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

U-20B07
NOV 99

STUDENT OUTLINE

PLAN FIELD ELECTRICAL POWER AND DISTRIBUTION SYSTEM WITH MEPDIS

LEARNING OBJECTIVES:

a. **Terminal Learning Objective**:

Provided a mission, a map, a camp layout, a utility site reconnaissance report, a T/E, a T/O, and references. Plan a field electrical power generation and distribution system such that it will provide electrical power of the voltage, current, and frequency specified for the number and location of tents and facilities per the references. (1141.08.01)

b. **Enabling Learning Objectives**:

(1) Provided an operation order and camp layout, with the aid of references, compute the total connected load in accordance with TM 5-765. (1141.08.01a)

(2) Provided an operation order, a camp layout, and power requirement worksheets, with the aid of references, calculate the total power demand required supporting the operation in accordance with FM 20-31. (1141.08.01b)

(3) Provided an operation order, a camp layout, and power requirement worksheets, with the aid of references, list the size generator for each generator site that is required to support the operation in accordance with FM 20-31. (1141.08.01c)

(4) Provided an operation order, a camp layout, and power requirement worksheets, with the aid of references, mark each generator site required to support the operation on the camp layout, in accordance with FM 20-31. (1141.08.01d)

(5) Provided an operation order, a camp layout, a power requirement worksheet, and a phase balancing worksheet, with the aid of references, balance the phases for each generator site required to support the operation in accordance with FM 20-31. (1141.08.01e)

(6) Provided an operation order, camp layout, a power requirement worksheet, and a phase balancing worksheet. With the aid of references, determine the number of each size Mobile Electric Power

Distribution System (MEPDIS) panel that is required to support the operation in accordance with the National Electric Code and the Operation Maintenance Manual for MEPDIS. (1141.08.01g)

(7) Provided an operation order, camp layout, a power requirement worksheet, and a phase balancing worksheet. With the aid of references, determine the number of each size MEPDIS cable required for each electrical circuit to support the operation in accordance with the National Electric Code and the Operation Maintenance Manual for MEPDIS. (1141.08.01h)

(8) Provided an operation order, camp layout, a power requirement worksheet, and a phase balancing worksheet, with the aid of references, determine the size of each over-current protection device required to protect each circuit supporting the operation in accordance with the National Electric Code and the Operation Maintenance Manual for MEPDIS. (1141.08.01j)

(9) Provided an operation order, camp layout, a power requirement worksheet, and a phase balancing worksheet, with the aid of references, determine the number of MEPDIS wiring harness set cables required to support the operation in accordance with the operation order and the Operation Maintenance Manual for MEPDIS. (1141.08.01l)

(10) Provided an operation order, camp layout, a power requirement worksheet, and a phase balancing worksheet. With the aid of references, draw the electrical distribution system required to support the operation on the camp layout in accordance with FM 20-31, the National Electric Code, the operation order, and the Operation Maintenance Manual for MEPDIS. (1141.08.01m)

(11) Provided an operation order, camp layout, the aid of references, list the tools sets required to install and maintain the electrical distribution system required to support the operation in accordance with the appropriate equipment technical manuals and the Operation Maintenance Manual for MEPDIS. (1141.08.01o)

(12) Provided an operation order, camp layout, a power requirement worksheet, and a phase balancing worksheet. With the aid of references, determine the logistical requirements for installing and maintaining the electrical distribution system required to support the operation, in accordance with the appropriate equipment technical manuals and the Operation Maintenance Manual for MEPDIS. (1141.08.01p)

BODY

1. **The Electrical Power Continuum**:

a. From the military perspective, electrical power encompasses the entire spectrum of power generation, distribution, and transmission systems that support military operations. It ranges from the power produced by the smallest tactical generator, to the power distributed by commercial power plants and their associated transmission and distribution systems.

b. Tactical generators range from 3 kW to 200 kW, and are standard military portable generator sets. They provide a mobile source of power to units operating in the field, Distribution systems for tactical generators are usually very simple and in the Marine Corps consist of the following:

(1) Light set general illumination, large.

(2) Light set general illumination, small.

(3) Mobile Electric Power Distribution System (MEPDIS)

(4) Field Wiring Harness Set (FWHS)

c. Prime Power is reliable commercial-grade utility power continuously generated by non-tactical generators ranging in size from 250 kW to 750 kW.

(1) Non-tactical generators require site preparation for installation.

(2) They also require the use of transformers and distribution equipment networks.

(3) Prime power usually requires the construction of nonstandard distribution networks.

(4) Prime power plants when operating at 60hz. have an output voltage of 2400/4160 volts 3 phase. This voltage is known as a medium voltage.

(5) Prime power plants can replace existing power sources such as large concentrations of tactical generators and make available these generators for tactical use.

(a) Initial design life is 6 months, using tactical generators.

(b) Temporary design life is 24 months, using prime power or commercial power.

d. Commercial power plants and their transmission and distribution systems are fixed nonstandard systems. These power systems are part of the infrastructure as are other utility systems. Commercial power is provided by a host nation(s).

(1) Worldwide voltage and frequency is not always the same as in the United States.

(2) Some equipment is sensitive and will not operate properly when powered by a source with different voltage and/or frequency.

(3) If your equipment is going to be connected to commercial power in a foreign country, you must first check to see if that countries electrical system is operating on a voltage and frequency you can use. For example, France uses both 50 Hz and 25 Hz at various voltages.)

