AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

FOR

ELECTRICAL POWER PRODUCTION

(3E0X2)

MODULE 24

AC GENERATING SYSTEM

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MODULE 24

AC GENERATING SYSTEM

Career Field Education and Training Plan (CFETP) references from 1 Aug 02 version.

OPR: HQ AFCESA/CEOF
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Notice. This AFQTP is _NOT_ intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

AIR FORCE QUALIFICATION TRAINING PACKAGES
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ELECTRICAL POWER PRODUCTION
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INTRODUCTION

Before starting this AFQTP, **refer to and read the "AFQTP Trainer/Trainee Guide."**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks*.*

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

Put this package to use. Subject matter experts under the direction and guidance of HQ AFCESA/CEOF revised this AFQTP. If you have any recommendations for improving this document, please contact the Career Field Manager at the address below.

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AC GENERATING SYSTEM

ALTERNATOR

MODULE 24 **AFQTP UNIT 1**

TROUBLESHOOT (24.1.2.)

TROUBLESHOOT ALTERNATOR

Task Training Guide

STS Reference Number:	24.1.2., Troubleshoot alternator.
Training References:	1. 35C2 series Technical Order. 2. Career Development Course (CDC) Electrical Power Production Journeyman 3E052A, Vol. 3, Unit 1-1: *Exciter and Alternator Maintenance.* 3. Manufacturer's Manual. 4. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags.*
Prerequisites	1. **Possess as a minimum a, 3E052 AFSC.** 2. **Review the following references:** 2.1. CDC 3E052A, Vol. 3, Unit 1-1. 2.2. Applicable TOs and Manufacturer's Manual. 2.3. AFOSHSTD 91-45 for lockout/tag out procedures.
Equipment/Tools Required:	1. Multimeter (Digital with diode check capability) with test leads. 2. DC variable power supply (minimum output voltage 20 volts, minimum output current 5 amps) with test leads. 3. Clamp-on DC ammeter (NOT AC). 4. Megger with test leads. 5. Hearing protection. 6. Eye protection. 7. Standard Power Production toolbox.
Learning Objective:	Troubleshoot alternator.
Samples of Behavior:	Trainee will successfully demonstrate troubleshooting an alternator.

Notes:

1. Any safety violation is an automatic failure.
2. Prior to performing any maintenance, technician **MUST** isolate the starting system, and apply lockout and tag-out procedures.
3. Trainer must develop an exercise scenario to validate ability of trainee to meet learning objective and samples of behavior.

TROUBLESHOOT ALTERNATOR

1. Background: In order to effectively troubleshoot any piece of equipment you must understand how it operates, the five basic steps of the troubleshooting process, and be able to think analytically. Before we briefly discuss the basic theory of operation for alternators let's look at the five basic steps in the troubleshooting process. They are:

1.1. Perform an operational check of the equipment.

1.2. Analyze the malfunction.

1.3. Locate the malfunction.

1.4. Perform corrective action.

1.5. Perform an operational check of the equipment.

2. It must be understood that along with these simple steps it is imperative to consider such things as:

2.1. Possible warning signs preceding the trouble.

2.2. Recent repairs made to the equipment.

2.3. Has a similar trouble occurred before?

3. Once we have taken all of this into consideration we can begin the troubleshooting process. Now we will take a brief look at the theory of operation for an alternator (AC generator) controls.

3.1. Alternators. They are used to produce electrical power to meet load demands. Alternators are designed for use in electrical generating systems and consist of three main assemblies: the rotor and shaft assembly, the stator and frame assembly, and the collector or rectifier assembly.

3.2. Exciters. They are used to produce DC voltage by means of electromagnetic induction. Exciters are basically, three phase AC alternators and are self-excited. The power from an exciter is rectified into DC power and used as a means of controlling the alternator's output voltage. There are two types of exciters, the brush type and brushless. The brush type changes AC power to DC power by use of a commutator and brushes. The brushless type uses solid-state devices (diodes) to rectify AC power to DC power and is the most common system used today.

NOTE:
All MEP generators are of the brushless type. (See Figure 1.)

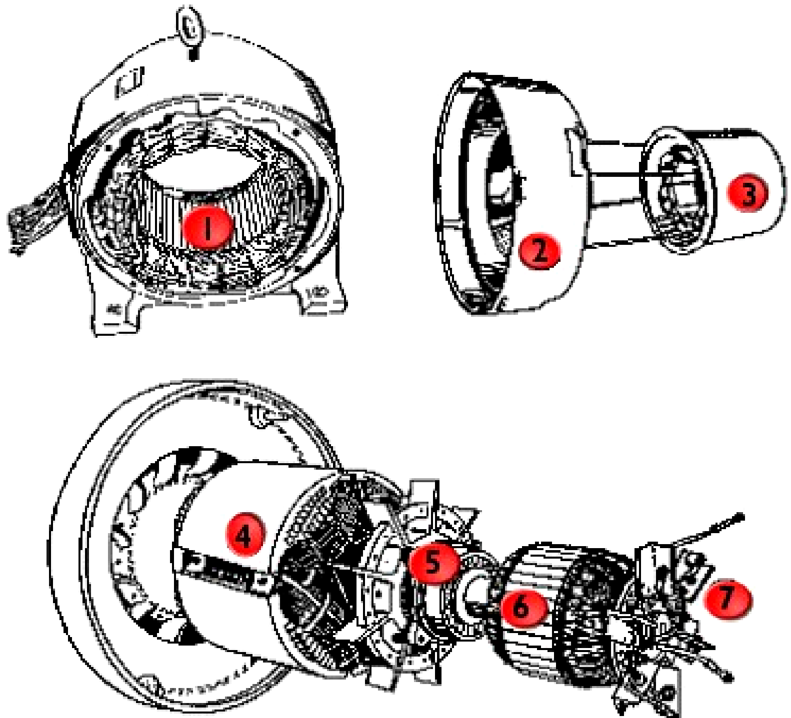

Figure 1. Brushless Generator Components

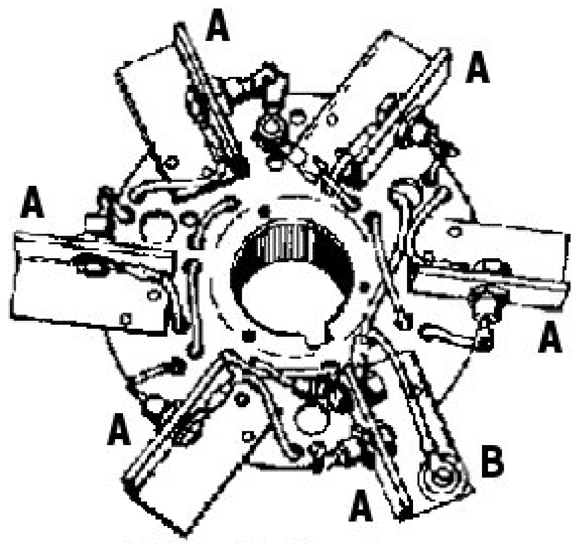

Figure 2. Rectifier Assembly

Figure 3. Fluke 77 Multimeter

Figure 4. Hewlett Packard Dual Variable DC Power Supply

Figure 5. Meg-Check Meter

4. Symptoms and Isolation of Malfunctions. Low output voltage or no voltage output usually indicates a malfunction of the generator.

4.1. To isolate the malfunction proceed as follows:

4.1.1. <u>Generator Run-Up Test</u>:

> **SAFETY:**
> **MAKE SURE JEWELRY IS REMOVED. GENERATORS SHOULD BE TURNED OFF AND DC BREAKER PULLED OUT.**

Step 1: Remove generator set air-intake doors, below control cubicle. (See Figure 6.)

Step 2: Remove generator set air-inlet louver and screen assembly.

Step 3: Remove wires to the exciter field terminals.

3.1. MEP 6: Disconnect the top two leads on terminals 15 and 16 of TB16 (located on the current transformer mount plate) and tag them 15 and 16.

3.2. MEP 7, 9: Disconnect electrical connector P61 from right side of generator end-bell.

Figure 6. Removal of Louver (MEP-6)

Step 4: Connect a variable voltage DC power supply.

SAFETY:
ALWAYS CHECK A CIRCUIT WITH A VOLTMETER BEFORE REMOVING LEADS BECAUSE THERE MAY BE VOLTAGE FROM CAPACITORS OR OTHER AUXILIARY POWER SUPPLIES IN THE CIRCUIT.

SAFETY:
DC POWER SUPPLY SHOULD BE TURNED OFF AND SET TO ZERO VOLTS DC.

4.1. MEP - 6: (See Figure 7.)

4.1.1. (+) Terminal to the positive side (wire that was connected to terminal 15) of the exciter.

4.1.2. (–) Terminal to the negative side (wire that was connected to terminal 16) of the exciter.

Figure 7. Connection of DC Power Supply to (MEP-6)

4.2. MEP 7, & 9:

4.2.1. (+) Terminal to the positive side (J61 pin C) of the exciter.

4.2.2. (–) Terminal to the negative side (J61 pin B) of the exciter.

Step 5: Clamp-on the DC ammeter to one of the leads, of the DC variable power supplies.

SAFETY:

THE CLAMP-ON AMMETER USED MUST BE CAPABLE OF BEING USED IN A DC CIRCUIT. NOT ALL CLAMP-ON METERS ARE RATED FOR BOTH AC AND DC.

