UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Engineer School
PSC Box 20069
Camp Lejeune, North Carolina 28542-0069

U-07F01
JAN 00

STUDENT HANDOUT

INSTALL ELECTRICAL DISTRIBUTION SYSTEM

1. **LEARNING OBJECTIVES**:

a. **TERMINAL LEARNING OBJECTIVE**: Provided a field electrical power generation and distribution system plan, MEPDIS system, generator sets, floodlight sets, general illumination set, an installation crew equipped with a lineman's tool kit, material for constructing a bus bar, tents, and references, install a field electrical power generation and distribution system. The system must satisfy power requirements in accordance with the field electrical power generation and distribution system plan. (1141.03.04)

b. **ENABLING LEARNING OBJECTIVES**:

(1) Provided a bus bar plan, lineman's tool kit and construction materials, without the aid of reference, construct a bus bar, in accordance with MCI 11.43 and FM 5-424. (1141.03.04b)

(2) Provided a selection of purposes, without the aid of reference, identify the 3 uses of a bus bar, in accordance with MCI 11.43 and FM 5-424. (1141.03.04c)

(3) Provided a selection, without the aid of reference, identify the purpose of the switch boxes that are contained in the small light set for use with the bus bar, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ab)

(4) Provided a selection of definitions, without the aid of reference, identify the definitions for equipment grounding, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ac)

(5) Provided a selection of definitions, without the aid of reference, identify the correct definition for system grounding, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ad)

(6) Provided a switch box and over current protection devices, without the aid of references, make the appropriate connections to the bus bar, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ae)

(7) Provided a 4 AWG wire, without the aid of reference, ground the system to the bus bar, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04af)

(8) Provided conductors and tools, without the aid of reference, perform a side tie, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ag)

(9) Provided conductors and tools, without the aid of reference, perform a corner tie, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ah)

(10) Provided conductors and tools, without the aid of reference, perform a dead end tie, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ai)

(11) Without the aid of reference, identify the 2 locations that over current protection devices are to be installed in a power distribution system, in accordance with MCI 11.43 and FM 5-424. (1141.03.04aj)

(12) Without the aid of reference, identify the 3 ratings of power distribution panels contained in the MEPDIS system, in accordance with MCI 11.43, FM 5-424. (1141.03.04ak)

(13) Provided a selection of devices, without the aid of reference, identify the 3 safety features that are built into the MEPDIS system, in accordance with TM 08712A-14/1 and MCI 11.43. (1141.03.04al)

(14) Provided a selection of definitions, without the aid of reference, identify the correct definition for the acronym MEPDIS, in accordance with TM 08712A-14/1 and MCI 11.43. (1141.03.04am)

(15) Provided a generator set, power poles, 8 AWG wire insulator assemblies and lineman’s tools, without the aid of reference, install a overhead wiring distribution system, in accordance with FM 5-424. (1141.03.04an)

(16) Without the aid of reference, identify the minimum height for wires over various crossings, in accordance with FM 5-424. (1141.03.04ao)

(17) Provided a generator set, MEPDIS power panels, a power distribution plan, MEPDIS cables and lineman’s tools, without the aid of reference install the MEPDIS power distribution system, in accordance with TM 08712A-14/1 and MCI 11.43. (1141.03.04ap)

(18) Provided a selection of definitions, without the aid of reference, identify the correct definition for a visual check on a power distribution system, in accordance with MCI 11.43, FM 5-424. (1141.03.04aq)

(19) Provided lineman’s tools, without the aid of reference, perform a visual check on the power distribution system, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04ar)

(20) Provided a selection of definitions, without the aid of reference, identify the correct definition for a voltage check on a power distribution system, in accordance with MCI 11.43, FM 5-424, and the NEC. (1141.03.04as)

(21) Provided a power distribution system, lineman’s tools, amp meter, multimeter and a light test, without the aid of reference, perform a voltage check on the power distribution system, in accordance with MCI 11.43, FM 5-424. (1141.03.04at)

(22) Provided wire and lineman’s tools, without the aid of references, perform a T-Tap, in accordance with MCI 11.43, FM 5-424. (1141.03.04aw)

Body

1. **Bus Bar Construction**:

a. Using the general illumination light sets, A bus bar (distribution system) can be fabricated. A bus bar is made utilizing six essential items as illustrated and shown in figure 1-1.

