AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

FOR

ELECTRICAL SYSTEMS
(3E0X1)

MODULE 18

UNDERGROUND DISTRIBUTION SYSTEMS

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MODULE 18

UNDERGROUND DISTRIBUTION SYSTEMS

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

OPR: HQ AFCESA/CEOF
(SMSgt Michael A. Trevino)
Supersedes AFQTP 3E0X1-17, 1 Jul 00

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Pages: 56/Distribution F

AIR FORCE QUALIFICATION TRAINING PACKAGES

FOR

ELECTRICAL SYSTEMS

(3E0X1)

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 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 Electrical Career Field Manager at the address below.

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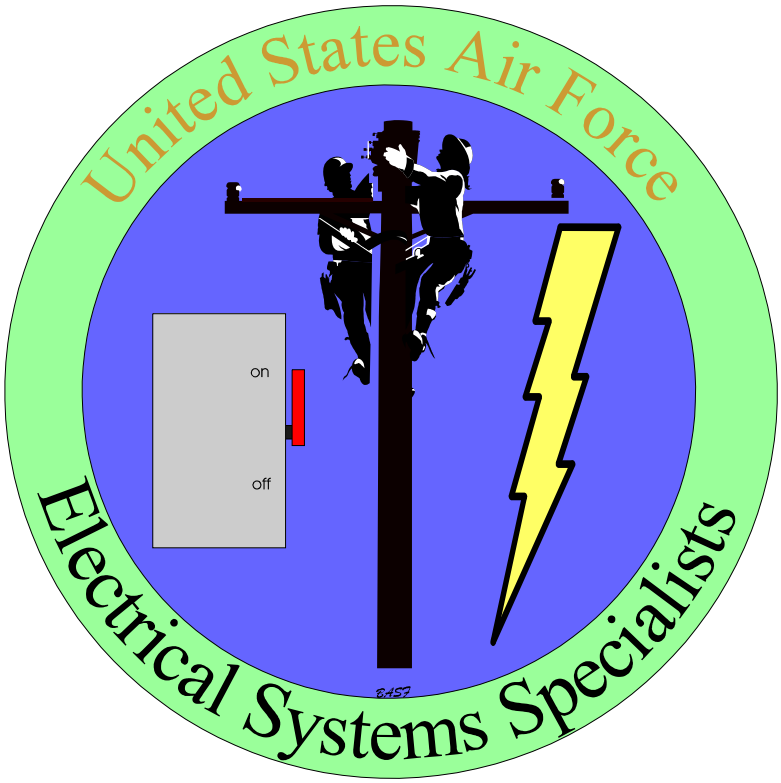
Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



INSTALL

MODULE 18 AFQTP UNIT 1

DIRECT BURIAL CABLE (18.1.1.)

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.

INSTALL DIRECT BURIAL CABLE

Task Training Guide

STS Reference Number/Title:	18.1.1., Install direct burial cable.
Training References:	1. Career Development Course (CDC) Electrical Systems 3E051B Vol. 3, Unit 1, Section 1-2: *Underground cables*. 2. The Lineman's and Cableman's Handbook, Eighth Edition, Section 34: *Underground Distribution.* 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01, *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.* 6. Air Force Joint Manual (AFJMAN) 32-1080, *Electrical Power Supply and Distribution.* 7. AFJMAN 32-1082, *Facilities Engineering Electrical Exterior Facilities.* 8. AFJMAN 32-1083, *Facilities Engineering Electrical Interior Facilities.* 9. Video AFQTP PIN # 613955: *Backhoe Operations.*
Prerequisites:	1. **Possess as a minimum a 3E031 AFSC.** 2. **Review the following references:** 2.1. CDC Electrical System 3E051B, Vol. 3, Unit 2.2. Lineman's and Cableman's Handbook, Section 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 2.5. AFJMANs 32-1080, 32-1082, and 32-1083. 2.6. Video AFQTP PIN # 613955. 3. **Complete Lesson 1 of the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01, *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Trencher. 2. Cable. 3. Shovels. 4. Marking tape. 5. Personal protective equipment.
Learning Objective:	Given equipment, install direct burial cable.
Samples of Behavior:	1. Follow approved methods to install direct burial cable. 2. Know safety requirements for installing direct burial cable.
Notes:	
Any safety violation is an automatic failure.	

INSTALL DIRECT BURIAL CABLE

1. Background: While use of underground cable is not new, in the past it was normally restricted to short runs in highly congested urban areas where overhead distribution was not practical. Recent developments in sheath materials, as well as better insulation materials, have produced lighter, more reliable cable. This fact, coupled with increased overhead costs and increased opposition from environmentalist groups, has brought about more and more underground transmission and distribution cable systems.

2. ***Complete Lesson 1, Direct Burial Cable, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly install direct burial cable using the step-by-step procedures listed below.***

NOTE:
The review questions for this material are contained in the above–mentioned CD-ROM.

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

Step 1: Before starting the excavation, you must have a approved AF Form 103, Base Civil Engineering Work Clearance Request, commonly called a digging permit.

1.1. This form allows the appropriate agencies the opportunity to identify any underground utilities in the area of the excavation site prior to digging.

Step 2: Digging trench.

2.1. If the requirement is for a single cable, a trencher can be use for the installation.

2.2. For installations requiring multiple runs of cable or more than one cable, a backhoe will provide a wider trench.

SAFETY:
USING A TRENCHER AROUND EXISTING POWER, PHONE, FIBER, AND WATER LINES CAN BE HAZARDOUS. THE TRENCHERS DIGGING CAPABILITY CAN EASILY SEAVER THESE UTILITY LINES.

Step 3: Measure the level of the trench throughout the excavation, to ensure the trench is level.

SAFETY:
REMAIN CLEAR OF ALL MOVING PARTS OF DIGGING EQUIPMENT DURING EXCAVATION, TO PREVENT ACCIDENTAL INJURY.

Step 4: Place cable(s) into trench.

4.1. The cable(s) must be shielded from sharp objects that could puncture the protective sheathing.

4.1.1. Lay a three-inch layer of sand in the bottom of the trench.

4.1.2. Place the cable on the sand.

4.1.3. Cover the cable with another six-inch layer of sand.

Step 5: Backfill trench.

5.1. Once the cable is shielded above and below, backfilling the trench may begin.

5.2. All cable installation must be properly identified with marking tape.

5.2.1. Marking tape is placed one foot from the surface of the trench.

5.3. After backfilling from both sides, leave a small mound of excess material directly over the trench. This will allow for soil settlement.

INSTALL DIRECT BURIAL CABLE

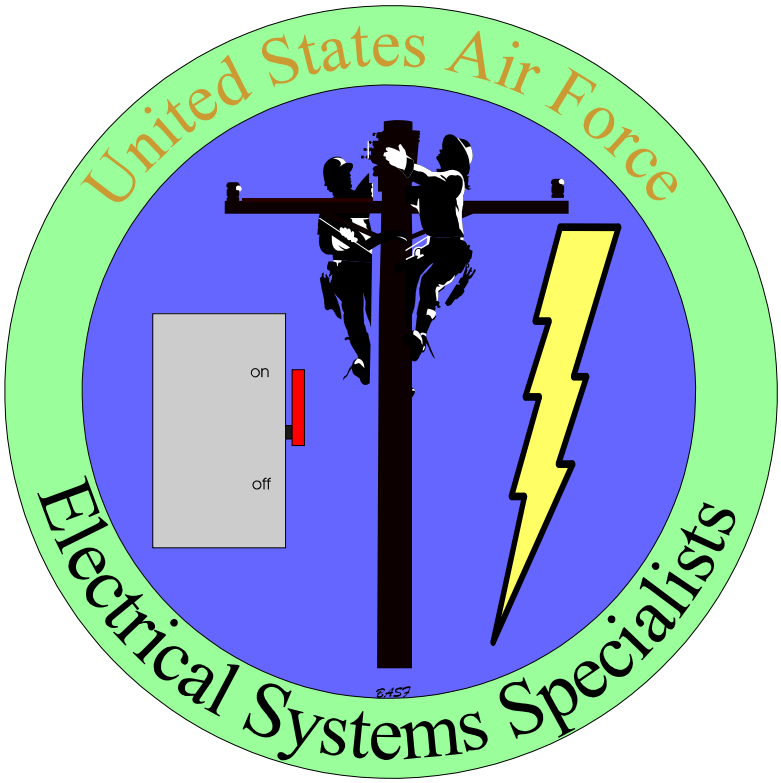
PERFORMANCE CHECKLIST

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. Obtain a digging permit (AF Form 103)		
2. Check trench to ensure it was level throughout the excavation		
3. Place a six-inch layer of sand above and a three-inch layer of sand below the cable		
4. Properly identify all cables with marking tape		
5. 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.



INSTALL

MODULE 18 AFQTP UNIT 1

TRANSFORMERS ON PADS (18.1.4.1.)

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.

INSTALL TRANSFORMER ON PAD

Task Training Guide

STS Reference Number/Title:	18.1.4.1., Install transformer on pad.
Training References:	1. Career Development Course (CDC) Electrical Systems 3E051A, Vol. 4, Unit 3, Section 3-2: *Transformers*. 2. The Lineman's and Cableman's Handbook, Eighth Edition, Section 34: *Underground Distribution.* 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.* 6. Air Force Joint Manual (AFJMAN) 32-1080, *Electrical Power Supply and Distribution.* 7. AFJMAN 32-1082, *Facilities Engineering Electrical Exterior Facilities.* 8. AFJMAN 32-1083, *Facilities Engineering Electrical Interior Facilities.* 9. Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags.* 10. AFQTP Module 11, AFSC Specific Safety Standards, Unit 1: *Use of AF Form 269.* 11. AFQTP Module 18, Underground Distribution Systems, Unit 1: *Grounding Set* and Unit 3: *Terminate High Voltage Underground Cable*.
Prerequisites:	1. **Possess as a minimum 3E031 AFSC.** 2. **Review the following references:** 2.1. CDC Electrical Systems 3E051A, Vol. 4, Unit 3, Section 3-2. 2.2. The Lineman's and Cableman's Handbook, Section 34. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 2.5. AFJMANs 32-1080, 32-1082, and 32-1083. 2.6. AFOSHSTD 91-45. 3. **Complete the following references:** 3.1. Lesson 2, Transformers on Pads, in CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 3.2. AFQTP Module 11, Unit 1: *Use of AF Form 269.* 3.3. AFQTP Module 18, Unit 1: *Grounding Set* and Unit 3: *Terminate High Voltage Underground Cable*.
Equipment/Tools Required:	1. Pad-mounted transformer. 2. Line truck or equivalent. 3. Electricians hand tools. 4. Anchors if necessary. 5. High voltage source. 6. Terminations. 7. Lifting devices.