SAFETY:

PERFORM ALL PRE-OPERATIONAL INSPECTIONS AND WEAR PROPER SAFETY EQUIPMENT WHILE THE GENERATOR IS IN OPERATION. MAKE SURE THAT ALL TEST EQUIPMENT AND LEADS ARE AWAY FROM ROTATING EQUIPMENT AND OTHER VOLTAGE SOURCES. TAPE THE ENDS OF THE TEST LEADS IF NEEDED. DISCONNECT ALL LOADS FROM THE OUTPUT TERMINALS OF THE GENERATOR BEFORE OPERATION.

Step 6: Start the generator set and operate the engine to 1800 RPM.

NOTE:

By applying a small amount of DC voltage from DC power supply the voltage and frequency meter will start operating. Increase frequency to 60 hertz. This will equal 1800 RPMs.

Step 7: Adjust the variable DC voltage supply until normal generator output voltage is obtained (120 / 208).

> **SAFETY:**
> **RAISE THE VOLTAGE ON THE DC POWER SUPPLY SLOWLY TO RATED VOLTAGE OR DAMAGE TO THE EXCITER MIGHT RESULT.**

Figure 8. Adjusting The Variable DC Voltage On A (MEP-6)

Step 8: DC clamp-on ammeter should indicate amperage between 1 and 1.75 amps.

Step 9: If the DC ammeter indicates correct input exciter current to obtain rated voltage then the problem lies in the excitation system (voltage regulator).

Step 10: If the DC ammeter indicates incorrect input exciter current to obtain rated voltage in steps 6 thru 8 above, the generator has failed.

10.1. The above steps were presented to enable isolation of the fault within the generator.

> **NOTE:**
> High current may indicate a short in the exciter stator windings. No current may indicate open in the exciter stator windings.

4.1.2. Exciter-stator winding test.

Step 1: Open test. Check resistance, with a wheatstone bridge or other suitable low resistance measuring device, between:

> **NOTE:**
> A digital multimeter such as the Fluke 8060a, 87, or 77 will accomplish this measurement.

> **SAFETY:**
> **TEST CIRCUIT WITH A VOLTMETER BEFORE REMOVING OR TOUCHING ANYTHING ELECTRICAL.**

1.1. MEP 6: the two top wires from pins 15 and 16, field resistance should be between 2.90 and 3.55 ohms +/- 10 percent.

1.2. MEP 7 & 9: J61 pins B and C, field resistance should be 1.23 ohms +/- 10 percent.

Step 2: A high resistance will indicate an open in the stator windings.

Figure 9. Stator Resistance Test with Multimeter (MEP-6)

4.1.3. Short-To-Frame and Insulation Resistance Test.

Step 1: Check resistance with a Megger between:

1.1. MEP 6: Connect red lead of megger to the top wires from pins 15 & 16, and the black lead of megger to the generator frame.

1.2. MEP 7 & 9: Electrical bond (jumper) J61 pins B & C and connect to red lead of megger, also connect the black lead of the megger to the generator frame.

> **SAFETY:**
> **A MEGGER WILL PRODUCE 500 VDC AND CAUTION SHOULD BE USED WHEN USING THIS PIECE OF TEST EQUIPMENT. DO NOT TRY TO HOLD ON TO THE LEADS WHEN IN TEST, SEVERE ELECTRICAL SHOCK MAY OCCUR.**

Figure 10. Stator Insulation Test with Megger (MEP-6)

Step 2: The resistance measured should be a minimum of 1 megohm.

Step 3: If the resistance is lower than this a short or insulation breakdown between the frame and exciter stator windings exits.

4.1.4. Rectifier-Diode Test.

Step 1: Remove cover plate and gasket from generator end-bell to expose the rectifier diodes.

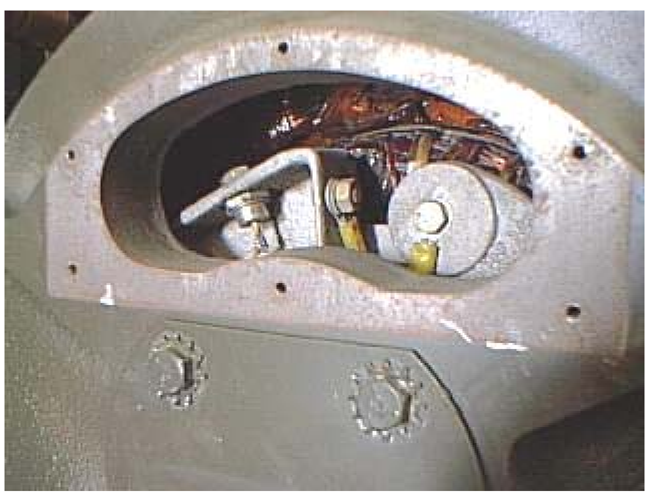

Figure 11. Rectifier Diodes (MEP-6)

Step 2: Remove the nuts to each diode and slide it off of the rectifier assembly one at a time and test. Make sure that the nut side of the diode is not touching anything when testing.

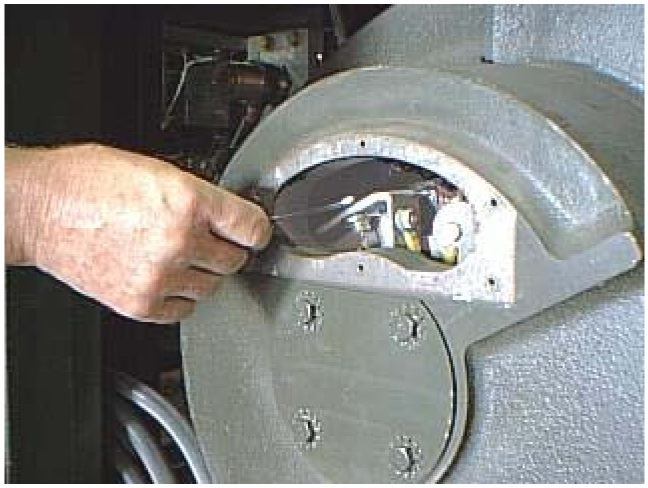

Figure 12. Removal of Diode Nuts (MEP- 6)

Step 3: Testing Diodes using:

SAFETY:

TEST CIRCUIT WITH A VOLTMETER BEFORE REMOVING OR TOUCHING ANYTHING ELECTRICAL.

3.1. Digital Multimeter.

3.1.1. Place the meter in the diode test function.

3.1.2. Place the black lead on the diodes cathode (end where the nut was on).

3.1.3. Place the red lead on the diodes anode (lead with the wire on it).

3.1.4. The reading should be ********.

NOTE:

1. *Do not* place the digital multimeter in the **ohm** scale to test diodes. The test current on a digital multimeter *is not* great enough to bias a semiconductor device. ***This will lead to a false reading.***

2. The **** reading above means that the * is of some numerical value, typically between .7 & .3.

3.1.5. Place the red lead on the diodes cathode (end where the nut was on).

3.1.6. Place the black lead on the diodes anode (lead with the wire on it).

3.1.7. The reading should be **OL**.

3.1.8. If these readings were not correct replace the diode.

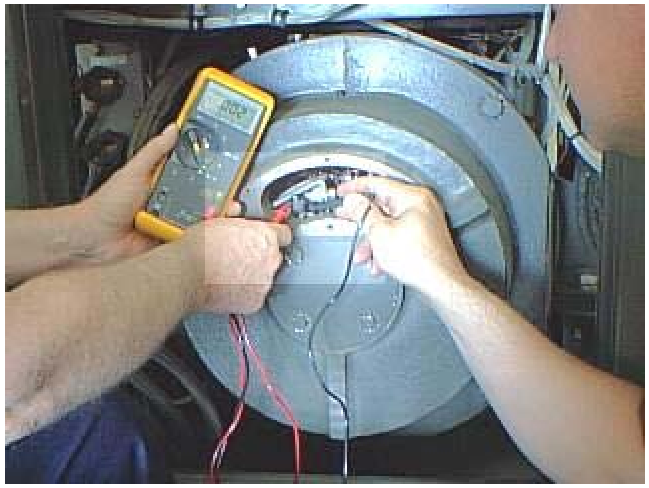

Figure 13. Testing Diodes with Multimeter (MEP-6)

3.2. Analog Multimeter.

3.2.1. Place the meter in the ohms Rx1 test function.

3.2.2. Place the black lead on the diodes cathode (end where the nut was on).

3.2.3. Place the red lead on the diodes anode (lead with the wire on it).

3.2.4. The reading should be between **20 to 40 ohms**.

3.2.5. Place the red lead on the diodes cathode (end where the nut was on).

3.2.6. Place the black lead on the diode anode (lead with the wire on it).

3.2.7. The reading should have **infinite** resistance.

3.2.8. If these readings were not correct replace the diode.

NOTE:
Only use the r x 1 setting other settings may not have a test current high enough to bias a diode. This may cause a false reading.

4.1.5. Alternator Stator Windings Test.

Step 1: Remove plastic shield from reconnection panel.

SAFETY:
TEST CIRCUIT WITH A VOLTMETER BEFORE REMOVING OR TOUCHING ANYTHING ELECTRICAL.

Step 2: Tag and disconnect the twelve stator leads at the voltage reconnection panel.

Step 3: Open Test.