2. **Computing the Total Connected Load**:
When planning an electrical system using one of the Marine Corps distribution systems, you must first determine all the loads that will be connected to the electrical system. You should have a detailed layout of the camp that you supplying power to.

a. The connected load is determined by all the electrical loads that are connected to the system. You must study the camp layout and determine the loads that must be served. You should consider:

(1) Structures that will require electrical power.

(2) Equipment that will require electrical power. If you are unable to take reading with a meter you can use two other methods to determine the power consumption of equipment:

(a) Read the data plate of the equipment

(b) Checking the equipment manuals to find the ratings.

(3) The connected load is calculated by 100% of watts or kW of all loads.

(4) The connected load is calculated by 100% of amps for all the loads.

(5) When determining the connected loads you can calculated and organize the information using a Connected Load Worksheet. This will prove useful in comparing other data and perhaps later during planning.

(a) List the type of load that are going to be served.

(b) List the total watts and amperes based on the quantity and type of structure or equipment all at 100%.

1 List the total watts for lights for the type of tent.

2 List the total watts for outlets for the type of tent.

3 List all the equipment and motor loads.

b. Using a Connected worksheet, you can list the connected loads.

3. **Calculating the Demand**:

a. When we examine the total connected we find that all the loads are considered at 100% of the potential draw. However, when we look at how many available receptacles are around us in our home or workplace, we realize how many are not being used or have small loads plugged into them. Taking notice of this allows us to understand why a demand is needed. A demand is a determined value placed on an item based on the average real draw or load that will be placed on it. For example, in public rest rooms we can find many toilets, sinks, and sometime urinals; Yet, we see that not all toilets, sinks, and urinals are flushed exactly at the same time. That would require an orchestrated event to occur. Therefore, a demand can be used to size the water supply pipe based on what is really needed taking into consideration the nature of how things are normally used. Likewise, we can see some receptacles that are rated at 20 amperes; yet, they might have nothing more then a clock or some other low current using device plugged into them. In contrast, applying a demand can sometimes take into account higher current draws that should be considered such as motor loads that may be subject to lock-rotor amperages.

b. When computing a demand we need to consider the load.

(1) When placing a demand for lighting there is 100% of the power consumed. This means a 120 volt, 60 watt, .5 ampere light bulb will consume 120 volt, 60 watt, .5 ampere always.

(2) When placing a demand on a receptacle in the field that is intended for general purpose uses the demand is 15% of the rating per outlet.

(a) When the demand factor is applied to a receptacle rated at 20 amps, the receptacle is taken at 3 amps.

(b) When the demand factor is applied to a receptacle rated at 20 amps the receptacle is taken at 360 watts.

(c) The voltage amperage, and wattage are all propionate to one another. Using ohms law allows the determination of an unknown value if two other values are known. Ohms law can be stated in several combinations. The most basic form is:

1 P = I/E

a P = Power (Wattage)

b I = Amperage (current)

c E = Electromotive Force (Voltage)

2 E = I/R

a R = Resistance

b I = Amperage (current)

c E = Electromotive Force (Voltage)

c. Calculating motor loads. In addition to determining the demand for lighting and general purpose receptacles it is also necessary to apply a demand to equipment powered by the electrical system. There are several things to consider when selecting the demand to be placed on equipment.

(1) When trying to find the amperes or wattage of a motor, it may be necessary to convert data to calculate the power required. The information required to calculate motor loads is:

(a) The total amperes per phase.

(b) The total three phase wattage

(2) Using the data plate, Technical Manuals and Utilities Handbook are some of the places electrical data may be found.

(3) The information we need is as follows:

(a) Amperes

(b) Kilowatts (kW)

(c) Kilovolt amperes (kva)

(d) Voltage

(e) Horsepower

SITUATION: In our Base Camp we have the following three-phase equipment that will be connected to our distribution system:

1. One Reverse Osmosis (R.O.) water purification unit

2. One Bare Base laundry unit

3. One Bare Base shower unit

4. One Ice Making Machine (Scotsman)

5. Two Electric Refrigeration Units (ERU’S)

Example #1: Finding the total wattage and Amperes of the R. O.

POWER REQUIREMENT WORKSHEET DEMAND LOAD

GENERATOR SITE ________________

COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7	COL 8	COL 9	COL 10	# PHASES
ITEM TYPE OF STRUCTURE /EQUIPMENT	**QTY OF ITEM** TYPE OF STRUCTURE /EQUIPMENT	**QTY OF 60 WATT BULBS EACH OR WATTAGE OF EQUIPMENT**	**TOTAL WATTS FOR LIGHTING OR EQUIPMENT COL 2 x COL 3**	**QTY OF120 VOLT RECEPTACLES EACH 15% OF RATING GENERAL PURPOSE = 360 WATTS EACH**	**TOTAL WATTS FOR RECEPTACLES CO L2 x** COL 5	**TOTAL AMPS FOR LIGHTING COL 4 / 120**	**TOTAL AMPS FOR RECEPTACLES COL 6 / 120**	**TOTAL WATTS COL 4+ COL 6**	**TOTAL AMPS COL 7+ COL 8**	

Page _______ of ________ Pages

Step: 1. Find electrical data, in this example the wattage is listed in the TM as 22,000 watts (22 kW), total three phase watts.

