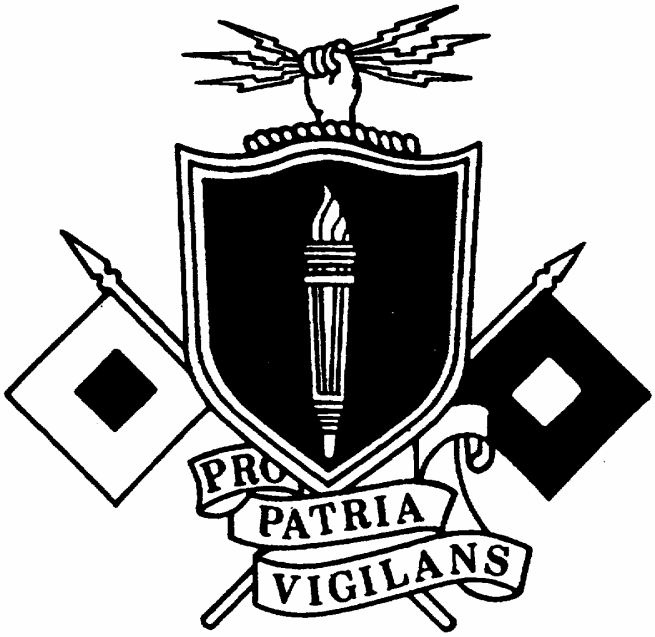
SUBCOURSE
SS 0437

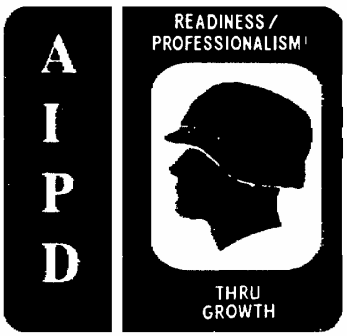
EDITION
7

TESTING WIRE LINES AND LOCATING FAULTS



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM



US ARMY WIRE SYSTEMS INSTALLER
MOS 31L SKILL LEVELS 1 AND 2 COURSE

TESTING WIRE LINES AND LOCATING FAULTS

SUBCOURSE No. SS 0437-7

US Army Signal Center and Fort Gordon
Fort Gordon, Georgia

Three Credit Hours

GENERAL

This subcourse is part of the Wire Systems Installer Course, Skill Levels 1 and 2. It is designed to provide the knowledge needed to perform tasks related to troubleshooting field wire WD-1( )/TT. Methods of testing wire lines and locating faults are provided. This subcourse is presented in two lessons, each corresponding to a terminal learning objective.

Whenever pronouns or other references denoting gender appear in this document, they are written to refer to either male or female unless otherwise indicated.

Lesson 1: TEST WIRE LINES TO IDENTIFY TROUBLE

TASK: Test wire line to identify trouble.

CONDITIONS:

1. PERFORMANCE. Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, gloves, a predetermined site, using simulated tactical scenario narrations and discussions, and with a qualified supervisory OJT monitor's assistance.

2. PERFORMANCE-ORIENTED. Lesson 1 material, pencil, paper, FM 24-20 and TM 11-5805-201-12 extracts, and without supervision.

STANDARDS:

1. PERFORMANCE. Correctly test wire line to identify trouble without error, within one out of two attempts, and within 30 minutes, under a simulated tactical scenario environmental condition.

2. PERFORMANCE-ORIENTED. Demonstrate competency of the task skills and knowledge by correctly responding to 80 percent of the multiple-choice test covering troubleshooting field wire WD-1( )/TT.

(This objective supports SM Task Number and title 113-588-0005, Troubleshoot Field Wire WD-1( )/TT.)

Lesson 2: LOCATE FIELD WIRE TROUBLE

TASK: Locate field wire trouble.

CONDITIONS:

1. PERFORMANCE. Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, gloves, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, a predetermined site, using simulated tactical scenario narrations and discussions with a qualified supervisory OJT monitor's assistance.

2. PERFORMANCE-ORIENTED. Lesson 2 material, pencil, paper, FM 24-20 and TM 11-5805-201-12 extracts, and without supervision.

STANDARDS:

1. PERFORMANCE. Correctly locate field wire trouble without error within one out of two attempts and within 30 minutes, under a simulated tactical scenario environmental condition.

2. PERFORMANCE-ORIENTED. Demonstrate competency of the task skills and knowledge by correctly responding to 80 percent of the multiple-choice test covering troubleshooting field wire WD-1( )/TT.

