NOTE: Reading this PDF course book is not a substitute for completing the Self-Paced Online training. This PDF course book is a resource that accompanies the online training.

V4 GENERATOR SAFETY

Presented by **Contract Services** as part of the

Safety Pass Training Program for the Motion Picture and Television Industry

English:
If you do not comprehend English, and you require Safety Pass training in a language other than English, please send notification in writing to 2710 Winona Avenue, Burbank, CA 91504. Please provide your name, along with contact information, and specify the language you comprehend. Thank you.

Spanish:
Si usted no comprende inglés y requiere la capacitación Safety Pass en un idioma diferente al inglés, por favor envíe una notificación por escrito a 2710 Winona Avenue, Burbank, CA 91504. Por favor provea su nombre, junto con la información de contacto, y especifique el idioma que usted comprende. Gracias.

Korean:
영어를 이해하지 못하시고 영어가 아닌 다른 언어로 **Safety Pass** 훈련을 받으셔야 한다면, 서면 통지를 **2710 Winona Avenue, Burbank, CA 91504** 로 보내주시기 바랍니다. 귀하의 성함과 연락처를 기재하시고 이해하실 수 있는 언어를 명시해주십시오. 감사합니다.

Armenian:
Եթե դուք անգլերեն չեք հասկանում և ձեզ հարկավոր է **Safety Pass**-ի մարզում անգլերենից տարբեր լեզվով, խնդրում ենք գրավոր ծանուցագիր ուղարկել հետևյալ հասցեով՝ **2710 Winona Avenue, Burbank, CA 91504**: Խնդրում ենք ներկայացնել ձեր անունը, ինչպես նաև կապի տեղեկությունը, հատկապես նշելով ձեր հասկացած լեզուն: Շնորհակալություն:

Contract Services Administration Training Trust Fund
2710 Winona Avenue
Burbank, CA 91504

Safety Pass Training Program

The Entertainment Industry is committed to maintaining a safe and healthful working environment. To that end, all major studios have a safety representative on staff. In addition, all employers have a safety program in force. This Safety Pass Program has been designed to further promote safety and health and to prevent injuries, illnesses, and accidents on all productions, both on-lot and off-lot.

Studios and production companies may have more restrictive safety requirements than those mandated by local, state, or federal laws or regulations. They also may assign different duties or responsibilities to employees. Therefore, in addition to this Safety Pass training course, employees should refer to the safety manual and materials provided by their employers.

Employees must adhere to all safety rules and regulations. Failure of any employee to follow safety rules and regulations can lead to disciplinary action, up to and including discharge. However, no employee shall be discharged or otherwise disciplined for refusing to perform work that the individual reasonably believes is unsafe.

No safety training can comprehensively cover all possible unsafe work practices. Each production and its employees, therefore, should fully promote each employee's personal obligation to work safely in order to prevent accidents involving, and injuries to, the employee and to his/her fellow employees.

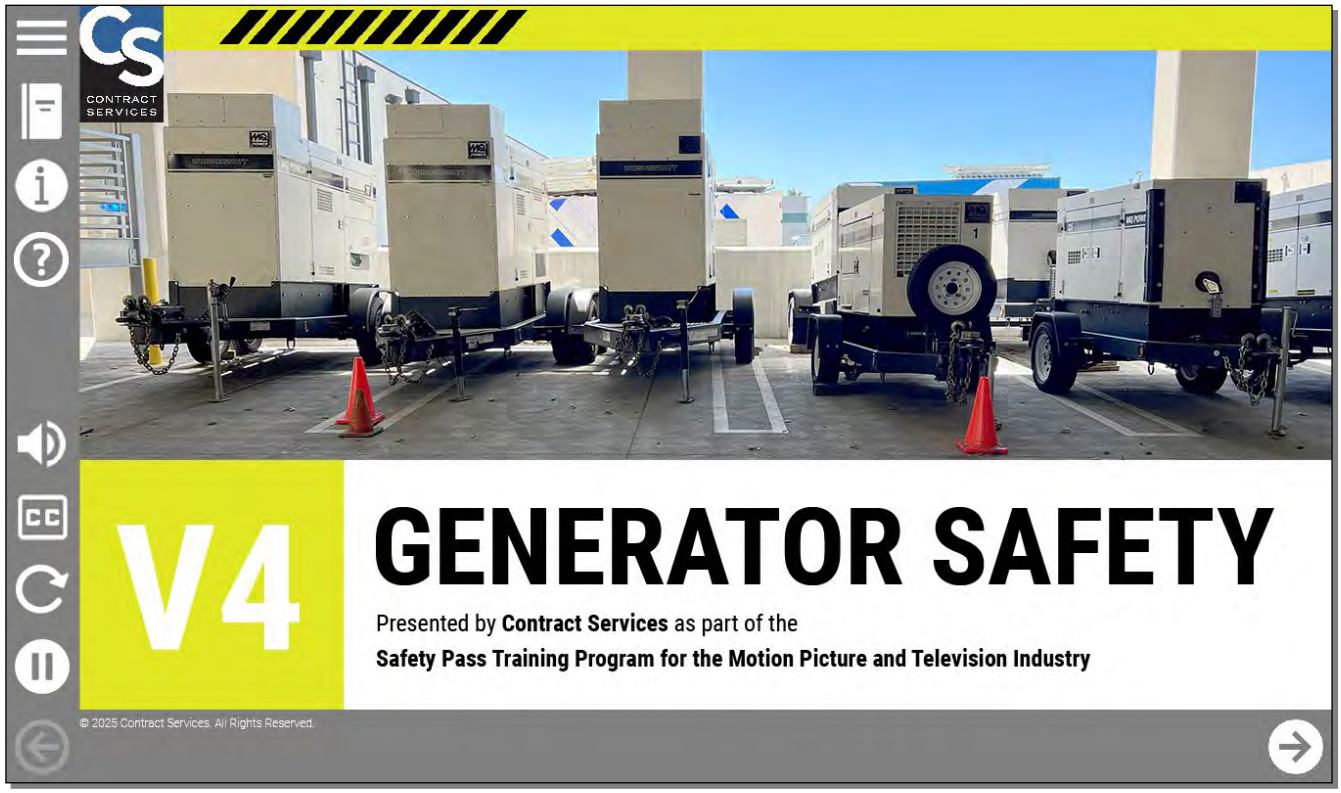
The Safety Pass Program derives from Federal and California Occupational Safety and Health Administration (OSHA) safety regulations. However, the material included in this workbook and its accompanying presentation should be used only as a general guideline. It is not intended as a legal interpretation of any federal, state, or local safety standard.

During the course of your employment, you may be acting as a supervisor or manager.In California, individuals with management authority and actual authority for the safety of a business practice could be convicted of a crime if they have actual knowledge of a serious concealed danger and fail to warn the affected employees and report the hazard. If a hazard exists, immediately notify the employer or studio safety department of the hazard and insure that potentially affected employees are informed of the danger and that steps are taken immediately to mitigate it.

Although the information contained in this training program has been compiled from sources believed to be reliable, the Alliance of Motion Picture and Television Producers, Contract Services Administration Trust Fund, Contract Services Administration Training Trust Fund, and the instructor make no guarantee nor warranty as to, and assume no responsibility for, the accuracy, sufficiency, or completeness of such information.

The Entertainment Industry is committed to maintaining a safe and healthful working environment.

Slide 1. WELCOME

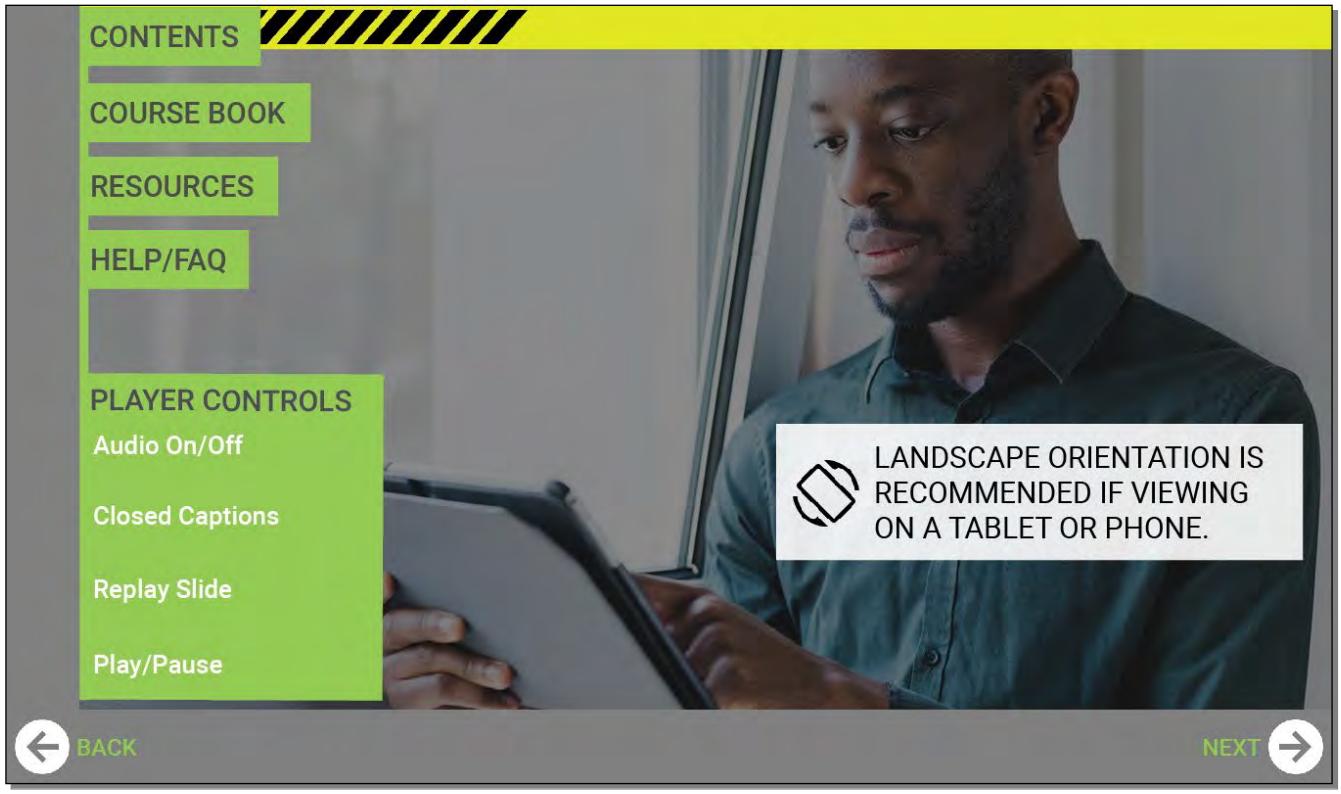


Hello, and welcome to course V4, *Generator Safety*. This two-hour course is part of the Safety Pass training program for the motion picture and television industry, presented by Contract Services.

At the end of the presentation, there will be a test. You must score at least 70 percent on the test to pass the course.

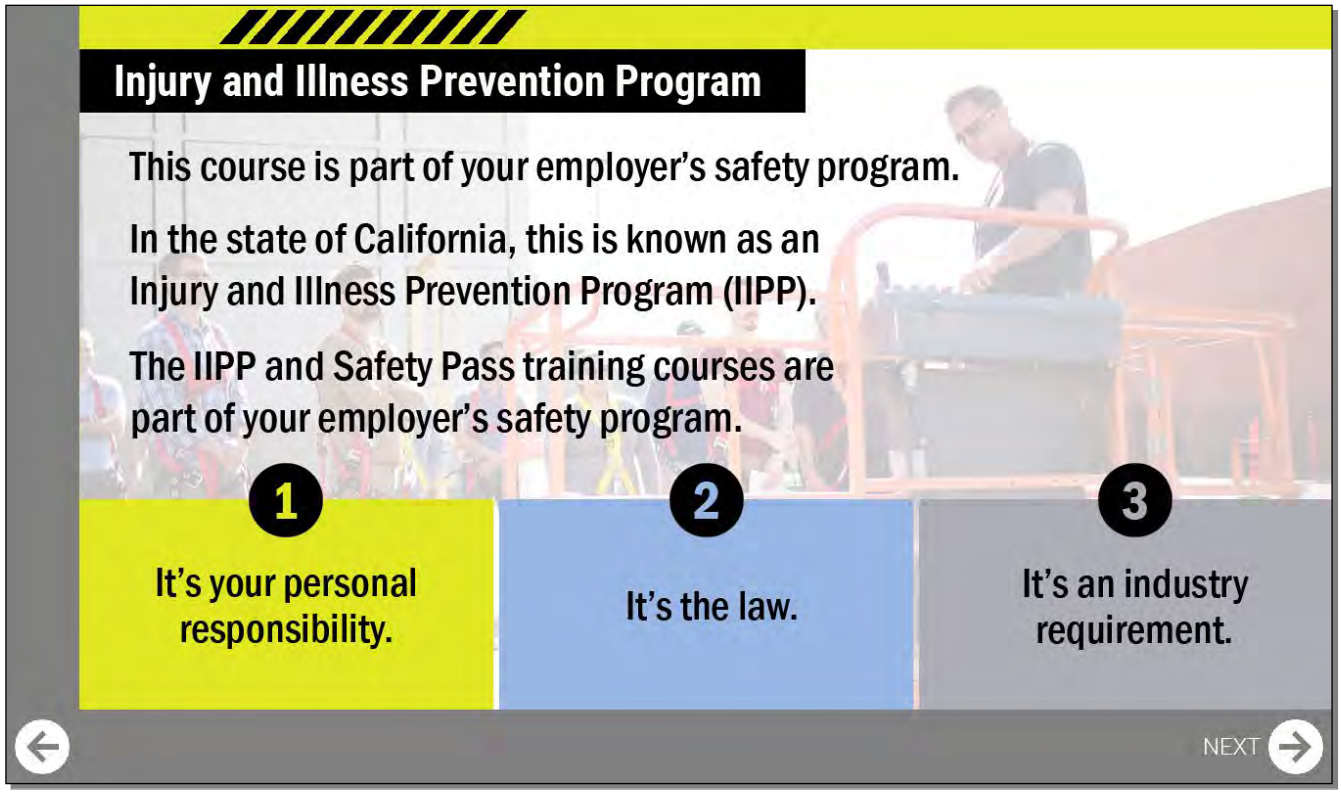
Click START to begin.

Slide 2. Navigation and Resources



At any time during the presentation, you can use the buttons on the side of the player window to view the Table of Contents, open the course book PDF, link to course references and resources, get technical support or help from an instructor about course content, and control the player. When you're ready to continue, select the NEXT arrow.

Slide 3. IIPP

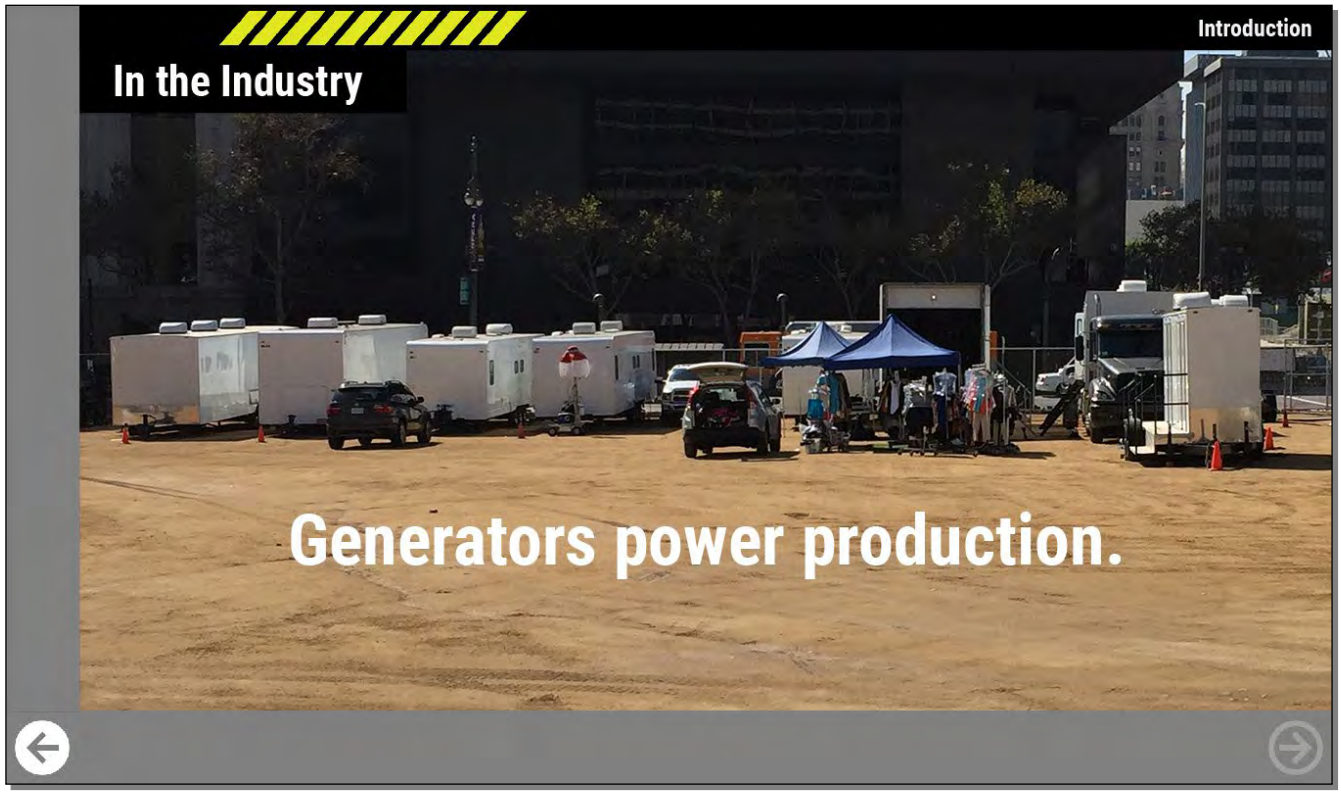


This course is part of your employer's safety program. In the state of California, this is known as an Injury and Illness Prevention Program (or IIPP). The IIPP and Safety Pass training courses are part of your employer's safety program. There are three reasons to get safety training. First, you are personally responsible for your safety. You owe it to yourself and your coworkers to avoid accidents and injuries. The way you make a living and your quality of life depend on it. Second, it is the law. Occupational safety and health standards guarantee the right to a safe workplace and require employers to train their employees in safety. And third, the industry requires it. This course is part of a cooperative commitment between major motion picture and television studios and industry labor unions to deliver safety training.

Slide 4. INTRODUCTION

Introduction.

Slide 5. In the Industry



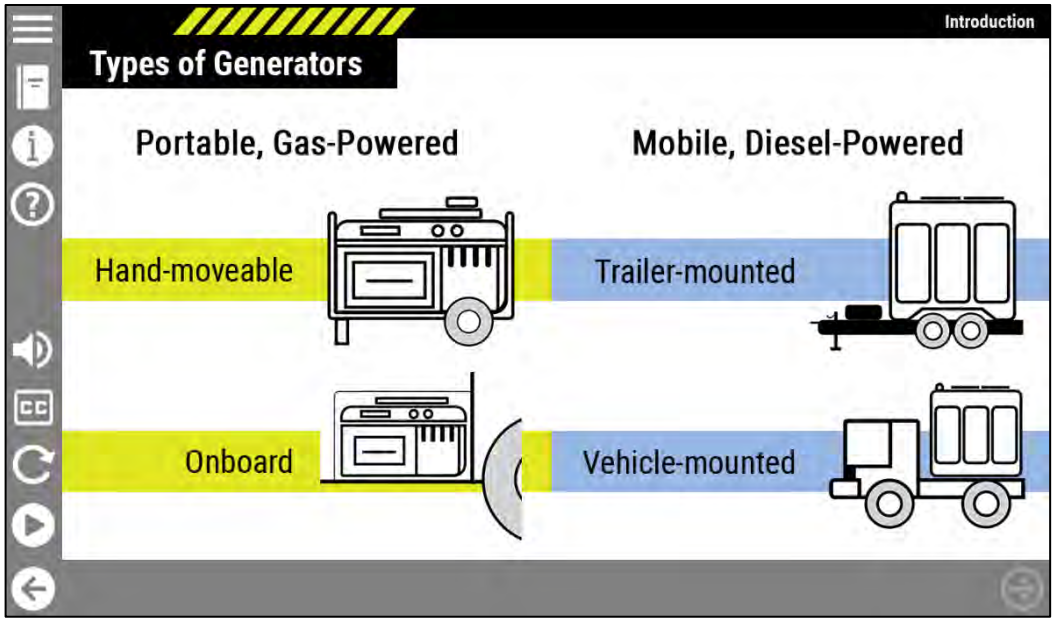
Mobile and portable generators routinely provide temporary or additional power on location and on studio lots for lighting and other electrical equipment.

Slide 6. Common Hazards

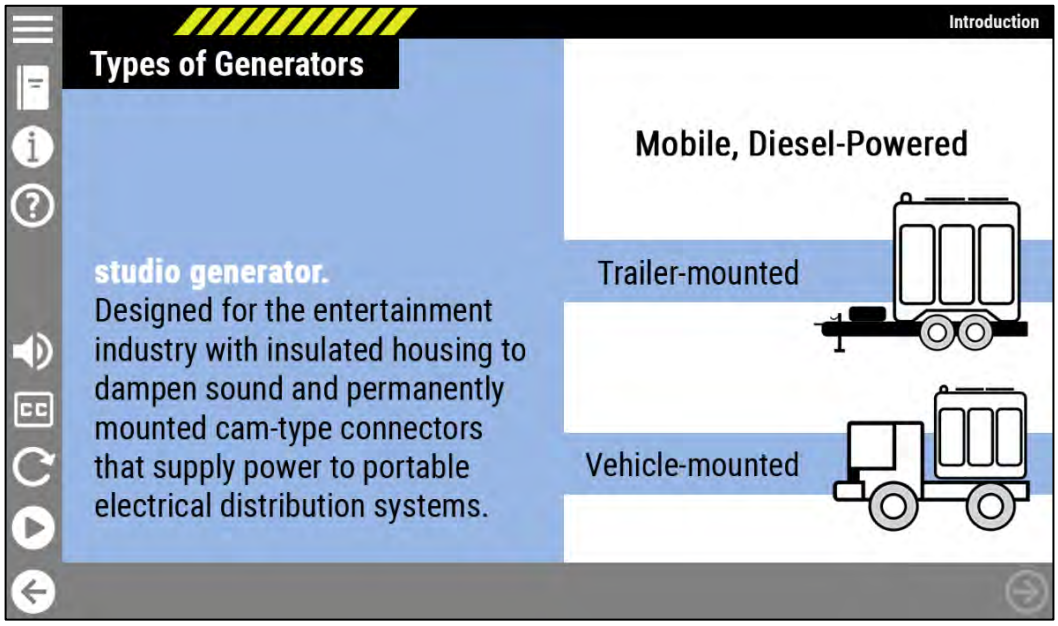
As a generator operator, possible hazards you must consider and avoid are electric shock, carbon monoxide poisoning, fire, explosions, hot surfaces, and fuel spills.

You'll also need to keep electrical- and fire-related hazards in mind when working in wet environments or when encountering extreme weather.

Slide 7. Types of Generators



Types of generators you're likely to interact with include portable, gas-powered units that are hand-moveable or onboard base camp vehicles and trailers, and mobile, diesel-powered studio generators (trailer-mounted and vehicle-mounted).

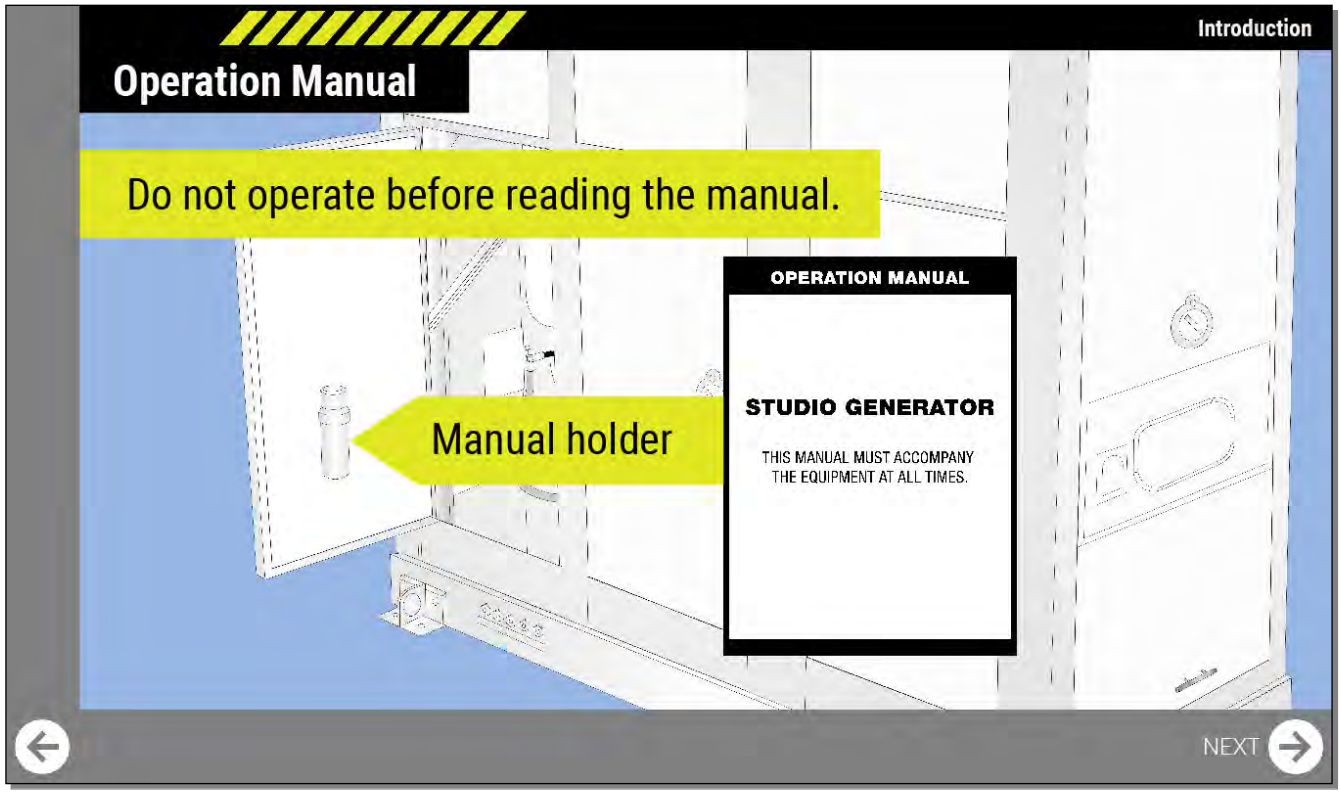


Studio generators are those designed specifically for the entertainment industry, with insulated housing to dampen sound and permanently mounted cam-type connectors that supply power to portable electrical distribution systems. Most of the examples in this course use the trailer-mounted studio generator. We'll specify when particular regulations or safe practices apply to another type of generator.

Slide 8. Stationary Generators

Some studios have permanently installed stationary generators for emergency power. While these generators are outside the scope of this course, you need to be aware that a stage being powered by a mobile generator may also be powered by a stationary generator.

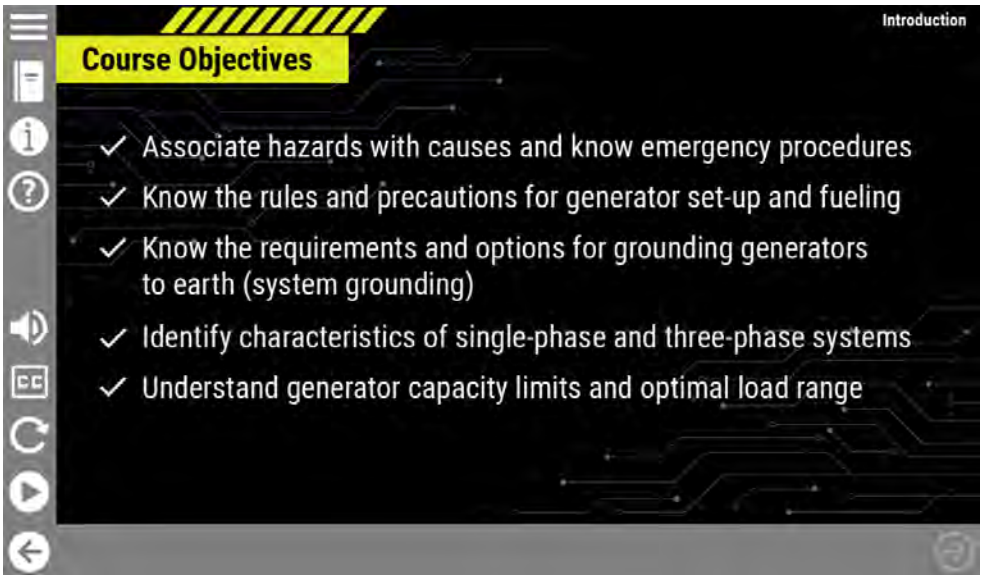
Slide 9. Operation Manual



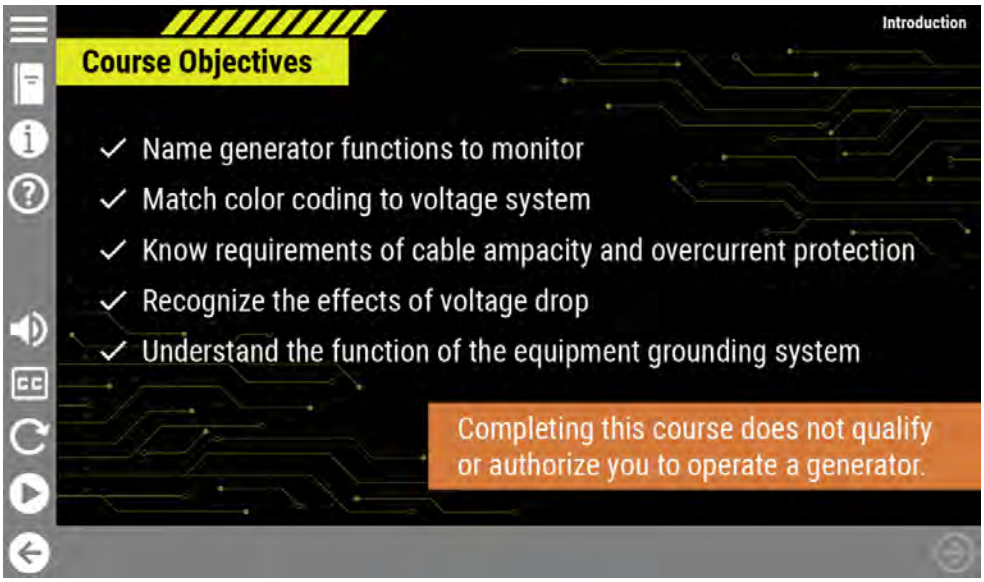
Each generator unit comes with an operation manual where you can find safety messages and operating instructions. Look for the manual on board or as accompanying material. Review it thoroughly before operation begins.

If the manual is missing, do not operate the generator and inform your supervisor or safety representative so that a replacement can be obtained.

Slide 10. Course Objectives



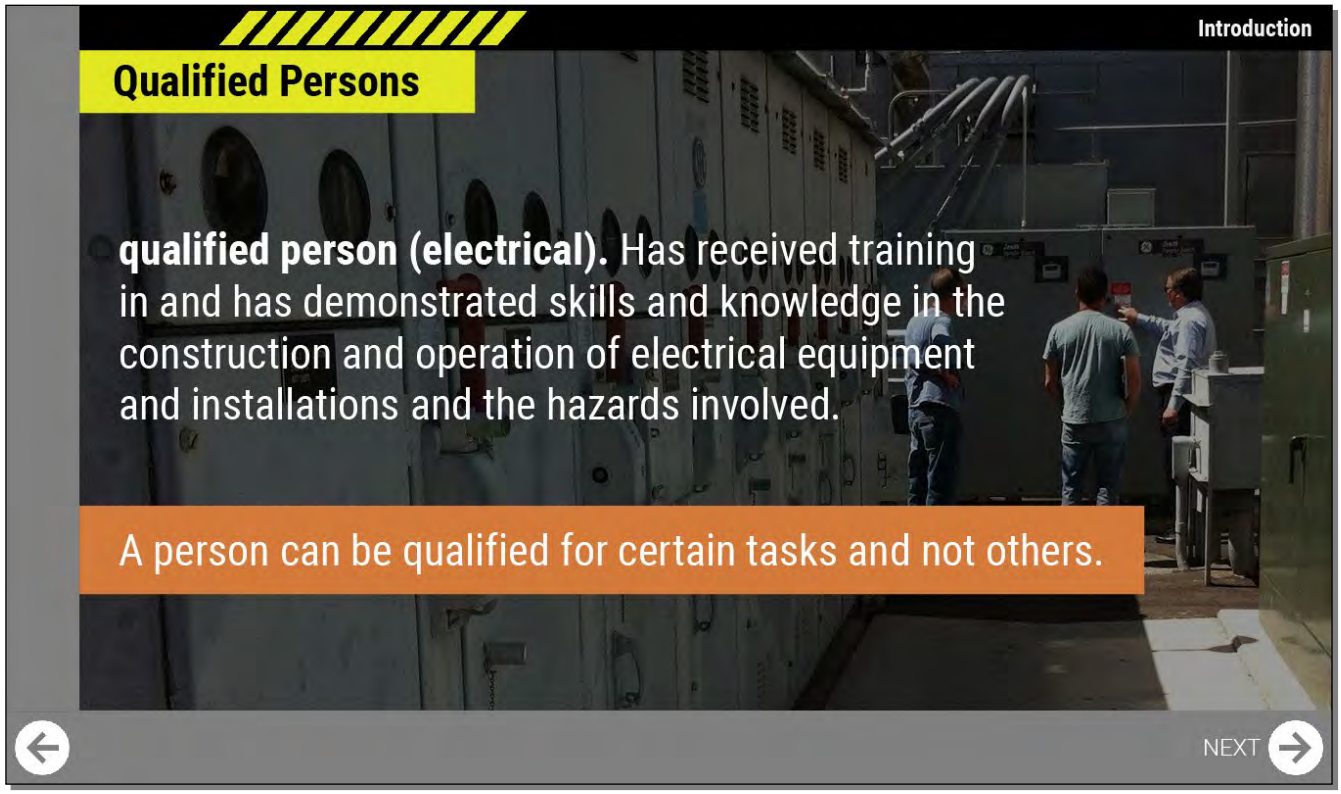
By the end of the course, you should be able to associate hazards of mobile and portable generators with possible causes and know what to do in an emergency; know the rules and safety precautions for generator set-up and fueling; know the requirements and options for grounding generators to earth (often called system grounding); identify characteristics of single-phase and three-phase systems; understand generator capacity limits and optimal load range;



name generator functions that need to be monitored; match color coding to voltage system; know the requirements of cable ampacity and overcurrent protection; recognize the effects of voltage drop; and understand the function of the equipment grounding system.

Note that completing this course does not qualify or authorize you to operate a generator.

Slide 11. Qualified Persons

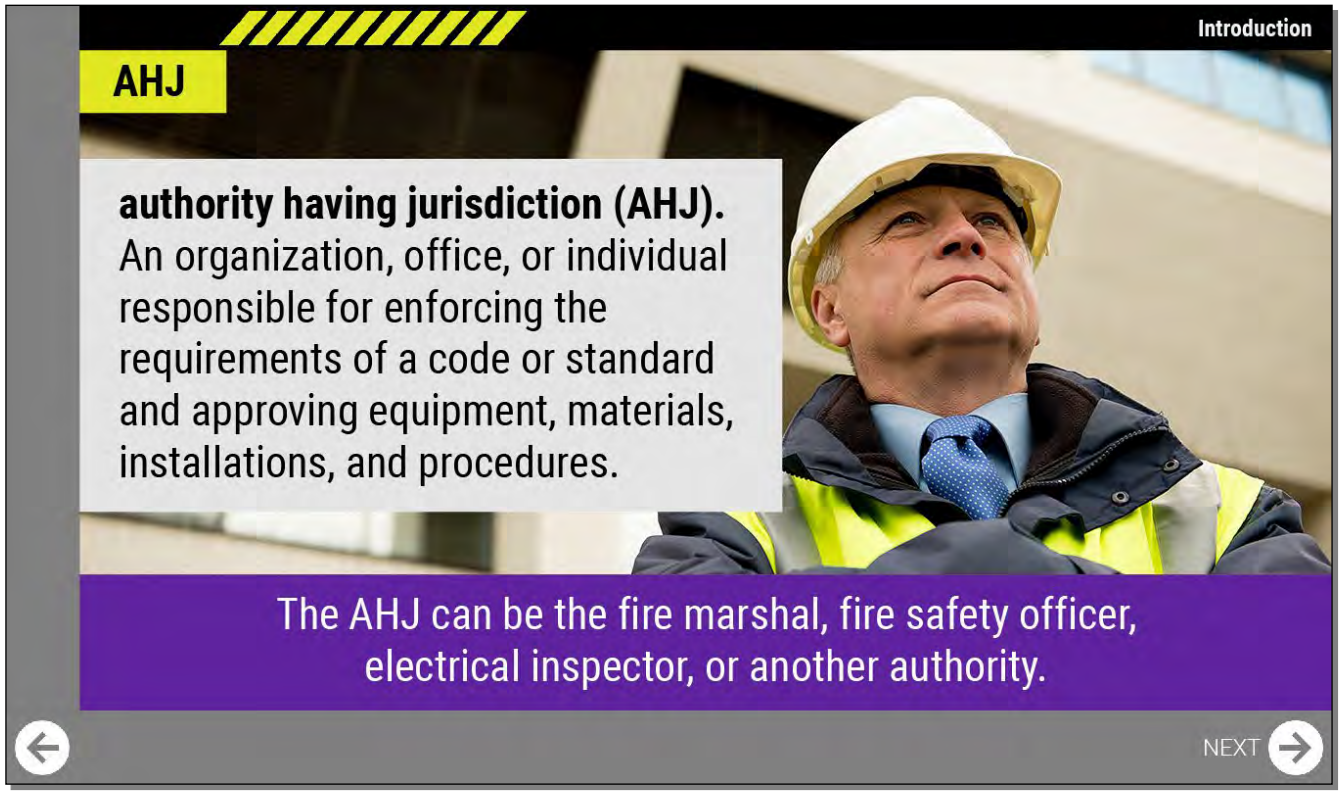


Some of the tasks we'll talk about in this course must be performed by an electrically qualified person—someone who has received training in and has demonstrated skills and knowledge in the construction and operation of electrical equipment and installations and the hazards involved.

Even if a generator operator is not an electrically qualified person, it's important that they know the rules for proper electrical set-up.

A person can be qualified to perform certain tasks and not others.

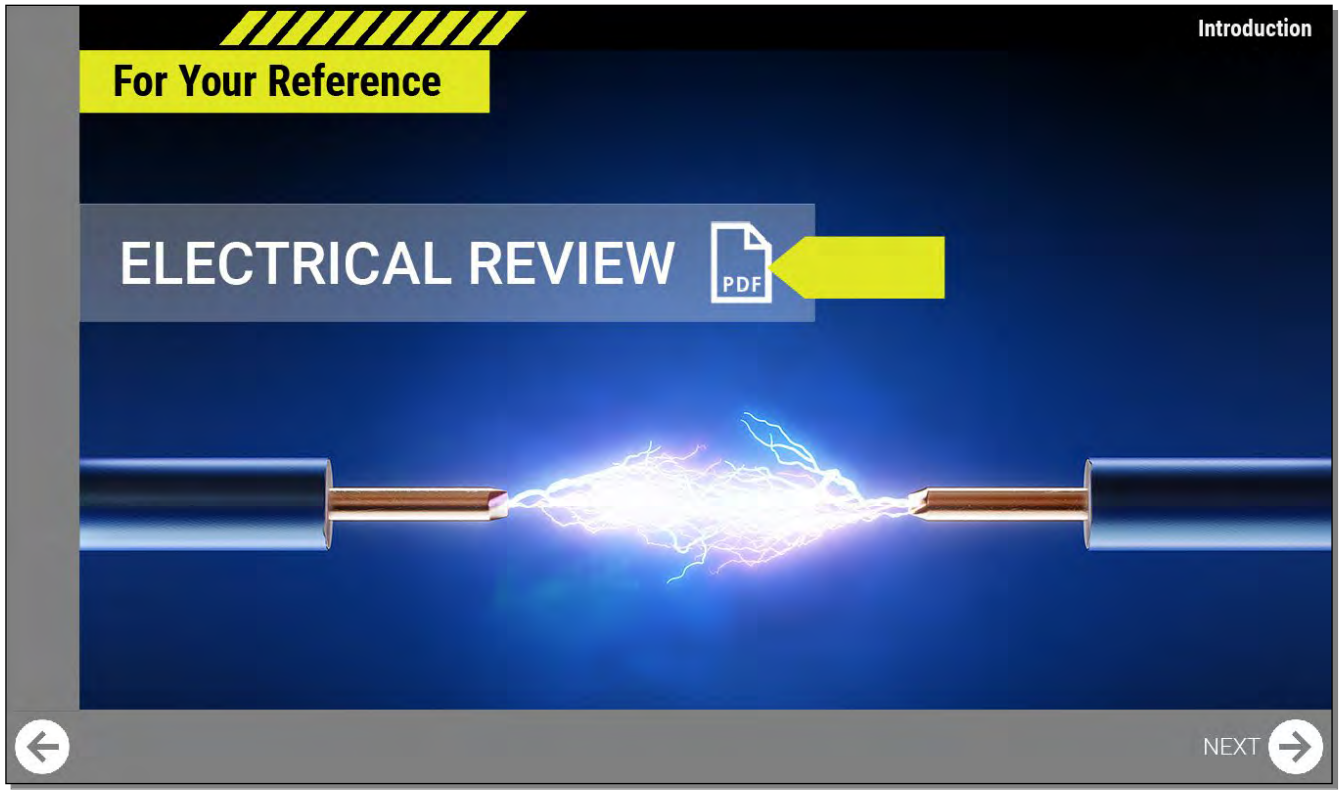
Slide 12. AHJ



The authority having jurisdiction (or AHJ) is the delegated authority responsible for enforcing code requirements, as well as rules established by local jurisdictional governing bodies. The AHJ approves equipment, materials, installations, and procedures.

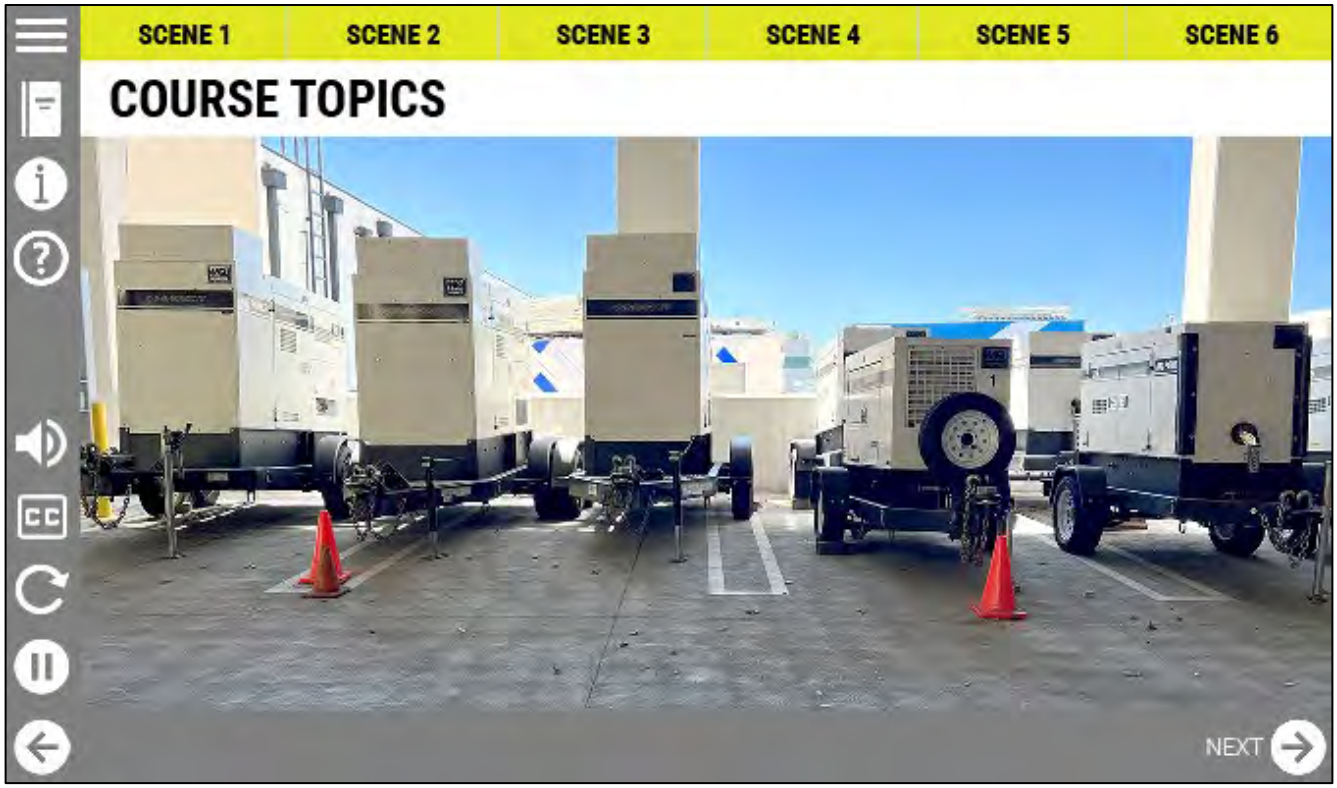
During planning, the production may need to reach out to the AHJ to determine local requirements. The AHJ can be the fire marshal, fire safety officer, electrical inspector, or another authority. If safety requirements are not met, the AHJ has the authority to shut down production.

Slide 13. For Your Reference



If you need to refresh your knowledge of electrical terms and concepts, click the PDF icon to view the *Electrical Review* sheet.

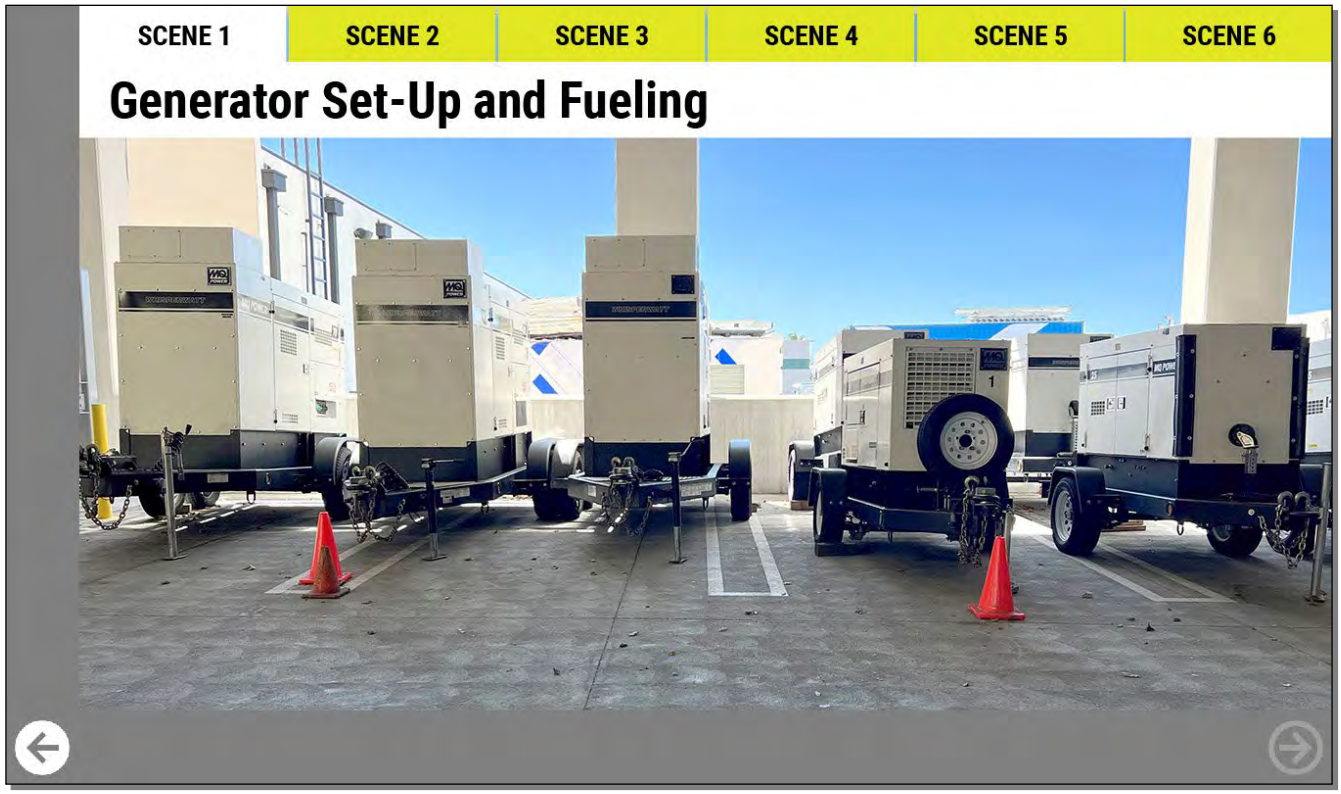
Slide 14. Course Topics



The course is organized into six scenes: Generator Set-Up and Fueling, Generator Grounding and Bonding, AC Power Systems, Generator Load Management, the Portable Power Distribution System, and Emergency Preparedness and Response.

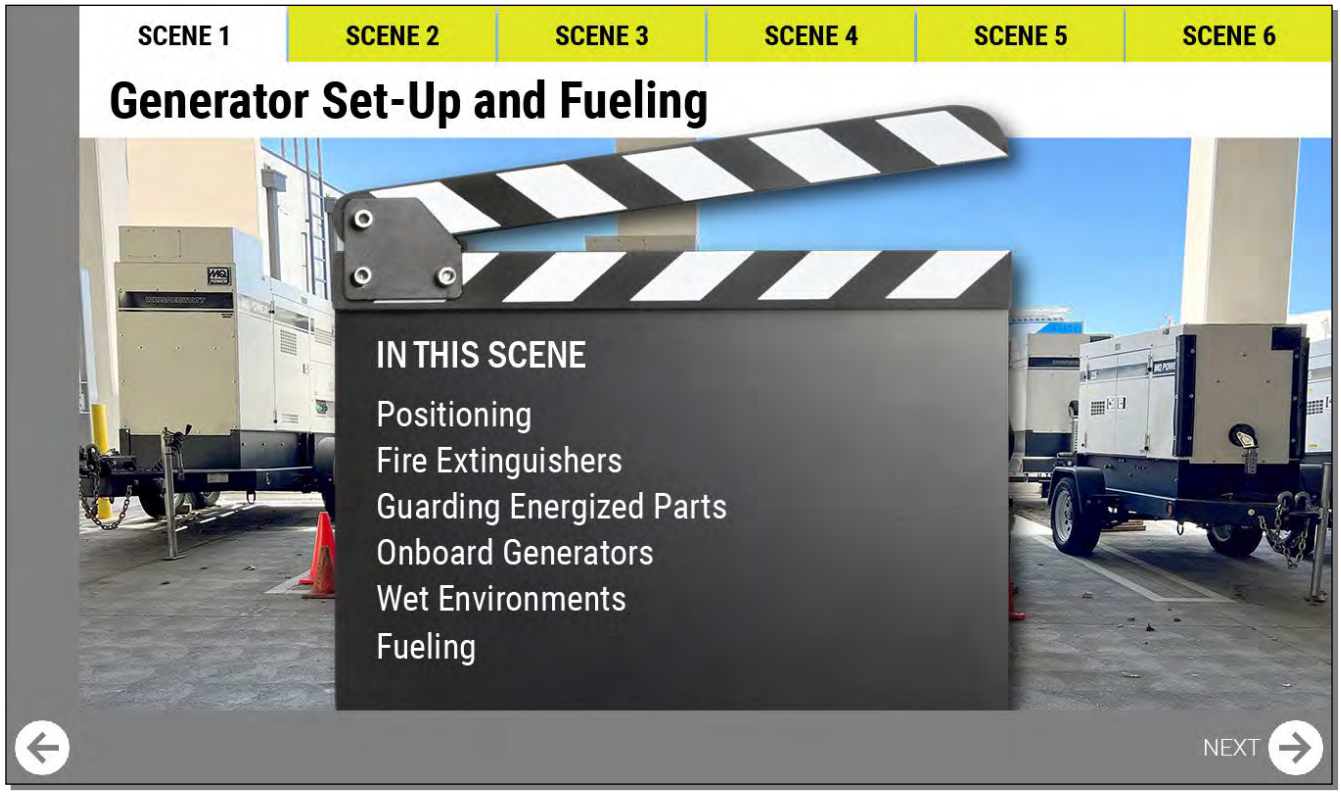
Okay. Let’s jump in.

Slide 15. SCENE 1, SET-UP AND FUELING



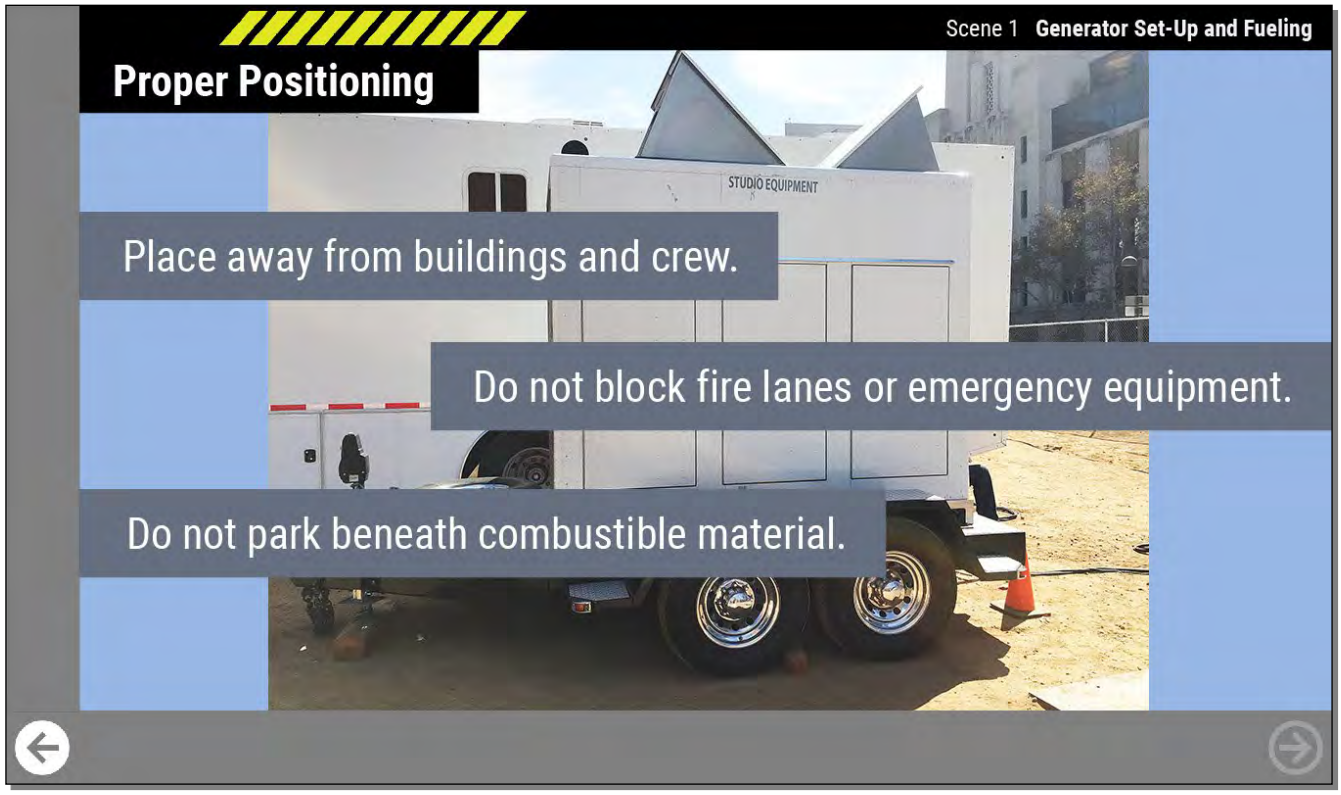
Scene One, Generator Set-Up and Fueling.

Slide 16. In This Scene



In this scene we'll look at rules and safe practices for proper positioning, fire extinguisher use, guarding energized parts, using onboard generators of base camp vehicles and trailers, using generator and power distribution equipment when working in wet environments, and fueling.

Slide 17. Proper Positioning 1



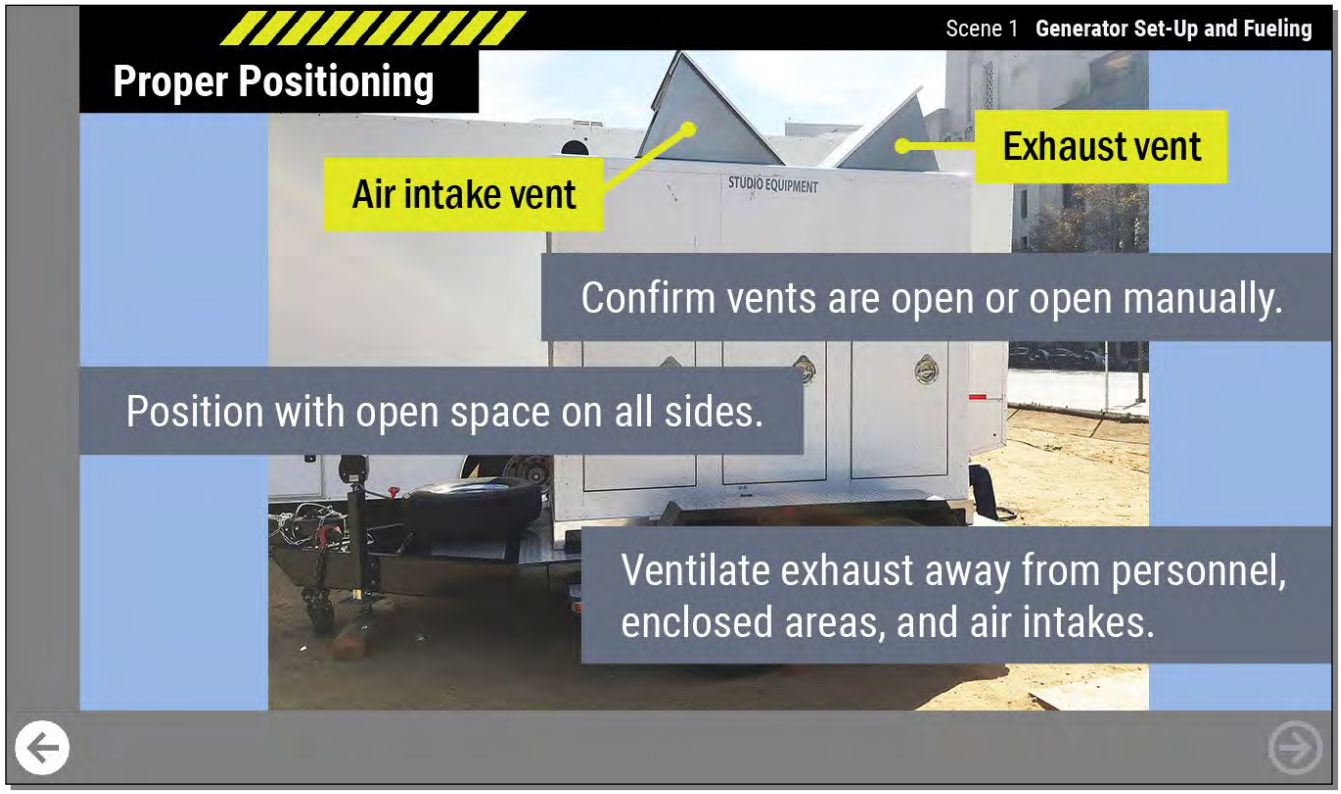
We'll start with proper positioning of the unit.

Place the generator away from buildings and crew to minimize interference with foot traffic and work tasks.

Do not block fire lanes or emergency equipment.

Do not park beneath combustible material. Hot exhaust can ignite combustibles, like dry vegetation or roof overhangs, that are above the generator vents.

Slide 18. Proper Positioning 2

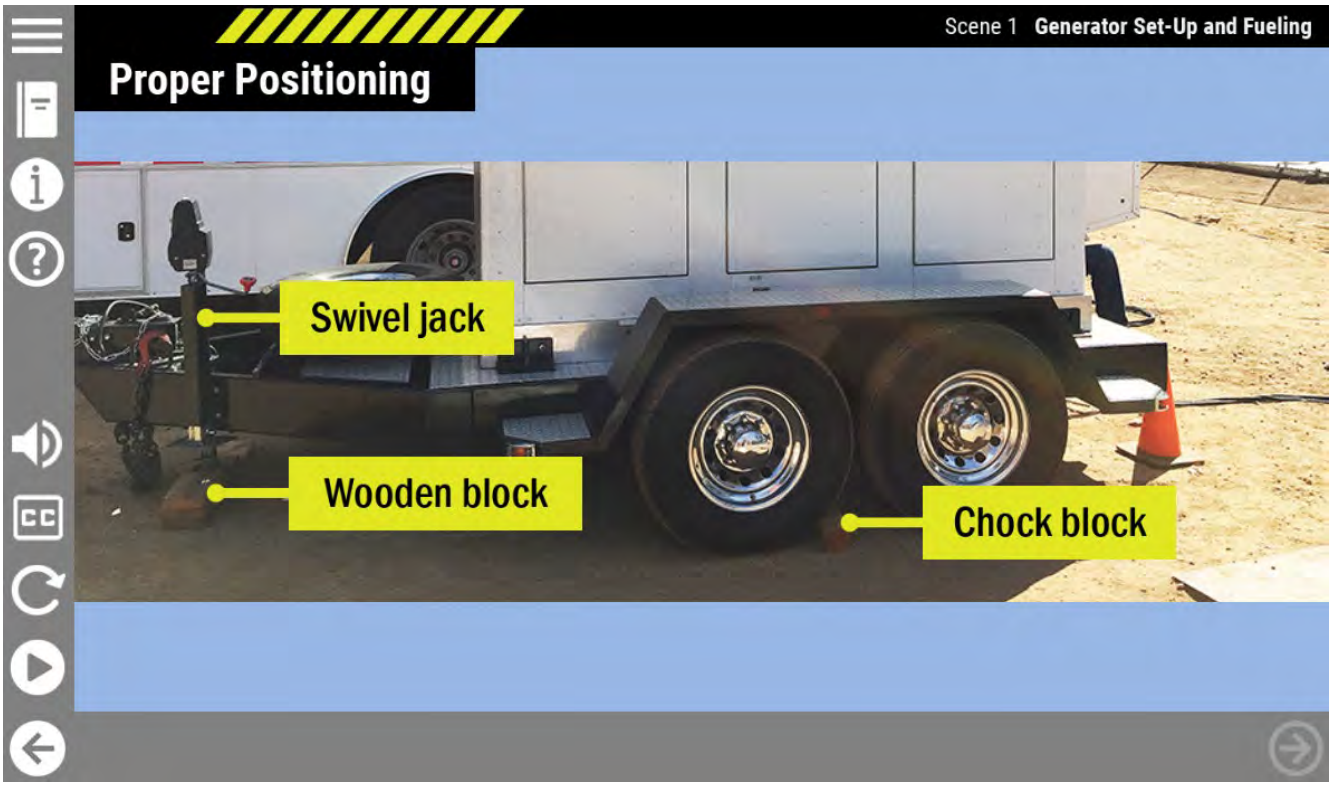


Carbon monoxide poisoning can occur from an accumulation of exhaust fumes. To allow for sufficient ventilation, position the unit with as much open space on all sides as possible—at least three to four feet.

Exhaust fumes must be ventilated away from personnel, enclosed areas, and air intake ducts of buildings and base camp vehicles and trailers.

On many generators, such as this one, the air intake and exhaust ventilation doors open automatically when the generator engine is started. After engine start-up, confirm that the vents are open. Some models require you to open the vents manually prior to starting the generator.

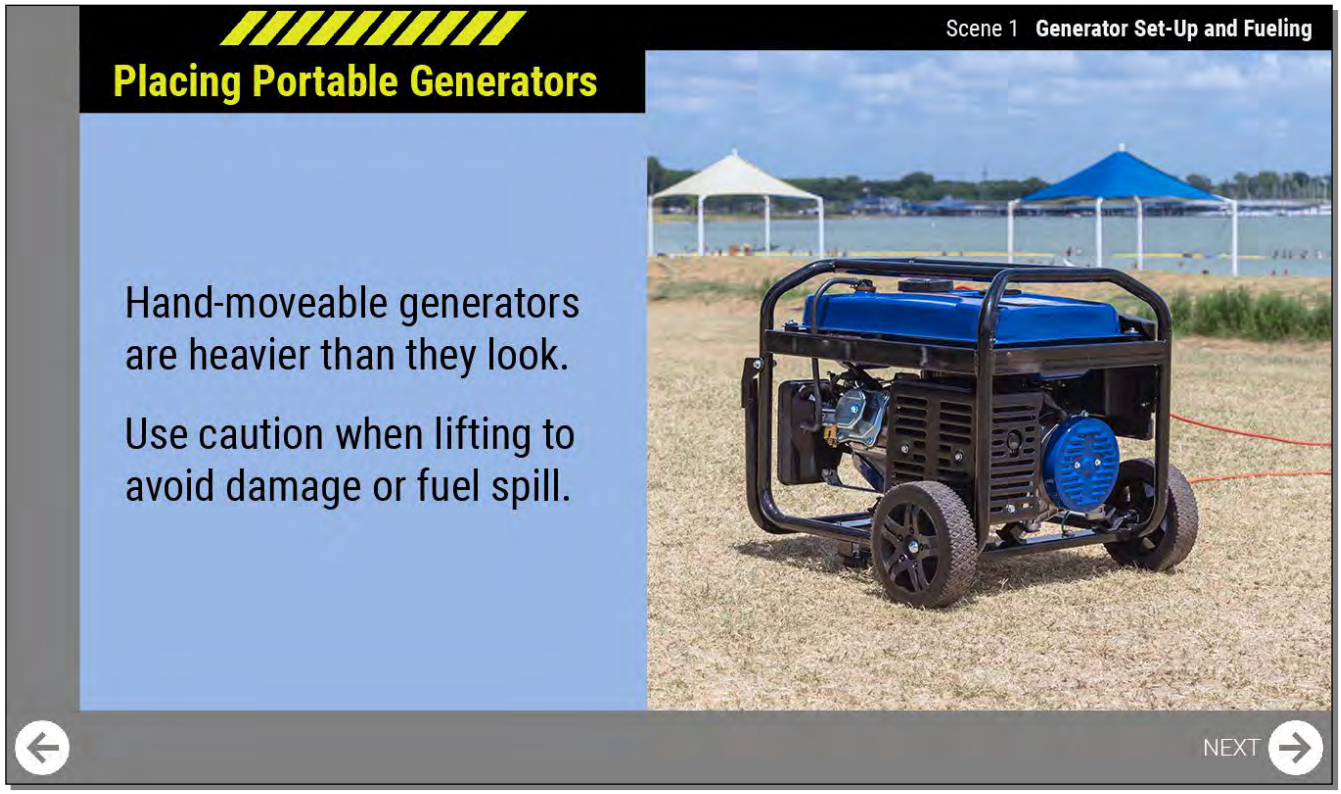
Slide 19. Proper Positioning 3



The generator should be placed on firm and level ground so that it cannot slide or shift around. Also, if a generator is low on fuel, a sloped surface could keep fuel from reaching the fuel intake. If necessary, use cribbing to create a level surface.

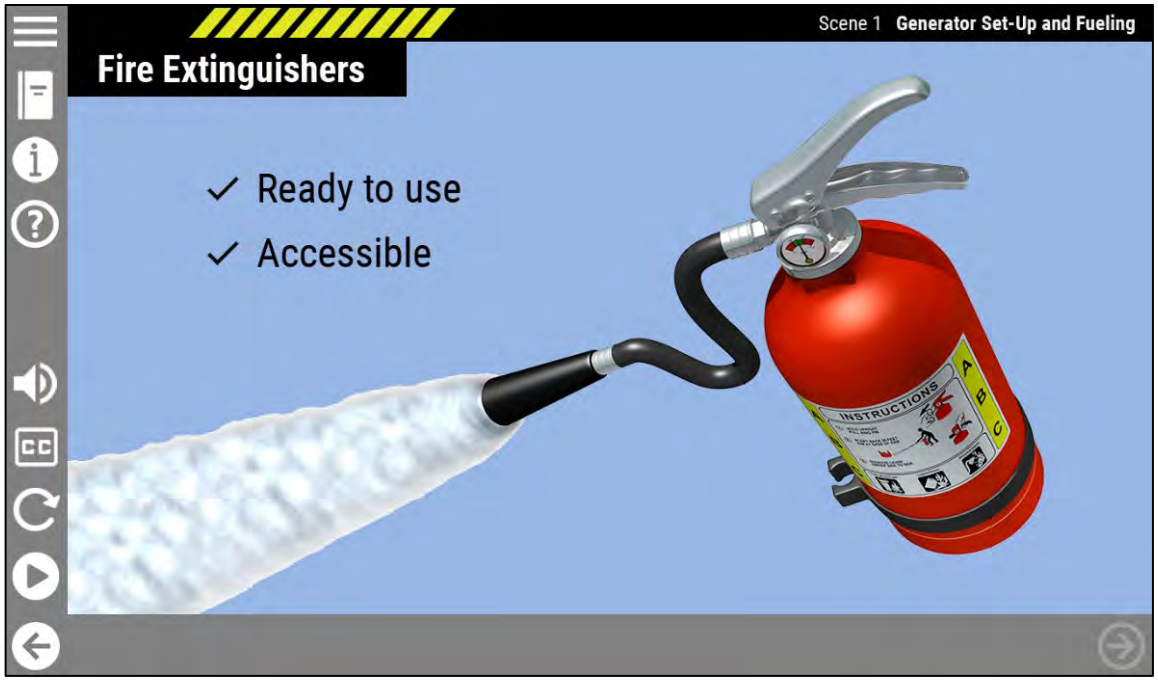
Use chock blocks to prevent rolling. Use the swivel jack to level the trailer front to back. Here, a wooden block is insulating the metal trailer from earth. We'll talk more about this in the next scene. Support blocks can also be wedged under the bumper to prevent tipping.