Step: 2. To find the amperes, we must use table 1-7. Look down the left-hand column, (to find), we see amperes when Kilowatts (kW) are know. Reading to the right hand column under alternating current three phase, we see the following formula.

$$\frac{KW \times 1000}{1.73 \times E \times PF}$$

kW = Kilowatts
1.73 = Three phase multiplier
E = Three phase voltage (208v)
PF = Power Factor (80%)

Step: 3. Fill in the formula with the information we know.22 x 1000 = 22000 watts

$$\frac{22000 \text{ watts}}{1.73 \times 208 \times .8} = \frac{22000}{287.287} = 76.4$$

TOTAL AMPERES PER PHASE ARE 76.4 AMPERES, TOTAL WATTAGE IS 22,000 WATTS.
There is another method we can use to find the required information for the R.O. using the following formula.

EXAMPLE 2: Step 1. Divide the total wattage of R.O. by 3 since it is 3 phase piece of equipment.

$$\frac{22000 \text{ watts}}{3 \text{ phases}} = 7333 \text{ watts per phase}$$

Step 2. Divide the wattage by the power factor to find the volt-amperes per phase.

$$\frac{7333 \text{ watts}}{.8 \text{ p.f.}} = 9166 \text{ volt-amperes per phase}$$

Step 3. Divide the volt-amperes per phase by the equipment single phase voltage (120v).

$$\frac{9166 \text{ volt-amperes}}{120 \text{ volts}} = 76.38 \text{ amperes}$$

Example #3: Finding the total wattage and Amperes of the Bare Base Laundry Unit

Step 1. Find electrical data, In this example the wattage of the laundry unit is unlisted and had to be determined by actually operating the equipment and checking the current with an amp meter. The wattage of the laundry unit is 9993 watts.

Step 2. To find the ampere we must use table 1-7 and use the same columns as in the previous problem.

$$\frac{kW \times 1000}{1.73 \times E \times PF}$$

Step 3. Fill in the Formula with the information we know.

$$\frac{9993 \text{ watts}}{1.73 \times 208 \times .8} = \frac{9993}{287.872} = 34.7 \text{ amperes}$$

TOTAL AMPERES PER PHASE IS 34.7 AMPERES.
TOTAL WATTAGE IS 9,993 WATTS

Using our alternative method:

EXAMPLE 4, Step 1. Divide the total wattage of the laundry unit. by 3 since it is 3 phase piece of equipment.

$$\frac{9993 \text{ watts}}{3 \text{ phases}} = 3331 \text{ watts per phase}$$

Step 2. Divide the wattage by the power factor to find the volt-amperes per phase.

$$\frac{3331 \text{ watts}}{.8 \text{ p.f.}} = 4164$$

Step 3. Divide the volt-amperes per phase by the equipment single phase voltage (120v).

$$\frac{4164 \text{ volt-amperes}}{120 \text{ volts}} = 34.7$$

Example #5: Finding the total wattage and Amperes of the Bare Base Shower Facility.

Step 1. Find electrical data, In this example the wattage of the shower facility is unlisted and had to be determined by actually operating the equipment and checking the current with an amp meter. The wattage of the shower facility is 2880 watts.

$$\frac{kW \times 1000}{1.73 \times E \times PF}$$

Step 2. To find the amperes we must use table 1-7 and use the same columns as in the previous problem.

Step 3. Fill in the Formula with the information we know.

$$\frac{2880 \text{ watts}}{1.73 \times 208 \times .8} = \frac{2880}{287.872} = 10 \text{ amperes}$$

TOTAL AMPERES PER PHASE IS 10 AMPS
TOTAL WATTAGE IS 2,880

Using our alternative method:

EXAMPLE #6 **Step 1.** Divide the total wattage of the laundry unit by 3 since it is a 3 phase piece of equipment.

$$\frac{2880 \text{ watts}}{3 \text{ phases}} = 960 \text{ watts per phase}$$

Step 2. Divide the wattage by the power factor to find the volt-amperes per phase.

$$\frac{960 \text{ watts}}{.8 \text{ p.f.}} = 1200 \text{ volt-amperes per phase}$$

Step 3. Divide the volt-amperes per phase by the equipment single phase voltage (120v).

$$\frac{1200 \text{ volt-amperes}}{120 \text{ volts}} = 10 \text{ amperes}$$

Example #7: Finding the total wattage and Amperes of the Scotsman Ice Flake Machine.

Step 1. Find electrical data, In this example the amperes are found on the equipment data plate and the wattage is unknown. The amperes are 12.5.

Step 2. To find the wattage we must use table 1-7. Looking down the left-hand column we see Kilowatts when amperes are known. Reading to the right under alternating current, three phase we see the following formula:

$$\frac{I \times E \times 1.73 \times pf}{1000}$$

I = Amperes

E = 3- phase voltage (208 volts)

1.73 = 3- phase multiplier

pf = power factor

Step 3. Fill in the Formula with the information.

$$\frac{12.5 \text{ amps} \times 208 \times 1.73 \times .8}{1000} \quad \frac{3598.4}{1000} = 3598 \text{ watts}$$

TOTAL AMPERS PER PHASE IS 12.5 AMPERS
TOTAL WATTAGE IS 3,598 WATTS

Using our alternative method:

EXAMPLE 8, Step 1. Find the volt-amperes per phase by multiplying the single phase voltage (120 volts) X the amperes (12.5 amps).