(1) Lineman’s Tool Kit.

(2) Grounding Rod.

(3) Insulator Racks.

(4) Appropriate Size Wire.

(5) Appropriate Switch Boxes and Breaker Boxes.

(6) Lumber 2(4x4’s) and 1(2x4).

FRONT VIEW OF BUS BAR

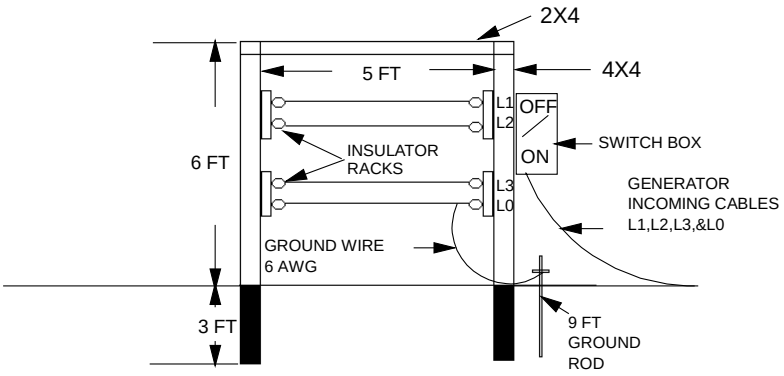


Fig 1-1 Bus Bar

b. Setting up the bus bar starts with the general guidelines in the diagram above and the following steps provided below. Keep in mind, that these are the minimum guidelines for construction of a bus bar. The bus bar can be made as elaborate as safety, time, materials, and your imagination will allow.

(1) Dig two holes 3 ft deep, 5 ft apart and set the 4x4's In the ground as shown in figure 1-1.

(2) Using a 2x6, nail a top brace cross member to the posts to make the framework sturdy.

(3). Use lag bolts to mount insulator racks provided by the Large and Small light set(s). Ensure that they are evenly spaced on the inside of each 4x4 so that the insulator racks

(4) The wiring for the bus bar must be strung between the 4x4's using the insulator racks.

(5) Ensure that the wire is tight as possible using a dead end tie. The size wire will be determined by the generator capacity and the power requirements.

(6) Place a grounding rod about 1 foot from the bus bar and drive it into the ground to the proper depth of 8 ft to 8 ½

(7) Once the wire has been positioned, mark each wire with tape so the phases can be identified or some other non-conducting material. Remember, the bus bar is the main connection point for all combined power. So the wire must be able to handle the entire load of the area being powered up. **(Procedures for determining load requirements will be covered in detail later in this course).**

2. **Bus Bar**:

a. A bus bar is a fabricated distribution center using the gen eral light sets and the lineman’s tool kit. It is used when the equipment requiring power is so widely scattered that two or more branch feeders are required.

b. It can also be used to connect two or more generator set(s) in parallel if the load requirements are greater than what a single generator set can supply.

c. Also by utilizing a bus bar, one generator set can be brought on line simultaneously as one is dropped off line by the use of a single pole double throw switch if a service is needed or if something goes wrong with a generator set.

3. **Switch Boxes**:

a. Once you have completed the bus bar, you will need to add a switch box to the frame as shown in figure 1-1. Switch boxes are provided in the large and small light set(s). The switch box is used for connecting and disconnecting generator(s). It is also a safety measure in that all power can be shut off from the bus bar, and the area being provided power. You will need to have the proper size switch box for your bus bar because your switch box will be required to handle the same amount of power that your wire used on the bus bar handles.

b. The large light set contains a (1) 70 ampere circuit breaker box with 15 and 30 ampere circuit breakers to provide over current protection for circuits.

c. The small light set provides (3) 30 ampere breaker boxes with 15 and 30 ampere breakers. The light set also provides (1) 100 and (3) 60 ampere Single throw single pole switch boxes which are three-phase. These switch boxes are to be used as the primary over current protection for our main circuits and feeder circuits.

4. **Equipment Grounding**:

An equipment ground is an additional ground that it attached to all metal frames and surfaces of appliances and circuit devices. It reduces the voltage to zero volts if a fault does occur in a circuit. The fuse or circuit breaker will open the circuit to prevent serious injury to any one who might come in contact with a metal surface of the appliance or device.