Slide 20. Placing Small Generators

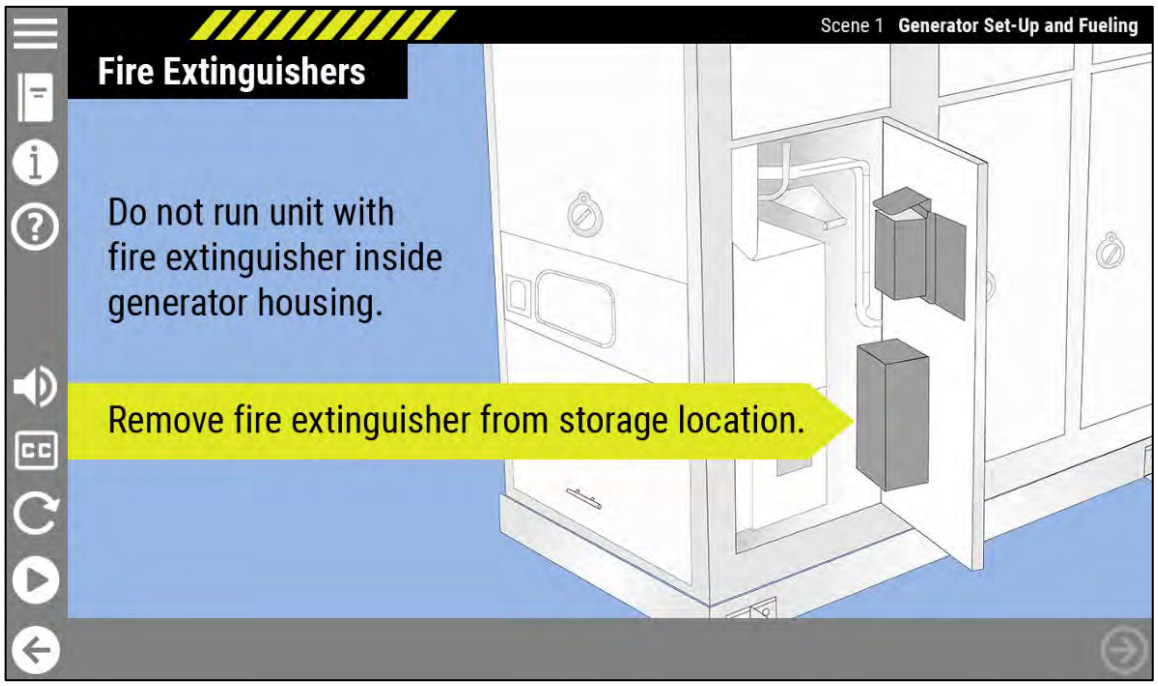


Despite their size, hand-moveable generators are often heavier than they look. Use caution when lifting them as they could easily be dropped, which could damage the unit or cause a fuel spill.

Slide 21. Fire Extinguishers



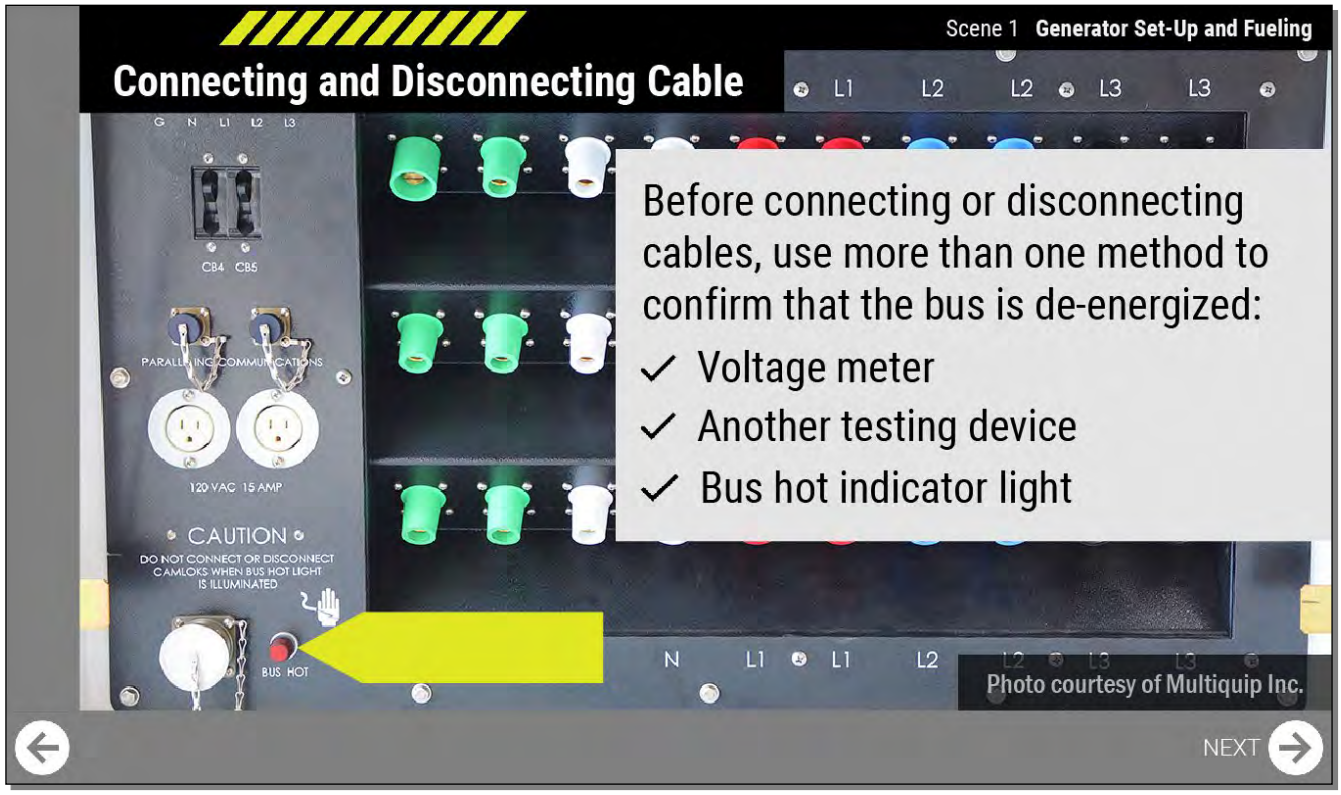
A fire extinguisher specific to the generator unit must be ready to use and easily accessible.



Some generators come with fire extinguishers stored in the unit housing. Remove the extinguisher from its storage location during the set-up process and keep it close by.

Do not run the generator with the fire extinguisher inside the generator housing.

Slide 22. Connecting/Disconnecting Cables



Before connecting or disconnecting cables, the bus must be de-energized. This is a serious electrical hazard.

Use more than one method to confirm that the system is de-energized. The most effective is to test voltage at the bus using a properly functioning voltage meter. A second method may involve another testing device, for example, a non-contact AC voltage detector or the onboard voltage meter. And check that the BUS HOT indicator light is off. Because it's possible that an indicator light could be broken, do not use it as the sole method of determining that the system is de-energized.

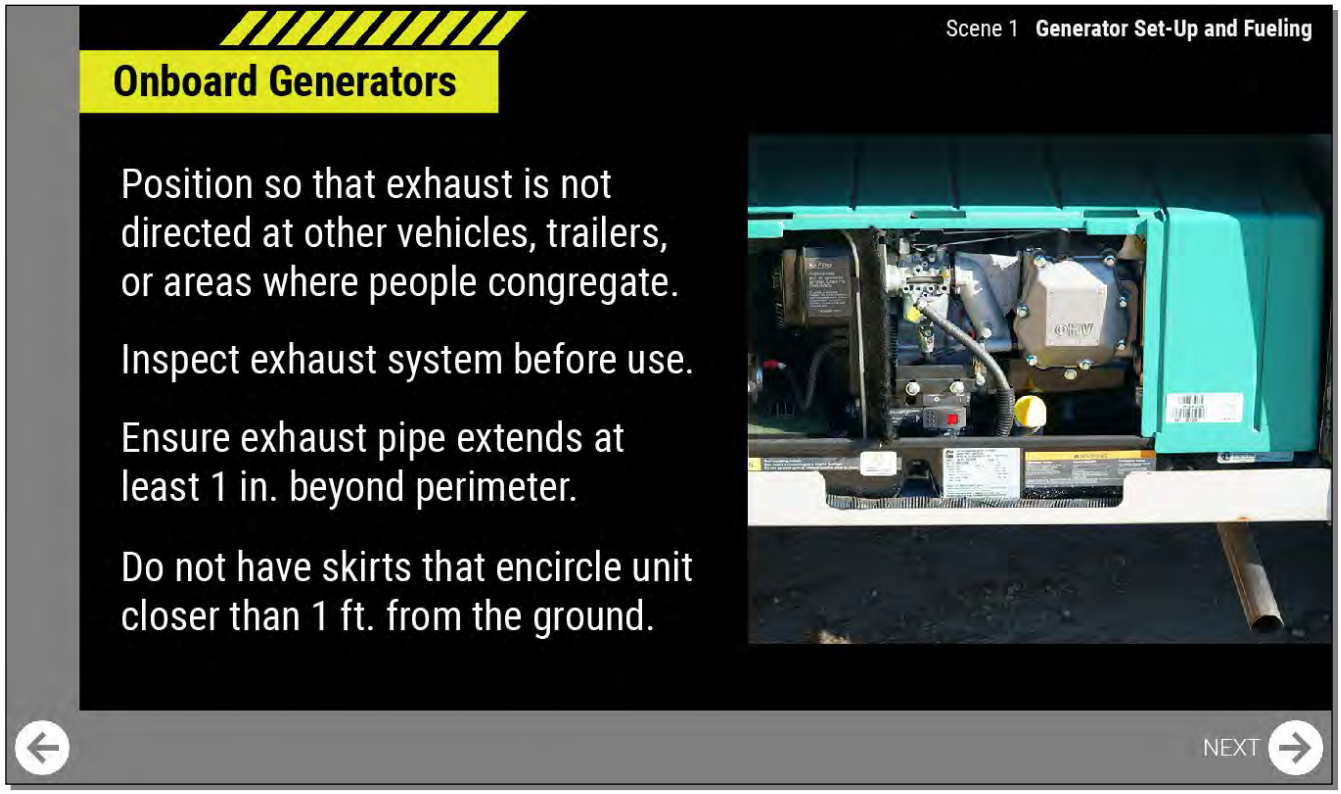
All connectors should be considered energized until otherwise verified.

Slide 23. Guarding of Energized Parts

Almost all large, modern generators used in our industry use cam-type connectors.

If you run across a generator that still has busbars, which are exposed connections, the energized parts must be protected, shielded, or barricaded, and precautions must be taken to prevent the approach of non-qualified people and conductive objects.

Slide 24. Onboard Generators 1



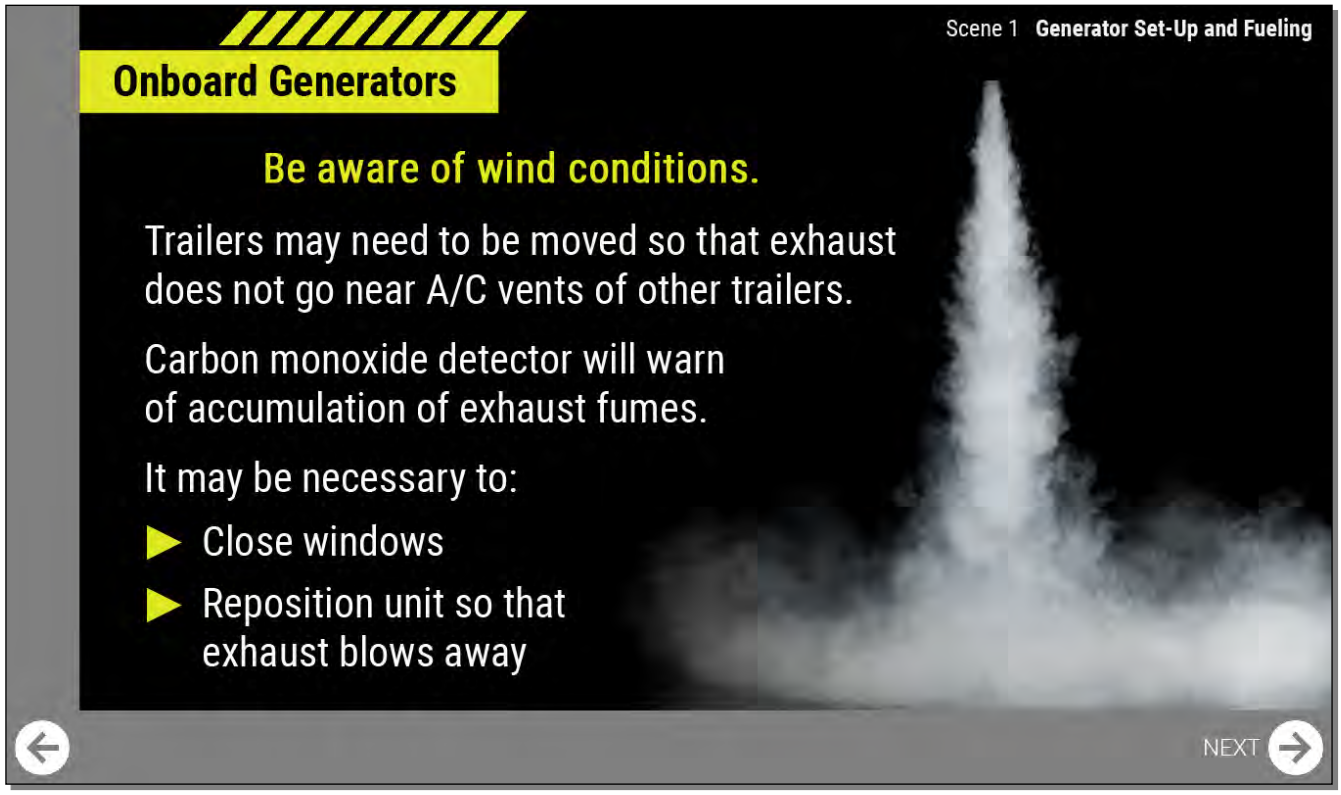
When using the onboard generator of a base camp vehicle or trailer—such as a motorhome, dressing room trailer, or honeywagon—position the unit so that generator exhaust is not directed toward other vehicles or trailers or areas where people congregate.

Inspect the generator's exhaust system before use to make sure it is in good working order.

Ensure the exhaust pipe extends at least one inch beyond the perimeter of the unit.

To prevent the accumulation of any dangerous fumes, do not have skirts or other downward projections that encircle the unit closer than one foot from the ground.

Slide 25. Onboard Generators 2

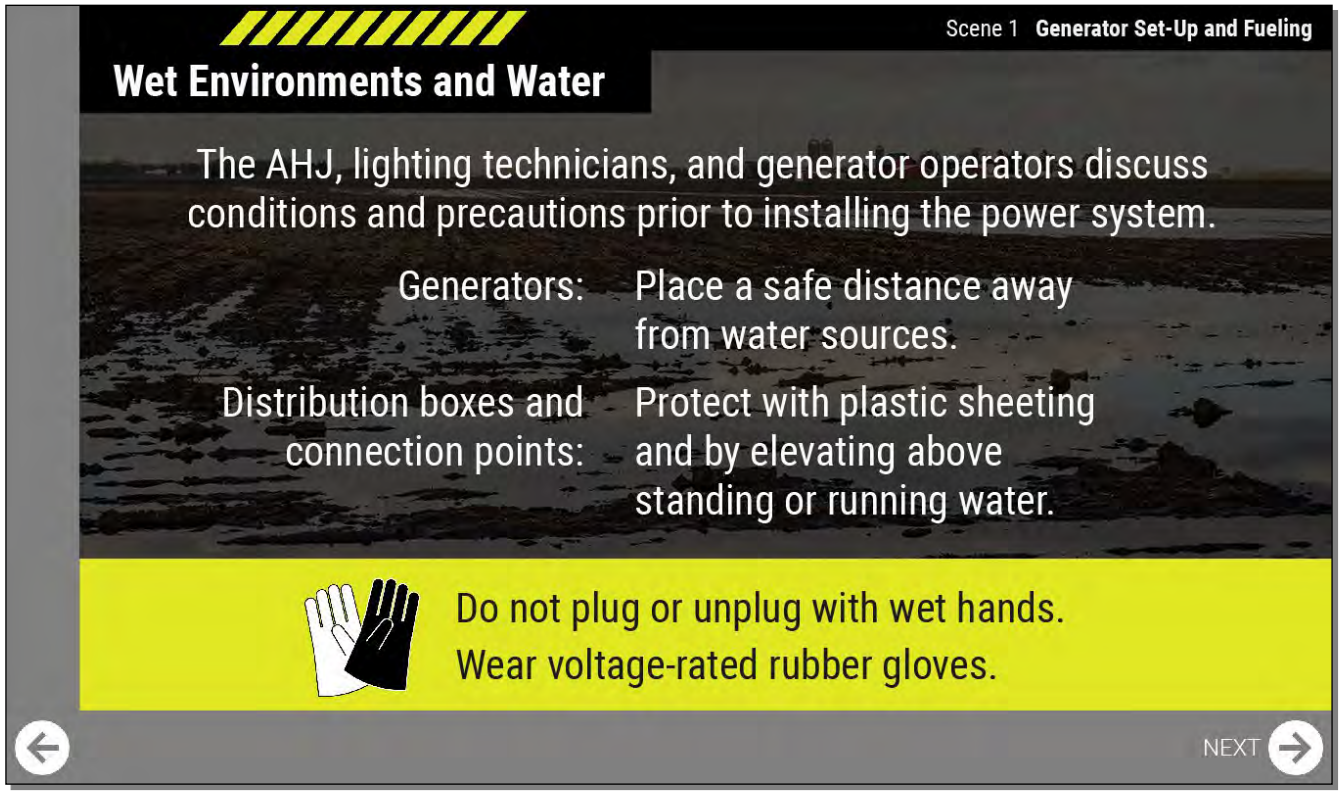


Be aware of wind conditions.

Trailers may need to be moved so that exhaust does not go near air conditioning vents of other trailers.

Base camp vehicles and trailers should be equipped with carbon monoxide detectors to warn of an accumulation of exhaust fumes. It may be necessary to close windows or reposition the unit so that exhaust blows away.

Slide 26. Wet Environments and Water



When a shoot involves wet environments or bodies of water, the AHJ, lighting technicians, and generator operators should discuss specific conditions and precautions prior to installing the power system.

Generators should be placed far enough away from water sources as to not create an electrical hazard. However, other equipment connected to generators needs to be considered. Work with the lighting crew to protect distribution boxes and connection points from moisture and water with plastic sheeting and by elevating the equipment above standing or running water.

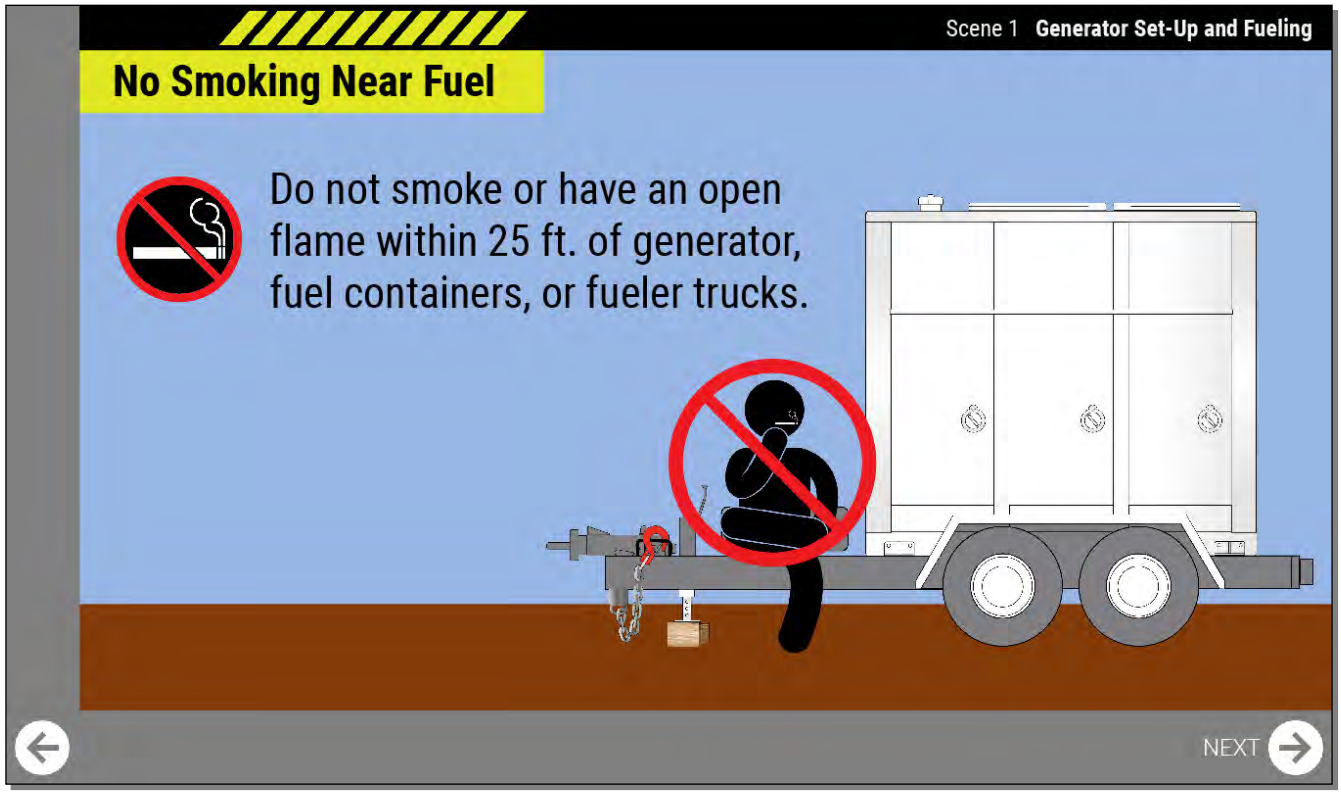
Protect yourself as well. Do not plug or unplug equipment with wet hands. When hands, feet, or equipment are likely to be wet, consider wearing voltage-rated rubber gloves.

Slide 27. Fuel Hazards

Gasoline and diesel fuel and their vapors can catch fire or cause an explosion if they come in contact with hot engine parts, electrical sparks, or other heat sources.

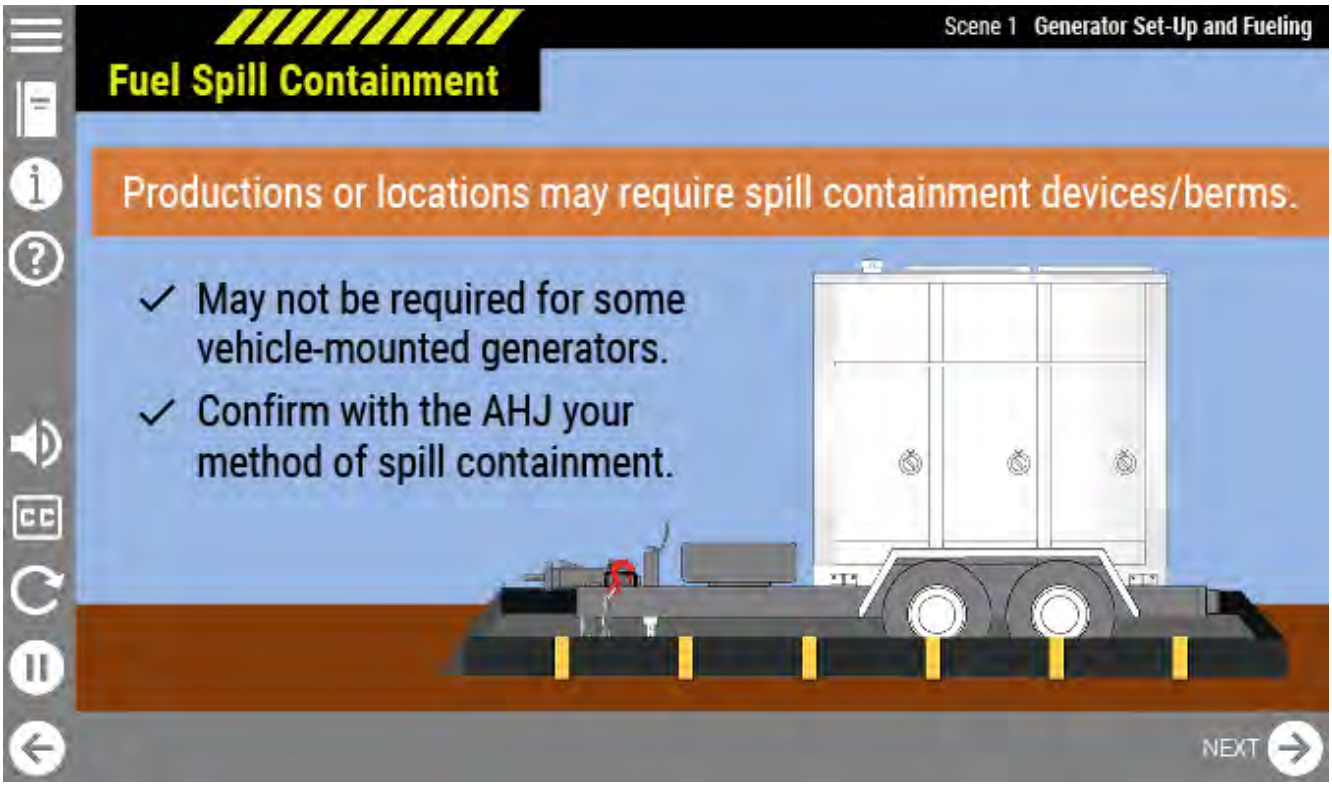
While gasoline and diesel fuel are both flammable, gasoline vapors ignite more easily than diesel vapors.

Slide 28. No Smoking Near Fuel



Do not smoke or have an open flame within 25 feet of the generator, fuel containers, or fueler trucks.

Slide 29. Fuel Spill Containment



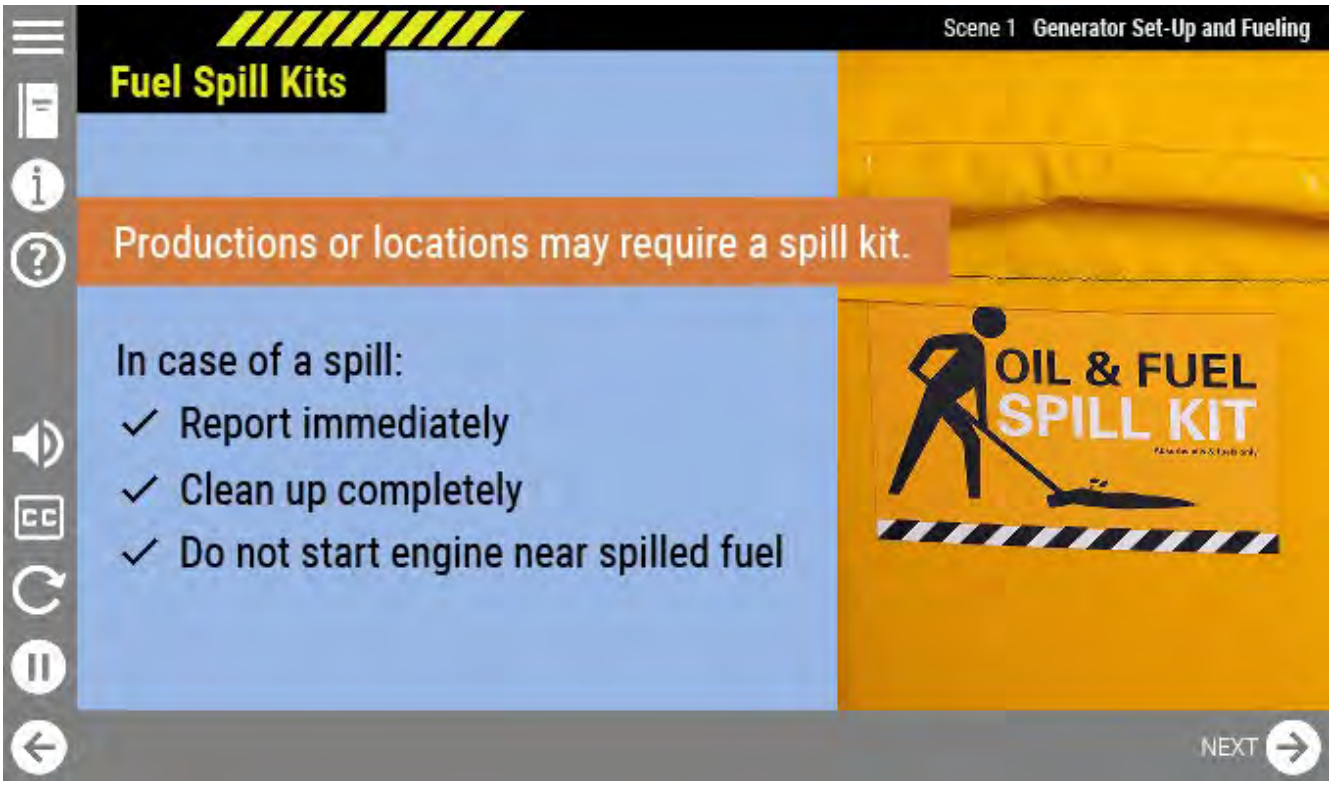
Because fuel is an environmental hazard, productions or locations may require spill containment devices, also called spill containment berms. The generator rental company may provide such devices.

Drive the generator onto the device or slide the device under the generator.

Spill containment devices may not be required for vehicle-mounted generators that are fueled from the vehicle's tanks if they are certified, dual-walled fuel tanks.

Confirm with the AHJ that the method of spill containment you are using is approved.

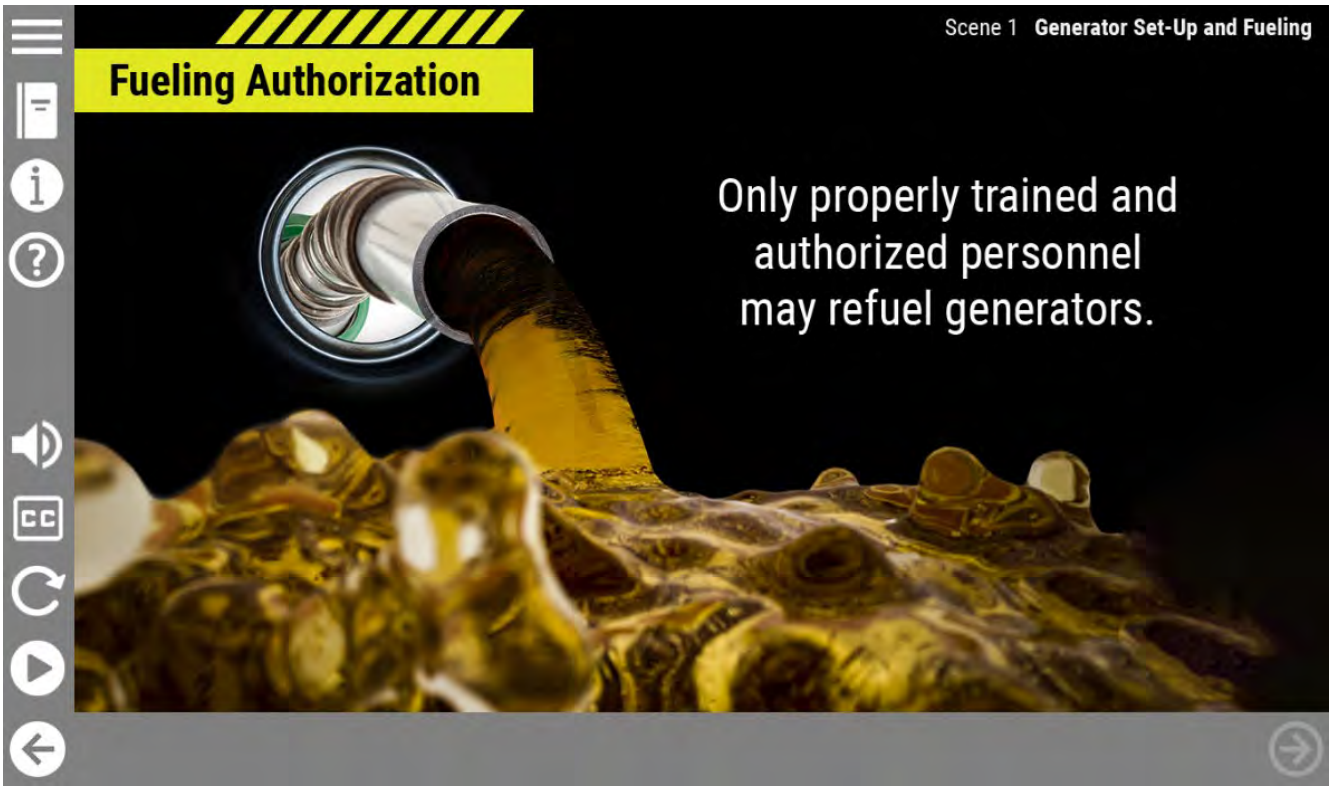
Slide 30. Fuel Spill Kits



Having a spill kit is recommended, but some productions or locations may require them. Generator rental companies and fueler trucks are required to have spill kits.

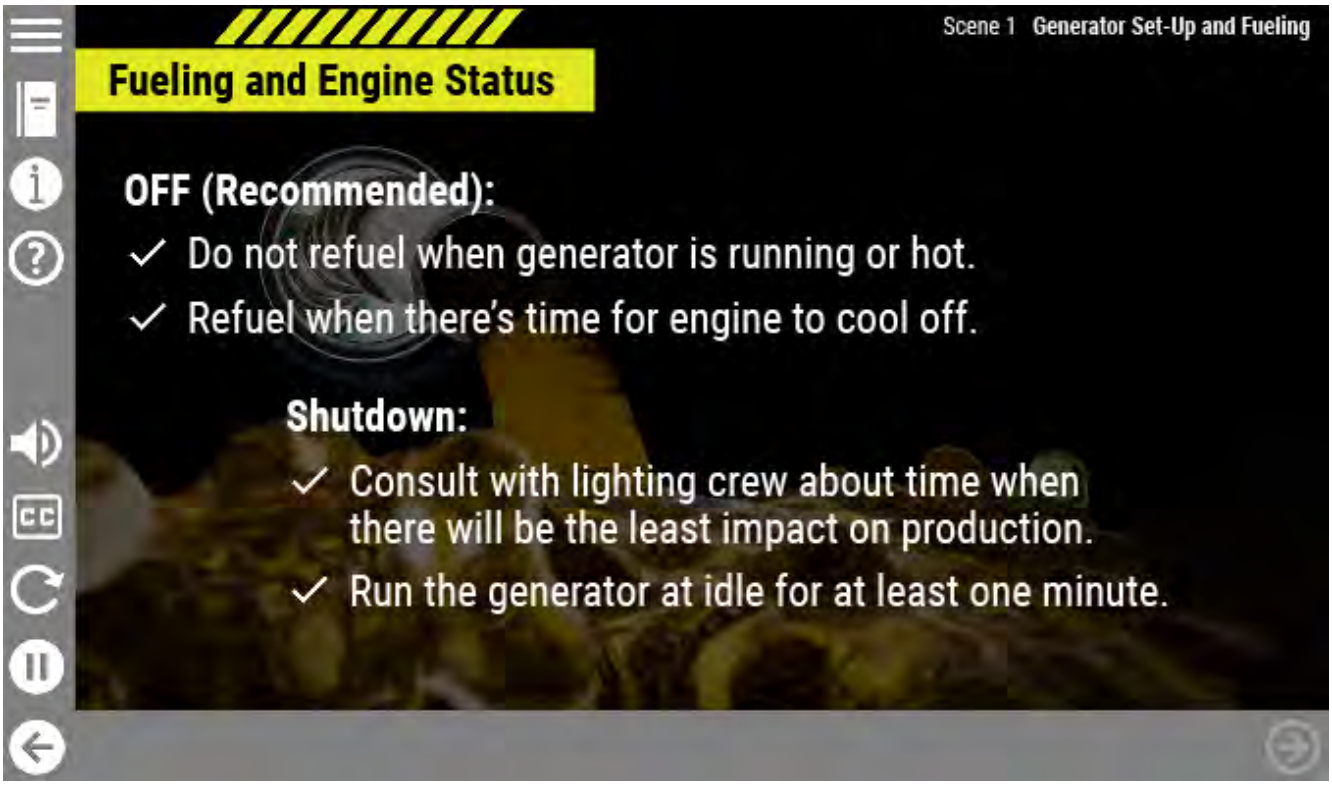
Report significant spills to your supervisor or safety representative immediately. Clean up all spills completely, and properly dispose of absorbent or rags used in the process. Do not start the generator engine near spilled fuel.

Slide 31. Fueling Authorization



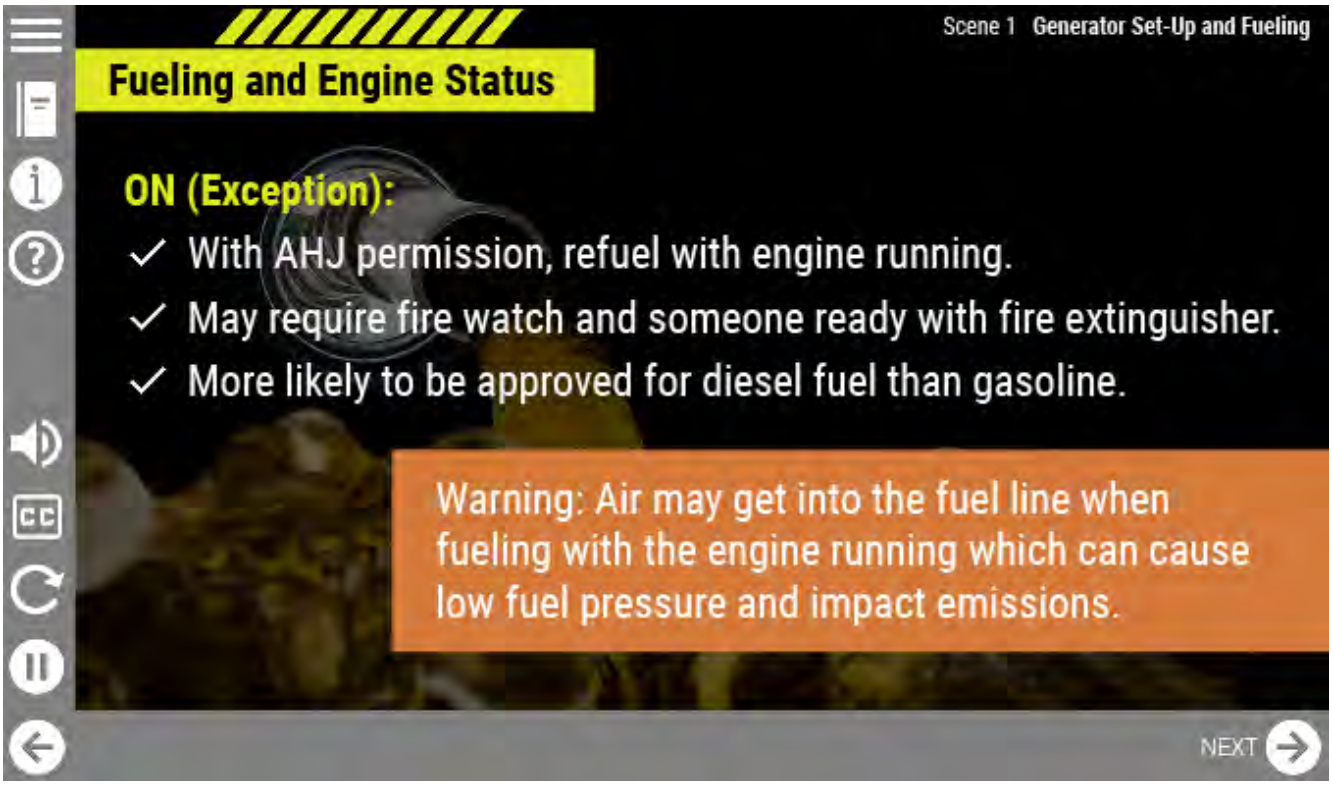
Generators typically arrive on set fully fueled by the rental company. When refueling is required, it is usually done by the driver of the fueler truck who has the proper training to do it safely. Only properly trained personnel authorized by their employer may refuel generators. If you are unsure if you are allowed to perform this task, consult with your transportation coordinator or safety representative.

Slide 32. Fueling and Engine Status OFF



It is recommended that you do not refuel when the generator is running or hot. Refuel when there's time to wait for the engine to cool off after shutdown. Consult with the lighting crew about a time when shutdown will have the least impact on the production. Run the generator at idle for at least one minute before shutting down. An abrupt shutdown can cause damage.

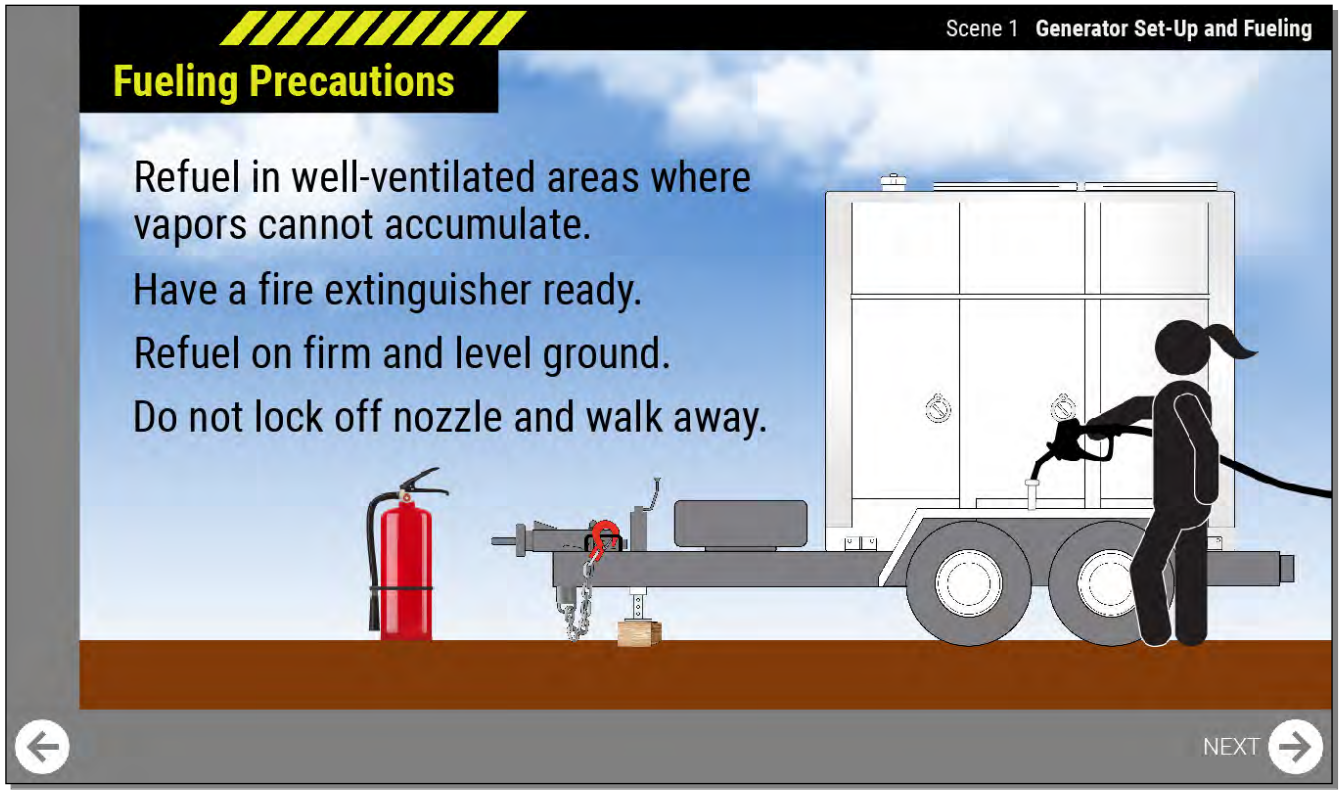
Slide 33. Fueling and Engine Status ON



In situations where power must be maintained and with permission from the AHJ, refueling may be done with the engine running. The AHJ may require fire watch and someone standing by with a fire extinguisher in hand. This scenario is more likely to be approved for diesel fuel than gasoline.

Keep in mind that air may get into the fuel line when fueling with the engine running. This can cause low fuel pressure and negatively impact emissions.

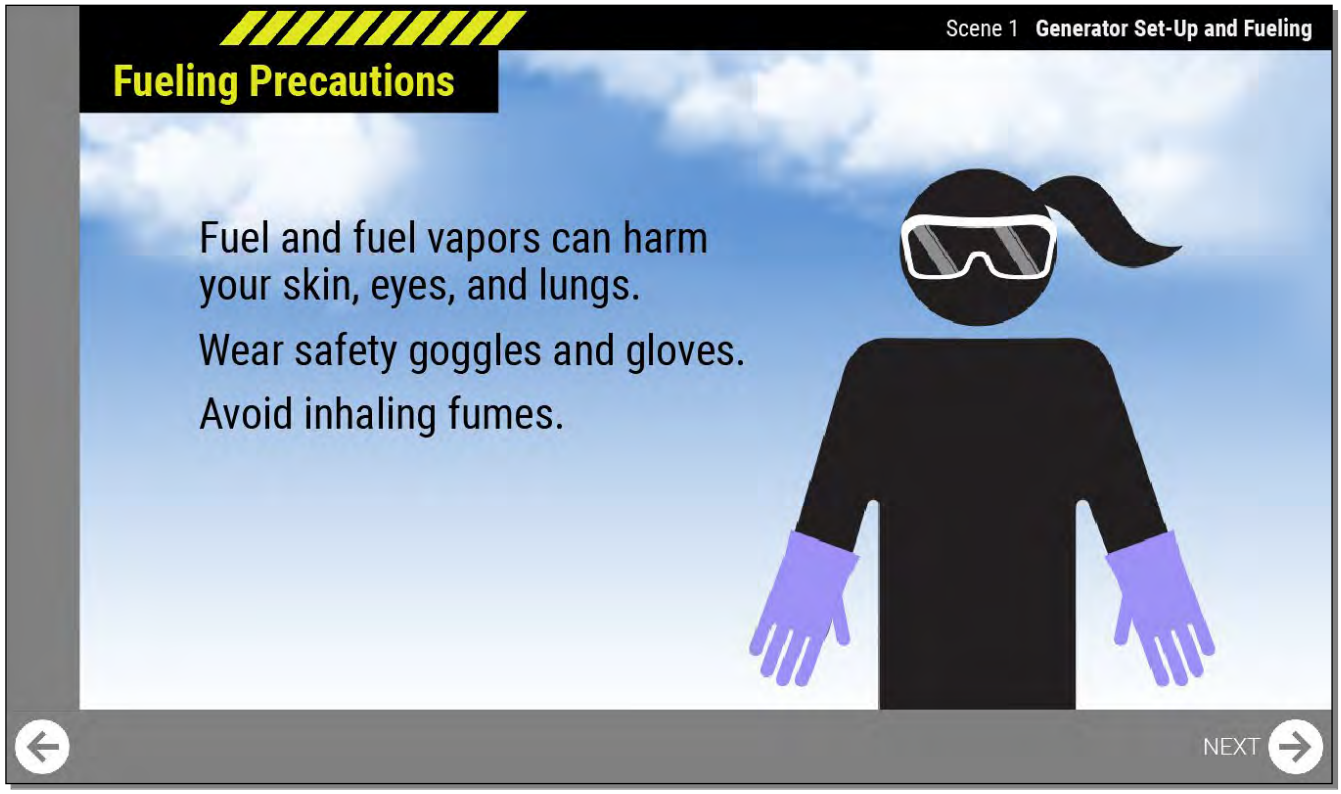
Slide 34. Fueling Precautions 1



Refuel in well-ventilated areas where vapors cannot accumulate, and have a fire extinguisher ready for use.

Refuel on firm and level ground. Not only will this help prevent spills, it will ensure the tank is filled completely. Do not lock off the nozzle and walk away.

Slide 35. Fueling Precautions 2

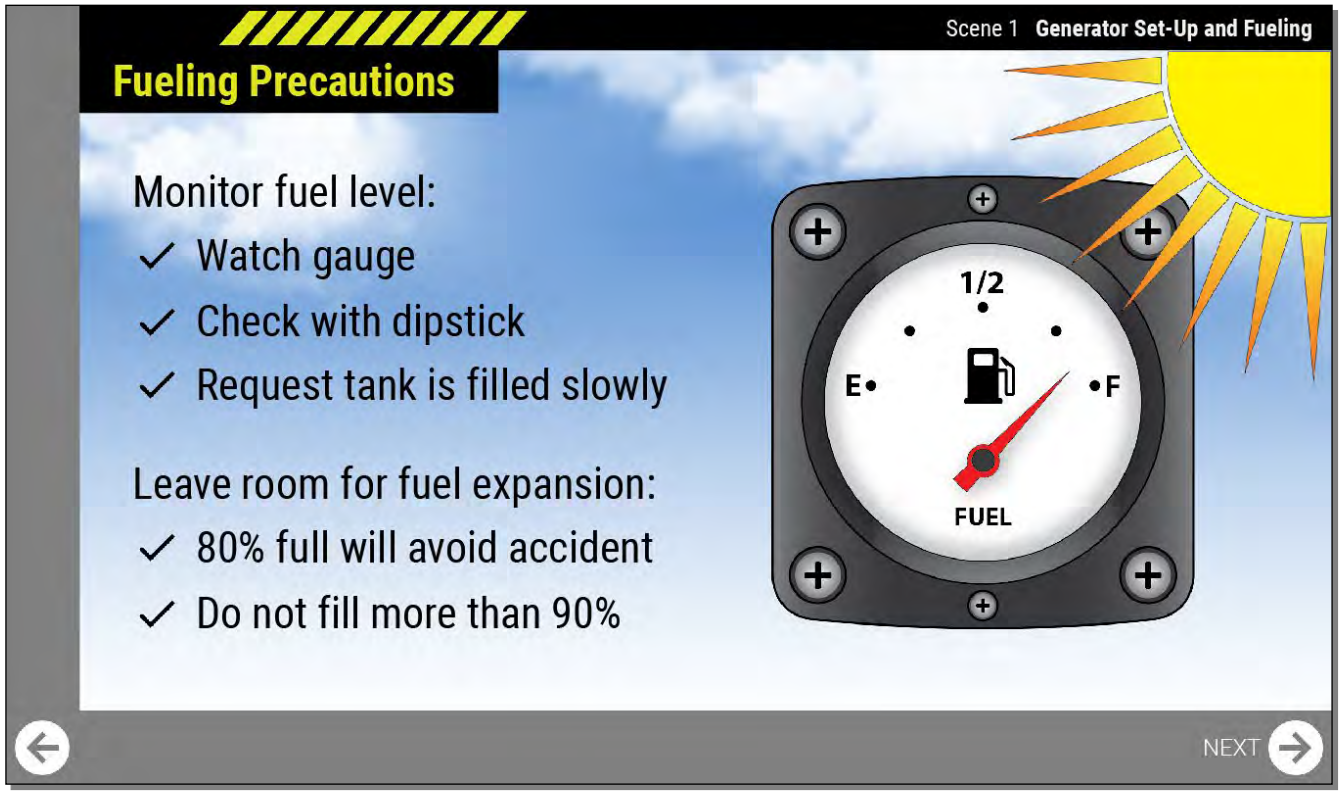


Fuel and fuel vapors can be harmful to your skin, eyes, and lungs.

You may want to wear safety goggles and nitrile gloves.

Avoid inhaling fumes.

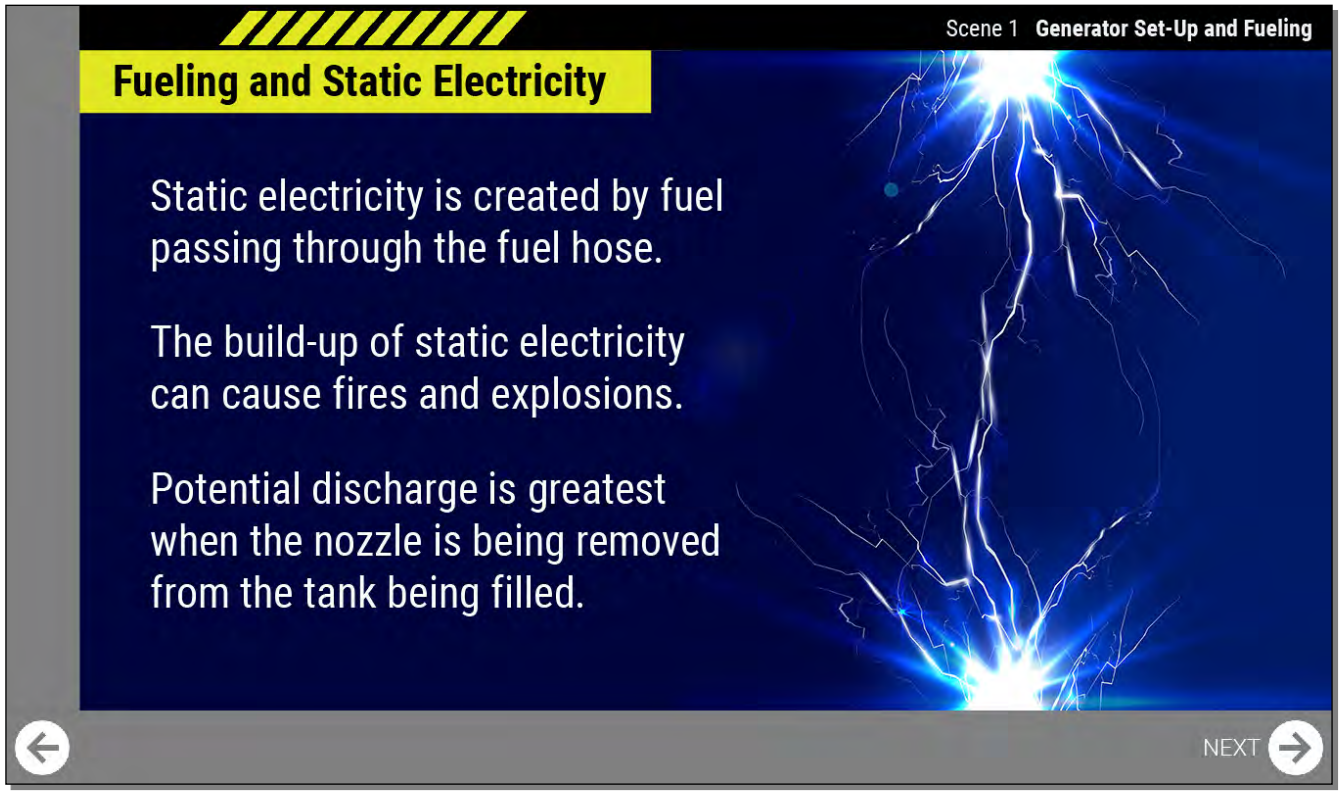
Slide 36. Fueling Precautions 3



Keep an eye on the fuel gauge and check the fuel level with a dipstick before the fueler truck leaves. You may want to request that the tank is filled more slowly to combat pressure flow of the fuel truck nozzle.

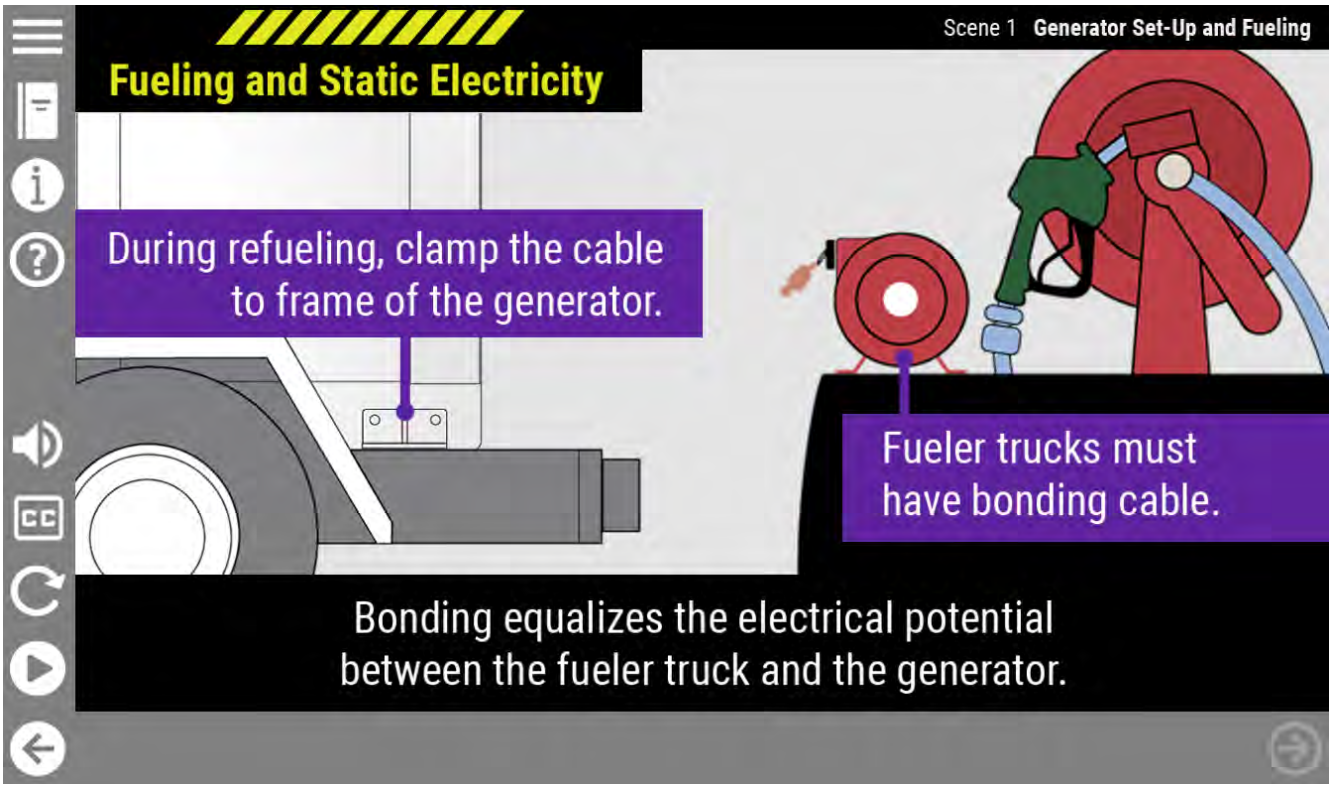
Do not overfill the tank. Leave room for fuel expansion, especially if you're working in a hot climate. Filling the tank 80 percent is adequate to avoid a fuel expansion accident. Do not fill the tank more than 90 percent.

Slide 37. Fueling and Static Electricity 1



Static electricity is created by fuel passing through the hose. The build-up of static electricity can cause fires and explosions. Its potential discharge and ignition of fuel vapors is greatest when the nozzle is being removed from the tank being filled.

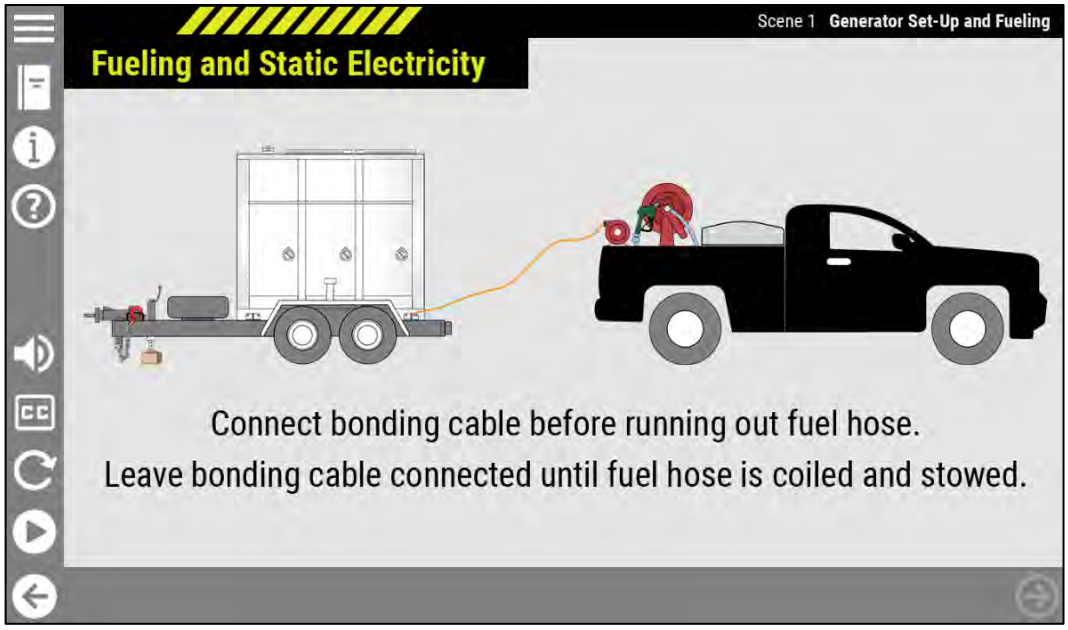
Slide 38. Fueling and Static Electricity 2



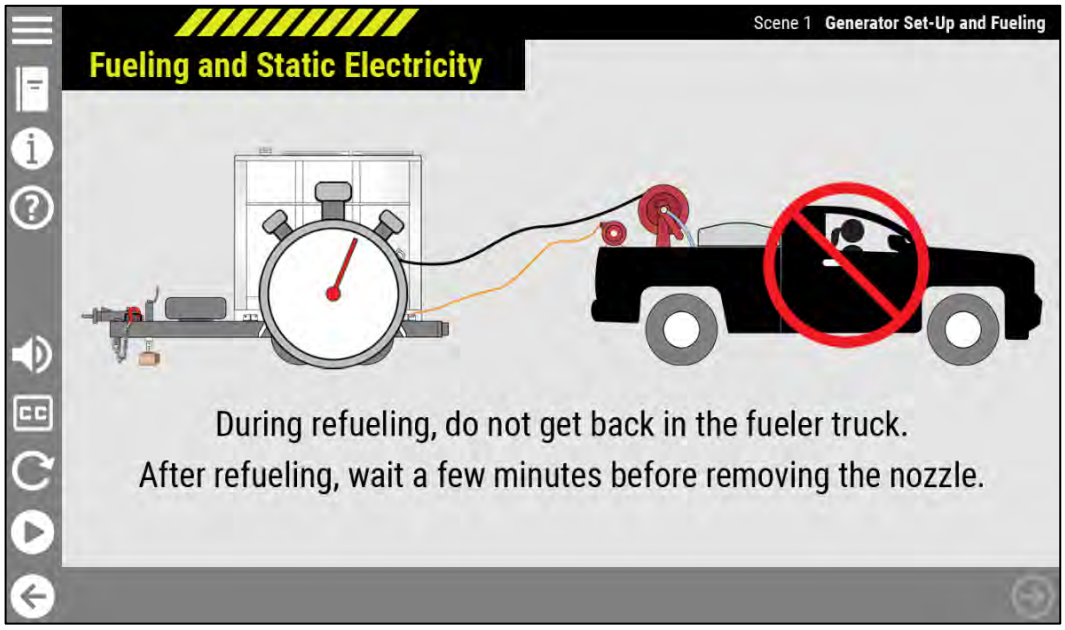
Multiple safety measures must be in place to help prevent the build-up and discharge of static electricity.

Fueler trucks are required to have a permanently connected bonding cable. During refueling, clamp the bonding cable to the frame of the generator anywhere a solid metal-on-metal connection can be made. Bonding equalizes the electrical potential between the fueler truck and the generator, reducing the chance of a static electrical discharge.

Slide 39. Fueling and Static Electricity 3



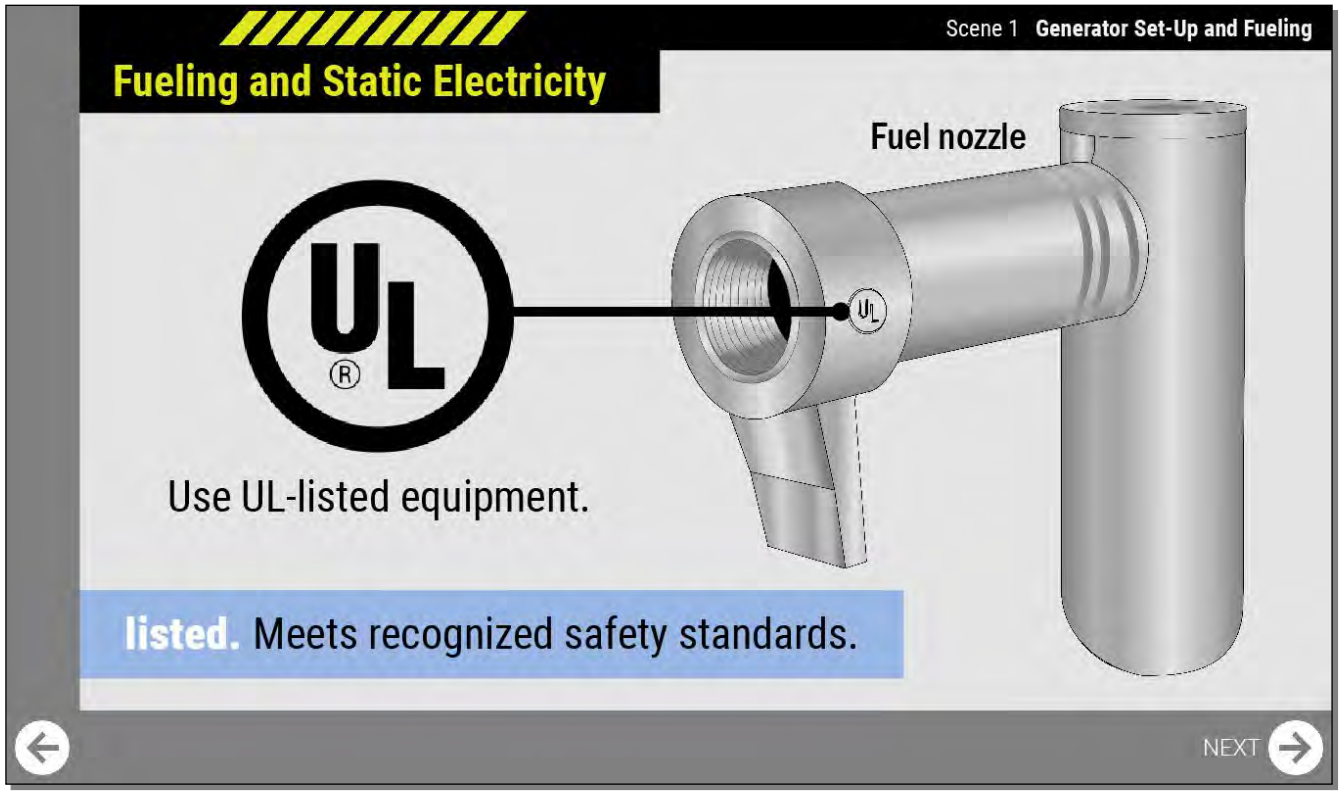
Connect the bonding cable to the generator frame *before* running out the fuel hose and *leave* it connected until the hose is completely coiled and stowed after fueling.



Do not get back in the vehicle during fueling operations. This increases static electricity, which can ignite fumes when you grab the nozzle after getting out of the vehicle.

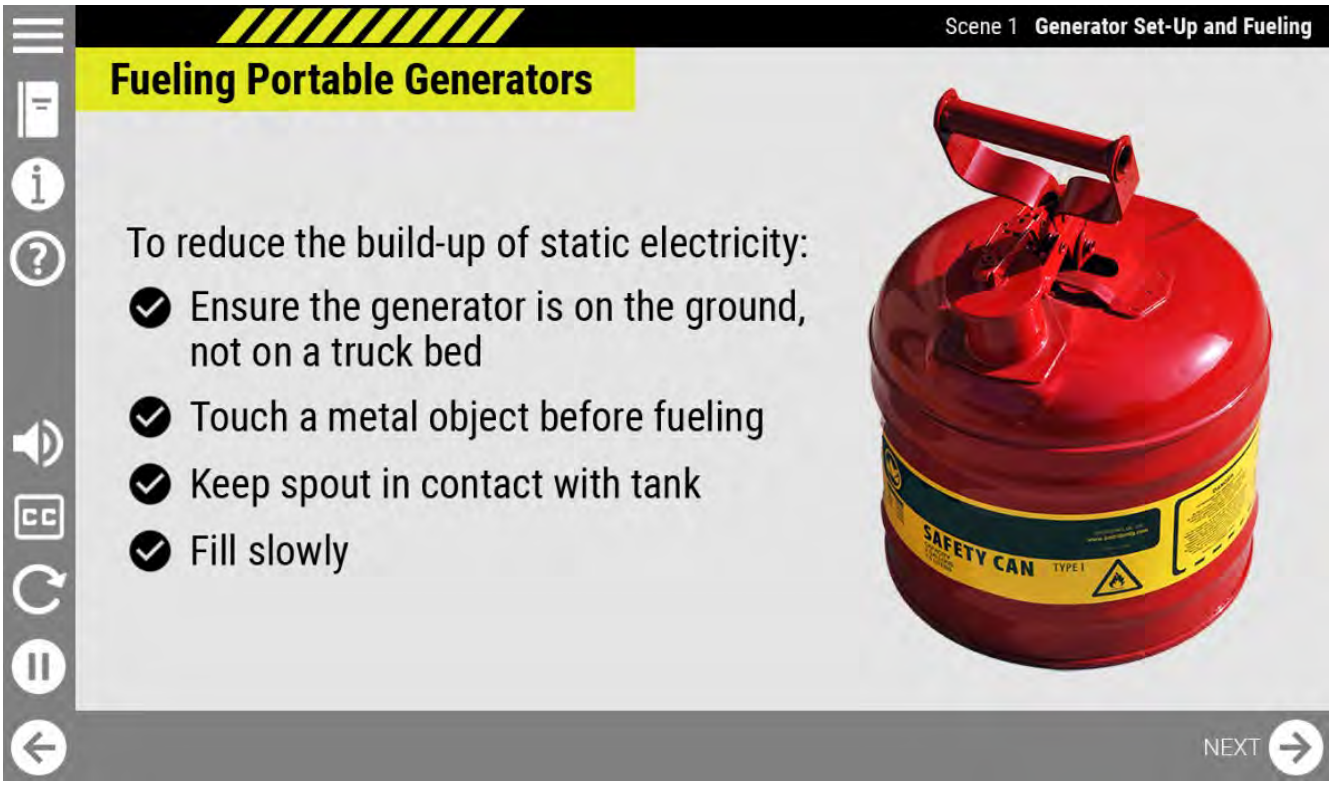
And after refueling, waiting a few minutes before removing the nozzle helps assure that static electricity has dissipated.