120 X 12.5 = 1500 volt-amperes

Step 2. Multiply the volt-amperes by the power factor .8.

1500 X .8 = 1200 watts

Step 3. Multiply the wattage by 3 (three phases).

1200 x 3 = 3600 watts

Example #9: Finding the total wattage and Amperes of the Electric Refrigeration Unit (ERU).

Step 1. Find electrical data, In this example the amperes are found in the technical manual and the wattage is unknown. The amperes are 8.5.

Step 2. To find the wattage we must use table 1-7 . Looking down the left-hand column we see Kilowatts when amperes are known. Reading to the right under alternating current, three phase we see the following formula:

$\frac{I \times E \times 1.73 \times pf}{1000}$

I = Amperes

E = 3- phase voltage (208 volts)

1.73 = 3- phase multiplier

pf = power factor

<u>Step 3.</u> Fill in the Formula with the information we know.

$\frac{8.5 \text{ amps} \times 208 \text{ volts} \times 1.73 \times .8}{1000} = \frac{2447}{1000} = 2447 \text{ watts}$

TOTAL AMPERES PER PHASE IS 8.5 AMPERES.

TOTAL WATTAGE IS 2,447 WATTS

Using our alternative method:

<u>EXAMPLE 10, Step 1.</u> Find the volt-amperes per phase by multiplying the single phase voltage (120 volts) X the amperes (12.5 amps).

120 x 8.5 = 1020 volt-amperes

<u>Step 2.</u> Multiply the volt-amperes by the .8 power factor.

1020 x .8 = 816 watts

<u>Step 3.</u> Multiply the wattage by 3 (three phases).

816 x 3 = 2448 watts

<u>TRANSITION</u>: What is percentage is used as a power factor when the power factor is unknown? We now know how to determine the power requirement of three phase equipment and we also know how to apply demand to all our loads. Using this information we can now look at how we can use this information to select a generator.

4. **<u>Selecting Generator Size</u>**:

a. Before you consider generator size you should first determine the power requirements. For camps using more then one generator you should consider breaking the camp loads down into power grids.

(1) The first step is to analyze the camp layout and gather information about the loads that you will be supporting. You can use the Power Requirement Worksheet to aid you in this step.

(2) You should determine what loads will operate for 24 hours.

(a) Most Battalion Aid Stations require power 24 hours.

(b) Command Centers normally require power 24 hours.

(c) If you are supporting Communication Centers they may require 24 hour power.

(d) The S-3, S-4 and other command elements should be consulted to determine who needs 24 hour support. Also research the operation order and points of contact.

(3) Likewise you should identify those loads that will not require power for 24 hours and determine the hours electrical support will be required. For example:

(a) Security lights normally operate only at night.

(b) Check the operations order for lighting requirements and other operational commitments.

(c) Determine through research the billeting areas and hours of required power.

(4) When breaking the camp down into what loads will be placed in what power grids you will need to determine the number of generator sites.

(a) Determine what loads will be connected to what generators when determining generator sites and power grids.

(b) When determining generator sites, use the power requirement worksheets and the camp layout and determine the sum of the loads.

(c) You should draw the amperage requirement on each structure and load on the camp layout to aid in selecting what loads will be connected to a generator site and perhaps devise a system to identify loads that require 24 hour support.

(d) Consider load diversity when selecting loads that will be connected to generator sites.

<u>1</u> The largest loads should be closest to the generator.

2 Consider that the distance from the generator to the load increases the voltage drop.

3 Along the line of load diversity you must consider that amperage draw of one load will affect the voltage drop of another load.

4. The size of available conductors will affect the

KW REQUIREMENTS FOR SINGLE AND THREE PHASE POWER

SITE#		TOTALS
1. KW FOR SINGLE PHASE		
2. KW FOR THREE PHASE		
3. TOTAL SINGLE PHASE AND 3 PHASE POWER		
4. ADD 20% FOR GROWTH		
5. TOTAL POWER REQUIRED		

QTY	TYPE OF GENERATOR(S) REQUIRED	KW RATING

SITE#		TOTALS
1. KW FOR SINGLE PHASE		
2. KW FOR THREE PHASE		
3. TOTAL SINGLE PHASE AND 3 PHASE POWER		
4. ADD 20% FOR GROWTH		
5. TOTAL POWER REQUIRED		

QTY	TYPE OF GENERATOR(S) REQUIRED	KW RATING

SITE#		TOTALS
1. KW FOR SINGLE PHASE		
2. KW FOR THREE PHASE		
3. TOTAL SINGLE PHASE AND 3 PHASE POWER		
4. ADD 20% FOR GROWTH		
5. TOTAL POWER REQUIRED		

QTY	TYPE OF GENERATOR(S) REQUIRED	KW RATING

Page _____ Of _____Pages

voltage drop and should be considered when studying loads, distance, and generator sites.

(4) Always allow 20% for camp growth when selecting a generator.

5. **Selecting Generator Sites:**

Once the camp is broken down into power grids and generators have been selected you must select generator sites and record them by making them on the camp layout. Remember you are in the planning stage and must adjust along each step as required upon discovering situations or new ideas.

a. You must consider several factors when selecting a generator site.

(1) Generator site should provide adequate protection.