5. **System ground**:

a. A system ground is the ground applied to the neutral conductor. It reduces the possibility of fire and shock by reducing the voltage to zero volts. System grounding protects a circuit and attached appliances from lightning, line surges, and contact with higher voltages.

b. The neutral wire, which is used for system grounding must be connected to a grounding bus bar within the circuit breaker or fuse box. This is usually done by a bonding screw that secures the grounding bus bar to the box. The entire grounding system is then bonded to the ground by attaching a #6 AWG or #8 AWG copper wire to the grounding bus bar and running it to a grounding rod. The grounding rod is nine feet long and at least eight feet must be driven into the ground.

6. **BUS BAR CONNECTIONS:**

a. The simplest method of connecting a generator to a bus bar is to run four conductors from the generator terminal board to the input connections of the switch box which is mounted to the bus bar as shown in figure 1-1. From the output connections of the switch box, connect the conductors to the appropriate conductors on the bus bar. This will ensure a disconnecting point between the generator and the bus bar.

b. Switch boxes are to be installed to the bus bar for each generator that is used when using multiple generators.

c. Weather one or two switches are used, the proper phase sequence must be maintained at all times as shown in figure 1-2.

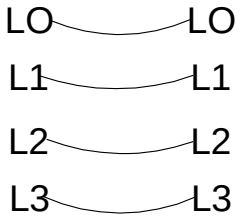


Fig 1-2 Proper Phase Sequence

7. **GROUNDING THE BUS BAR:**

To ground the bus bar to the system, you can use #4 AWG wire. Once you have the wire, you need to connect the wire to the grounding rod. The grounding rod is drove in the ground at least 8 ft as shown in figure 1-1. To connect the wire to the bus bar and grounding rod, use a splice connector that is located in the light set. Ensure that you have continuity between the bus bar and grounding rod. Bad continuity could cause loss or damage to Life or equipment!

8. **SIDE TIE:**

a. A side tie is used for supporting the conductor when it is not feasible to run the conductor through the insulator racks. Ex: If you are running your conductor over your tents and one of the tents needs to be moved, you would then have a problem with the insulator still being on the conductor. This would cause a problem because of the extra weight that it would bring on the conductor.

b. Side ties are used with a small piece of #14 AWG wire about 6-8 inches long. You then run two wires through the insulator rack wrapping the wires around the insulator rack once pulling firmly. Once the wires are around the insulator rack, you wrap the extra wire around the conductor that is running through the insulator rack. Make sure that you make several wraps around the conductor that is running through the insulator as shown in figure 1-3. This will ensure a good firm hold.

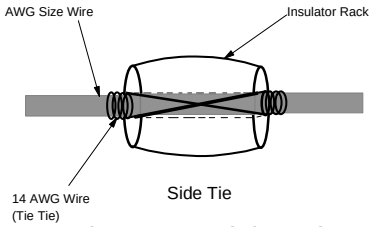


Fig 1-3 Side Tie

9. **CORNER TIE**:

a. A corner tie is used for supporting the conductor when support is needed at direction changes. Ex: If you are running your conductor from your bus bar up to a insulator rack on a pole and you have to continue to another pole, a corner tie would be needed to support the conductor at the insulator rack. This gives the conductor support from moving around and possibly causing damage. Corner ties are used in the same manner as the side tie with exception of it being a corner as shown in figure 1-4.

b. Corner ties are used with a small piece of #14 AWG wire about 6-8 inches long too. You also run two wires through the insulator rack wrapping the wires around the insulator rack once pulling firmly. Once the wires are around the insulator rack, you wrap the extra wire around the conductor that is running through the insulator rack. Make sure that you make several wraps around the conductor that is running through the insulator as shown in figure 1-4. This will ensure a good firm hold.

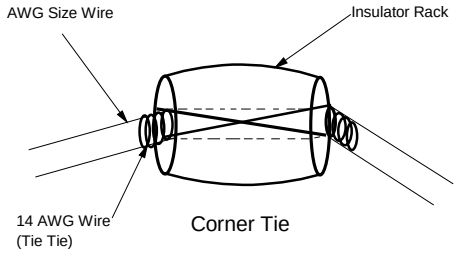


Fig 1-4 Corner Tie

10. **DEAD END TIE**:

a. Dead end ties work like an anchor point where stress and tension are unavoidable. To make a dead end tie, you only need the insulator rack and the conductor as shown in figure 1-5.

b. To make a dead end tie you need to wrap the conductor around the insulator twice. Once this is accomplished, you then need to wrap the remaining conductor around the supporting conductor several times to ensure a firm tie as shown in figure 1-5.