Slide 40. Fueling and Static Electricity 4



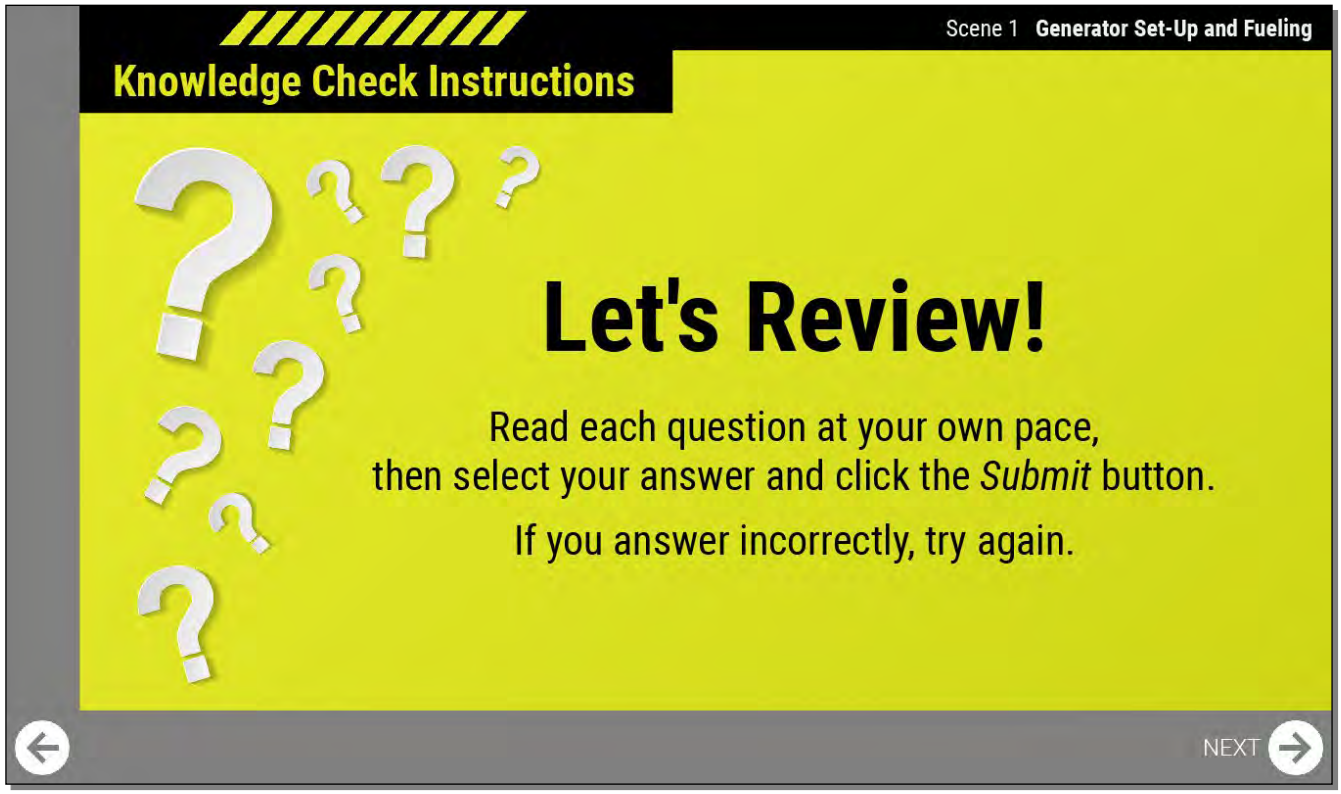
Use fuel-dispensing equipment with an Underwriters Laboratories (or UL) listing mark. A UL listing means that the equipment has passed required usage and safety testing. Listed fuel dispensing equipment is designed with a continuous bond that allows static electricity to flow to ground.

Slide 41. Fueling Portable Generators



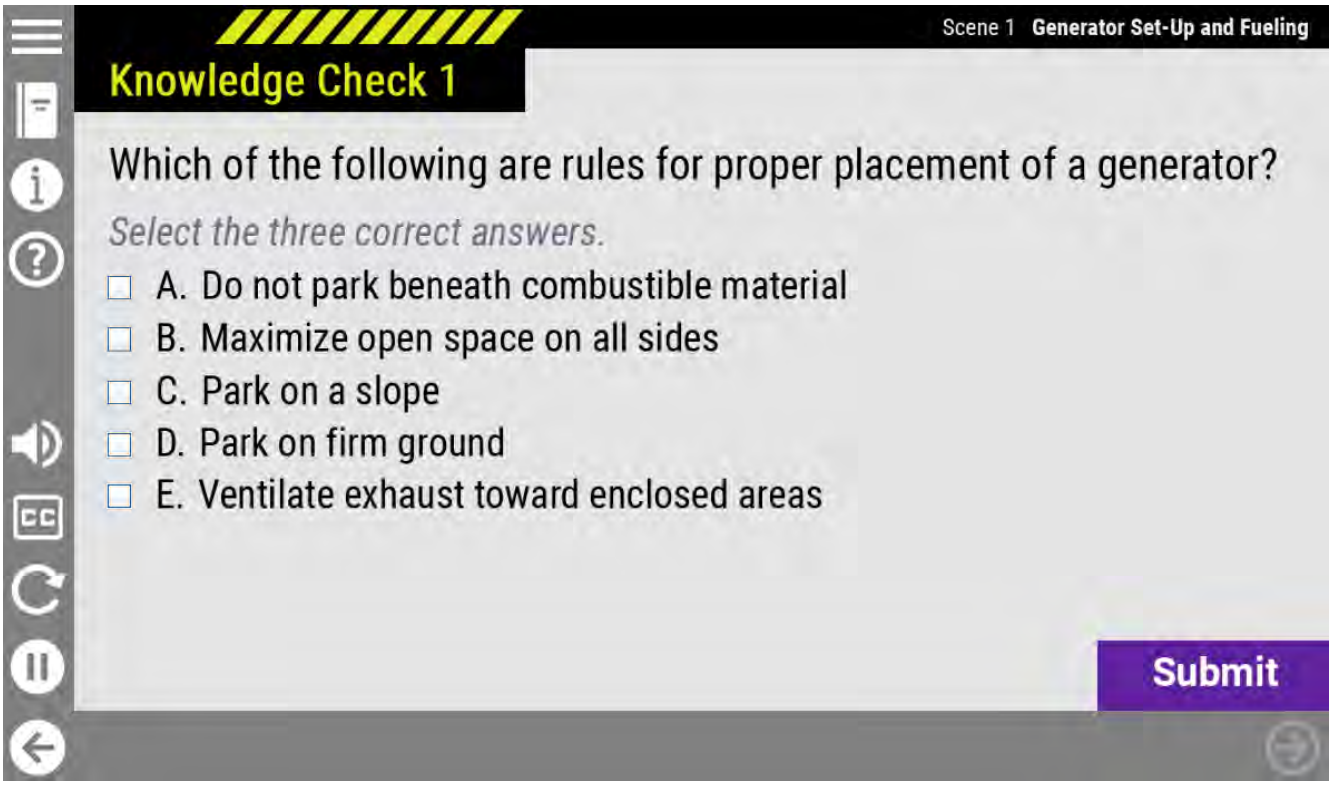
Fueling portable, gas-powered generators is usually done with a plastic or metal can. To reduce the build-up of static electricity when using a metal can with a metal spout, ensure the generator is on the ground (not on a truck bed), touch a metal object before you begin fueling, keep the spout in contact with the fuel tank, and fill slowly.

Slide 42. Knowledge Check Instructions

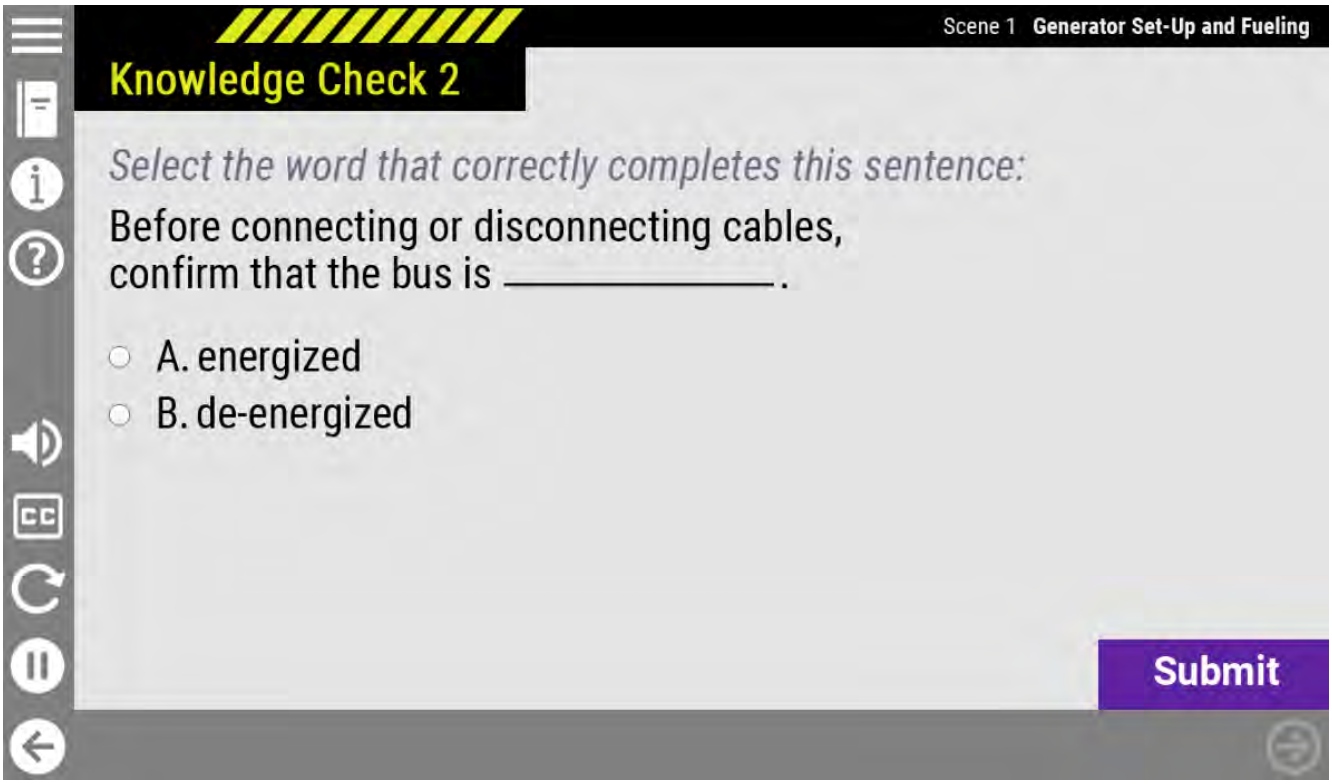


Okay. We've reached the first set of knowledge checks. Read each question at your own pace, then select your answer and click the *Submit* button. If you answer incorrectly, try again.

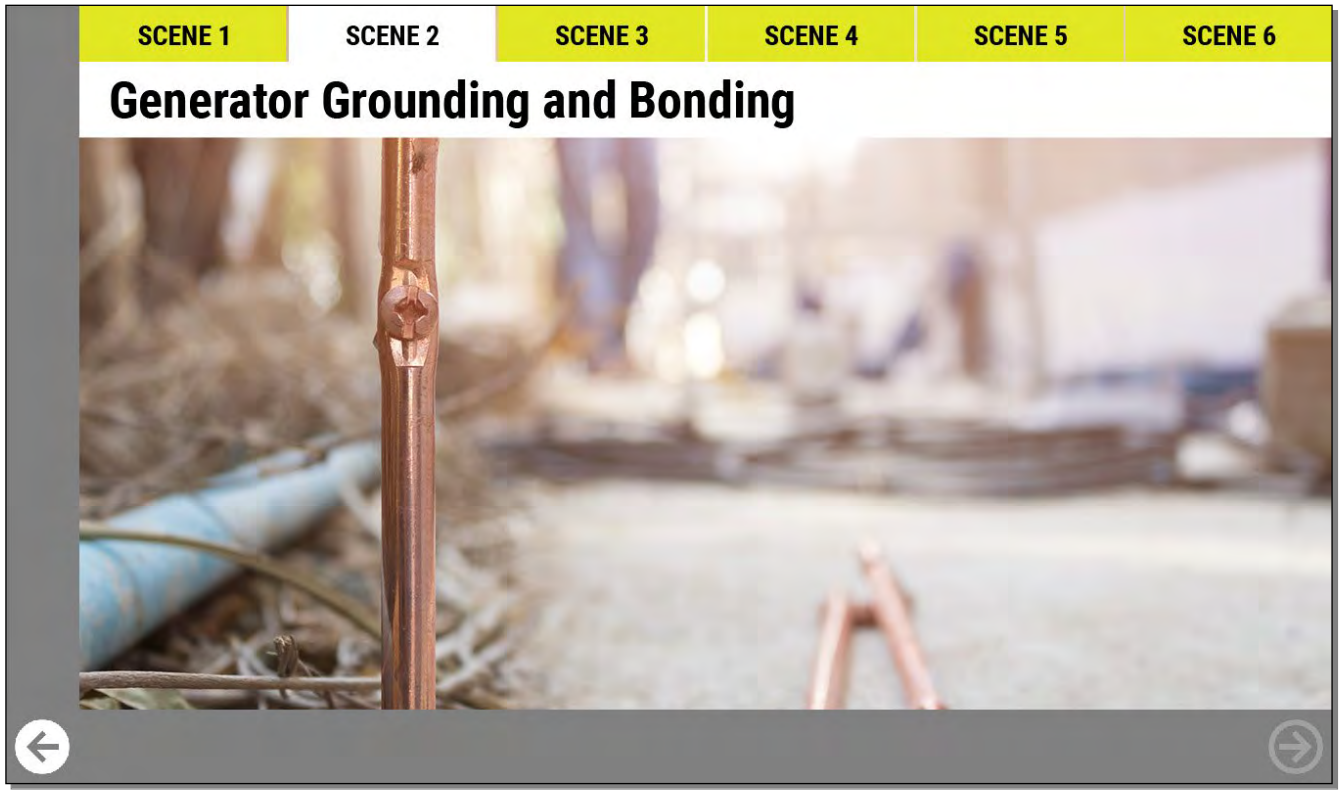
Slide 43. Knowledge Check 1



Slide 44. Knowledge Check 2

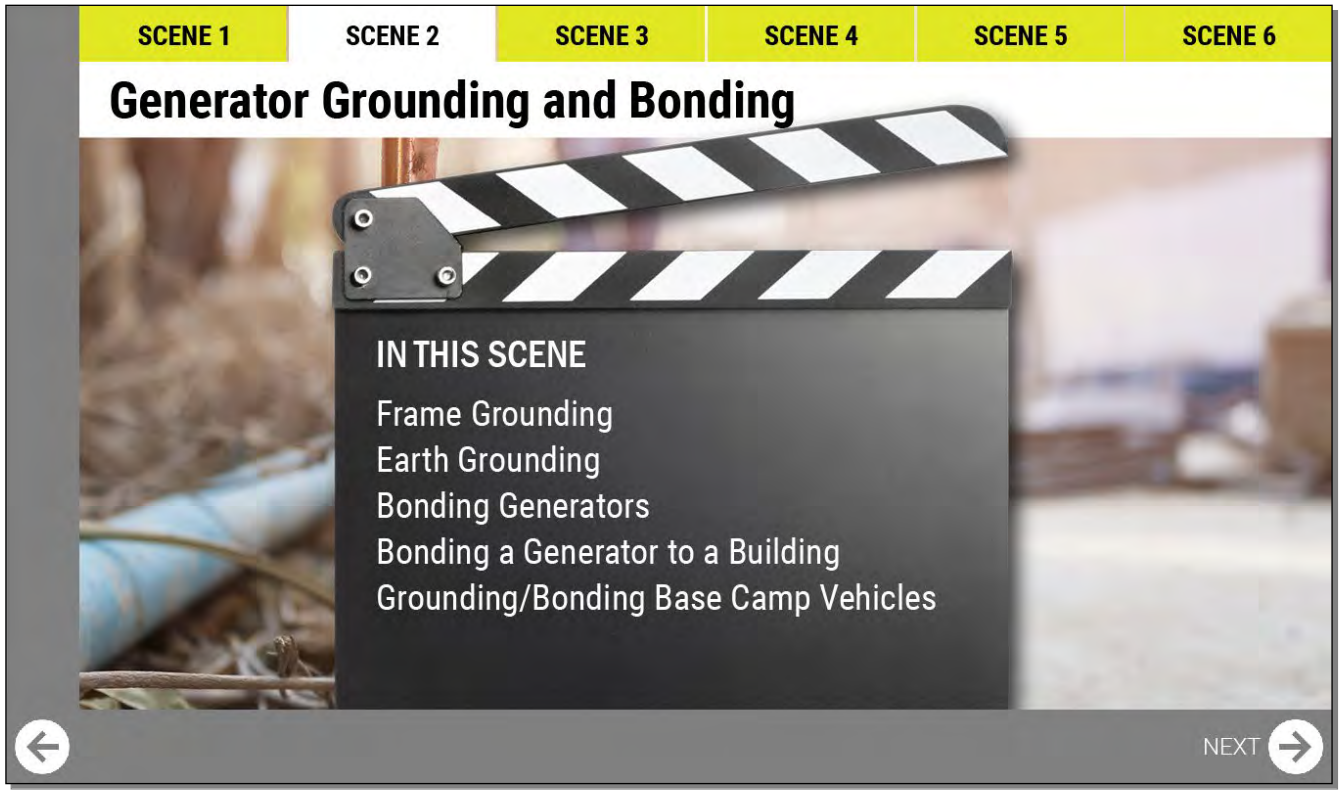


Slide 45. SCENE 2, GROUNDING AND BONDING



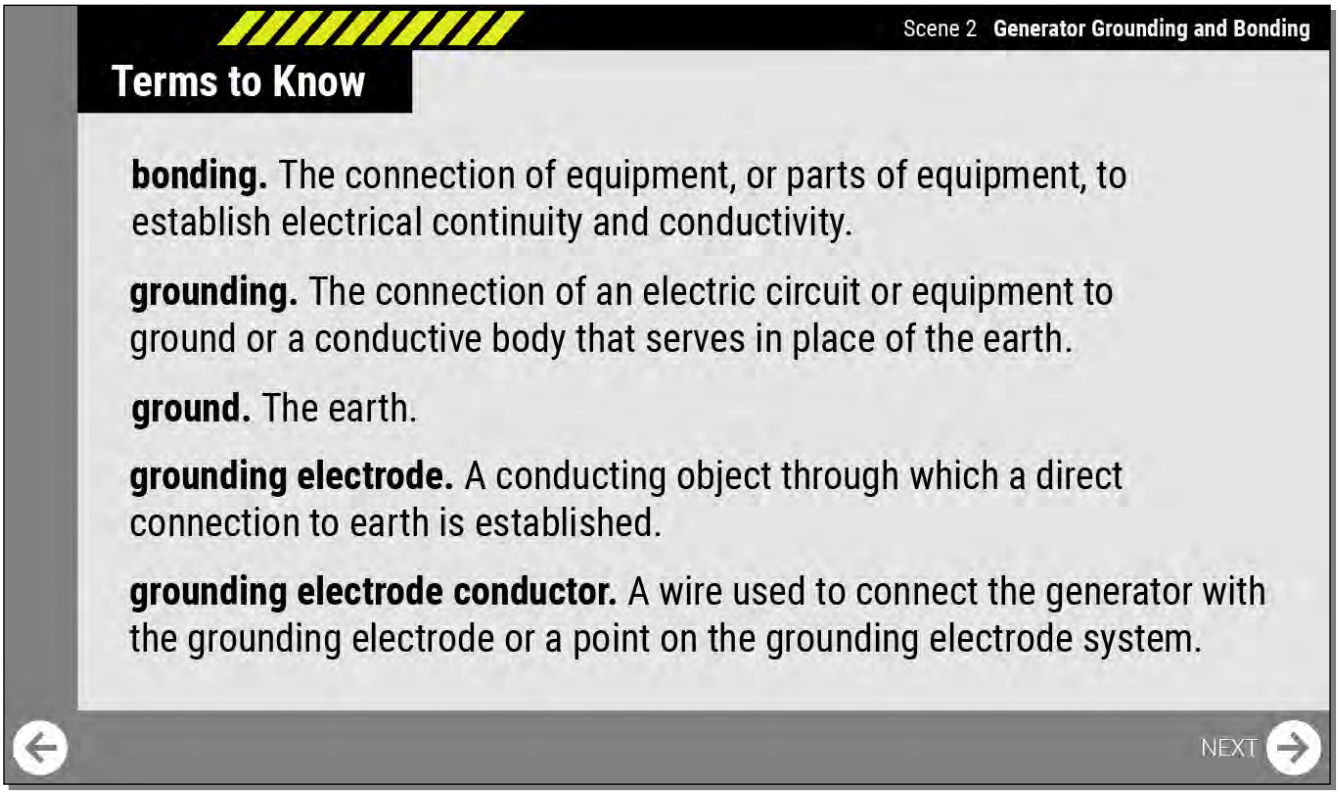
Scene Two, Generator Grounding and Bonding.

Slide 46. In This Scene



This scene covers the regulatory requirements for grounding and bonding mobile and portable generators. We'll talk about frame grounding, earth grounding, bonding generators together, bonding a generator to a building, and grounding and bonding base camp vehicles.

Slide 47. Terms to Know



Let’s take a moment to review some key terms.

Bonding is the connection of equipment, or parts of equipment, to establish electrical continuity and conductivity.

Grounding is the connection of an electric circuit or equipment to ground or a conductive body that serves in place of the earth.

When we say **ground** or **to ground**, we’re referring to the earth.

A **grounding electrode** is a conducting object through which a direct connection to earth is established.

And a **grounding electrode conductor** is the wire used to connect the generator with the grounding electrode or a point on the grounding electrode system.

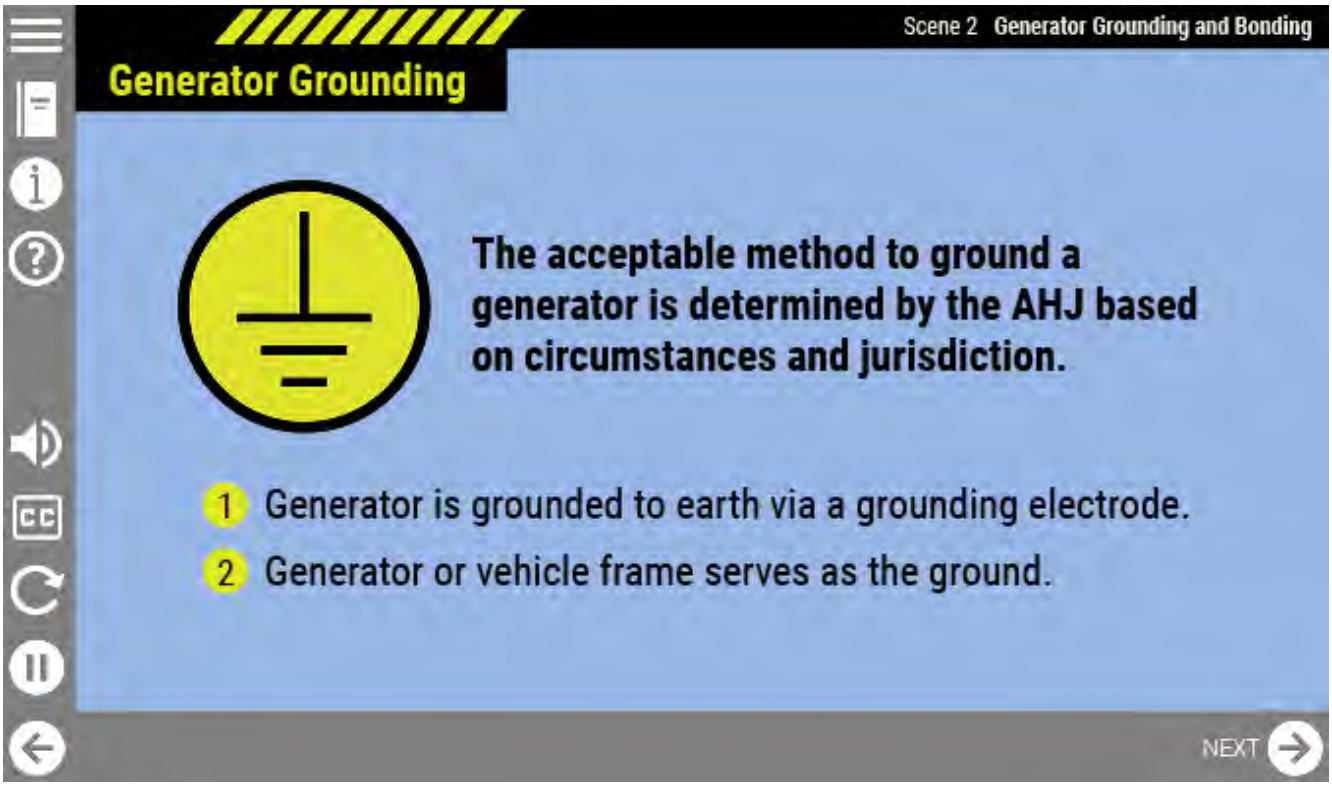
You’ll get a better sense of these terms as we move through this scene.

Slide 48. Performing Grounding and Bonding

Grounding and bonding must be performed by an electrically qualified person in accordance with the National Electrical Code (or NEC), state and local regulations, and industry guidelines. You are encouraged to read *Article 250, Grounding and Bonding* of the NEC.

The grounding and bonding plan is subject to the approval of the AHJ.

Slide 49. Generator Grounding

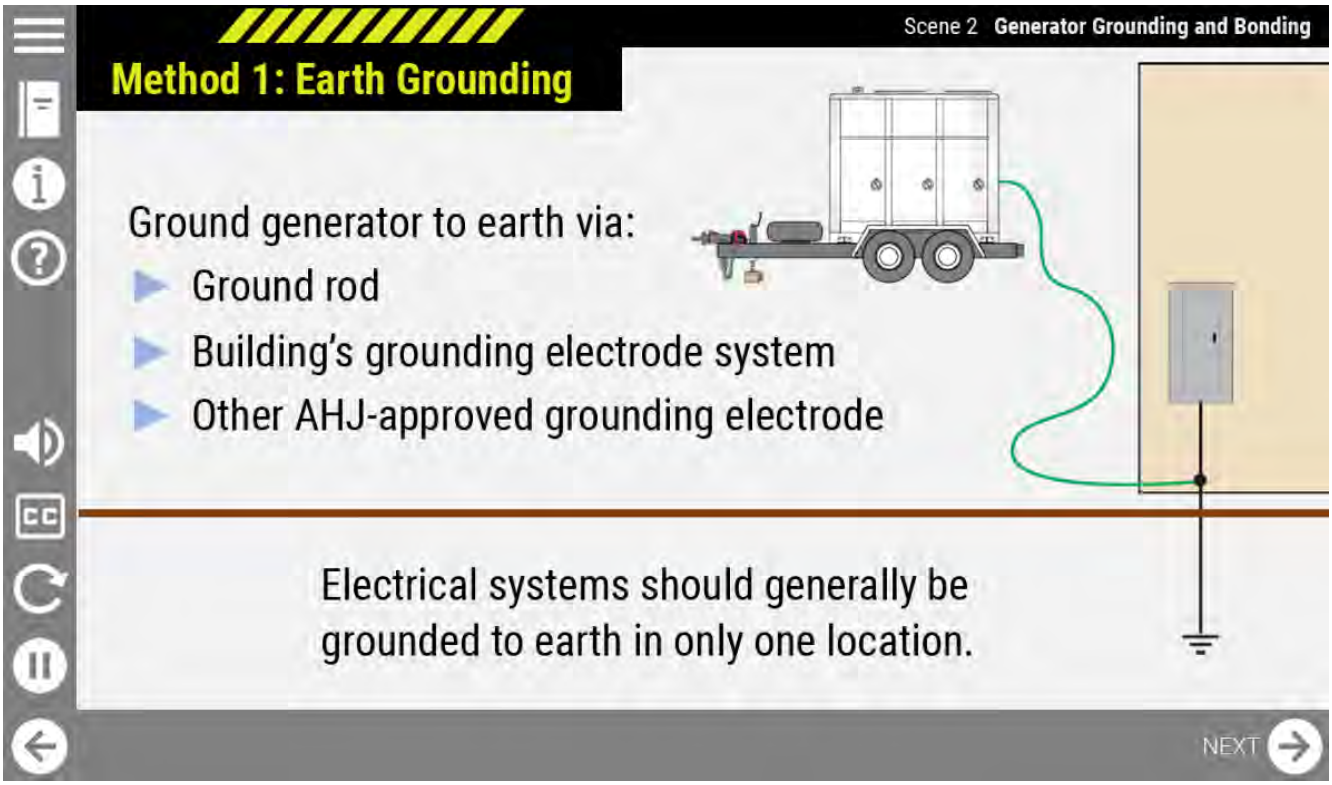


The acceptable method to ground a mobile or portable generator is determined by the AHJ based on specific circumstances and the jurisdiction.

One method is to ground the generator to earth via a grounding electrode, usually a ground rod.

The other is to have the generator frame or vehicle frame serve as the ground in place of an earth ground.

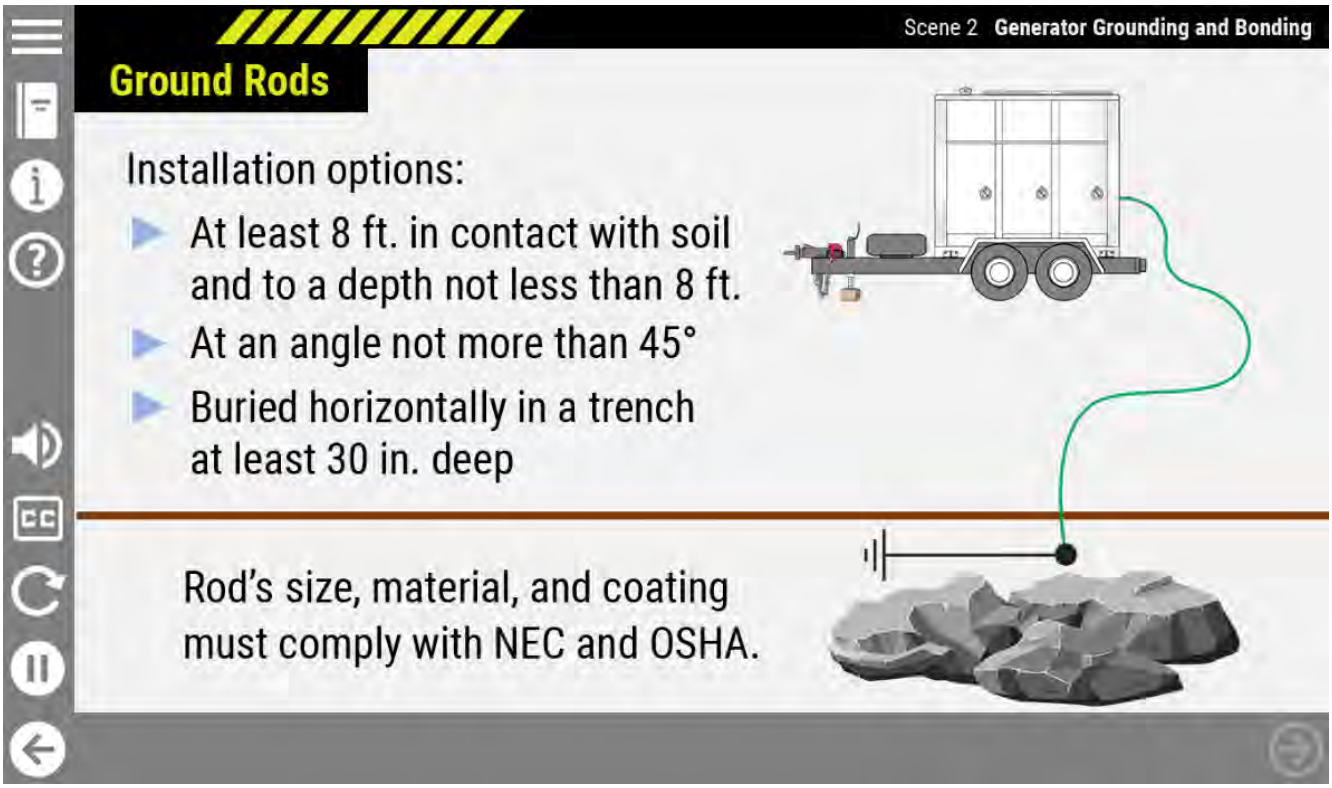
Slide 50. Earth Grounding



A generator may be grounded to earth via a ground rod, a building's grounding electrode system, or some other grounding electrode approved by the AHJ.

Electrical systems should generally be grounded to earth in only one location.

Slide 51. Ground Rods



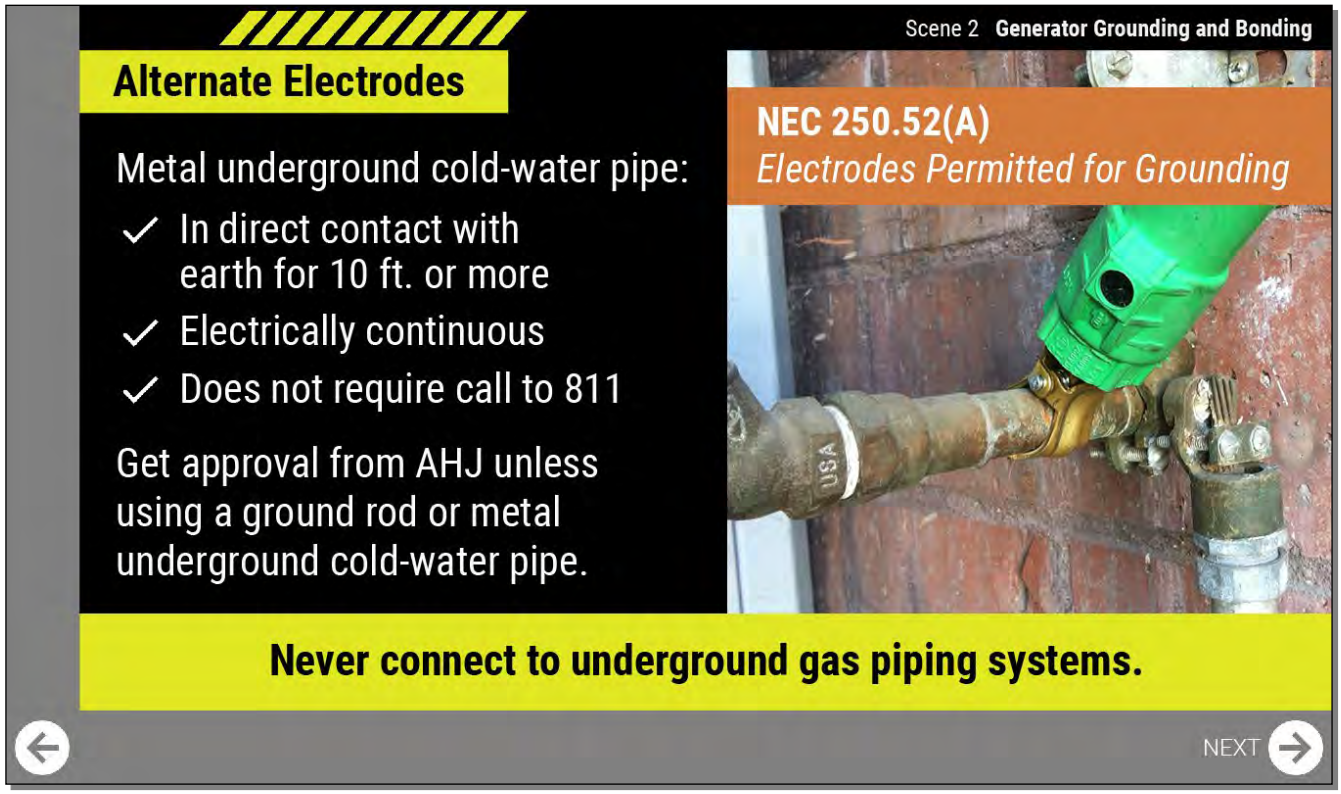
A ground rod must be installed so that at least eight feet of length is in contact with the soil, and generally, it must be driven to a depth not less than eight feet. In some circumstances, such as the presence of rock, it may be positioned at an angle not more than 45 degrees. If rock bottom is still encountered when driving a ground rod at 45 degrees, the electrode is permitted to be buried horizontally in a trench that is at least 30 inches deep.

Be sure the rod's size, material, and coating comply with NEC and OSHA requirements.

Slide 52. “Call Before You Dig”

When planning to use a ground rod, the production must contact the “Call Before You Dig” center by calling 811 at least two working days, but not more than fourteen calendar days beforehand. The production must identify the proposed placement of the ground rod with white paint or other suitable markings, such as flags or cones. “Call Before You Dig” will contact the utility companies, who will mark the site to indicate where utility lines are buried. Never drive the ground rod within two feet on either side of a marked utility line.

Slide 53. Alternate Electrodes



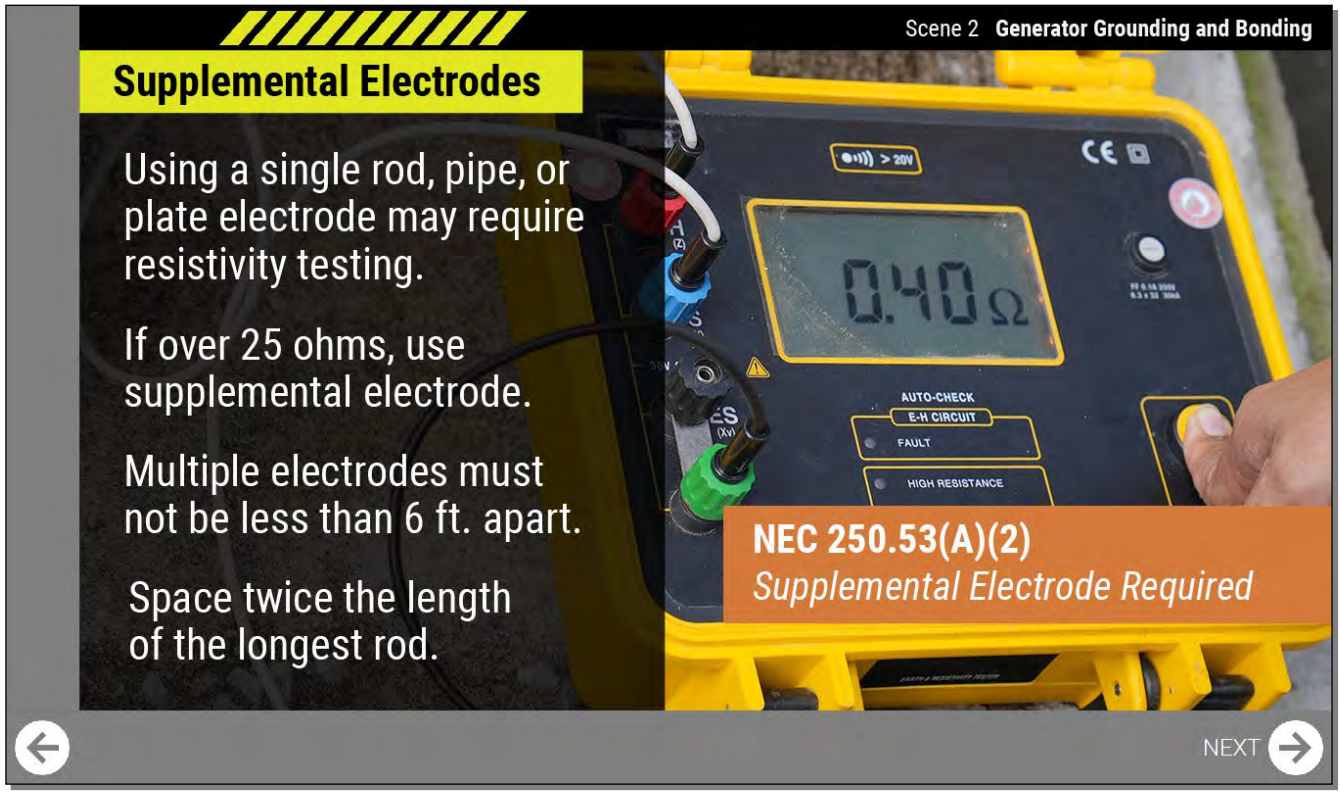
The NEC permits the use of a metal underground cold-water pipe as a grounding electrode under certain conditions. The pipe must be in direct contact with earth for 10 feet or more and be electrically continuous. This is often an easier alternative to sinking a ground rod and calling 811. A copper or cast-iron cold-water service line may, therefore, be a candidate as a grounding electrode.

Get approval from the AHJ unless using a ground rod or cold-water pipe.

Never connect to underground gas piping systems.

Refer to the NEC, section 250.52(A) to see electrodes permitted for grounding.

Slide 54. Supplemental Electrodes

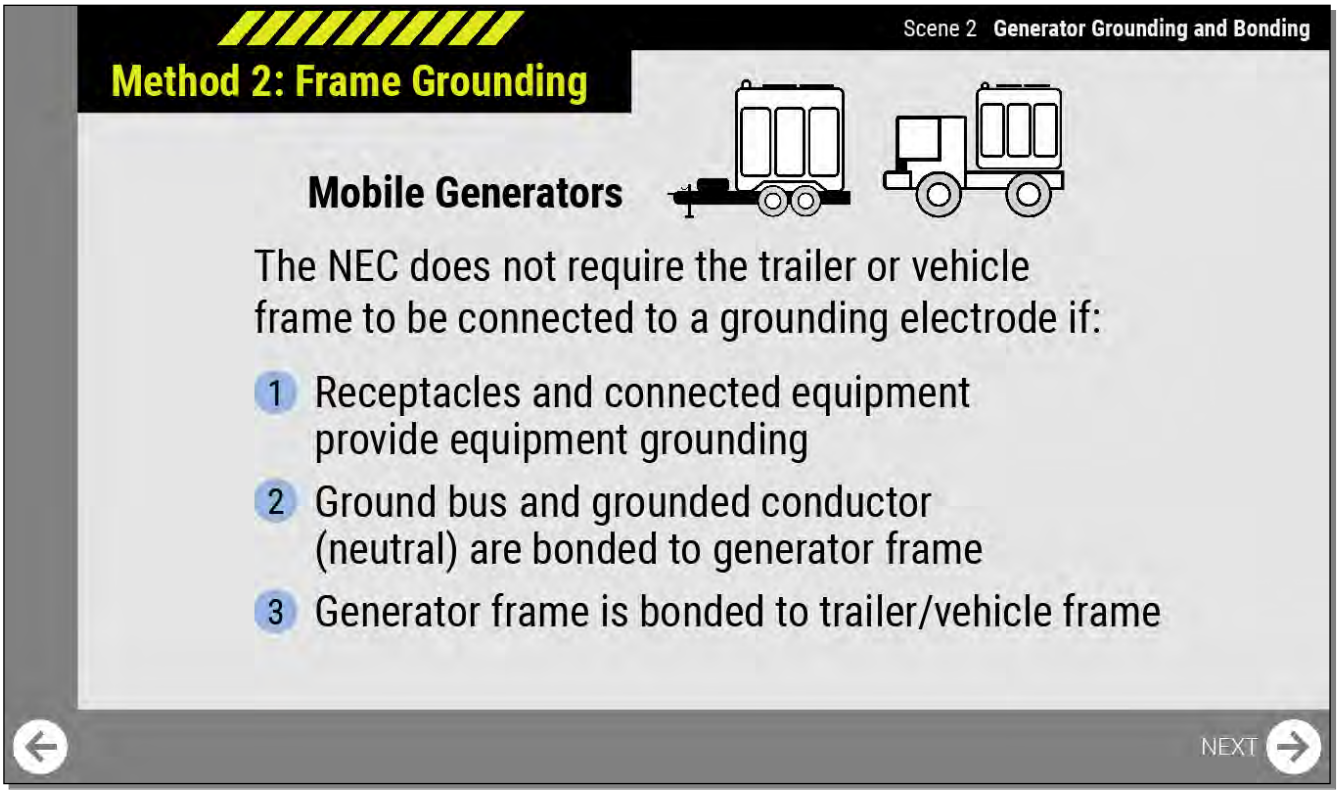


Using a single rod, pipe, or plate electrode may require resistivity testing to show 25 ohms or less. If over 25 ohms, a supplemental electrode must be used.

When multiple electrodes are used, they must not be less than 6 feet apart. The paralleling efficiency of ground rods is increased by spacing them twice the length of the longest rod. For example, if using 8-foot electrodes, they should be at least 16 feet apart.

Refer to the NEC, section 250.53(A)(2) for requirements on supplemental electrodes.

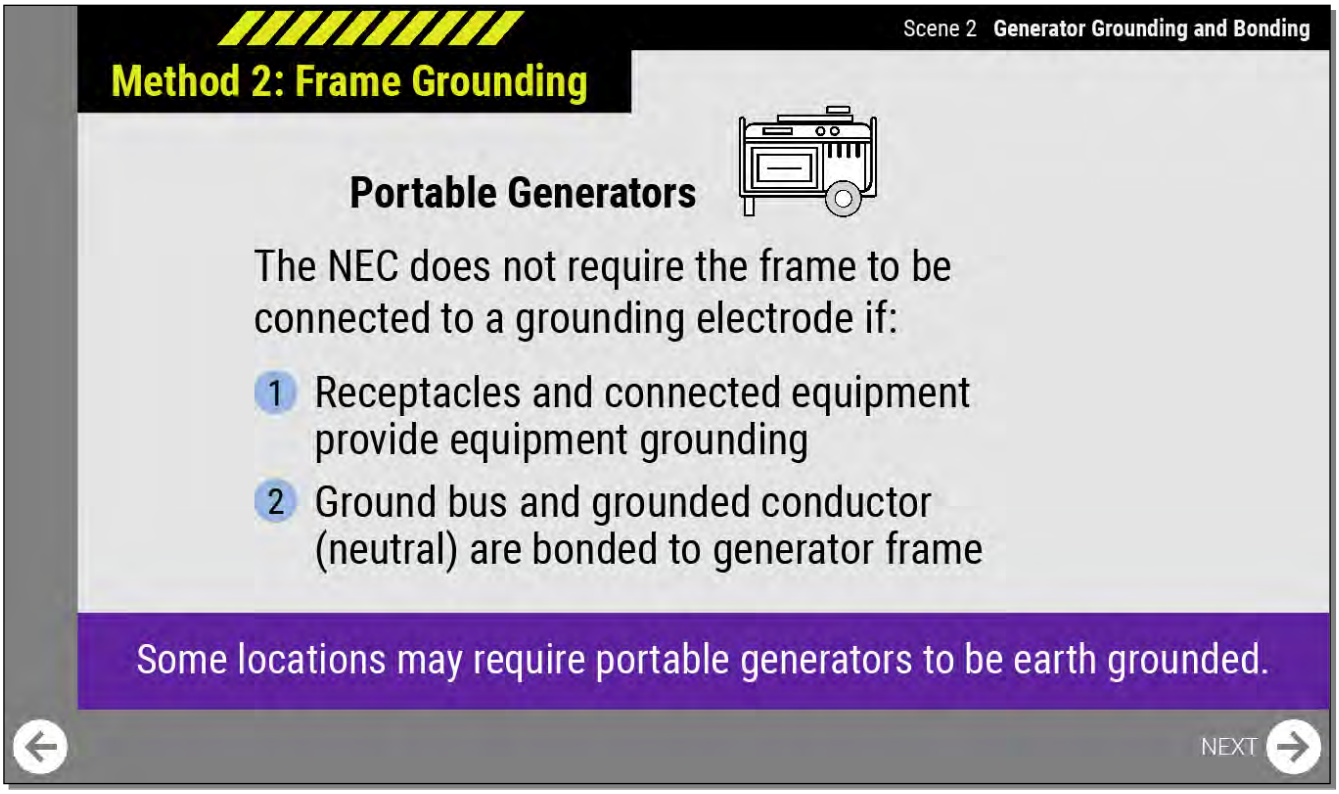
Slide 55. Frame Grounding 1



The NEC does not require the trailer or vehicle frame to be connected to a grounding electrode if all receptacles and connected equipment provide equipment grounding; the generator's ground bus and grounded conductor (the neutral) are bonded to the generator frame; and the generator frame is bonded to the trailer or vehicle frame.

Studio generators and onboard trailer generators are generally constructed or installed to meet NEC requirements for operation without connection to a grounding electrode.

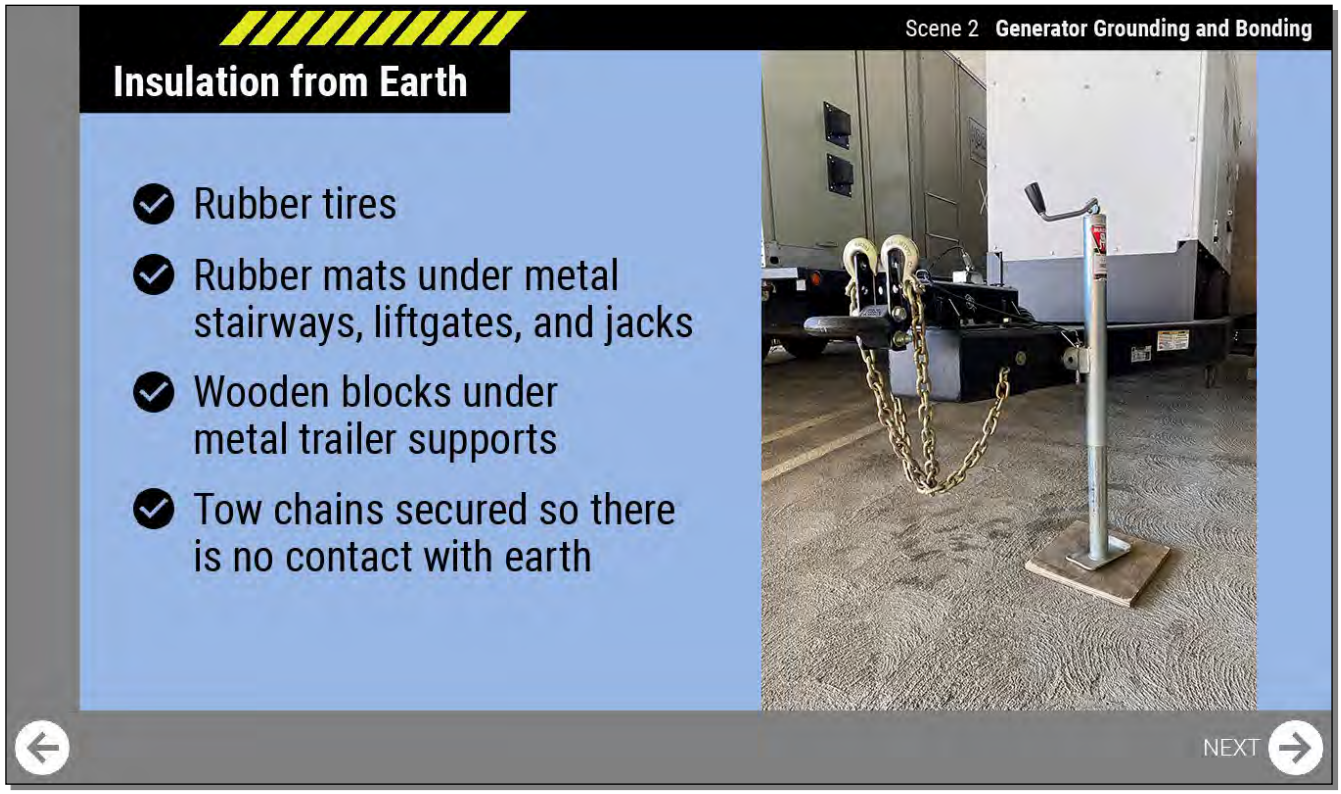
Slide 56. Frame Grounding 2



Likewise, for portable generators, the NEC does not require the frame to be connected to a grounding electrode if the conditions of numbers one and two are met.

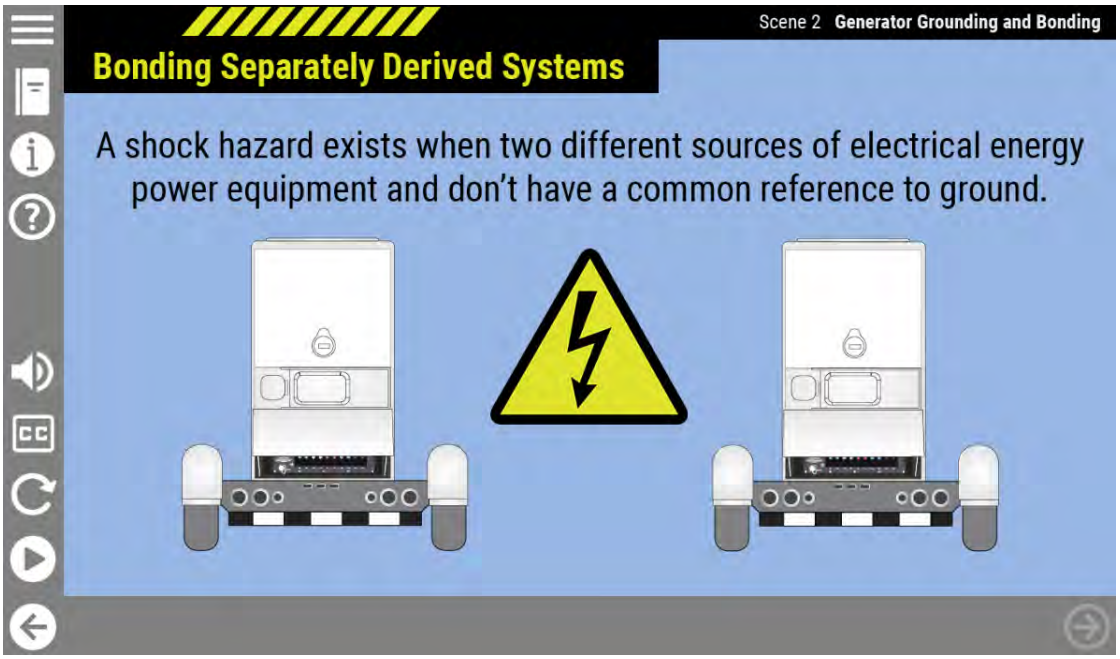
However, some locations may require portable generators to be earth grounded.

Slide 57. Insulation from Earth

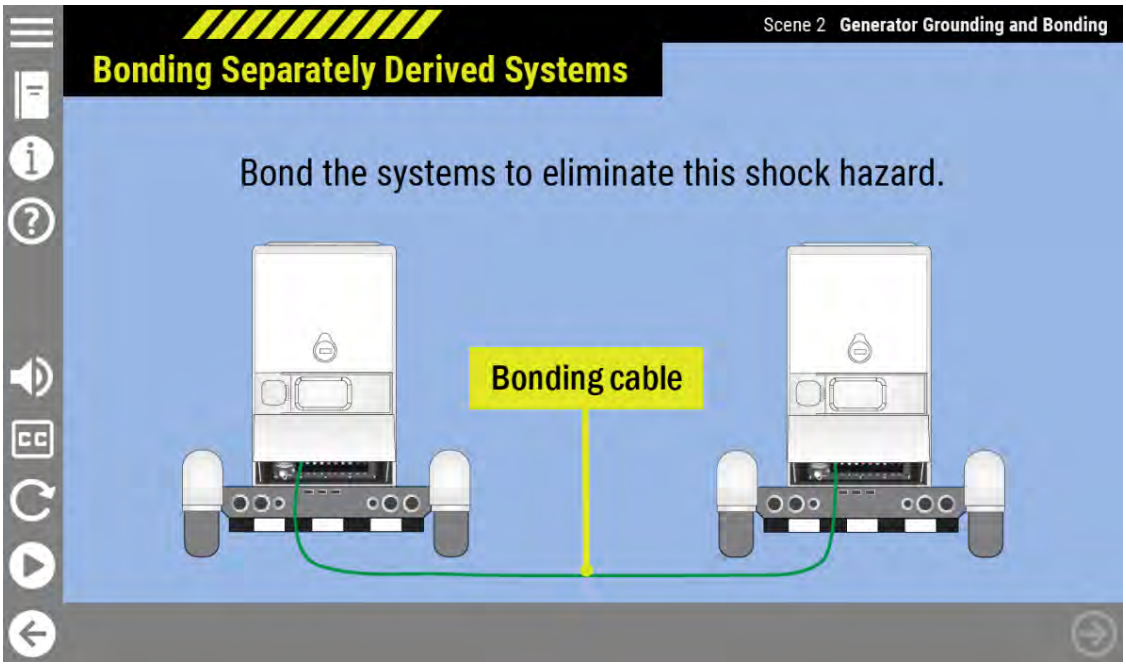


When the trailer or vehicle frame serves as the ground, the generator must be completely insulated from earth by means of rubber tires; rubber mats under metal stairways, liftgates, and jacking devices; wooden blocks under metal trailer supports; and tow chains secured so that there is no contact with earth.

Slide 58. Bonding Separately Derived Systems 1

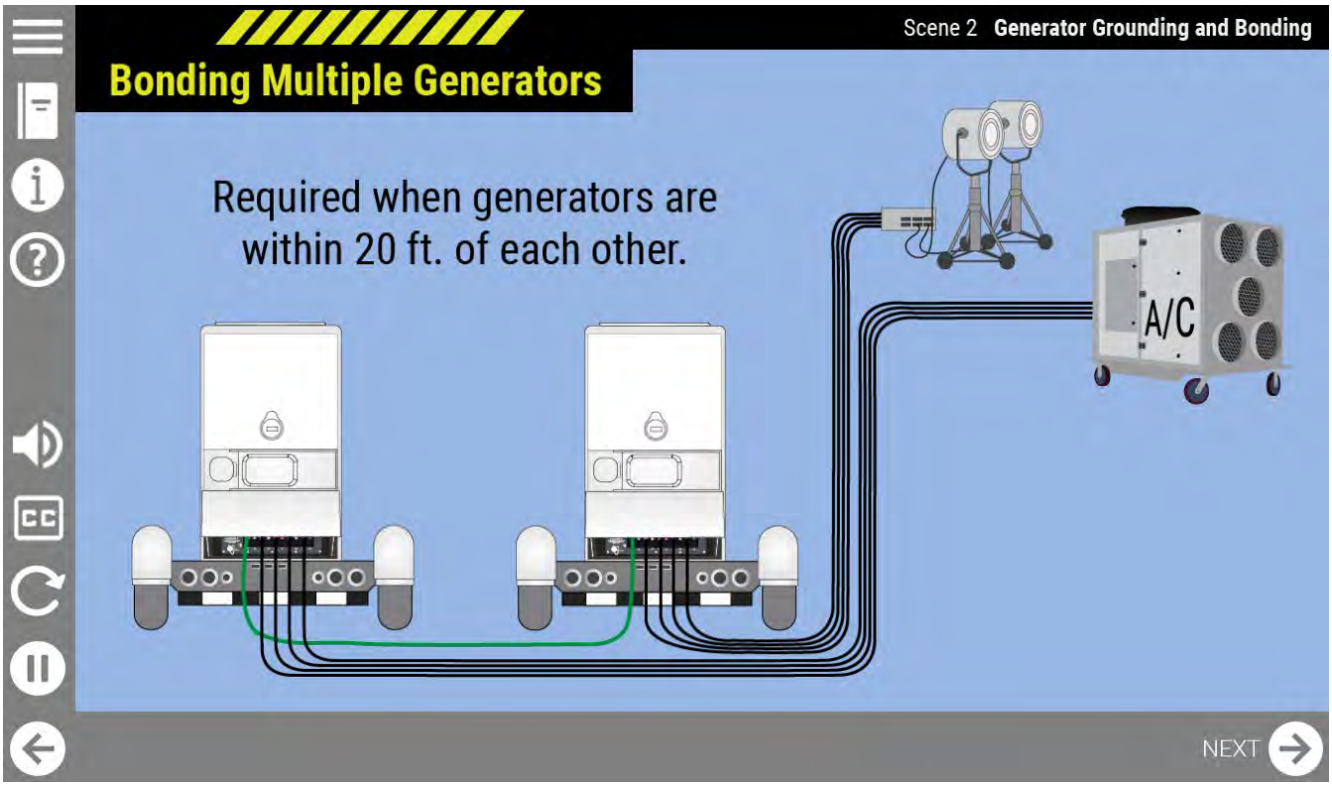


A shock hazard exists when two different sources of electrical energy (separately derived systems) are used to power equipment and don't have a common reference to ground.



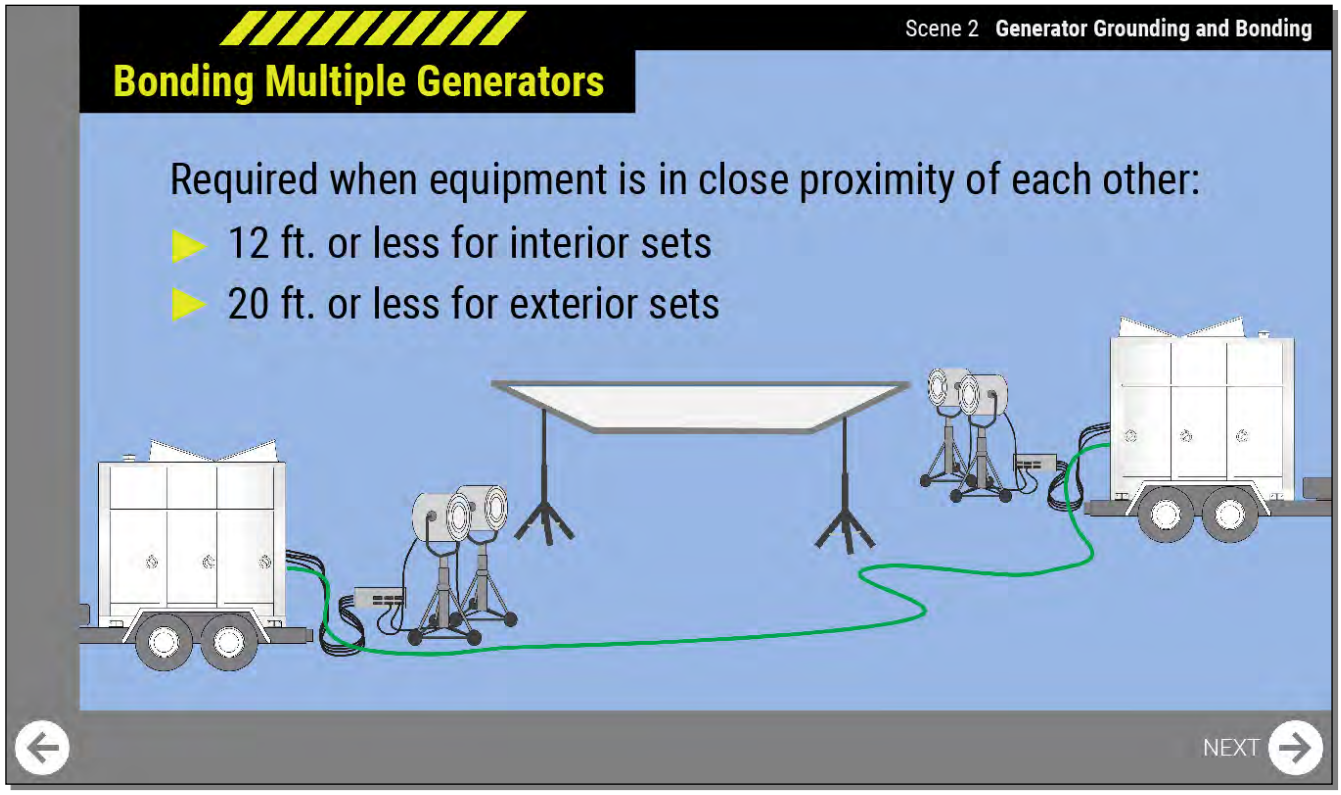
To eliminate this possibility, the systems should be bonded by running a cable from the ground of one power source to the ground of the other power source.

Slide 59. Bonding Multiple Generators 1



Bonding is required when two or more generators are within 20 feet of each other. For example, it is often the case that when multiple generators are used, they are lined up side-by-side with the cables following the same path to set, powering lights, portable A/C units, and other production equipment.

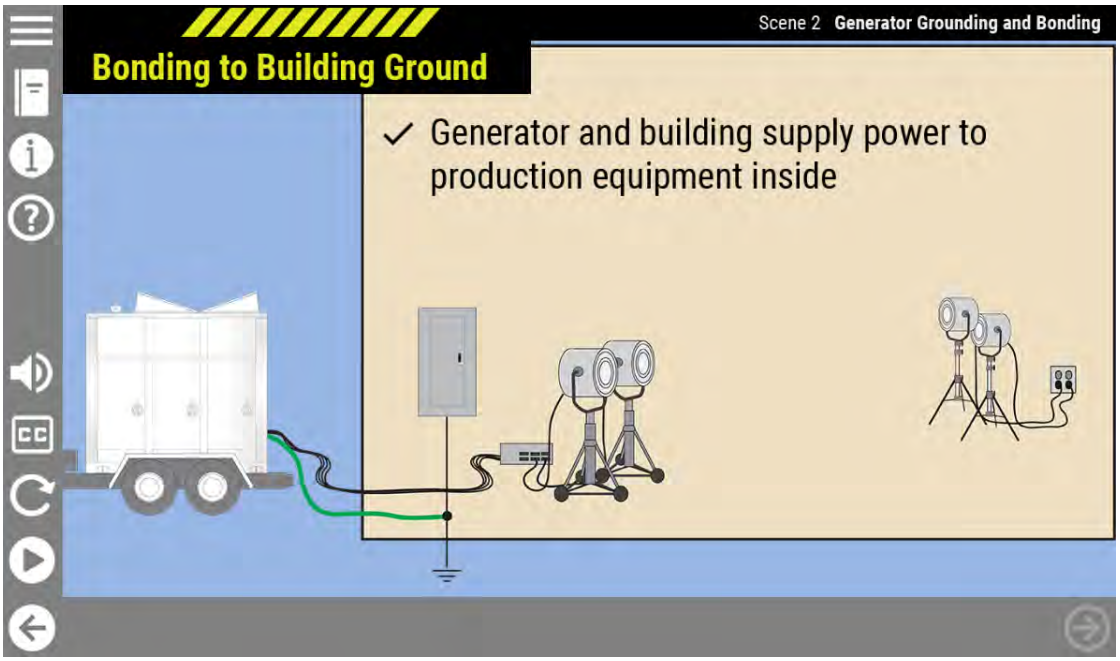
Slide 60. Bonding Multiple Generators 2



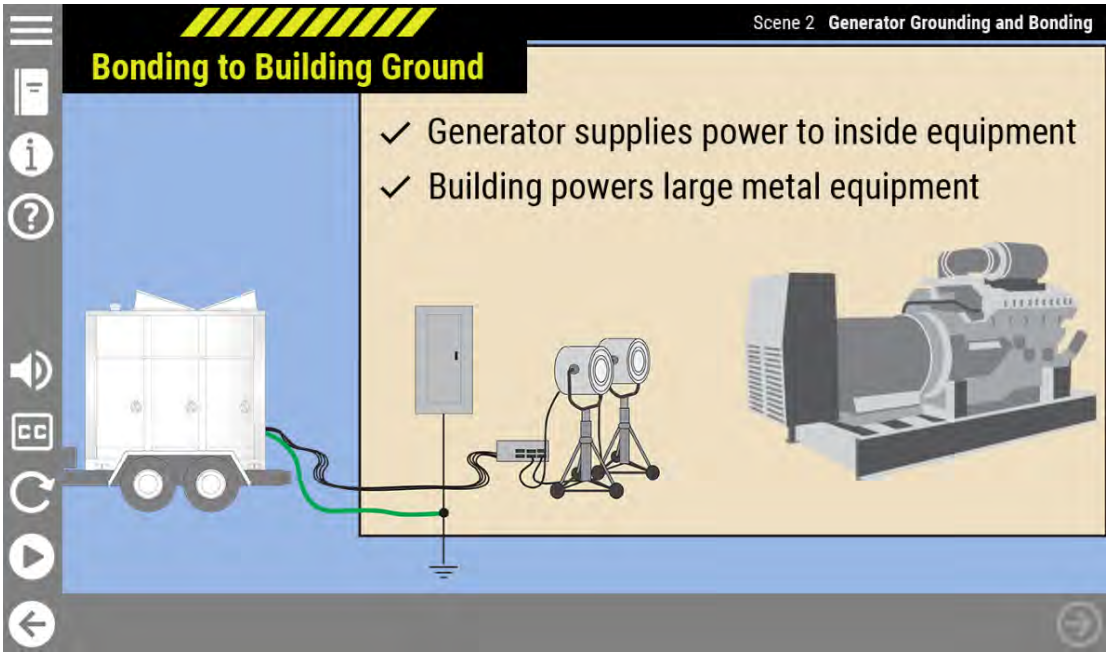
Bonding is also required when two or more generators supply power to equipment that is in close proximity of each other—12 feet or less for interior sets and 20 feet or less for exterior sets.

This distance is based on the standard size of aluminum grip frames, which are typically the longest conductive items handled and moved around on set. This general rule assumes that you cannot fit a 20-foot grip frame into an interior set. However, for large interior sets, where a 20-foot grip frame can fit and may be used, safety dictates that you use the 20-foot separation minimum as the threshold for when systems should be bonded.