Task Training Guide (Continued)

Learning Objective:	Given the necessary equipment, install a pad-mounted transformer.
Samples of Behavior:	1. Follow approved methods and install a pad-mounted transformer. 2. Know safety requirements for installing pad-mounted transformer.
Notes:	
1. Any safety violation is an automatic failure. 2. Pad must be already properly sized and installed. 3. Primary and secondary cables are already installed.	

INSTALL PAD-MOUNTED TRANSFORMER

1. Background: Pad mounted transformers are used to provide underground service and can be fed from an overhead or underground source. Exterior pad-mounted transformers should be installed as close to the building served as permissible and as near as practicable to the secondary distribution center. This will help keep line loss and the installation cost to a minimum. If the primary service is from an overhead system, locate the medium voltage riser pole as close as practicable to the transformer. If the service is being fed from an underground source, pick the manhole closest to the transformer location.

2. ***Complete Lesson 2, Transformers on Pads, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly install transformer on pad using the step-by-step procedures listed below.***

> **NOTE:**
> The review questions for this material are contained in the above–mentioned CD-ROM.

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

Step 1: Select lifting device of proper weight capacity.

1.1. The most common devices used are steel cables, straps, or chains. It is important to ensure the lifting devices used to position the transformer are able to handle the weight of the transformer.

Step 2: Select proper equipment for positioning and lifting of the transformer.

2.1. Forklift, line truck, or crane are some of the more common heavy equipment items used for positioning and lifting.

2.2. If the transformer is too heavy for a line truck or forklift to handle, assistance from the Pavement and Equipment Shop may have to be obtained.

Step 3: Ensure facility main breaker/disconnect is open following proper locking and tagging procedures.

3.1. This will prevent any possible back feed and will protect the facility equipment when checking voltage and phase rotation (if three phase) after initial energizing of new transformer after installation.

3.2. Refer to AFOSHSTD 91-45 for lock-out/tag-out procedures.

Step 4: Position the transformer on the pad.

4.1. Keep the transformer as close to the ground as possible to keep personnel from walking under it and to reduce possible damage to the transformer and/or equipment if it were to fall.

4.2. Position the transformer on the pad and ensure it is in the direction intended (high voltage cabinet over the high voltage conduits). Extra care should be taken to protect the cables when lowering the transformer.

4.3. After the transformer is in place, check the pad to make sure that the additional weight of the transformer has not caused the pad to settle unevenly.

Step 5: Anchor transformer.

Step 6: Make transformer connections.

6.1. Refer to Module 18, Unit I: Grounding Set for proper grounding of the transformer.

6.2. Refer to Module 18, Unit 3: Terminate High Voltage Underground Cable for terminating cable.

Step 7: Energize transformer.

7.1. Refer to AFQTP Module 11, Unit 1: Use of AF Form 269 for interpreting AF Form 269 when performing switching.

Step 8: Take secondary voltage reading and check phase rotation (if 3 phase). This is done prior to closing the main breaker to ensure the voltage and phase rotation is correct. If the voltage or rotation is incorrect, damage to the facility equipment may occur.

8.1. If the secondary voltage is incorrect, adjust the taps according to local specifications.

8.2. If the phase rotation is incorrect, swap any two current carrying conductors. These conductors can be moved at either the transformer or main breaker/disconnect

Step 9: Close main breaker/disconnect and take another secondary voltage reading to ensure you have the required voltage after the load has been applied. Occasionally when applying a load, the voltage may drop and have to be readjusted.

9.1. If the voltage drops beyond acceptable parameters, reopen facility main breaker/disconnect, de-energize transformer and readjust taps.

9.2. If transformer has to be readjusted, repeat readings after closing all circuits.

Step 10: Clean up job site.

INSTALL PAD-MOUNTED TRANSFORMER

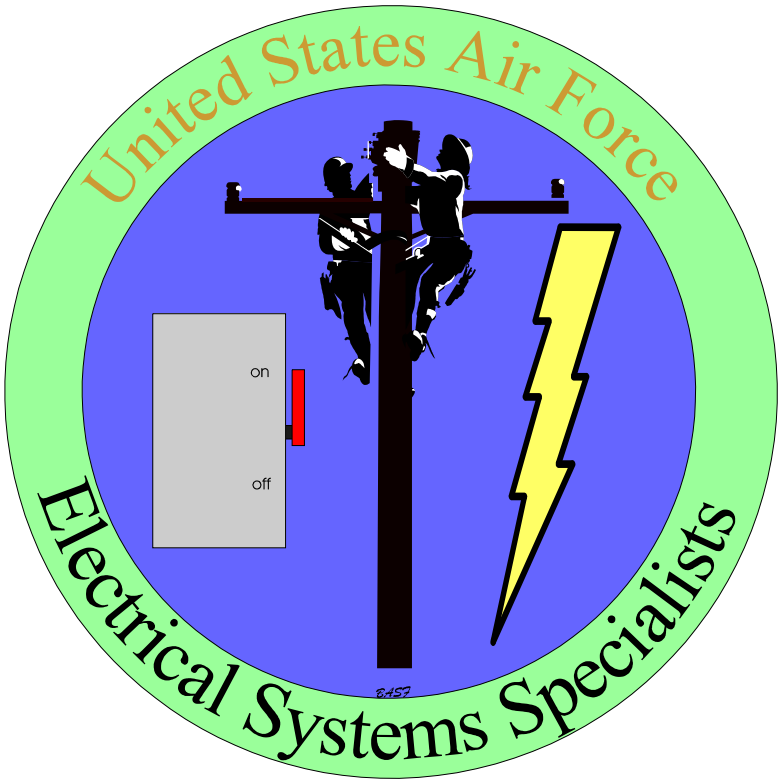
PERFORMANCE CHECKLIST

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. Lock out/tag out facility's main breaker/disconnect prior to the installation of the pad-mounted transformer		
2. Properly position the transformer on the pad without damaging the primary and secondary cable		
3. Anchor transformer		
4. Make all primary and secondary connections to the transformer		
5. Properly test a pad-mounted transformer after installation		
6. 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.



INSTALL

MODULE 18 AFQTP UNIT 1

GROUNDING SET (18.1.5.)

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.

INSTALL GROUNDING SET

Task Training Guide

STS Reference Number/Title:	18.1.5., Install grounding set.
Training References:	1. Career Development Course (CDC) Electrical Systems, 3E051A Vol. 3, Unit 2: *Grounding*. 2. Lineman's and Cableman's Handbook, Eighth Edition, Section 26, *Grounding.* 3. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 4. AFI 32-1063, *Electric Power Systems.* 5. AFI 32-1065, *Grounding Systems.* 6. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.* 7. National Electric Safety Code (NESC). 8. National Electric Code (NEC). 9. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.*
Prerequisites:	1. Possess as a minimum a 3E031 AFSC. 2. Review the following references: 2.1. CDC Electrical Systems, 3E051A Vol. 3, Unit 2. 2.2. Lineman's and Cableman's Handbook, Eighth Edition, Section 26. 2.3. AFIs 32-1064, 32-1063, and 32-1065. 2.4. AFMAN 32-1185. 2.5. NEC and NESC. 3. **Complete Lesson 3, Grounding Sets, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution, Lesson 3***
Equipment/Tools Required:	1. Grounding set. 2. Personal protective equipment. 3. Rubber protective equipment. 4. Hand tools.
Learning Objective:	Given equipment, install grounding set on pad mounted transformer.
Samples of Behavior:	1. Follow approved methods while installing grounding set. 2. Know safety requirements for installing grounding set.
Notes:	
1. Any safety violation is an automatic failure. 2. Trainer will brief trainee on the components of the particular transformer to be grounded as well as describe operation of the grounding set used.	

INSTALL GROUNDING SET

1. Background: The purpose of a grounding set is to ground the high voltage side of transformers to bleed off any stray, induced or static voltage. Also if the circuit were to accidentally become energized, the set would provide a direct short between the phases, which would activate the protective equipment to open. This voltage could be from the high voltage cables feeding the transformer or from possible back feeds from the secondary side of the transformer. In either case it is important to removed the voltage and ground the transformer. This is done so that work may be accomplished safely around and on the transformer. Grounding sets will have four connection points, three will connect to the transformer while the fourth will connect to the system ground or a temporary ground rod. Grounding sets will have one of two types of connectors: an elbow type or grounding clamp type. Each has similar procedures for installation. Each will be covered in this training package.

2. Grounding equipment in partially energized substations and vaults.

2.1. It is often impractical to leave the equipment being worked on grounded. For example; the ground set is plugged into the bushing that needs to be replaced. So the circuit would have to be grounded in another location i.e. the other end of the de-energized circuit.

2.2. In the case of indoor equipment, it may be possible to permanently ground the equipment on the outside. This would be possible where oil circuit breakers are being inspected one at a time with disconnects open between the circuit breaker and the bus. Grounding on the outside and closing the oil circuit breaker ground everything in the bay is grounded.

2.3. In other instances, it may be practical to ground on the de-energized side of the open disconnects. Care must be taken to avoid confusion in tracing out the feeder being worked on between the outside and inside construction. Where the feeder is grounded on the outside, the equipment to be worked on should be checked with an approved high voltage testing device and then grounding cables attached before touching it.

2.4. Where it is practical to leave the equipment grounded while work is in progress, it is mandatory that each phase of the equipment to be worked on be tested to see that it is de-energized and then touched with a grounded cable before the work begins. This should be done even though all disconnects or other devices for clearing the equipment or jumpers to be worked on are in plain view.

3. *Complete Lesson 3, Grounding Sets, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly install grounding set using the step-by-step procedures listed below.*

> **NOTE:**
> The review questions for this material are contained in the above–mentioned CD-ROM.

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

Step 1: Inspect the grounding set.

1.1. Check for loose, broken, or burnt connections.

1.2. Also check for split, cracked, or burnt insulation.

1.3. When conductor connections on grounding sets are not visible, use an ohmmeter or a megohmmeter to test the connections.

Step 2: Inspect the system ground.

2.1. Check for loose connections, signs of corrosion, and sufficient space for installation of the temporary grounding set.

2.2. If the grounding system does not have enough space to connect the grounding set, then a temporary grounding rod will have to be installed.