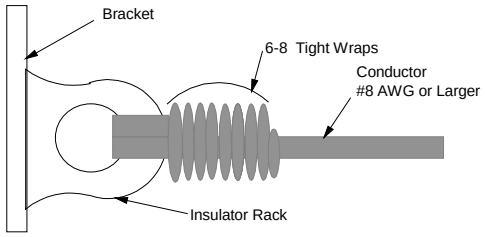


Fig 1-5 Dead End Tie

11. **Over Current Protection**:

a. The first place that over current protection is needed is at the bus bar. This provides a protection for the generators and for the entire area that power is being provided for.

b. Another place that over current protection is needed is at each separate circuit that comes off the bus bar. This must be protected according to the total load that the circuit is expected to carry. Figure 1-6 shows how the placement of the over current protection devices which support the entire camp.

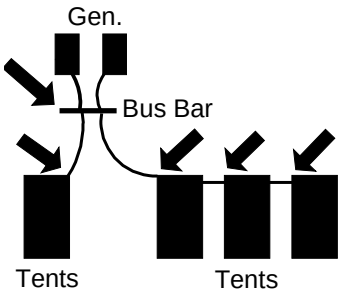


Fig 1-6 Camp Layout

12. **Power Distribution Panels**:

a. The power distribution panels come in three types of panels. These panel boards are nothing more than the service panels in your house with the exception that they are completely encased and weather-proofed for use outdoors use.

b. The first of these panels is the 100 kW panel. This is the largest panel of the three. It is designed to be hardwired directly to the generator, by use of the connections (Benelux system) underneath the panel, the generator terminal lugs and the wire provided with the panels (350KCM). This panel is equipped with a 3 phase 350 amp main breaker and has the capability to have another 350 amp main breaker added. This panel is designed for your larger three phase loads and for feeding the other smaller panels. It does not have a single phase output capability and it weighs approximately 350 pounds. The following is the load outputs that the 100 kW provide.

(1) (2)3 phase 20 amp

(2) (2)3 phase 30 amp

(3) (2)3 phase 60 amp

(4) (4)3 phase 100 amp

c. The 30 kW is the middle size panel and it can be wired two ways. First by being connected to the 100 kW panel or it can be wired straight from the generator. This panel contains a 3 phase 100 amp main breaker and has the capability of having a second 100 amp breaker added. This panel is designed for medium size loads and has limited single phase capability and it weighs approximately 150 pounds. The 30 kW panel provides the following outlets.

(1) (2)single phase 20 amp

(2) (2)3 phase 20 amp

(3) (2)3 phase 30 amp

(4) (4)3 phase 60 amp

d. The 15 kW panel is the smallest of the three panels. The 15 kW panel contains a 3 phase 60 amp main breaker and has the capability of having a second 3 phase 60 amp breaker added. These panels can only be used in conjunction with one of the larger panels.
The 15 kW panel is designed to carry your smaller loads in a power distribution system. The 15 kW panel has a limited 3 phase small amp carrying capacity and it weighs approximately 50 pounds. The 15 kW panel contains the following outputs.

(1) (9) single phase 120v 20 amp

(2) (2) 3 phase 20 amp. The cables that come with the power distribution panels are marked with the following information: Part # and Amperage rating. This is for easy identification.

13. **SAFETY FEATURES:**

a. The power distribution panels has many safety features built in and offers many safety features to the Marine Corps. The first being the circuit breakers themselves. As long as you are using them, each circuit you run and operate has automatic safety of a breaker sized for that circuit. All single phase power circuits have Ground Fault Circuit Interrupt Breakers (GFCI) to prevent electrical shock in the case of a fault, a short or a bad ground. Each cable has multiple ground wires for added safety.

b. The 100 kW and 30 kW panels also have solenoids that lock the rear access door while the unit is in operation. Each panel is also marked with indicator lights which allows you to identify the lose of any phase.