Slide 61. Bonding to Building Ground

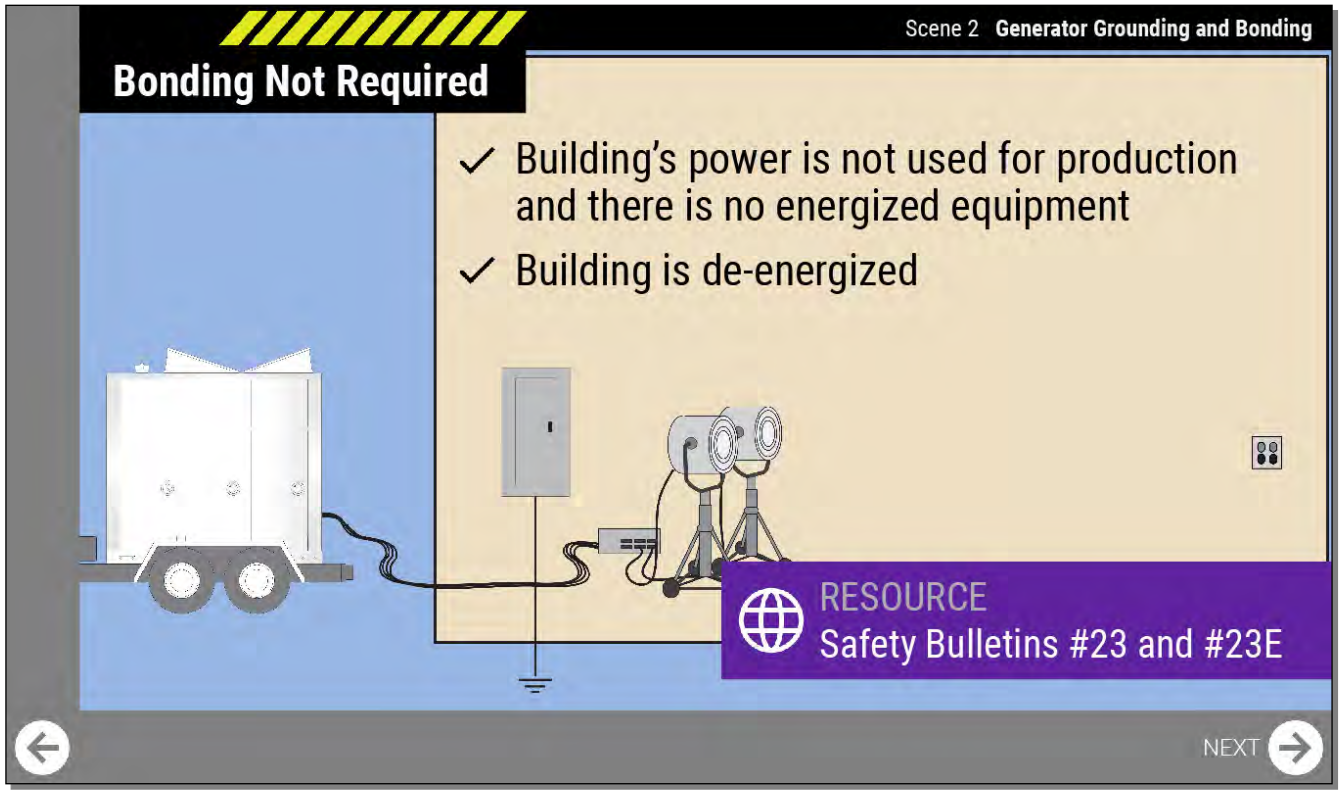


Bonding a generator to a building's grounding electrode is required when both the generator and the building's electrical system are used to supply power to production equipment inside the building or



when a generator supplies power to production equipment inside the building and the building powers large metal energized equipment that may come in contact with the production equipment.

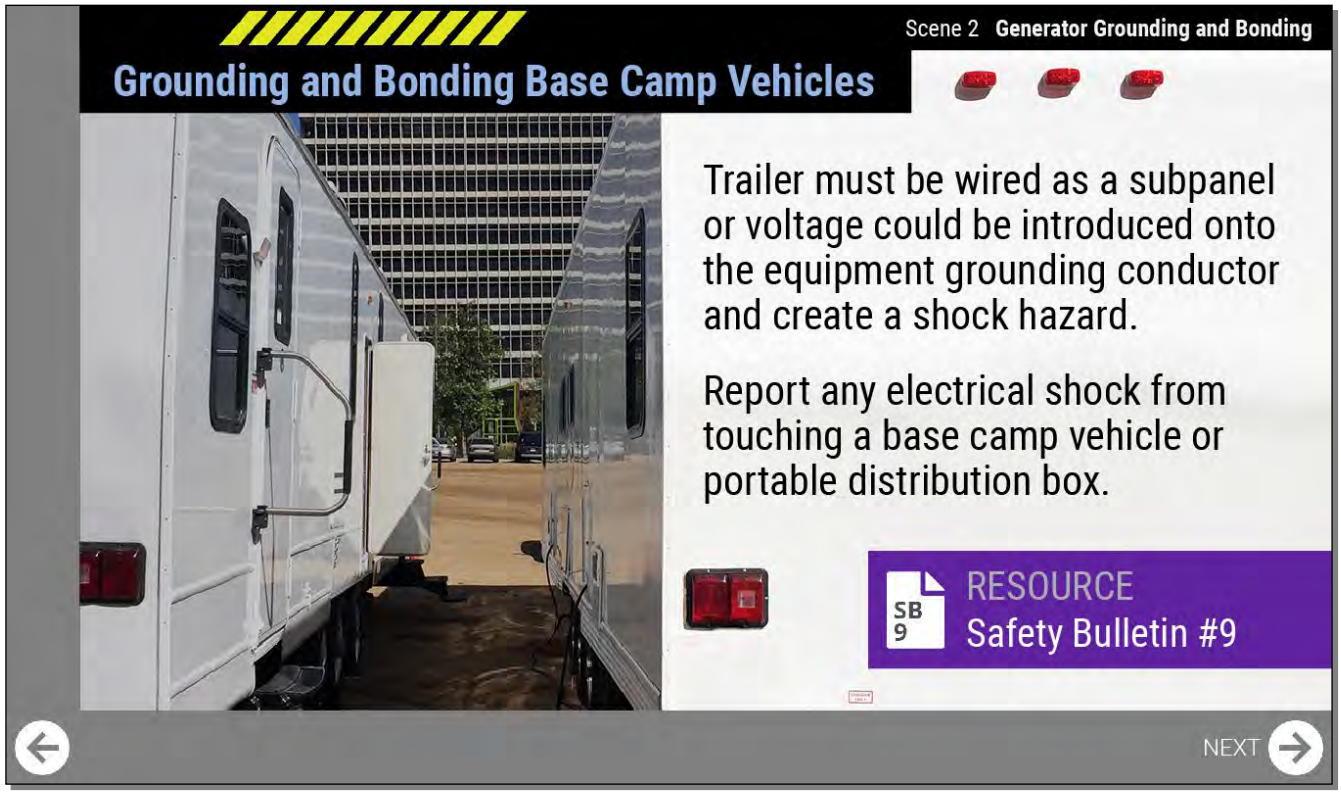
Slide 62. Bonding Not Required



Bonding to the building's grounding electrode is NOT required if the building's power is not used for production and there is no large metal energized equipment in the building or if a building is de-energized.

Click here to read about bonding requirements in Safety Bulletins #23 and #23E.

Slide 63. Grounding and Bonding Base Camp Vehicles

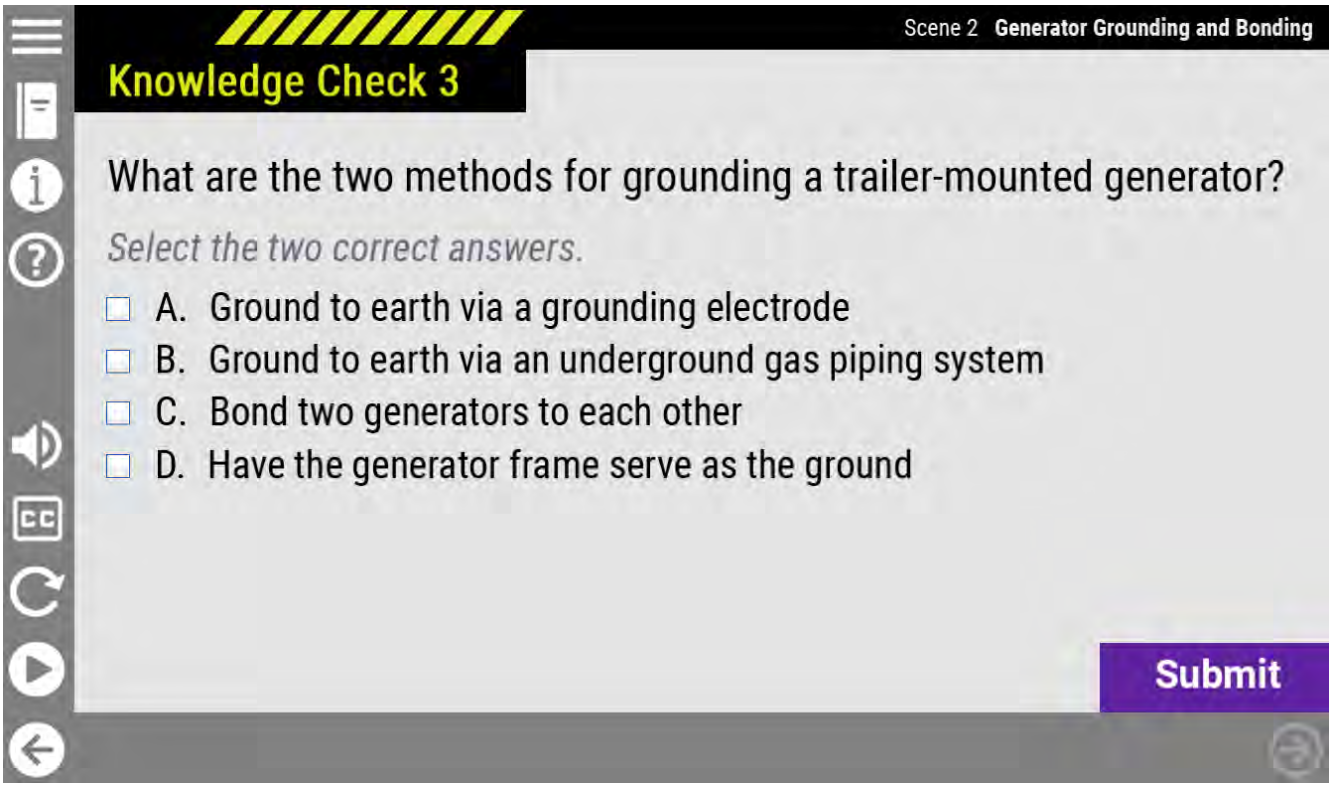


A trailer's electrical panel must be wired correctly as a subpanel, keeping the neutrals and grounds isolated from each other. Otherwise, when it is connected to a portable electrical system, voltage could be introduced onto the equipment grounding conductor, potentially creating a shock hazard throughout the system. The wiring can be easily tested by a qualified person. For details, see Safety Bulletin #9, *Recommended Guidelines for Working in and Around Base Camps*.

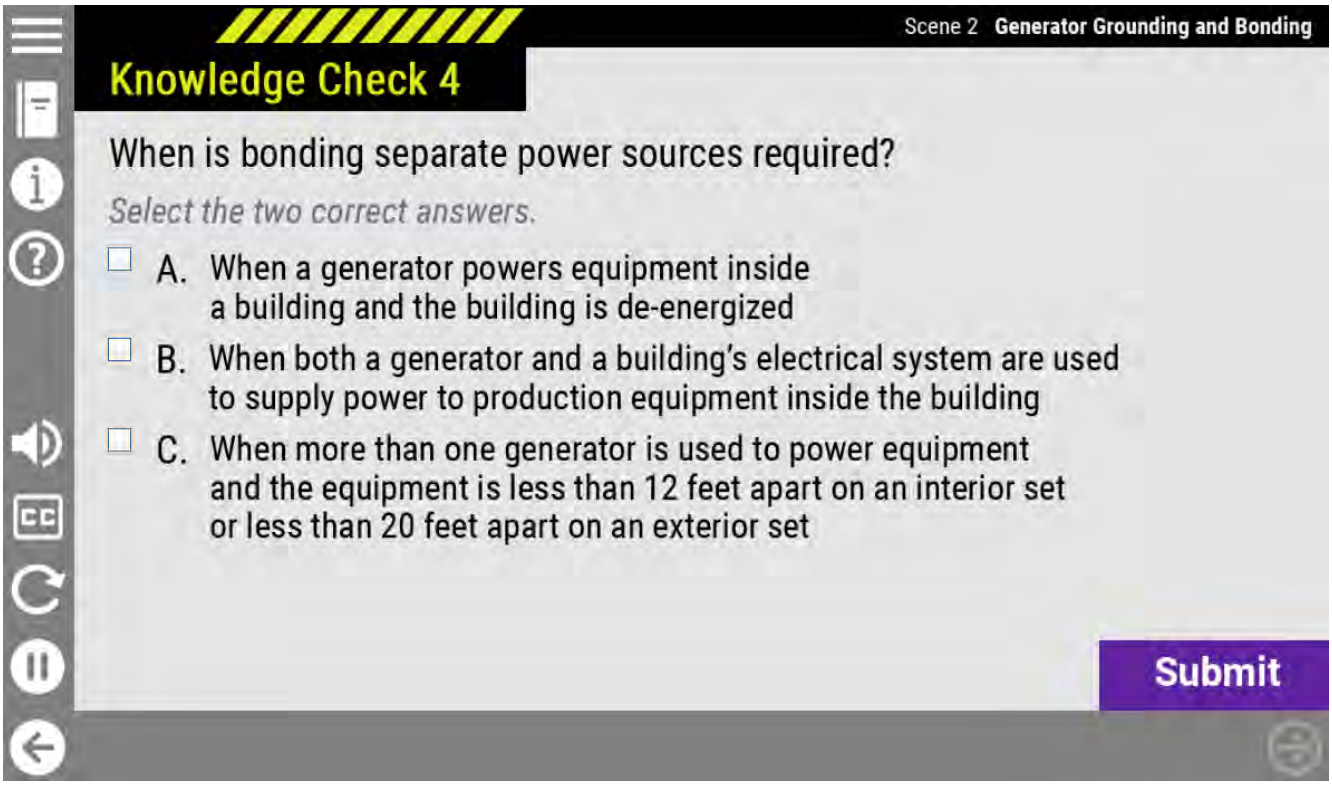
If anyone experiences an electrical shock when touching a base camp vehicle or portable distribution box, they should immediately report it.

This brings us to the end of this scene. Let's see if you can correctly answer a couple knowledge check questions.

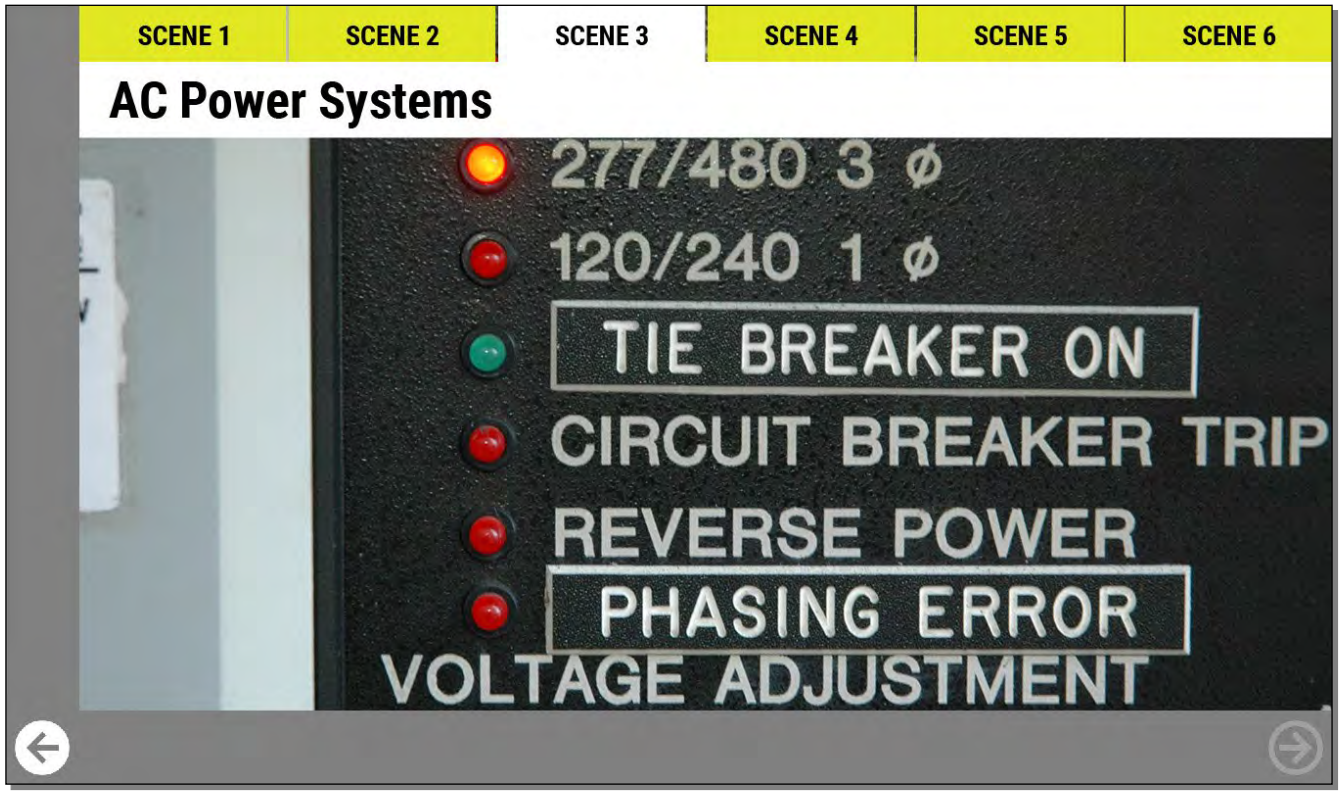
Slide 64. Knowledge Check 3



Slide 65. Knowledge Check 4

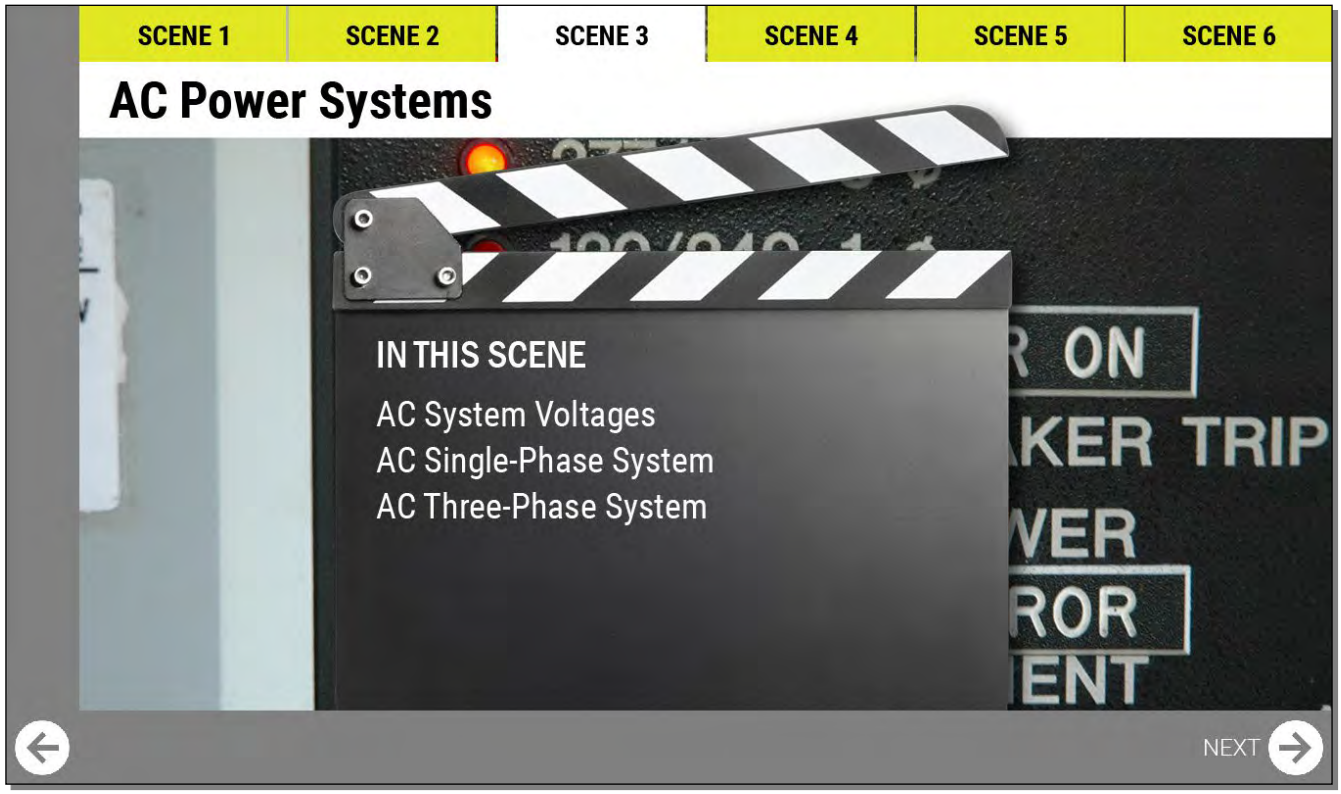


Slide 66. SCENE 3, AC POWER SYSTEMS



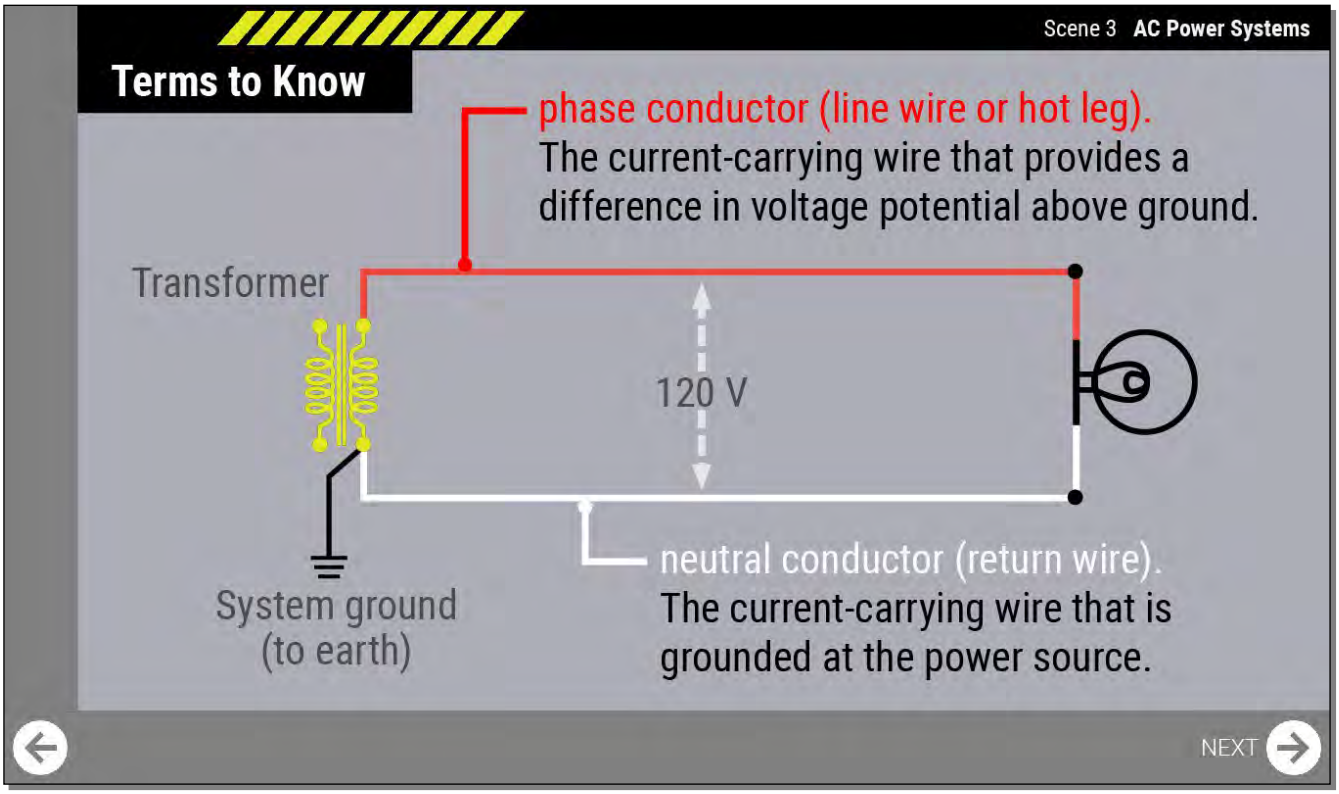
Scene Three, AC Power Systems.

Slide 67. In This Scene



This scene reviews AC system voltage options and explains single-phase and three-phase AC systems. These concepts are fundamental to understanding electrical distribution systems generally and understanding generator settings, readings, and load balancing, which we'll talk about in the next scene.

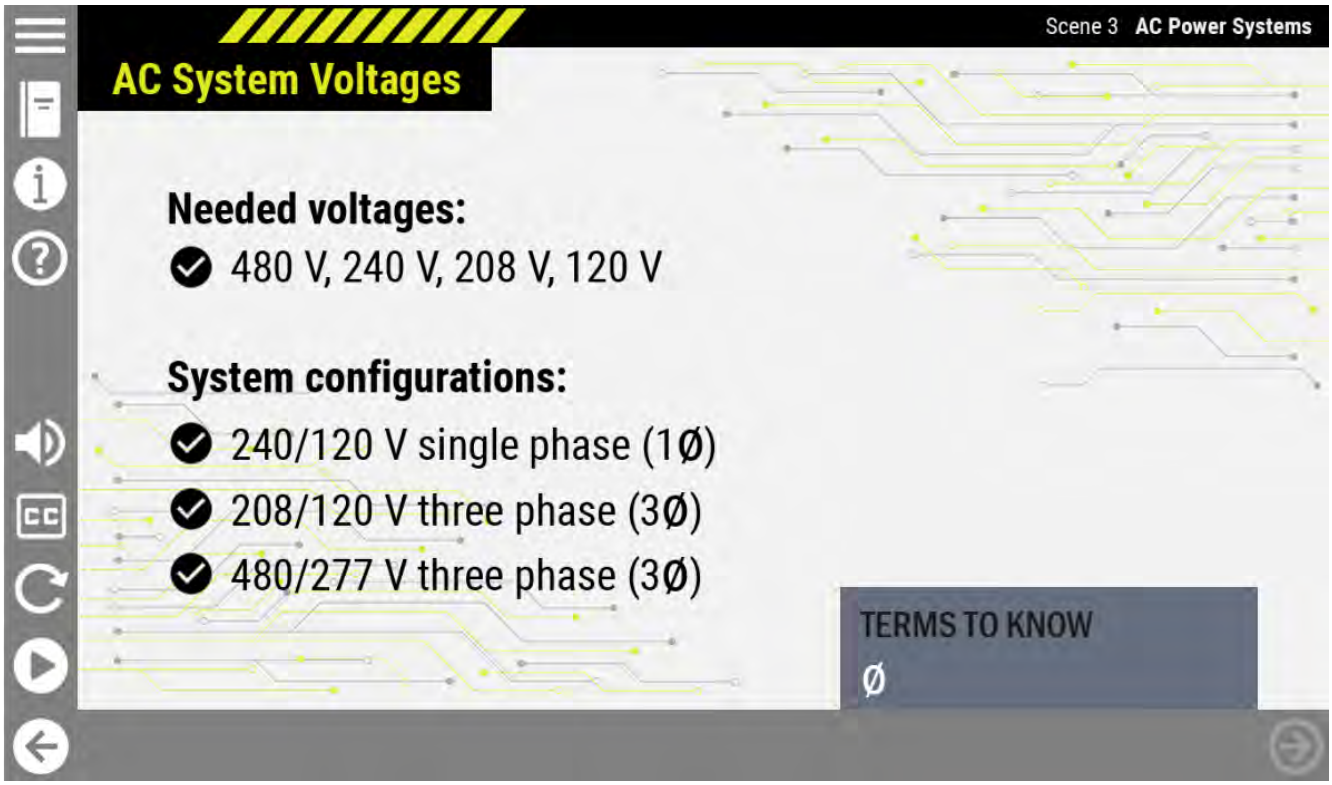
Slide 68. Terms to Know



Let's begin by defining some terms. A power source like a transformer coil or generator alternator creates the difference in potential needed to power the circuit. One end of that coil is grounded to earth. This becomes the **neutral conductor** or **return wire**. The other end of the coil feeds the **phase conductor**, also called the **line wire**, or **hot leg**.

In this circuit, ground potential is zero volts and phase potential is 120 volts.

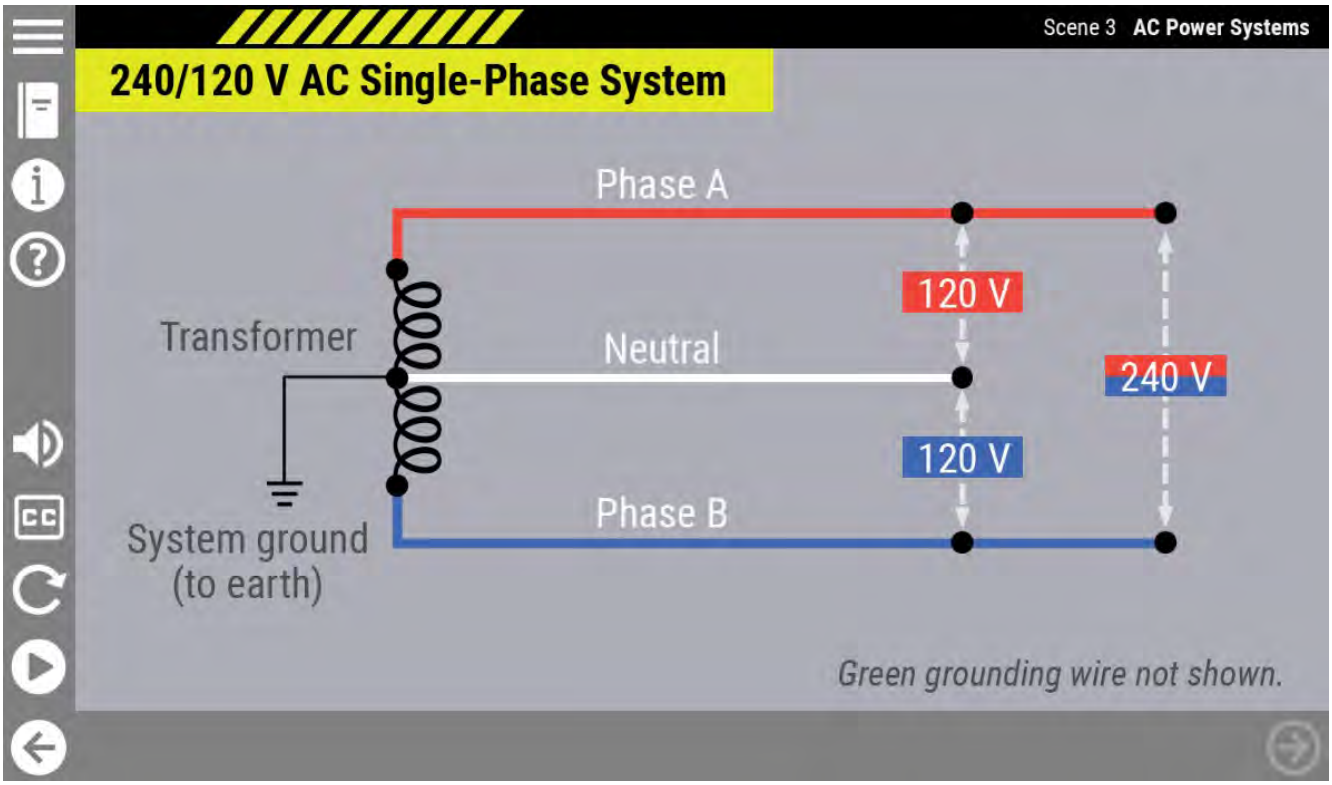
Slide 69. AC System Voltages



AC lights require a few different voltages. Power sources for set lighting are configured one of three ways: 240/120-volt single-phase, 208/120-volt three-phase, or 480/277-volt three-phase. On most mobile generators, any one of these voltage configurations can be selected.

Click here to read the definition of the aught symbol.

Slide 70. 240/120 V AC Single-Phase System

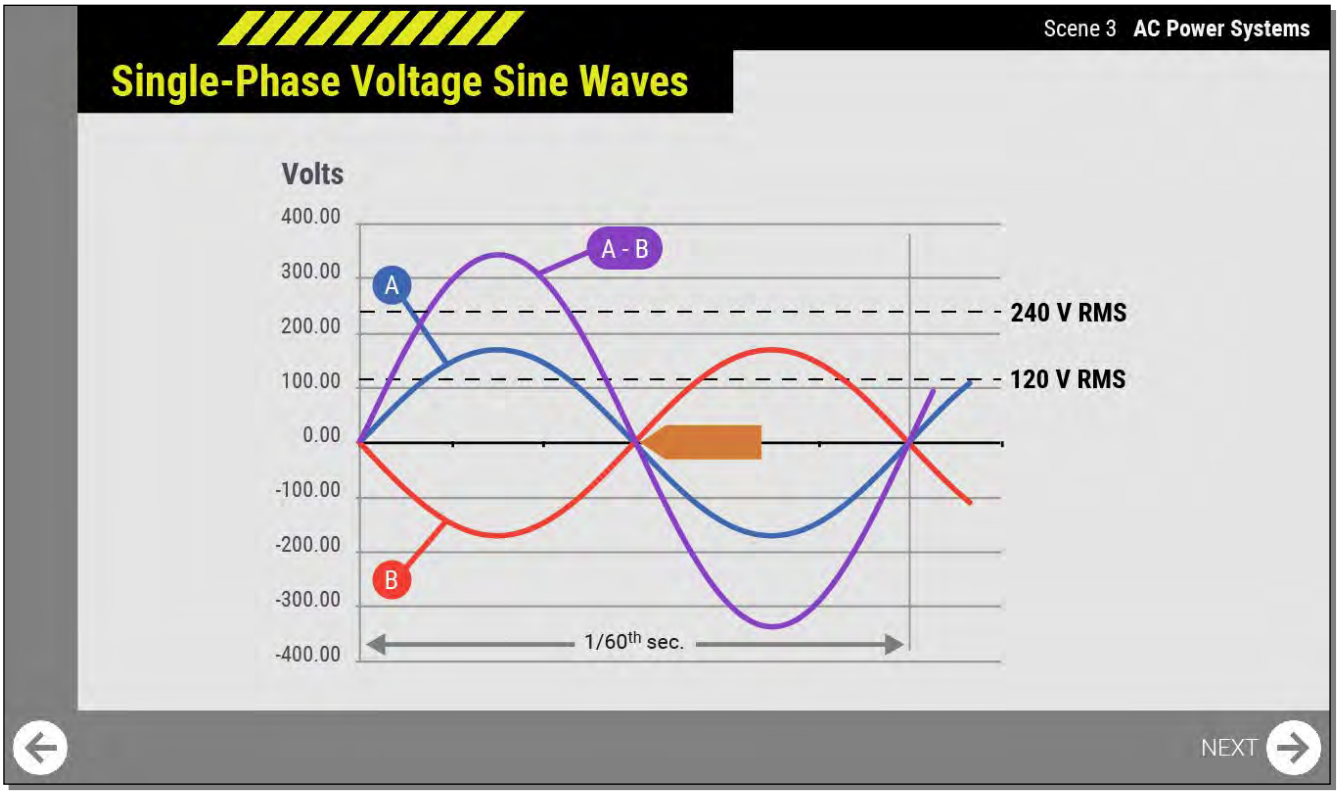


This illustration shows a simple single-phase system, with the transformer's secondary coil tapped in the center. The center tap of the coil is common to both phases, making it the neutral of the system. The neutral is normally connected to earth at the source of service. The arrangement enables a choice of two voltages from three wires.

The voltage across the entire coil is 240 volts. The voltage between the neutral to either phase leg is 120 volts. A 240/120-volt system is a **single-phase system**. This means that AC voltage increases and decreases in both halves of the coil simultaneously with each AC cycle. The two halves of the coil have a single phase, but the two halves are opposite in polarity.

In a generator, the arrangement of coils is more complicated because the generator alternator is innately three-phase. To emulate the single-phase output shown here, the alternator coils are connected in a "zigzag" configuration, which you may see referenced on the generator. The resulting voltage options are the same, however.

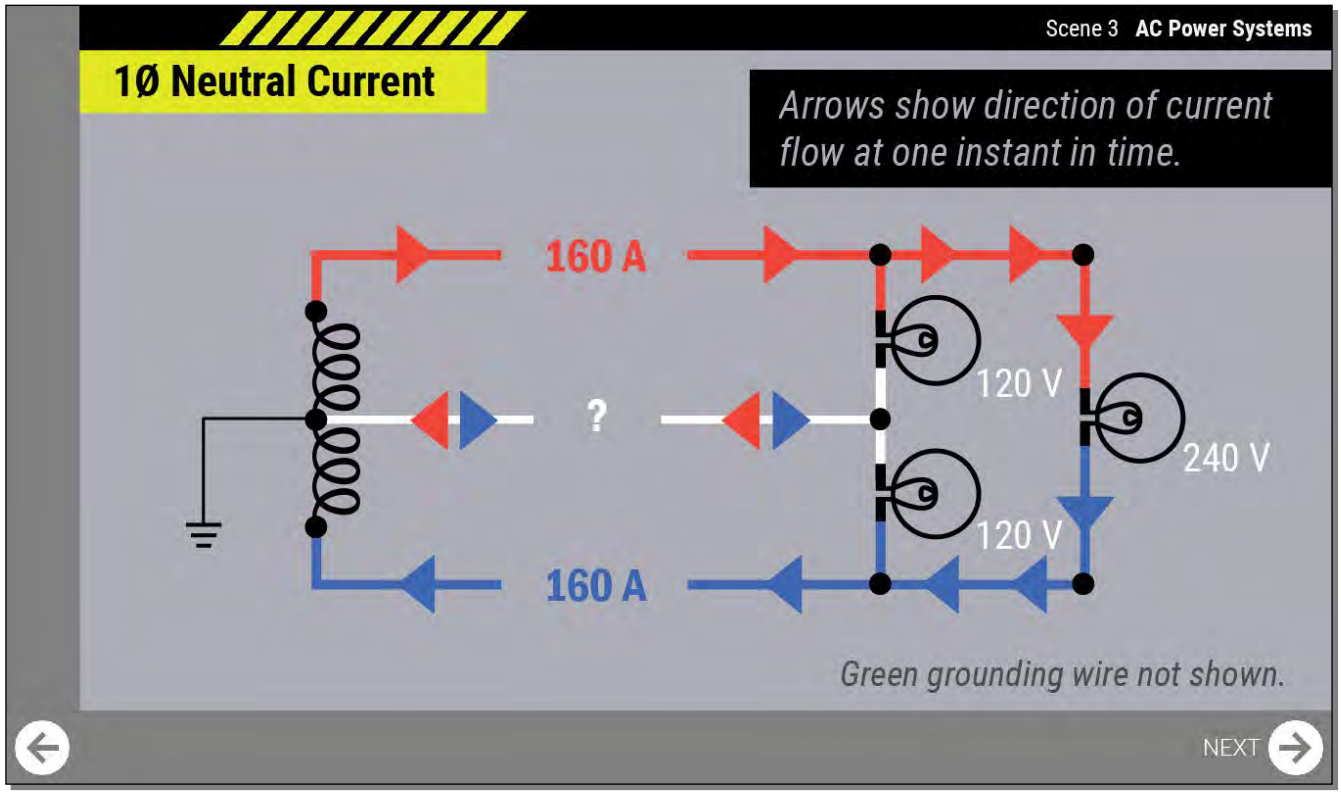
Slide 71. Single-Phase Voltage Sine Waves



A graph of voltage in a single-phase system looks like this. The blue and red increase and decrease together, but in opposite directions. A 240-volt load sees the difference between the voltage of blue and red, shown here by the purple line. As blue reaches its peak voltage, red reaches its negative peak. So, the load experiences the difference, which is 240 volts RMS.

Don't confuse the number of **phases** with the number of phase **wires**. The terms **single phase** and **three phase** refer to sine waves' positions **in time**. As the graph illustrates, the voltage of the red, blue, and purple circuits all cross zero at a single point in time, thus it is **single phase**. This is different from a three-phase power source, which we'll look at in a minute.

Slide 72. Single-Phase Neutral Current



On a single-phase system, lights can be connected as part of three possible circuits: the red circuit, the blue circuit, or the 240-volt circuit, which adds amperage to both legs and does not involve the neutral.

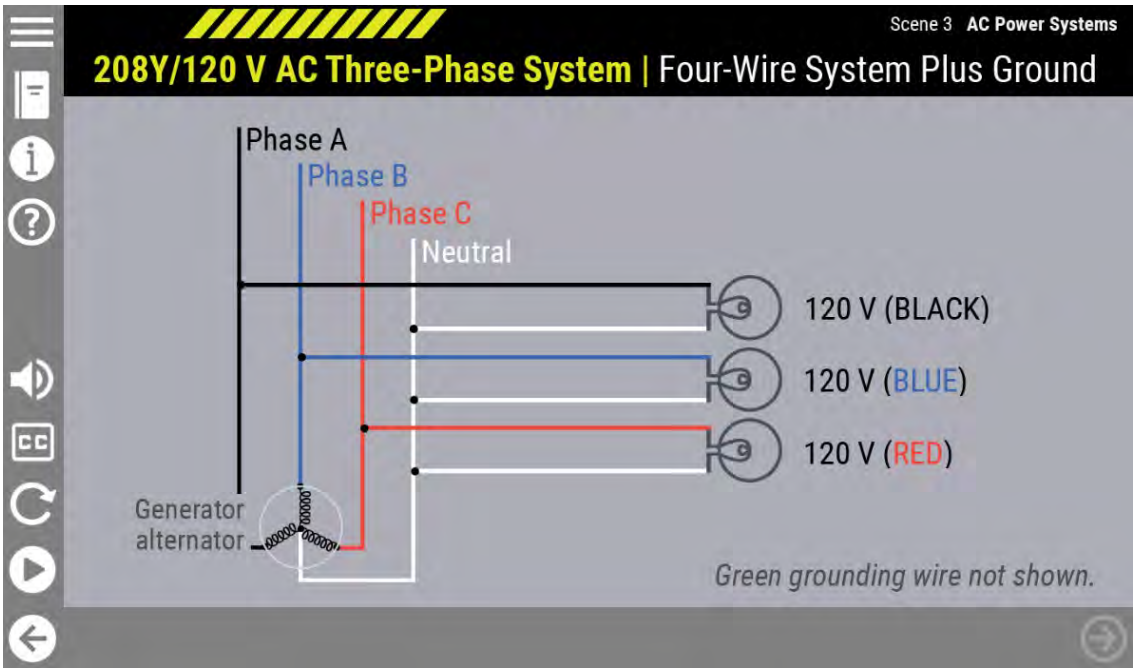
The neutral carries return current from both red and blue, so you might think that it has to carry more current than the phases. But you'll notice, the red and blue current on the neutral flow in opposite directions, so they cancel each other out.

The neutral only carries the **difference** in current between the red and the blue legs.

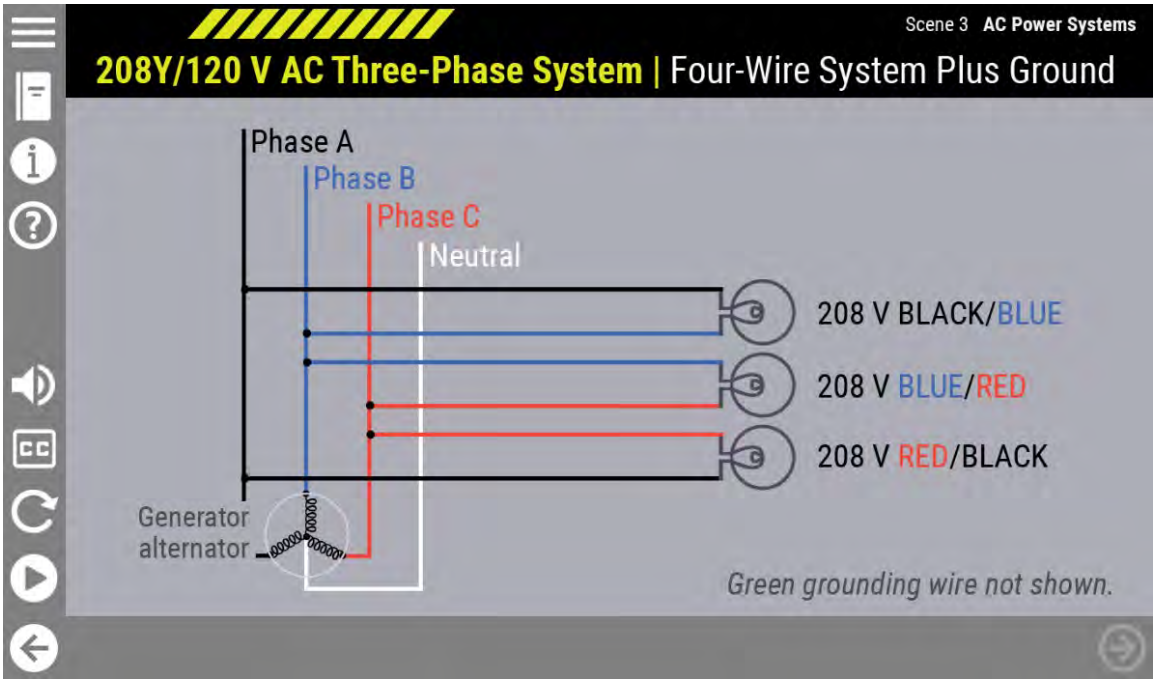
For example, if there is 160 amps on red and 120 amps on blue, then the neutral carries the difference, 40 amps. If the load is perfectly balanced so that the same load is on red and blue, the neutral carries no current.

There is one caveat to add to this. Some electronic loads can cause some amount of current on the neutral even when the phases are evenly loaded. We'll come back to this later in the scene.

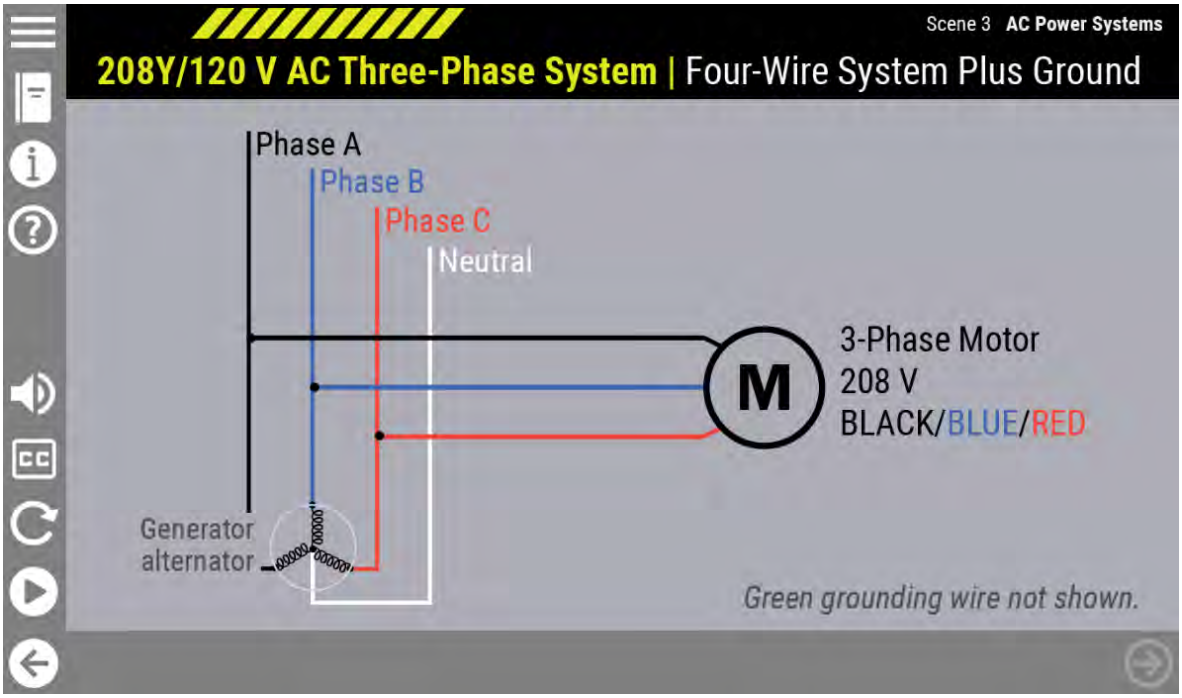
Slide 73. 208Y/120 V AC Three-Phase System 1



Let's move on now to three-phase systems. The wye or "star" 208/120-volt configuration is the most common type of AC system. The system can power numerous different types of loads by connecting loads to one, two, or all three phase wires. It powers three separate 120-volt circuits by connecting between neutral and either black, blue, or red.

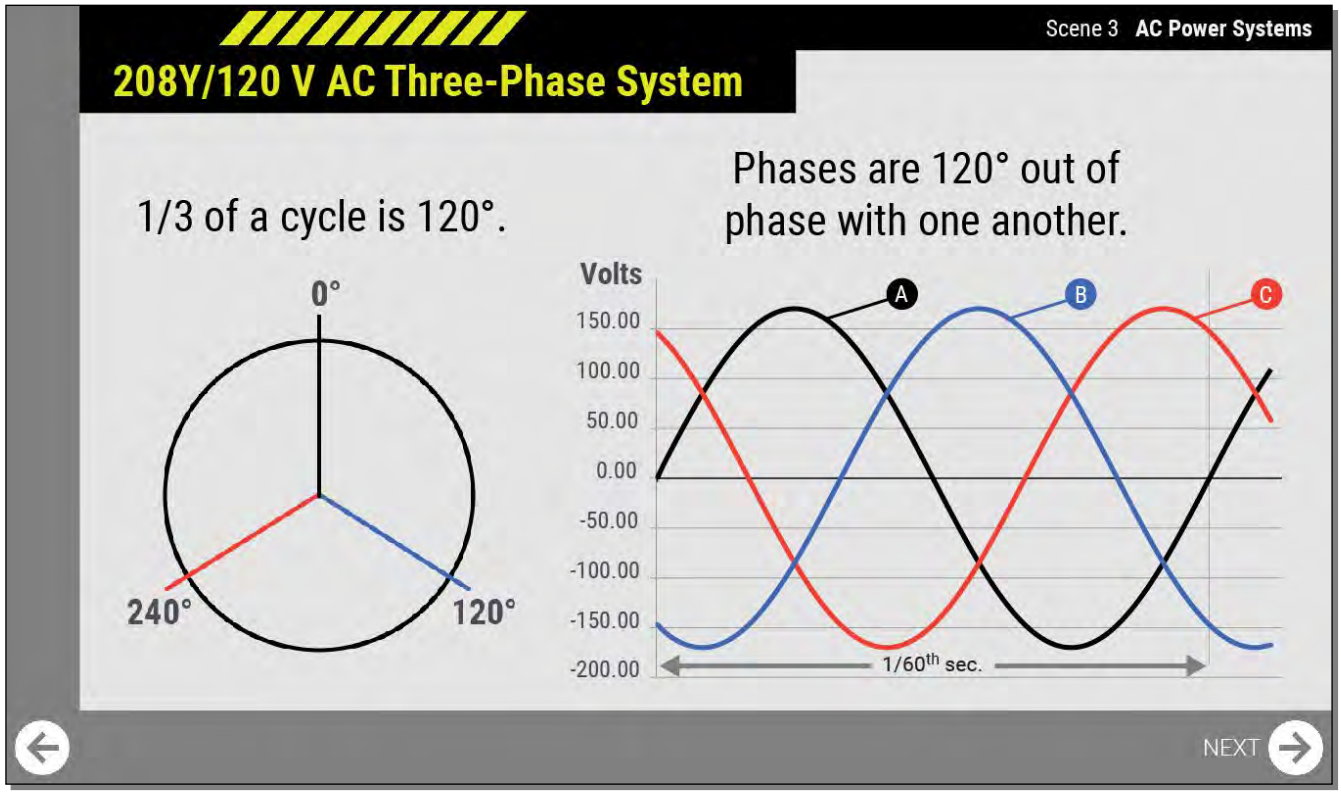


It also powers three 208-volt circuits by connecting between any two of the phase wires: black/blue, blue/red, or red/black.



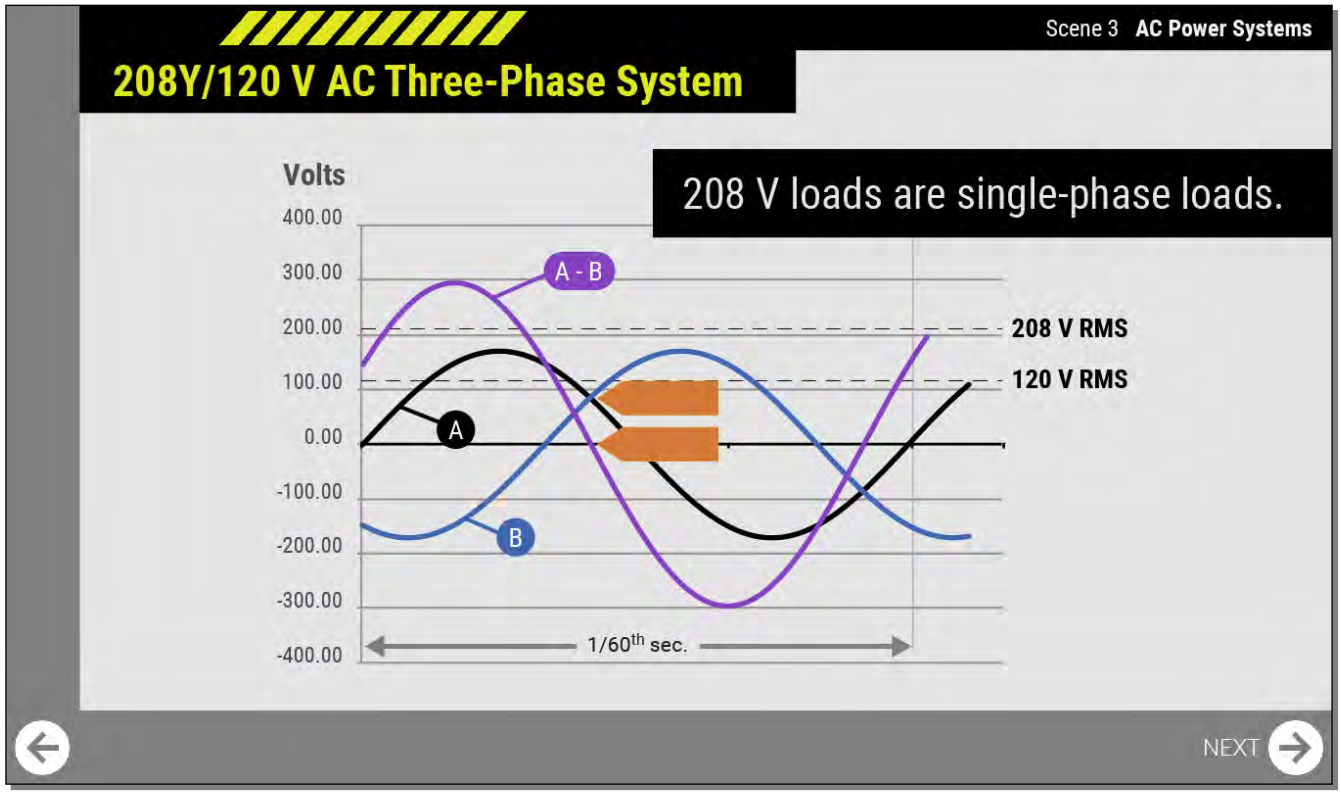
It can also power three-phase loads by connecting to all three phases. Large air conditioning units, xenon power supplies, and some chain motor systems are examples of three-phase loads.

Slide 74. 208Y/120 V AC Three-Phase System 2



In a three-phase system, the three sine waves are one-third of a cycle out of phase with one another. One cycle is 360 degrees. Therefore, the phases are 120 degrees out of phase with one another.

Slide 75. 208Y/120 V AC Three-Phase System 3

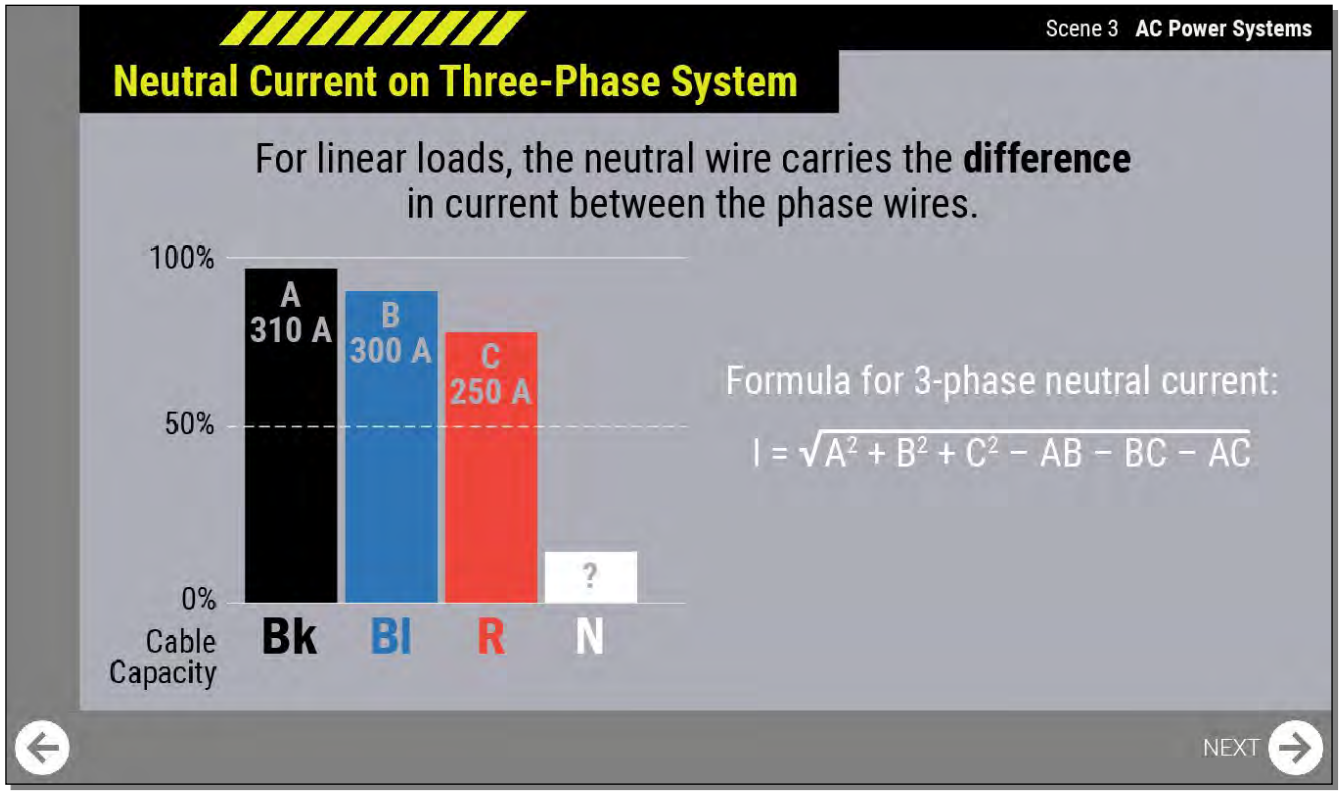


As we said, the voltage between any two phases is 208 volts. We can see why this is by looking at just two of the three phases. A 208-volt load connected to black and blue sees the **difference** between their voltages, which makes a new 60 Hz sine wave shown here in purple. Because phases are offset, the phase-to-phase voltage never reaches 240 volts because the phases do not reach opposite peaks simultaneously. Notice that, even though a 208-volt load is fed from two phase wires, the load sees only a single sine wave. A 208-volt load is a single-phase load.

You'll notice that the purple line crosses zero volts when the black and blue lines cross each other—when the voltage difference between them is zero.

In contrast, a three-phase motor is truly a "three-phase load." It actually uses the rotation of the phases to drive the motor. That's the difference between single-phase and three-phase loads.

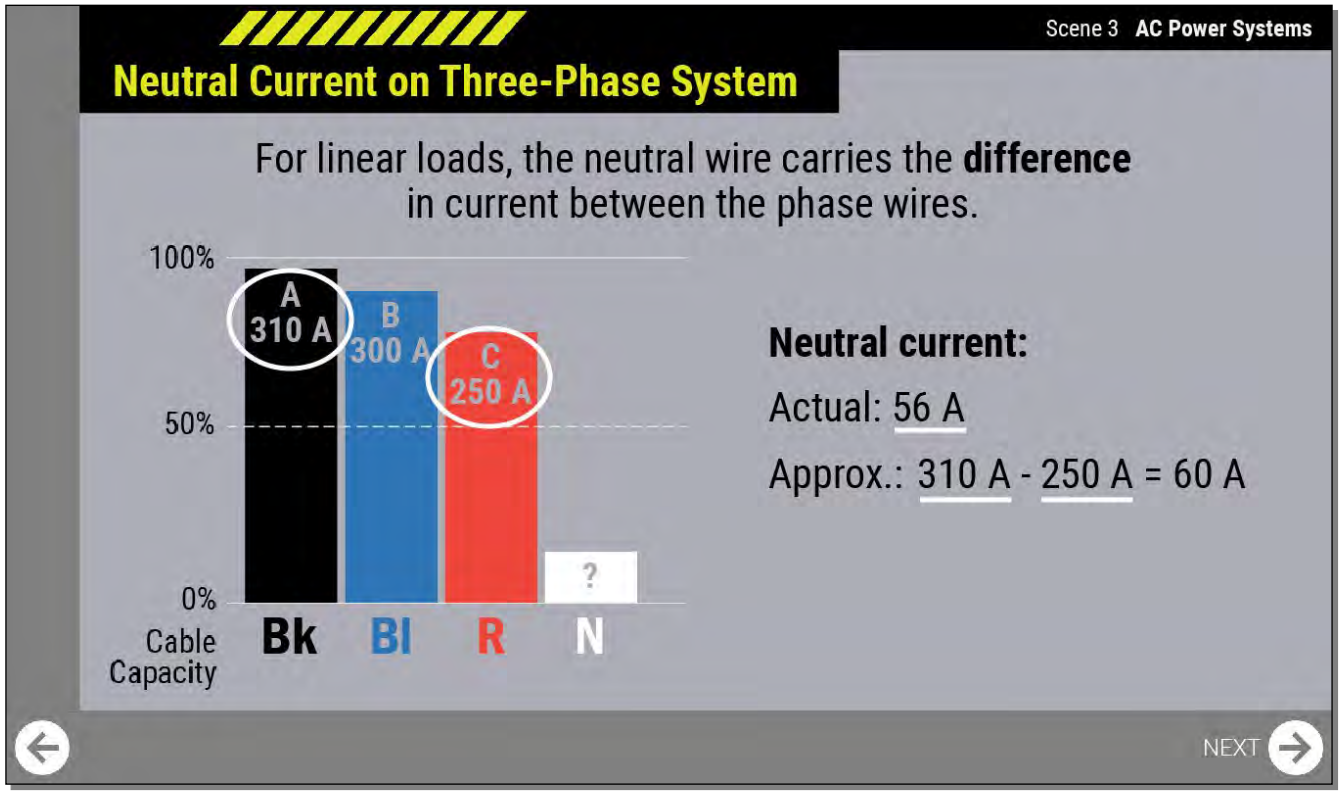
Slide 76. Neutral Current on Three-Phase System 1



Let's talk about the current on the neutral in a three-phase system.

We'll use a bar graph to represent the amperage load on the three phases (black, blue, and red) and neutral load (white). As before, the neutral conductor carries the **difference** of amperage between the three phases. The three-way difference is not as easy to show with simple math.

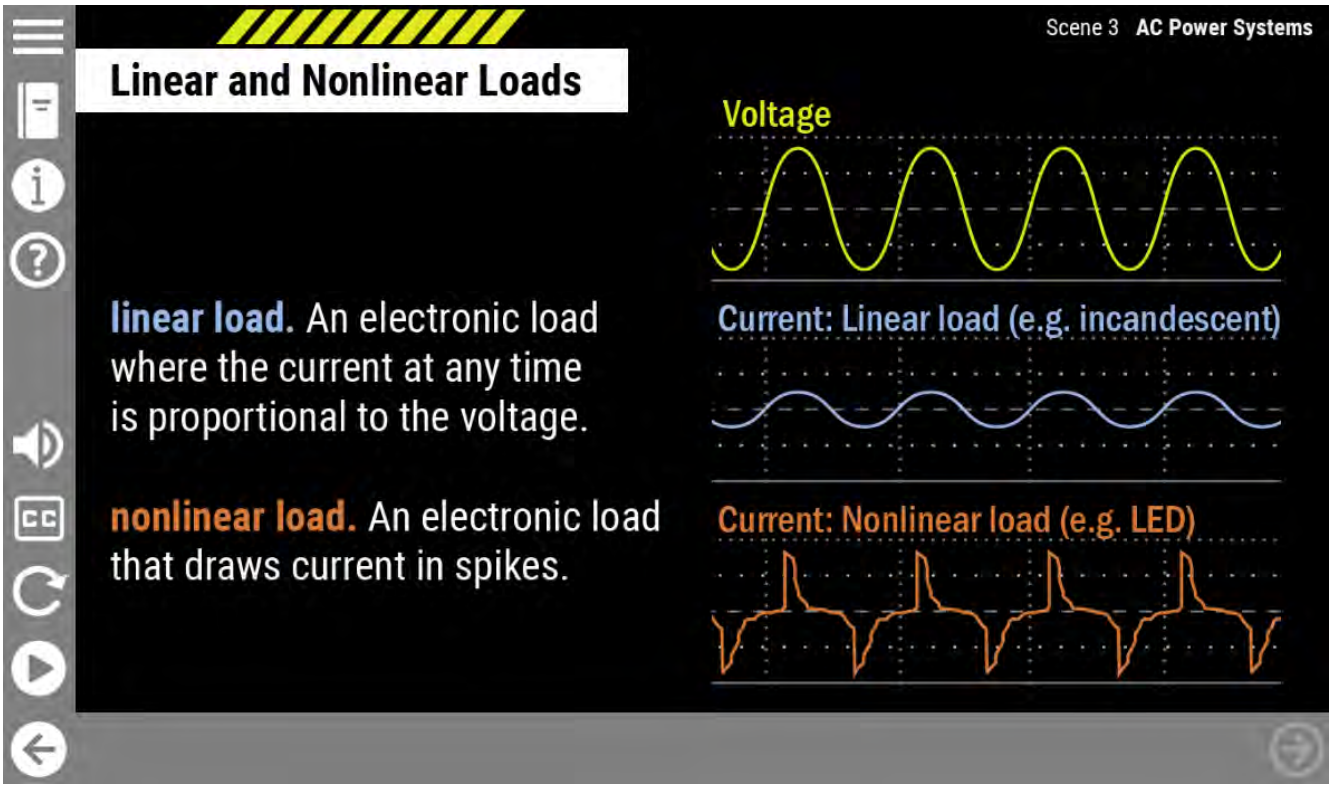
Slide 77. Neutral Current on Three-Phase System 2



In this example, the three-way difference is 56 amps, which you'll notice is approximately the amperage difference between the highest (310 amps) and the lowest (250 amps).

The takeaway here is that no matter how unbalanced the phases are, the current on the neutral will never exceed the most heavily loaded phase if the system powers only linear loads. When that is the case, the neutral wire can be the same size as the phase wires without any risk of being overloaded. However, for reasons we'll discuss in the next scene, an effort should be made to load the three phases as evenly as possible by distributing the loads thoughtfully. If the phases are equally loaded, the neutral current is theoretically zero.

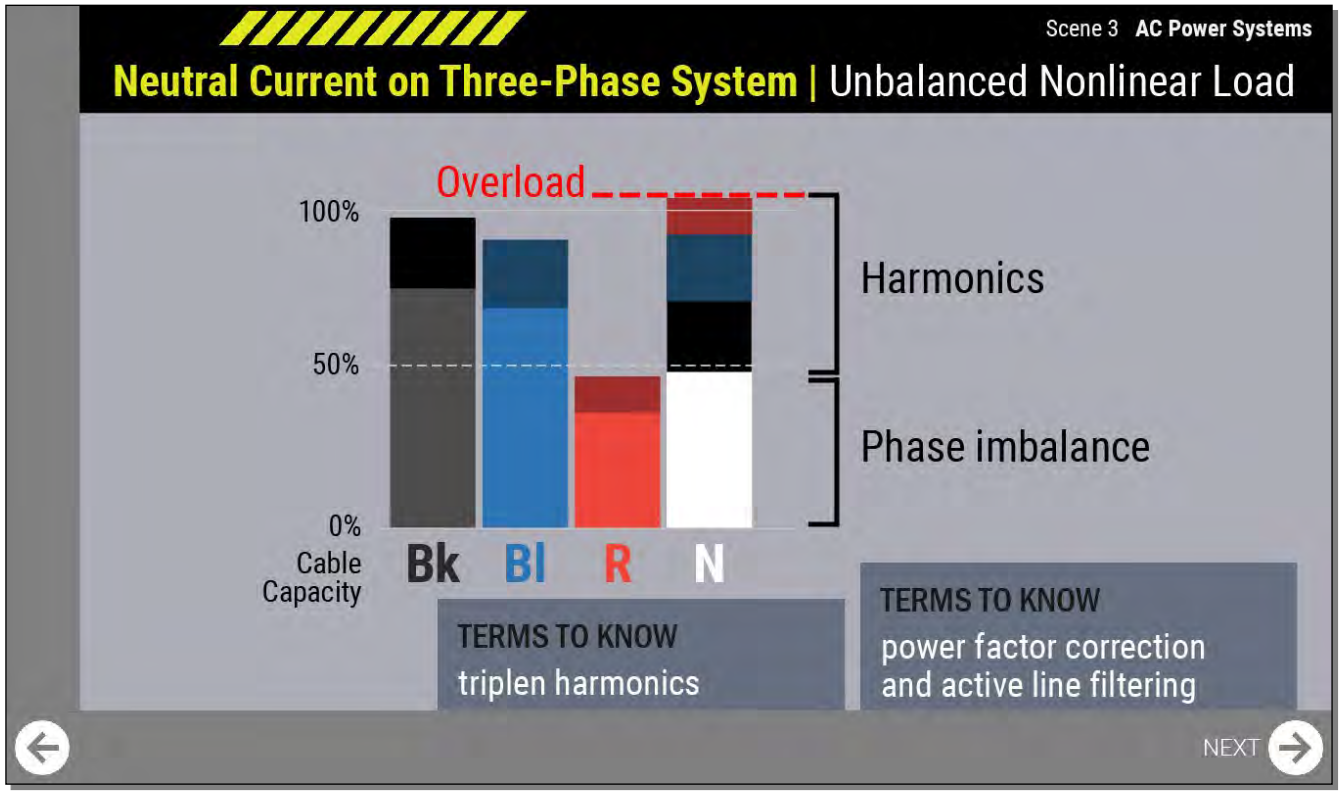
Slide 78. Linear and Nonlinear Loads



Let's briefly describe the difference between linear and nonlinear loads. For a linear load, the current is always proportional to the voltage. A nonlinear load does not draw current in proportion to the input voltage, but rather in spikes, which can affect the distribution system and the generator. Nonlinear loads include solid-state dimmers and certain electronic power supplies. For small loads, these effects are negligible, but when a large load has a substantial nonlinear component, one of the possible effects is higher-than-normal current on the neutral.

Let's look at this more closely.