3.1. Check resistance, using a Kelvin bridge or other suitable low resistance-measuring device between:

3.1.1. Generator leads T1-T4, T2-T5, T3-T6, T7-T10, T8-T11, and T9-T12. This will measure each of the six-stator windings.

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NOTE:
A digital multimeter such as the Fluke 8060a, 87, or 77 will accomplish this measurement.

3.1.2. Resistance should be:

3.1.2.1. MEP 6: 0.0141 to 0.0173 ohms +/- 10 percent.

3.1.2.2. MEP 7: 0.00974 ohms +/- 10 percent.

3.1.2.3. MEP 9: 0.00455 ohms +/- 10 percent.

3.1.3. A high resistance will indicate an open in the stator windings.

4.1.6. Short-To-Frame and Insulation Resistance Test.

Step 1: Check resistance with a Megger between:

1.1. Connect all stator leads together and connect to the red lead of megger.

1.2. Connect the black lead of megger to the generator frame.

Step 2: The resistance measured should be a minimum of 1 megohm.

Step 3: If the resistance is lower than this a short or insulation breakdown between the frame and alternator stator windings exits.

SAFETY:
A MEGGER WILL PRODUCE 500 VDC AND CAUTION SUCH BE USED WHEN USING THIS PIECE OF TEST EQUIPMNET. *DO NOT* TRY TO HOLD ON TO THE LEADS WHEN IN TEST, SEVERE ELECTRICAL SHOCK MAY OCCUR.

5. If the following checks above are met, then the problem lies in the rotor of the exciter or alternator and must be replaced. If the problem was in the stator of the alternator or exciter then they must be replaced. If the only problem was the rectifier diodes then replace them, reassemble and restart the generator.

6. Remember the main purpose of troubleshooting is to narrow down as much as possible the probable cause. Even though these procedures might be extensive they will definitely identify the cause without undue expense. The cost of a new alternator or exciter will be in the thousands of dollars, this is far more expensive then the comparative cost of a couple of hours of good troubleshooting for a less expensive item.

NOTE TO TRAINER/CERTIFIER:
You must provide the trainee with the equipment and scenario for troubleshooting alternator in order to complete task. Use troubleshooting chart on the next page for guidelines if needed.

7. ***To perform troubleshooting of alternator, follow these steps:***

Step 1: Trainee is provided equipment and alternator problem scenario in which to perform task.

Step 2: Use five-step process in troubleshooting:

2.1. Perform an operational check.

2.2. Analyze the malfunction.

2.3. Locate the malfunction.

2.4. Perform corrective action.

2.5. Perform an operational check.

Step 3: Document maintenance on AF Form 719.

ALTERNATOR & EXCITER TROUBLESHOOTING CHART

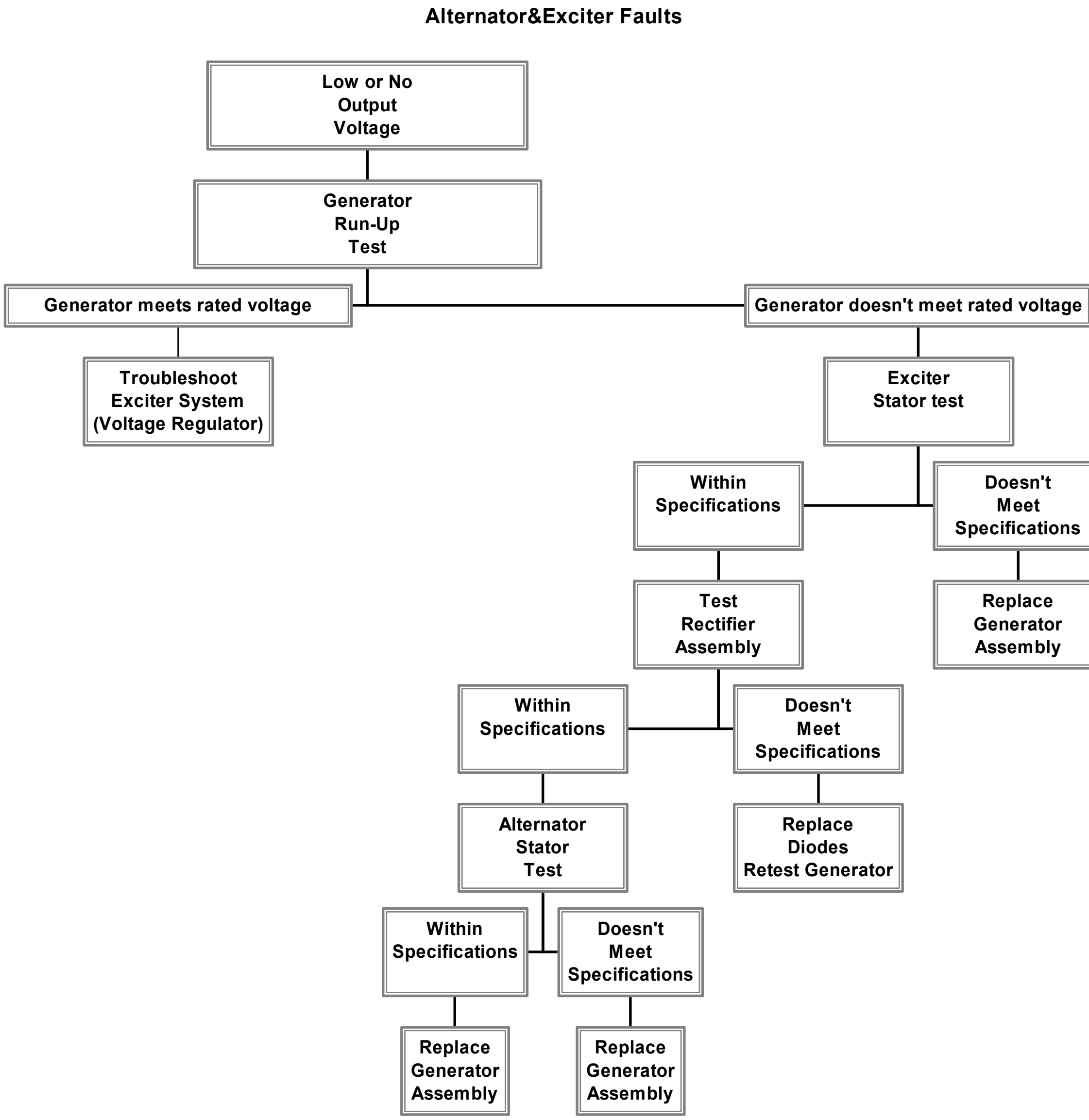


Chart 1. Troubleshooting Chart

REVIEW QUESTIONS
FOR
TROUBLESHOOT ALTERNATOR

QUESTION	ANSWER
1. The brushless type generator uses a ______________ to rectify AC power to DC power.	a. silicon controlled rectifier b. commutator c. transistor d. diode
2. What is the purpose of the variable DC power supply?	a. To apply a current to the exciter stator windings. b. To apply a current to the voltage regulator. c. To apply a current to the exciter rotor. d. To apply a current to the alternator stator windings.
3. If the DC ammeter reads zero amps during the run-up test, what is the possible cause?	a. Open in the exciter rotor windings. b. Open in the alternator rotor windings. c. Open in the exciter stator windings. d. Open in the alternator stator windings.
4. If the reading on the megger is 10 kilo ohms during the exciter-stator winding test, what is the possible cause?	a. Open in the exciter stator windings. b. Open in the alternator stator windings. c. Short in the alternator stator windings. d. Short in the exciter stator windings.
5. When testing the rectifier section with a digital multimeter, which of the following readings would indicate a good reading?	a. OL in direction and a **** in the other. b. **** in both directions. c. OL in both directions. d. None of the above.

TROUBLESHOOT ALTERNATOR

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE….?	YES	NO
1. Have equipment and scenario available to perform task		
2. Perform an operational check		
3. Analyze the malfunction		
4. Locate the malfunction		
5. Perform corrective action		
6. Perform an operational check		
7. Document maintenance action on AF Form 719		
8. Comply with all safety requirements		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

AC GENERATING SYSTEM

CONTROLS

MODULE 24 **AFQTP UNIT 2**

TROUBLESHOOT ALTERNATOR (24.2.2.)

Notice. This AFQTP is ***NOT*** intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

TROUBLESHOOT ALTERNATOR CONTROLS

Task Training Guide

STS Reference Number:	24.2.2., Troubleshoot Alternator Controls.
Training References:	1. 35C2 series Technical Orders (TOs). 2. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags.* 3. Manufacturer's Manual. 4. Local Procedures.
Prerequisites	1. **Possess as a minimum a, 3E052 AFSC.** 2. **Review the following references:** 2.1. Applicable TOs and Manufacturer's Manual. 2.2. AFOSHSTD 91-45 for lockout/tag out procedures.
Equipment/Tools Required:	1. General tool kit. 2. Applicable Technical References. 3. Generator to perform troubleshooting task on. 4. Hearing protection. 5. Eye protection. 6. Multimeter.
Learning Objective:	1. Demonstrate troubleshooting alternator controls. 2. Safely isolate and repair probable malfunctions.
Samples of Behavior:	Trainee will demonstrate proper procedures for troubleshooting alternator controls.
Notes:	
1. Any safety violation is an automatic failure. 2. Prior to performing any maintenance, technician **<u>MUST</u>** isolate the starting system, and apply lockout and tag-out procedures. 3. Trainer must develop an exercise scenario to validate ability of trainee to meet learning objective and samples of behavior.	