14. **MEPDIS:**

a. The power distribution panels are important part of the MEPDIS system. Mobile Electric Power Distribution Systems (MEPDIS) where designed to augment overhead single strand conductors as a means of power distribution. MEPDIS provides a network of multiple 120/208-volt, 3-phase loads and 120-volts single phase load from a remote location. They have been made to withstand the weight and stress of any vehicle with the exception of tracked vehicles.

15. **OVER HEAD WIRING INSTALLATION:**

a. There are two main types of layouts when installing a power distribution system with single strand overhead wire. They are the ring layout and the radial layout.

b. The most common power distribution layout is the radial layout as shown in figure 1-7. The radial layout runs a main feeder through the approximate center of the installation and circuits are run to the various facilities as needed

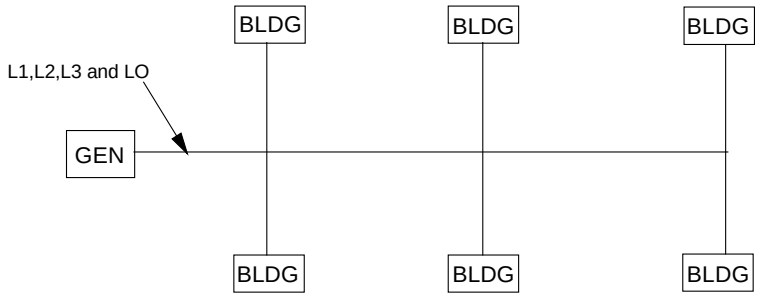


Fig 1-7 Radial Layout

(1) The advantages of the radial layout is that it requires minimal material, time and manpower to install and if power is interrupted at one facility, power will still remain at the other facilities. Also, repairs my be done on certain areas by disconnecting the facility at the over current protection device without interrupting any other facilities power.

(2) The only disadvantage of this layout is that if a break occurs before any of the facilities, then no power will be received by any facility.

c. The ring layout is another type of layout that is used by electricians as shown in figure 1-8.

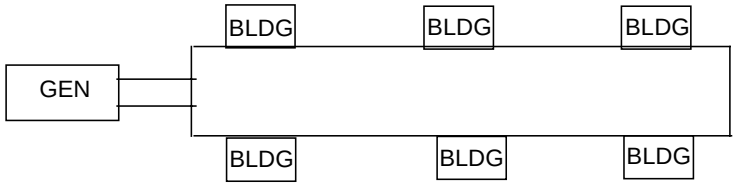


Fig 1-8 Ring Layout

(1) The advantages of the ring layout is that it requires minimal material, time and manpower as well to install.

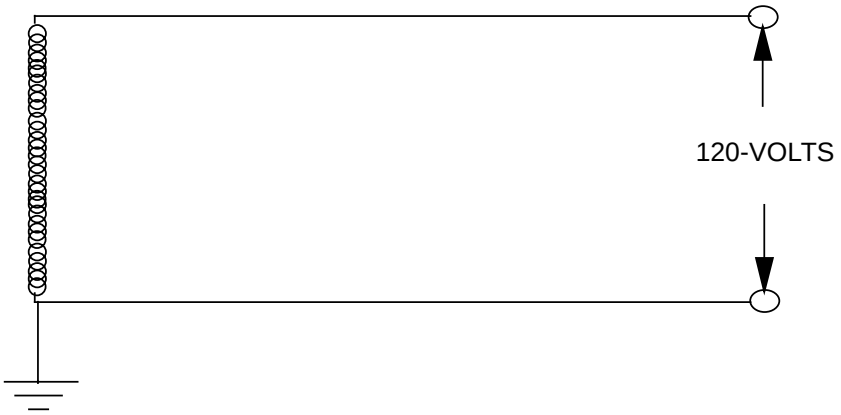
(2) The only disadvantage of this layout is that if a break occurs before any one facilities, then no power will be received by any facility beyond that particular facility.

d. Another important factor in installing a power distribution system, is the types of wiring that can be used. There are four types of wiring which may be utilized in a power distribution system: Sin-

gle-Phase Two-Wire; Single-Phase Three-Wire; Three-Phase Three-Wire and Three-Phase Four-Wire. The number of phases, the number of wires and the voltages between the wires will be dictated by the load requirements.

e. In the Single-Phase Two-Wire system one of the two wires from the generator is connected to the ground by means of a grounding rod and is called the grounded wire or neutral wire. The other wire is called the hot wire or ungrounded wire. Normally the voltage between these two wires is 120-Volts as shown in figure 1-9. Typical Single-Phase Two-Wire, 120-Volts loads are lights, portable tools, low power equipment and Single-Phase 240-Volt loads.