Step 3: Clean the points of contact.

3.1. For an uncontaminated connection, clean the contact points or jaws of the grounding clamp.

3.2. Then use a wire brush to remove oxidation, corrosion, or paint from the area on the grounding system where the grounding set will be attached.

Step 4: De-energize the transformer.

4.1. When de-energizing a transformer, always work from the load to the source.

4.2. Disconnect the load side of the transformer by opening the main breaker at the service entrance.

4.3. Open any primary fuses or switches that may be located on the transformer.

4.4. Isolate the primary system voltage feeding the transformer by opening any protective devices, such as overhead cutouts, load break elbows, oil circuit breakers, or switches.

Step 5: Test to ensure transformer has been completely de-energized.

NOTE:
All meters/testers **MUST** be checked for proper operation on a known energized source, **BEFORE** and **AFTER** use on a de-energized circuit, to ensure the reliability of the test equipment.

5.1. To properly test de-energized circuits, use an Audible Noise Indicator or a high voltage phase tester.

5.1.1. Either can be used for this purpose, but one may work in a different situation better than the other.

5.1.1.1. For example, the high voltage phase tester works best on Dead-Front transformers because of the load break elbows.

5.1.1.2. When using an Audible Noise Indicator, sometimes called a Noisy Tester, extra caution must be given since its power source is batteries. If the batteries are weak or dead a false sense of security could cost someone their life.

5.2. When testing Live-front transformers, test for voltage at the cable termination.

5.2.1. If there is tape over the lug, it will have to be removed.

5.2.1.1. One way to remove tape coving a high voltage cable lug is to use a universal stick with a knife attachment to cut it loose.

5.2.1.2. Another way would be to wear rubber gloves and sleeves and peel it off.

5.2.2. After the tape is removed, use the desired tester to check for voltage at the termination. (Removing the tape will also make grounding the termination easier later on.)

5.3. When testing Dead-front transformers, portable load-break-feed-through will have to be installed on the parking stands located in the high voltage cabinet of the transformer.

5.3.1. These feed through provide a bushing for the load break elbow to be attached to temporarily.

5.3.2. Using a hotstick, place the cables in the first bushing of the feed through.

5.3.3. Then using a bushing adapter for the high voltage phase tester, test for voltage in the second bushing of the feed through.

5.4. When testing de-energized circuits, do not overlook the secondary voltage.

5.4.1. Testing the secondary is accomplished by using an appropriate voltmeter. This is critical due to the possibility of back feeding from another source. Back feeding the secondary through a transformer will step up the voltage and create a high voltage on the primary side of the transformer, exposing the worker to risk.

Step 6: Connect the grounding set to the grounding system.

6.1. A tight connection between the grounding set and the system ground or temporary grounding rod is imperative.

6.2. Once securely connected to the ground, place the other three ends of the grounding set slightly apart and away from the cables feeding the transformer.

Step 7: Connect the grounding set to the transformer.

7.1. Dead Front.

7.1.1. To ground a dead-front transformer, use a grip-all stick or an elbow-pulling tool to place the elbow from the ground set into the second bushing of the load break feed-through.

7.1.2. This is the same feed-through used to test for voltage in.

7.1.3. When finished, there should be two elbows on each feed-through, one from the grounding set and one from the cable being grounded.

7.1.4. Repeat this process for each remaining cable.

7.2. Live Front.

7.2.1. When making the final connections to a live front transformer, use a grip-all to place the grounding clamps of the temporary grounding set directly to the cable termination.

7.2.2. Some transformers may have other means of connecting a ground set, but regardless of how the ground is connected, always use the appropriate hot line tools.

SAFETY:
HOT LINE CLAMPS ARE NOT DESIGNED TO HANDLE FAULT CURRENTS AND SHOULD NEVER BE SUBSTITUTED FOR GROUNDING CLAMPS.

Step 8: The ground set must be in place for a minimum of 15-20 minutes before any work on the cables can be accomplished.

8.1. This time will allow the stored voltage to bleed off.

INSTALL GROUNDING SET

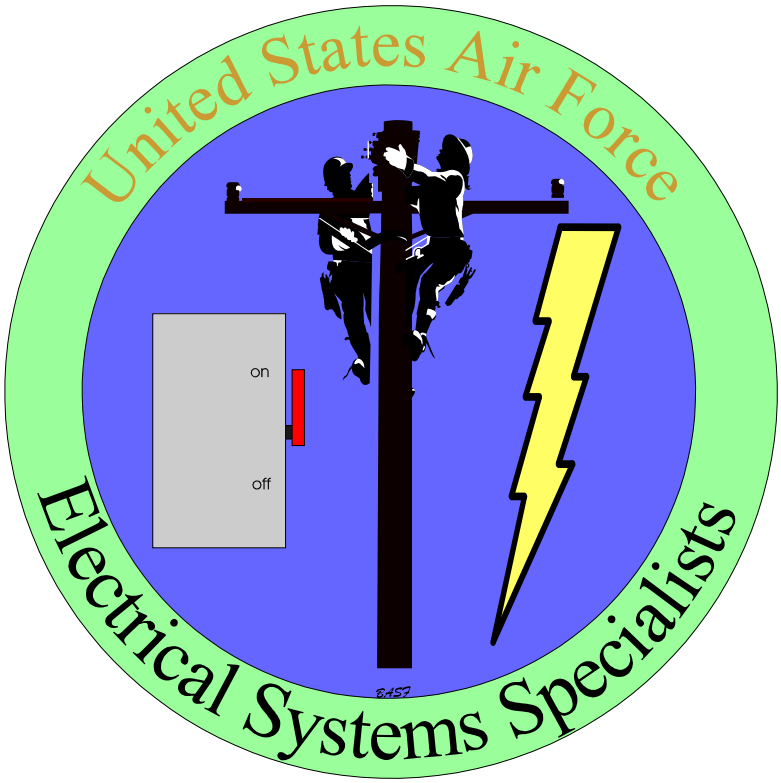
PERFORMANCE CHECKLIST

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. Perform an inspection of the grounding set prior to use		
2. Open the transformer using the proper safety procedures		
3. If needed, clean contact points on connectors cleaned with a wire brush		
4. Inspect ground rod for serviceability		
5. Disconnect power from all possible sources		
6. Test the transformer for the lack of voltage prior to grounding		
7. Verify test equipment for proper operation prior to and after checking for voltage		
8. Take care while handling the bushings so not to damage them		
9. Use proper procedures when removing and placing load-break elbows		
10. 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 the trainer.



SPLICE HIGH VOLTAGE UNDERGROUND CABLE

MODULE 18 AFQTP UNIT 2

USING TAPE (18.2.1.)

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.

SPLICE HIGH VOLTAGE UNDERGROUND CABLE USING TAPE

Task Training Guide

STS Reference Number/Title:	18.2.1., Splice high voltage underground cable using tape.
Training References:	1. Career Development Course (CDC) Electrical Systems, 3E051B, Vol. 3, Unit 1, Section 1-2: *Underground Cable*. 2. Lineman's and Cableman's Handbook, Eighth Edition, Section 33, *Splicing Cables.* 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.* 6. Manufacturer's instructions.
Prerequisites:	1. **Possess as a minimum a 3E031 AFSC**. 2. **Review the following references:** 2.1. CDC Electrical Systems, 3E051B, Vol. 3, Unit 1, Sect. 1-2. 2.2. Lineman's and Cableman's Handbook, Eighth Edition, Section 29. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 2.5. Manufacturer's instructions. 3. **Complete *Lesson 4, Splice Cable Using Tape, in the* CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Trenching means. 2. Cable. 3. Shovels. 4. Tape splice kit. 5. General tool kit.
Learning Objective:	Given equipment, splice high voltage underground cable.
Samples of Behavior:	1. Following approved methods, splice high voltage underground cable. 2. Know safety requirements for splicing high voltage underground cable.
Notes:	
Any safety violation is an automatic failure.	

SPLICE HIGH VOLTAGE UNDERGROUND CABLE USING TAPE

1. Background: Underground cable is usually either direct burial or installed in ducts. While repair methods are basically the same for any underground cable, there are some differences that depend on the installation condition. The goal of splicing cables is to connect two-cables together maintaining the original cables mechanical and electrical strength.

1.1. In most cases, the fault is in either an existing splice or a termination and the repair is comparatively simple. In other cases, though, the fault is in the cable itself and the repair involves removing a defective cable length and splicing in a good length. The replacement must be the same as the original cable or a type of cable that is comparable to and compatible with the original cable. Use splice kits and termination kits as much as possible.

1.2. The manufacturer of the cable or the kit used for any specific splice provides detailed instructions. After the repair is completed (and before backfilling for direct-burial cable), make insulation resistance and potential tests to determine that the cable, including the new repair, is suitable for use.

2. ***Complete Lesson 4, Splice Cable Using Tape, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly splice cable using tape with the step-by-step procedures listed below.***

NOTE:
The review questions for this material are contained in the above–mentioned CD-ROM.

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

NOTE:
The steps shown here are for a shielded, single conductor, primary URD Cable. Depending on the type of cable being spliced, it may not be necessary to complete all these steps. Be sure to follow the splicing specifications for the type of cable being used.

3.1. CABLE PREPARATION PROCEDURES.

Step 1: Train the Cables.

1.1. This is nothing more than moving, bending, and cutting the cables into their final position.

1.2. The ends of the cable need to be as straight as possible to permit stripping tools to work correctly.

1.3. Ensure the cable is cleaned of any dirt or grease before cutting the cable to prevent contaminates from entering the splice area.

1.4. Before making the cut, overlap the two cable ends and mark a straight line on the cable jacket of both cables, at the center of the overlap.

1.5. Cut the cable on the marks with either a cable cutter or a hacksaw.

Step 2: Remove Cable Jacket.

2.1. Measure from the end of the cable back the required distance as indicated in the specification sheet for this type conductor and place a mark.

2.2. At that mark, use a knife to lightly score horizontally around the cable jacket, halfway through its thickness. Care must be taken to ensure the metallic shielding below the jacket is not damaged in any way.

2.3. If the shielding is copper tape, score the jacket lengthwise from the horizontal mark to the end of the cable. Then carefully use pliers to peel the jacket back to the horizontal score line.

2.4. If the metallic shielding is composed of wire strands, use plies to grip one of the strands and pull it back to the horizontal score line. As the strand is peeled back, it will rip through the jacket and make it easy to remove.

Step 3: Remove Metallic Shielding.