TROUBLESHOOT ALTERNATOR CONTROLS

1. Background: In order to effectively troubleshoot any piece of equipment you must understand how it operates, the five basic steps of the troubleshooting process, and be able to think analytically. Before we briefly discuss the basic theory of operation for alternator controls let's look at the five basic steps in the troubleshooting process. They are:

1.1. Perform an operational check of the equipment.

1.2. Analyze the malfunction.

1.3. Locate the malfunction.

1.4. Perform corrective action.

1.5. Perform an operational check of the equipment.

2. It must be understood that along with these simple steps it is imperative to consider such things as:

2.1. Possible warning signs preceding the trouble.

2.2. Recent repairs made to the equipment.

2.3. Has a similar trouble occurred before?

3. Once we have taken all of this into consideration we can begin the troubleshooting process. Now we will take a brief look at the theory of operation for an alternator (AC generator) controls.

4. <u>Theory of Operation</u>: When you think about any alternator you must start by thinking about the basic principles of electromagnetic induction. What is required to make an alternator work? The three requirements for electromagnetic induction are a conductor (stator windings), magnetic field (main rotor), and relative motion (prime mover). These three requirements are met in all alternators. Controlling the output voltage of such a device is needed in order for the generator to be useful. How do we do this? We can accomplish this task by controlling the field strength of the magnetic field and maintaining a constant speed on the prime mover. Flow of DC current through the field windings produces a magnetic field. By increasing the flow of DC current the magnetic field is made stronger. Decreasing the flow of DC current weakens the magnetic field. The stronger the magnetic field the higher the output voltage. The weaker the magnetic field the lower the output voltage. In modern generators the voltage regulator is used to control the DC current. The governor controls the speed of the prime mover.

4.1. Voltage Regulators: These devices are used to control the output voltage of an alternator. They can be broken down into several categories. For simplification purposes we will discuss manual excitation control and automatic excitation control designs.

4.1.1. The manual excitation control design (manual voltage regulator) depends solely on the operator of the unit to adjust the voltage of the generator based on the desired output. When the load demands change the operator must be present to correct the output voltage of the unit. This design is used as a back-up system on the MEP-12 generators.

4.1.2. The automatic excitation control design (automatic voltage regulator) is the most commonly type used in today's generator systems. It should be noted automatic voltage regulators varying greatly in size, power output capability, and sophistication. They all monitor output voltage of the generator and adjust the exciter DC output level to maintain the desired generator voltage. Most allow the operator to set the output voltage desired by adjusting the voltage-adjust rheostat or potentiometer. Below is a chart found in the MEP-806 technical orders. It details the basic voltage regulator circuit operation.

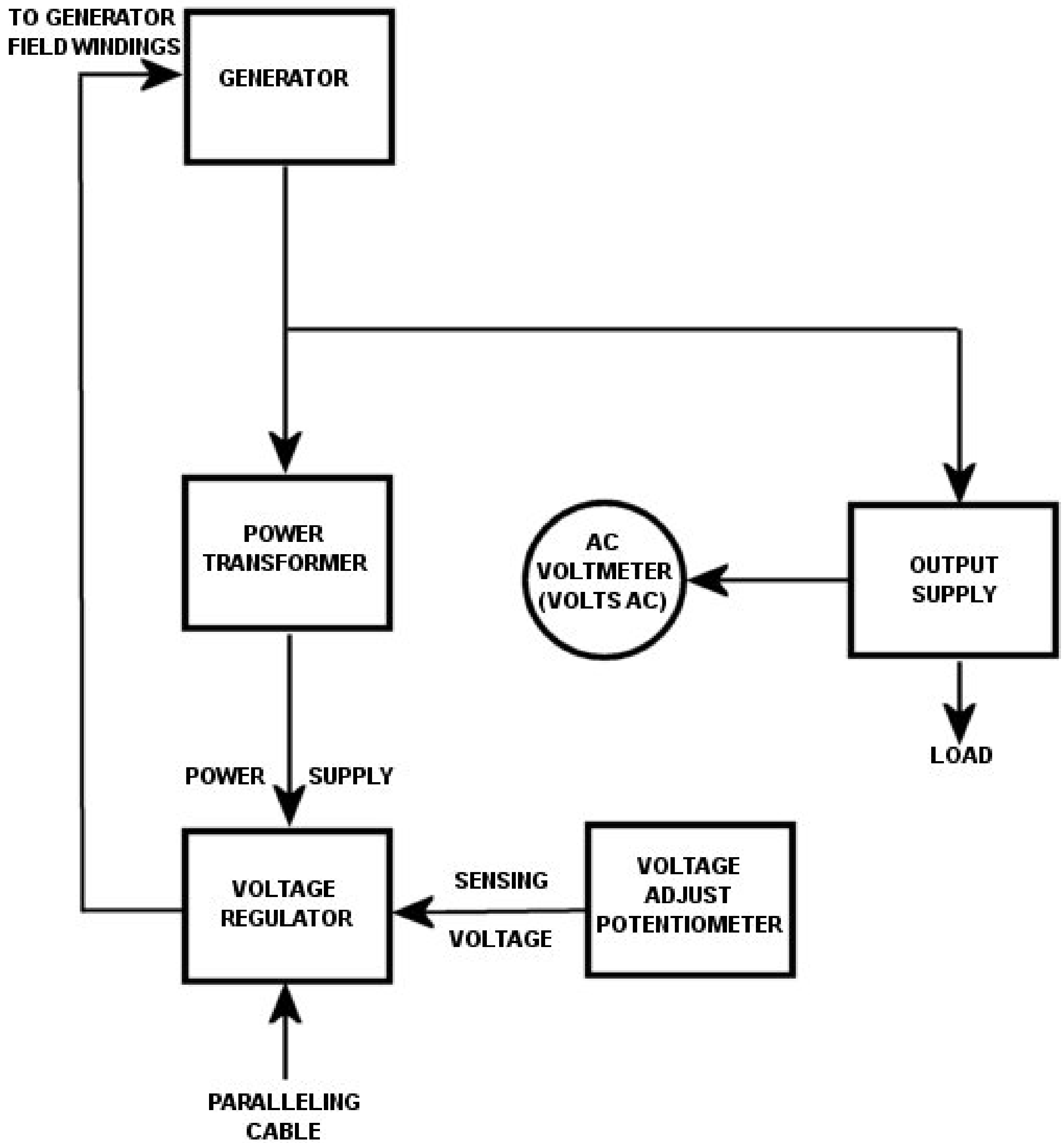


Figure 1. MEP-806 Voltage Regulator Overview

4.1.3. The voltage regulator on the MEP-806 receives its input power from a power transformer. This design allows the generator to sustain itself from some of the power it produces. It alleviates the problems associated with dead batteries or malfunctions in the battery charging alternator circuit. The sensing for the voltage regulator is a two-step approach. The operator has input from the potentiometer and the voltage regulator compares this desired setting to the sensing circuit attached to the alternator. Once the comparison is made between the user desired input voltage and the generator's actual output voltage the regulator makes adjustments to the DC current in the magnetic field accordingly.

4.2. Transformers: These devices are used to step down current and voltage levels to the desired levels needed for the electronic devices in the alternator circuit. What does this mean? Think about the television set or personal computer. The 120 volts AC you send into these devices is immediately stepped down to a lower voltage upon entering the machine for almost all of the components inside. In many cases the AC is even rectified into DC to run the machine.

4.3. Exciter: This device is needed to produce the magnetic field in a revolving field alternator. Without it you have nothing more than a bunch of wires being turned by a prime mover. There are numerous different designs of exciters. Some common examples are the brush type, static, brushless, and the permanent magnet pilot exciter. The most common type utilized is the brushless exciter design.

4.4. Control Panel Components: These devices consist of the meters (ammeter, voltmeter, KW meter, frequency meter, and the power factor meter). These devices are normally for monitoring purposes only and rarely calibrated items. It is recommended the operator validate the meter readings with the proper test equipment (example: multimeter) when there are doubts about the accuracy of the meters. It should also be noted these items are rarely the cause of a malfunction due to their design characteristics. It they are found to be at fault applicable technical data should always be used to troubleshoot and replace these items.

4.5. Protective Devices: These devices include such things as fuses, circuit breakers, and relays. These items are intended to protect the operator and machine from internal malfunctions. There is always an exception to the rule, but it is often these items that are to blame when a malfunction occurs. If this is the case, one must analyze why the protective device failed before simply replacing the item. A common mistake made is to simply replace the fuse with a larger one or bypass the protective circuits to keep the machine operating. "*Necessity is the mother of invention*" but the risk involved in doing this almost always outweighs the short-term benefit. There could never be enough emphasis placed on the need to operate the machine as the technical data recommends and understand the protective devices are put there for a very good reason.

5. Now we have covered the primary components of the alternator we need to look into the troubleshooting aspect. What kinds of things normally go wrong with this part of the machine? Where should the operator start the troubleshooting process? The answer to both of these questions is never concrete. The only absolutes in this equation are the need to use the applicable technical data for any maintenance activity and use the five general rules of troubleshooting. In this section we will look at some general troubleshooting guidelines.