(This objective supports SM Task Number and title 113-588-0005, Troubleshoot Field Wire WD-1( )/TT.)

IMPORTANT NOTICE

THE PASSING SCORE FOR ALL ACCP MATERIAL IS NOW 70%.

PLEASE DISREGARD ALL REFERENCES TO THE 75% REQUIREMENT.

TABLE OF CONTENTS

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INTRODUCTION TO TROUBLESHOOTING FIELD WIRE WD-1( )/TT

In many repair shops there are repair persons who repair the equipment, and there are those we call troubleshooters. These persons, in most cases, just troubleshoot the equipment, locate the trouble, write down what is wrong, and one of the repair persons repairs the equipment. However, frequently when working with field wire lines, you will be both troubleshooting and repairing field wire lines.

Upon completion of the subcourse, using a TA-312/PT, you will be able to properly test wire line and locate faults on a field wire line.

This subcourse consists of two lessons and an examination.

LESSON 1

TEST WIRE LINES TO IDENTIFY TROUBLE

TASKS

Test wire line to identify trouble.

CONDITIONS

1. PERFORMANCE. Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, gloves, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, a predetermined site, using simulated tactical scenario narrations and discussions, and with a qualified supervisory OJT monitor's assistance.

2. PERFORMANCE-ORIENTED. Given Lesson 1 material, FM 24-20 and TM 11-5805-201-12 extracts, pencil, paper, and without supervision.

STANDARDS

1. PERFORMANCE. Correctly test wire line to identify trouble without error within one out of two attempts, and within 30 minutes, under a simulated tactical scenario environmental condition.

2. PERFORMANCE-ORIENTED. Demonstrate competency of the task skills and knowledge by correctly responding to 80 percent of the multiple-choice test covering troubleshooting field wire WD-1( )/TT.

REFERENCES

FM 24-20 and TM 11-5805-201-12 extracts with all changes.

Learning Event 1:

CONNECT WIRE TO TEST TELEPHONE.

1. Field wire plays an important role in communication systems requiring telephone lines. Field wire is subject to short circuits, open circuits, grounded circuits, and crossed circuits. The repair person will determine the nature, location, and extent of any line-fault with the use of test instruments and correct testing procedures.

2. During this lesson, you will learn the procedures for testing a wire line to identify trouble. The tests on a field wire line are performed to locate a line fault promptly with minimum service interruptions (Chapter 11, FM 24-20).

3. Field wire line tests normally originate from terminal equipment. In most cases, fault-detection tests are completed at this point along with reasonably accurate fault location.

4. Lines entering terminal equipment are connected to the equipment line binding posts. When a working line is reported in trouble, the lineman makes an operational test to determine if the fault is inward toward the operating equipment, or outward toward the local line.

5. The lineman would report to the terminal equipment to determine which is the faulty line and to ensure he has the correct line reported with fault (Chapter 11, FM 24-20).

WARNING

NEVER OPEN A CIRCUIT THAT IS IN USE.

6. Connect wire line to test telephone for testing to verify faults (paragraph 2-3d, TM 11-5805-20-12).

a. The lineman should depress the line binding post on the terminal equipment and remove ends of wire from the equipment.

b. Place the test telephone on a level surface and pull the zipper to open telephone carry case.

c. Push down on one of the line binding posts on test telephone and insert the bare end of one wire into the binding post slot.

d. Release the post and check to see that the wire is securely clamped.

e. Connect the other wire to the other binding post as in 6c-d above.

Learning Event 2:

TEST WIRE TO VERIFY CIRCUIT TROUBLE.

1. The basic kinds of faults that occur on all kinds of wire lines are open circuits, short circuits, crossed circuits, and grounded circuits. When wire lines are reported unserviceable, lines have to be tested to verify the kind of faults reported.

2. To test wire line, each end of wire line must be connected to the test telephone (paragraph 2-3d, TM 11-5805-201-12).

3. An open occurs in a wiring line when one or both conductors are broken or cut (Chapter 11, FM 24-20). An intermittent open also occurs in poor splices.

4. To verify an open, turn the handcrank on the test telephone and notice the amount of force you must use to turn it.

5. An open line will allow the handcrank of the test telephone to turn freely without resistance and signaling will not be transmitted or received (Chapter 11, FM 24-20).