3.1. Now that the cable jacket has been removed, the excess metallic shielding should be cut according to the specification sheet for this type of conductor.

3.2. Normally, it is cut leaving approximately one inch of shielding material from the cable jacket. Removing the excess metallic shielding will prevent it from being damaged during the splicing process.

Step 4: Remove Semi-Conductive Material.

NOTE:
The metallic shielding should never touch the insulation below the semi-conductive material.

4.1. Lightly score the semi-conductive material one-quarter inch (1/4”) from the metallic shielding.

4.2. Then carefully peel the semi-conductive material away from the cable, being extra careful not to damage the insulation below.

Step 5: Remove Primary Insulation and Strand Shielding.

NOTE:
In this step, extra care must be taken to prevent damaging the conductor underneath the primary insulation. The slightest nick or cut into the conductor will render that section of cable useless and everything done up to that point will have to be re-accomplished.

5.1. Determining how much insulation and shielding to remove depends on the system voltage and size of conductor. Refer to the manufacturer’s specifications to help make this determination.

5.2. The insulation and shielding can be removed in several ways.

5.2.1. One such way is to use a knife and lightly score through the insulation, then use pliers to peel it off the conductor.

5.2.2. Another way to remove insulation from Cross-linked Polyethylene or Ethylene Propylene Rubber type insulated cables is to use a nylon string. Pulling the string back and forth across the insulation can easily cut through without harming the conductor below.

5.2.3. The final method is to use stripping tools. This method has become very popular due to the ease and speed at which insulation can be removed from a conductor.

Step 6: Pencil the Insulation Ends.

6.1. The next step in cable preparations is to taper or pencil the end of the primary insulation.

6.2. This process provides a smooth transition between the primary insulation and the insulation that will be added during the splicing process.

6.3. Penciling also reduces the chance of voltage stress by eliminating air pockets that could form when applying the insulating tape.

6.4. There are tools specially designed to properly taper cable insulation, but a knife can do the job just as easily. In either case, care must once again be taken to ensure the conductor is not damaged in anyway.

Step 7: Clean Prepared Area.

7.1. The last step in preparing a cable for splicing is to clean all traces of contaminates from the prepared areas. Any residue remaining on the cable could create a conductive path that might cause a direct ground fault.

7.2. Using an approved cleaning solvent and clean rag, wipe the cable ends from the jacket toward the end of the cable.

7.3. Never wipe from the cable end back to the cable jacket as this can re-deposit contaminates across the insulation or within the metallic shielding.

7.4. Reposition the rag on the cable often enough, and in such a way as to prevent placing contaminates back on the cable. If need be, a second rag may be used to ensure the cleanliness of the splice area.

Step 8: Once all these steps have been accomplished on both ends of the cables to be spliced, cable preparations are complete.

3.2. CABLE SPLICING PROCEDURES.

Step 1: Clean Conductors.

1.1. Use a wire brush, steel wool, or similar abrasive tool to remove the oxide film from the conductors.

Step 2: Apply Connector.

2.1. Use the appropriate crimping machine to crimp the connector onto the conductor. Begin the compressions in the middle and rotate the crimper 90 degrees after each crimp.

2.2.1. Check for splicing instructions as to the type of press to use, the proper size die needed and the number of compressions required. Often this information can be found on the connector itself.

2.2.2. Make sure there are no obstructions inside the connector, then slide the two ends of the conductors into the connector until seated fully.

2.2.3. Using the appropriate crimper, begin the compressions in the middle, working outward. This will prevent the connector from expanding away from the middle, creating a gap between the conductor ends.

2.2.4. The amount of pressure exerted on the connector during the compressions is enormous. To help keep the connector somewhat straight, rotate the crimper 90 degrees after each crimp.

Step 3: Smooth The Edges.

3.1. Use a file or wire brush to smoothen out any and all sharp edges on the connector to prevent weakening the splice.

Step 4: Clean Splice Area.

4.1. Use an approved cleaning solvent and clean rag to clean the splice area free of contaminants.

4.1.1. It is imperative that metal shavings or particles of any kind be wiped from the splice area.

4.1.2. Begin by using an approved cleaning solvent and clean rag to remove any joint compound that might have been squeezed out during crimping.

4.1.3. Then reposition the rag and wipe the rest of the splice clean.

4.1.4. Repositioning the rag should be done in such a way as to prevent re-depositing particles back onto the splice.

4.1.5. If need be, a second rag may be used to ensure the cleanliness of the splice area.

4.1.6. And finally, the workman should clean their hands to ensure all conductive contaminants are removed prior to beginning the taping portion of the splice.

Step 5: Apply Semi-Conductive Tape.

5.1. This tape is applied over the connector and any exposed portions of the conductor to replace the cables strand shielding.

5.2. It is important to build up the area next to the connector to eliminate any chance of air pockets being formed.

5.3. The result of the applied semi-conductive tape should be flat in the middle and tapered off on each side, almost resembling a cigar.

Step 6: Calculate Tape Buildup.

6.1. Use an outside caliper to measure semi-conductive tape thickness, then follow splice specifications to re-adjust calipers to desired thickness of rubber insulating tape.

Step 7: Apply Rubber Insulating Tape.

7.1. Apply half-lap layers of rubber insulating tape over the semi-conductive tape until building up to a thickness equal to the outside caliper setting.

Step 8: Apply Semi-Conductive Tape.

8.1. This layer of semi-conductive tape will even out the voltage stress from the metallic shielding above it.

8.2. It must be stretched when applied to ensure proper bonding and to prevent air pockets.

Step 9: Apply Metallic Shielding Tape.

9.1. Since fault currents will pass through a splice, the metallic shielding tape should be soldered to the cable's metallic shielding.

9.1.1. The best results will be obtained when the metallic shielding tape, or metal tape as it is sometimes called, is soldered directly to the concentric neutral using a resin-based flux.

9.1.2. **Never** use an acid core flux, as this does not permit the solder to melt into the wire properly and damage to the lower levels of the splice may occur.

Step 10: Seal Concentric Wires.

10.1. Use a rubber cement to seal the area where the concentric wires run back into the cable jacket.

10.2. Then wrap a layer of high voltage rubber tape over the entire splice.

Step 11: Apply Final Covering.

11.1. Wrap a final layer of vinyl tape over the entire splice, overlapping the original cable jacket.

SPLICE HIGH VOLTAGE UNDERGROUND CABLE USING TAPE

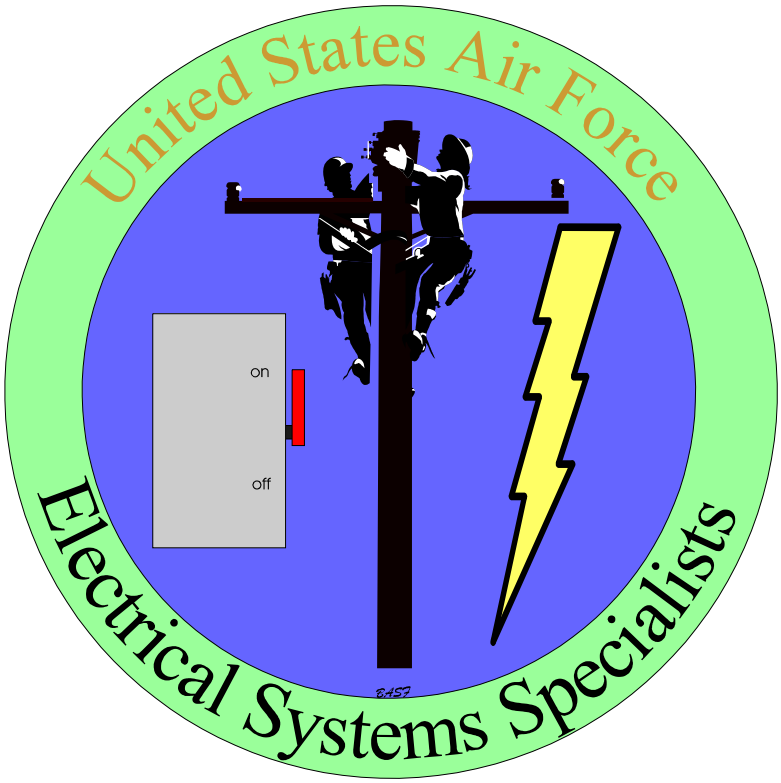
PERFORMANCE CHECKLIST

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
Cable Preparation.		
1. Train the cables correctly		
2. Remove cable jacket correctly		
3. Remove metallic shielding correctly		
4. Remove semi-conductive material correctly		
5. Remove primary insulation and strand shielding correctly		
6. Pencil the insulation ends correctly		
7. Clean prepared area		
Cable Splicing.		
1. Clean conductors		
2. Use the appropriate crimper when applying connector (rotate 90 degrees after each crimp)		
3. Smooth the edges on the connector		
4. Clean splice area		
5. Apply semi-conductive tape correctly		
6. Calculate tape buildup with caliper		
7. Apply rubber insulating tape correctly		
8. Apply semi-conductive tape correctly		
9. Apply metallic shielding tape correctly		
10. Seal concentric wires with rubber cement		
11. Apply final layer of vinyl tape over the entire splice		
12. 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.



UNDERGROUND DISTRIBUTION SYSTEMS

MODULE 18 AFQTP UNIT 3

TERMINATE HIGH VOLTAGE UNDERGROUND CABLE (18.3.)

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.

TERMINATE HIGH VOLTAGE UNDERGROUND CABLES

Task Training Guide

STS Reference Number/Title:	18.3., Terminate high voltage underground cables.
Training References:	1. Career Development Course (CDC) Electrical Systems, 3E051B, Vol. 3, Unit 1, Section 1-2: *Underground Cable*. 2. Lineman's and Cableman's Handbook, Eighth Edition, Section 34, *Underground Distribution.* 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety*. 6. Manufacturer's instructions. 7. National Electric Safety Code (NESC). 8. National Electric Code (NEC).
Prerequisites:	1. **Possess as a minimum a 3E031 AFSC**. 2. **Review the following references:** 2.1. CDC Electrical Systems, 3E051B, Vol. 3, Unit 1, Sect. 1-2. 2.2. Lineman's and Cableman's Handbook, Eighth Edition, Section 34. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 2.5. Manufacturer's instructions. 2.6. NESC. 2.7. NEC. 3. **Complete *Lesson 5, Terminations, in the* CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Termination kit. 2. A four-foot section of cable. 3. Personal protective equipment. 4. Hand tools.
Learning Objective:	Given equipment, install a termination on high voltage cables.
Samples of Behavior:	1. Following approved methods; fabricate a termination on high voltage cables. 2. Know the safety requirements for terminating high voltage cables.
Notes:	
1. Any safety violation is an automatic failure. 2. Trainer will brief trainee on the components of the particular termination kit used as well as the type of cable to be terminated.	