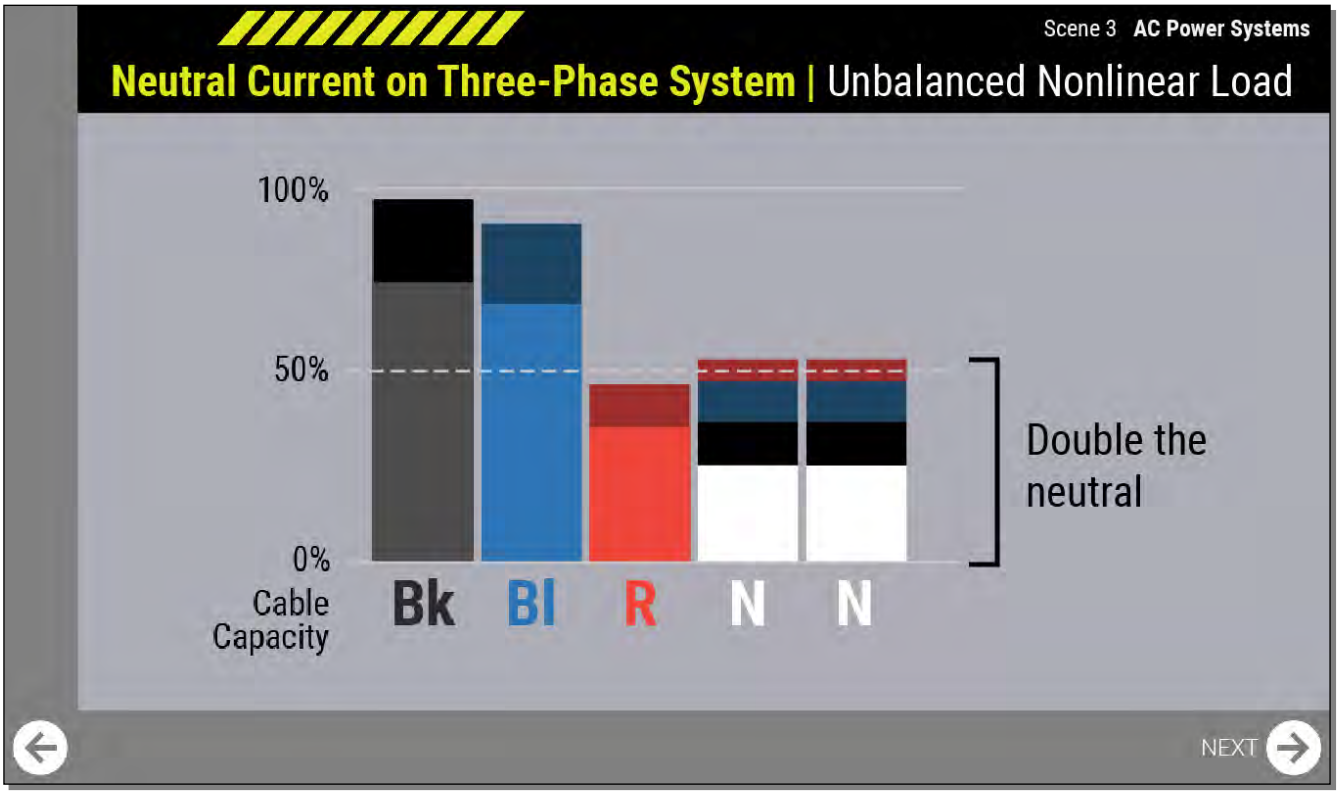
Slide 79. Neutral Current on Three-Phase System 3



When powering large numbers of phase-control dimmers or electronic power supplies that are not power-factor corrected, a portion of the load does not cancel. Here, the portion that does not cancel is shown in the darker shade. The non-cancelling currents are called **triplen harmonics**. The neutral must carry these harmonic currents, which add together: black plus blue plus red. You can see how the harmonics could overload the neutral, especially if they are added on top of current created by phase imbalance. Harmonic currents also create more heat than normal 60-hertz current, so overloading **and overheating** are both possible.

To safely carry the current, the NEC requires that, when the system supplies nonlinear loads, the neutral feeders must be larger than the phase feeders.

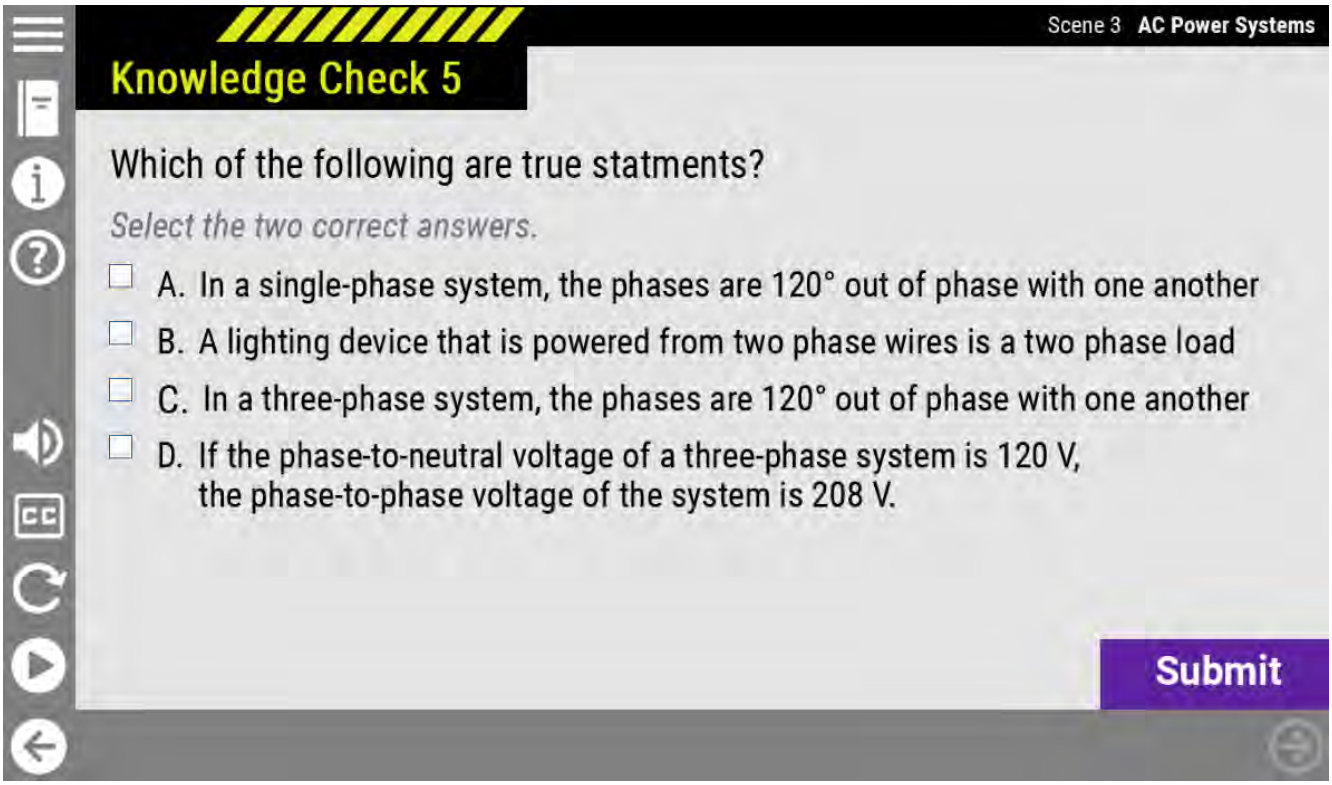
Slide 80. Neutral Current on Three-Phase System 4



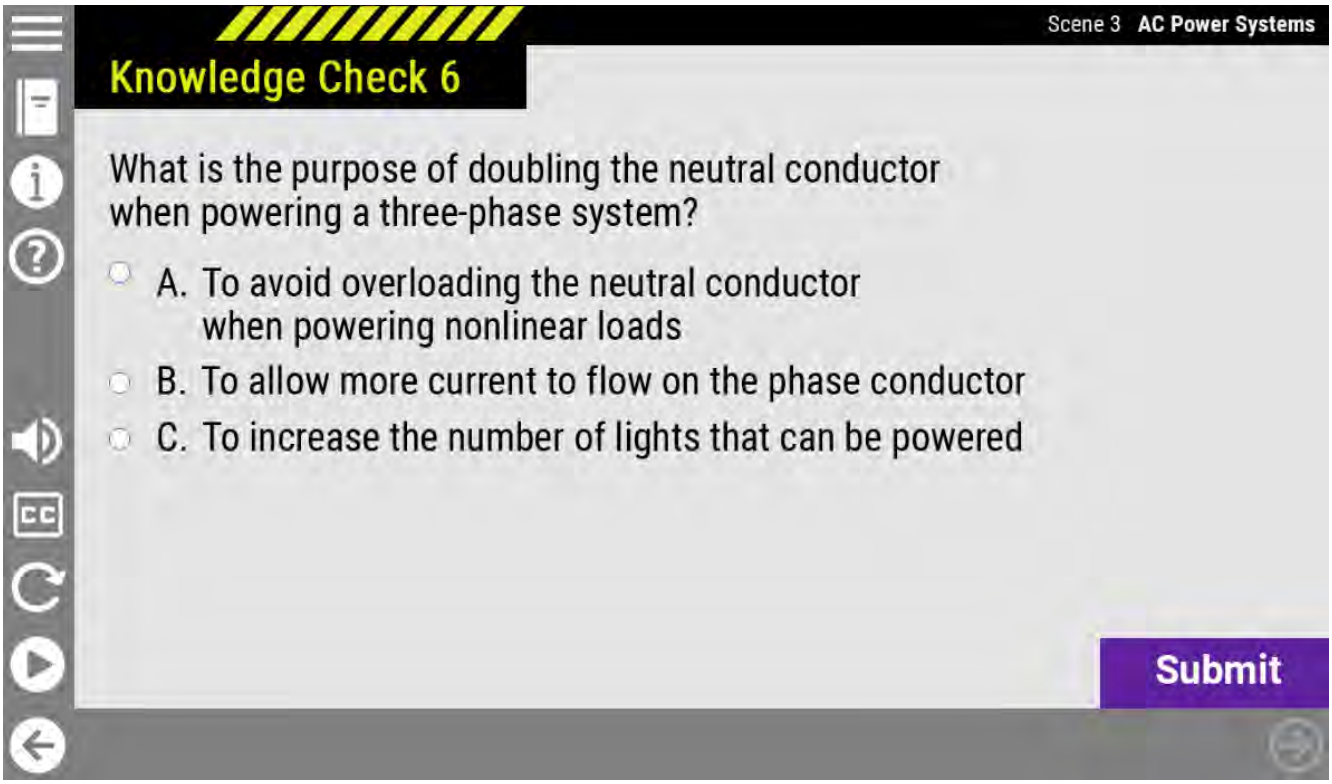
In our portable system, that means that we double the neutral by running a second neutral feeder cable in parallel. By doubling the neutral, the additive harmonic currents can be carried without overloading the neutral feeder cable.

That concludes our discussion on power systems. Let’s apply your knowledge with a couple review exercises.

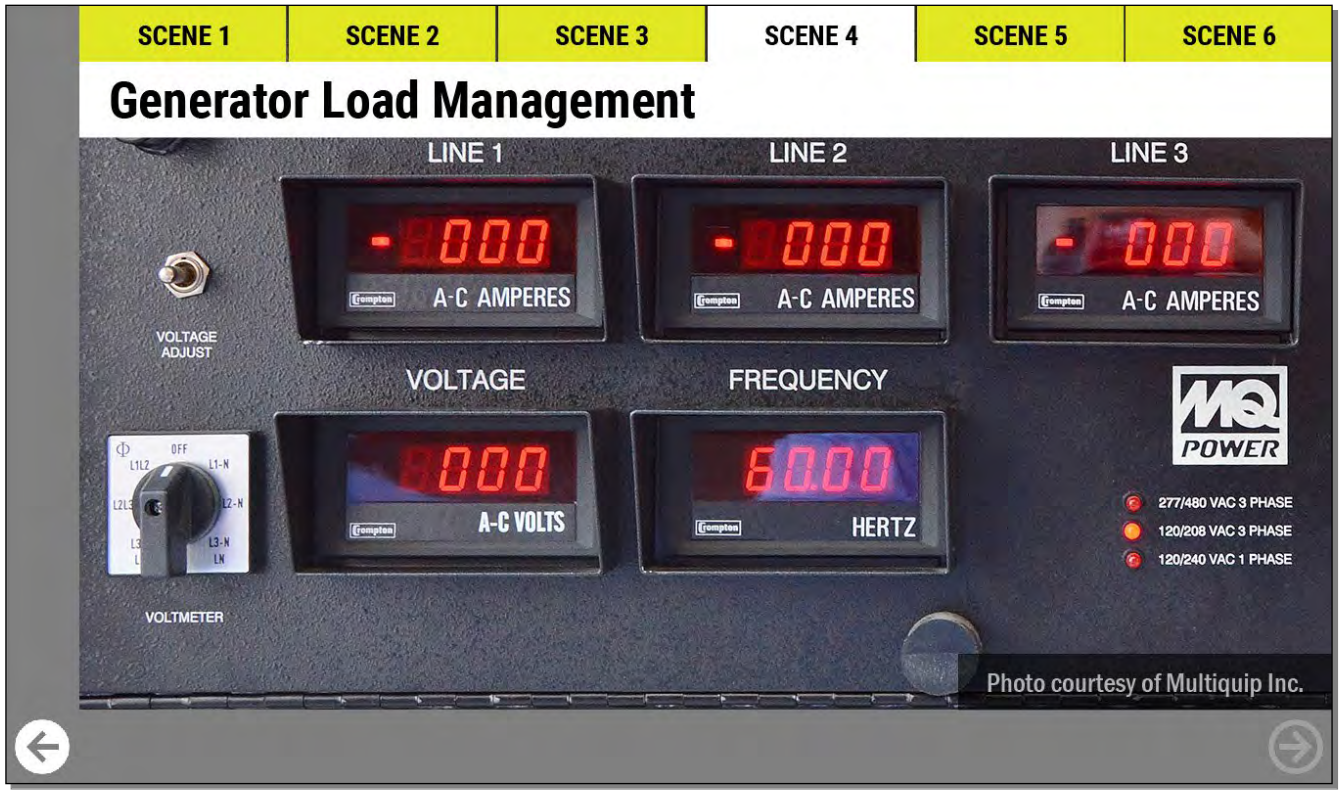
Slide 81. Knowledge Check 5



Slide 82. Knowledge Check 6

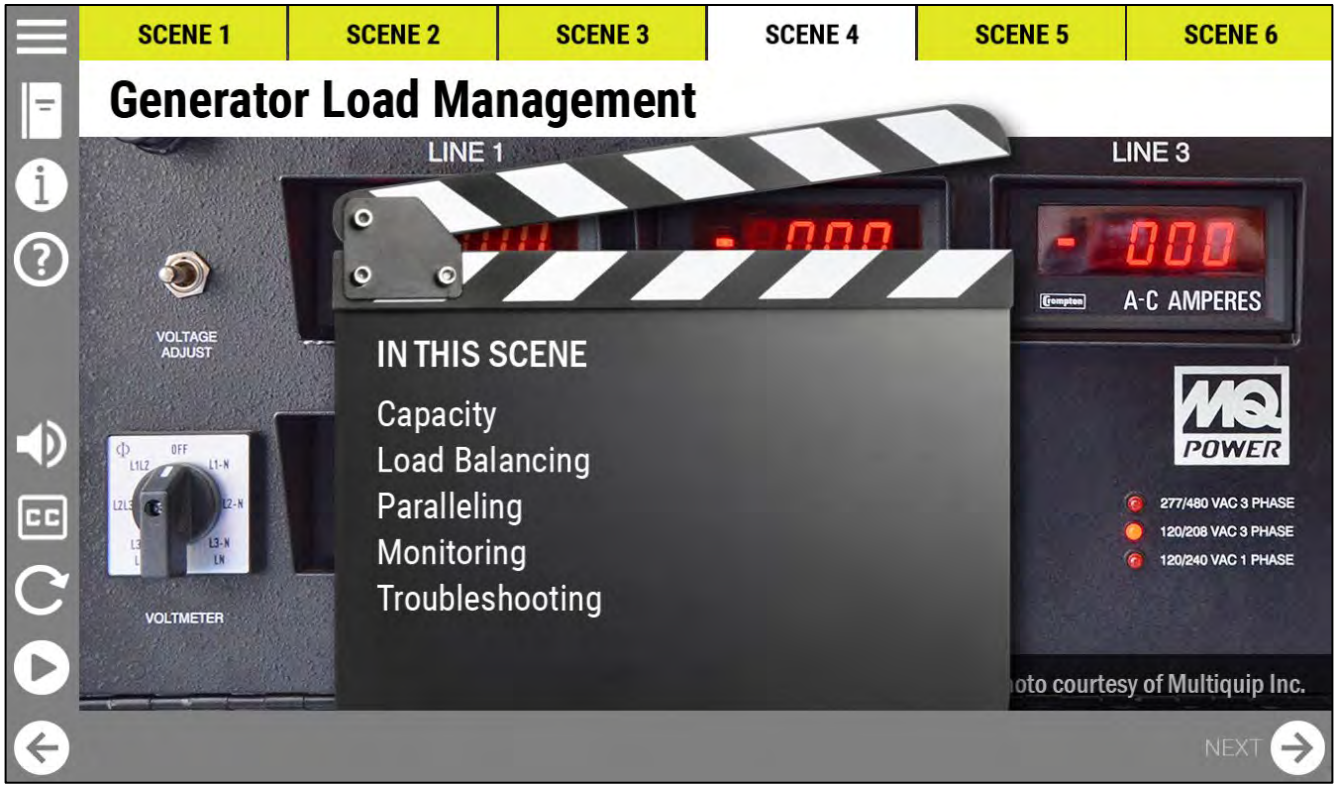


Slide 83. SCENE 4, GENERATOR LOAD MANAGEMENT



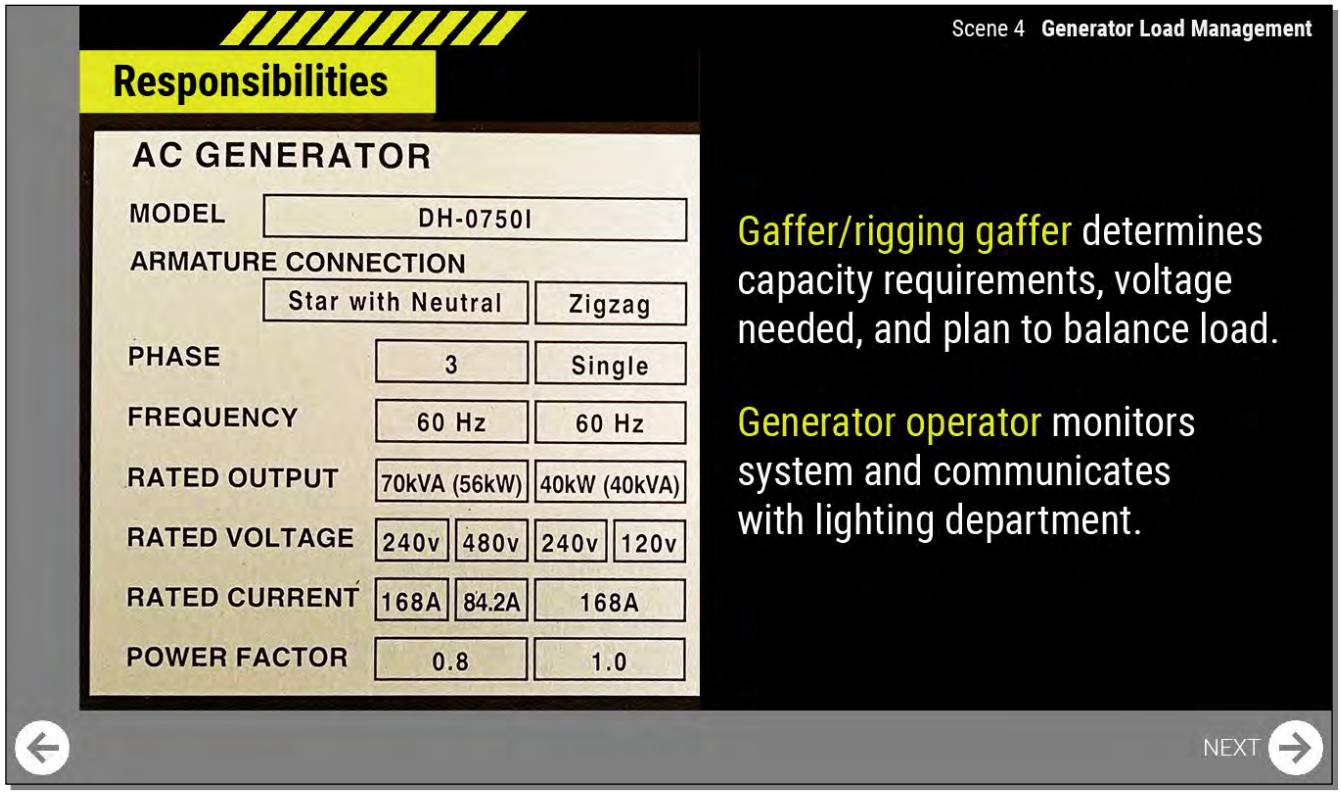
Scene Four, Generator Load Management.

Slide 84. In This Scene



Proper load management is critical to a generator running optimally. In this scene, we'll look at key aspects of load management: capacity, load balancing, paralleling generators, monitoring loads, and troubleshooting.

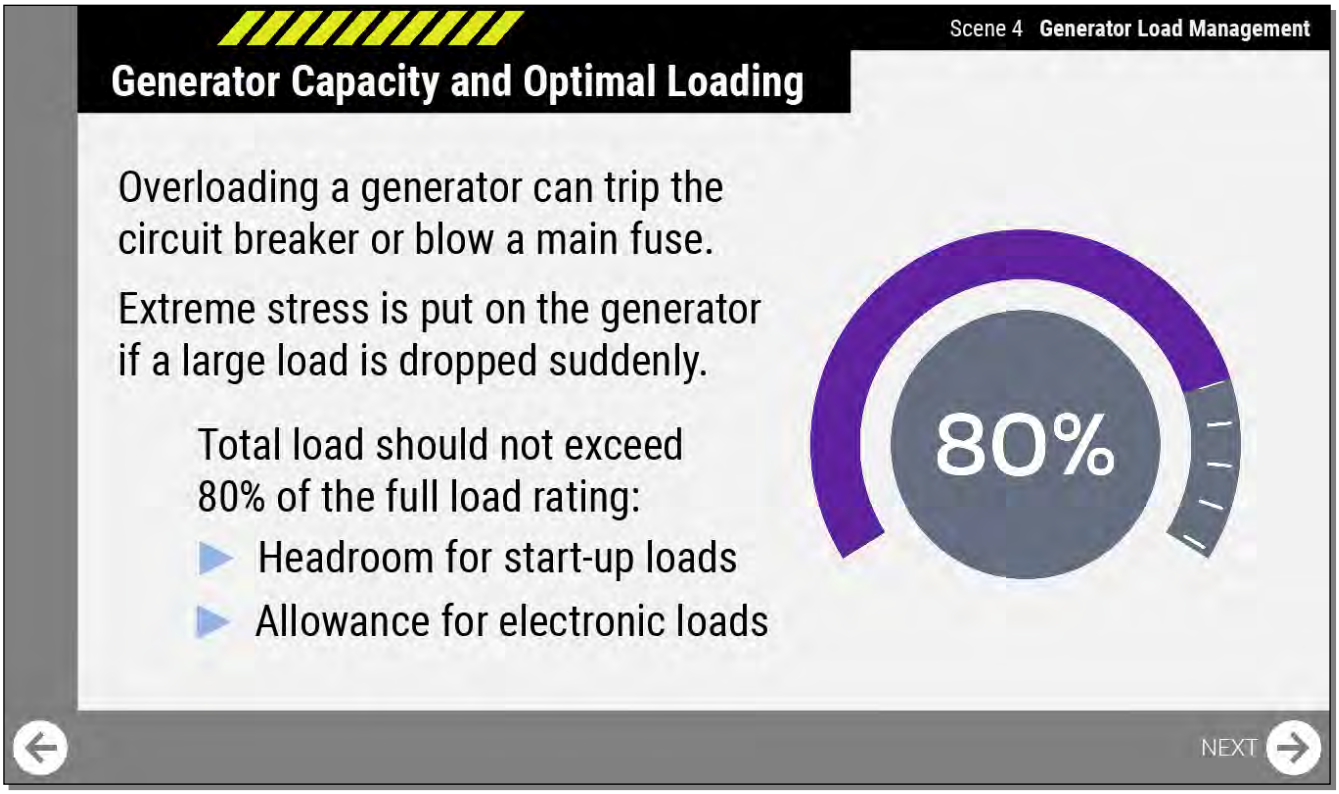
Slide 85. Responsibilities



The gaffer or rigging gaffer determines minimum generator capacity requirements based on the lighting loads. They specify the voltages needed and plan the distribution to balance the load more or less evenly between phases.

The generator operator monitors the system and communicates load status and potential issues to the lighting department.

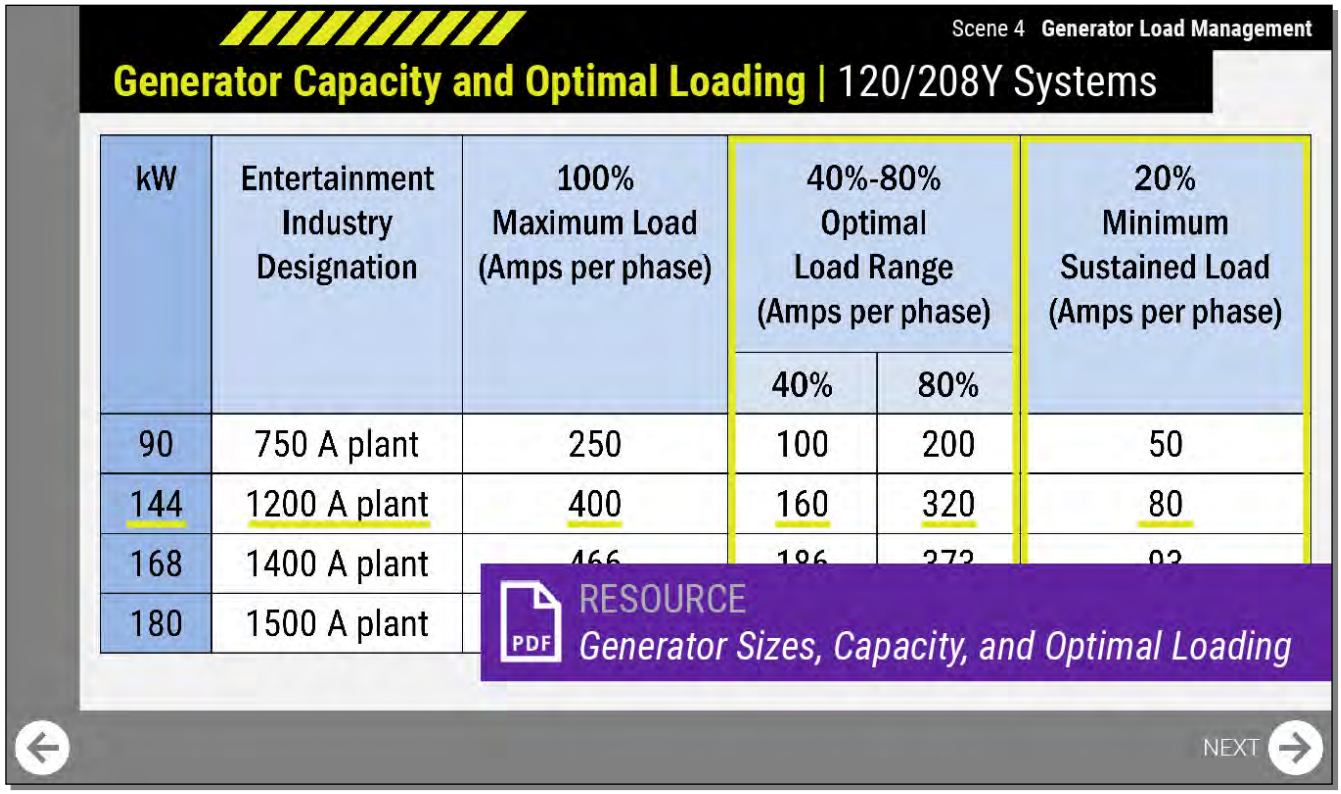
Slide 86. Capacity and Optimal Loading 1



Overloading the generator can trip the circuit breaker or blow a main fuse. Dropping a large load suddenly, like this, would put extreme stress on the generator.

The maximum load should not exceed 80 percent of the generator's full capacity. This allows overhead for momentary start-up loads. It is also required to account for certain electronic loads that could otherwise cause an overload.

Slide 87. Capacity and Optimal Loading 2



Entertainment industry technicians often refer to generator capacity by total amperage. For example, we'll refer to a 144-kilowatt generator as a 1200-amp plant because it has a maximum load rating of 400 amps per phase at 120 volts.

Outside our industry, generators are identified in kilowatts because it gives the unit's capacity in a way that is independent of the voltage being used. Whichever way you name the generator, remember, the maximum capacity is well above the load that is actually safe.

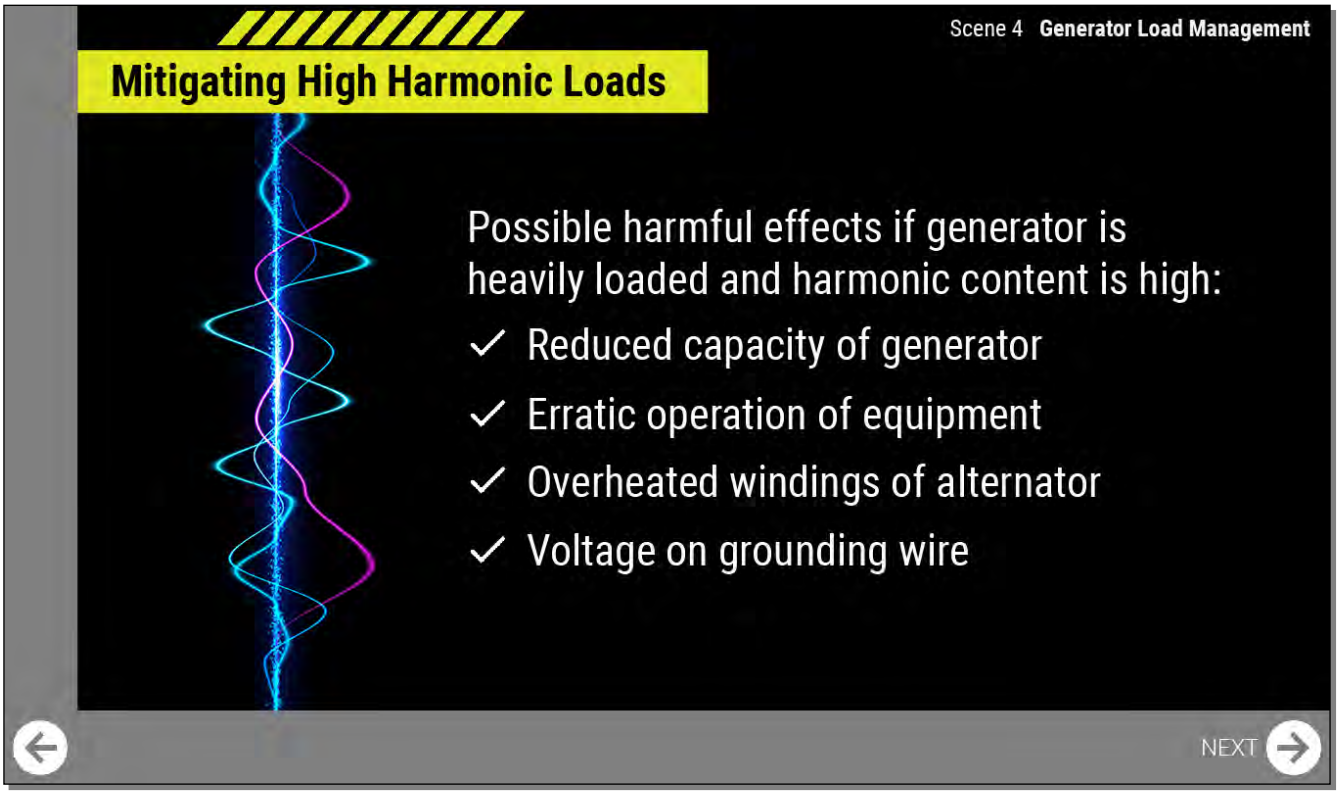
In this table, the 40 and 80 percent columns define the optimal range for sustained loads. When sizing the generator, planned loads should be 40 to 80 percent of the generator's maximum load rating.

The 20 percent column is the minimum sustained load. Running the generator for long periods under very light loads can be harmful to the generator.

So, a 1200-amp plant would be ordered if the planned loads fall between 160 and 320 amps per phase. And, when using the generator, the minimum sustained load should not be less than 80 amps.

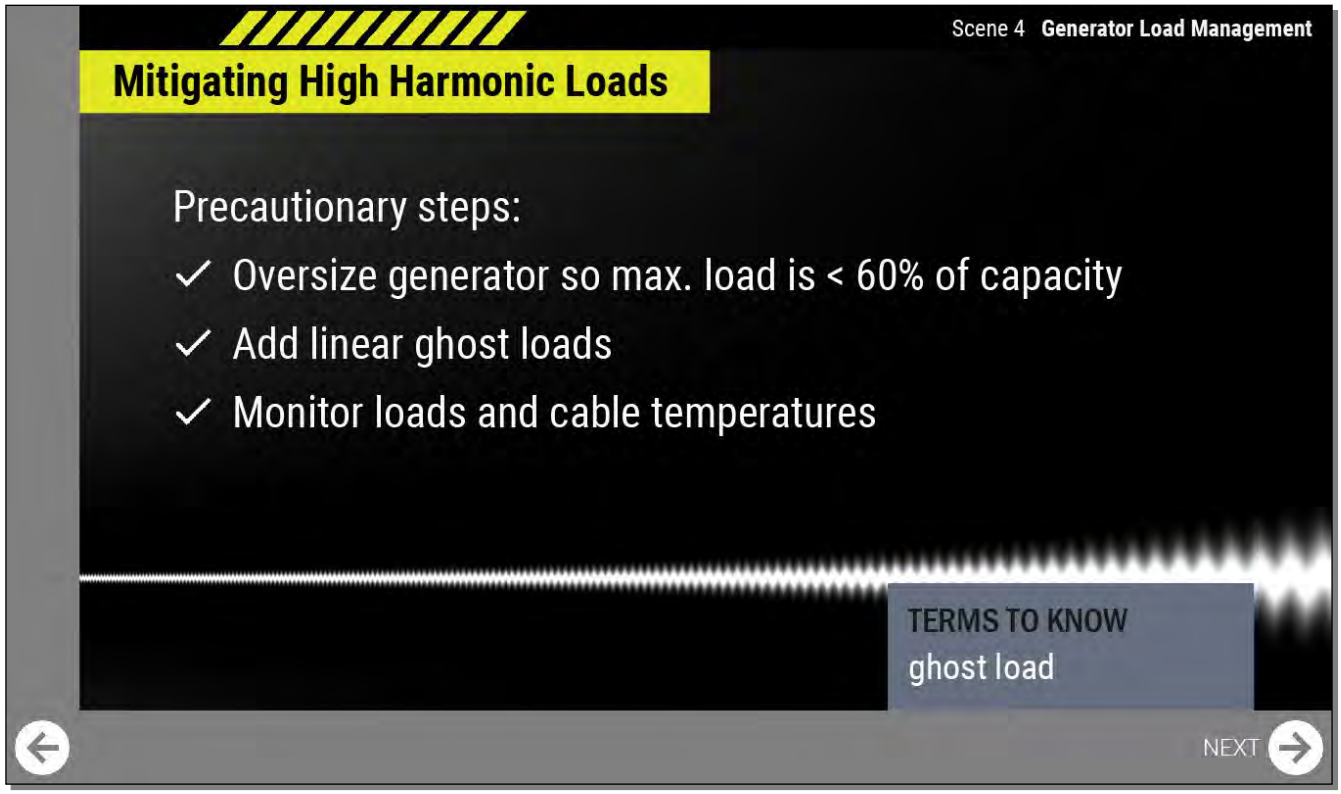
Click here to view the complete table that lists generator sizes from 600 amps up to one Megawatt. This document is also available through the *Resources* icon.

Slide 88. Mitigating High Harmonic Loads 1



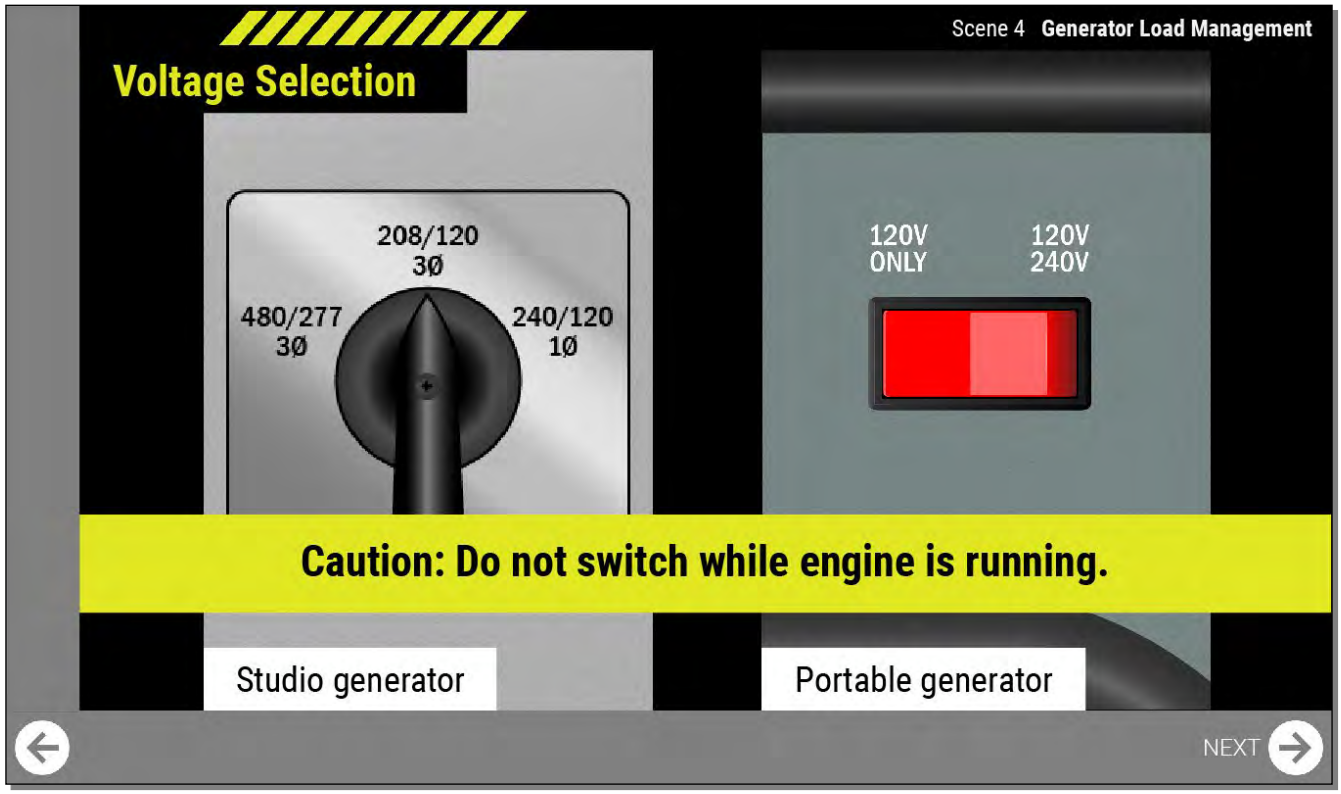
Earlier we mentioned the effects of harmonic currents on the neutral. Doubling the neutral protects the cable from overheating, but other harmful effects may still appear if the generator is heavily loaded and the harmonic content is high, such as reduced capacity of the generator, erratic operation of equipment, overheated windings of the generator alternator, and voltage on the grounding wire.

Slide 89. Mitigating High Harmonic Loads 2



The primary remedy is to oversize the generator so that the maximum load is not more than 60 percent of the generator capacity. In addition, the rigging gaffer may take steps to reduce possible harmful effects such as adding linear **ghost loads** and monitoring the loads and temperature of distribution cables.

Slide 90. Voltage Selection



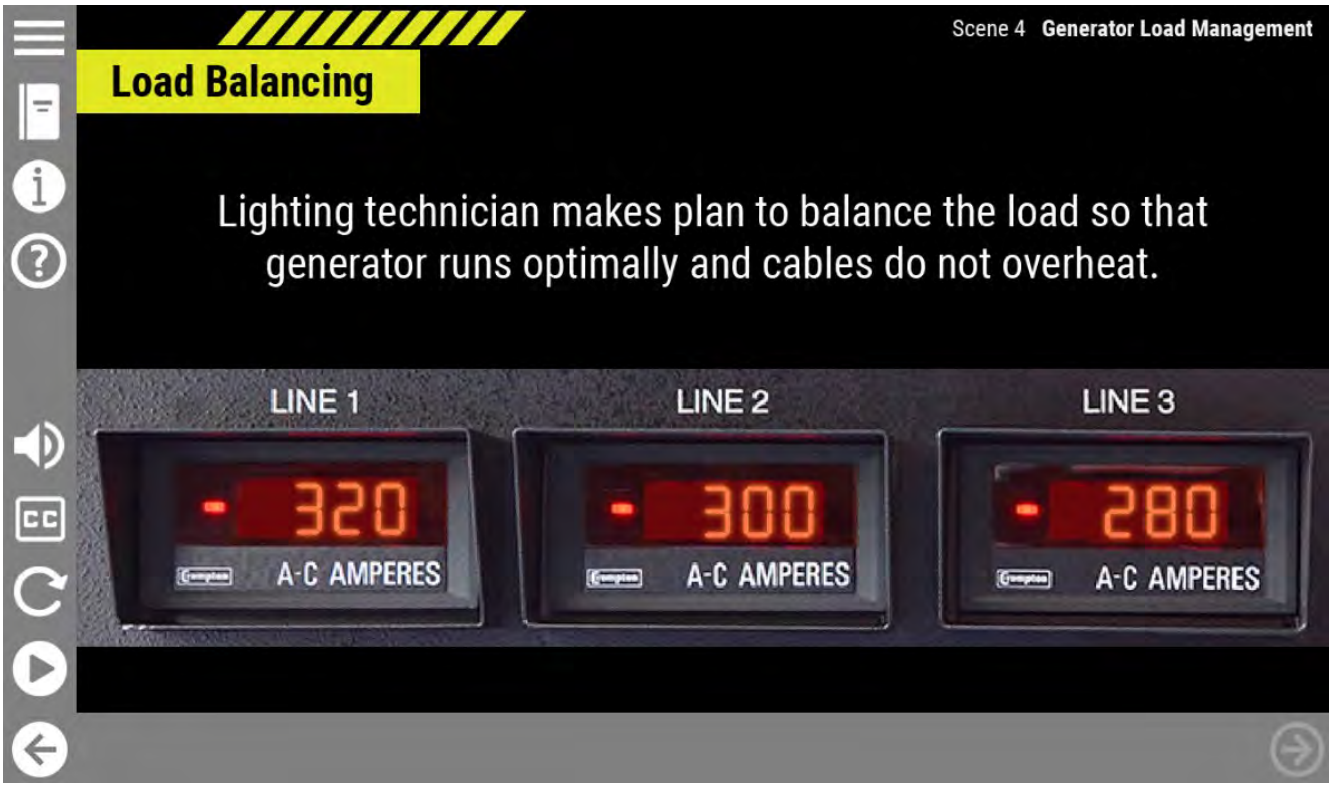
As mentioned previously, larger studio generators have three options for voltage configuration: 240/120-volt single-phase, 208/120-volt three-phase, or 480/277-volt three-phase.

Smaller gas-powered units are 240/120-volt single-phase.

When switching the system voltage, the generator's engine must be shut off. The engine and alternator must not be turning when the voltage selection switch is operated. Some models, and especially larger generators, require that the main circuit breaker be in the OFF position before changing system voltage.

Check the operation manual for all safety precautions and to locate the voltage selector for the model you are using.

Slide 91. Load Balancing 1



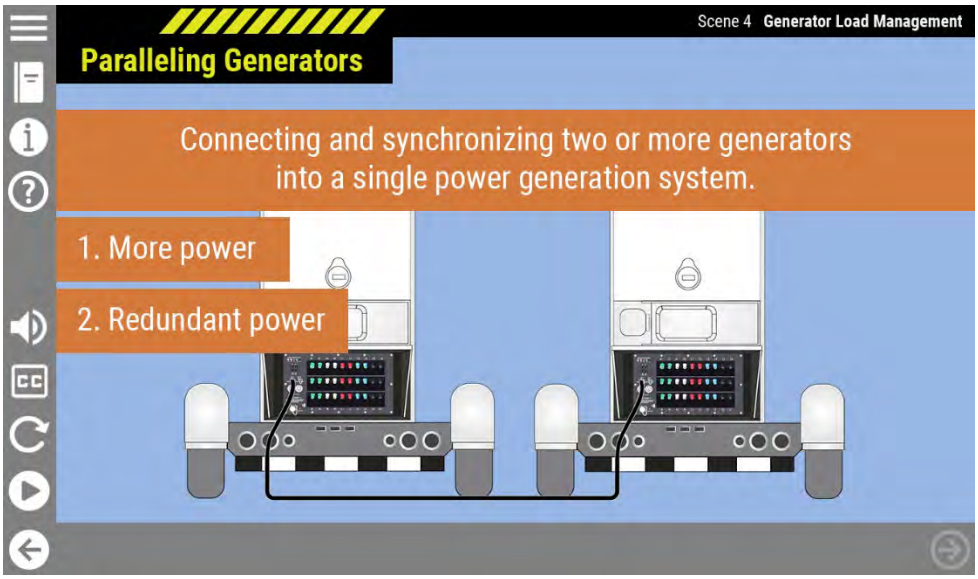
Load balancing means that there is about the same amount of amperage on each phase.

As we mentioned earlier, the lighting technician will have made a plan to balance the load ahead of time so that the generator runs optimally and cables do not overheat. If the generator operator sees a load become significantly unbalanced between phases, communicate that to lighting technicians.

Slide 92. Load Balancing 2

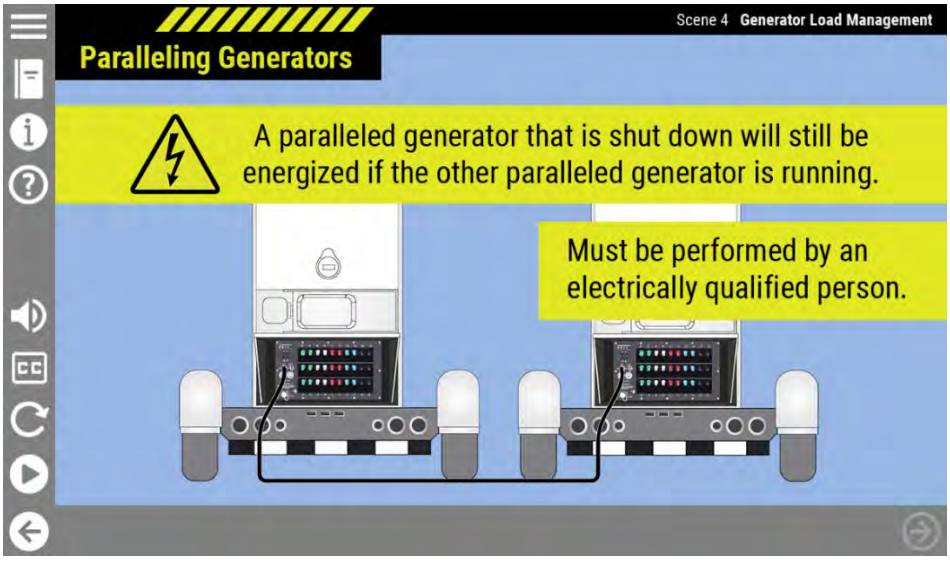
Possible effects of large load imbalances include poor engine performance, unreliable performance of some lighting equipment, an increase in voltage drop, equipment damage, and fire.

Slide 93. Paralleling Generators 1



Paralleling generators means connecting and synchronizing two or more generators into a single power generation system.

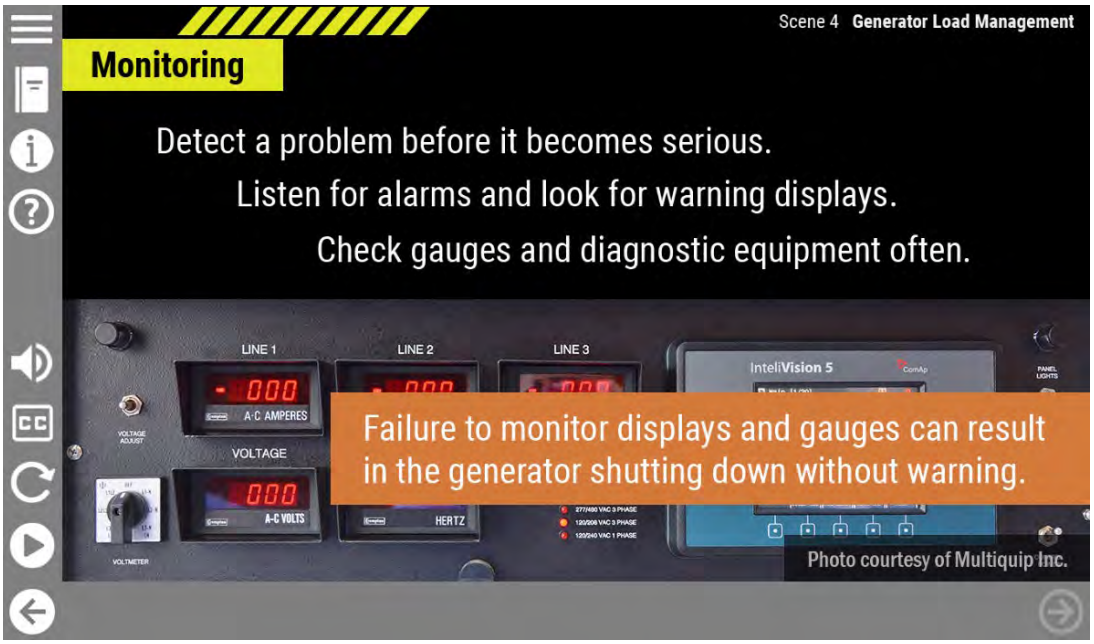
A production may elect to parallel generators to increase their power supply rather than obtaining a larger-capacity generator. Paralleling is also used for redundant power, mostly for live broadcasts or live-to-tape shows. Redundancy ensures that there is no loss of power if one generator goes offline or is shut down to refuel. In these cases, the load must not exceed the capacity of either unit.



But be careful. A paralleled generator that is shut down will still be energized if the other paralleled generator is running.

Paralleling must be performed by an electrically qualified person.

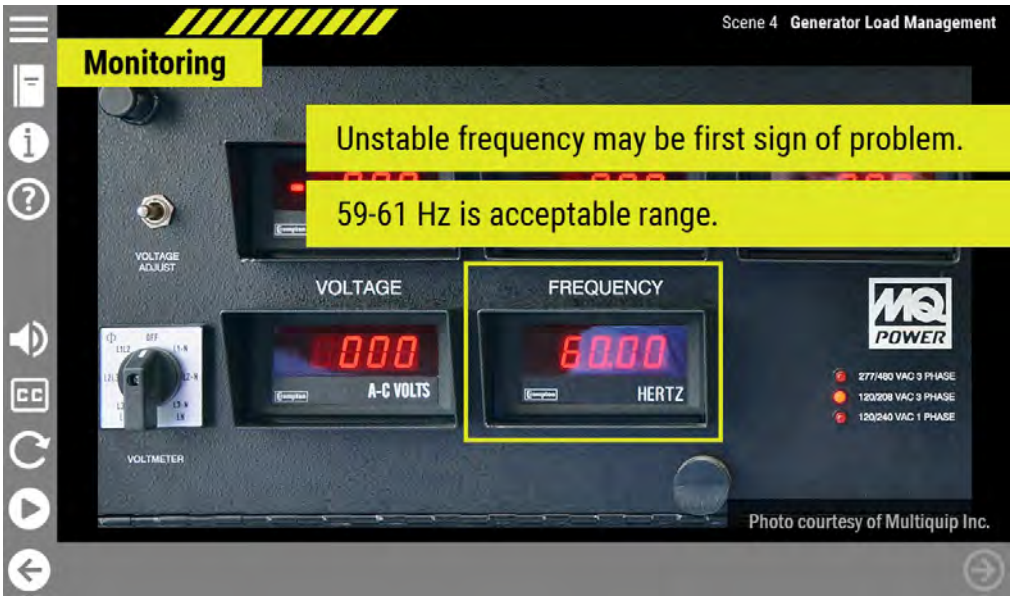
Slide 94. Monitoring 1



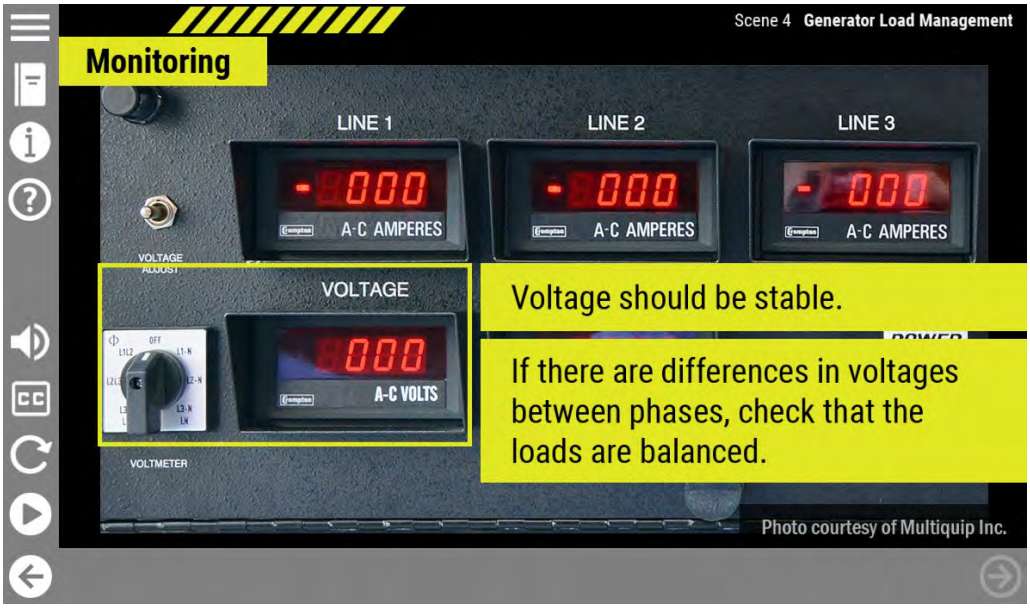
Monitoring generator functions helps ensure that a problem is detected before it becomes serious. On modern generators, almost all aspects of operation are monitored by sensors that sound an alarm, display a warning, or automatically shut down if a failure in the system is detected. Check engine gauges and electrical diagnostic equipment periodically throughout the day. Failure to monitor displays and gauges can result in the generator shutting down without warning.

Regularly check the engine temperature, engine speed, oil pressure, fuel level, and battery voltage.

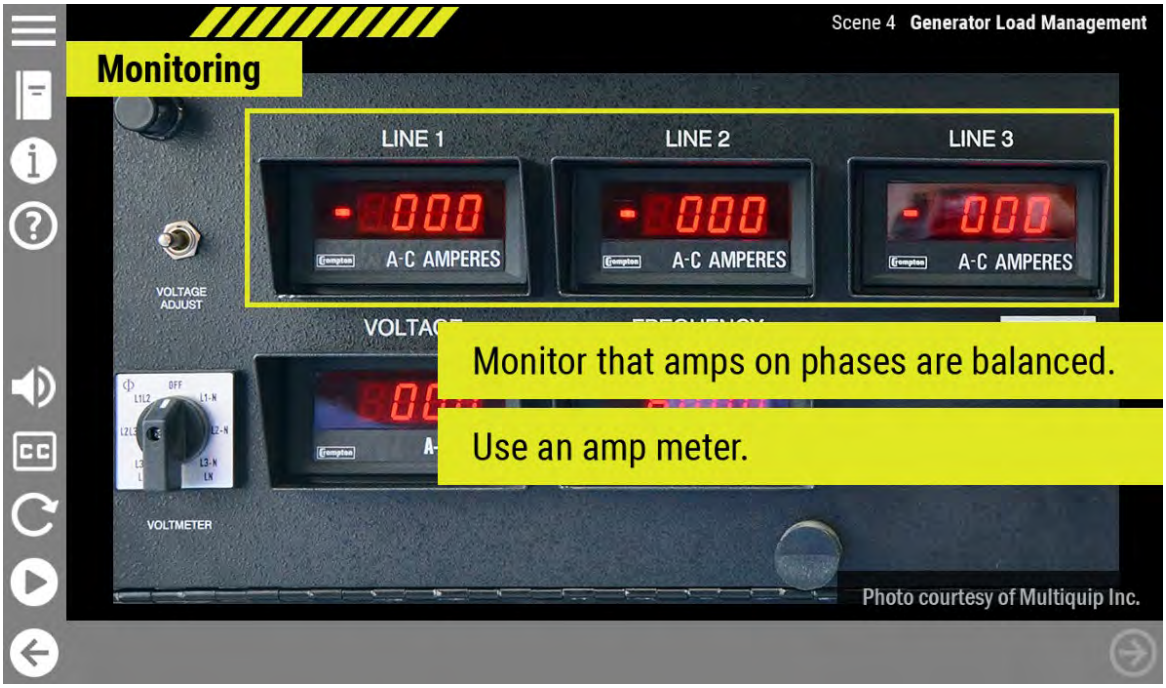
Slide 95. Monitoring 2



Often, unstable frequency regulation is the first sign of a problem. Frequency should be between 59 and 61 hertz. Anything outside of this range is problematic and may indicate that something is wrong with the generator engine, the flow of fuel, or factors external to the generator such as damaged distribution cables or adverse harmonic loads. Let the lighting crew know if there is a problem maintaining an acceptable frequency. Before replacing a generator, confirm that external factors are not the source of the problem.

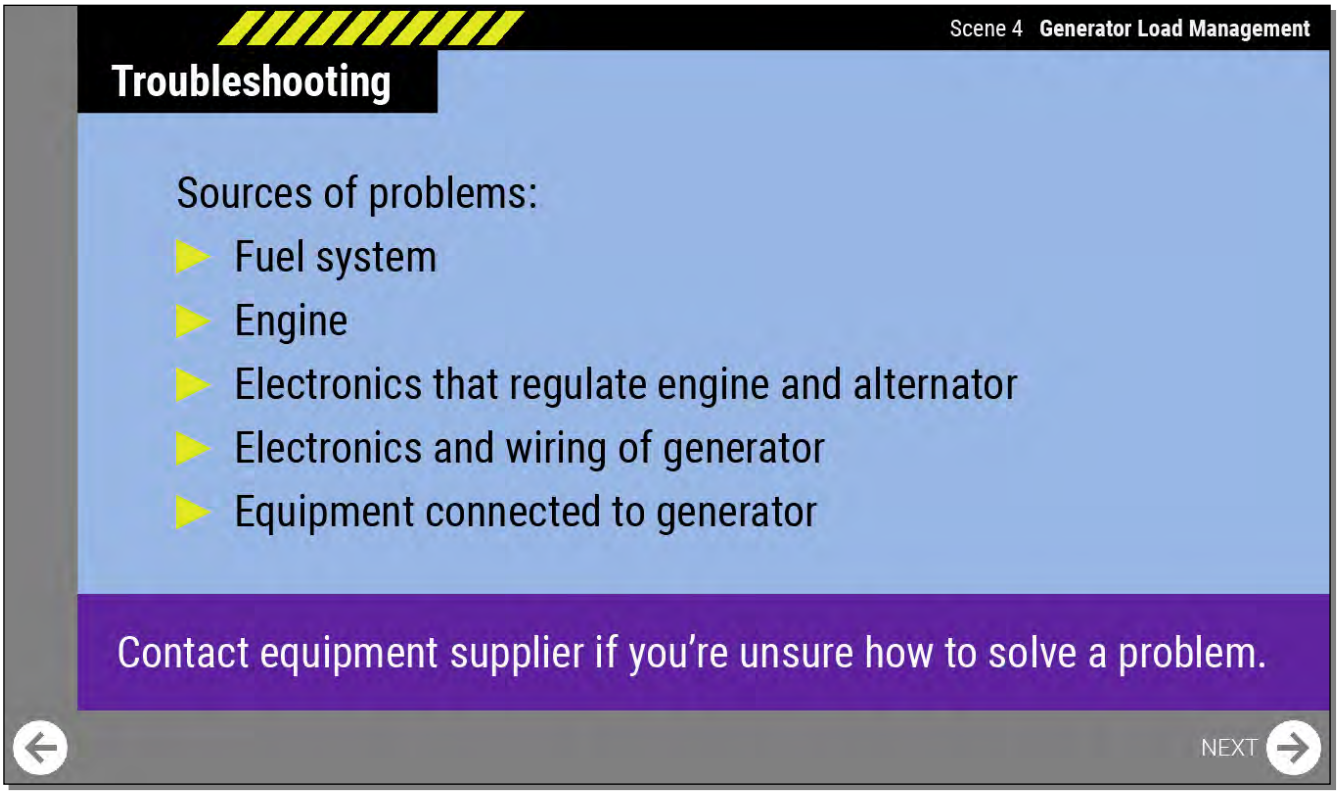


The voltage should be stable. Large fluctuations in voltage could be a sign of a malfunction. If there are differences in voltages between phases, check that the loads are balanced. We'll talk more about voltage in the next scene.



Monitor that the amps on each phase are balanced. Use an amp meter to compare against the generator readout and to read the current in any feeder cable throughout the system as well as the neutral. Notify the lighting crew if phases are drastically out of balance with one another or if the load on any phase is too high.

Slide 96. Troubleshooting

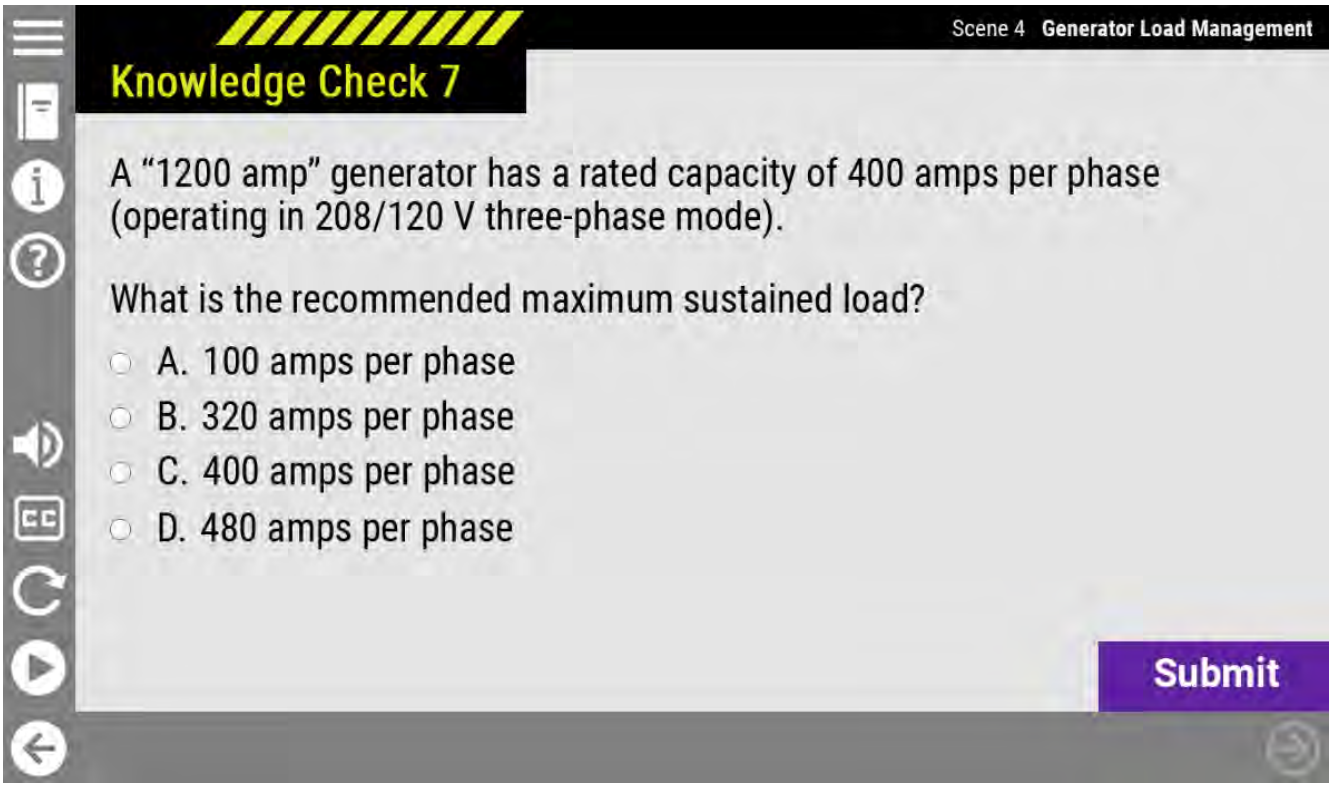


Problems with generators usually fall into one or more of the following categories: the fuel system, the engine, electronics that regulate the engine and alternator, electronics and wiring of the generator, and other equipment connected to the generator. A problem in one area can manifest in other areas.

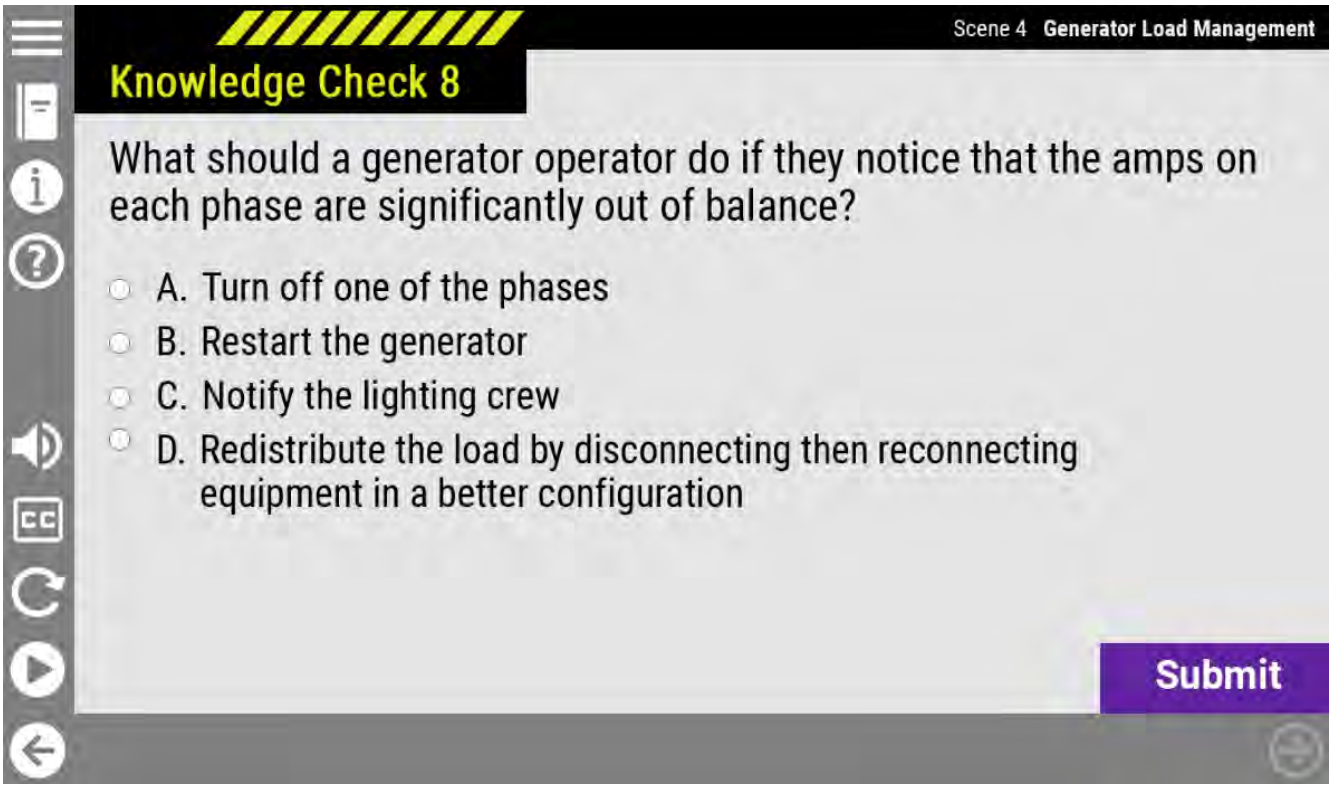
Your ability to troubleshoot will depend on your knowledge and experience. If there's a problem that doesn't have an obvious cause or that you don't know how to handle, do not delay in contacting the equipment supplier. Problems that start small can grow into a cascading series of failures and cause serious damage if not attended to.

To finish up this scene, try a couple of review questions.