5.1. The generator we are going to focus on is the MEP-806. The model of generator available to you may vary but the same general rules should apply. This statement refers to the idea that we have the same basic components in all generators (exciter, alternator, voltage regulator, control panel components, protective devices).

6. *To perform troubleshooting of alternator controls, follow these steps:*

WARNING:

FAILURE TO FOLLOW APPLICABLE TECHNICAL ORDERS OR MANUFACTURER MANUALS COULD RESULT IN SERIOUS INJURY TO PERSONNEL AND/OR DAMAGE TO EQUIPMENT.

NOTE:
The troubleshooting charts, pictures, and associated information included in this troubleshooting procedure are taken from the MEP 806 technical orders. Your equipment may vary.

NOTE TO TRAINER/CERTIFIER:
You must provide the trainee with the equipment and scenario for troubleshooting alternator in order to complete task. Use troubleshooting chart on the next several pages for guidelines if needed.

6.1. Malfunction or Symptom: Generator Set Fails To Generate Power or Generator Set Fails To Generate Sufficient Voltage.

Step 1: Gather all technical data, required hand tools, and test equipment.

Step 2: Follow all required safety procedures.

Step 3: Perform operational check of equipment.

Step 4: Follow the troubleshooting chart in the applicable technical orders or manufacturer manuals. (See Figure 2.)

TABLE 3-1. DIRECT SUPPORT TROUBLESHOOTING	
11. GENERATOR SET FAILS TO GENERATE POWER.	
TEST OR INSPECTION	**CORRECTIVE ACTION**
Step 1. Test for defective governor control unit, paragraph 4-2.1.	a. If governor control unit is not defective, do Step 2. b. If defective, replace governor control unit, paragraph 4-2.3.
Step 2. Test for defective AC voltage regulator.	a. If voltage regulator is not defective, do Step 3. b. If defective, replace AC voltage regulator, paragraph 4-1.
Step 3. Test for defective generator exciter stator, paragraph 4-20.1.	a. If exciter stator is not defective, do Step 4. b. If defective, replace exciter stator, paragraph 4-20.
Step 4. Test for defective generator stator, paragraph 4-23.1.	a. If generator stator is not defective, do Step 5. b. If defective, replace generator stator and housing assembly, paragraph 4-23.
Step 5. Test for defective diode(s) in generator rotating rectifier, paragraph 4-17.1.	a. If diodes are not defective, do Step 7. b. If defective, replace diode(s), paragraph 4-17.
Step 6. Test for defective generator rotor, paragraph 4-22.1	a. If generator rotor is not defective, do Step 7. b. If defective, replace generator rotor assembly, paragraph 4-22.
Step 7. Test for defective generator exciter rotor, paragraph 4-21.	If defective, replace generator rotor assembly, paragraph 4-22.
12. GENERATOR SET FAILS TO GENERATE SUFFICIENT VOLTAGE.	
TEST OR INSPECTION	**CORRECTIVE ACTION**
Step 1. Check for low engine speed; refer to TM 9-2815-256-24.	a. If engine is operating correctly, do Step 2. b. If engine is not operating correctly, repair in accordance with TM 9-2815-256-24.
Step 2. Test for defective power potential transformer, paragraph 4-12.	a. If power potential is not defective, do Step 3. b. If defective, replace power potential transformer, paragraph 4-12.4.
Step 3. Test for defective AC voltage regulator.	a. If voltage regulator is not defective, do Step 4. b. If defective, replace AC voltage regulator, paragraph 4-1.
Step 4. Test for defective generator stator, paragraph 4-23.1.	If defective, replace generator stator and housing assembly, paragraph 4-23.

Figure 2. MEP-806 Troubleshooting Chart

Step 5: Analyze the malfunction.

5.1. One of the most commonly replaced items on a generator is the voltage regulator. Therefore the following steps in this procedure are geared toward troubleshooting this item.

5.2. The following pictures include the control panel components and charts detailing the test procedures for voltage regulators. Notice there are different procedures from various voltage regulator part numbers. They have been extracted from the Technical Order (35C2-3-444-11/12) and other sources.

A5 GOV. ASSY. Terminal Tests - Approximate Values based on several samples

UNIT LOAD	LMU to A5 - 11/12	MAG P/UP to A5 - 16/17	A5 - 9/10 to A6
0 KW	0 Vdc @ 180 HZ 33 % Duty Cycle	12 - 18 VAC [1800 RPM] @ 3.45 KHZ signal * VAC depends upon the	[8 - 9 Vdc] @ 8Vdc -652 HZ 32 % duty cycle
22 KW	2 Vdc @ 180 HZ 46 % Duty Cycle	positioning of the MAG P/UP relative to the engine flywheel	[9 - 10 Vdc] @ 9 Vdc- 680 HZ 35 % duty cycle
44 KW	2.5 Vdc @ 180 HZ 61 % Duty Cycle	VAC and HZ remain stable with with engine RPM	[10 - 11 Vdc] @ 9.5 Vdc - 738 HZ 38 % duty cycle
60 KW	3.7 Vdc @ 180 HZ 74 % Duty Cycle		[10 - 11 Vdc] @ 10.4 Vdc -800 HZ 39 % duty cycle

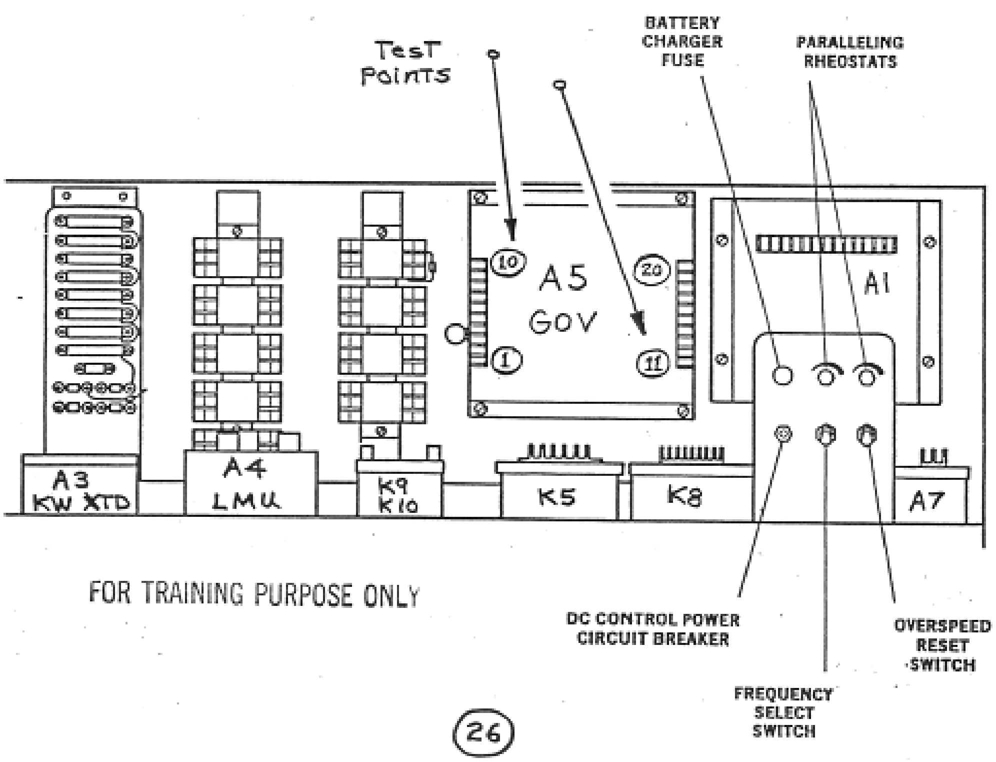


Figure 3. Control Panel View (A1=Voltage Regulator)

Notice. This AFQTP is ***NOT*** intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

SECTION I. MAINTENANCE OF CONTROL BOX ASSEMBLY

4-1 AC VOLTAGE REGULATOR.

WARNING

High voltage is produced when this generator set is in operation. Improper operation could result in personal injury or death.

4-1.1 Testing. (Regulator, P/N: 122-3056 For MEP-806A Generator Set).

a. Shut down generator set.

b. Open output box access door.

c. Note position of voltage reconnection terminal board and set FREQUENCY SELECT switch to 60 Hz position.

d. Start generator set and turn VOLTAGE adjust potentiometer to ensure the adjustment ranges on TABLE 4-1 are met, depending on position of voltage reconnection terminal board.

e. Shut down generator set.

f. If no voltage or low voltage was indicated, or voltage adjustment range could not be achieved, perform the following steps. Otherwise, AC voltage regulator (2, FIGURE 4-3) is serviceable.

g. Disconnect wire 141A from terminal 1 of AC voltage regulator.

h. Set multimeter for DC volts and connect positive lead to wire 141A. Connect negative lead of multimeter to terminal 3 of AC voltage regulator. Start generator set and operate at rated frequency. Move and hold MASTER SWITCH in START position. Multimeter should indicate between 4 and 12 VDC. If no voltage, proceed to troubleshooting govenor control unit, paragraph 4-2.

i. Shut down generator set. Isolate wire 141A.

j. Set multimeter for AC volts and connect to terminals 10 and 11 of AC voltage regulator. Start generator set and operate at rated frequency. Move and hold MASTER SWITCH in START position. Multimeter should indicate 280 to 360 VAC. If no or low voltage is indicated, proceed to troubleshooting the transformer, paragraph 4-12.

k. Shut down generator set.

l. Disconnect wire 137A from terminal 5 of AC voltage regulator. Set multimeter for ohms and connect positive lead to wire 137A and negative lead to terminal 4 of AC voltage regulator. Move VOLTAGE adjust potentiometer to full counterclockwise position. Multimeter should indicate approximately 3,000 ohms with FREQUENCY SELECT switch in 60 Hz position, and approximately 0 ohms with FREQUENCY SELECT switch in 50 Hz position. Move VOLTAGE adjust potentiometer clockwise slowly while observing multimeter. Multimeter should increase smoothly to approximately 10,000 ohms.

m. Place frequency select switch in the 60Hz position.

n. If steps h., j., and l. are as indicated above, AC voltage regulator is defective and must be replaced.