TERMINATE HIGH VOLTAGE UNDERGROUND CABLE

1. Background: A termination is a transition between the cable and a piece of line equipment. This transition is needed to contain and dissipates the corona effect that is associated with high voltage power cables. Without a proper termination or transition the corona effect will deteriorate the cable causing eventual failure and subsequent replacement. In this unit we will look at the different types of terminations as well as the procedures used to fabricate two of these types. The procedures are quite close and, with slight modifications, can be used for all termination types. You will carry with you an understanding of what a termination does and how to make them.

1.1. Around every power cable there are lines of magnetic flux. When a cable is whole (by whole I mean completely intact, no layers of the cable are missing) these lines of flux are present and do not cause much harm, because the natural makeup of the cable contains them. When you remove certain layers (the concentric neutral and the semi-conductive) these lines of flux expand and contract around this area. To dissipate these lines of flux and reduce the chance of cable failure we must terminate the cable in a prescribed manor. A termination provides this means by giving us a smooth transition between the cable and line equipment and dissipating the corona effect. A termination is effectively a choke point for these lines of flux.

1.2. There are many different types of prefabricated terminations: cold shrink, heat shrink, molded rubber, and porcelain, are a few. For the purposes of this lesson we will discuss the cold shrink type and the-do-it-yourself tape termination. The cold shrink type is widely used, while the tape termination is a good procedure that may come in handy one day when your out in the middle of nowhere with little to no supplies and have to fix a termination.

2. Complete Lesson 5, Terminations, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly terminate high voltage underground cable using the step-by-step procedures listed below.

> **NOTE:**
> The review questions for this material are contained in the above–mentioned CD-ROM.

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

3.1. <u>Solid Load</u>.

Step 1: Prepare Cable.

1.1. The cable must be properly prepared to receive the connecting lug.

1.1.1. If this step is not completed properly, the entire termination will fail causing a power outage and possible damage to the cable or equipment the cable terminates to.

1.1.2. The instruction sheets that accompany the termination kit will have specific guidelines for final cable preparations.

Step 2: Install Ground Braid.

2.1. Any exposed portion of a conducting surface on a terminating device **MUST** be grounded.

2.1.1. This is a separate ground from that used for energized equipment and parts. For this reason, grounding braids must be brought out of the terminating device to be in accordance with the NESC standard.

2.1.2. Specific guidelines for applying grounding braids to the termination you'll be fabricating will be found in the termination instruction sheet.

Step 3: Install Lug Connector.

3.1. The terminal lug is compressed onto the conductor.

3.1.1. The terminal lug is what connects the end of the cable to the piece of equipment. Terminal lugs must be of a similar material as the cable being used. Dissimilar metals cause corrosion and corrosion on the conductor will cause the line to fail.

3.1.2. The instructions that accompany the connector contain detailed information. Often this information is stamped directly on the connector as well.

3.1.3. One trick that will prove helpful when installing a lug connector to the conductor is to rotate the crimper 90 degrees after each compression. The tremendous force applied to the connector during crimping will cause it to distort, rotating the crimper 90 degrees will help distort the connector back and help keep it somewhat straight.

Step 4: Clean Cable Insulation and Lug Barrel.

4.1. After the terminal lug is compressed onto the conductor.

4.1.1. A non-conductive abrasive cloth and an approved cable cleaner should be used to properly clean the cable and lug.

4.1.2. Once the cable has been cleaned, every precaution should be taken to prevent re-contamination.

Step 5: Install Termination.

5.1. The final protective coating is ready to be applied.

5.1.1. If a taped termination is being used, refer to the instruction sheet for the proper layers of various tapes to be applied.

5.1.2. If a heat-shrink sleeve is being used, apply the heat evenly around the sleeve allowing it to shrink into its final position.

5.1.3. For a cold-shrink sleeve, ensure the sleeve is properly positioned, and then carefully remove the plastic core by pulling the tab.

5.1.4. And finally, if using a porcelain termination, ensure it is in its final resting position with the cable secured in it, then fill with epoxy to complete the termination.

Step 6: Test the Termination.

6.1. The final step in any termination is to test it.

6.1.1. Testing a termination is accomplished by using a DC high potential tester, more commonly known as a Hypot. With this tester, several thousand volts can be applied to the termination to test its effectiveness.

6.1.2. It is important to note however, that a high potential tester can generate more voltage than some cables can handle. Improper testing can cause undo stress, resulting in extensive cable damage. As each cable is designed differently, be sure to read the manufacturer's specifications for the cable being used before conducting a High Potential Test.

TERMINATE HIGH VOLTAGE UNDERGROUND CABLES

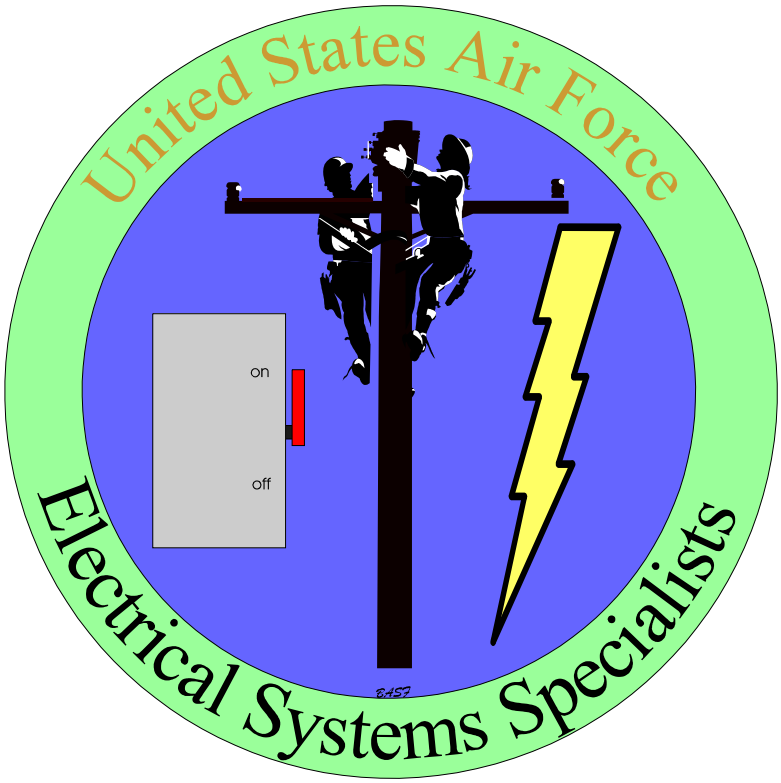
PERFORMANCE CHECKLIST

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. Prepare cable properly		
2. Install ground braid correctly		
3. Install lug connector correctly (rotate the crimper 90 degrees after each compression)		
4. Clean cable insulation and lug barrel properly		
5. Install termination correctly for: 5.1. Taped termination 5.2. Heat-shrink 5.3. Cold-shrink 5.4. Porcelain		
6. Test the termination correctly		
7. 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 the trainer.



UNDERGROUND DISTRIBUTION SYSTEMS

MODULE 18 AFQTP UNIT 5

PERFORM HIGH POTENTIAL (HYPOT) DC TEST ON UNDERGROUND CABLE (18.5.)

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.

PERFORM HYPOT DC TEST ON UNDERGROUND CABLE

Task Training Guide

STS Reference Number/Title:	18.5., Perform HYPOT DC test on underground cables.
Training References:	1. Career Development Course (CDC) Electrical Systems, 3E051B, Vol. 3, Unit 1, Section 1-4: *Inspecting and Maintaining Underground Distribution Systems*. 2. Lineman's and Cableman's Handbook, Eighth Edition, Section 34, *Underground Distribution.* 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.* 6. Manufacturer's instructions. 7. National Electric Safety Code (NESC). 8. National Electric Code (NEC). 9. 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 3E051 AFSC**. 2. **Review the following references:** 2.1. CDC Electrical Systems, 3E051B, Vol. 3, Unit 1, Sect. 1-4. 2.2. Lineman's and Cableman's Handbook, Eighth Edition, Section 34. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 2.5. Manufacturer's instructions. 2.6. NESC. 2.7. NEC. 2.8. AFOSHSTD 91-45. 3. **Complete *Lesson 8, High Potential DC Test, in the* CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Grounding set. 2. Personal protective equipment. 3. Rubber protective equipment. 4. Test set. 5. Hand tools.
Learning Objective:	Given equipment, properly test underground distribution cables.
Samples of Behavior:	1. Following approved methods, properly use test set. 2. Know the safety requirements for properly testing underground distribution cables.
Notes:	
1. Any safety violation is an automatic failure. 2. Trainer will brief trainee on the components of the particular transformer to be grounded as well as describe operation of the grounding set used.	

PERFORM HYPOT DC TEST ON UNDERGROUND CABLE

1. Background: The reasons for testing underground cables are many and can range from doing the installation acceptance test to testing the integrity of a cable after splicing. In either case or extreme you are simply applying voltage to the cable to ensure that it can hold the source voltage normally applied. In this section we will show two methods of testing cables the high potential test set and high voltage fault locator (thumper). The HYPOT test is used to check the integrity of the cable's construction. It will determine if the cable will handle the system voltage and help detect deteriorating cables. The thumper will assist you in locating a cable fault.

2. ***Complete Lesson 8, High Potential DC Test, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly perform HYPOT DC test on underground cable using the step-by-step procedures listed below.***

NOTE:
The review questions for this material are contained in the above–mentioned CD-ROM.

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

SAFETY:
PRIOR TO MAKING ANY TEST CONNECTIONS, ENSURE THE TEST CABLE OR EQUIPMENT HAS BEEN DE-ENERGIZED AND GROUNDED. THE HYPOT IS NOT DESIGNED TO WORK ON ENERGIZED CIRCUITS; SO, ENSURE THIS CRITICAL STEP HAS NOT BEEN OVERLOOKED.

Step 1: To prevent the circuit from being re-energized during the test, be sure to follow all lock-out/tag-out procedures. Refer to AFOSHSTD 91-45.

Step 2: Turn the POWER and HIGH VOLTAGE switches to the OFF position.

Step 3: Connect the CONTROL CABLE to the CONTROL and HIGH VOLTAGE sections.