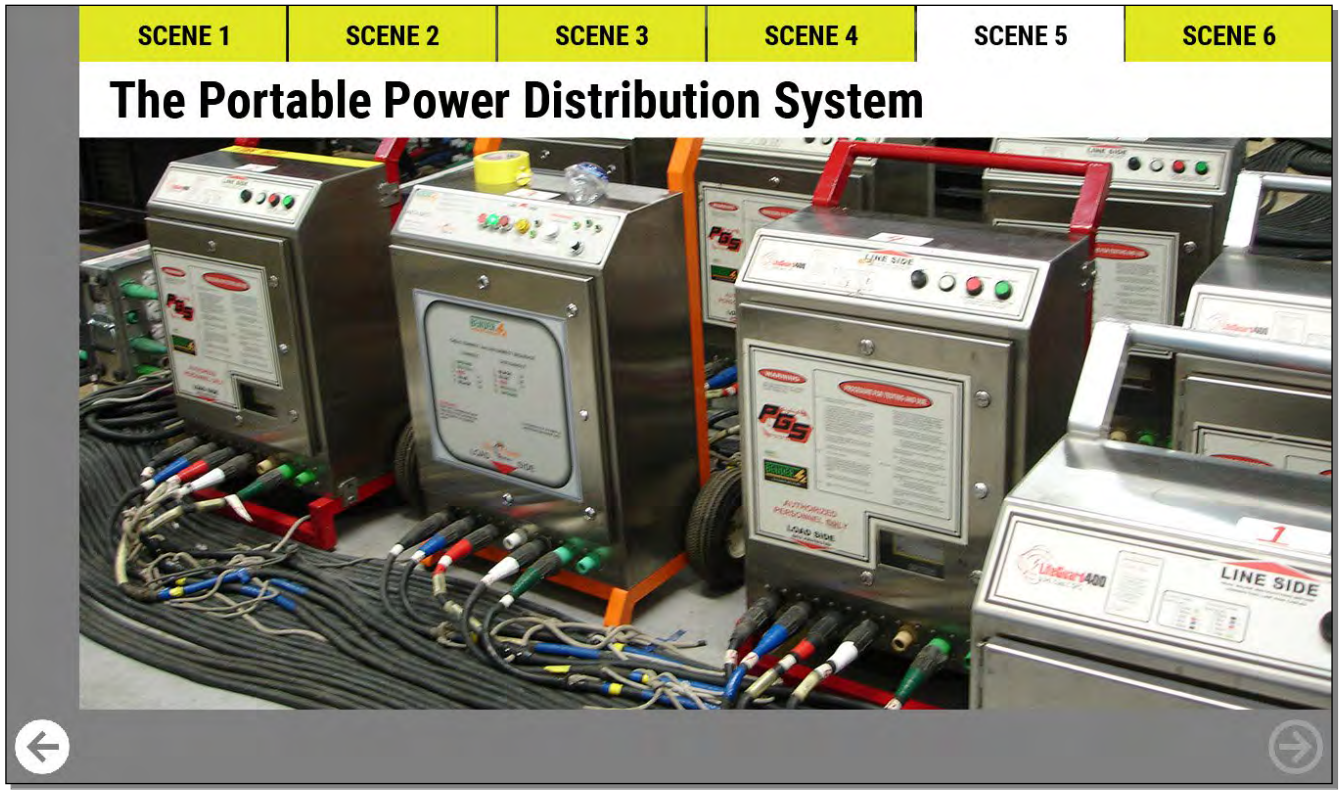
Slide 97. Knowledge Check 7



Slide 98. Knowledge Check 8



Slide 99. SCENE 5, PORTABLE POWER DISTRIBUTION SYSTEM

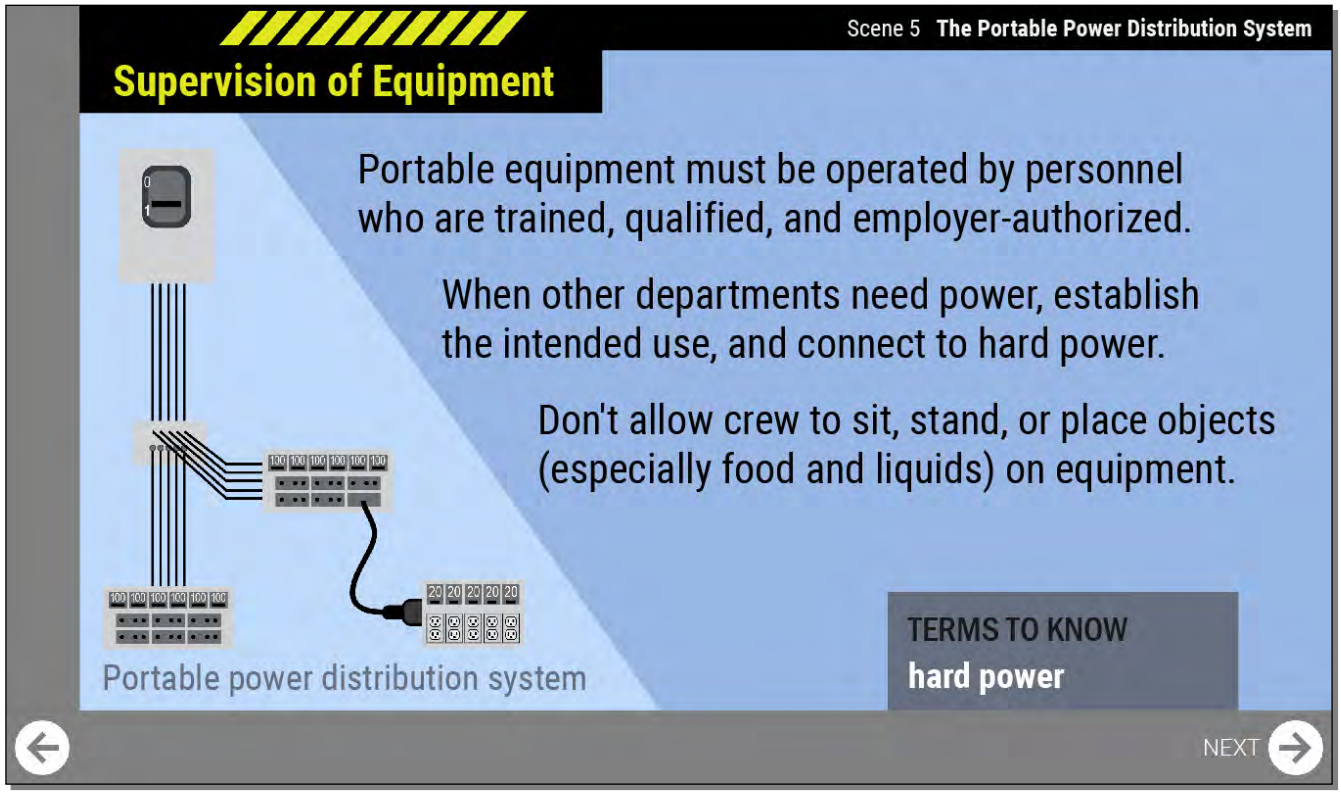


Scene Five, The Portable Power Distribution System.

Slide 100. In This Scene

As the generator operator, you interact with the portable distribution system and need to know the requirements for safety systems like overcurrent protection and equipment grounding and be familiar with issues like voltage drop which may affect settings you make on the generator. We'll start with supervision of equipment and color coding.

Slide 101. Supervision of Equipment



A portable system is highly adaptable and safe in the hands of qualified technicians, but it requires supervision and is not designed to be foolproof for use by anyone. That's why portable electrical equipment, including distribution systems, generators, battery systems, and other power sources, must be deployed, energized, and operated by trained, qualified, and employer-authorized personnel. The equipment must be continuously supervised while energized.

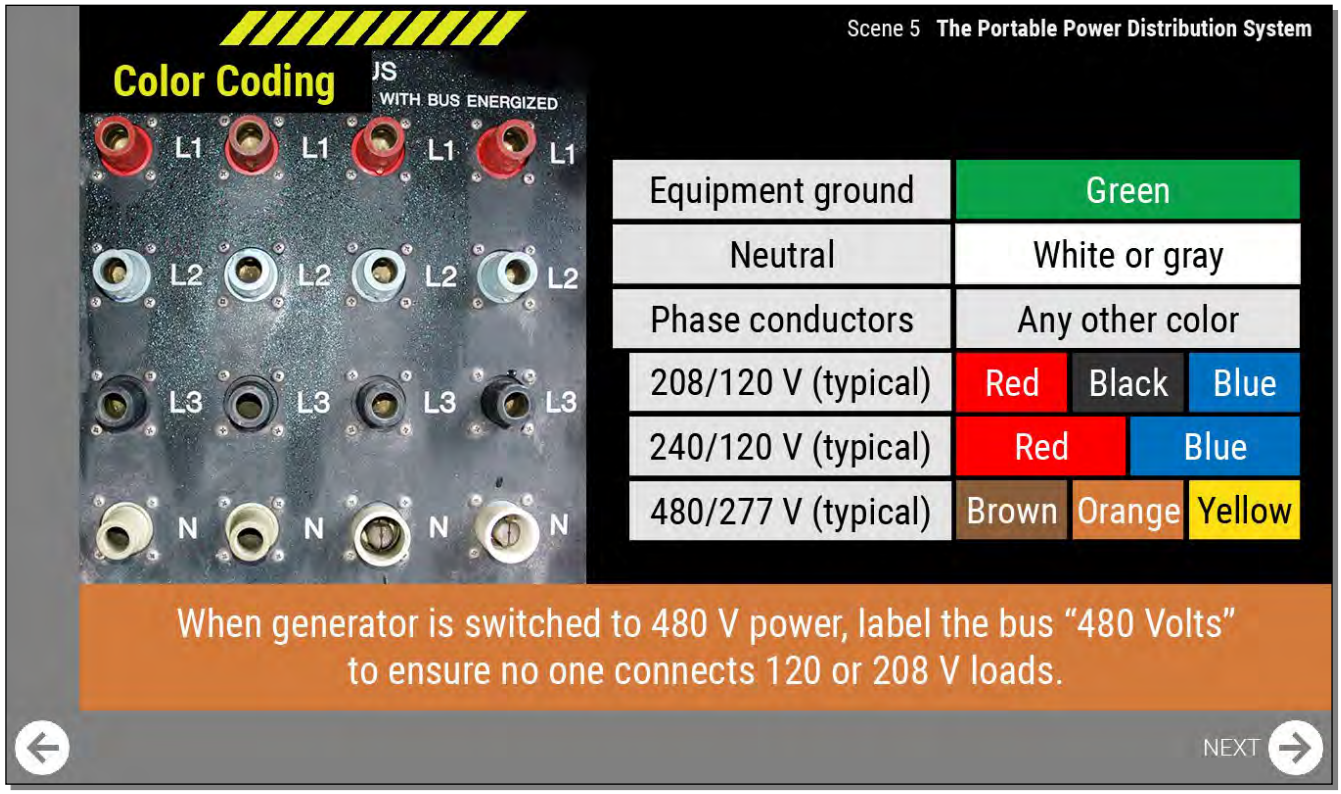
When other departments need power, they should ask for assistance. If someone wants to plug in, find out what it's for, and show them where they can access **hard power.** This helps ensure they don't mistakenly plug a piece of sensitive electronics into a dimmer line, for example.

Do not allow personnel to sit on distribution boxes or electronic ballasts. Do not allow them to stand on equipment or place objects, food, or liquids on the equipment.

Slide 102. Outdoor Use

Most portable distribution boxes used in motion picture and television production are rated for indoor use. Their enclosures don't provide much protection against the elements. However, this equipment is permitted to be used outdoors, provided that it is supervised by a qualified person when it is energized. The NEC also requires that where the equipment is deployed on location, public access must be restricted such as by physical barriers or other access-control measures.

Slide 103. Color Coding 1



Single-conductor cable connectors must be color-coded or otherwise identified by ground, neutral, and phase, and by system voltage.

The NEC requires that the ground be green. The neutral must be white or gray. (Gray is used in 480/277-volt systems.) The phase wires must be other colors, never green, white, or gray.

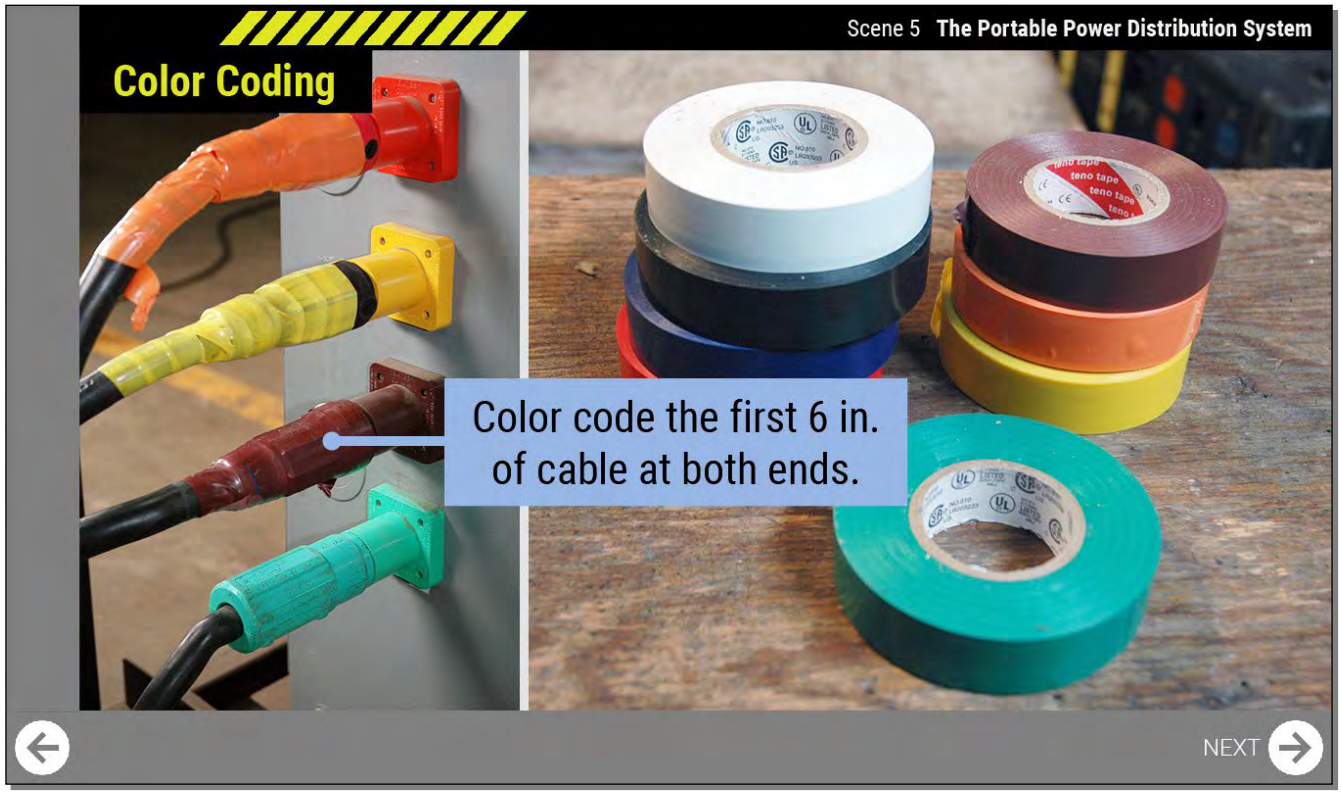
In our industry, the convention for phase colors for 208/120-volt three-phase systems is **red, black,** and **blue.**

For 240/120-volt single-phase systems the phase colors are **red** and **blue.**

And for 480-volt systems the phase colors are **brown, orange,** and **yellow.**

When the generator is switched to provide 480-volt power, label the generator bus prominently “480 Volts” to ensure no one inadvertently connects 120- or 208-volt loads to it.

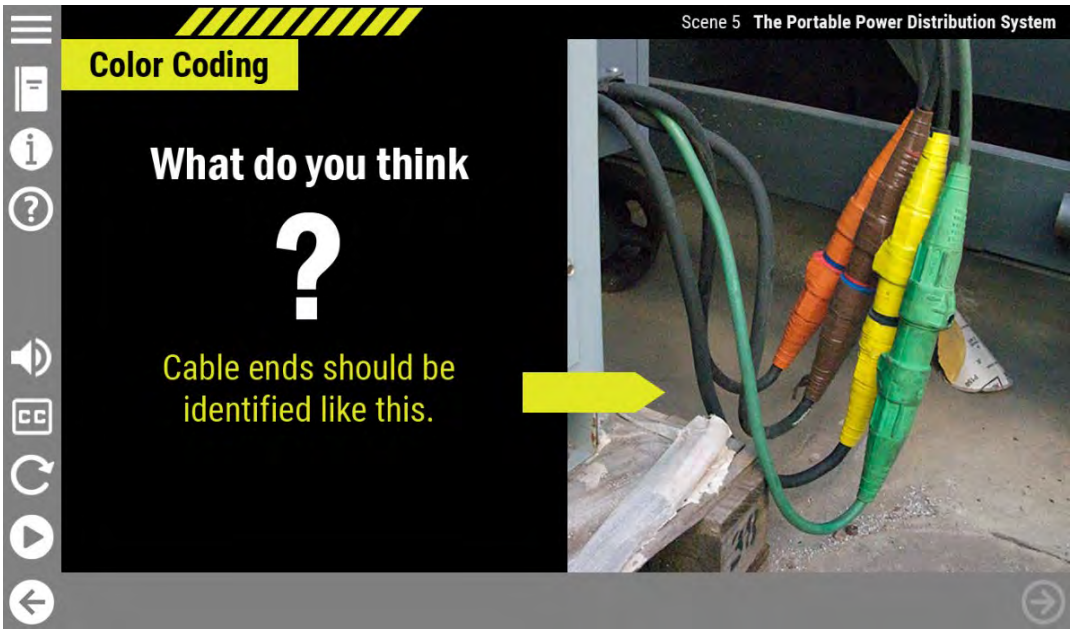
Slide 104. Color Coding 2



Both ends of every single-conductor cable should have at least six inches of color coding. If the connector is not appropriately color-coded, the end should be taped over with the correct color.

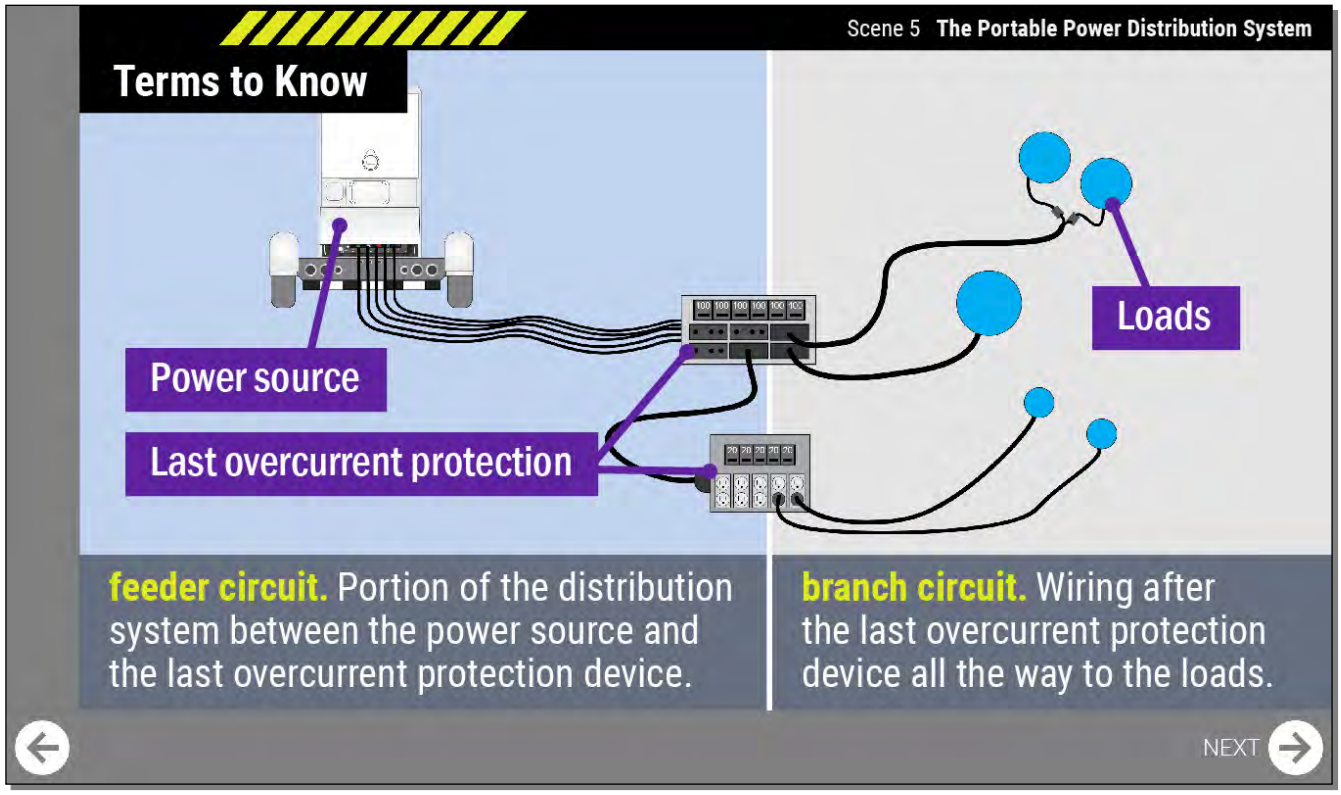
Slide 105. What Do You Think?

Okay, quick! Can you identify the voltage of this system? This is an example of how confusing it can be when color coding is ignored. This is a portable 480-volt air conditioning unit. The phase wires are incorrectly color-coded orange, black, and blue, and they are plugged into red, blue, and white banded cable without properly taping over the ends and color-coding them appropriately. There is no way to visually identify what voltage is present or be certain about the identity of **any** of the wires.



Instead, the cable ends should be identified like this.

Slide 106. Terms to Know 1



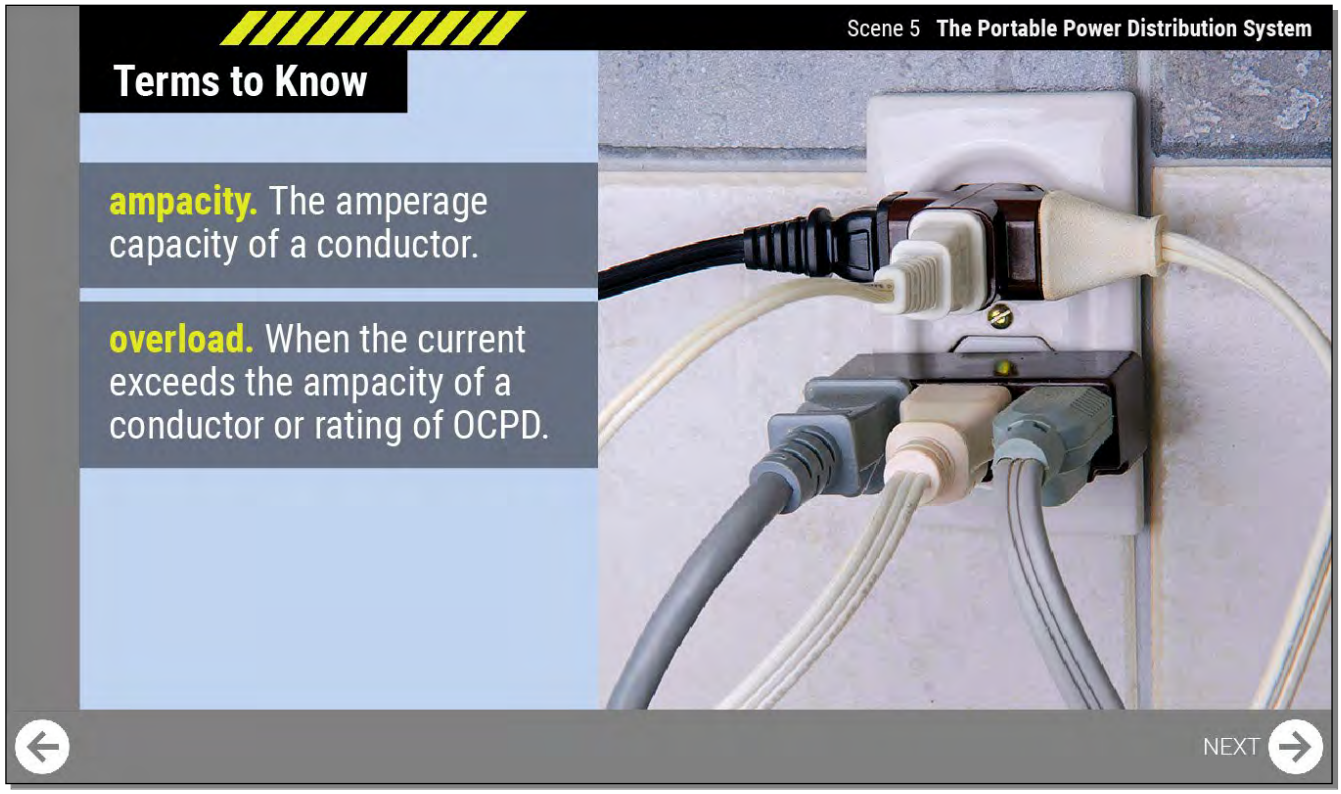
Out next topic is overcurrent protection. Let's begin by defining some essential electrical terms.

The **feeder circuit** is the portion of the distribution system between the power source and the last overcurrent protection device.

The **branch circuit** is the wiring after the last overcurrent protection device all the way to the loads.

The rules for protecting feeder circuits are different than branch circuits, which we'll get to later.

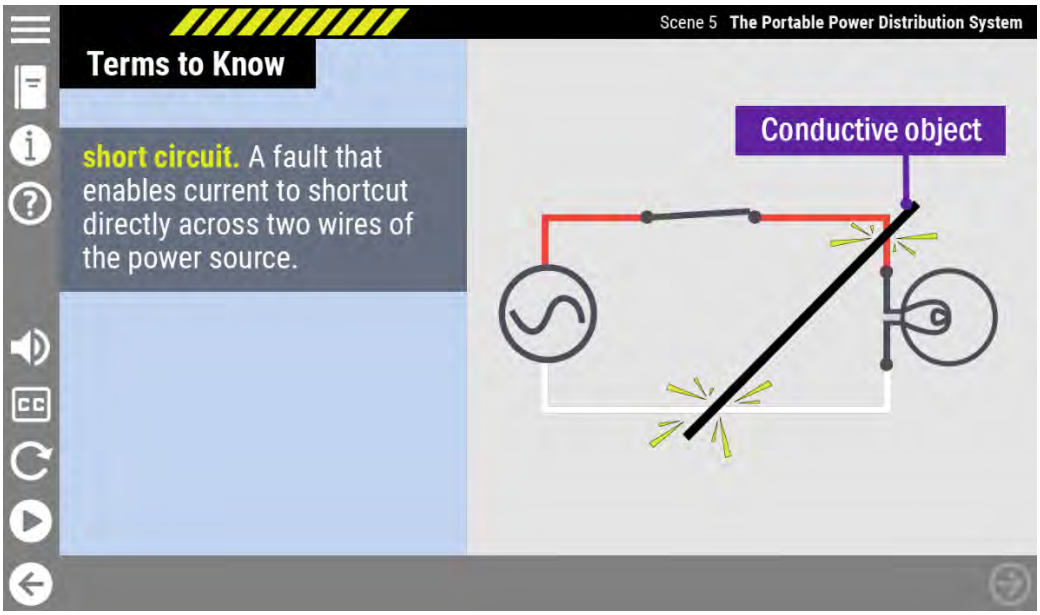
Slide 107. Terms to Know 2



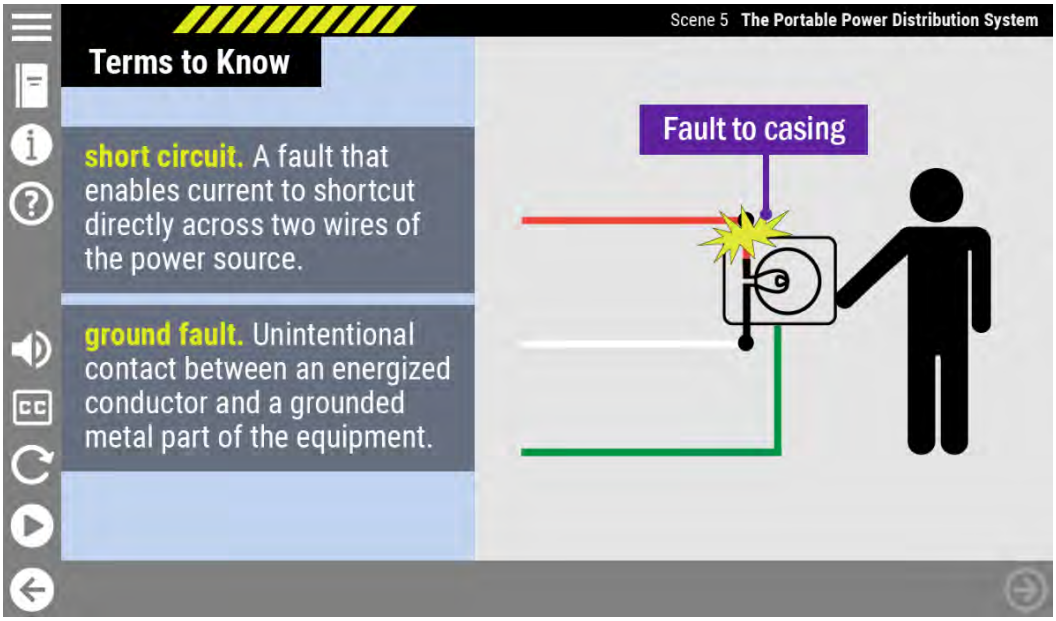
Ampacity is the maximum amperage capacity of a conductor, such as a cable.

An **overload** is a condition where current through a conductor is greater than its ampacity or greater than the rating of the fuse or circuit breaker.

Slide 108. Terms to Know 3

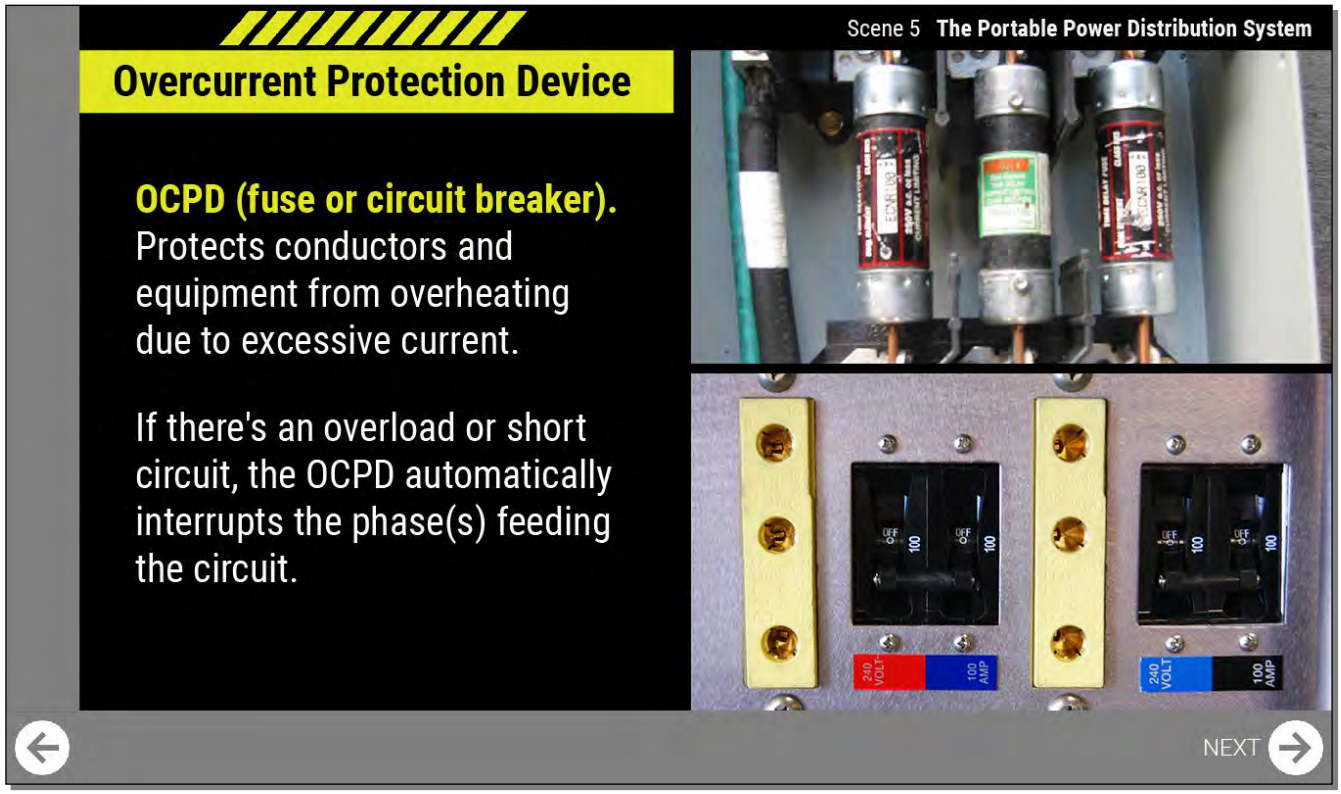


A **short circuit** is a fault in the circuit that enables current to bridge directly between two parts of the circuit that have a difference in potential, like between phase and ground or phase and neutral or between two phases. In a short circuit, current rises to a dangerous level very quickly. Common causes of short circuits are wires coming loose inside an outlet box or a light fixture, damaged insulation, or a conductive object or tool unintentionally completing a short circuit.



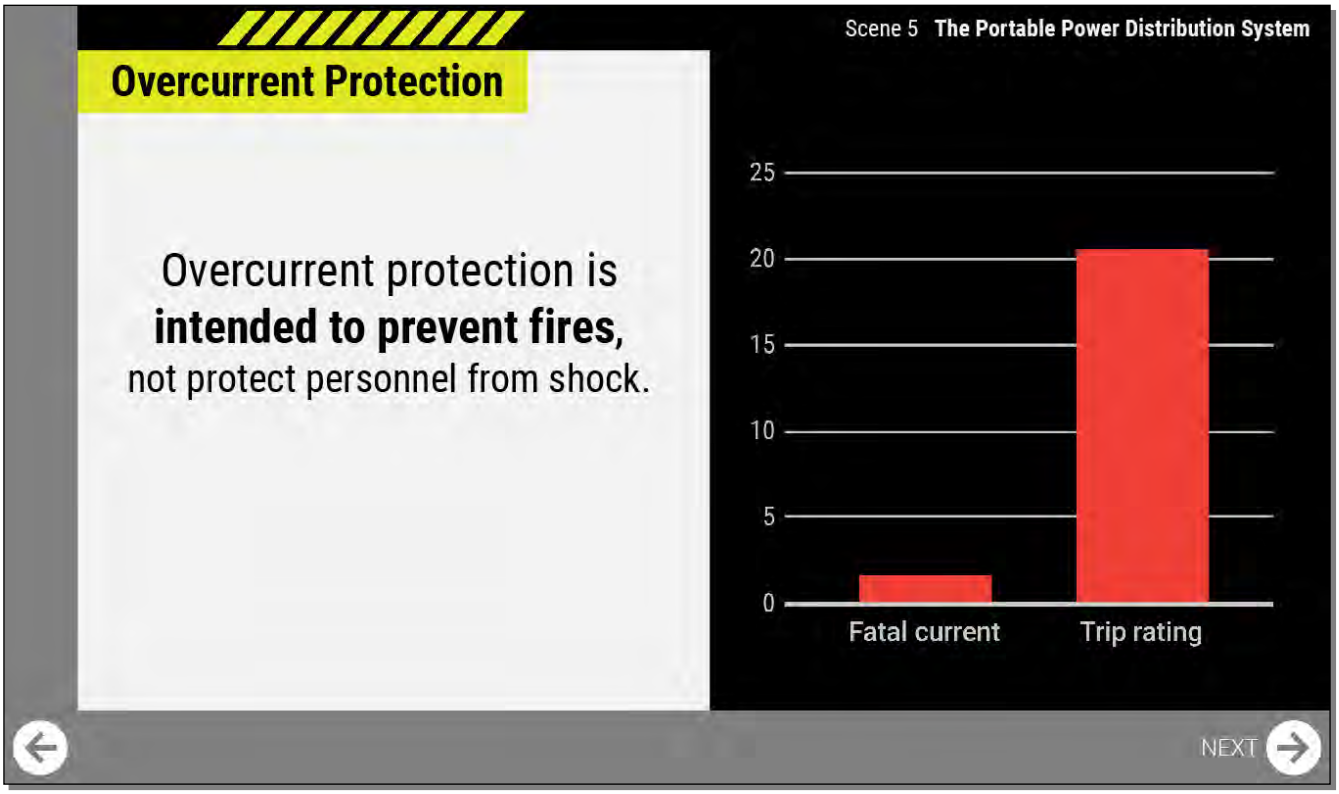
A **ground fault** is unintentional contact between an energized conductor and normally non-current-carrying parts such as the casing or housing of equipment. A ground fault would create a serious shock hazard if the circuit breaker failed to trip.

Slide 109. Overcurrent Protection Device



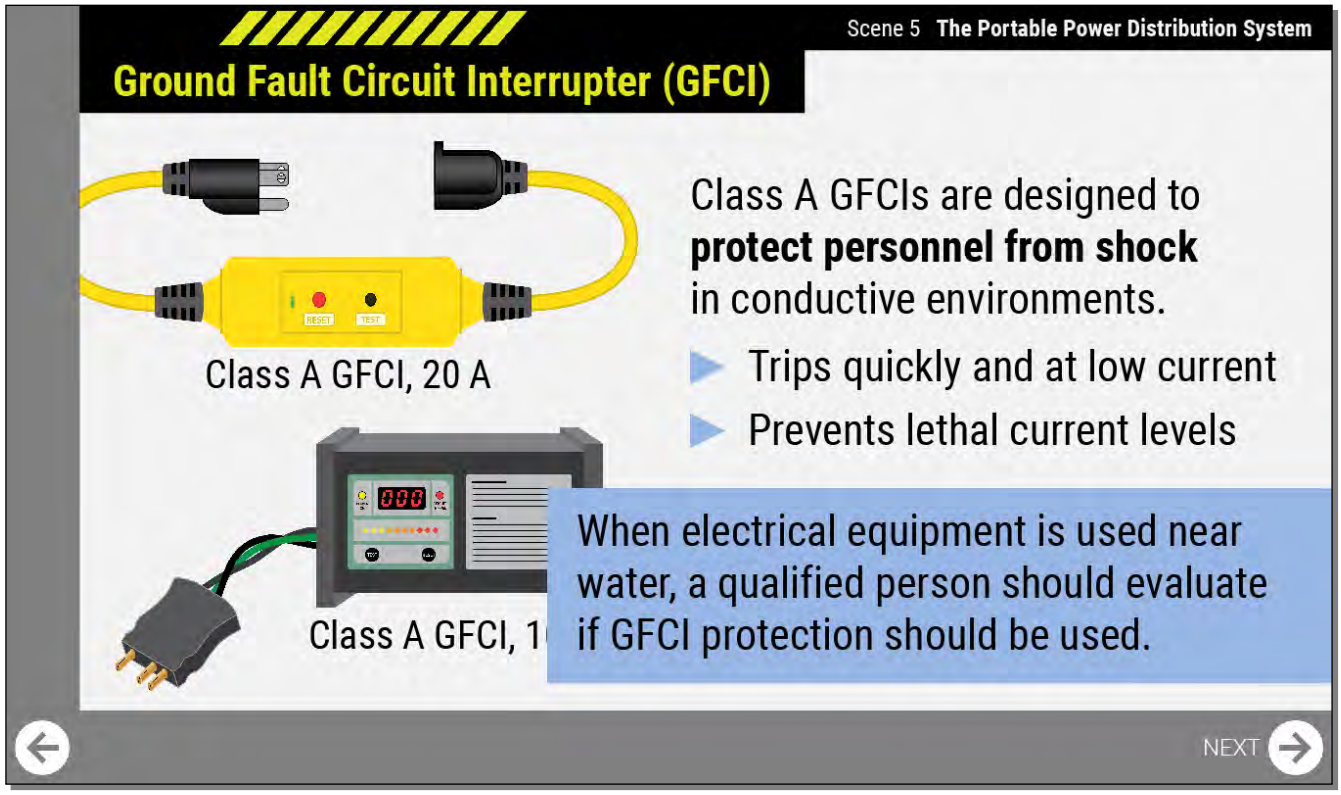
An **overcurrent protection device**, or OCPD, better known as a **fuse** or **circuit breaker,** is a required safety feature of any power circuit. Its purpose is to protect the conductors and equipment downstream of the overcurrent protection from overheating due to excessive current. Overheated cables can lead to destruction of the insulation, short circuits, sparks, fire, and possible exposure to electrical shock. In the event of an overload or short circuit, the overcurrent device automatically interrupts the phase (or phases) feeding the circuit.

Slide 110. Overcurrent Protection



Circuit breakers and fuses are primarily intended to prevent fires. They do *not* protect a person who is being shocked. It takes only about 0.2 amps of electricity traveling across a person's chest to cause heart failure, whereas it can take up to 20 amps or more to trip the smallest circuit breaker we use. The amount of current and time required to trip the OCPD is far greater than that required to deliver a potentially lethal shock. They are not designed or intended to protect you from shock if your body is in the path of a short circuit.

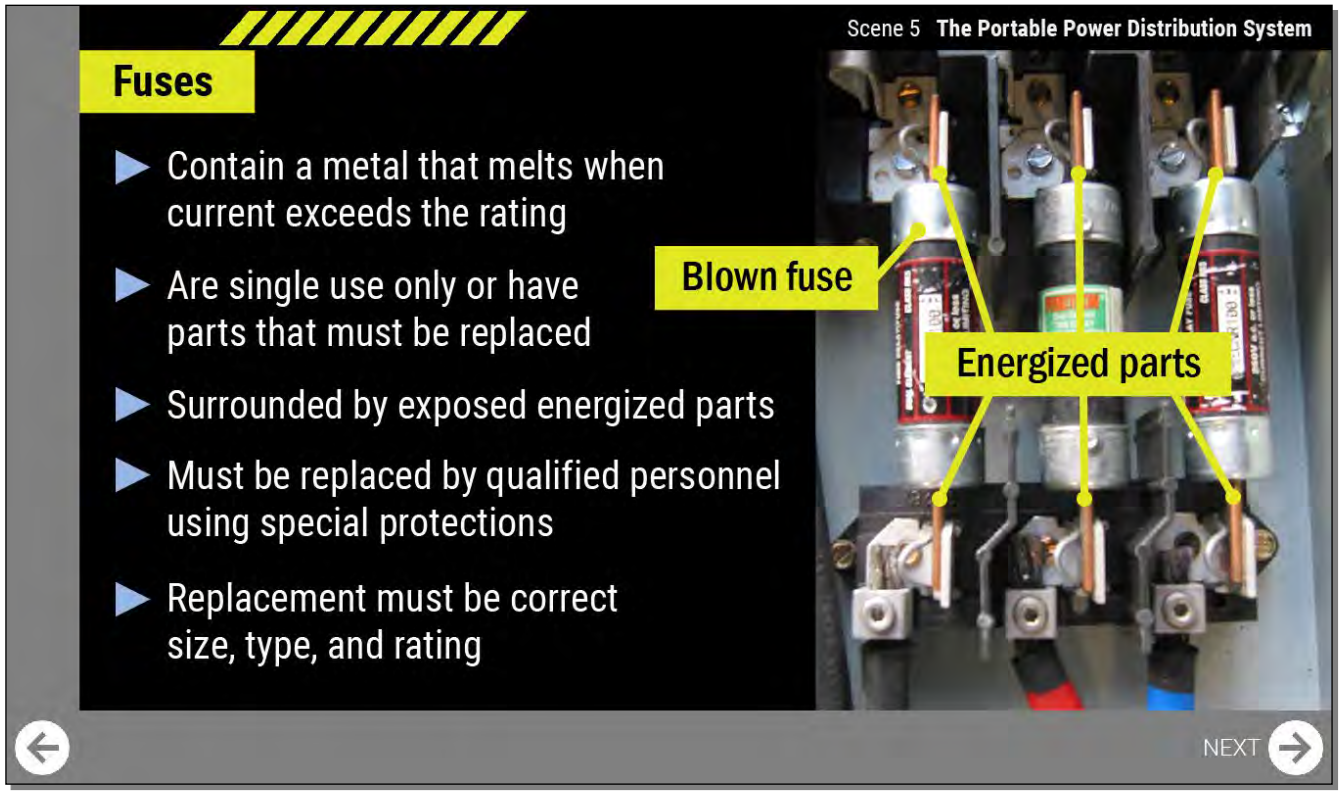
Slide 111. GFCIs



Unlike a circuit breaker or fuse, a **ground fault circuit interrupter**, or GFCI, is designed to protect personnel from shock in conductive environments, like around water. It trips before leakage current can reach a dangerous level. A GFCI IS NOT an overcurrent protection device. It serves a different purpose and is not a substitute for overcurrent protection.

Any time electrical equipment is used near water, a qualified person should evaluate if GFCI protection should be used.

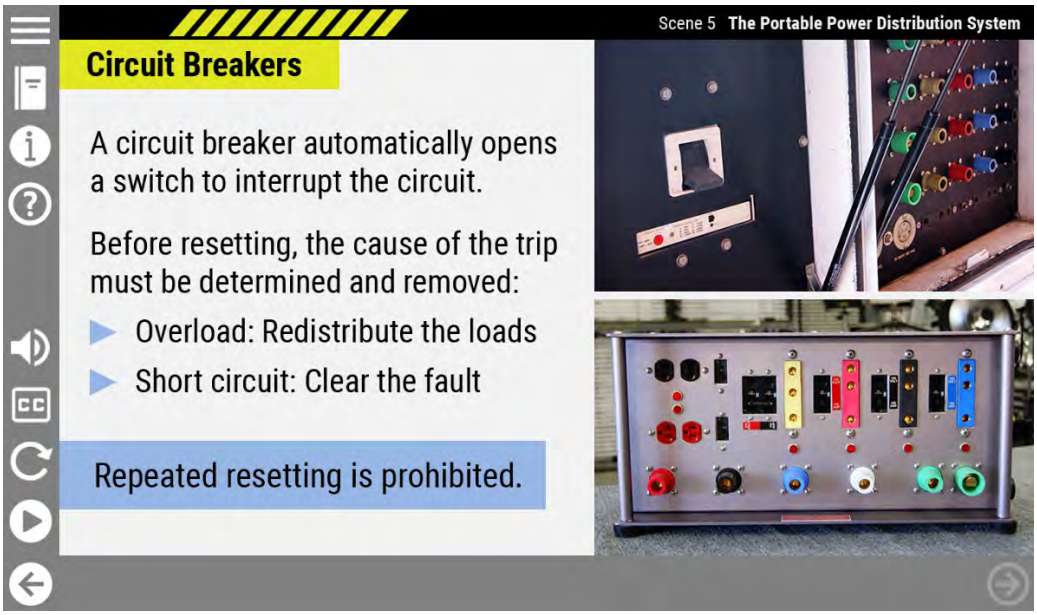
Slide 112. Fuses



Getting back to our discussion of overcurrent protection devices, let's begin with fuses. A **fuse** is an electrical device containing a metal that melts when current exceeds the rating of the fuse, thereby interrupting the circuit. Fuses are single use only or have parts that must be replaced once they have blown. Fuses are surrounded by other exposed parts that remain energized even if one fuse has blown.

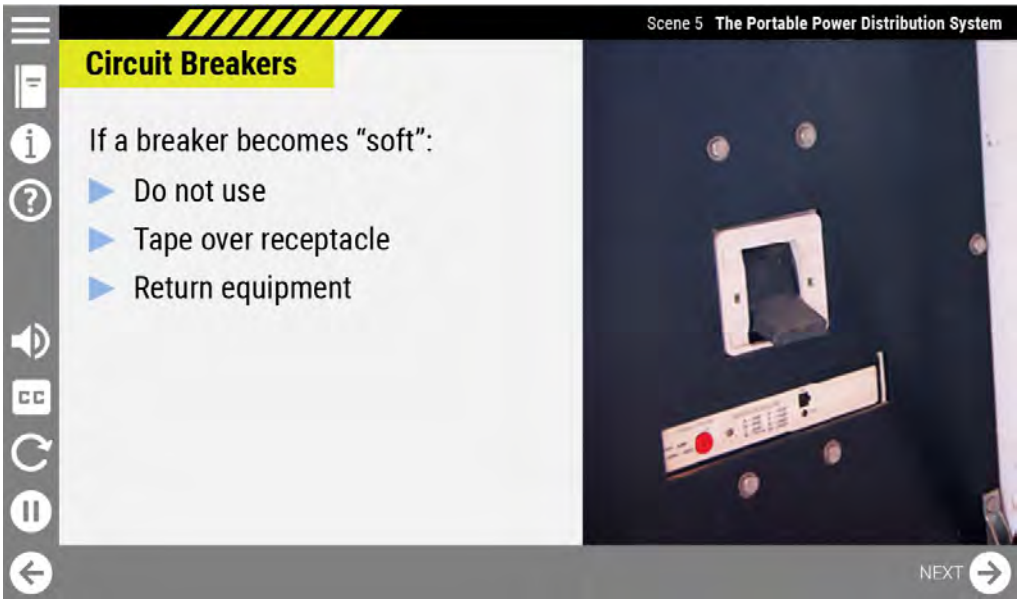
Only qualified personnel are permitted to replace fuses on energized systems. Appropriate voltage-rated and arc-rated PPE may be required, and safe procedures must be used. Fuse specifications affect the function and operational safety of the system. A blown fuse must be replaced with one of the correct size, type, and rating. Replacing a fuse with a metal slug is prohibited.

Slide 113. Circuit Breakers



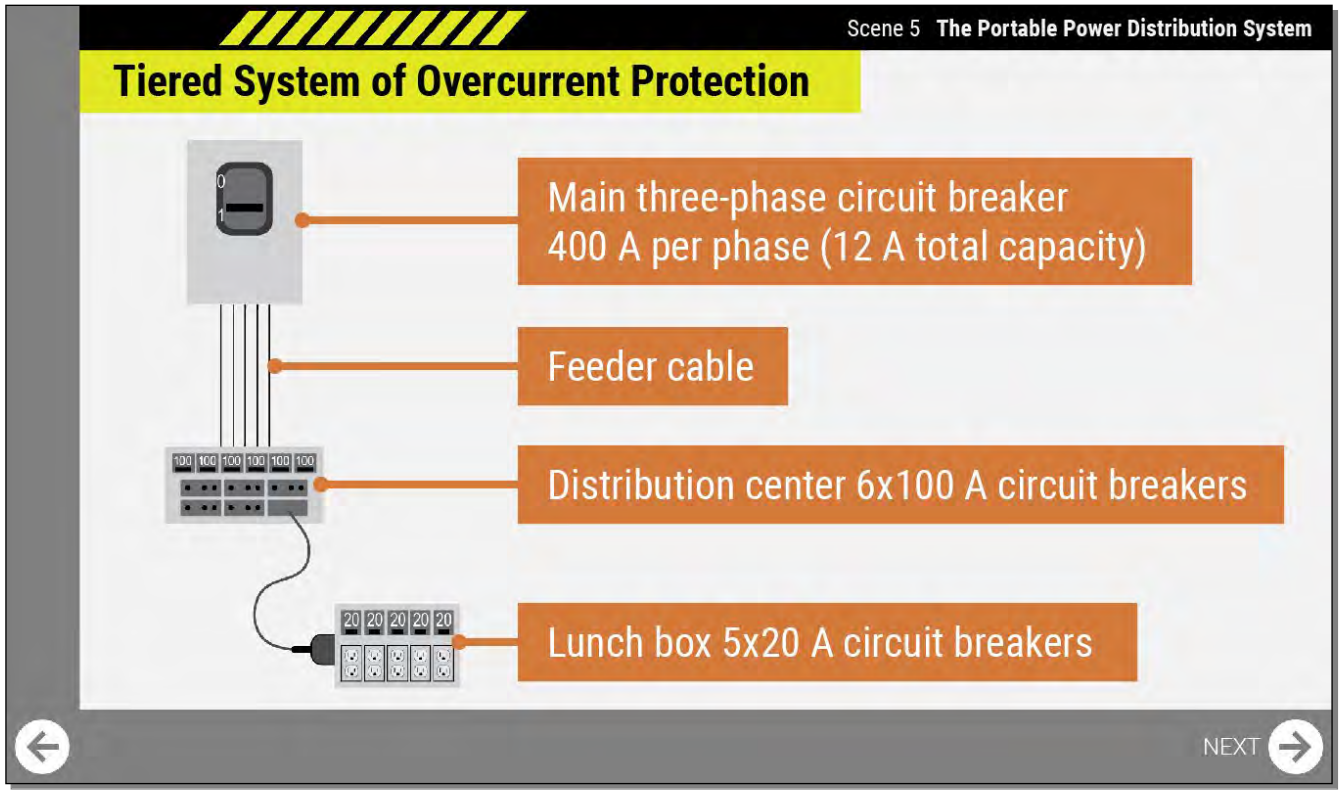
A circuit breaker is an automatic switch that opens to interrupt the circuit in the event of overload or short circuit. A circuit breaker may be reset many times before it wears out.

Before resetting a circuit breaker, the cause of the trip must be determined and removed. If the trip was due to an overload, the loads should be redistributed. If it was a short circuit, the fault should be cleared. Repeated resetting is prohibited.



If a breaker becomes "soft" and trips repeatedly for no reason, it should not be used. Tape over the receptacle and breaker and label it "Do not use." Have the equipment returned for repair.

Slide 114. Tiered System

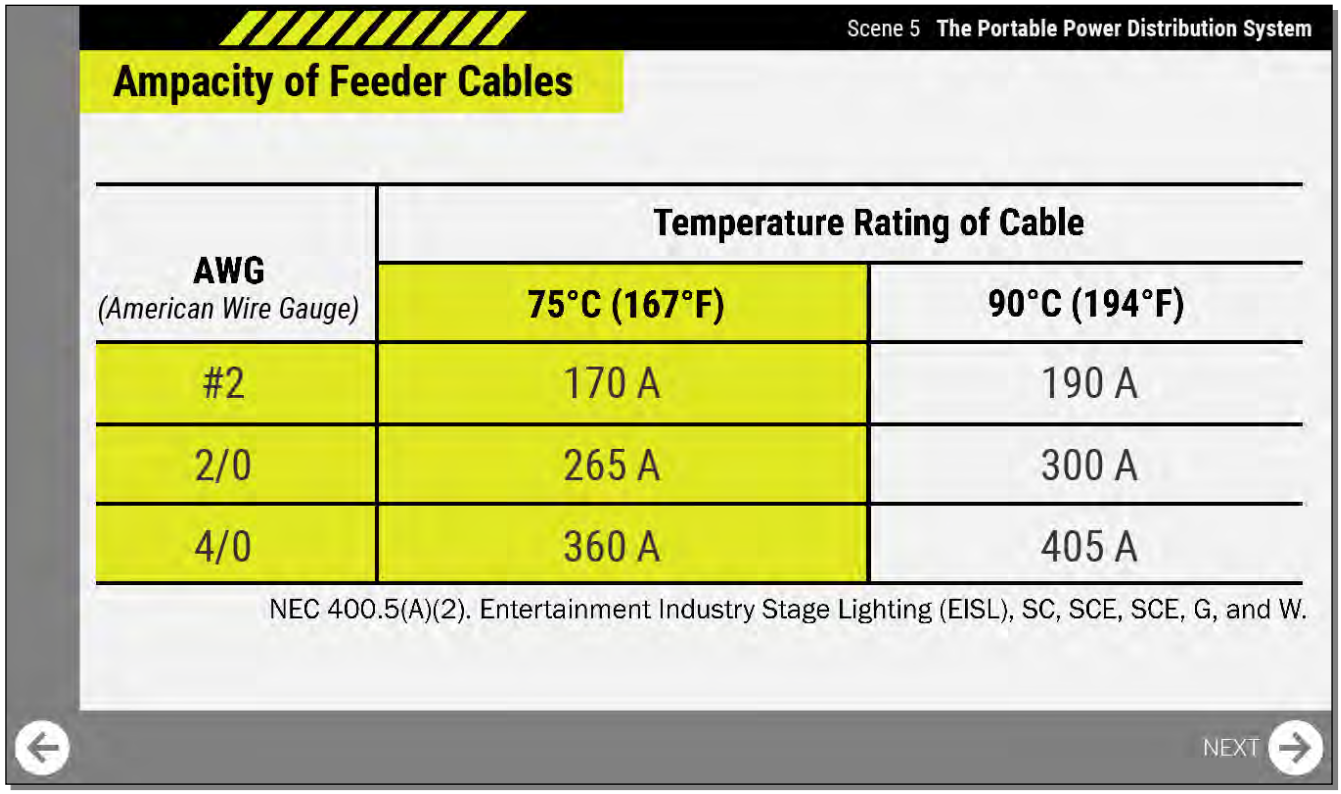


As you know, overcurrent protection is used in a tiered system, with large capacity circuit breakers protecting feeder cables and lower capacity circuit breakers protecting smaller cables.

The illustration shows a main circuit breaker like the one on a generator. It protects the main feeder at 400 amps. The distribution center provides six, 100-amp circuit breakers to protect each of the sub-circuits. And finally, a lunch box provides five, 20-amp circuit breakers to protect the branch circuits.

But there is more to the relationship between the rating of overcurrent protection and the ampacity of the feeder cables. Let's dig a little deeper, starting with the ampacity of the cables.

Slide 115. Ampacity of Feeder Cables 1

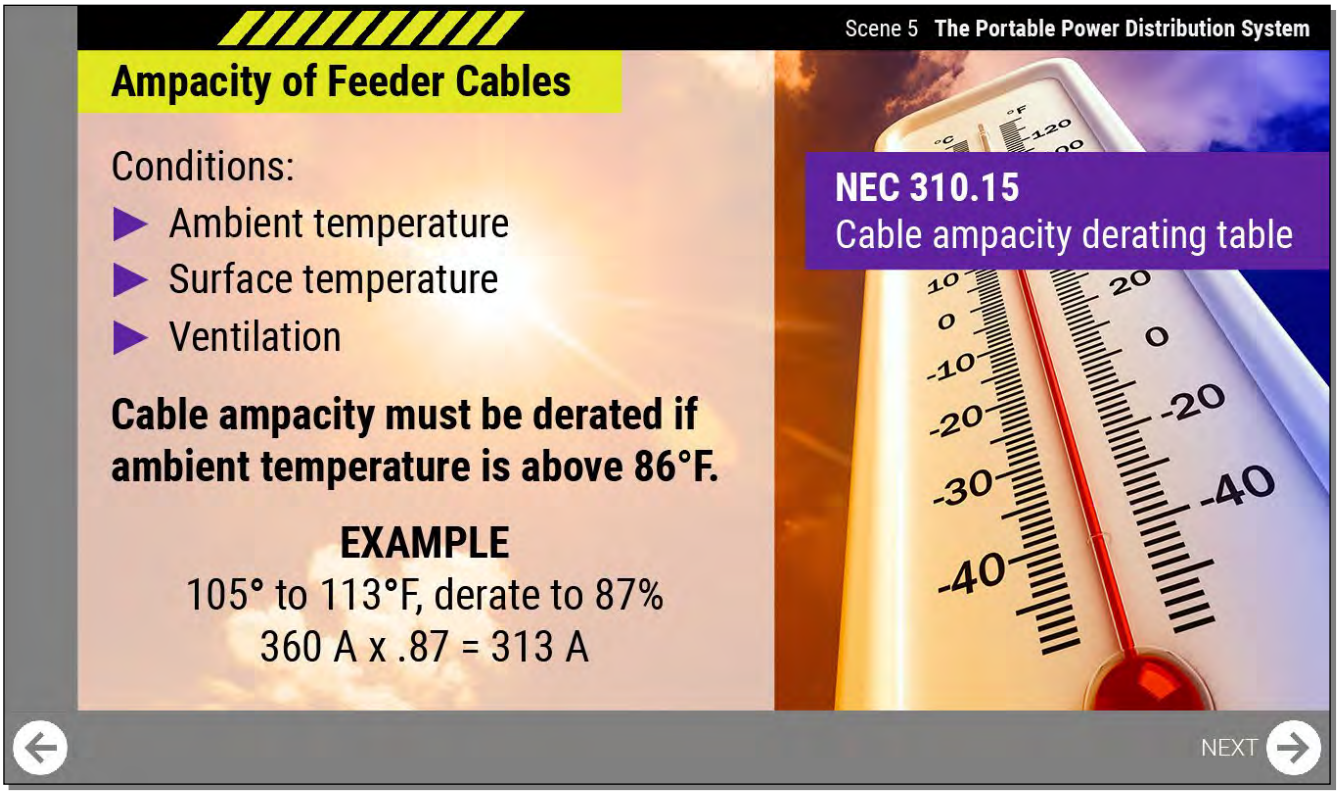


The two primary factors that determine the amperage capacity of a cable are wire gauge and the temperature rating that is applied.

This table is an excerpt from the NEC showing the ampacity of three commonly used feeder sizes. For portable power systems, cable ampacity is based on the 75-degree column: 170 amps for banded #2 cable, 265 amps for two-aught, and 360 amps for four-aught cable.

The 75-degree column is used because, even though the cable we use has a higher temperature rating, circuit breakers, connectors, and other component parts are rated at 75 degrees, so the whole system gets rated at 75 degrees.

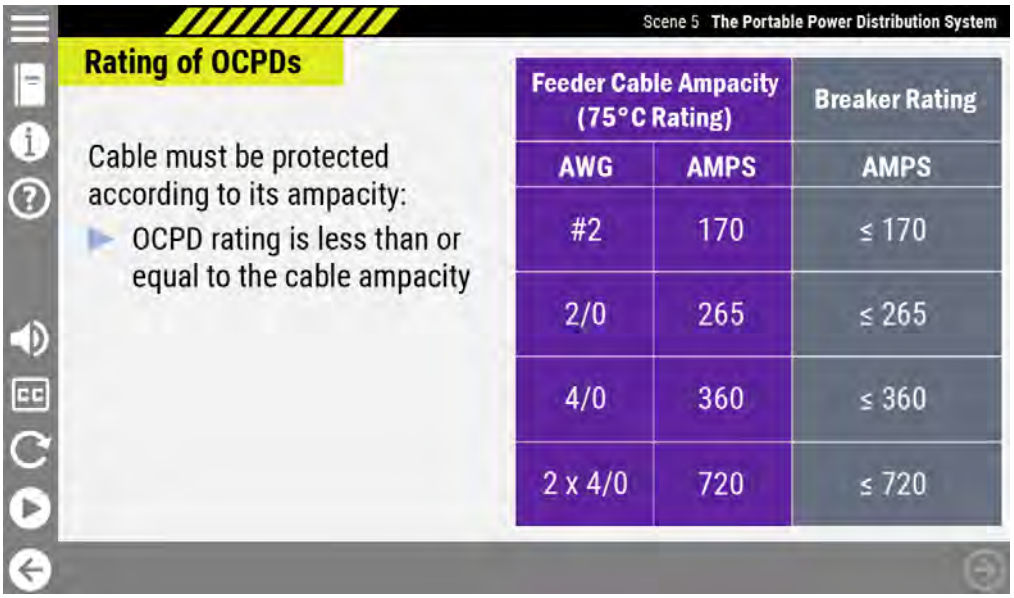
Slide 116. Ampacity of Feeder Cables 2



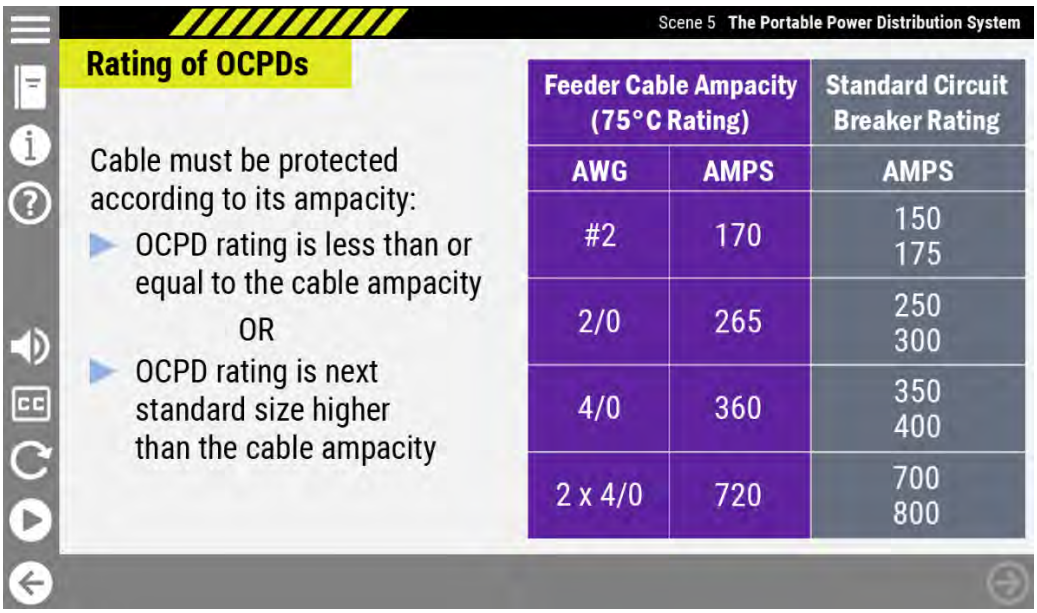
The conditions in which cable is used also affect its ampacity. Cable temperature can increase if the ambient temperature is high, if the cable is laid out on hot asphalt or concrete, or if the cable can't properly ventilate.

The NEC requires that cable ampacity be derated if the ambient temperature is above 86 degrees Fahrenheit. For example, if the ambient temperature is between 105- and 113-degrees Fahrenheit, NEC tables specify that cable ampacity must be derated to 87 percent of the allowable ampacity. So, 4/0 cable with an ampacity of 360 amps, would be derated to 313 amps.

Slide 117. Rating of OCPDs



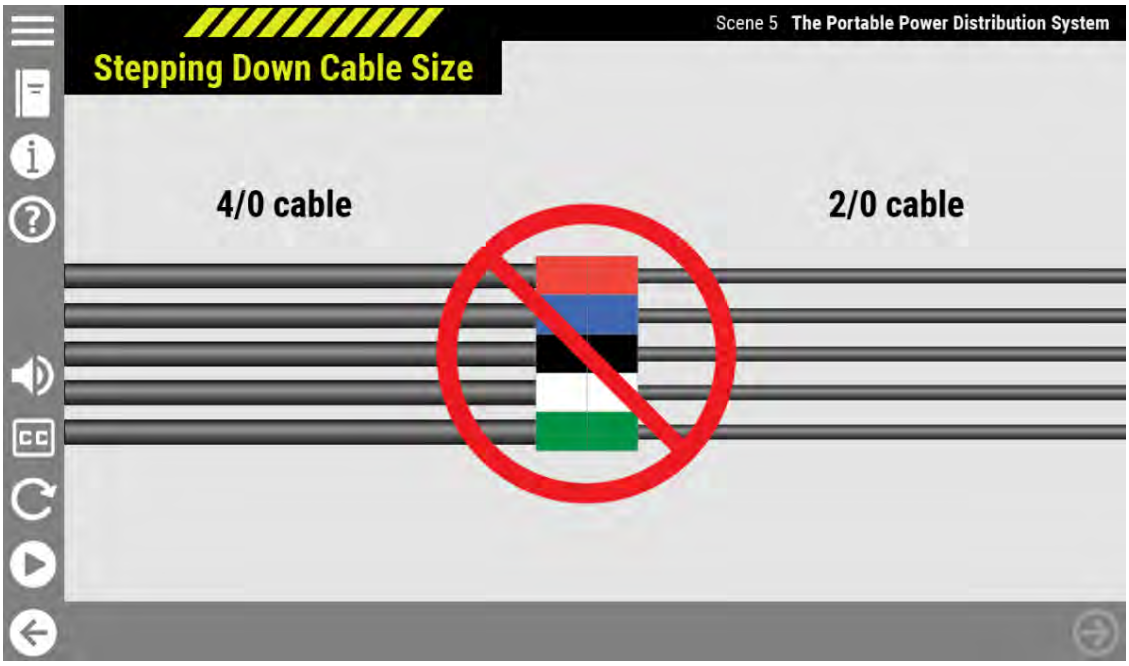
As a rule, for **feeder circuits**, the electrical code requires that the rating of the overcurrent protection is less than or equal to the ampacity of the portable feeder cables being protected. That way, the circuit breaker will always trip before the cable's capacity can be exceeded.



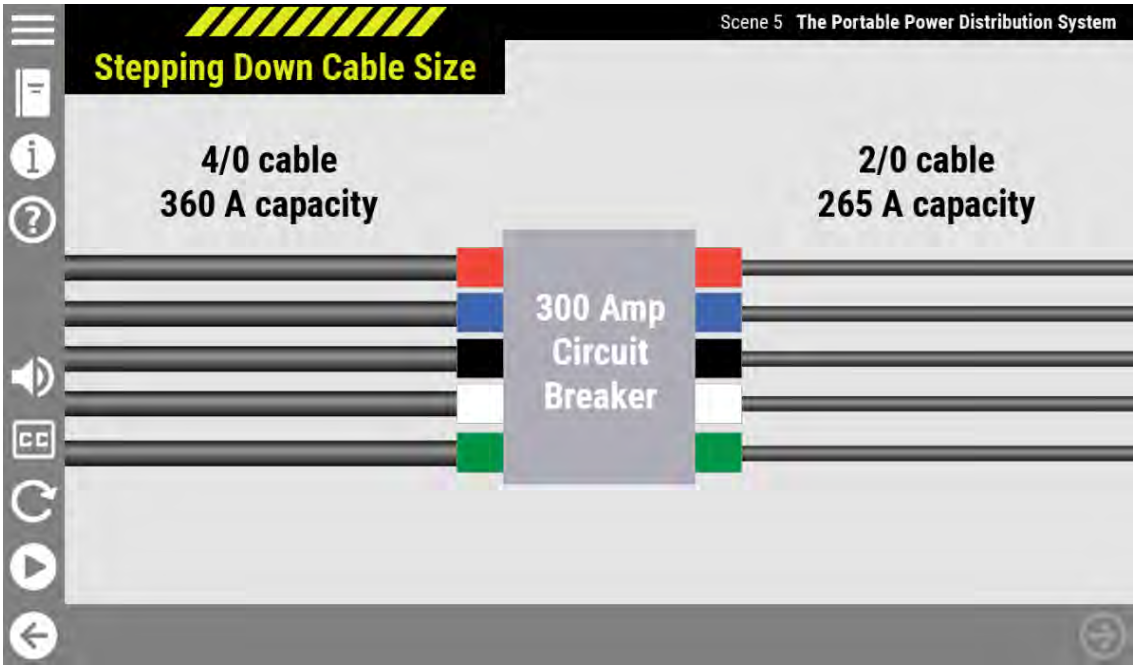
However, if the ampacity of the feeders is between the standard overcurrent ratings, the NEC permits using the next higher standard OCPD rating above the ampacity of the cable.

For example, 4/0 cable is typically rated at 360 amps. Standard sized circuit breakers are 350 amps and 400 amps. It is permissible to use a 400-amp circuit breaker as it is the next higher standard size. This rule applies to OCPDs that are rated 800 amps or less.