(a) Know to Provide protection from the elements of weather.

(b) Know to provide protection from enemy

b. Generator site must provide enough space to perform maintenance on the equipment.

(1) The site must provide space for drip pans.

(2) Methods of delivering fuel.

(3) Accessibility in the event the generator must be changed out.

(4) Room for the operator and mechanics to safely perform maintenance.

c. Even if you're using Tactical Quiet Generators (TQG), equipment noise should be considered when selecting a generator site.

d. When selecting a generator site consider ventilation.

e. When selecting generator sites consider the terrain.

(1) The terrain should offer ground that is level enough so that the generator does exceed a 15% angle. This prevents unnecessary equipment wear of engine.

(2) The terrain should provide good ground stability to support the equipment in case of hard rains.

(3) The terrain should also provide good drainage. Standing water can pose a hazard to equipment and personnel.

(4) Consider the type of support equipment i.e. forklifts, trucks, cranes and the terrain they may have to negotiate in order to provide assistance when supporting your generators. Is a road required? Are there to many hills that may make it a hazard to refuel or move a new generator into the site?

6. **<u>Balancing the Loads and Phases</u>**:

a. Generators supply balanced power. The generator attempts to supply the required power to satisfy the load on each phase. The three phase loads are automatically balanced. The single-phase loads are not automatically balanced and must be balanced by us. If the system is not balanced the following can occur:

(1) System voltage regulation becomes poor, since unbalancing causes high voltage on the lightly loaded phases and low voltage on the heavily loaded phases.

(2) Prolonged unbalance operation will damage the generator.

b. Procedures for balancing the phases are as follows:

PHASE BALANCING WORKSHEET

ITEM	PHASE1	PHASE 2	PHASE 3
TOTAL CURRENT PER PHASE			
ADD 20% FOR GROWTH			
	TOTAL CURRENT		

(1) Total up all three-phase amperes and list them on the phase balancing sheet for each generator site.

(2) Total up all the single-phase amperes and divide by three. This will give you the single-phase amperes for each phase, if we could balance the phases perfectly.

(3) List the perfect balance on the back of the phase balancing sheet or scratch paper.

(4) Phases must be balanced within plus or minus 10%. Determine the 10% tolerance by multiplying the perfect balance by 10% and adding

and subtracting this number from the perfect balance. This will give us a high and low number, which is our tolerance per phase. List the high and low numbers on the phase balance sheet on the indicated line.

(5) Determine the total amperes per phase, by adding the single phase and three phase amperes. List the total amperes on the phase balancing sheet, on the indicated line.

(6) Allow 20% for growth by multiplying the amperes on the heaviest laded phase by 20% and list this number on the phase balancing sheet, on the indicated line.

(7) Total up the total current per phase and the 20% for growth and list this number on the phase balancing sheet, on the indicated line.

7. **Determining the Number Of Each Size Of MEPDIS Panel**:

a. The MEPDIS is a secondary power distribution system. This system provides branch circuit isolation and protection and is recoverable after field exercises. The cables that are used for the MEPDIS are designed for direct burial, (18” deep) on ground or pole installation.

b. The MEPDIS is made up of three separate systems.

(1) 100 kW panel is the largest distribution panel.

(a) The supply power to the panel or inputs are:

1 208/120 volts.

2 Three phase, 5 wire.

3 350 amp main breaker.

(b) The supplying power or outputs to other loads/panels are:

1 Four, 3 phase, 100 amp outputs, with voltages 208/120.

2 Two, 3 phase, 60 amp outputs with voltages 208/120.

3 Two, 3 phase, 30 amp outputs with voltages 208/120.

4 Two, 3 phase, 20 amp outputs with voltages 208/120.

(2) The next distribution panel is the 30 kW panel.

(a) The supply power to the panel or inputs are:

1 208/120 volts.

2 Three phase, 5 wire.

3 100 amp main breaker

(b) The supplying power or outputs to other loads/panels are:

a Four, 3 phase, 60 amp outputs, with voltages 208/120.

b Two, 3 phase, 30 amp outputs, with voltages 208/120.

c Two, 3 phase, 20 amp outputs, with voltages 208/120.

d Two, single phase, 20 amp outputs, with voltages 120.

(c) Finally the smallest panel used in the MEPDIS is the 15 kW panel

1 the 15 kW panel has input connection as follows:

a A main breaker of 60 amp.

b 3 phase, 5 wire.

2 The branch circuit outputs are as follows:

a Two, 3 phase, 20 amp outputs, with voltages 208/120.

b Nine, single phase, 20 amp outputs, with voltages 120.

c. The MEPDIS Panels are arranged in acceding order setup. Just like wire, panels get smaller in size rather then larger. For example, a 100 kW panel would be used to feed a 30 kW panel and the 30 kW would feed a 15 kW panel.

d. The limits to the number of panels each of the larger size panel can feed are limited to the loads that are connected and the available connections. MEPDIS panels do not consume power, but rather distribute electrical energy through circuits. Therefore, a 30 kW panel could feed three 15 kW panels provided the sum of all the panels does not exceed the main breaker of the 30 kW panel. Likewise, the 100 kW panel may appear to be feeding many panels in the system, but it is the total current draw from all the loads that must be considered.