Step 4: Rotate the VOLTAGE control knob fully counter-clockwise.

Step 5: Connect the LINE cord to a power source as suggested on the name plate.

Step 6: Connect the shield of the high voltage ground to the SAFETY GROUND terminal and plug the high voltage cable into the HIGH VOLTAGE UNIT.

Step 7: Don personal protective equipment.

NOTE:
If the test set is utilized properly and all grounds are made correctly, rubber gloves would not be required. However, as sound safety procedure, manufacturers of test equipment recommend rubber gloves be worn when making connections and manipulating controls.

Step 8: Connect the test item to the HIGH VOLTAGE OUTPUT CABLE and to the METERED RETURN terminal and select METERED RETURN with the GROUND SWITCH.

Step 9: Turn the KILIVOLTS switch to the desired range.

Step 10: Turn the MICROAMPERES switch to the required range depending on the expected current. If the leakage current is unknown, turn this switch to the highest range.

Step 11: Turn the POWER switch to the ON position and allow a 90-second warm-up period.

Step 12: Activate the H.V. switch by turning it to the ON position.

Step 13: Rotate the VOLTAGE CONTROL clockwise until the required test voltage on the KILOVOLTMETER is attained or until the MICROAMMETER reaches the maximum acceptable leakage current.

Step 14: The leakage current can be read on the MICROAMMETER. If greater sensitivity is desired, select a lower current range on the MICROAMPERES range switch.

Step 15: The MICROAMPERES range may be changed at any time during a test to maintain the best readability.

Step 16: The HIGH VOLTAGE unit will automatically de-energize if the tested item fails

Step 17: To re-energize the HIGH VOLTAGE unit repeat steps 4 and 11.

Step 18: To re-energize the HIGH VOLTAGE unit when a remotely located switch has been opened, it will be necessary to re-close the switch and then repeat steps 4 and 11.

PERFORM HYPOT DC TEST ON UNDERGROUND CABLE

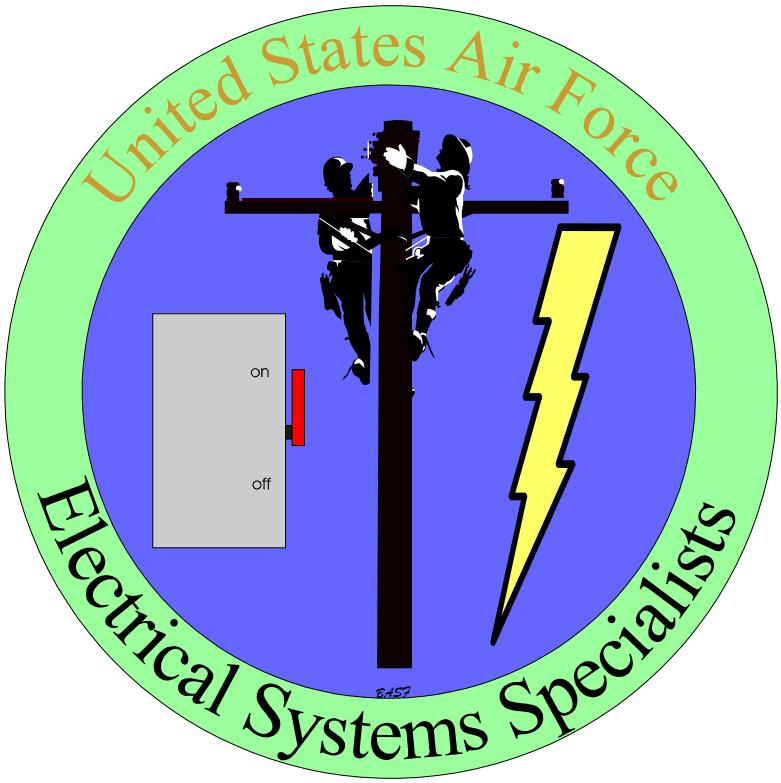
PERFORMANCE CHECKLIST

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. Use warning barricades to create a safety work zone		
2. Properly isolate and ground the cable prior to testing		
3. Connect the HYPOT as per manufacturer instructions		
4. Use the HYPOT as per manufacturer instructions		
5. Allow the cable to sit for 15 minutes before discharging it to ground		
6. 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 the trainer.



UNDERGROUND DISTRIBUTION SYSTEMS

MODULE 18 AFQTP UNIT 6

TROUBLESHOOT UNDERGROUND CABLES FOR FAULTS (18.6.)

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 UNDERGROUND CABLES FOR FAULTS

Task Training Guide

STS Reference Number/Title:	18.6., Troubleshoot underground system cables for faults.
Training References:	1. Career Development Course (CDC) Electrical Systems, 3E051B, Vol. 3, Unit 1, Section 1-5: *Troubleshooting Underground Distribution Systems*. 2. Lineman's and Cableman's Handbook, Eighth Edition, Section 34, *Underground Distribution.* 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety*. 6. Manufacturer's instructions. 7. National Electric Safety Code (NESC). 8. National Electric Code (NEC). 9. 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 3E031 AFSC**. 2. **Review the following references:** 2.1. CDC Electrical Systems, 3E051B, Vol. 3, Unit 1, Sect. 1-5. 2.2. Lineman's and Cableman's Handbook, Eighth Edition, Section 34. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 2.5. Manufacturer's instructions. 2.6. NESC. 2.7. NEC. 2.8. AFOSHSTD 91-45. 3. **Complete *Lesson 7, Troubleshoot for Faults, in the* CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Grounding set. 2. Personal protective equipment. 3. Rubber protective equipment. 4. Test sets. 5. Hand tools.
Learning Objective:	Given equipment, troubleshoot underground cable systems for faults
Samples of Behavior:	1. Following approved methods; troubleshoot underground cable systems for opens, shorts and grounds. 2. Know the safety requirements for troubleshooting underground cable systems.
Notes:	
1. Any safety violation is an automatic failure. 2. Trainer will brief trainee on the components of the particular transformer to be grounded as well as describe operation of the grounding set used.	

TROUBLESHOOT UNDERGROUND CABLES FOR FAULTS

1. Background: To find a fault in a cable whether it is in a duct or a direct buried cable, a megohmmeter (commonly referred to as a megger) is used in conjunction with a cable tracer/fault locator. You may have seen a megger before when conducting checks for transformer opens, shorts, and grounds. Remember--a reading of zero (0) means there is no resistance or a short between the leads; Infinity (∞) indicates there is an infinite amount of resistance or an open between the megger leads. When troubleshooting underground cable, you might be testing several miles of cable at a time. Attaching the meter leads to each end of the cable, as you did to measure continuity of transformer windings, would be impossible. Therefore, you need a set of jumper leads which will be used to short the cables at the far end so megger readings can be taken without having meter leads several miles long. A fault in a cable means it is defective. There are three basic kinds of cable faults: opens, shorts, and grounds. Each type has its own characteristic that can be detected by using a megger. However, regardless of the type of fault, your system is out of service until the cable can be repaired.

1.1. An open, for instance, in a conductor simply means there is a break in the conductor. There can be no current flow through the open. Opens rarely occur by themselves in high voltage cables. If a high voltage cable is cut, the resulting fire usually causes the cable to ground out and possibly burn other cables near it. A short, on the other hand, in a circuit results when two or more conductors touch, or a conductive material goes across two or more conductors. The conductive material in high voltage cables is usually water. The insulation weakens and current flows through the insulation between the conductors. Grounded conductors, however is a situation in which one or more conductors have made an electrical contact with a ground. The result is current flow through ground back to the source. When a high voltage cable is grounded the insulation has gone bad. The current flows through the insulation and causes over-current condition.

2. ***Complete Lesson 7, Troubleshoot for Faults, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly troubleshoot underground cables for faults using the step-by-step procedures listed below.***

NOTE:
The review questions for this material are contained in the above–mentioned CD-ROM.

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

Step 1: Isolate cables.

1.1. Before attempting to troubleshoot an underground cable, it is imperative you isolate the cable from all voltage sources. Refer to AFOSHSTD 91-45.

Step 2: Check for voltage.

2.1. Using the appropriate meter, ensure the cable has in fact been isolated from all possible voltage sources.

2.2. This is accomplished by checking the readings on the meter from a known live circuit, before and after checking the isolated cable.

Step 3: Ground the cables.

3.1. A simple remedy to avoid incident from static charge is merely to ground the cables using a temporary ground set to bleed off any residual voltage still on the line.

3.2. If a permanent ground is not accessible, a temporary grounding rod will need to be installed.

Step 4: Disconnect the cable.

4.1. In order to get an accurate reading when testing the cable, it must be disconnected from any piece of line equipment.

4.2. Again, residual voltage is still a concern, so be sure to use personnel protective equipment, such as the hotstick and rubber gloves, when doing so.

Step 5: Inspect the megohmmeter.

NOTE:
As Meggers differ from manufacturer to manufacturer, make sure you are adequately trained in the operations of the Megger being used.

5.1. Do a quick visual check to ensure the megger was not damaged in transport.

5.2. Then connect the leads together and depending on the make of megger, either push the test button or turn the hand crank.

5.2.1. If the meter is working properly, the reading will be 0.

5.2.2. Now separate the test leads and again push the test button or turn the hand crank. If the reading is a sideways #8, you are ready to begin.

5.2.3. Any other readings and the megger will need replaced.

Step 6: Connect the megohmmeter. The type of fault determines the way the megger is connected to the cables.

6.1. To check for a **grounded conductor fault**, successively connect the megger leads to each conductor and ground with the far end of the cable open circuited. Any reading other than infinity on the megger will mean the conductor is grounded.

6.2. To determine a **short-circuited fault**, successively connect the megger leads between each possible combination of conductors. Again, the far ends of the cable must be open-circuited. Any reading other than infinity on the megger will indicate a short circuit exists.

6.3. When checking for an **open circuit fault**, determine the continuity of the conductors by grounding the conductors at the far end and then testing between conductor pairs. If the conductors are continuous, the megger will read 0 ohms. Anything other than a reading of 0 ohms will indicate that an open fault exists.