6. Short circuit occurs when the conductors of a pair come in contact with each other (Chapter 11, FM 24-20). Most shorts occur at the ties and at the terminal.

a. If a field wire pair is jerked or pulled too hard, the insulation may be cut or crushed in its own tie to a tree or pole; that is, the conductors may cut their own insulation in the tie because of too much tension. This usually causes a short circuit on the line. If an aerial span has too much tension, the conductors will usually short circuit themselves by cutting their own insulation at the tie.

b. Short also occurs on line at terminal connections. Bare ends or some of the strands of stripped conductors sometimes are not properly placed on binding posts. When this happens, the bare strands of conductors of the same pair usually touch.

7. To verify a short circuit, turn the handcrank on the test telephone and notice the action of the handcrank (paragraph 3-2c, TM 11-5805-201-12).

8. A short is present when the handcrank turns hard with jerky motion (Chapter 11, FM 24-20). Opens and shorts are the two faults that cause complete line failure most frequently.

9. The two faults that cause cross talk between lines, as well as noisy lines, are cross and ground.

10. When a line is grounded, one or both line conductors are in contact with a grounded object (Chapter 11, FM 24-20). This produces weak communications, noise, and weak reception over a wire line.

a. When one conductor of a local-battery line is grounded, the line is balanced. The line picks up noise inductively from other adjacent lines. If the soil near the ground is moist or wet and rich and dark, the ground contact on the conductor will probably be of low resistance. If the soil near the ground is dry and light clay, sandy, or rocky, the ground contact on the conductor will probably be of high resistance.

b. On local battery lines, low-resistance ground usually causes the line to pick up noise as well as weak reception. Noise and weak reception usually comes from induction caused by line grounded with the metallic contact with the earth.

11. To verify a ground circuit, turn the handcrank on the test telephone, if the handcrank turned hard and you heard noise on the line, a ground circuit is on the line (Chapter 11, FM 24-20).

12. A cross circuit occurs when the conductor of one wire line comes in electrical contact with the conductor of a second or both wire lines (Chapter 11, FM 24-20).

a. The electrical contact of crossed pairs on local-battery lines unbalances both lines. The unbalance tends to cause inductive cross talk. The single electrical connection itself does not provide a closed voice circuit, except in the unlikely event that both conductors of each pair are crossed.

b. The result of cross on two common-battery telephone lines will also cause cross talk; but, there may also be a permanent signal on the line.

13. Cross talk may be verified by connecting the wire line to the test telephone and lifting up on the handset (paragraphs 2-3d and 3-2c, TM 11-5805-201-12).

a. Place receiver end of handset to your ear and operate the PRESS-TO-TALK switch by pressing down on the switch.

b. Cross talk is present when you hear your transmission with the other line transmission.

14. Routine test is performed on line to maintain proper maintenance at slack or light traffic over circuit.

LESSON 1

PRACTICE EXERCISE

(PERFORMANCE/TEST VERSION 1)

TASK: Test wire line to identify trouble.

CONDITIONS: Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, gloves, a predetermined site, using simulated tactical scenario narrations and discussions, and with a qualified supervisory OJT monitor's assistance.

STANDARDS: Correctly test wire line to identify trouble without error, within one out of two attempts, and within 30 minutes, under a simulated tactical scenario environmental condition.

(This objective supports SM Task Number and title 113-588-0005, Troubleshoot Field Wire WD-1( )/TT.)

	1st Attempt			2d Attempt		
	GO	NO-GO	SOJT MONITOR'S INITIALS	GO	NO-GO	SOJT MONITOR'S INITIALS
1. Connect wire to test telephone.						
a. Remove lines from terminating equipment.						
b. Insert lines into binding post of test telephone.						
2. Test wire to verify circuit trouble.						
a. Check condition of both conductors.						
b. Check for open, short, ground, and cross.						

LESSON 1

PRACTICE EXERCISE

(PERFORMANCE-ORIENTED/TEST VERSION 2)

TASK: Test wire line to identify trouble.

CONDITIONS: Given Lesson 1 material, pencil, paper, FM and TM extracts, and without supervision.

STANDARDS: Demonstrate competency of the task skills and knowledge by correctly responding to 80 percent of the multiple-choice test covering testing wire line to identify trouble.

In each of the following questions, select the one answer which BEST completes the statement or answers the question. Indicate your response by circling the correct letter below.

1. When connecting wire line to test telephone, the wireman checks the wire that is reported faulty. Where is the check performed?

   a. Patch panel.

   b. Signal center.

   c. Terminal equipment.

   d. Test station.