8. **Determining the Size of Each MEPDIS Cable**:

Based on the distribution panels that are selected we must determine the size cables, type of connections, and the length that will distribute power to and from the components of the system. To select a cable you should understand how the cables assemblies are identified and classified.

a. Cable assemblies are identified by eleven digit part numbers.

b. Cable assemblies have various connections on the ends of cables assemblies. They can be classified as follows:

(1) Lug or Direct to Socket type of connections.

(2) Plug to Socket type connections.

(3) Lug to Plug type connections.

c. Likewise, Cables are also classified by the number of phases, either 3 phase or single phase.

d. Furthermore, cables are classified by amperes. The current rating are as follows:

(1) 350 amperes.

(2) 100 amperes.

(3) 60 amperes.

(4) 30 amperes.

(5) 20 amperes.

d. Moreover, cables are classified by size or diameter to match the current caring capacity. The cable diameters are listed either by MCM or AWG American Wire Gauge (AWG). The Cable size as they relate to amperage is as follows:

(1) 350 amperes cable is size 250 MCM.

(2) 100 amperes cable is size #2 AWG.

(3) 60 amperes cable is size #4 AWG.

(4) 30 amperes cable is size #8 AWG.

(5) 20 amperes cable is size #10 AWG.

(6) 20 amperes field wiring harness is #12 wire AWG.

e. Finally, cable selection is based on the size of the circuit. The circuit breaker determines the size of the circuit. For example, anything connected to a 20 ampere circuit breaker would be considered to be part of a 20 ampere circuit. The cable must be capable of handling that current.

9. **Determining the Size of Overcurrent Protection**:

In many cases wire or cable can have a higher ampere rating then the circuit breaker designed to protect it. There are some situations that the code may allow where the breaker might have a higher current rating then the wire or cable. For example, the lock rotor amperage of motor loads might require larger breakers or fuses when compared to the conductor size.

Also article 240-3 (b) of the National Electric Code gives some guidance for situations where the wire may have a lower rating then the overcurrent protection. However, when using MEPDIS, the cable will only connect to the input and output of the panel where the breaker matches and controls that conductor. Therefore, it is important to consider the current draw of the loads that will be on any circuit or breaker.

a. If the circuit is going to be part of a feeder then the breaker must be sized to handle all loads that are depending on that feeder.

b. When the final connection to loads are made (branch circuits), it is a good rule to follow the guidance of the National Electric Code. Article 210-23 (a) and (b) under Permissible Loads talks about not exceeding 80% of the branch circuit rating. Nothing that has been published concerning the MEPDIS requires this; however, following the code book could help prevent nuisance tripping of circuit breaker when the loads are consider general purpose, i.e. receptacles whereas the planner is unsure what will actual be plugged in.

1. THE PANEL ID BLOCK: STUDENTS SHOULD PLACE A NUMBER OR LETTER ALONG EACH PANEL ON THEIR CAMP LAYOUT TO HELP IDENTIFY WHICH PANEL THE FORM REFERS TO.

2. EACH SCHEDULE WORKSHEET HAS A BLOCK DEDICATED TO EACH AVAILABLE BREAKER.

3. ALL CIRCUITS ARE IDENTIFIED BY CIRCUIT NUMBER, VOLTAGE, AMPERAGE, NUMBER OF PHASES, AND WHICH PHASE (A, B, OR C AND OR ALL FOR THREE PHASE)

4. EACH SCHEDULE HAS DARK OR THICK LINES THAT ARE POSITIONED AS A BOUNDARY TO IDENTIFY A GROUP OF CIRCUITS AND PHASES.

5. EACH WORKSHEET CONTAINS AN AREA FOR TOTALS FOR PHASE A, B, AND C. THE AMPERAGE TOTALS OF ALL BREAKERS FOR ANYONE PANEL CANNOT EXCEED THE TOTAL AMPERAGE LISTED FOR THAT PANEL.

PANEL ID	

15 kW, 60 AMP DISTRUBUTION PANEL CIRCUIT SCHEDULE WORKSHEET

CIRCUIT **(5)** 120V / 20A / 1Ø - **A**			CIRCUIT **(7)** 120V / 20A / 1Ø - **B**			CIRCUIT **(9)** 120V / 20A / 1Ø - **C**		
ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(11)** 120V / 20A / 1Ø - **A**			CIRCUIT **(8)** 120V / 20A / 1Ø - **B**			CIRCUIT **(10)** 120V / 20A / 1Ø - **C**		
ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(12)** 120V / 20A / 1Ø - **A**			CIRCUIT **(13)** 120V / 20A / 1Ø - **B**			CIRCUIT **(14)** 120V / 20A / 1Ø **- C**		
ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(3)** 208/120V / 20A / 3Ø - **ABC**			CIRCUIT **(4)** 208/120V / 20A / 3Ø - **ABC**			TOTAL Ø A	TOTAL Ø B	TOTAL Ø C
ITEM/EQUIPMENT	QTY	TOTAL AMPS	ITEM/EQUIPMENT	QTY	TOTAL AMPS			

Page ____ of ____Pages

PANEL ID	

30 kW, 100 AMP DISTRUBUTION PANEL CIRCUIT SCHEDULE WORKSHEET

CIRCUIT **(3)** 208/120V / 60A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(4)** 208/120V / 60A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(5)** 208/120V / 60A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(6)** 208/120V / 60A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(7)** 208/120V / 30A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(8)** 208/120V / 30A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