NOTE

To replace voltage regulator see paragraph 4-1.4 and 4-1.5

o. Connect all wires previously disconnected.

p. Close output box access door.

TABLE 4-1. Voltage Adjustment Range (MEP-806A)

Voltage Reconnection Terminal Board Position	Adjustment Range
120/208	197-240 volts
240/416	395-480 volts

Figure 4. Testing Voltage Regulator

4–1.2 Testing. (Regulator, P/N: 19880-002 For MEP-806A Generator Set).

a. Shut down generator set.

b. Open output box access door.

c. Note position of voltage reconnection terminal board and set FREQUENCY SELECT switch to 60 Hz position.

d. Start generator set and turn VOLTAGE adjust potentiometer to ensure the adjustment ranges on TABLE 4–1 are met, depending on position of voltage reconnection terminal board.

e. Shut down generator set.

f. If no voltage or low voltage was indicated, or voltage adjustment range could not be achieved, perform the following steps. Otherwise, AC voltage regulator (2, FIGURE 4–3) is serviceable.

g. Disconnect wire 141A from terminal 1 of AC voltage regulator.

h. Set multimeter for DC volts and connect positive lead to wire 141A. Connect negative lead of multimeter to terminal 3 of AC voltage regulator. Start generator set and operate at rated frequency. Move and hold MASTER SWITCH in START position. Multimeter should indicate between 4 and 12 VDC.

i. Shut down generator set. Isolate wire 141A.

j. Set multimeter for AC volts and connect to terminals 10 and 11 of AC voltage regulator. Start generator set and operate at rated frequency. Move and hold MASTER SWITCH in START position. Multimeter should indicate 110 to 160 VAC.

k. Shut down generator set.

l. Disconnect wire 137A from terminal 5 of AC voltage regulator. Set multimeter for ohms and connect positive lead to wire 137A and negative lead to terminal 4 of AC voltage regulator. Move VOLTAGE adjust potentiometer to full counterclockwise position. Multimeter should indicate no more than 2 ohms with FREQUENCY SELECT switch in 60 Hz position or 50 Hz position. Move VOLTAGE adjust potentiometer clockwise slowly while observing multimeter. Multimeter should increase smoothly to approximately 20,000 ohms.

m. If steps h., j., and l. are as indicated above, AC voltage regulator is defective and must be replaced.

n. Connect all wires previously disconnected.

o. Close output box access door.

4–1.3 Testing. (Regulator, P/N: 19890-003 For MEP-816A Generator Set).

a. Shut down generator set.

b. Open output box access door.

c. Note position of voltage reconnection terminal board.

d. Start generator set and turn VOLTAGE adjust potentiometer to ensure the adjustment ranges on TABLE 4–2 are met, depending on position of voltage reconnection terminal board.

e. Shut down generator set.

f. If no voltage or low voltage was indicated, or voltage adjustment range could not be achieved, perform the following steps. Otherwise, AC voltage regulator (2, FIGURE 4–3) is serviceable.

g. Disconnect wire 141A from terminal 1 of AC voltage regulator.

h. Set multimeter for DC volts and connect positive lead to wire 141A. Connect negative lead of multimeter to terminal 3 of AC voltage regulator. Start generator set and operate at rated frequency. Move and hold MASTER SWITCH in START position. Multimeter should indicate between 4 and 12 VDC.

i. Shut down generator set. Isolate wire 141A.

j. Set multimeter for AC volts and connect to terminals 10 and 11 of AC voltage regulator. Start generator set and operate at rated frequency. Move and hold MASTER SWITCH in START position. Multimeter should indicate 110 to 160 VAC.

k. Shut down generator set.

Figure 5. Testing Voltage Regulator (Continued)

Step 6: Locate the malfunction following the applicable technical reference.

6.1. Notice the troubleshooting chart listed in the Technical Order has you check the governor control before the voltage regulator. Why? Remember the three things needed to produce electromagnetic induction were conductor, magnetic field, and relative motion. If the generator's prime mover (engine) is not operating properly we will be missing part of the equation necessary to produce the proper output voltage and frequency.

6.2. Another question you may want to answer for yourself is whether the exciter field was flashed when the unit started up. Consider the relay that controls this along with the engine speed switch or the electronic governor circuit. Something has to get the ball rolling.

6.3. When testing the voltage regulator one of the first steps is to check and see if it is sending any DC voltage to the exciter field. These are normally labeled F1 and F2 on the voltage regulator.

6.4. Then check to see if the voltage regulator is getting power into it. On the MEP-806 checking the voltage at terminals 10 and 11 does this. This is the power coming in from the potential transformer. The voltage regulator needs electrical power to function. (No power in = No power out)

6.5. It might be a good idea to proceed by checking the 50/60-hertz switch (if applicable) and the potentiometer for proper operation. The lower the setting on potentiometer the lower the resistance.

Step 7: Perform corrective action.

Step 8: Perform an operational check of the equipment.

Step 9: Record any maintenance completed on the appropriate form (AF Form 719).

**REVIEW QUESTIONS
FOR
TROUBLESHOOT ALTERNATOR CONTROLS**

QUESTION	ANSWER
1. The three requirements for electromagnetic induction are relative motion, conductor, and a magnetic field.	a. True. b. False.
2. Output voltage of the generator running at a constant speed will _______ when the DC current to the magnetic field is increased.	a. remain the same b. decrease c. increase
3. What item in the alternator represents the magnetic field?	a. Stator windings. b. Rectifier assembly. c. Exciter. d. Main Rotor.
4. When the speed of the prime mover is decreased what must the automatic voltage regulator do to maintain the desired output voltage?	a. Increase DC current to exciter. b. Decrease DC current to exciter. c. Nothing.
5. The automatic voltage regulator compares the generator output voltage to the setting of the voltage-adjust potentiometer and adjusts the magnetic field strength accordingly.	a. True. b. False.
6. The MEP-806 voltage regulator receives its control power from what component?	a. Engine batteries. b. Internal battery. c. Potential transformer. d. Current transformer.

TROUBLESHOOT ALTERNATOR CONTROLS

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE….?	YES	NO
1. Have equipment and scenario available to perform task		
2. Perform an operational check		
3. Analyze the malfunction		
4. Locate the malfunction		
5. Perform corrective action		
6. Perform an operational check		
7. Document maintenance action on AF Form 719		
8. Comply with all safety requirements		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

AC GENERATING SYSTEM

PROTECTIVE DEVICES

MODULE 24 **AFQTP UNIT 3**

TROUBLESHOOT (24.3.2.)

Notice. This AFQTP is ***NOT*** intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

TROUBLESHOOT PROTECTIVE DEVICES

Task Training Guide

STS Reference Number:	24.3.2., Troubleshoot Protective Devices.
Training References:	1. 35C2 series Technical Order. 2. Career Development Course (CDC) Electrical Power Production Journeyman 3E052A, Vol. 3, Unit 2-2: Components and Circuitry. 3. Manufacturer's Manual. 4. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags.* 5. Local Procedures.
Prerequisites	1. **Possess as a minimum a, 3E052 AFSC.** 2. **Review the following references:** 2.1. CDC 3E052A, Vol. 3, Unit 2-2. 2.2. Applicable TOs and Manufacturer's Manual. 2.3. AFOSHSTD 91-45 for lockout/tag out procedures.
Equipment/Tools Required:	1. Multimeter (Digital with diode check capability) with test leads. 2. Applicable TOs and/or Manufacturer Manuals. 3. Applicable safety equipment. 4. Standard Power Production toolbox.
Learning Objective:	Given the equipment, trainee will be able to troubleshoot protective devices.
Samples of Behavior:	Trainee will successfully demonstrate troubleshooting alternator protective devices procedures.

Notes:

1. Any safety violation is an automatic failure.
2. Prior to performing any maintenance, technician **MUST** isolate the starting system, and apply lockout and tag-out procedures.
3. Trainer must develop an exercise scenario to validate ability of trainee to meet learning objective and samples of behavior.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

TROUBLESHOOT PROTECTIVE DEVICES

1. Background: In order to troubleshoot protective devices found on a generator effectively we must first look at the different types and their purpose. The types of devices may include over-voltage relay, under-voltage relay, over-load relay, reverse power relay, permissive-paralleling relay, short circuit relay, ground-fault relay, fuses, circuit breakers, and the battle-short switch. Not all generators will have all of these protective devices and some will have additional devices. Most MEP-class generators have more protective devices than commercial generators. The MEP-class units are designed for contingency operations. They may be sitting in water or mud whereas the standard commercial unit typically has the luxury of sitting inside of a building. In either case the protective devices are there for the protection of the operator and all electrical equipment connected to the generator. When a fault in the system is detected the protective device(s) will sense the malfunction and take the appropriate action to safeguard the system. The action taken may include opening the AC interrupter (load contactor or circuit breaker), shutting the generator down, and illuminating some sort of fault indicator light. Some generators will have audible indicators, display fault codes, and log the fault in a computer-based logbook. When any fault occurs it is essential for the technician to analyze (troubleshoot) why the fault occurred before resetting the fault and continuing with normal operations. Remember the protective devices are there for safety. It is understood that some of these devices are very sensitive and have had the tendency to become problematic on some generators. Understanding their theory of operation and how they fit into the "big picture" should give you the necessary knowledge needed to alleviate nuisance malfunctions when they occur.