2. When connecting wire to test telephone, how is the wire connected to the binding posts?

   a. Wrapping wire end around post.

   b. Push down on the binding post and insert wire.

   c. Clamp wire to binding posts with clips.

   d. Splice wire to binding posts.

3. When connecting wire line, where is the wire checked to ensure it is securely clamped?

   a. Patch panel.

   b. Signal center.

   c. Binding posts.

   d. Test station.

4. In testing wire line, what fault causes the telephone handcrank to turn freely?

   a. Short.

   b. Open.

   c. Ground.

   d. Cross.

5. When testing wire line, what is noticed after the handcrank is turned?

   a. If handcrank can turn.

   b. If circuit is in use.

   c. If lines are identified.

   d. Amount of force you must use to turn handcrank.

6. When testing wire line, noise and weak reception are caused by which wire fault?

   a. Wet trouble.

   b. Grounded cross.

   c. Wet spot.

   d. Ground.

7. When testing cross circuit, what indication over the line indicates a cross?

   a. Little or no tone can be heard.

   b. Capacity kick.

   c. Voltage drop.

   d. Cross communication.

8. Where does taping begin when taping splice?

   a. 1 1/2 inches left of splice.

   b. 1 1/2 inches at either end of splice.

   c. 1 1/2 inches right of splice.

   d. Center of splice.

9. What kind of splice is performed with pliers TL-13A?

   a. Friction tape splice.

   b. Field expedient.

   c. Vulcanize splice.

   d. Crimped sleeve splice.

10. In splicing field wire, the wire tensile strength is maintained principally by the

   a. tape covering splice.

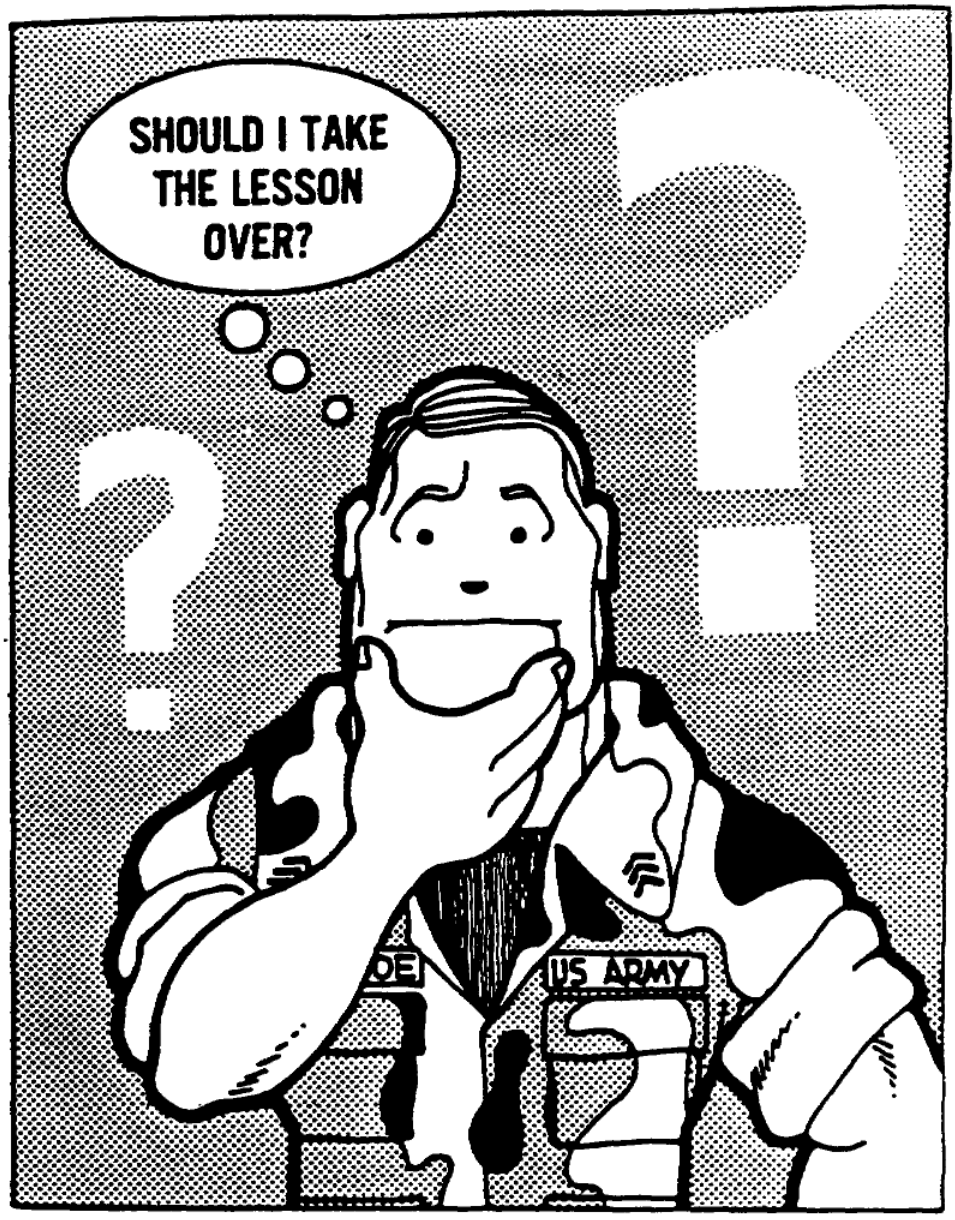
   b. tension bridge or splice.