NOTE:
SINGLE PHASE 20 AMP PHASE " A"
AND "B"
THERE IS NO PHASE "C"
SINGLE PHASE

TOTAL Ø A	TOTAL Ø B	TOTAL Ø C

CIRCUIT **(9)** 208/120V / 20A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(10)** 208/120V / 20A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(11)** 120V / 20A / 1Ø - **A**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(12)** 120V / 20A / 1Ø - **B**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

Page ____ of ____Pages

PANEL ID	

100 kW, 350 AMP DISTRUBUTION PANEL CIRCUIT SCHEDULE WORKSHEET

CIRCUIT **(3)** 208/120V / 100A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(4)** 208/120V / 100A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(5)** 208/120V / 100A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(6)** 208/120V / 100A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(7)** 208/120V / 60A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(8)** 208/120V / 60A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

REMARKS: ____________________

TOTAL Ø A	TOTAL Ø B	TOTAL Ø C

CIRCUIT **(9)** 208/120V / 30A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(10)** 208/120V / 30A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(11)** 208/120V / 20A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

CIRCUIT **(12)** 208/120V / 20A / 3Ø - **ABC**

ITEM/EQUIPMENT	QTY	TOTAL AMPS

Page ____ of ____Pages

10. **Determining the Number of Light Harness Sets**:

The number of light harnesses required depends on the type of tent and or structure being served. It is important to take into consideration the number of wye connections that might be used when planning the system. Using the wye connections to jump from one tent to another is common when there are a large number of tents being connected. However, there are only so many components available. The bags and components are as follows:

TABLE 1

CABLE ASSEMBLIES

ITEM	CABLE NOMENCLATURE	PRINCIPAL DIMENSION	# CABLES/BAGS GP	# CABLES/ BAGS CP	# CABLES/ BAGS MAINT	CABLES FWH SET
CABLE 1	LEAD-IN	15 FT.	1	1	-	12
CABLE 2	EXTENSION	25 FT.	1	-	-	10
CABLE 3	EXTENSION	8 FT.	1	1	-	12
CABLE 4	WYE	2 FT.	1	-	2	12
CABLE 5	SWITCH	6 FT.	1	1	2	14
CABLE 6	LIGHT	8 FT.	3	2	6	40
CABLE 7	RECEPTACLE	8 FT.	1	1	6	18
CABLE 8	GENERATOR LEAD-IN	20 FT.	1	1	1	13
CABLE 9	COMMERCIAL POWER JUMPER	4 FT.	1	1	1	13
CABLE 10	ARMY SYSTEM CONVERSION	4 FT.	1	1	1	13

(ON CAG #94)

TABLE 2
PACKING

ITEM	PRINCIPAL DIMENSION	QTY BAGS/FWH GP	QTY BAGS/FWH CP	QTY BAGS/FWH MAINT	TOTAL ITEMS FWH SET
DUFFEL BAG	36″L X 12″W X 12″H	10	2	1	13
LAMP BOX	18″L X 7″W X 6.75″H	1	1	2	4
CRATE	4′L X 2′W X 2′H	-	-	-	2

(INSTRUCTOR NOTE: PLACE THE CLASS ON A 10-MINUTE BREAK)

TRANSITION: What component can be used for the purpose of jumping a branch circuit from one tent and then to another? We have gather much information up to this point. It is now time to start drafting our data into a workable plan. Lets look at how we will draw our plan out on the camp layout.

11. **Drawing the Distribution System**:

It would be extremely difficult to plan out the use of a distribution system without drawing out the whole plan. The first item needed is a camp layout. If one is not provided then you should attempt to draft one yourself. The following should be contained on a camp:

a. A scale is a must. A scale is using a unit of measurement that can be worked as a ratio that will allow measurements to be taken on the camp layout and converted into feet. The scale is determined based on the paper size and on how large the items must appear on the drawing. An Architects Rule is a valuable tool for drafting this layout and also for measuring distances on the plan to determine lengths of cable need from one point to another. The common scales available are:

(1) 3/32″ = 1′

(2) 3/16″ = 1′

(3) 1/8″ = 1′

(4) 3/8″ =1′

(5) 1/4″ = 1′

(6) 1/2″ = 1′

(7) 3/4″ = 1′

(8) 3/8″ = 1′

(9) 1/16″ = 1′

(10) 1 ½″ = 1′

(11) 3″ = 12′

b. A ledger is also required. The ledger is where a symbol can be identified that is being used on the plan to represent an item. The ledger should have simple symbols or shapes that can be easily duplicated on the drawing. These symbols are best drawn using a template or stencil. All labeling should be neat and professional.

c. The distribution system should be drawn into place on the camp layout as it is intended to be employed. Cables should be drawn into place and distribution boxes should be established and easy to identify.

d. Ensure the selected cables match circuit requirements. You must ensure that after the distance is travel by the cables and considering the loads that are supplied that the voltage drop is at an acceptable level. Although cable and wire is designed to be a conductor you must realize that it does offer some resistance and as loads and distances are increased so does the drop in electromotive force. Therefore, you must calculate voltage drops and adjust cables and circuits to larger sizes when necessary.

(1) To determine the voltage drop we must use the following formula to determine the resistance of the cable assembly.

$$\frac{\text{ohms per 1000 ft x length x 2}}{1000}$$

(2) To use this formula you must know the ohms per 1000' for each cable. The ohms per 1000' for the cables is as follows:

(a) 250 MCM is .005.