TROUBLESHOOT UNDERGROUND CABLES FOR FAULTS

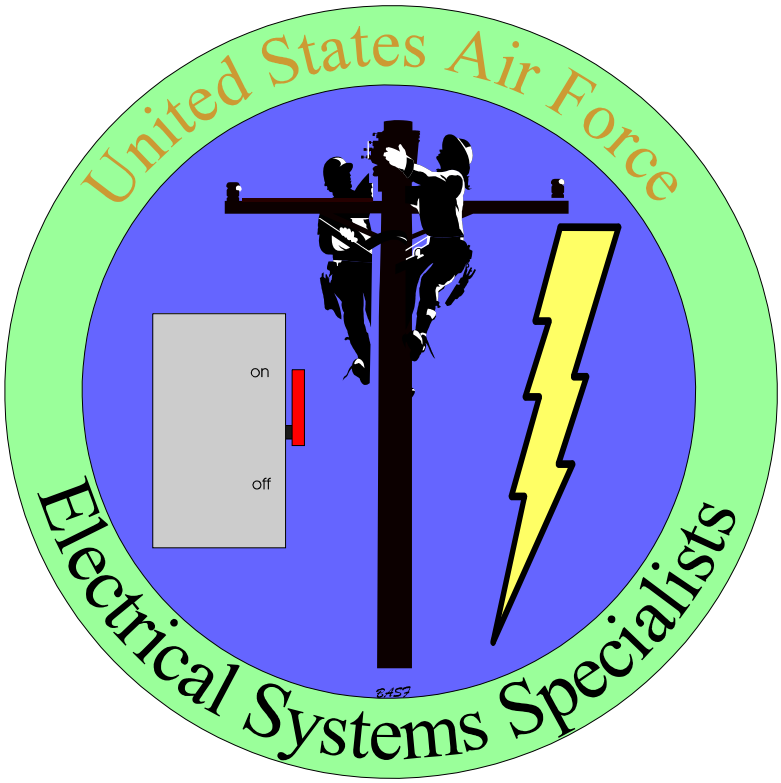
PERFORMANCE CHECKLIST

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. Isolate the cable before troubleshooting		
2. Correctly use the megohmmeter to check cable		
3. Locate a: 3.1. Grounded conductor fault 3.2. Short-circuited fault 3.3. Open circuit fault		
4. 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 the trainer.



UNDERGROUND DISTRIBUTION SYSTEMS

MODULE 18 AFQTP UNIT 7

TRACE UNDERGROUND CABLES WITH CABLE TEST SET (18.7.)

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.

TRACE UNDERGROUND CABLES WITH CABLE TEST SET

Task Training Guide

STS Reference Number/Title:	18.7., Trace underground cables with cable test set.
Training References:	1. Career Development Course (CDC) Electrical Systems 3E051B, Vol. 3, Unit 1, Section 1-4: *Inspecting and Maintaining Underground Distribution Systems* and Section 1-5: *Troubleshooting Underground Distribution Systems.* 2. Manufacturer's operating instructions. 3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1, Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 4. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 5. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.*
Prerequisites:	1. **Possess as a minimum a 3E031 AFSC.** 2. **Review the following references:** 2.1. CDC Electrical Systems 3E051B, Vol. 3, Unit 1, Sections 1-4 and 1-5. 2.2. Manufacturer's operating instructions. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 3. **Complete *Lesson 6, Tracing Underground Cable, in the* CD-ROM AFQTP 3E0X1, Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Underground cable test set. 2. Cable.
Learning Objective:	Given equipment, locate underground cable
Samples of Behavior:	1. Follow required steps while locating underground cable using a cable test set. 2. Know safety requirements to locate underground cable.
Notes:	
Any safety violation is an automatic failure.	

TRACE UNDERGROUND CABLES WITH CABLE TEST SET

1. Background: There are many reasons we must be able to trace cable locations, the most common being, clearing an area for digging. Although maps will give a general location and route, we must be able to locate a buried line with-in a few feet. How well you can locate cable could mean the difference between a smooth job and a major power outage with lots of overtime. Another reason to trace cables would be to locate a fault. With a quick visual check we can find faults or flaws in exposed conductor joints or equipment. Driving over the conductor route may enable you to locate faults. While driving the conductor route, you might spot things that imply possible conductor failure. Things such as displaced manhole covers, smoke coming from a manhole, places where digging has taken place, melted snow, and burnt grass or holes dug by rodents are usually good indications. Sometimes a burnt smell will reveal a fault has recently happened. If none of the above are apparent some type of conductor tracing and fault finding technique must be used.

2. ***Complete Lesson 6, Tracing Underground Cable, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly trace underground cables with cable test set using the step-by-step procedures listed below.***

> **NOTE:**
> The review questions for this material are contained in the above–mentioned CD-ROM.

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

3.1. Procedures for testing equipment.

> **NOTE:**
> The procedures that follow are general in nature and common among similar types of cable tracing equipment. However, as some differences between these devices do exist, be sure to follow the instructions furnished with the model your shop employs. For the purpose of this program, we will be using the METROTECH 810.

Step 1: Push the power test button.

1.1. With the power switch on, push the power test button.

1.2. If the battery power is sufficient, the power test lamp will light.

1.3. If not, the batteries are in need of replacing or recharging.

Step 2: Extent the receiver antenna.

2.1. Fully extend the receiver antenna by loosening the nut on the stem assembly and extend the stem as far as possible.

2.2. Then re-tighten the nut to secure the stem assembly.

Step 3: Switch meter to *Battery Test* position.

3.1. Place the receiver function switch to the second position, or battery test.

3.2. The needle should move to the right of the battery test line found on the receiver display. In fact, the greater the battery charge, the further to the right the needle will go.

3.3. Should the needle be to the left of the battery test line, the batteries are in need of replacing or recharging.

Step 4: Switch meter to *Tracing* position.

4.1. Move the receiver function switch to the third position or the tracing position.

4.2. Then place the end of the receiver no more than 6 inches away from the transmitter.

4.3. The digital signal strength indicator should show 950 or higher.

Step 5: Move receiver back from transmitter.

5.1. With the receiver function switch still in the tracing position, move the receiver away from the transmitter at least 2-5 feet.

5.2. As long as the receiver is pointing at the transmitter, the left/right guidance needle should be centered, with no tone emitted.

Step 6: Move receiver left and right of center.

6.1. At this point, if everything is functioning properly, move the receiver to the right.

6.2. A continuous tone should be heard and the needle moves over the solid line on the meter.

6.3. Then move the receiver to the left of the transmitter and a broken tone will be heard and the needle will move to the broken line on the meter.

Step 7: Test depth reading.

7.1. Point the receiver back at the transmitter so the needle is centered on the meter.

7.2. Once the needle is centered and steady, press and release the depth button.

7.3. A false depth reading will be displayed giving the indication that the depth capability is functioning.

Step 8: Turn the transmitter off.

8.1. If during the equipment inspection all tests yielded the desired results, turn the transmitter off and make ready to transport to the job site.

8.2. If any of the tests were not favorable, inform your supervisor of the discrepancy so the unit can be sent to a servicing representative for repairs.

3.2. Applying the signal to the conductor using the transmitter. There are three ways in which this can be accomplished:

3.2.1. <u>DIRECT CONNECTION METHOD</u>.

NOTE:
When using this method, the conductor ***must*** be de-energized before a direct connection is made.

Step 1: With the transmitter in the off position, insert the direct connect cable plug into the jack labeled *"direct"* on the transmitter.

Step 2: After thoroughly cleaning a metallic portion of the questionable conductor, attach the red lead of the direct connect cable and move the transmitter in a right angle away from the conductor.

Step 3: While maintaining a right angle course, extend the black lead of the direct connect cable as far away from the transmitter as possible. Drive a grounding spike as deep into the ground as possible and attach the black lead to it.

Step 4: Turn the transmitter on by pulling the power switch up and begin tracing the signal with the receiver.

Step 5: Once the conductor is located, mark its location by spray painting or flagging.

3.2.2. INDUCTIVE METHOD.

Step 1: Begin by placing the transmitter directly over the buried cable to be located. When placing the transmitter directly over the buried cable, ensure the conductor directional arrow on the transmitter is parallel to the cable.

Step 2: Turn the transmitter on by pulling the power switch up and begin tracing the signal with the receiver.

Step 3: Once the conductor is located, mark its location by spray painting or flagging.

3.2.3. INDIRECT METHOD (Coupling with the Metroclamp).

Step 1: With the transmitter in the off position, insert the Metroclamp cable plug into the jack labeled "direct"

Step 2: Place the clamp end of the Metroclamp cable around the conductor or conduit to be located. Placing the clamp below the electrical ground is imperative to this operation.

Step 3: Turn the transmitter on by pulling the power switch up and begin tracing the signal with the receiver.

Step 4: Once the conductor is located, mark its location by spray painting or flagging.

3.3. Once the decision is made and the equipment is set up accordingly, you are ready to trace the signal to locate the cable. From that point on, a successful cable locate will be dependant on reading the receiver correctly. Follow these steps in reading the cable tracing equipment accurately.

Step 1: Begin sweeping the receiver from side-to-side and monitor the meter.

1.1. With the power switch of the receiver in the "on" position, move to the search area and begin sweeping the receiver from side to side.

1.2. When the receiver is directly over the conductor being traced, the needle on the guidance meter will move to the center of the gauge, the field strength of the digital display will show at its peak and the tone will become silent.

Step 2: Determine conductor direction.

2.1. To determine conductor direction or conductor stop, raise the receiver vertically and slowly turn in a circle to the right or left.

2.2. The highest signal strength reading will indicate the conductor direction.

2.3. Continue tracing the conductor in the direction indicated using the sweeping motion described in Step 1.

2.4. Should the signal strength drop abruptly, the conductor may have changed direction or stopped.

Step 3: Verify conductor's location.

3.1. After the needle has centered in the guidance meter, press the receiver's depth button.

3.2. A stable depth reading on the digital display will confirm the conductor's location. A blank reading on the display is an indication that the conductor has been lost.

3.3. If lost, return to the last known signal location and perform another conductor directional check.

3.4. Should the numbers on the digital display be registering illogically or be flickering, either an unwanted conductor has been found or the desired conductor has traveled beyond the 13-foot depth tolerance of the receiver. Continue in the direction previously traveled in hopes of regaining the desired signal again.

Step 4: Identify the conductor's path.

4.1. Mark its location by either spray painting or placing small flags directly over its path.

4.1.1. Since flags can catch the eye of children playing and are easily removed, spray-painting tends to be the better method for identification in residential areas.

4.1.2. Be sure to check local state and base policies on using paint for this purpose.

Step 5: Turn power off and return to storage case.