> **NOTE:**
> Below is a brief description of the common protective devices. For clarity the majority of these devices, and their setting are taken form the MEP-806 generator.

2. Over-voltage Relay: This device will activate when the 120 VAC generator coil winding has risen to and remained at a voltage greater than 153+/- 3 VAC.

2.1. This device will open the AC interrupter (load contactor) and give a fault light indication on the malfunction panel.

3. Under-voltage Relay: This device will activate instantaneously when the 120 VAC generator coil winding has dropped to 48 volts and will trip after a time delay when the coil voltage drops below 99 volts.

3.1. This device will open the AC interrupter and give a fault light indication on the malfunction panel.

4. Over-Load Relay: This device will activate when load current exceeds the rated value for the generator.

5. Reverse power Relay: (Often called motorization) This device will operate if power flow into the generator exceeds 20 percent of rated value.

6. Permissive-Paralleling Relay: This device will not allow the AC circuit interrupter to close without the proper phase relationship when paralleling generators. **This device is not included on all generators.**

7. Short circuit Relay: This device will activate when the generator output current in any phase exceeds 425 percent of the rated value.

8. Ground-Fault Relay: This device will activate anytime there is a malfunction in the system causing an imbalance in current flow. This device is part of the MEP-12 electrical system.

9. Fuses: These devices will activate and open the circuit when the current value exceeds the circuit's rated value. The importance of properly checking these devices cannot be over-rated. Paper cartridge style fuses have been known to give false indications in the MEP-12 circuit for example. The metal ends vibrate loose from the paper cartridge causing the fuse to fail.

10. Circuit Breakers: These devices will activate and open the circuit when current value exceeds the circuit rated value. Some types of circuit breakers have adjustable trip settings. The settings should never be adjusted without consulting the technical data. The most common malfunction on the circuit breaker is probably associated with the notion they can be reset an infinite number of times. Unfortunately circuit breakers are only rated for so many trips.

11. Battle-Short Switch: This device is utilized in an ***emergency*** to override most of the safety circuits on the generator. This device should only be used when it is absolutely necessary.

12. Protective devices are an integral part of any generator system. Without them we would be in grave danger anytime we started the machine. Your job as a technician is to have a basic knowledge of the types of devices and how they function. The information you need to work on these devices can be found in the technical order, manufacturer manual, and in many cases the internet. Do not be afraid to do a little research if you do not know the answer and think long and hard before you bypass any of these devices to keep the machine operating.

NOTE:
The following troubleshooting procedures are taken from the MEP-806 TO 35C2-3-444-12. Your equipment may vary and if so the procedures may vary.

NOTE TO TRAINER/CERTIFIER:
You must provide the trainee with the equipment and scenario for troubleshooting alternator protective devices in order to complete task. Use the following procedures for MEP-806 as guidelines if needed.

13. ***To perform troubleshooting of protective devices, follow these steps:***

13.1. Troubleshooting Procedures for Testing the Over/Under Voltage Relay

Step 1: Gather the applicable technical order and/or manufacturer manual.

Step 2: Gather all necessary tools and test equipment.

2.1. Multimeter.

Step 3: Adhere to all safety requirements.

3.1. Remove jewelry.

3.2. Hearing protection.

3.3. Generator properly grounded.

Step 4: Perform an operation check of the equipment.

Step 5: Inspection.

5.1. Shutdown generator set.

5.2. Inspect relay for cracked casing, burned or broken terminals, and other damage.

5.3. Where is this item? It is located in the control Panel on the MEP-806.

Step 6: Disconnect the batteries.

6.1. Negative always comes off first and goes on last.

6.2. Do not forget about the static battery charger if you have one.

Step 7: Disconnect wire 137A from the voltage regulator at terminal 5. Insulate the wire end.

7.1. Insulate with electrical tape.

7.2. Removing terminal 5 removes the voltage adjust potentiometer from the circuit.

WARNING:

THE FOLLOWING PROCEDURE DISABLES THE VOLTAGE REGULATOR AND ALLOWS THE UNIT TO REACH AN OVERVOLTAGE CONDITION. DO NOT ALLOW THE UNIT TO RUN FOR AN EXTENDED PERIOD OF TIME IN THIS CONDITION.

Step 8: Connect the batteries.

Step 9: Start generator. As the unit accelerates to rated speed it should automatically shutdown and the over-voltage fault light should be illuminated on the malfunction indicator panel.

9.1. If this does not happen shutdown the generator immediately.

Step 10: Reconnect wire 137A and disconnect wire 141A from the voltage regulator, terminal 1. Insulate wire end.

10.1. Insulate wire with electrical tape.

10.2. Removal and isolation of wire 141A, at terminal 1, disables the DC current flow to the exciter field.

Step 11: Start generator. As generator accelerates to rated speed, the under-voltage lamp on the malfunction indicator panel should illuminate.

Step 12: Move the AC Circuit Interrupter switch to the closed position. AC interrupter relay should not close.

Step 13: Shutdown the generator.

Step 14: Replace the relay if the generator set does not operate as above.

Step 15: If no repair is needed reconnect wire 141A at the voltage regulator.

Step 16: Raise and secure control panel.

Step 17: Record any maintenance actions on the appropriate maintenance form (AF Form 719).

REVIEW QUESTIONS
FOR
TROUBLESHOOT PROTECTIVE DEVICES

QUESTION	ANSWER
1. What is the purpose of voltage relays?	a. Adjust generator voltage. b. Provide equipment protection. c. Control the engine speed. d. Control the generator output voltage.
2. Over-voltage and under-voltage relays normally open the load contactor and shutdown the generator.	a. True. b. False.
3. What is the purpose of the reverse power relay?	a. Eliminate crosscurrents. b. Protect unit from motorization. c. Prevent generator overload. d. Prevent engine over speed.
4. All generators have permissive paralleling relays?	a. True. b. False.
5. The battle-short switch overrides all safety devices on the generator.	a. True. b. False.

TROUBLESHOOT PROTECTIVE DEVICES

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE….?	YES	NO
1. Have equipment and scenario available to perform task		
2. Perform an operational check		
3. Analyze the malfunction		
4. Locate the malfunction		
5. Perform corrective action		
6. Perform an operational check		
7. Document maintenance action on AF Form 719		
8. Comply with all safety requirements		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

AC GENERATING SYSTEM

PROTECTIVE DEVICES

MODULE 24 **AFQTP UNIT 3**

REPLACE FUSES (24.3.4.3.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

REPLACE FUSES

Task Training Guide

STS Reference Number:	24.3.4.3., Replace fuses.
Training References:	1. 35C2 series Technical Orders (TOs). 2. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags.* 3. Manufacturer's Manual. 4. Applicable multimeter manual.
Prerequisites	1. **Possess as a minimum a, 3E032 AFSC.** 2. **Review the following references:** 2.1. Applicable TOs and Manufacturer's Manual. 2.2. AFOSHSTD 91-45 for lockout/tag out procedures. 2.3. Applicable multimeter manual.
Equipment/Tools Required:	1. Multimeter. 2. Applicable Technical Order and/or Manufacturer manual. 3. Applicable safety equipment. 4. Standard Power Production toolbox.
Learning Objective:	Replace fuses.
Samples of Behavior:	Trainee will successfully demonstrate replacing a fuse.

Notes:

1. Any safety violation is an automatic failure.
2. Prior to performing any maintenance, technician **MUST** isolate the starting system, and apply lockout and tag-out procedures.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

REPLACE FUSES

1. Background: Replacing fuses seems like a very simple task on the surface but it has been known to trip-up even the most experienced technician from time to time. One of the most common mistakes made is not isolating the circuit before testing the fuse. The best method of testing a fuse is to remove it from the circuit entirely. Fuses can be tested when the circuit is energized but the technician must understand what readings to look for. Replacing fuses should always be done on a de-energized circuit and with the proper tools. When choosing a replacement fuse it is essential to consult proper tech data for the appropriate type and rating. This means the technician should use fuse pullers instead of the "*Leatherman*" or "*Gerbe*r" they are carrying. Fuses come in all different sizes and types and to list them all would be a lengthy process. Instead let's focus on the physical act of replacing them and briefly discuss some of the common errors made in the process.

2. ***To perform this task, follow these steps:***

Step 1: Gather applicable technical reference for the piece of equipment.

Step 2: Adhere to all safety procedures.

Step 3: Gather all necessary hand tools and test equipment.

3.1. Fuse pullers.

3.2. Multimeter.

Step 4: De-energize equipment.