(b) #2 is .156.

(c) #4 is .249.

(d) #8 is .628.

(e) #10 is .999

(f) #12 is 1.59

(3) When determining distance you must measure distances on your camp layout using the proper scale. Next, you must select the cable based on its length. Remember, even if a cable is coiled and is longer then the distance that must be spanned, current will still have to travel the whole length. The length of the cables are as follows:

(a) 350 amp cable is 50' in length.

(b) 100 amp cable is 50' in length.

(c) 60 amp cable is 100' in length.

(d) 30 amp cable is 100' in length.

(e) 20 amp cable made of #10 wire is 100' in length

(f) The lead in cable is 15' in length.

(g) The extension cable is 25' in length.

(h) The Wye connection cable is 2' in length.

(i) The light harness cable is 8' in length.

(j) The switch cable is 6' in length.

(k) The receptacle cable is 8' in length.

VOLTAGE DROP WORK SHEET SITE#_______ PHASE#_______

From__________ to __________
Size conductor __________ Ohms per 1000' _____________
Amps________ (total amps that conductor supports)
Distance________ (total amps on that connection)

[Ohms per 1000'] X [Distance] x 2 / 1000 = [Line Resistance]

[Line Resistance] X [Amps] = [Voltage]

From__________ to __________
Size conductor __________ Ohms per 1000' _____________
Amps________ (total amps that conductor supports)
Distance________ (total amps on that connection)

[Ohms per 1000'] X [Distance] x 2 / 1000 = [Line Resistance]

[Line Resistance] X [Amps] = [Voltage]

From__________ to __________
Size conductor __________ Ohms per 1000' _____________
Amps________ (total amps that conductor supports)
Distance________ (total amps on that connection)

[Ohms per 1000'] X [Distance] x 2 / 1000 = [Line Resistance]

[Line Resistance] X [Amps] = [Voltage]

Total of Voltage drops

Page ________ of _________ Pages

12. **Tools Required**:

It is important that you determine what tools are required to put in place the distribution system. You should become familiar with tool kits and what tools are available. Furthermore, you will have to consider what tools you will need to perform maintenance. You should consider:

a. Drip pans.

b. Rags.

c. General mechanics tool kit.

d. Tools for performing test on the electrical system.

(1) Ampere meters (Amp probe)

(2) Multimeter for reading voltage and resistance

e. Hand pumps to manually pump fuel. Consider what action you will take either for repair on equipment or refueling if complications with support occurs.

f. Tools to dig with may be needed. Consider tools that you may need to prepare the generator site. Likewise, since the MEPDIS cables are approved for use underground, it may prove useful to protect cables from damage buy burying them in the ground where vehicle traffic is heavy or when crossing a road. You should research if there will be track vehicles traveling around the system. Special care and judgment should be used when burying cables depending on the soil and type of equipment. Check with your NCOIC for guidance when your not sure. For digging you may select to take:

(1) Shovels

(2) Pick axes

(3) Tank bars

13. **Determining the Logistical Requirements**:

a. Our first step for determining our logistical requirements is examining the Table of Equipment (T. E.)

(1) You must consider the overall number of MEPDIS components:
(a) Number of MEPDIS panels that will have to be loaded for the operation.

(b) Reels of MEPDIS cable that will be need for the operation.

(c) Consider the number of Light harness bags.

(d) Extra light bulbs.

(e) Consider the generators that will be moved to the field. Make arrangements ahead of time to determine the following:

1 If the equipment is trailer mounted, what vehicles will pull them.

2 If the generators that are going will remain on the skids, consider how they will they be moved.

a Consider the truck that might be needed.

b Consider heavy equipment support to load and off load the generators.

3 Consider if any of the generators are going to be operated off the back of a truck.

b. Consider fuels and lubricants. Examine how much fuel and oil will be required during the operation. Determine if you will be using auxiliary fuel drums.

e. Determine the environmental considerations.

(1) Prefabricated containment’s or Tarps and sand bags to construct fuel containment’s under and around the generators. Just as mentioned before, will you require drip pans?

(2) Over-pack barrels for auxiliary fuel drums.

(3) Waste oil containers

f. Ensuring that you have all signs prefabricated to serve as warning for safety you should consider:

(1) High Voltage signs

(2) No smoking signs

(3) Hearing Protection Required

g. Maintenance Materials to consider:

(1) Filters

(2) Oil dispensers

(3) As covered earlier, Tools, drop lights, manuals and other library items to support maintenance

h. We considered tool that may be needed to for digging, now consider what materials will be needed for cables to negotiate crossings. Consider if you will required:

(1) Lumber or wooden poles to suspend cables.

(2) Metal piping combined with plywood or steel plates to make road ramps that will allow vehicle to pass over cable without crushing it.

(3) Determine what materials might be need to mark generators sights or help draw attention to cables suspended at low heights or on the ground.

(4) Examine what materials will be required to protect cables from barb or razor wire if cables must pass underneath.

LOGISTICAL REQUIREMENT WORKSHEET

ITEM#	NOMENCLATURE	U/I	QUANITY

Page ____Of ____ Pages

REFERENCES:

NATIONAL ELECTRICAL CODE
FM 5-424
LINEMAN’S AND CABLEMAN’S HANDBOOK