TRACE UNDERGROUND CABLES WITH CABLE TEST SET

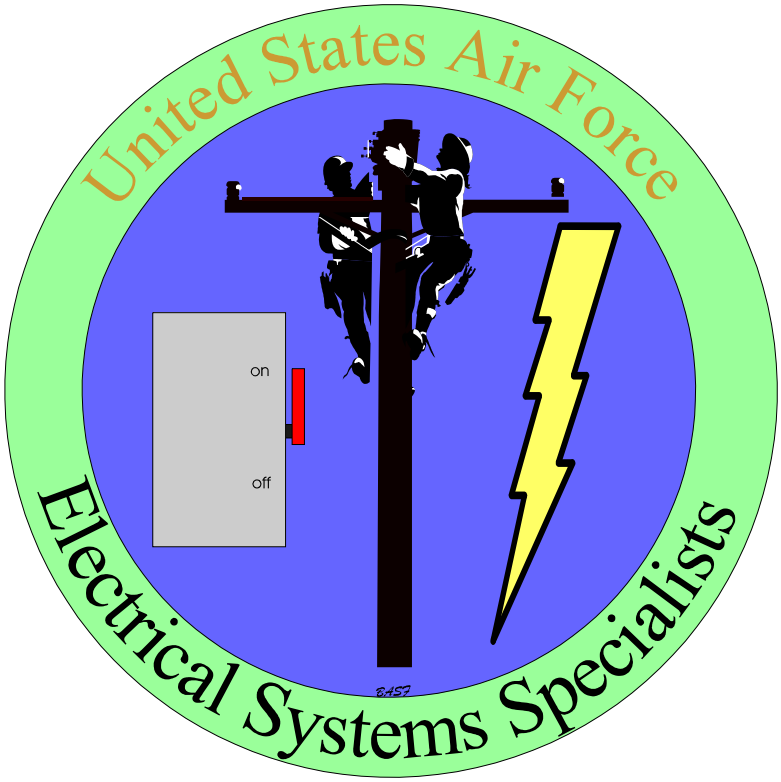
PERFORMANCE CHECKLIST

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. Check for proper operation of equipment prior to use		
2. Properly isolate circuit before tracing wire		
3. Connect the transmitter leads properly to target conductor		
4. Properly use the receiver		
5. Properly mark the circuit as it was traced		

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.



UNDERGROUND DISTRIBUTION SYSTEMS

MODULE 18 AFQTP UNIT 9

FABRICATE LOADBREAK ELBOW (18.9.)

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.

FABRICATE LOADBREAK ELBOW

Task Training Guide

STS Reference Number/Title:	18.9., Fabricate loadbreak elbow.
Training References:	1. Career Development Course (CDC) Electrical Systems 3E051B, Vol. 3, Unit 1, Section 1-2: *Underground Cable.* 2. TO 35CA2-2-10-1, Secondary Distribution Center (SDC), Section III, Para. 3-2d. (Page 3-5) 3. Manufacturer's specifications. 4. CD-ROM Air Force Qualification Training Package (AFQTP) 3E0X1, Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.* 5. Air Force Instructions (AFI) 32-1064, *Electrical Safety Practices*. 6. Air Force Manual (AFMAN) 32-1185, *Electrical Worker Safety.*
Prerequisites:	1. **Possess as a minimum a 3E031 AFSC.** 2. **Review the following references:** 2.1. CDC Electrical Systems 3E051B, Vol. 3, Unit 1, Section 1-2. 2.2. Manufacturer's specifications. 2.3. AFI 32-1064. 2.4. AFMAN 32-1185. 3. **Complete Lesson 5, Terminations, in the CD-ROM AFQTP 3E0X1, Electrical Systems, Version 1.0, Dec 01: *Underground Electrical Distribution.***
Equipment/Tools Required:	1. Loadbreak elbow kit. 2. Knife. 3. Ruler. 4. Crimper. 5. Lineman pliers. 6. Cable. 7. Needle nose pliers.
Learning Objective:	Given equipment, fabricate a loadbreak elbow.
Samples of Behavior:	1. Follow the required steps in fabricating a loadbreak elbow. 2. Know the safety requirements for fabricating a loadbreak elbow.
Notes:	
Any safety violation is an automatic failure.	

FABRICATE LOADBREAK ELBOW

1. Background: Because of the increasing need to test and isolate underground cable, a means of separating the cables quickly was developed. By the use of loadbreak elbows, you can separate lines with ease and connect them back together without fabricating time consuming terminations.

1.1. Elbow connectors provide a quick and reliable means of terminating cables. An elbow termination does not require the need for any special tools or equipment. It is one of the quickest and easiest methods of terminating high voltage underground cable. A cut away view of a typical loadbreak elbow is illustrated in Figure 1.

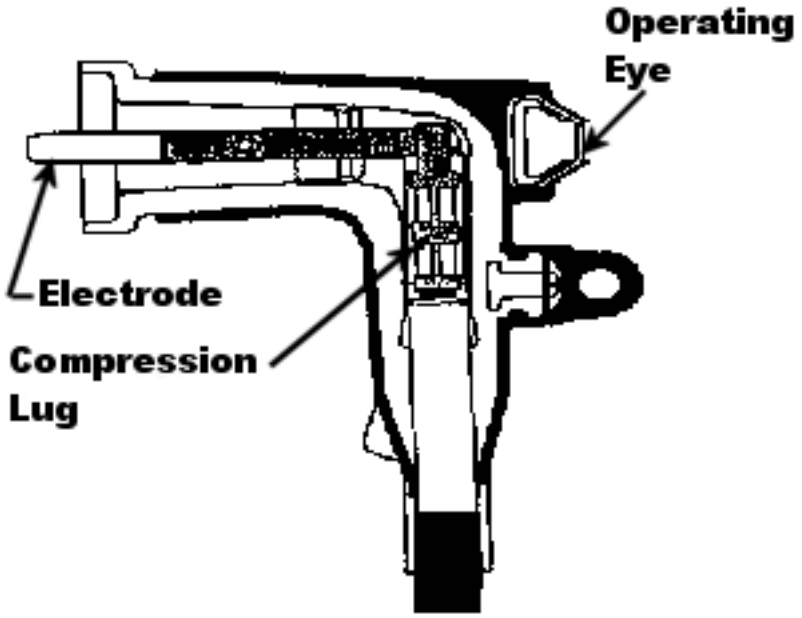


Figure 1, Cut away of Loadbreak Elbow

1.2. Loadbreak elbows have been designed to make isolating underground systems very easy. There are two types of elbows, loadbreak elbow and a bolt-on elbow. The primary difference between the two is the ability for the loadbreak elbow to be opened under a load bearing condition. A loadbreak elbow contains a ceramic tip that will break the arc formed when the loadbreak elbow is pulled from its bushing. Without this ceramic tip an elbow cannot be opened under a load condition.

1.3. When using a loadbreak elbow to isolate a circuit, make sure to use the proper equipment to remove the loadbreak elbow from the bushing. A Grip-all hot stick (shotgun) can be used to remove an elbow, however this is not the preferred tool for the job. The ideal tool is an elbow puller tool. This tool is designed specifically for removing elbows from bushings; whenever possible use this tool for removing elbows under a load condition.

2. ***Complete Lesson 5, Terminations, in the CD-ROM AFQTP 3E0X1 Electrical Systems, Version 1.0, Dec 01: Underground Electrical Distribution. Upon completion of the above-lesson, properly fabricate a loadbreak elbow using the step-by-step procedures listed below.***

NOTE:
The review questions for this material are contained in the above–mentioned CD-ROM.

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

Step 1: Train cable.

1.1. Straightening out and cutting the end of the cable so the termination can be attached and set properly on the equipment's bushing.

Step 2: Prepare cable.

2.1. Cable preparation is the most crucial step in ensuring a successful termination.

2.2. Follow the instruction that comes with the termination kit.

2.2.1. These instructions always include a template as a graphical representation of all the dimensions necessary to remove the various layers of cable.

Step 3: Clean conductor.

3.1. Use a wire brush to remove contaminants from between conductor strands.

3.2. For cleaning the various layers of cable, there are a number of cleaning kits available.

3.2.1. Most kits contain cloths saturated with a cleaning solvent, which works perfectly for this purpose.

Step 4: Attach connector.

4.1. Immediately after the cable and conductor have been sufficiently cleaned, place the connector over the conductor.

4.2. Align the threaded hole at the top of the connector with the bushing of the equipment being used.

4.3. Using the appropriate crimper, begin crimping and with each successive crimp, rotate the crimper 90 degrees.

4.4. And lastly, file smooth any sharp edges or ears on the connector caused by the crimping process and clean again if necessary.

Step 5: Lubricate cable.

5.1. Apply a small amount of silicon grease over the cable covering and in the cable end of the elbow will alleviate some of the friction when trying to slide the elbow over the cable.

5.1.1. A small tube or packet of approved lubricant can be found in almost all elbow kits.

Step 6: Install elbow.

6.1. Slide the elbow boot over the cable end. In doing so, be sure not to over-stress or bend the cable.

6.2. Ensure the cable is inserted completely in the elbow sleeve.

6.3. Make sure the threaded connector eye is facing squarely with the open bushing cavity. This will save a lot of aggravation later when attaching the threaded electrode.

Step 7: Attach electrode.

7.1. Place the threaded end of the electrode into the bushing opening of the elbow sleeve.

7.2. Then insert the threaded electrode into the female threads of the lug on the end of the cable.

7.3. Use the one-time tightening tool to tighten the electrode until the tool is substantially deformed. At which point the electrode is sufficiently tightened and the tool is then discarded.

Step 8: Attach ground.

8.1. Tie two strands of the concentric neutral wires through the grounding eye of the elbow. Tightly twist the two strands at least two turns.

8.2. Then connect the concentric neutral wires to the ground bus or ground rod.

SAFETY:
BE CAREFUL NOT TO OVER TIGHTEN THE STRANDS CAUSING THEM TO BREAK OR DAMAGE THE GROUNDING EYE.

Step 9: Install elbow to bushing.

9.1. Lubricate the bushing, the elbow receptacle, and the arc follower with the special lubricant included in the elbow kit.

9.2. Attach the elbow to an insulated hot stick.

9.3. Align the elbow with the bushing, ensuring the probe and socket match up properly.

9.4. With a quick but firm push, seat the elbow onto the bushing.

FABRICATE LOADBREAK ELBOW

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. Straighten and cut cable correctly		
2. Utilize the template for preparing the cable end		
3. Remove dirt and oil from conductor end		
4. Attach connector correctly		
5. Install elbow boot correctly		
6. Attach electrode correctly		
7. Tighten electrode until enclosed wrench was bent		
8. Attach ground correctly		
9. Install elbow to bushing correctly		

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.

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