Slide 118. Stepping Down Cable Size 1



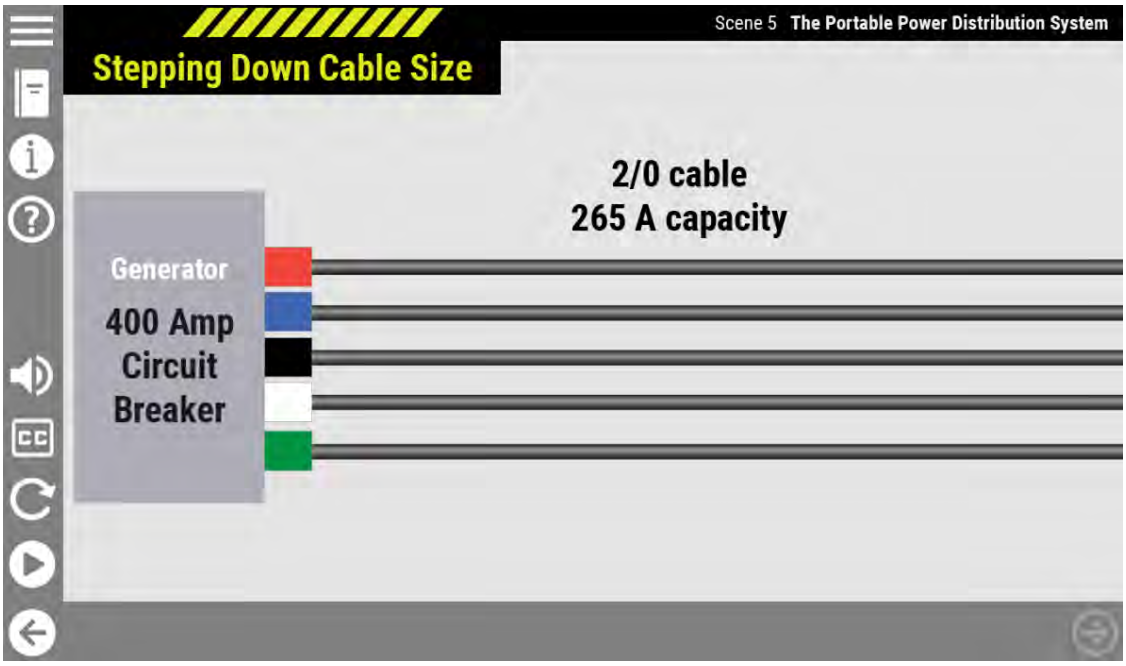
As a rule, you are not permitted to step down the size of the cable without providing



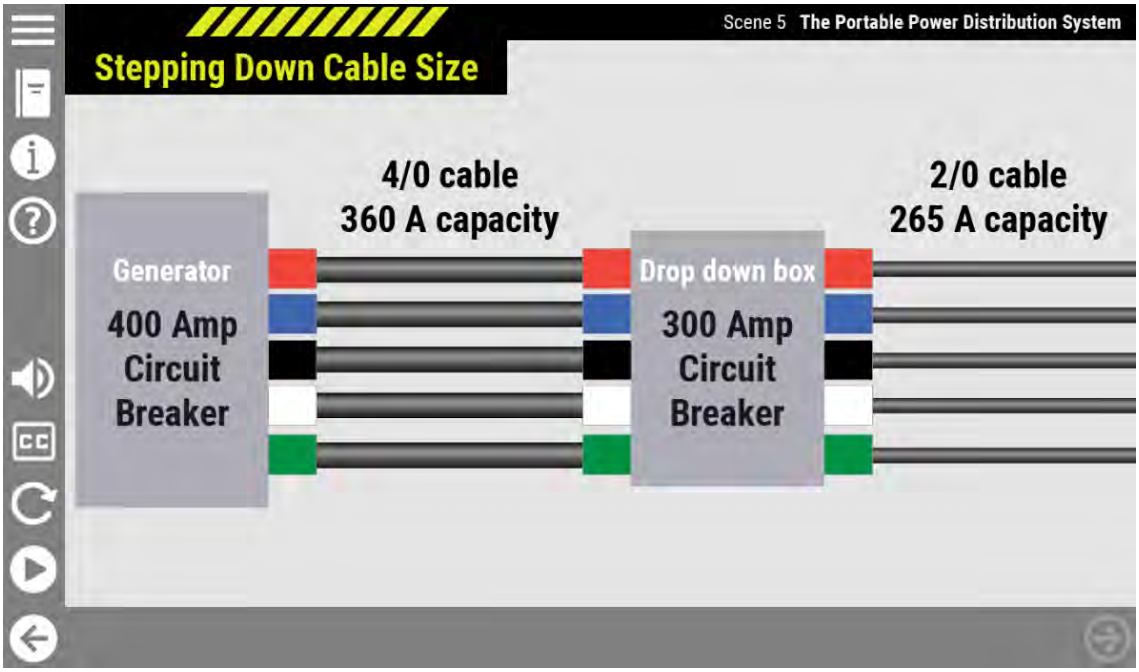
overcurrent protection that is sized appropriately for the downstream feeder cable.

Can you think of a situation where a cable is not protected at its ampacity?

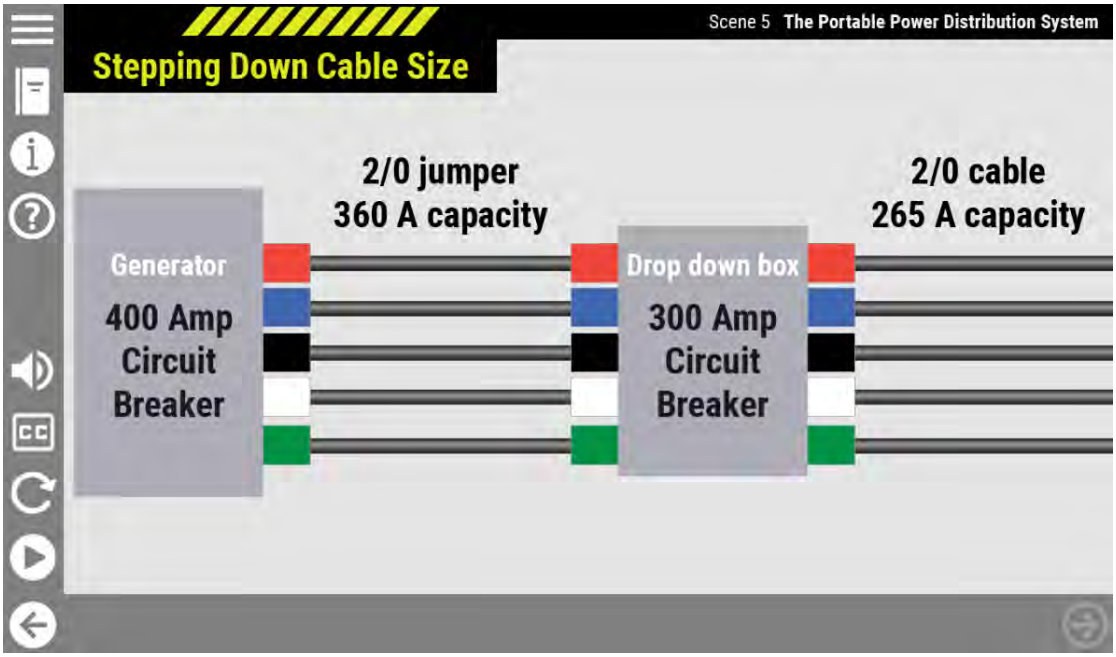
Slide 119. Stepping Down Cable Size 2



What if you just want to run a 2/0 or banded cable from the generator, but the generator has a 400-amp circuit breaker? According to the NEC, 2/0 cable must be protected at no more than 300 amps and banded at no more than 175 amps. There are two methods that solve this problem.

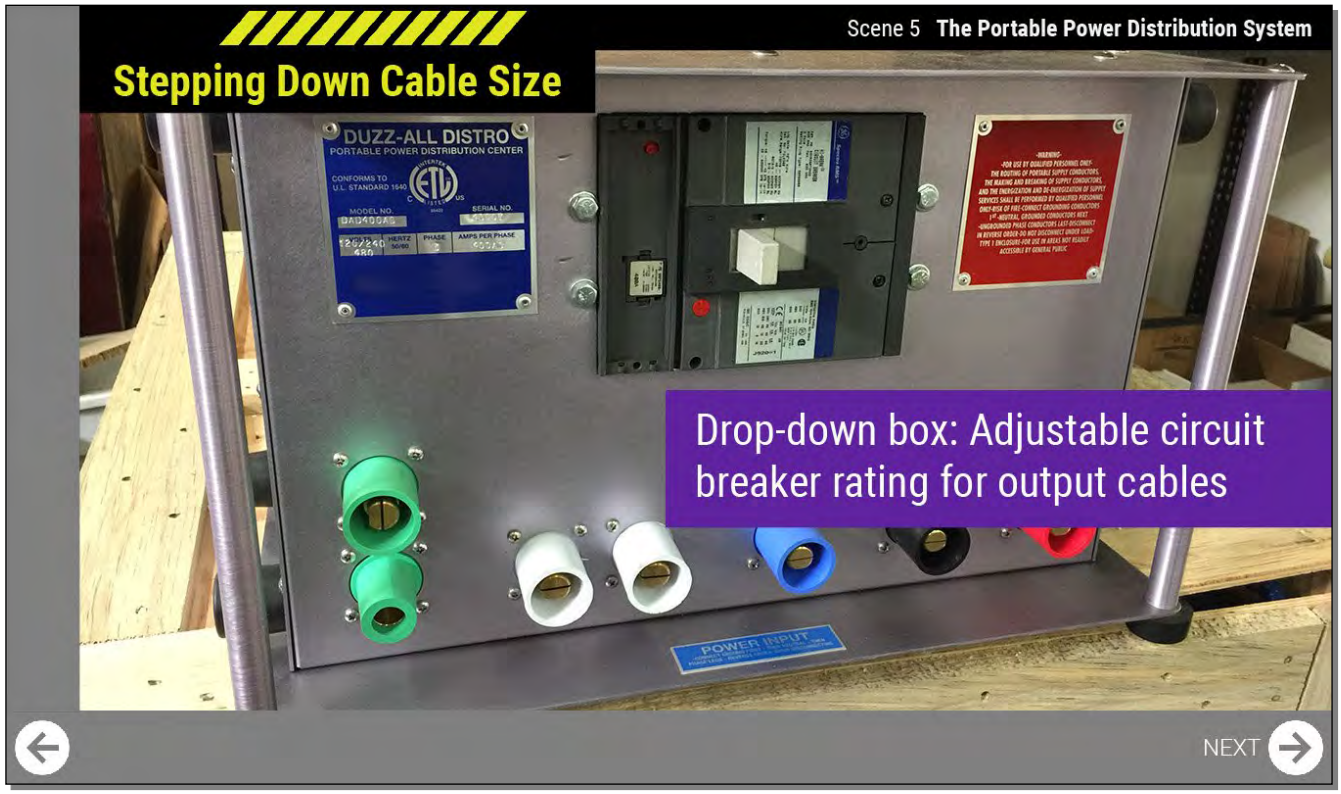


One solution is to run short 4/0 cables from the power source to a **drop-down box** that provides appropriately rated overcurrent protection for the smaller cables. These are typically ten-foot cables and are not permitted to be longer than 25 feet.



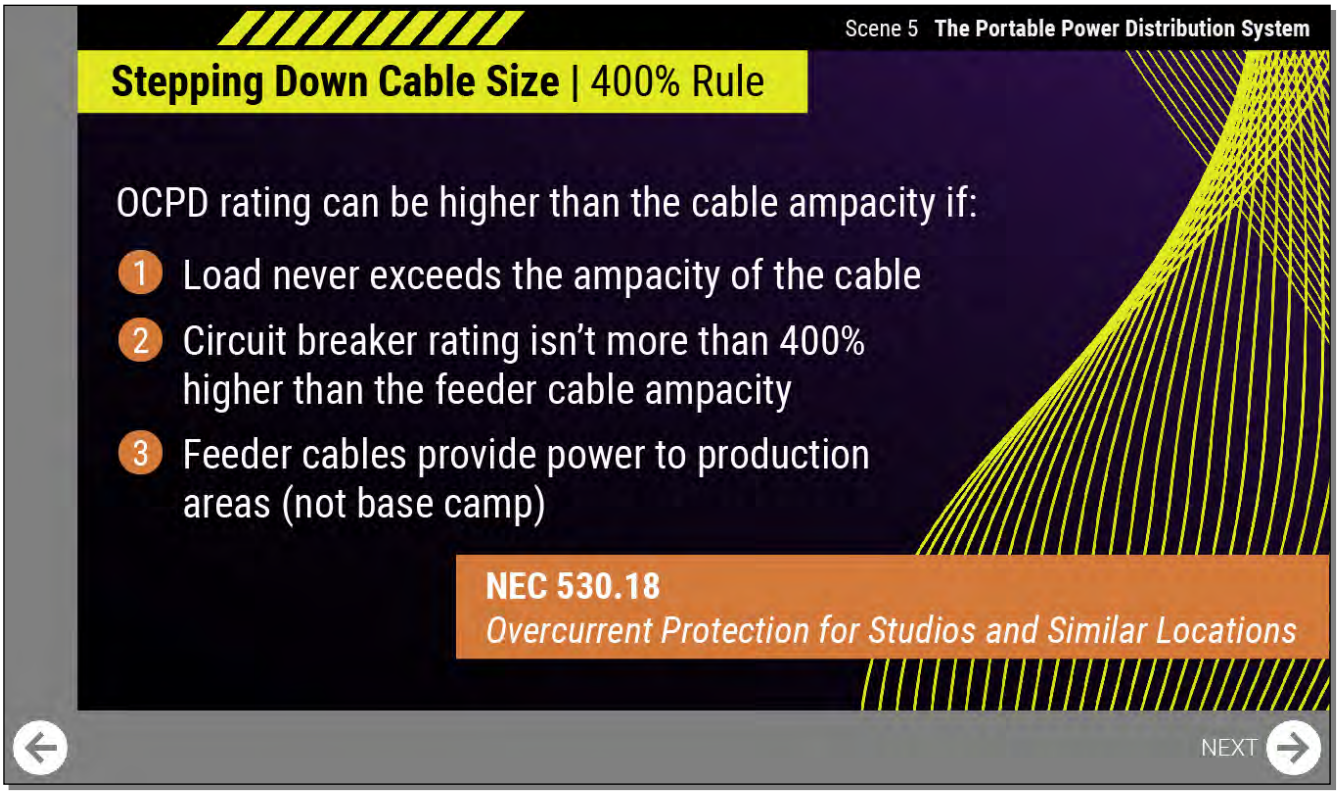
Alternatively, you can use the smaller-sized cables to feed the drop-down box, provided that those cables are jumpers no longer than 25 feet in length.

Slide 120. Stepping Down Cable Size 3



The rating of the circuit breaker on a box like this one is adjustable from 170 to 400 amps, so it can be used to protect banded, 2/0, or 4/0 feeder cable.

Slide 121. The 400% Rule



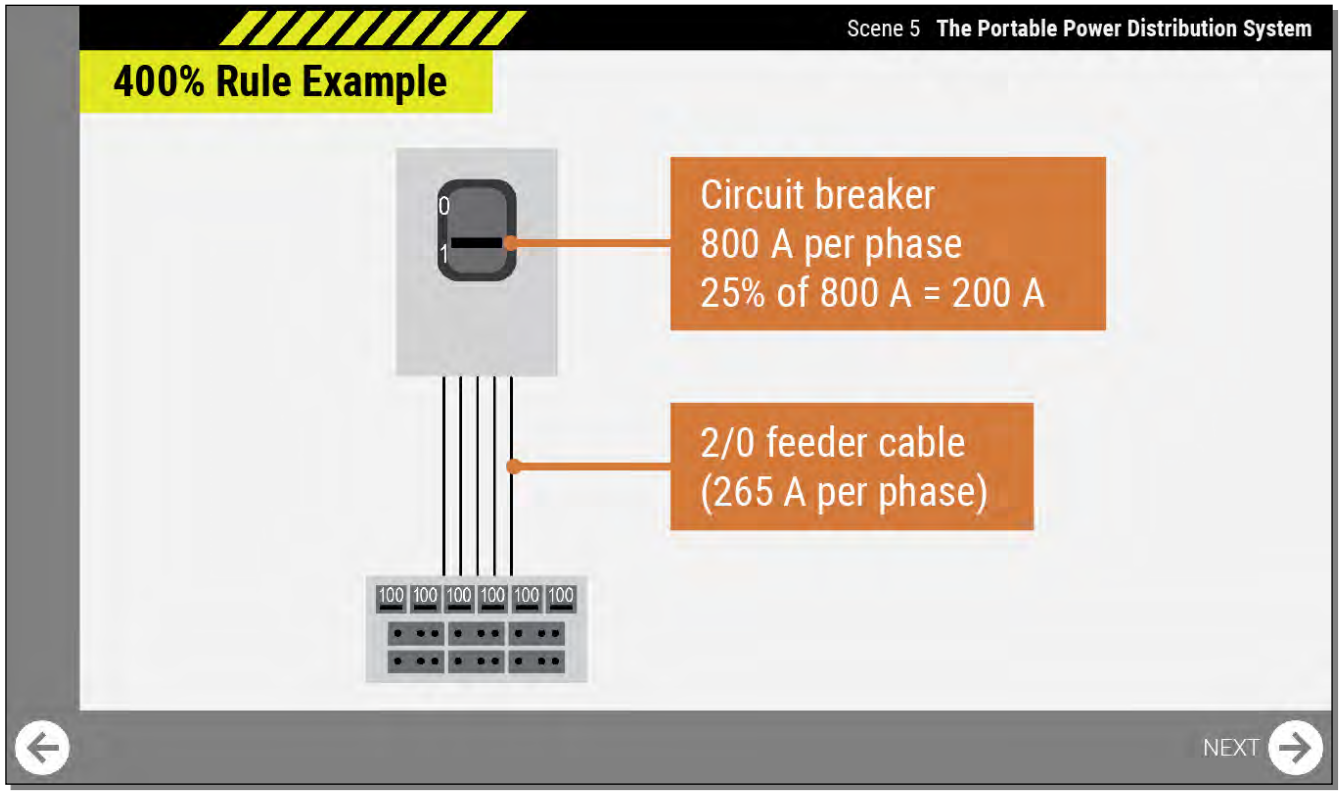
Another way that can sometimes be used to step down cable size is to follow a special rule provided in Article 530 of the NEC known unofficially as the **400% Rule**. Under this rule, the rating of the overcurrent protection can be higher than the cable ampacity, provided three conditions are met.

One: The load must never exceed the ampacity of the cable.

Two: The circuit breaker rating cannot be more than 400% higher than the feeder cable ampacity. The NEC sets this limit to ensure the circuit breaker can still provide reliable short circuit protection. Connecting a cable that is too small could be dangerous.

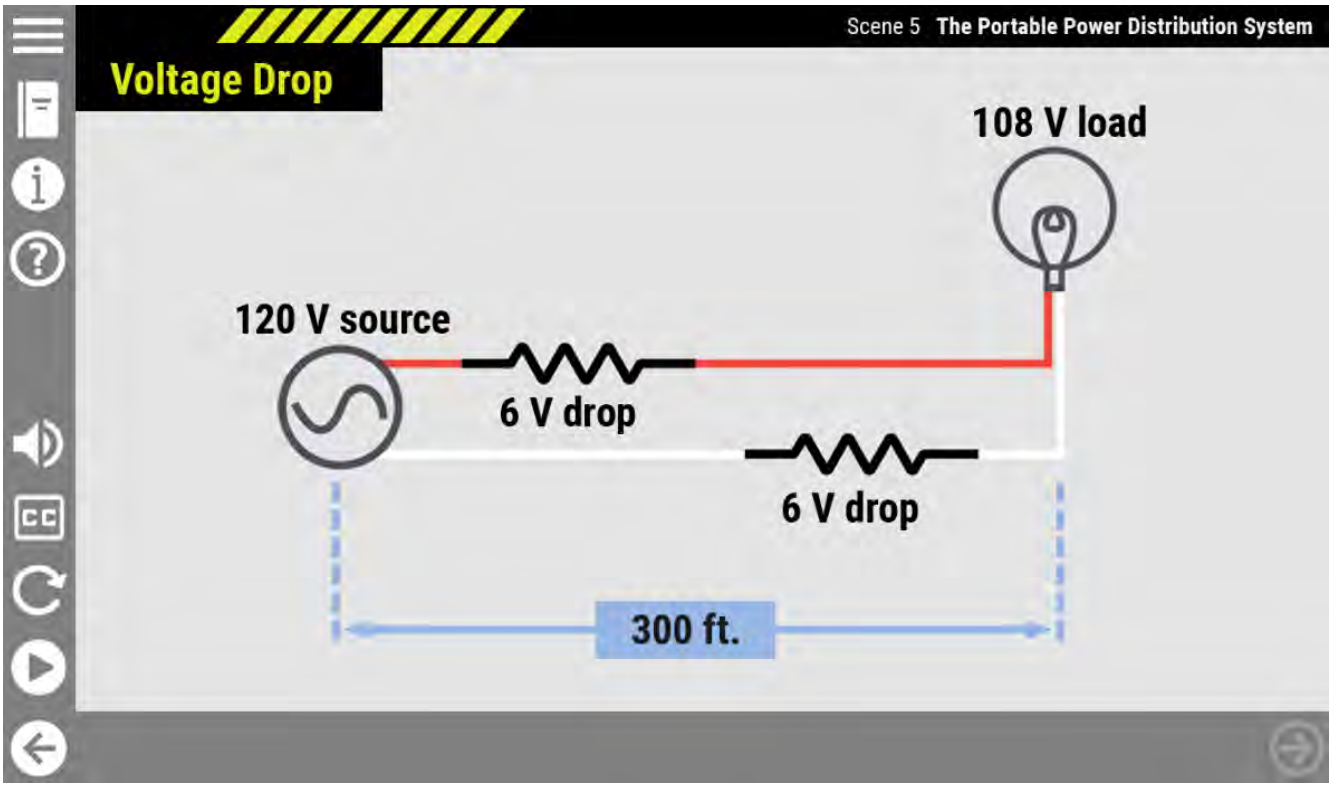
And **three:** The rule applies only to single-conductor feeder cables with single-pole separable connectors that are used in **production areas**. It does not apply to basecamp or any other non-production areas.

Slide 122. The 400% Rule Example



As an example, let's say a generator has an 800-amp circuit breaker. The 400% Rule says the circuit breaker cannot be more than 400% of the cable ampacity, so in this example the smallest cable that could be connected directly to the generator bus is 200-amp cable. 2/0 cable is rated at 265 amps, so it would be permissible. However, banded cable rated at 170 amps would be too small.

Slide 123. Voltage Drop

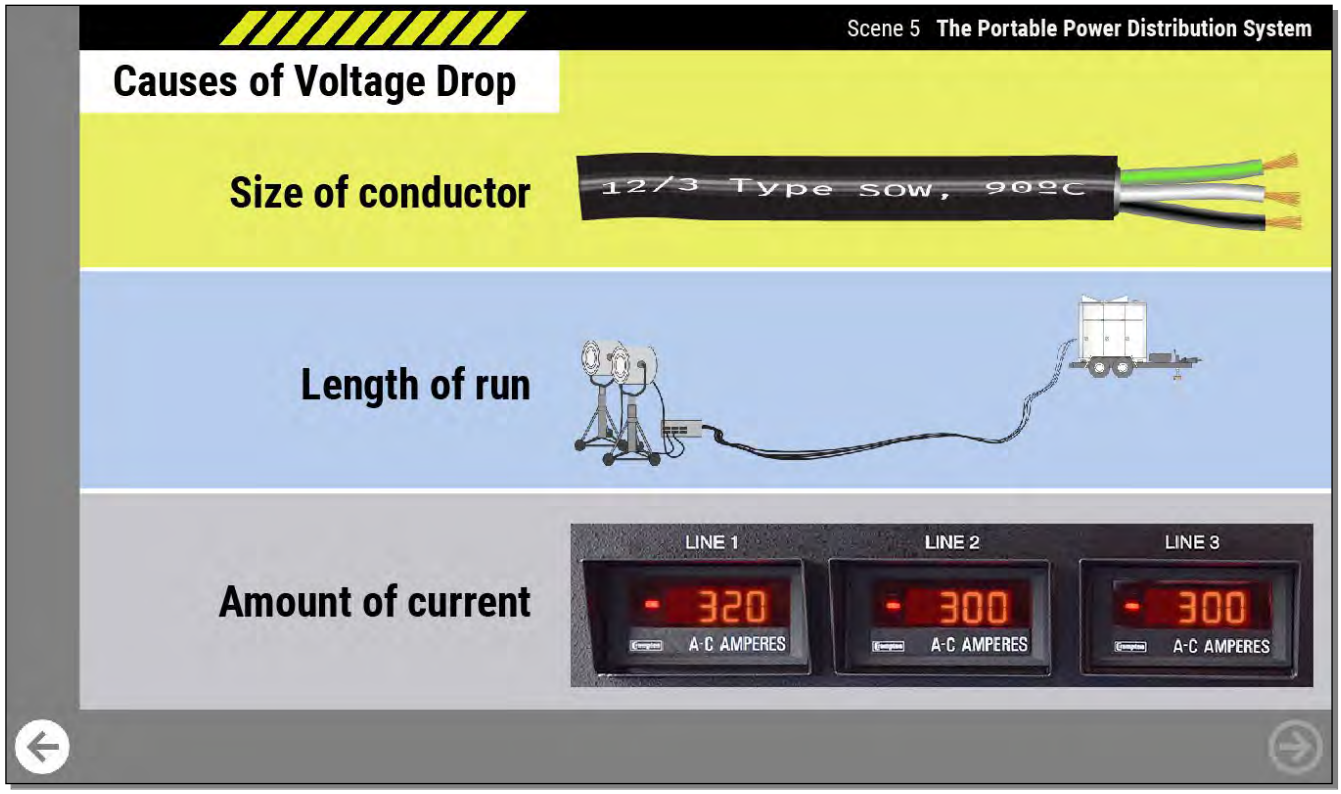


Voltage drop is a decrease in voltage from one end of the feeder to the other due to the resistance of the cable. The illustration shows an example where the electricity makes a 600-foot round trip journey from source to load and back. The cable eats up a total of 12 volts, leaving only 108 volts to power the loads.

Depending on the type of load, excessive voltage drop could also cause unreliable operation and possible damage to the load.

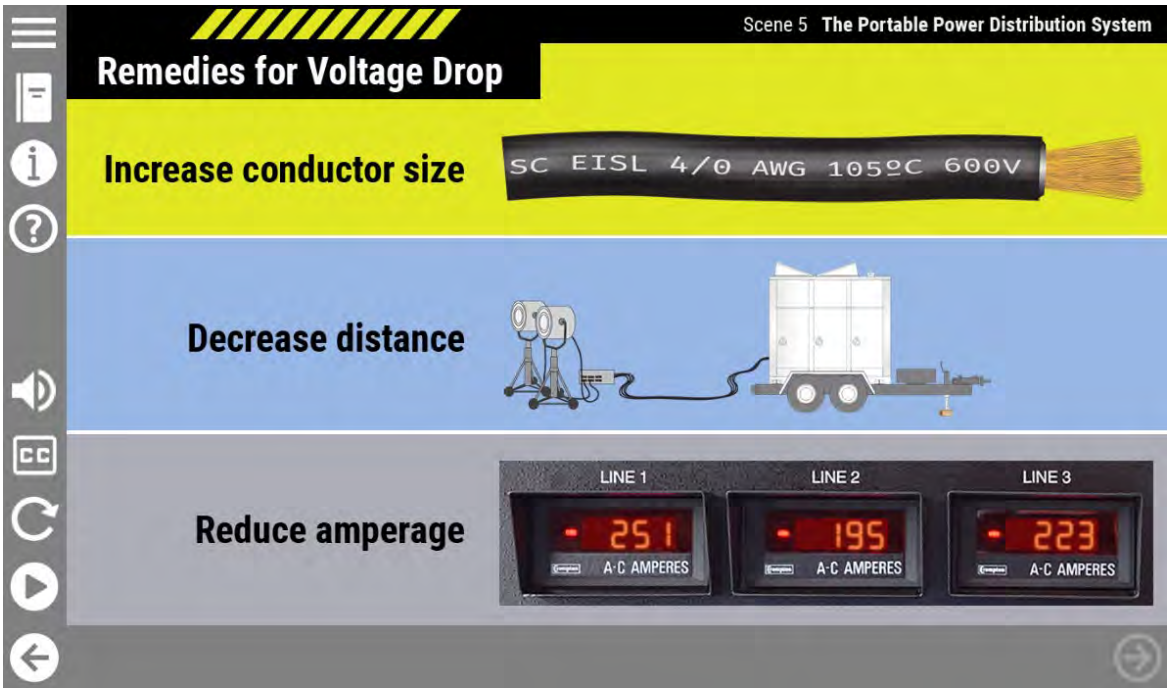
The generator operator can help ensure that the voltage that is delivered to electrical devices on set is optimal. To do this you need to understand the factors that affect **voltage drop**.

Slide 124. Causes of Voltage Drop

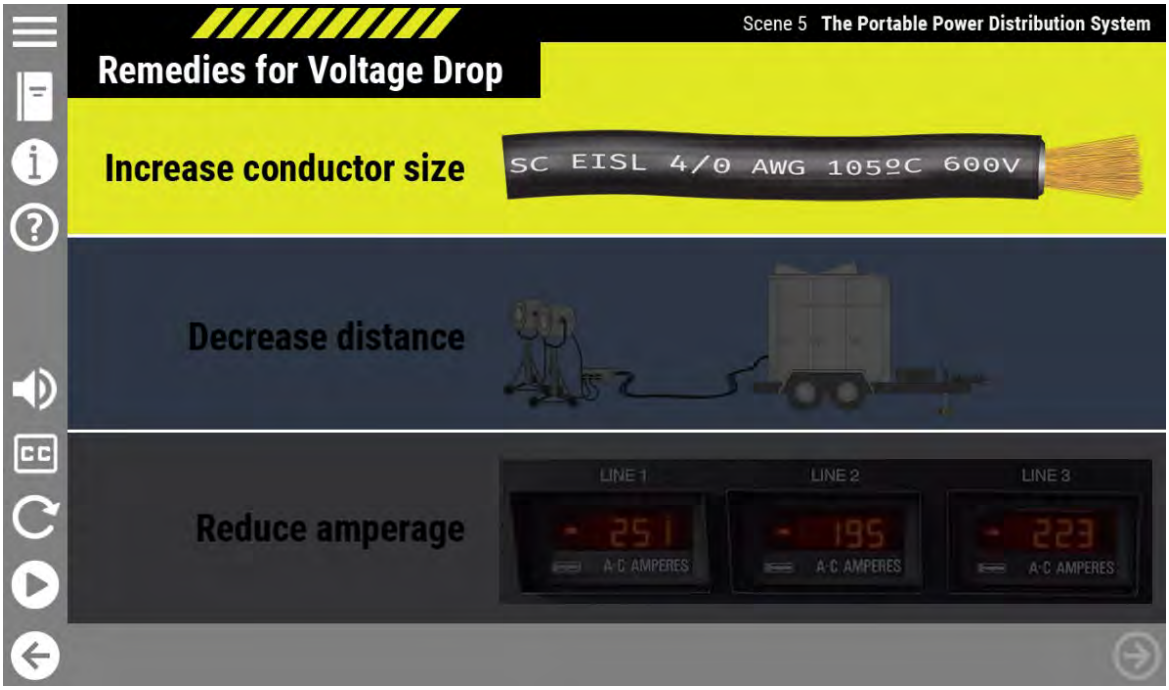


Three primary factors contribute to the amount of voltage drop: the **size** of the conductors, the **length** of the run, and the **amperage load** that the cable carries.

Slide 125. Remedies for Voltage Drop 1

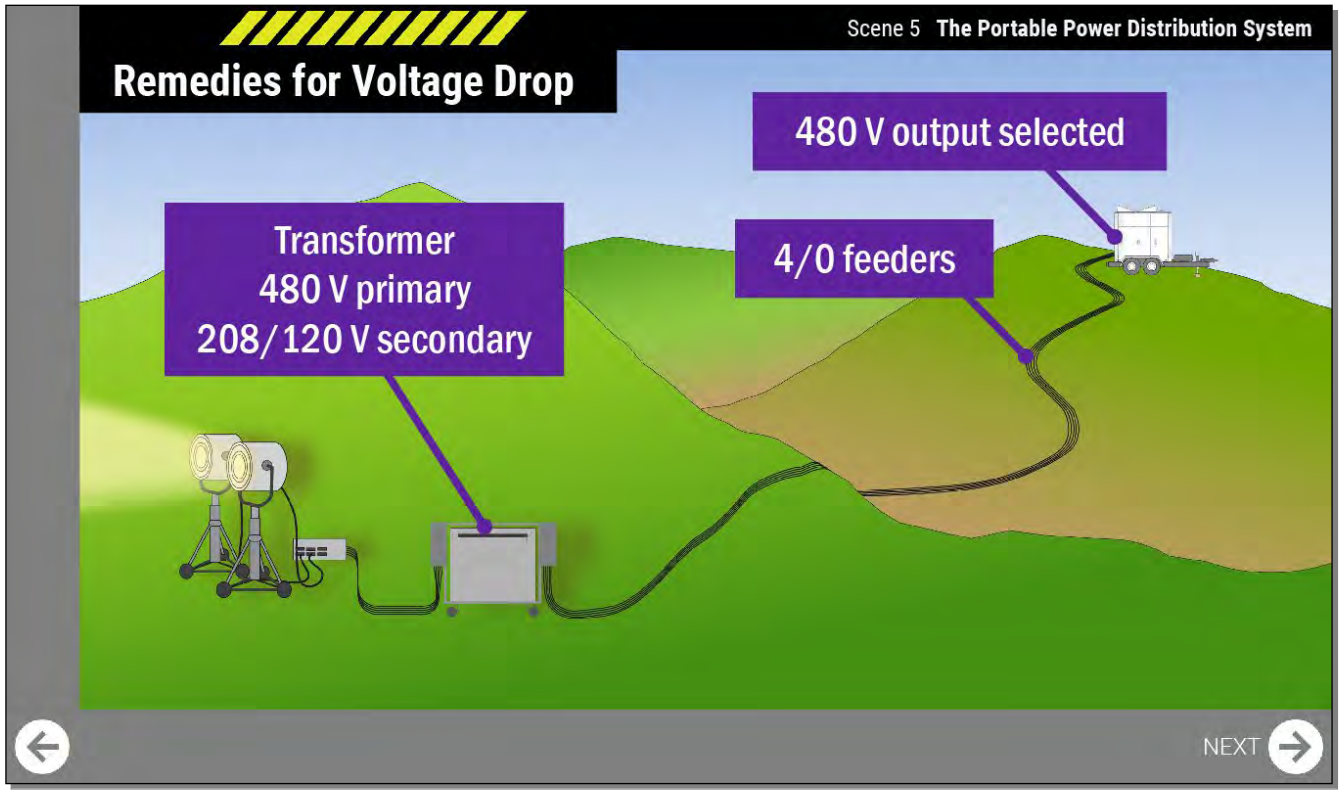


The remedy for excessive voltage drop, therefore, is to increase the conductor size, decrease the distance, or reduce the amperage. Usually, the amperage and the distance are dictated by the location and the lighting plan,



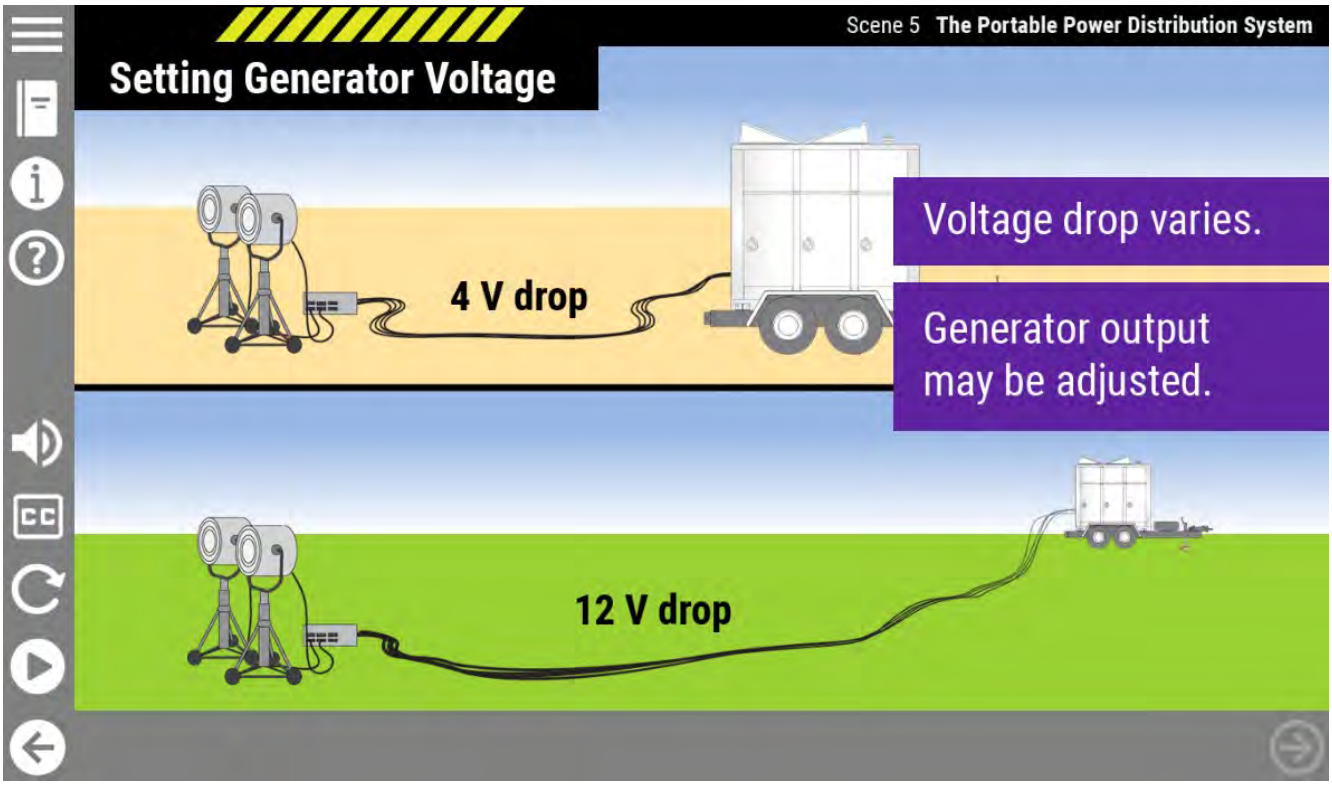
leaving the lighting crew with the option to increase the conductor size either by using a larger cable or by running conductors in parallel.

Slide 126. Remedies for Voltage Drop 2



The only other possibility is to use a 480-volt feeder with a transformer to drop to a usable voltage near the set. This option reduces voltage drop because it reduces the amperage in the feeders while providing the same amount of power.

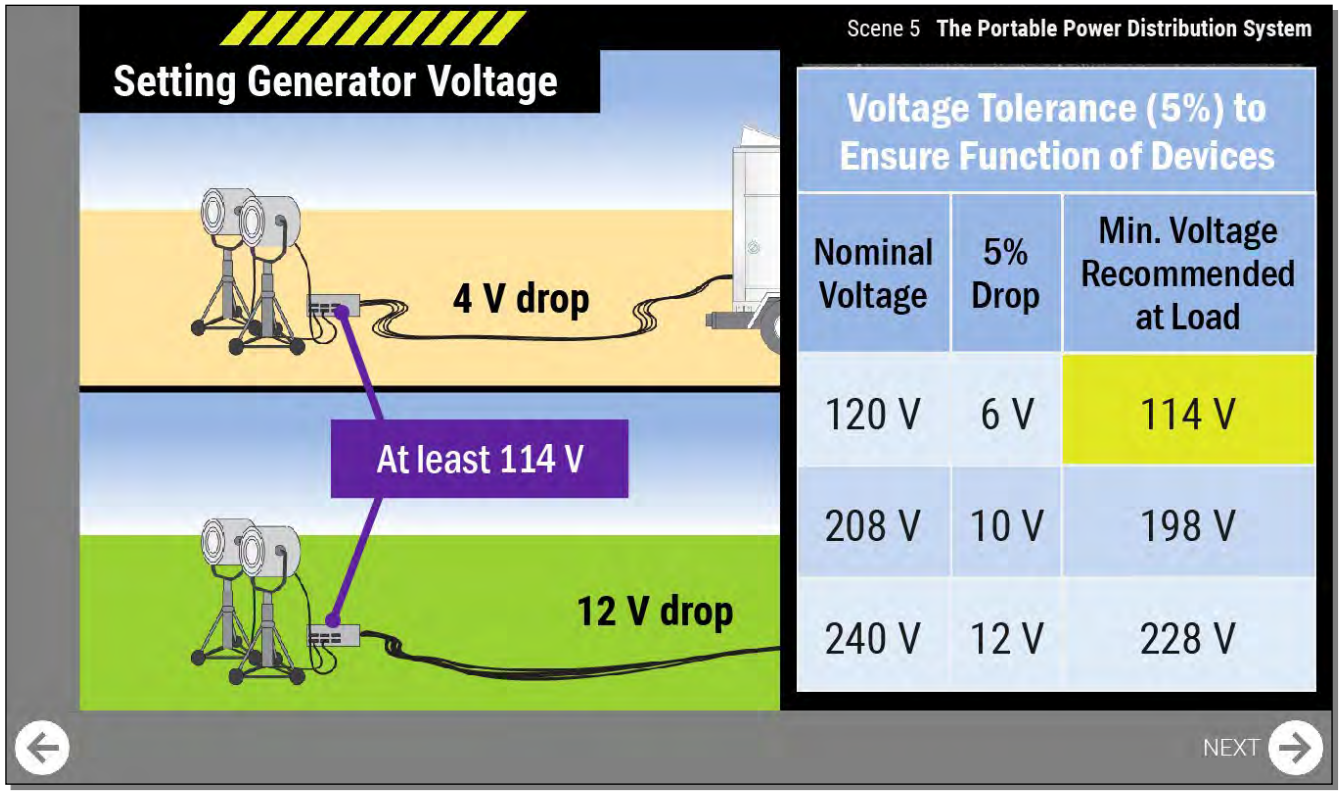
Slide 127. Setting Generator Voltage 1



Here's how voltage drop impacts the generator operator. The amount of voltage drop in the system changes each time the generator is connected to a different distribution system. So, the generator's output may need to be adjusted to ensure the voltage is neither too high nor too low at the loads.

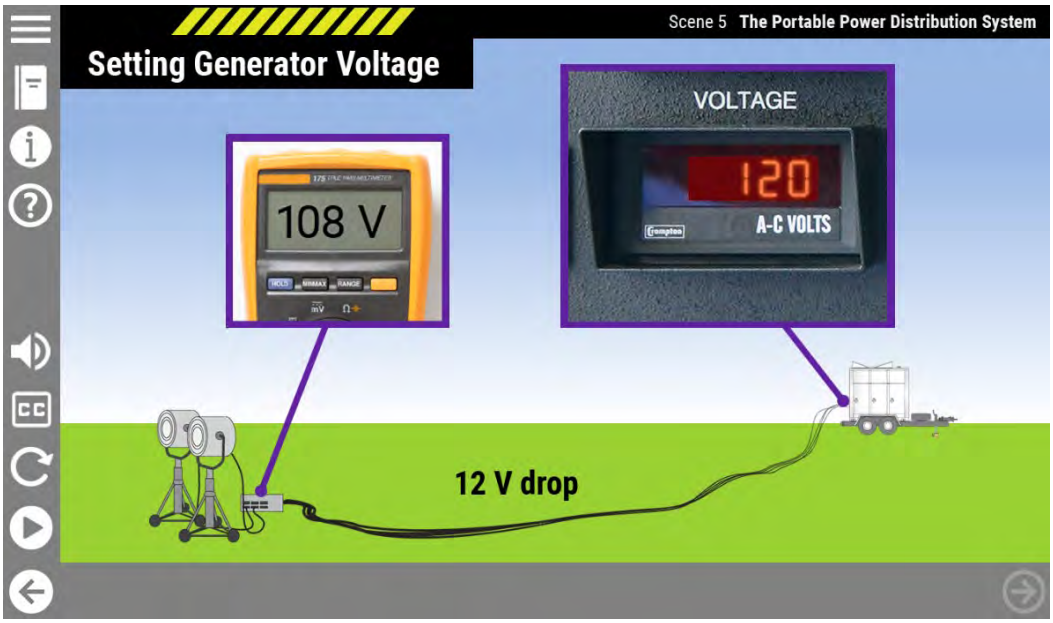
There's a voltage knob or adjustment interface on the generator's control panel. Ideally, the voltage on set should be as close to 120 volts as possible.

Slide 128. Setting Generator Voltage 2

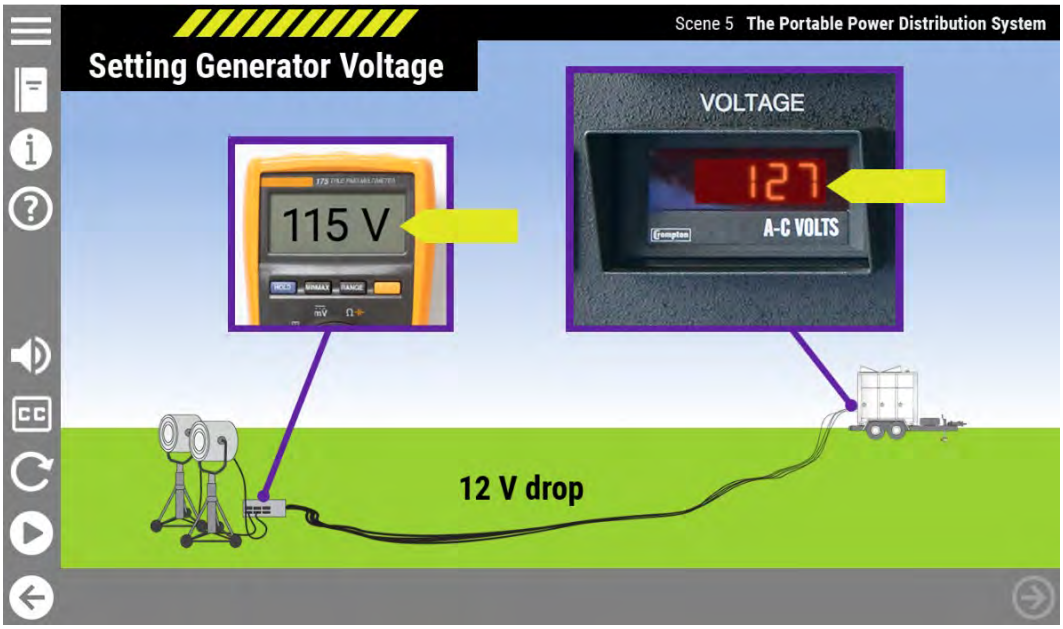


Acceptable tolerances vary between electrical devices, but the NEC recommends that the voltage at the load should be within 5 percent of the nominal voltage to ensure normal operation of equipment, which means no less than 114 volts for 120-volt loads.

Slide 129. Setting Generator Voltage 3

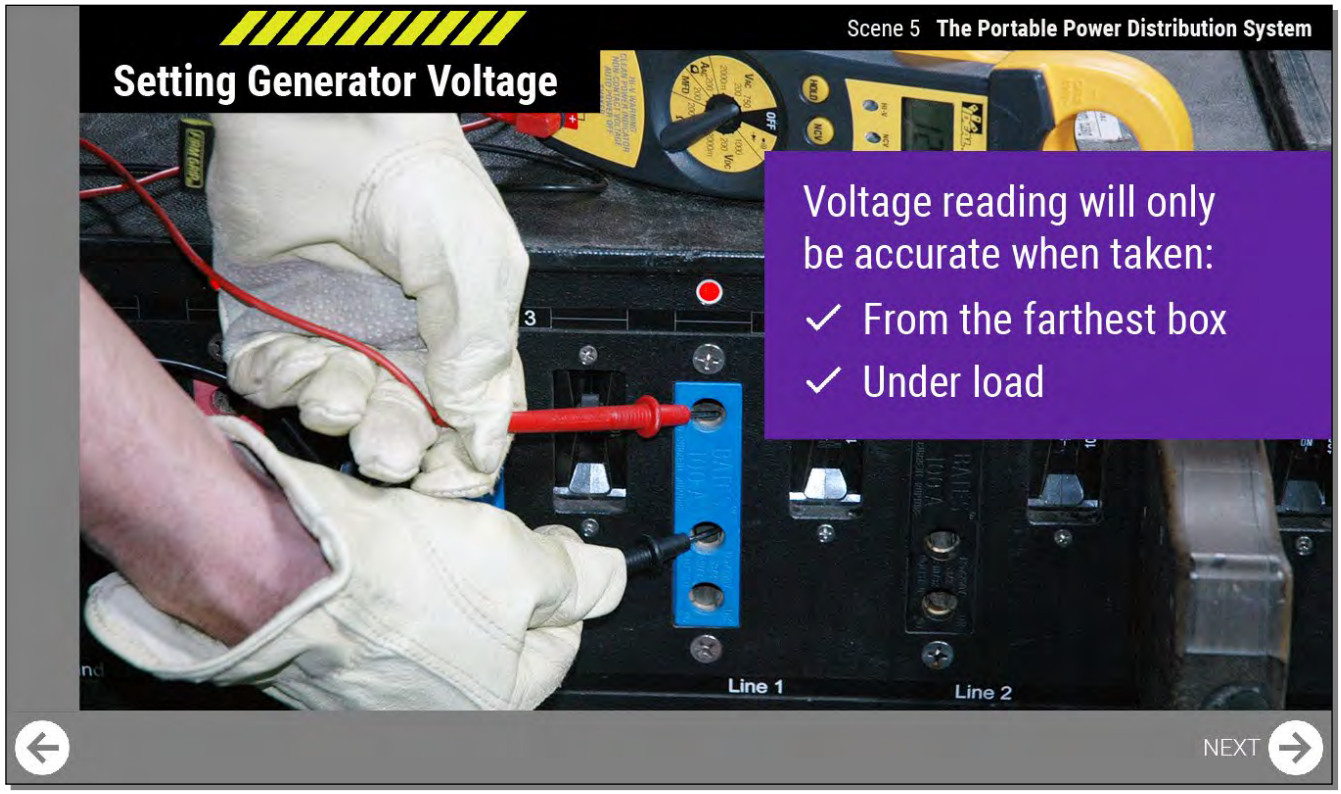


In this example, the generator output minus the voltage drop yields only 108 volts, which is likely to lead to unacceptable performance of the lights and devices. The color of tungsten lights will shift toward orange and electronic devices may shut off or some could overheat or be damaged.



The generator's output voltage can generally be raised to as much as 127 volts without any adverse effects. In this example, raising the generator's output voltage to 127 volts provides 115 volts on set, which brings it within the acceptable range.

Slide 130. Setting Generator Voltage 4

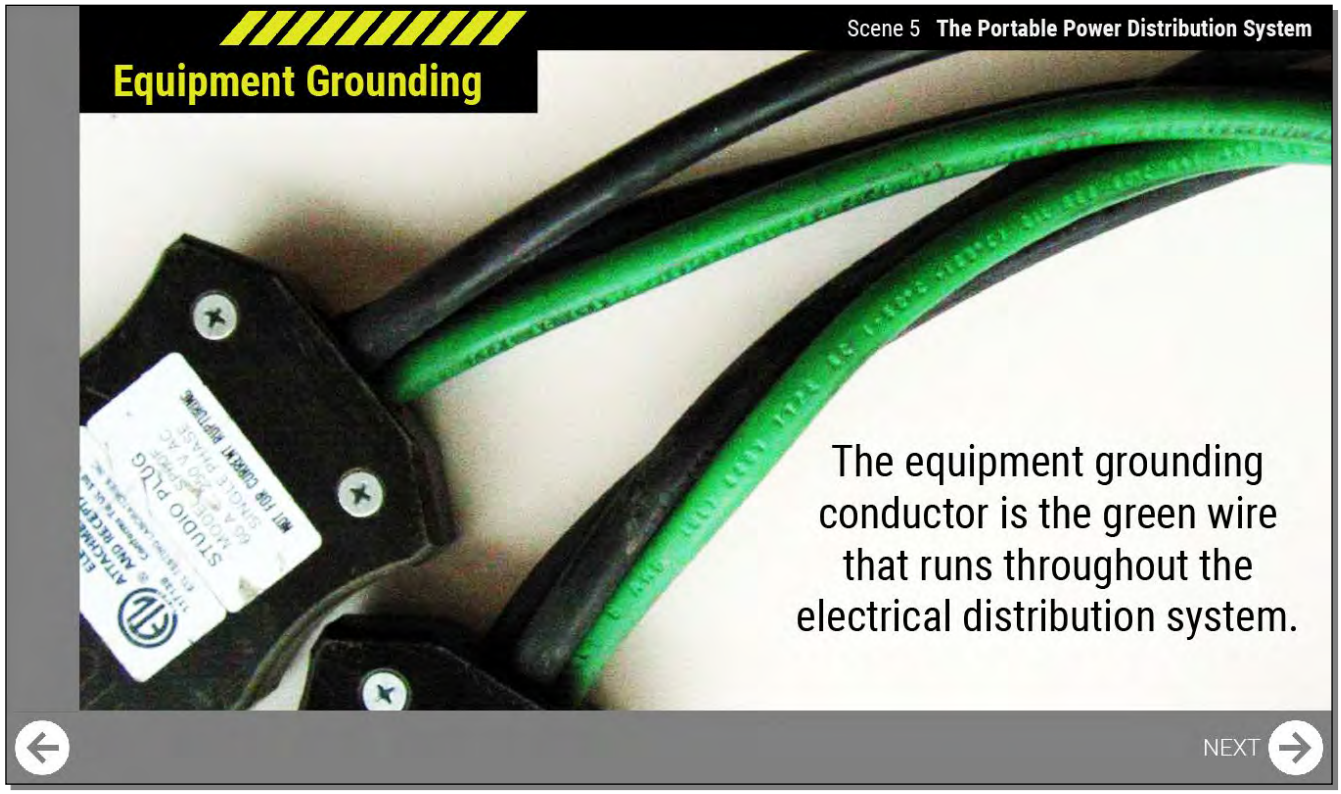


As you can see, to determine the actual voltage received by devices, someone must measure the voltage at the farthest distribution box from the generator using a handheld voltage meter. In addition, voltage measurement must be made under load. You cannot get an accurate measurement prior to firing up the lights because voltage drop increases with the load.

Slide 131. Setting Generator Voltage 5

Ideally, the person who supervises the installation of the distribution system takes voltage drop into account and may make voltage drop calculations in order to specify the correct cable gauge to use. However, if the voltage is still too low, the generator operator can help make up the difference by checking the voltage on set and making adjustments.

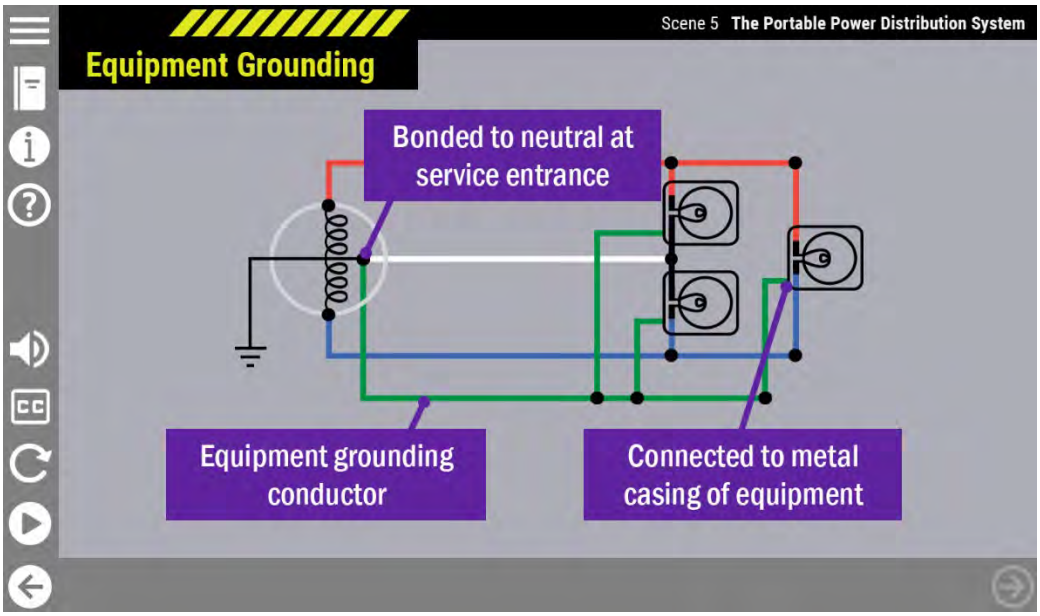
Slide 132. Equipment Grounding 1



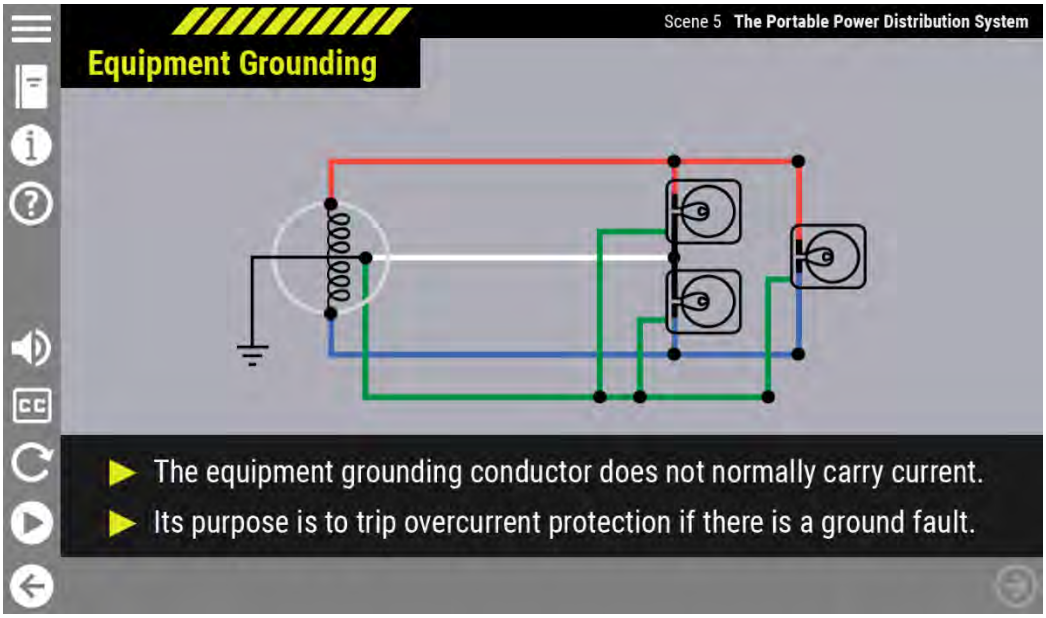
Okay, let's move on now to our last topic, equipment grounding.

The equipment grounding conductor is the green wire that runs throughout the electrical distribution system. What does it do?

Slide 133. Equipment Grounding 2

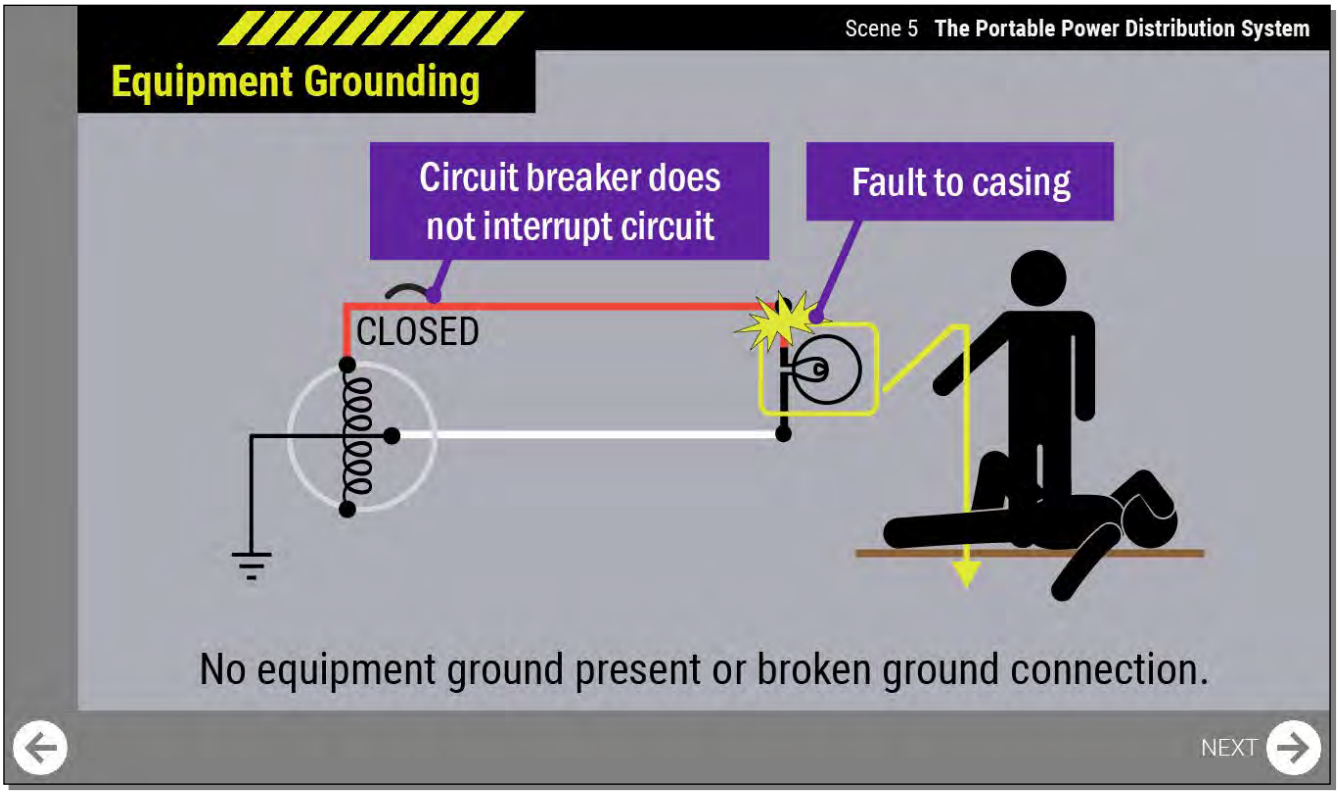


The **equipment grounding conductor** connects the casings or other metal parts of electrical equipment back through the distribution system to the ground bus at the generator. Here, the ground bus is bonded to the neutral bus.



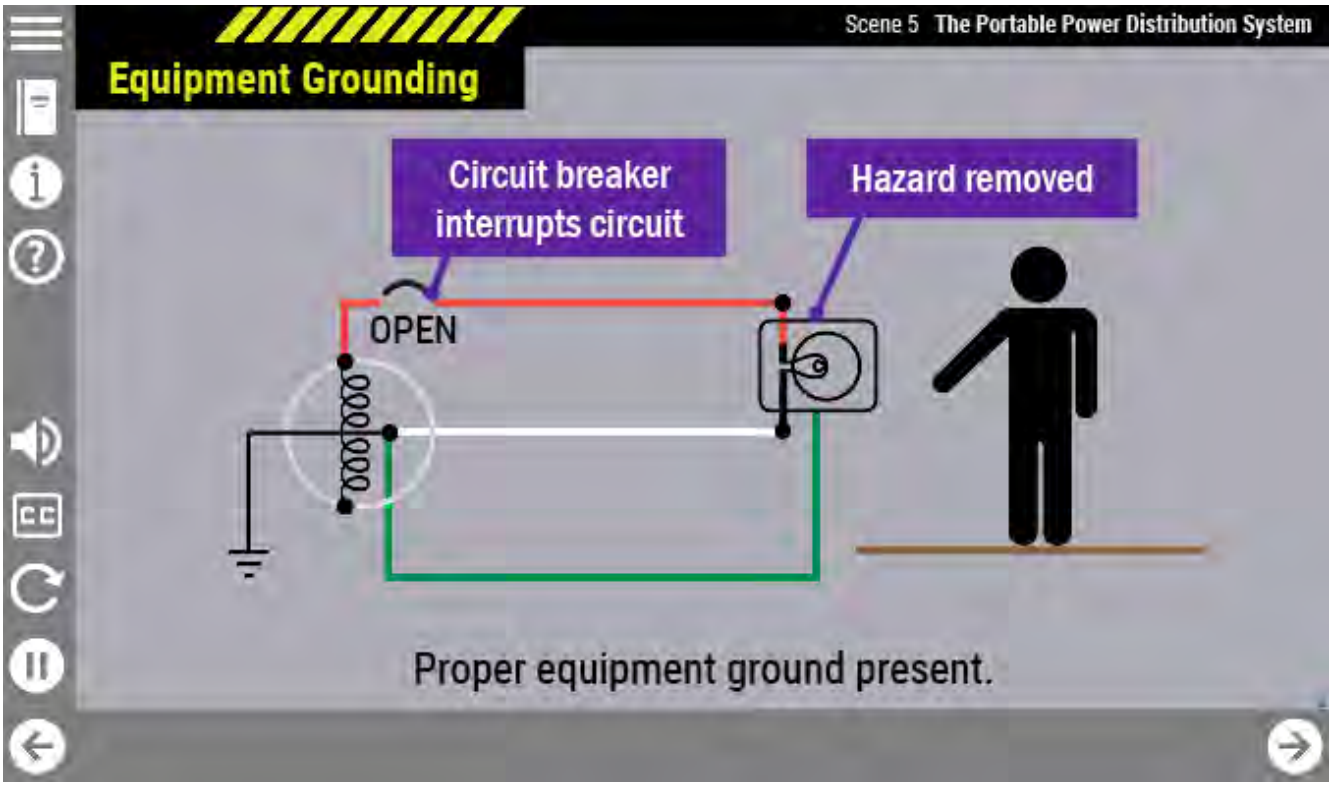
Under normal circumstances, the equipment grounding conductor does not carry any current. Its purpose is to quickly trip the circuit breaker or blow the fuse if a ground fault occurs. Remember, a ground fault occurs when an energized conductor makes inadvertent contact with a grounded metal part.

Slide 134. Equipment Grounding 3



If there were no equipment grounding conductor, when a fault occurred that energized the casing of the equipment, anyone who touched the electrified casing would provide a path to ground and could receive a dangerous shock.

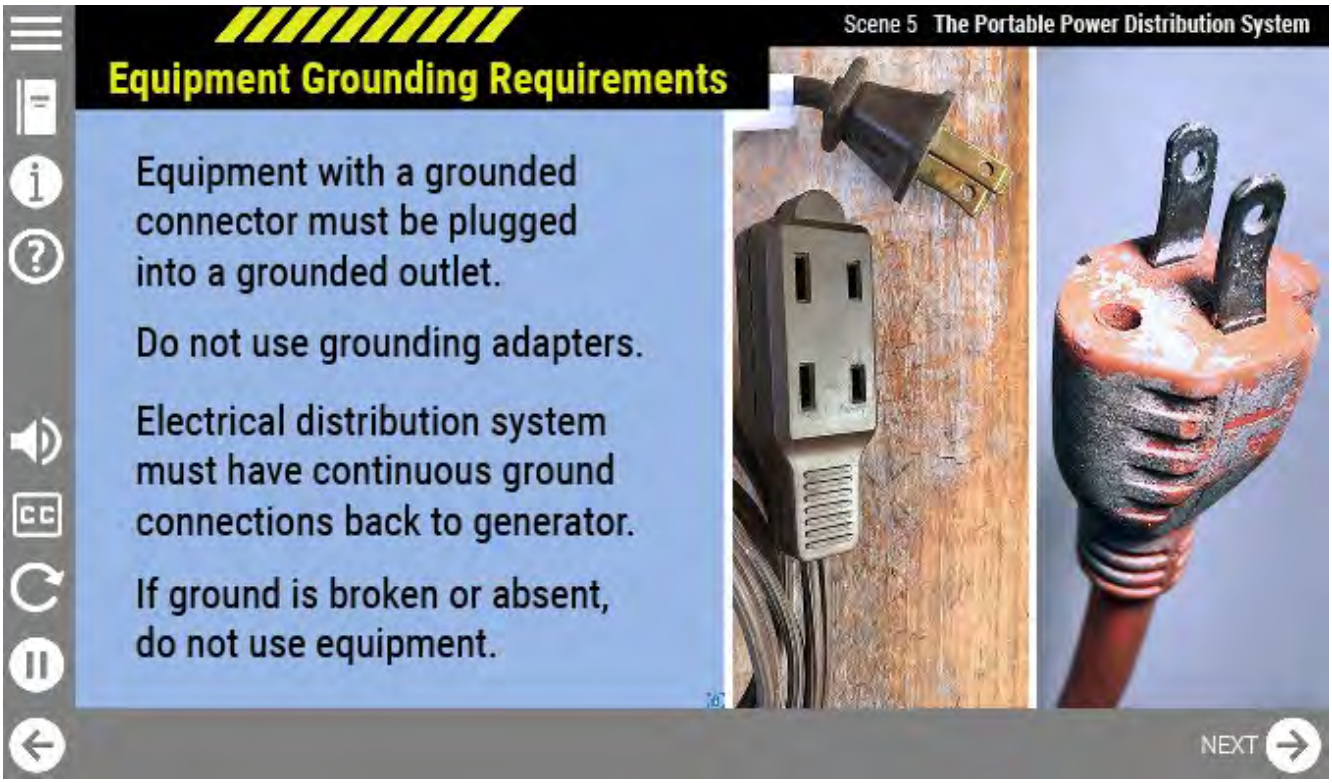
Slide 135. Equipment Grounding 4



If the same thing happens to equipment that is properly grounded, the equipment grounding conductor provides a lower-resistance path, and most of the current will take that path. The grounding wire completes a short circuit, tripping the circuit breaker or fuse, which removes the shock hazard.

This system protects people by removing the hazard before anyone touches the energized equipment. However, a person who is in contact with the equipment when the ground fault occurs could still receive a shock before the overcurrent trips.

