why this decreases the risk of electric shock for the linemen, based on what you know about *electrically common points* in a circuit.

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Answer 2

By connecting the three wires together, you make them electrically common to each other. This prevents any substantial voltage (potential difference) developing between them. Likewise, connecting the three wires to the earth makes them electrically common to the earth, preventing any substantial voltage from developing between any of the wires and ground.

Follow-up question: after the linemen are done with their work, they remove the grounding wires from the power lines before they close the disconnect switches. Explain why this is done, by describing the catastrophic consequences of closing the disconnect switches with the grounding wires still in place.

Notes 2

A physicist would describe such a "grounded" system as being one large *equipotential surface*. This is an important concept for students to grasp, not only for safety but also for the purpose of better understanding where voltage drops should and *should not* be in working circuits.

Some students may (wisely) ask how any voltage at all could be developed between the isolated conductors in the absence of grounding wires, since the disconnect switches are open at all points. Although it may be premature to discuss with your students how capacitive coupling with nearby (energized) conductors could cause voltages to appear between non-grounded conductors and ground (depending on their level of electrical understanding), you can still answer the question by appealing to a general sense of safety conservatism. With the wires all made electrically common to each other and to earth ground, there is still some measure of protection even in the event of one or more of the disconnect switches accidently closing, a lightning strike, or a bird landing between the open poles of a disconnect switch.

If your students have not yet studied three-phase AC systems, they may (wisely) ask why three power line conductors are necessary instead of two. You may tell them that this is irrelevant to the safety question: that all they need to know is that there will be high voltage present between each wire pair (A and B, B and C, A and C) and between each wire and ground, when the power lines are in operation.

Question 3

Describe what the phrase *zero energy state* means for a system, in terms of safety for those performing maintenance work on it.

file 00572

Answer 3

"Zero energy state" means that all sources of energy, either conducted from an outside source or stored within components of the system, have been secured so as to pose no danger to the people working on the system.

Identify some sources of energy in a system that could pose a safety hazard to people working on it.

Notes 3

When discussing this with your students, be sure to emphasize that "zero energy" is not just limited to electrical energy, but to all forms of energy that could cause harm. This includes mechanical and thermal energy as well.

Question 4

When using a padlock to secure a disconnect device in the "open" (off) state, who should be able to open that lock? In other words, how many other people should share a key to the lock you use to secure a breaker or switch in the safe position, if you are the one working on the system?

file 00571

Answer 4

You and you alone should be able to open that lock. It needs to be a *personal* lock, not a lock whose key is shared by other people.

Notes 4

Discuss with your students why a personal lock is preferred over a "group" lock for locking out circuit disconnect devices.

Question 5

When securing equipment for safe maintenance, special *tags* are attached with the lock(s) used to keep circuit breakers and other disconnect devices in the open (off) state. A typical "lockout" tag looks something like this:

What is the purpose of attaching such a tag to an electrical disconnect device in addition to locking it in the open position? Why is a lock, by itself, not sufficient from a safety perspective?

file 00573

Answer 5

A tag informs anyone wishing to turn the disconnect device "on" as to *when* it was turned off, and *who* placed the lock(s) on it. Many lockout tags have space on for a written description so that the reason for the lockout may be explained.

Notes 5

Discuss with your students the need for good communication between all people performing maintenance work on large and (potentially) dangerous systems. Tags are an integral part of this communication.

Question 6

Large power distribution circuit breakers look nothing like the small breakers seen in residential and commercial electrical systems. They are large units, which "plug" into cubicles so as to facilitate removal and replacement for routine maintenance.

When securing an electrical system in a *zero energy state* prior to commencement of maintenance work, it is common practice to "rack out" any large circuit breakers feeding power to the system. What exactly does this term mean, and what is the procedure for "racking out" a circuit breaker?

file 00570

Answer 6

To "rack out" a circuit breaker means to unplug it from its cubicle so that it cannot conduct electric power to the circuit where work is being performed, even if someone were to close its contacts.

Notes 6

Ask your students whether the circuit breaker should be opened (turned off) before or after racking it out of the cubicle. Does this sequence matter? Why or why not? Also, ask your students where they think the standard locking and tagging procedures apply in a breaker that it racked out. What, exactly, should the lock prevent someone from doing?

Question 7

What step(s) must be taken after locking and tagging an electrical disconnect device for a circuit to be worked on, and prior to actually proceeding with the work? What step(s) come between the lock-out and the work itself?

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Answer 7

Check for the presence of voltage on the conductors of the circuit to be worked on.

Notes 7

There is more to this answer than simply "check for voltage." Ask your students to explain what types of voltage they need to check for, and how they can ensure their voltmeters are properly functioning, so as not to "miss" detecting a dangerous condition.

Question 8

Suppose you are finishing a maintenance project where an electric motor was locked out and tagged, and now the work is complete. Your lock is the last one to be removed from the circuit breaker, everyone else already having taken their locks and tags off. What should you do before removing your lock and turning the circuit breaker back on?

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Answer 8

You should check the equipment site to be sure no one is still working on it, unaware of the impending startup.

Notes 8

Real-life story here: I was once asked to place an electric motor back in service after it had been locked out for a few days, for routine maintenance. I removed my lock and tag, and was just about to turn the breaker back on, when better judgment prevailed and I decided to first check the job site. Lo and behold, there, still working on the motor coupling, were two contract employees completely oblivious to the situation. They had not been told there was a circuit breaker to secure power to that electric motor, nor were they aware that they needed to lock it out in addition to everyone else on the project! Had I turned that circuit breaker back on, the motor could have started up and severely injured at least one of them!

Lesson to be learned: if you are performing work on a piece of equipment, *you* need to have *your* lock and *your* tag securing energy to that equipment. Never, ever trust someone else to lock-out and tag-out a circuit breaker for you!