4.1. Validate the equipment is de-energized with a multimeter.

4.2. Follow log-out/tag-out procedures if applicable.

Step 5: Remove the fuse with the fuse pullers.

Step 6: Set-up multimeter to read ohms.

6.1. Place the meter leads on the ends of the fuse.

6.2. With the meter set to ohms a good fuse should read 0 ohms.

6.3. A bad fuse should give you a reading of OL (Infinity) on the meter.

Step 7: Set-up the meter to read continuity (Diode Check).

7.1. Place the meter leads on the ends of the fuse.

7.2. With the meter set to continuity a good fuse should read 0 ohms and give you an audible beep.

7.3. A bad fuse should give you a reading of OL and no audible beep.

WARNING:
THE FOLLOWING PROCEDURE REQUIRES AN ENERGIZED CIRCUIT. CAUTION SHOULD BE TAKEN TO ENSURE IT IS SAFE TO PERFORM THIS OPERATION.

CIRCUIT MUST BE ENERGIZED FOR THIS PROCEDURE. A POWER SOURCE OF 120 VAC IS HIGHLY RECOMMENDED.

Step 8: Set-up the meter for Volts AC/DC (depending on application).

8.1. Measure from one side of fuse to ground. (One lead to the top of the fuse and the other to a ground source).

8.2. Annotate or mentally note the reading. (Example 120 VAC)

8.3. Measure across the fuse. (One lead on each end of the fuse)

8.4. Annotate or mentally note the reading. (Example 0 VAC)

8.5. There should not be a difference of potential across the fuse.

8.6. Think of the fuse like a wire. What goes in one side of the wire should come out the other side. If 120 volts goes in one end it should come out the other end. When you measure with a voltmeter you are checking for a difference of potential. If there is 120 volts at one end and 120 volts at the other then 120-120=0 volts. *Remember the word difference means subtraction*.

Step 9: Replace the fuse.

9.1. It is essential that you replace the bad fuse with the proper size and type. Consult the applicable technical reference for guidance.

9.2. *It is also a good idea to check the physical condition of the fuse when testing it. Paper cartridge-style fuses (like those used on MEP-12 low voltage circuits) are known to deceive the technician due to their design. The vibrations from the running unit and exposure to the environment often make the metal crimped ends come loose. This can produce nuisance malfunctions of the equipment. It is a good idea to check for security of these ends and the associated fuse holder for security.*

Step 10: Record any maintenance actions on the applicable form (AF Form 719).

REVIEW QUESTIONS FOR REPLACE FUSES

QUESTION	ANSWER
1. The circuit should be de-energized before removing the fuse.	a. True. b. False.
2. Fuses should be inspected for physical condition, security, and proper size rating.	a. True. b. False.
3. What reading should the multimeter indicate for a **bad** fuse when set-up for ohms?	a. 0 ohms. b. 120 VAC. c. 0 VAC. d. OL (Infinite).
4. What reading should the multimeter indicate for a **good** fuse when set-up for Continuity (Diode check)?	a. 0 VAC. b. OL (Infinite). c. Audible tone and 0 ohms. d. No audible tone and OL.
5. Using a multimeter to check for a difference of potential relates to what setting on the meter?	a. Amps. b. Ohms. c. Volts.

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

REPLACE FUSES

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE….?	YES	NO
1. Follow all safety procedures		
2. Follow the applicable technical order and/or manufacturer manual procedures		
3. Successfully demonstrate testing and replacing a fuse		
4. Document maintenance action on AF Form 719		

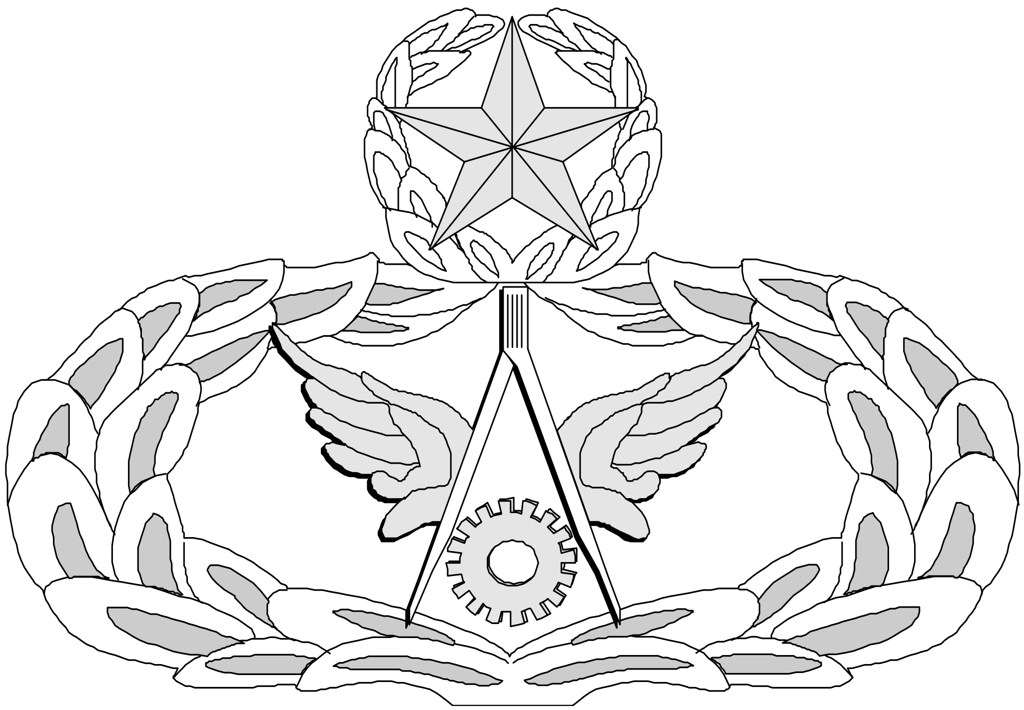
FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

ANSWER KEY



FOR

ELECTRICAL POWER PRODUCTION

(3E0X2)

MODULE 24

AC GENERATING SYSTEM

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

TROUBLESHOOT ALTERNATOR
(3E0X2-24.1.2)

QUESTION	ANSWER
1. The brushless-type generator uses a ______________ to rectify AC power to DC power.	d. diode
2. What is the purpose of the variable DC power supply?	a. To apply a current to the exciter stator windings.
3. If the DC ammeter reads zero amps during the run-up test, what is the possible cause?	a. Open in the exciter stator windings.
4. If the reading on the megger is 10 kilo ohms during the exciter stator test, what is the possible cause?	d. Short in the exciter stator windings.
5. When testing the rectifier section, which of the following readings would indicate a good reading?	a. OL in direction and a **** in the other.

TROUBLESHOOT ALTERNATOR CONTROLS
(3E0X2-24.2.2.)

QUESTION	ANSWER
1. The three requirements for electromagnetic induction are relative motion, conductor, and a magnetic field.	a. True.
2. Output voltage of the generator running at a constant speed will ________ when the DC current to the magnetic field is increased.	c. increase
3. What item in the alternator represents the magnetic field?	d. Main Rotor.
4. When the speed of the prime mover is decreased what must the automatic voltage regulator do to maintain the desired output voltage?	a. Increase DC current to exciter.
5. The automatic voltage regulator compares the generator output voltage to the setting of the voltage-adjust potentiometer and adjusts the magnetic field strength accordingly.	a. True.
6. The MEP-806 voltage regulator receives its control power from what component?	c. Potential transformer.

TROUBLESHOOT PROTECTIVE DEVICES
(3E0X2-24.3.2.)

QUESTION	ANSWER
1. What is the purpose of voltage relays?	b. Provide equipment protection.
2. Over-voltage and under-voltage relays normally open the load contactor and shutdown the generator.	b. False.
3. What is the purpose of the reverse power relay?	b. Protect unit from motorization.
4. All generators have permissive paralleling relays?	b. False.
5. The battle-short switch overrides all safety devices on the generator.	b. False

REPLACE FUSES
(3E0X2-24.3.4.3.)

QUESTION	ANSWER
1. The circuit should be de-energized before removing the fuse.	d. True.
2. Fuses should be inspected for physical condition, security, and proper size rating.	d. True.
3. What reading should the multimeter indicate for a **bad** fuse when set-up for ohms?	d. OL (Infinite).
4. What reading should the multimeter indicate for a **good** fuse when set-up for Continuity (Diode check)?	c. Audible tone and 0 ohms.
5. Using a multimeter to check for a difference of potential relates to what setting on the meter?	c. Volts.

MEMORANDUM FOR HQ AFCESA/CEOF
139 Barnes Drive Suite 1
Tyndall AFB, FL 32403-5319

FROM:

SUBJECT: Qualification Training Package Improvement

1. Identify module.

   Module # and title____

2. Identify improvement/correction section(s):

   ______ STS Task Reference
   ______ Training Reference
   ______ Evaluation Instructions
   ______ Performance Resources
   ______ Steps in Task Performance
   _______ Performance Checklist
   _______ Feedback
   _______ Format
   _______ Other

3. Recommended changes--use a continuation sheet if necessary.

   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____

4. You may choose to call in your recommendations to DSN 523-6392 or FAX DSN/Commercial 523-6488 or (850) 283-6488 or email ceof.helpdesk@tyndall.af.mil.

5. Thank you for your time and interest.

YOUR NAME, RANK, USAF
Title/Position