Fig 1-9 Single-Phase, Two-Wire, 120-Volt system



f. Single-Phase Three-Wire systems have one grounded or neutral wire and two hot wires as shown in figure 1-10. Generally the voltage between either of the hot wires and the neutral is 120-Volts. The difference between the two hot wires is then 240-Volts. The reason this is called a Single-Phase system is because there is no Phase difference between any of the three wires. This type of system is used for lighting loads, portable tools, low power equipment and Single-Phase 240-Volt loads.

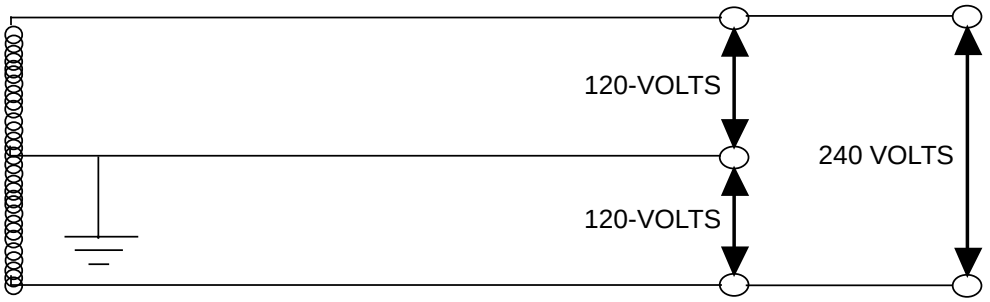


Fig 1-10 Single-Phase, Three-Wire 120/240-Volt system

g. In Three-Phase, Three-Wire, 120-Volt systems, all three wires are live wires. Any three-phase, three-wire, 120-Volt load can be connected to this setup. However, this system requires the kind of generator set designed to produce three-phase voltage (and only produces one magnitude of voltage). As you can see from figure 1-11, no matter which two wires you take your reading from, you get the same voltage reading. There is no way to change the wiring configuration to receive different voltages. This system is used for supplying power to loads in structures where the three-phase power load is larger than a single-phase lighting load. The single-phase lighting load in such a structure is supplied either from a separate single-phase service or a step-down transformer.

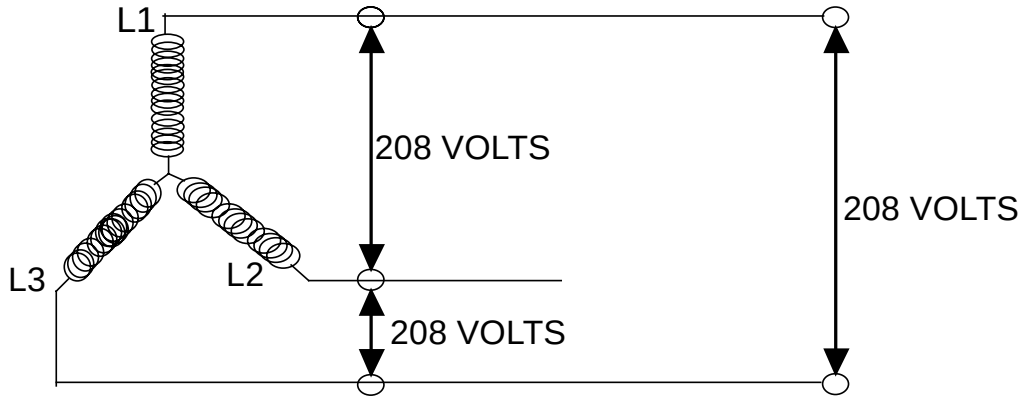


Fig 1-11 Three-Phase, Three-Wire, 208-Volt system

h. Three-Phase, Four-Wire, 120/208-240/416-Volt system is designed for different voltages such as 120/208 volts or 240/416 volts as shown in figure 1-12. Any single-phase, 120-volt load can be fed by a hot and a neutral wire. In figure 1-12, it shows that any single-phase two-wire, 208-volt load can be fed by two hot wires. Any three-phase, three-wire, 208-volt load can be fed by all three hot wires. Finally, any three-phase, four-wire, 120/208-volt load can be fed by all four wires. This is the most common system used since it can accommodate both single-phase lighting and three-phase motor loads.