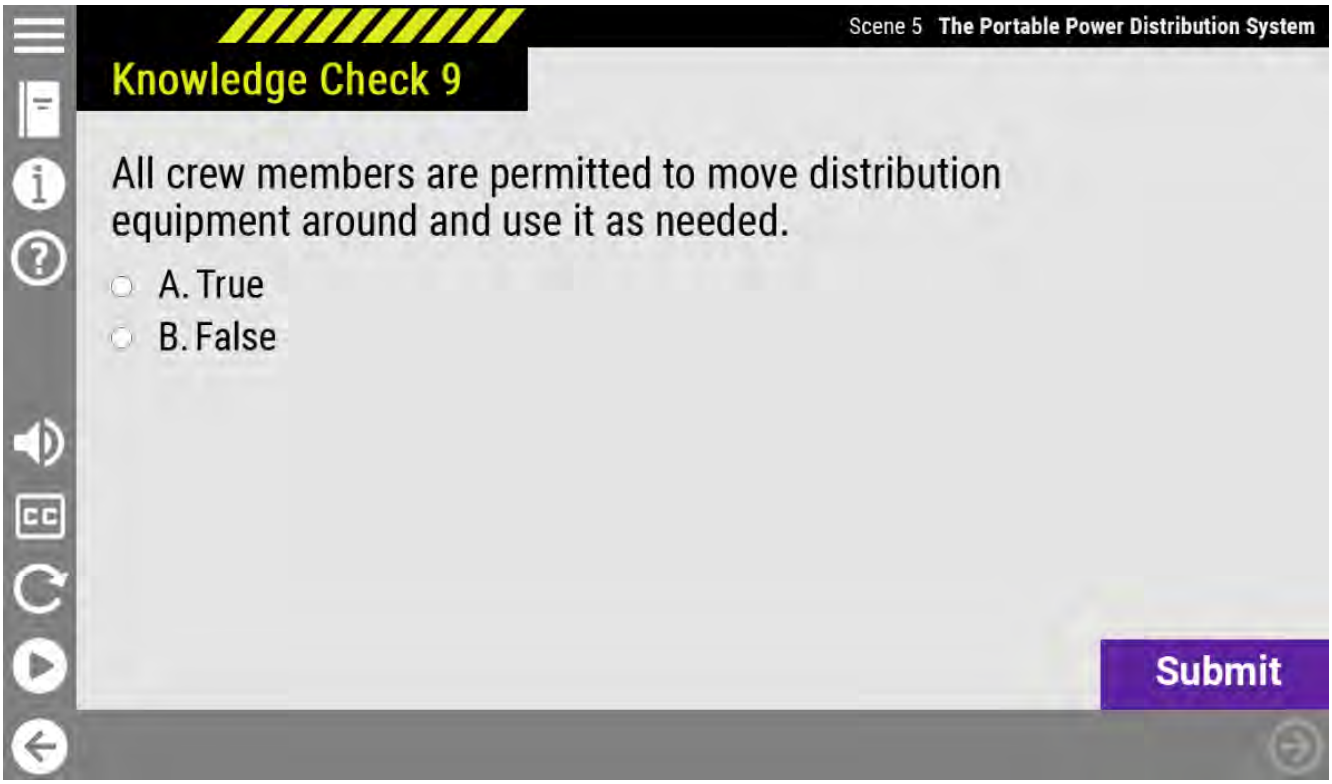
Slide 136. Grounding Requirements



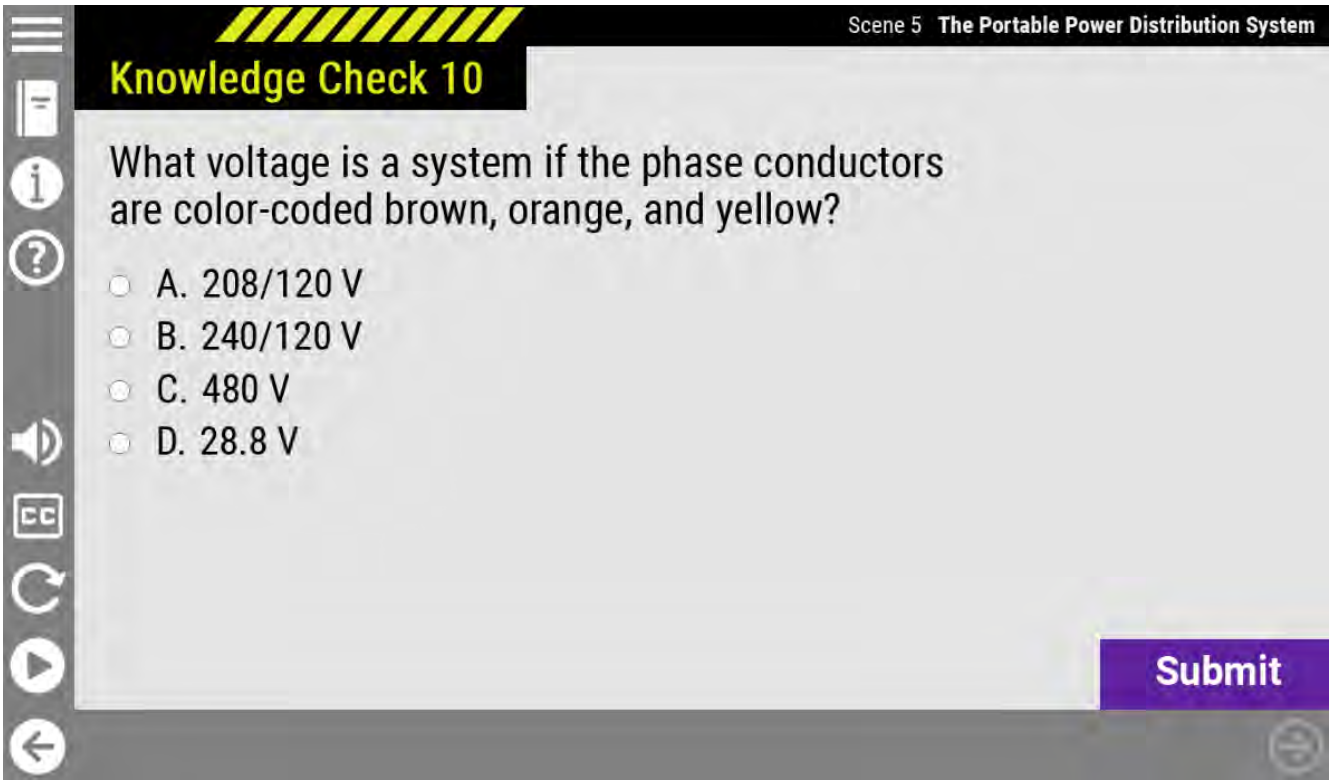
Equipment that is designed with a grounded connector, including practical fixtures, must be plugged into a grounded outlet. Do not use grounding adapters. The electrical distribution system is required to have continuous ground connections back to the generator or other power source. Do not use cords or equipment that do not have a ground or if the ground prong has broken off or been removed.

Let’s wrap up this scene with some knowledge checks.

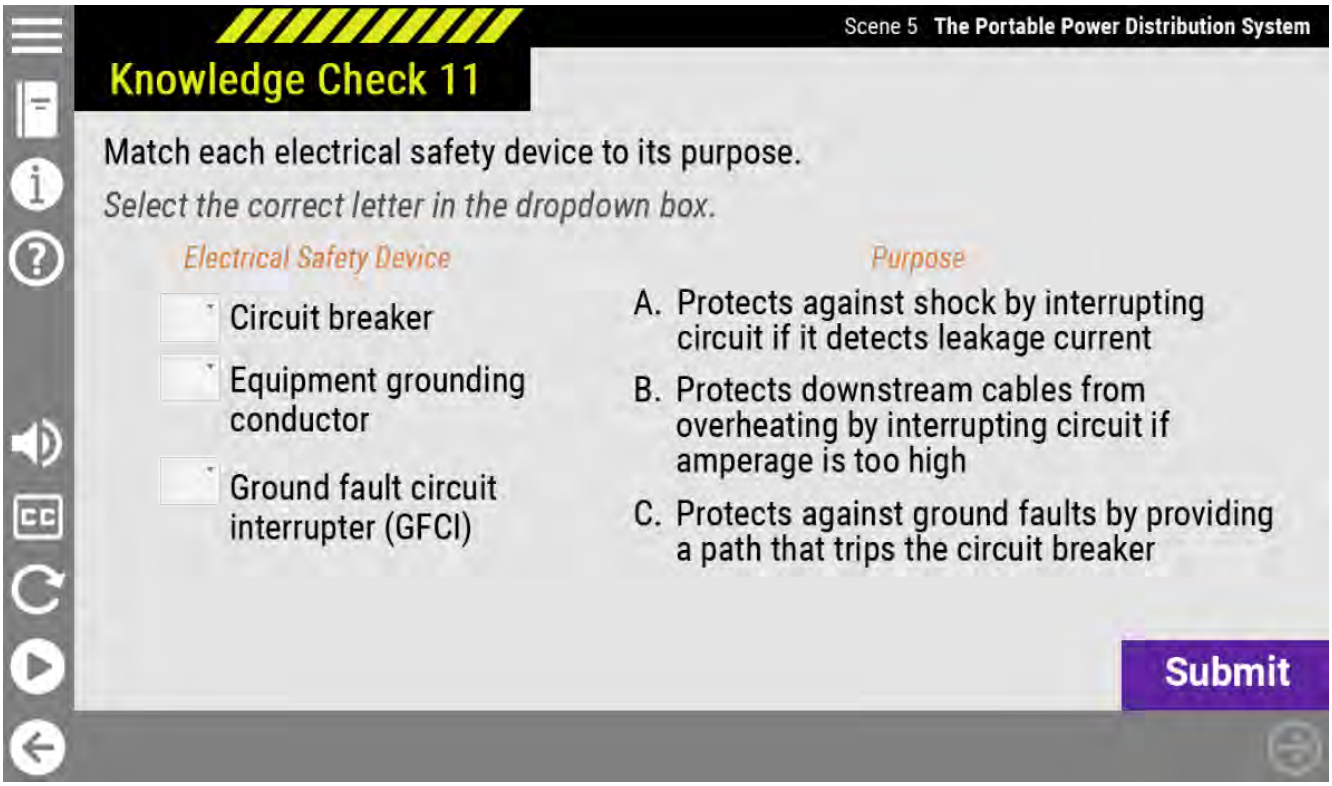
Slide 137. Knowledge Check 9



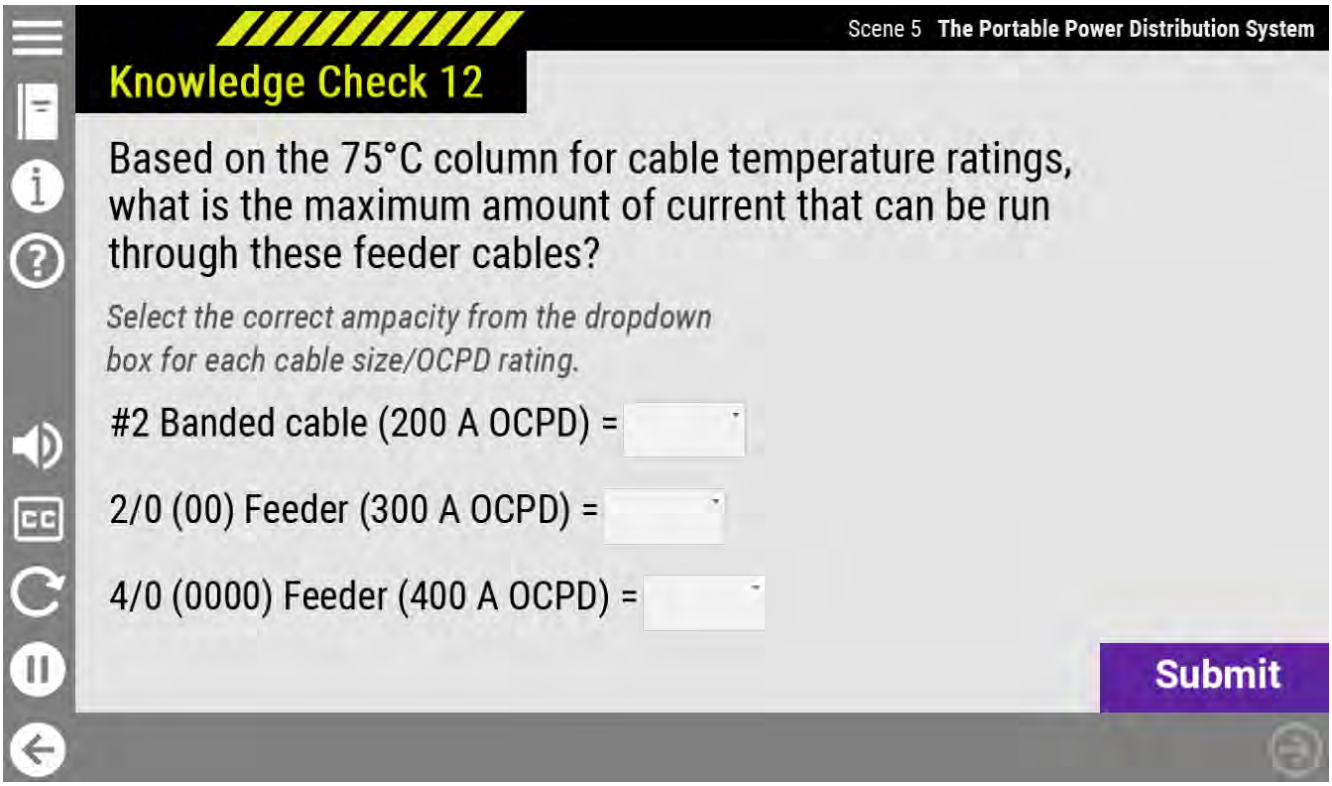
Slide 138. Knowledge Check 10



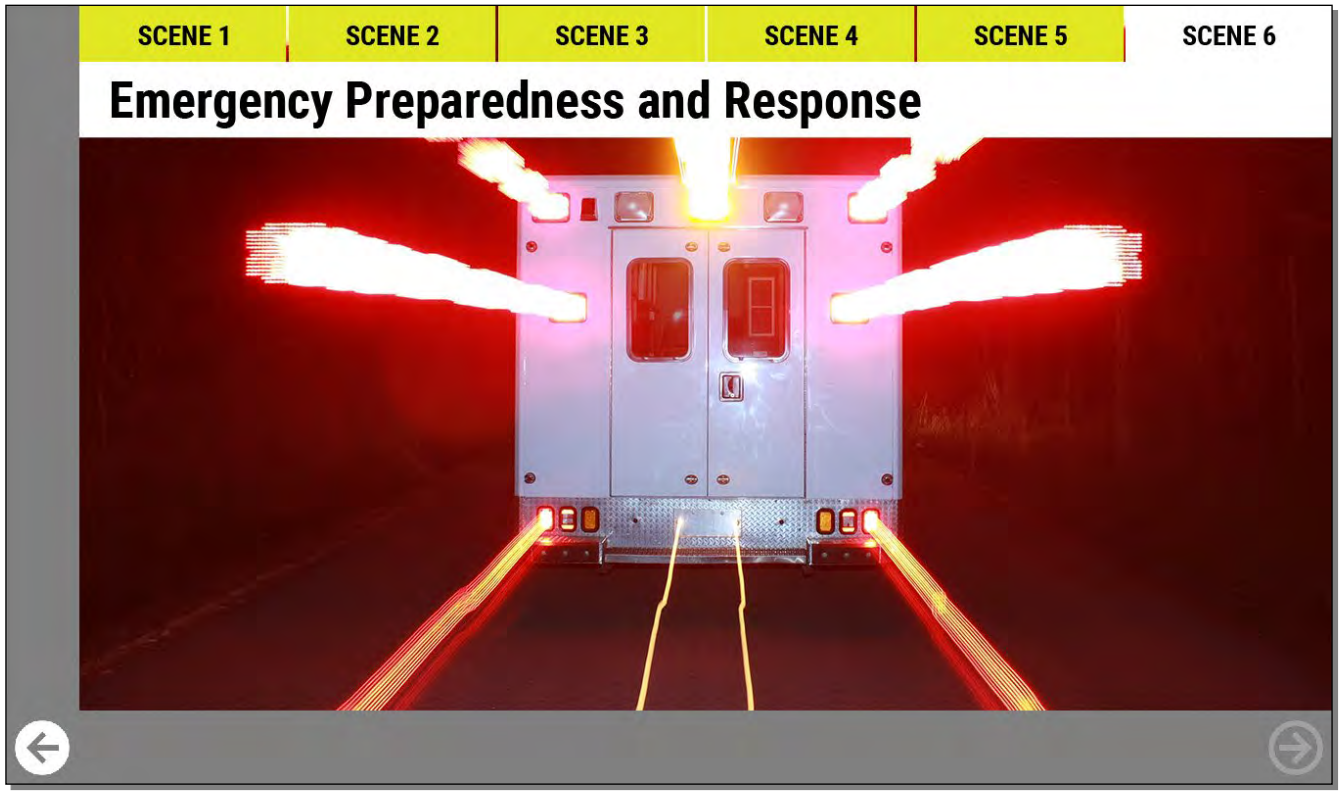
Slide 139. Knowledge Check 11



Slide 140. Knowledge Check 12

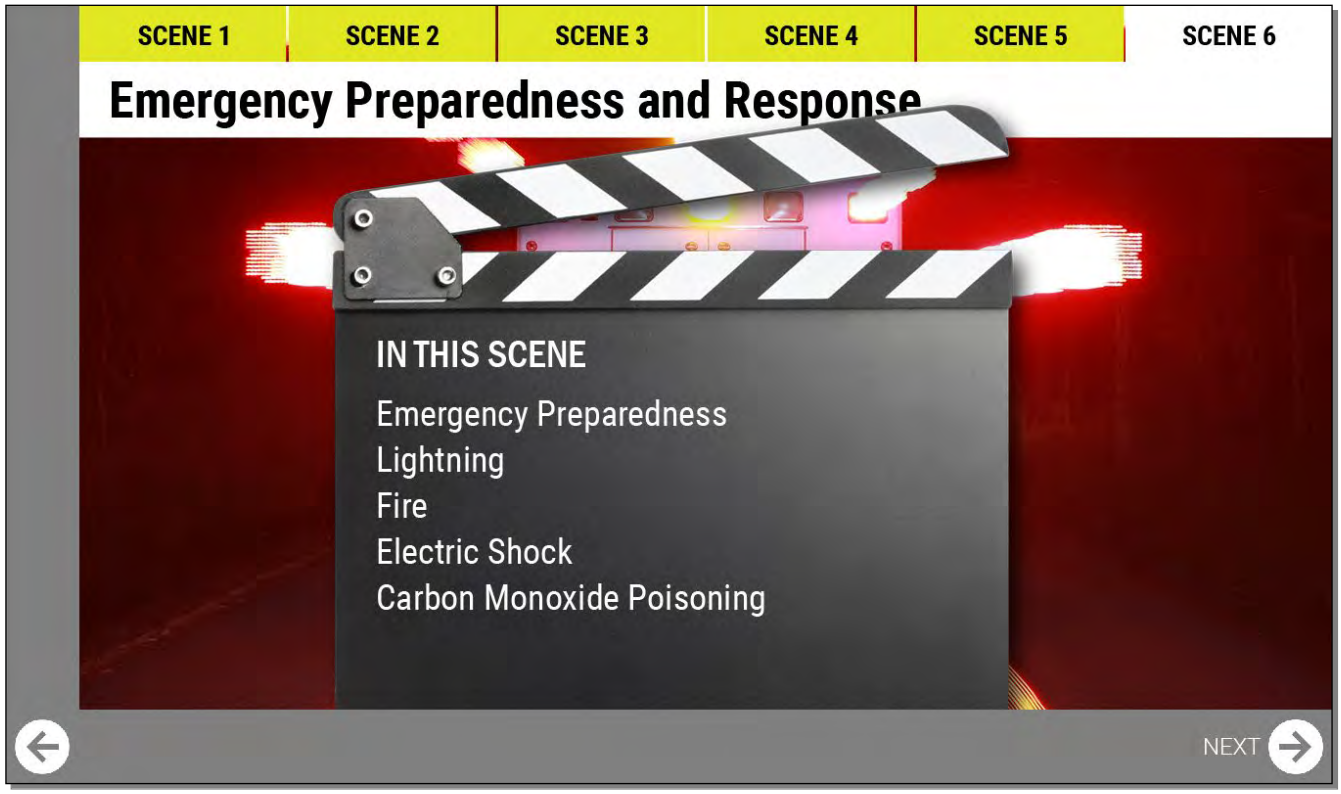


Slide 141. SCENE 6, EMERGENCY PREPAREDNESS AND RESPONSE



Scene Six, Emergency Preparedness and Response.

Slide 142. In This Scene



In this scene, we'll briefly review how you should prepare for an emergency and then how to respond to lightning, fire, electric shock, and carbon monoxide poisoning.

Slide 143. Emergency Preparedness

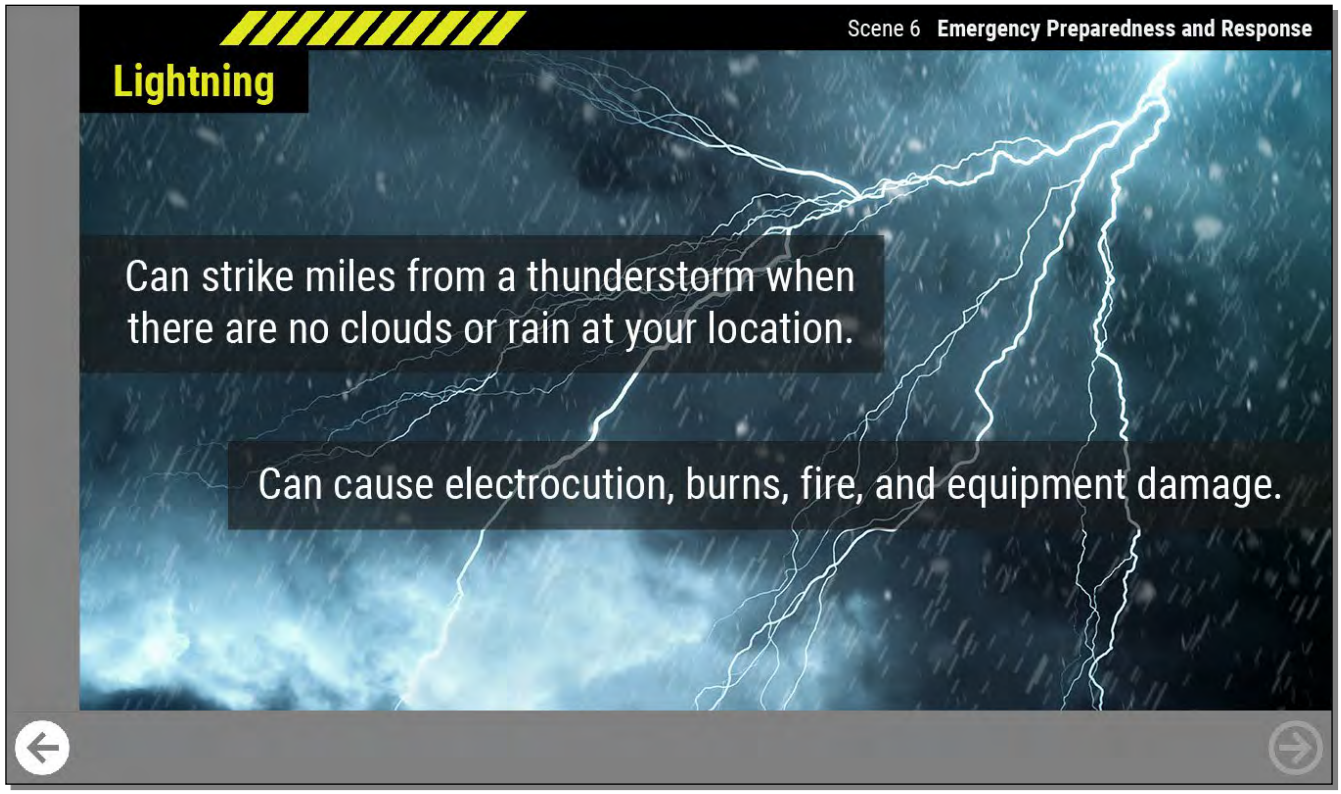
The best way to prepare for an emergency situation is by planning ahead. Before beginning work, identify the hazards of the location and the job. Could hot and dry conditions make a fire more likely? Is there the potential for the weather taking a turn?

Know the production's emergency action plan, including how to contact emergency medical services (EMS), the location of emergency equipment, and emergency shutdown processes and procedures for the type of generator you are operating. Some of this information will also be reviewed during daily safety meetings.

Make sure you know your exact location: the street address, the stage number, or one section of a much larger space, for example, the southwest corner of base camp. You may need to provide this information to EMS.

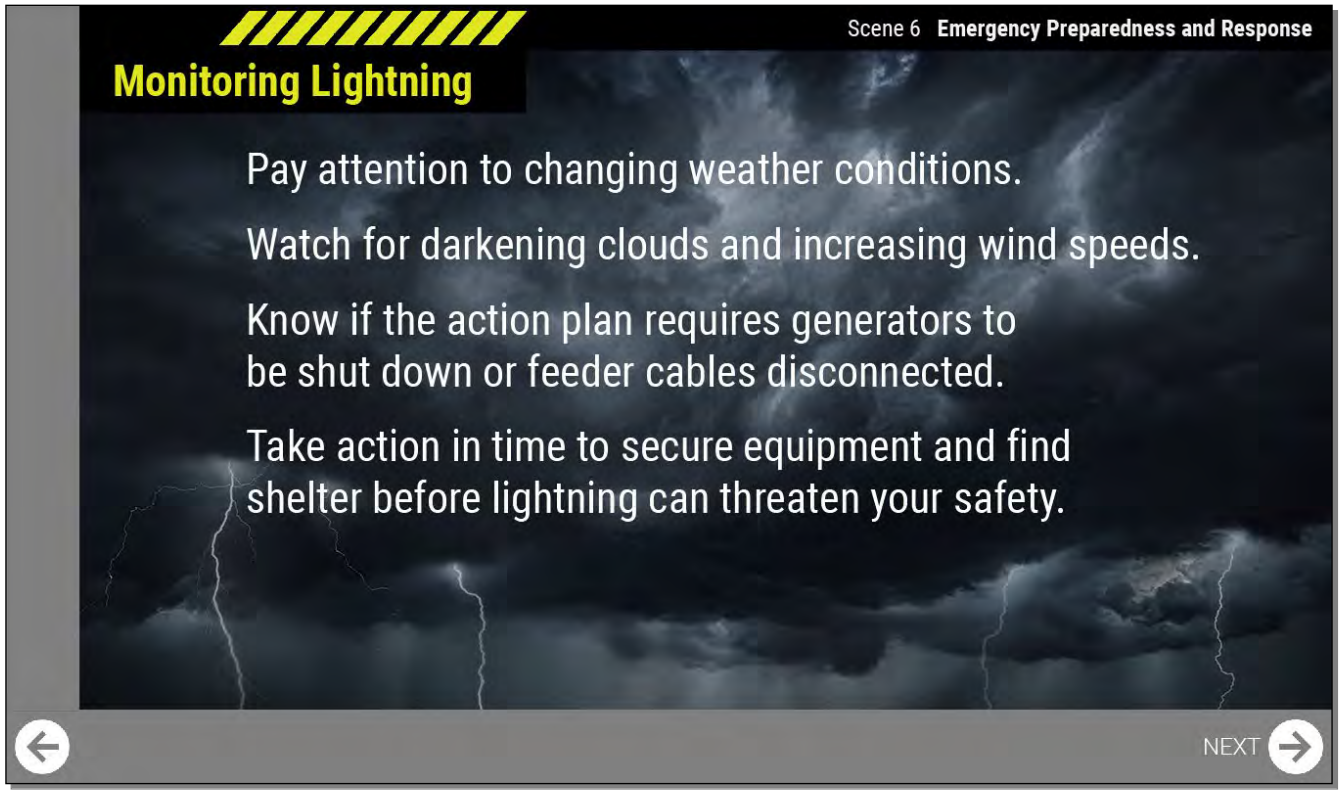
It is up to you to act quickly in an emergency. Be ready.

Slide 144. Lightning



Lightning can strike miles from a thunderstorm even when there are no clouds or rain at your location and can cause electrocution, burns, fire, and equipment damage.

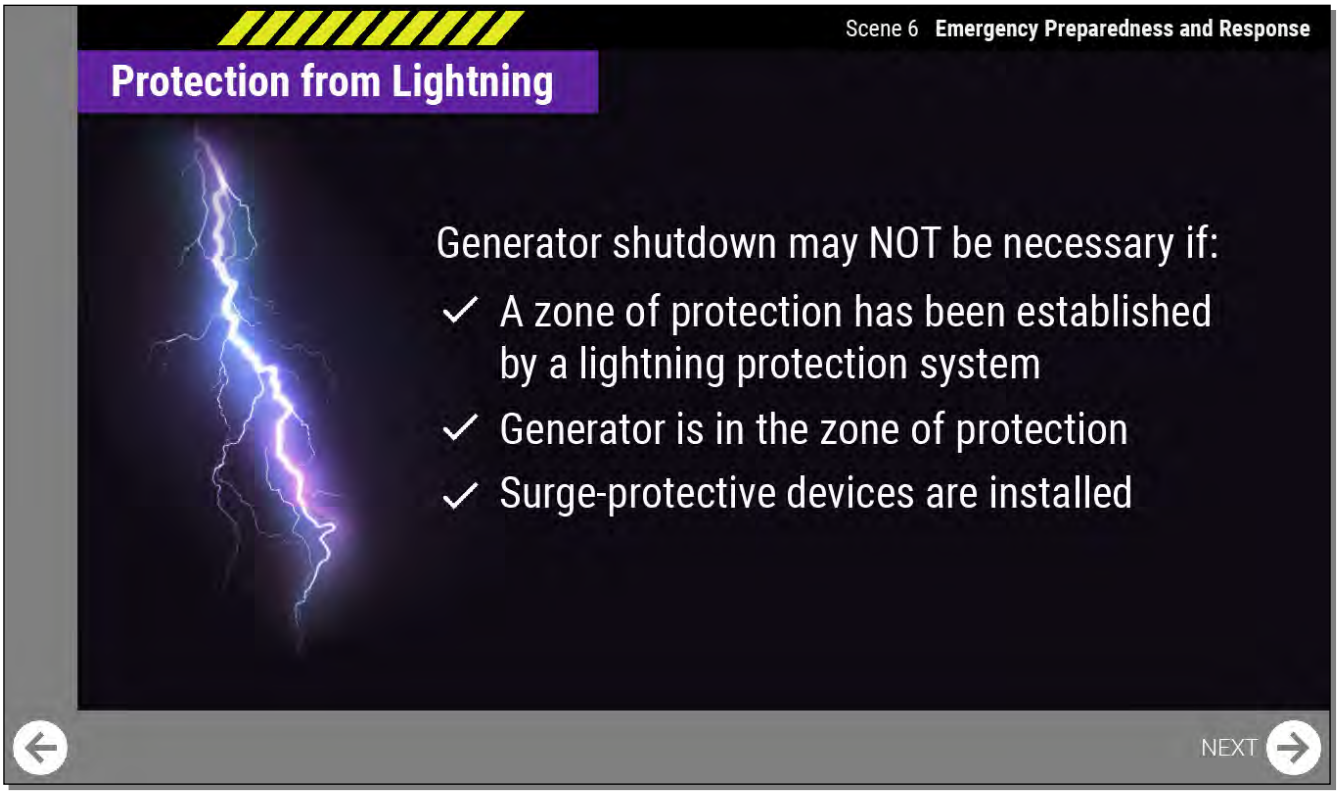
Slide 145. Monitoring Lightning



Even though production checks weather reports prior to beginning outdoor work, everyone should pay attention to changing weather conditions; darkening clouds and increasing wind speeds can indicate developing thunderstorms.

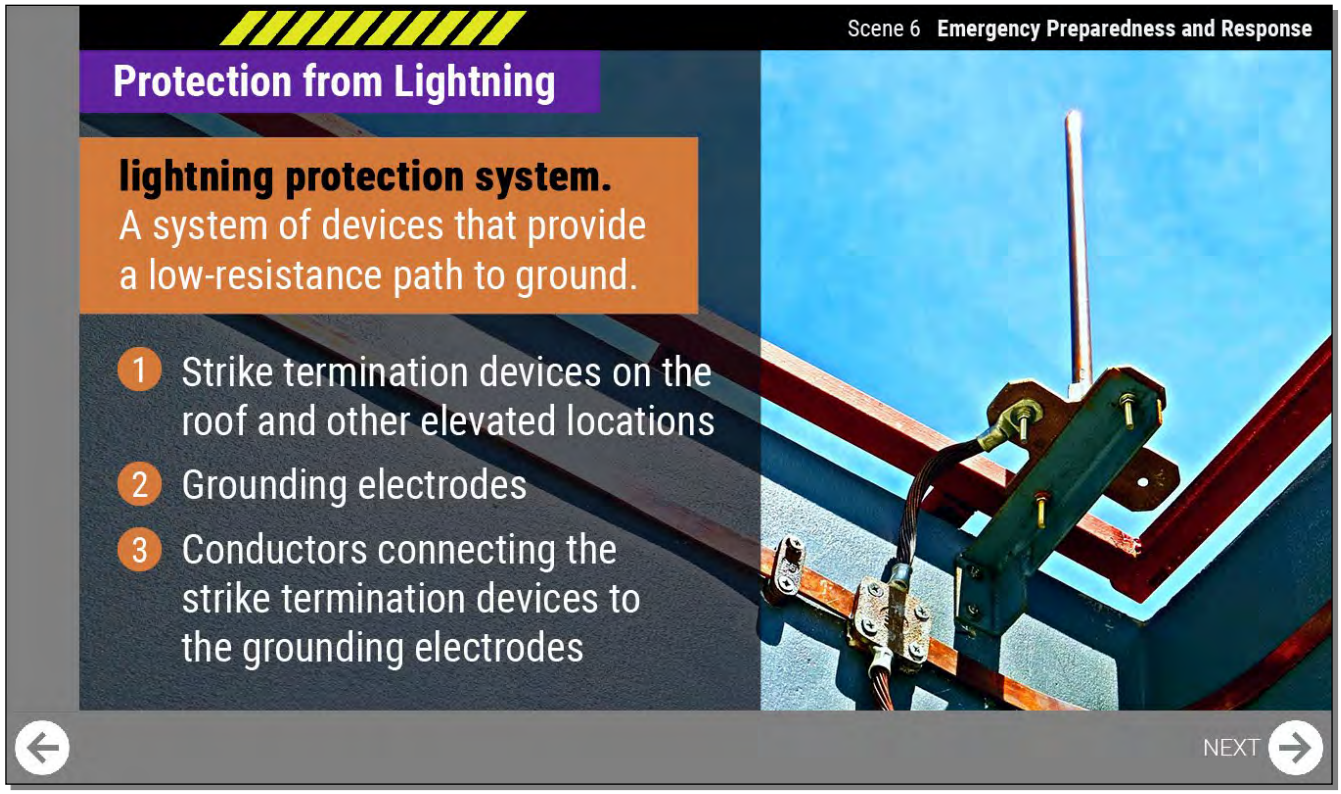
When there is the potential for lightning, refer to the action plan to see if generators need to be shut down or feeder cables disconnected. Take action in time to secure equipment and get yourself to shelter before lightning is close enough to threaten your safety.

Slide 146. Generator Protection from Lightning 1



Generator shutdown may not be necessary if a zone of protection has been established by a lightning protection system, the generator is in the zone of protection, and surge-protective devices are installed as required.

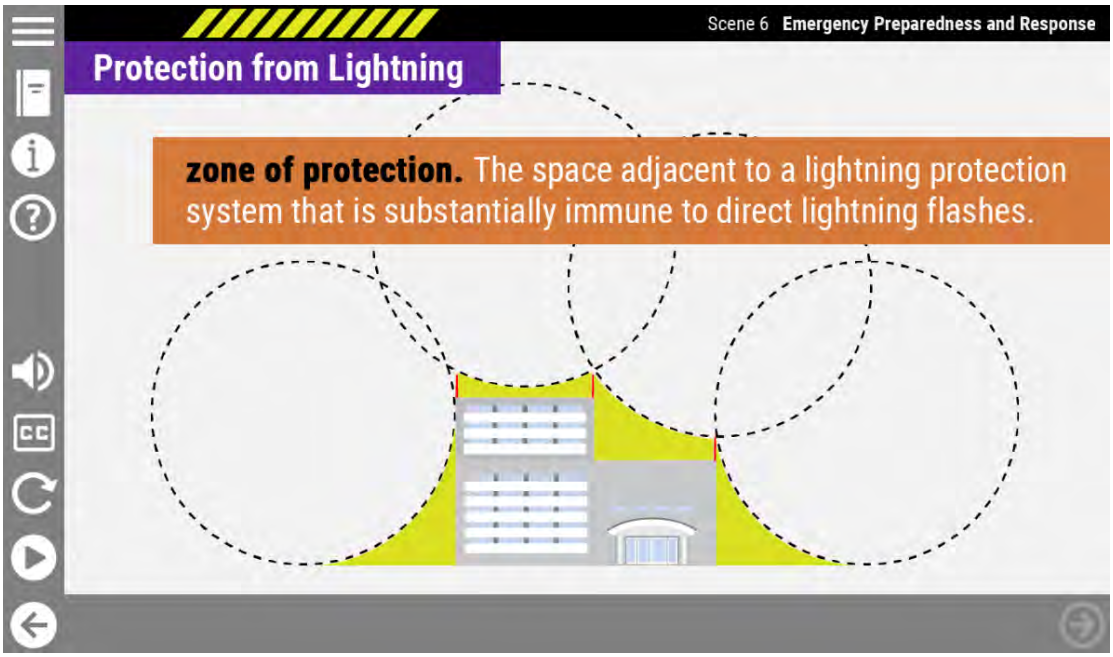
Slide 147. Generator Protection from Lightning 2



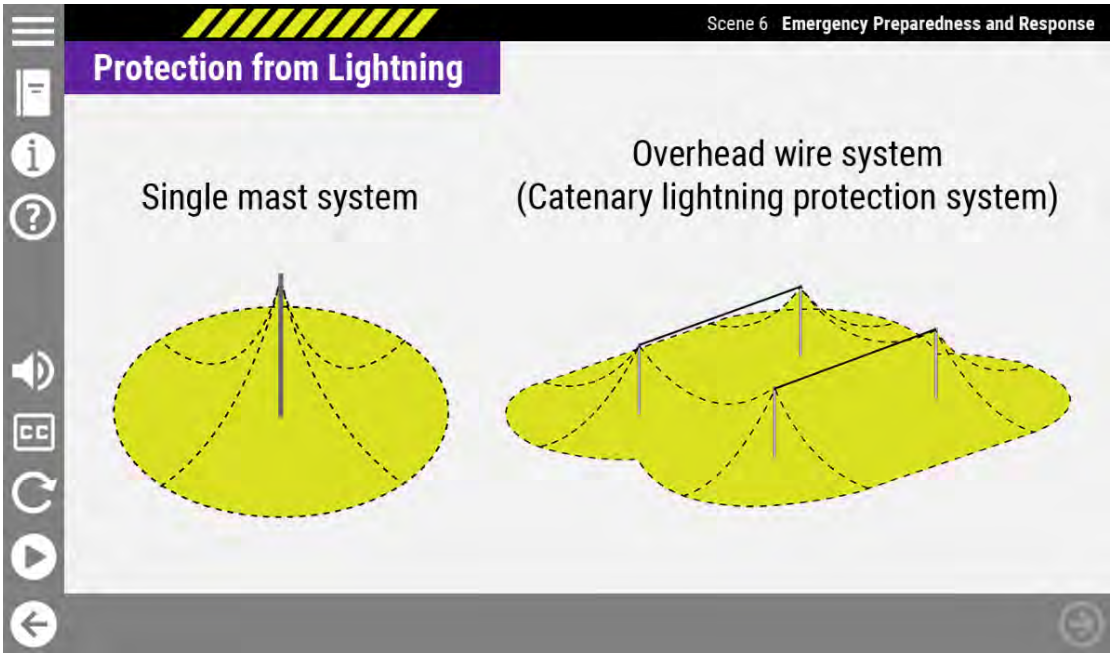
A lightning protection system provides a low-resistance path to ground.

It must have three basic parts: A system of strike termination devices, such as metal masts or permanent metal parts of structures, on the roof and other elevated locations; a system of grounding electrodes; and, a conductor system connecting the strike termination devices to the grounding electrodes.

Slide 148. Generator Protection from Lightning 3

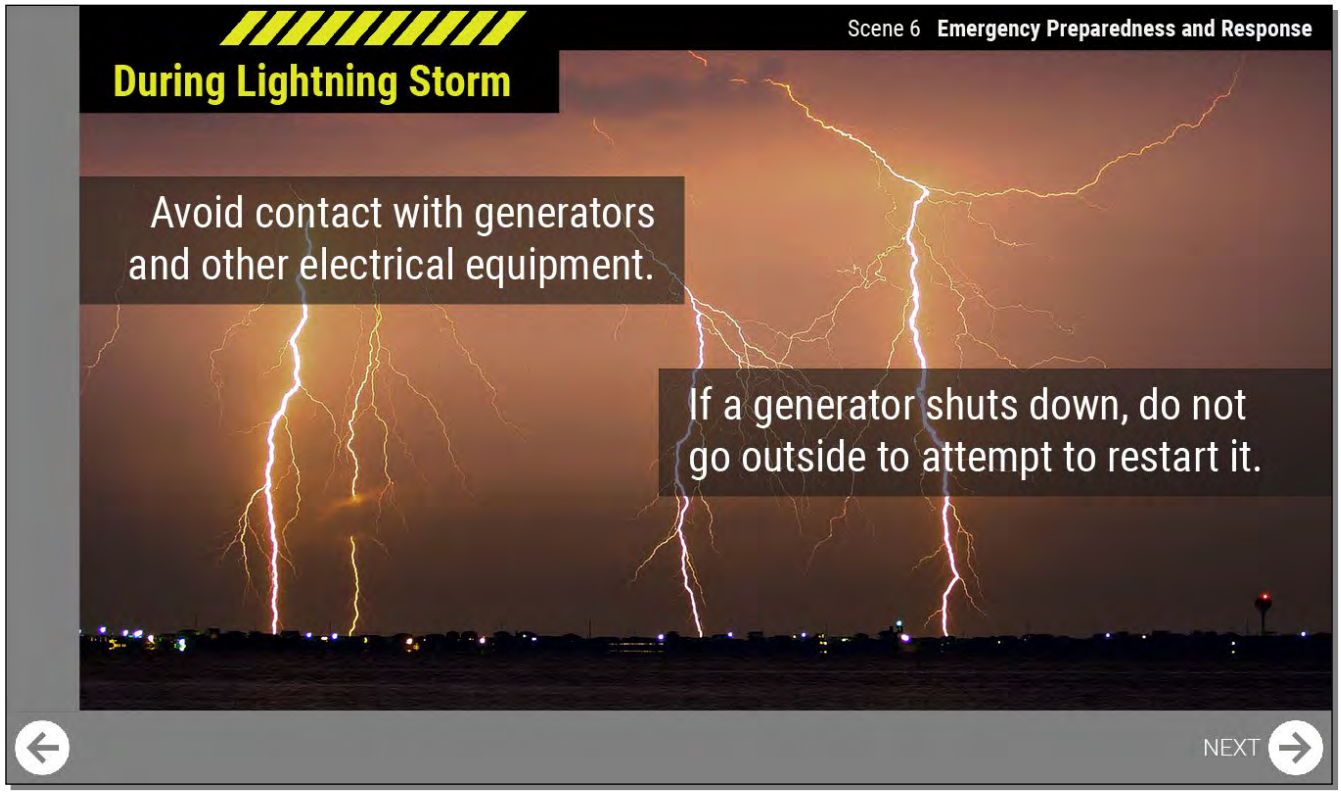


A zone of protection is the space adjacent to a lightning protection system that is substantially immune to direct lightning flashes. Lightning protection systems are mostly installed permanently on buildings,



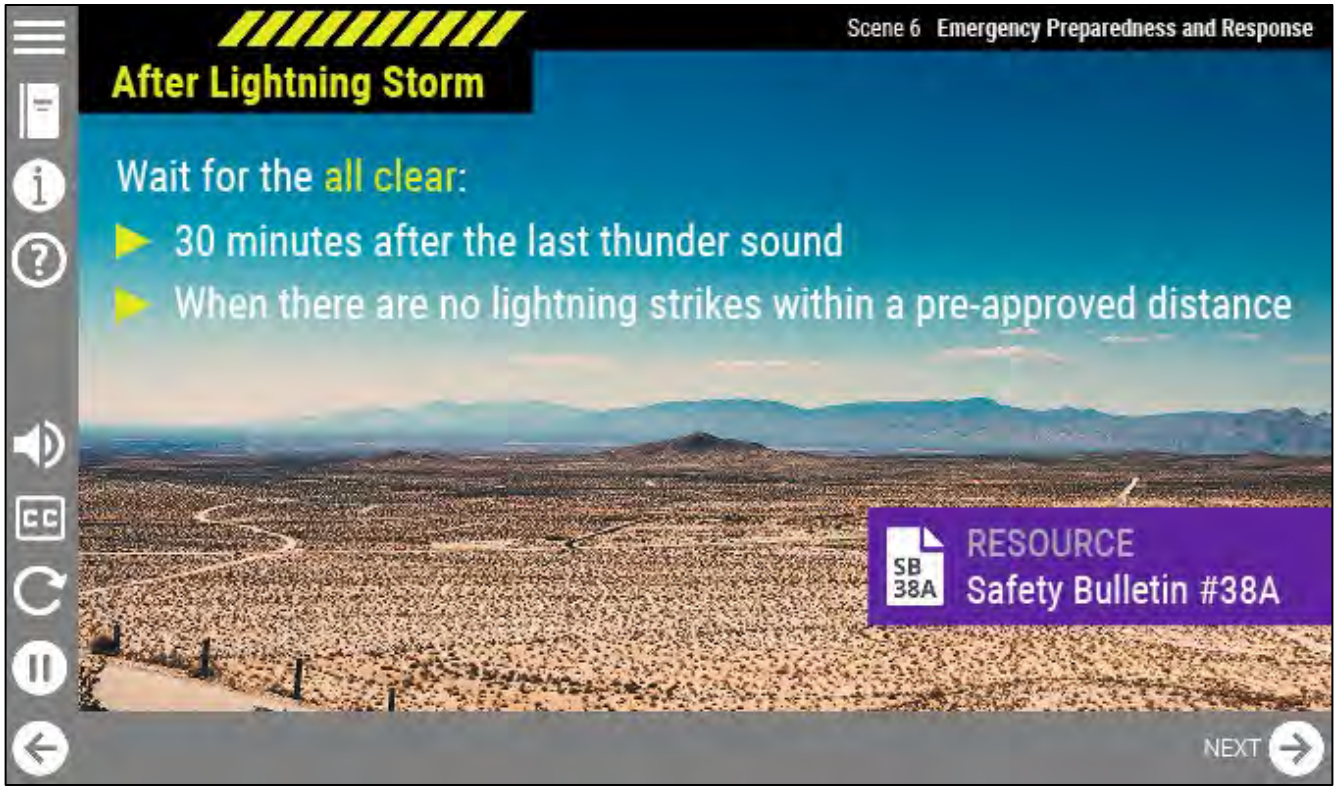
but a zone of protection can also be established by other methods such as a single mast system or overhead wire system, known as a catenary lightning protection system. Check with studio safety or facility personnel to determine what lightning protection system may be installed or otherwise provided on location.

Slide 149. During Lightning Storm



During potential lightning strikes, avoid contact with generators and other electrical distribution equipment. If a generator shuts down on its own during a lightning storm, do not go outside to attempt to restart it.

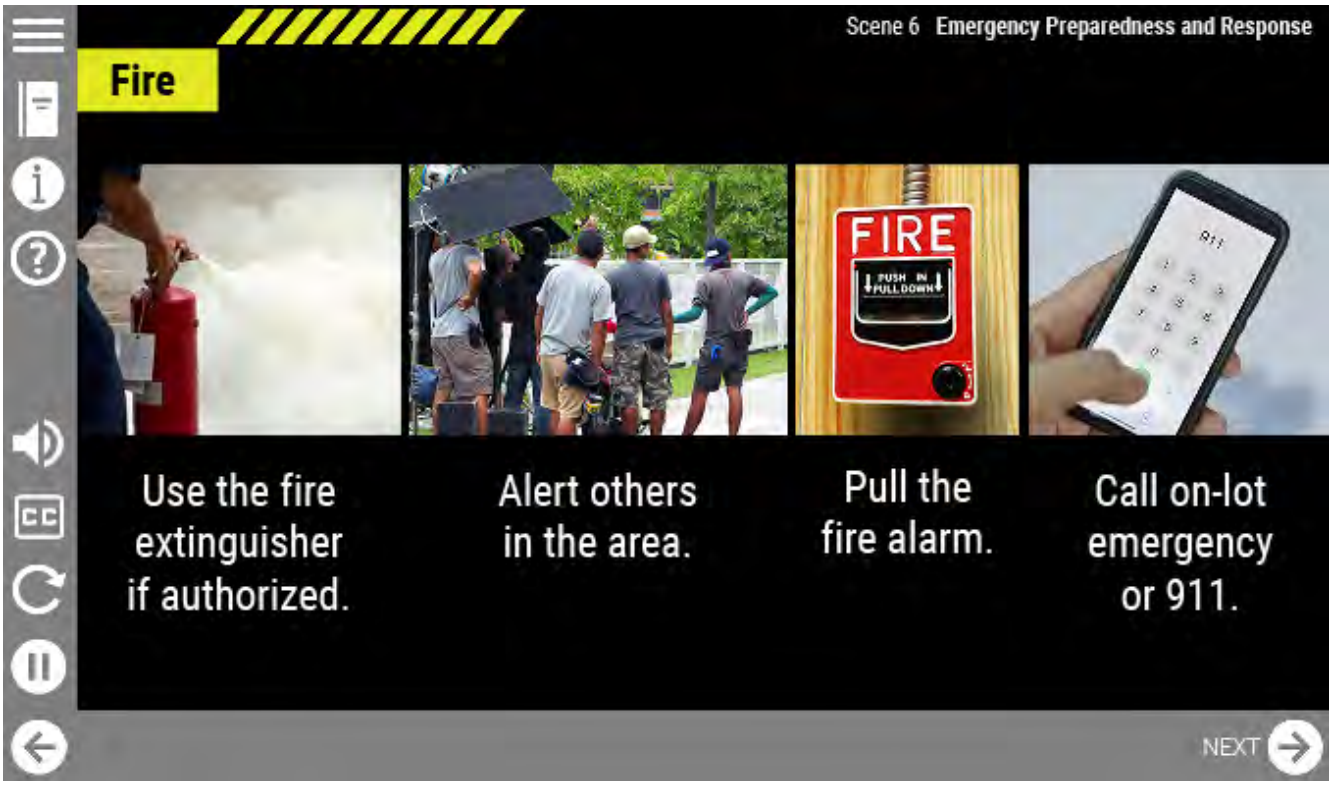
Slide 150. After Lightning Storm



Wait for the “all clear” from the AHJ representative or production management before returning to work. This will usually be 30 minutes after the last thunder sound is heard or when there are no lightning strikes within a pre-approved distance.

Click here for more information on lightning safety in Safety Bulletin #38A.

Slide 151. Fire Response



In the event of a fire, generator operators authorized to use a fire extinguisher may go ahead and use it to put out small fires that are within the capacity of the fire extinguisher.

If there is any doubt about the capability of the fire extinguisher being able to completely extinguish the fire, do not attempt to put out the fire. Instead, follow the production's fire response plan.

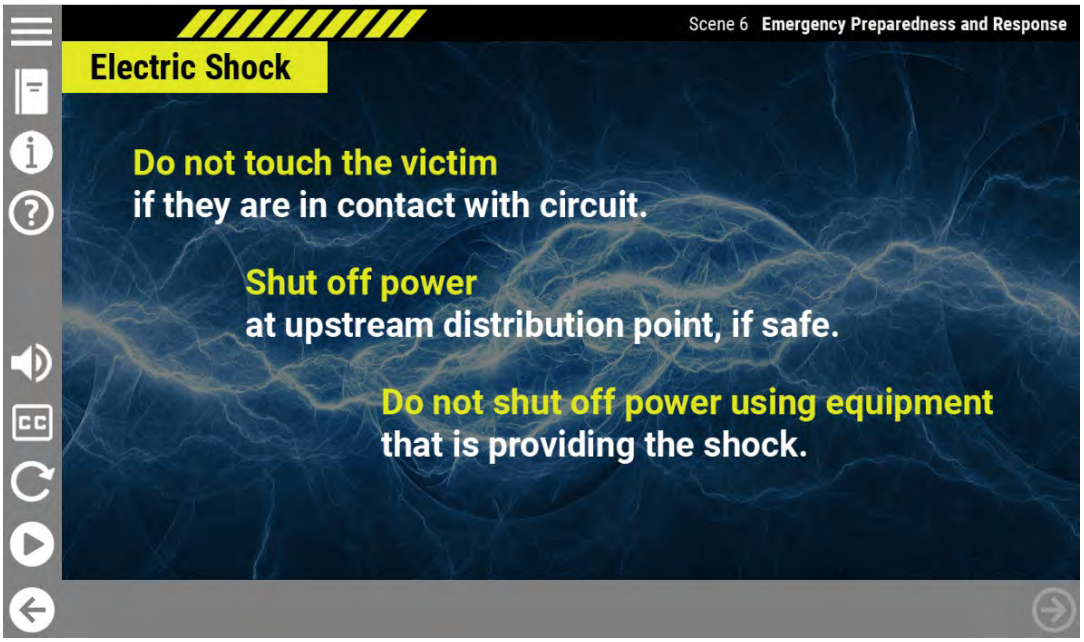
At a minimum, it will include the following: Alert others, starting with the people in your immediate area. Pull the fire alarm if there is one nearby, or have someone else do it. Then, call the on-lot emergency number or 911 if you're on location. Be prepared to provide a description of the fire and your exact location.

Slide 152. Electric Shock 1

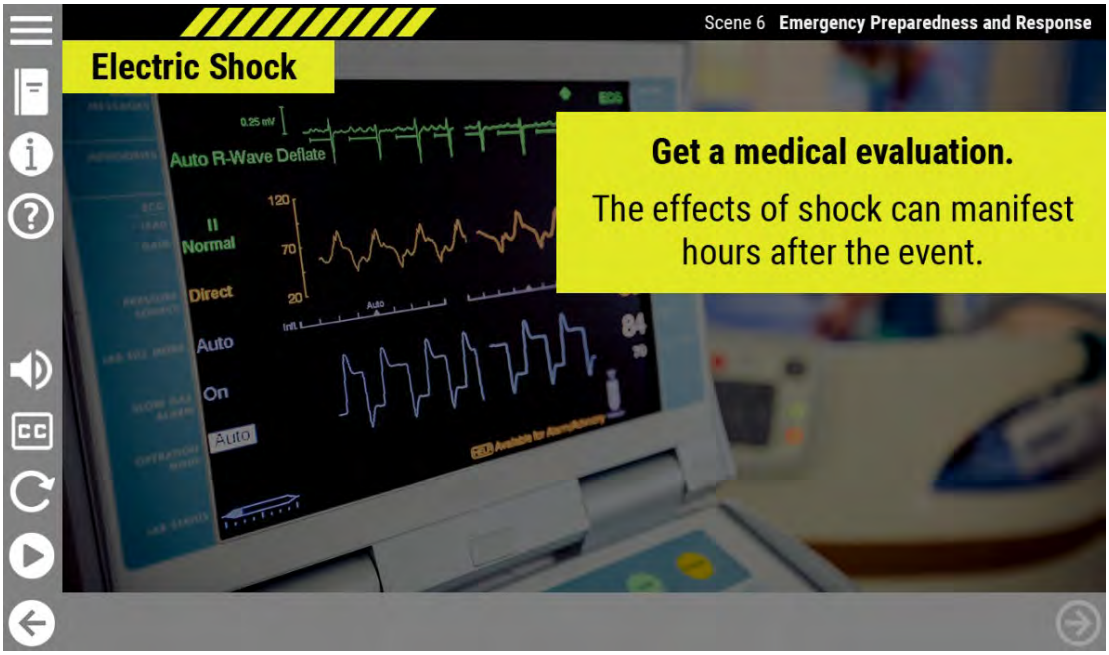
How should you respond if a crew member experiences an electrical shock?

Notify EMS as well as a supervisor or electrically qualified person immediately. Stay clear of the electrical hazard and secure the accident area to prevent others from approaching until the circuits are de-energized.

Slide 153. Electric Shock 2

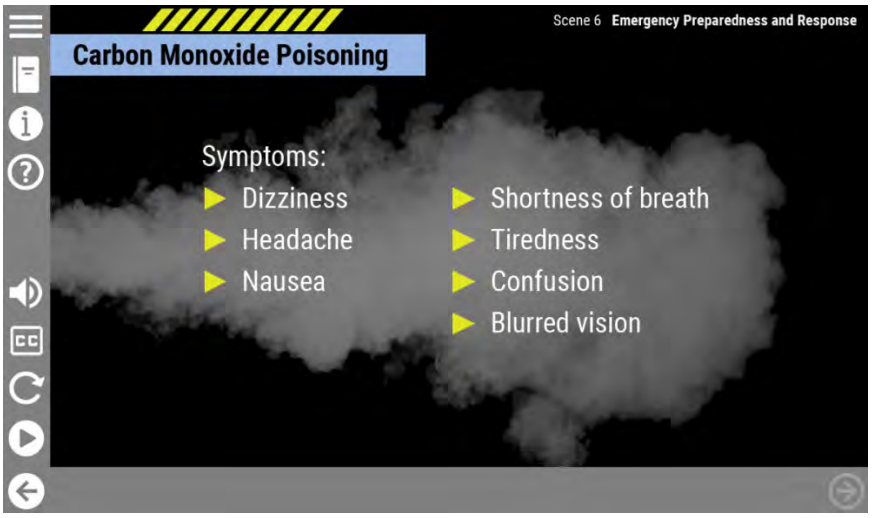


Do not touch the victim if they are still in contact with the circuit. Would-be rescuers can become part of the circuit and require rescue themselves. Immediately shut off the power at an upstream distribution point (provided it is safe to do so). Do not attempt to shut off the power using the equipment that is providing the shock.

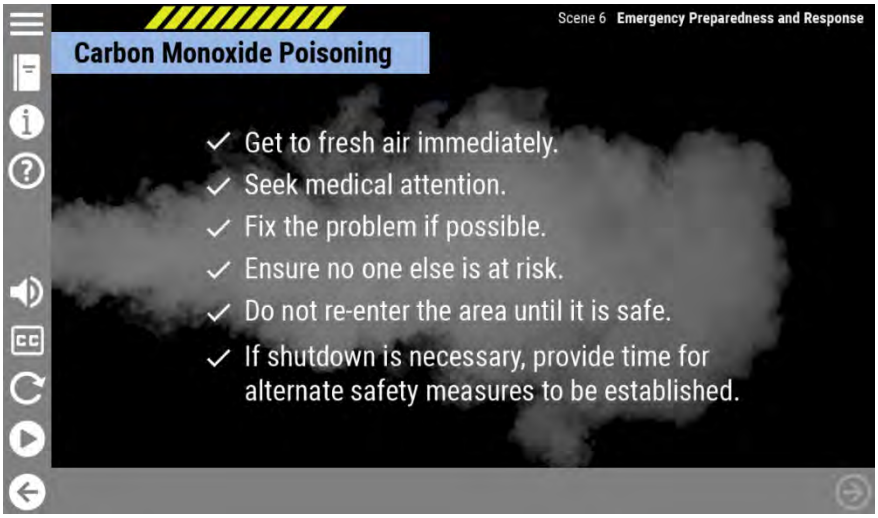


A victim of electric shock must be properly evaluated by a medical professional. Internal injuries may not be readily apparent, and possible side effects can manifest hours after the event.

Slide 154. Carbon Monoxide Poisoning Response



If you or anyone else is experiencing symptoms of carbon monoxide poisoning—dizziness, headache, nausea, shortness of breath, tiredness, confusion, blurred vision—



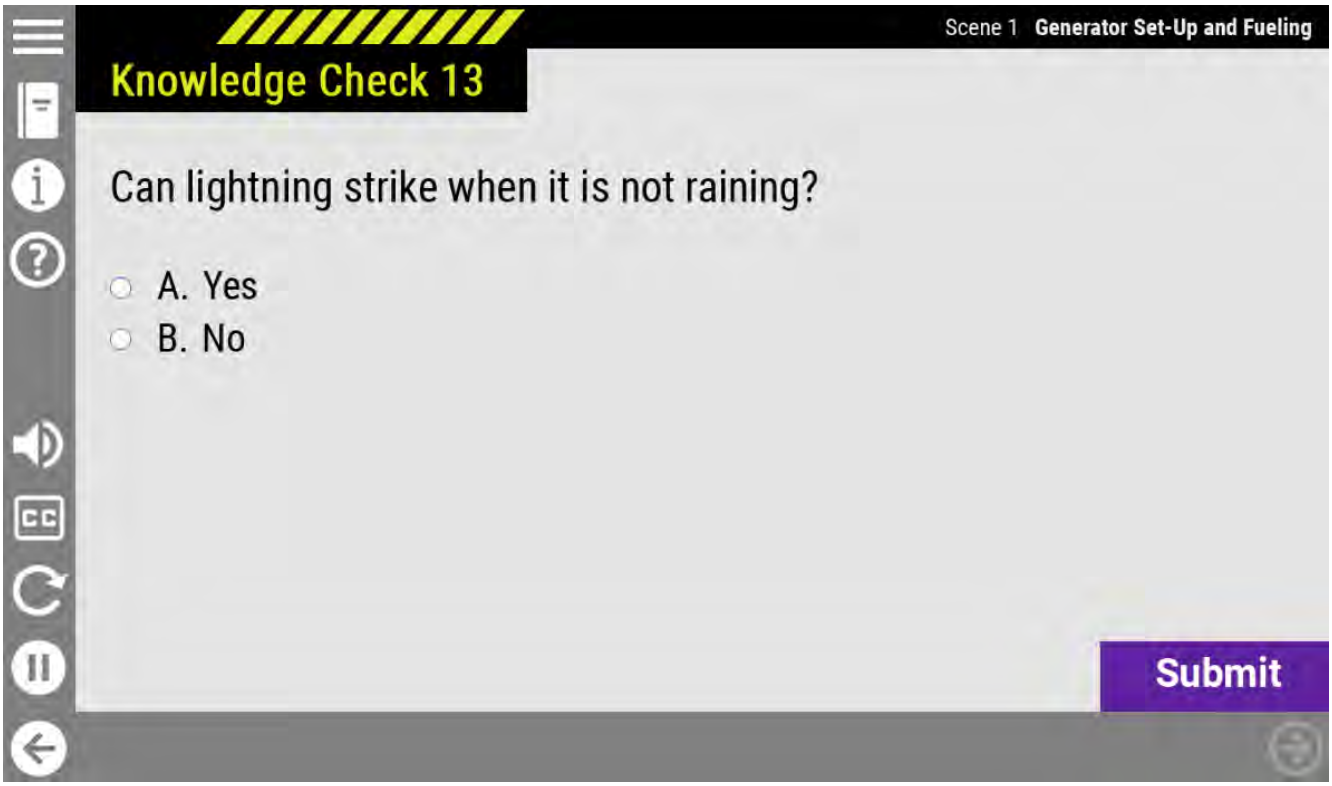
get to fresh air immediately.

Use your discretion to determine what to do next. If symptoms are severe, seek medical attention right away. If you can safely find the source of the carbon monoxide and remedy the situation quickly, you may want to do that before anyone else is put at risk. Do not re-enter the area until it is okayed by a trained and properly equipped person.

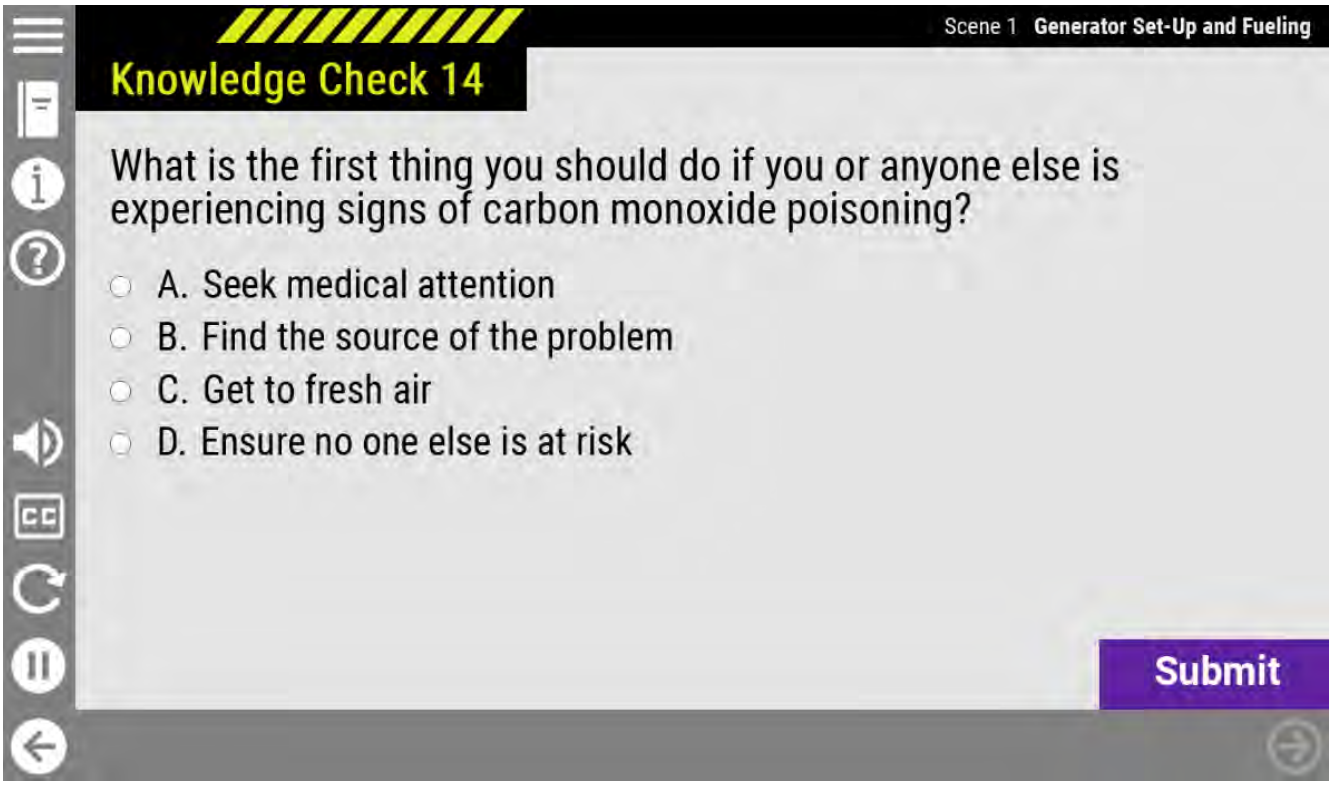
Shutting down the unit may be problematic, especially if the generator is providing vital functions such as safety lighting. Inform others before the generator is shut down and provide time for alternate safety measures to be established.

We're at our last couple of knowledge checks. Let's see how you do.

Slide 155. Knowledge Check 13



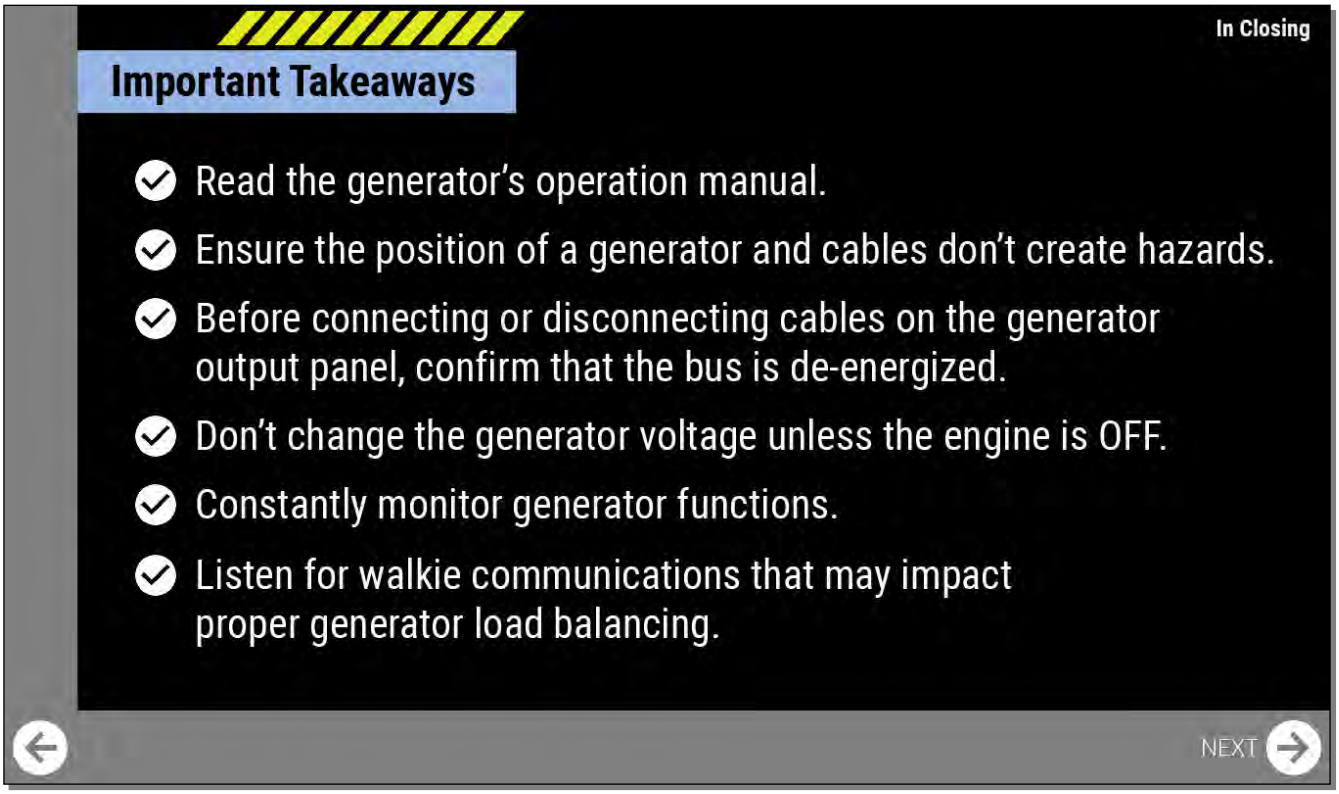
Slide 156. Knowledge Check 14



Slide 157. IN CLOSING

We've reached the end of the presentation. Let's review some important takeaways from the course.

Slide 158. Important Takeaways



Read the generator's operation manual.

Ensure the position of a generator and cables don't create hazards.

Before connecting or disconnecting cables on the generator output panel, confirm that the bus is de-energized.

Don't change the generator voltage unless the engine is OFF.

Constantly monitor generator functions.

And, listen for walkie communications that may impact proper generator load balancing.

Slide 159. A Safe Attitude

Your safe attitude impacts how you act and react to workplace conditions and challenges. Speak up about safety issues. Ask questions. Look out for your coworkers and for yourself. Remember, safety starts with you.