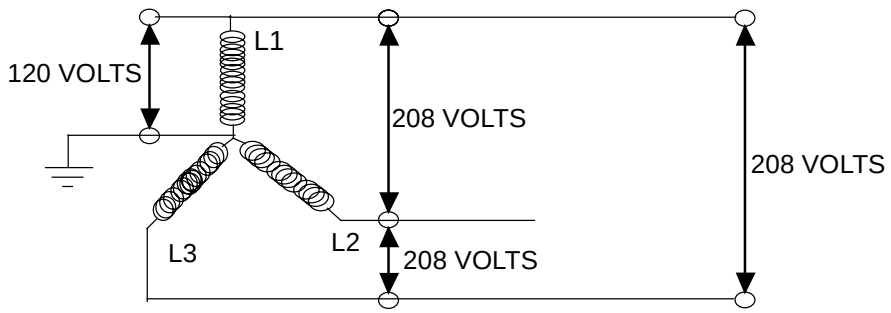


Fig 1-12 Three-Phase, Four-Wire, 120/208-240/416-Volt system

i. Once you have figured out what type of layout that you are going to be using, and you know what wiring system you will need, you are finally ready to install your power distribution system.

16. **CLEARANCES**:

17.

a. Above roof tops, conductors shall have a vertical clearance of not less than 8 ft above the roof surface. The vertical clearance above the roof level shall be maintained for a distance of not less than 3 ft in all directions from the edge of the roof.

b. The minimum height requirement is 10 ft for electric service entrances to buildings, above sidewalks or areas accessible to pedestrians, and service-drops.

c. The minimum height requirements is 12 ft over residential property, driveways and commercial areas not subject to truck traffic.

d. The minimum height requirements is 18 ft over public streets, alleys, roads, parking areas subject to truck traffic, driveways other than residential property and other lands such as forest and orchards.

17. **MEPDIS INSTALLATION**:

a. In the lesson, you have identified the different types of MEPDIS panels that are available. MEPDIS also has a wiring harness set that was designed specifically for MEPDIS. These wiring harnesses are durable and have connections that make assembly easy.

b. Using the power distribution panels and the field wiring harness set, installing becomes an easy process. The wiring harness set was designed to supply the electrical requirements for various billeting tents. It was also designed to provide electrical power distribution and illumination through receptacle circuits and power outlets.

This wiring harness set is weatherproof and it contains various cables such as switches, receptacles and extensions.

c. To install the MEPDIS system, you simply connect the designated cables to the required power distribution panels and the wiring harness set. Ensuring that the load requirements are met, all that is needed is to install the power distribution panels in the required areas.

18. **VISUAL CHECK:** A proper visual check consist of visually checking the entire system and ensuring that everything is visually correct.

19. **PERFORM VISUAL CHECK:** Once that you have completed the overhead wiring, you will need to inspect the system. The first thing that is required in a visual check is to ensure that all power is off. Also you need to physically check every location that a connection has been made. Check for proper phase connections and all of the over current protection devices.

20. **VOLTAGE CHECK:** A voltage check is checking to ensure that proper voltage is m

21. **PERFORM VOLTAGE CHECK:** The proper way to ensure that the voltage is continues throughout a system is to run the generator and do a voltage check at each point that has over current protection or a switch box. From the generator to the end of the circuit, voltage should be required to remain constant.

22. **T-TAP:** The reason for a T-Tap is so that a main feeder circuit can be tapped into to supply an additional circuit. To perform a T-Tap, you need to ensure that the are that is required to be tapped into is not damaged. Then use the desired wire to wrap around the feeder circuit forming a “T”. This is then protected by covering with insulated tap.

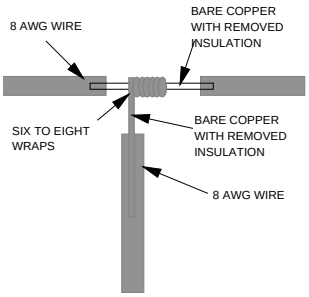


Fig 1-13 T-Tap