   c. natural twist and square knot.

   d. steel strands in square knot.

LESSON 1

TEST WIRE LINES TO IDENTIFY TROUBLE



LESSON 2

LOCATE FIELD WIRE TROUBLE

TASK

Locate field wire trouble.

CONDITIONS

1. PERFORMANCE. Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, gloves, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, tape, a predetermined site, using simulated tactical scenario narrations and discussions, and with a qualified OJT monitor's assistance.

2. PERFORMANCE-ORIENTED. Given Lesson 2 material, FM 24-20 and TM 11-5805-201-12 extracts, pencil, paper, and without supervision.

STANDARDS

1. PERFORMANCE. Correctly locate field wire trouble without error within one out of two attempts and within 30 minutes under a simulated tactical scenario environmental condition.

2. PERFORMANCE-ORIENTED. Demonstrate competency of the task, skills, and knowledge by correctly responding to 80 percent of the multiple-choice test covering troubleshooting field wire WD-1( )/TT.

REFERENCES

FM 24-20 and TM 11-5805-201-12 extracts with all changes.

Learning Event 1:

LOCALIZE TROUBLE.

1. After a fault has been detected and identified, the faulty segment of line must be isolated. Thus, faults on field wire lines usually must be located by fault location tests. The principles of line testing are basically the same regardless of the type of line to be tested. The purpose of testing is--

a. To determine the condition of a line or circuit.

b. To detect any existing trouble, and to determine the nature of the fault.

c. To locate the fault and clear it with as little interruption to service as possible.

2. To simplify and speed up testing when the line is faulty: One of the lineman, who installed the line, should be familiar with the route and can inspect the line and locate the trouble more rapidly than the other.

3. To localize trouble by testing wire is as follows:

a. The wireman will proceed to the first splice from the nearest terminal equipment and untape the splice (Chapter 11, FM 24-20).

b. Depress the line binding post on test telephone and insert bare wire (paragraph 2-3c, TM 11-5805-201-12).

c. Release line binding posts and turn handcrank rapidly. Pick up handset and when operator answers, determine what side is good.

d. Disconnect wire from test telephone and retape splice.

4. If wireman did not receive answer from distant end, he will proceed to halfway along the wire section that has the fault (Chapter 11, FM 24-20).

a. Wireman will cut the wire or remove tape if a splice exists there and connect wire to test telephone.

b. Test wire in both directions to locate which side contains the fault.

c. When testing is complete in that area, disconnect wire from telephone and repeat testing procedures until fault is narrowed down to the section that you know contains the fault.

5. Retape or splice each opening made in the wire line.

Learning Event 2:

SPLICE WIRE LINE.

1. Splicing is used to join the conductors if field wire line is to maintain electrical continuity. A splice should have the same tensile strength, conductivity, abrasion and weather protection and insulation resistance as the unspliced portion of the wire. A bad splice causes transmission loss, noise, and impairs the circuit quality.

2. The splicing of field wire to repair faults is as follows:

a. Wire ends should be cut to have equal length. One conductor of each wire pair is cut 6 inches from the end. Using the cutting edge of pliers TL-13A, remove 6 inches of both conductors' insulation 2 inches at a time (Figure 6-13, Chapter 6, FM 24-20).

b. Pull the third 2-inch section of the insulation to the ends of the conductor.

c. Tie square knot on ends of wire to secure wire together (Figure 6-16, Chapter 6, FM 24-20).

(1) Join the end of the long conductor of one pair and the end of the short conductor of the other pair after restoring the normal twist of the conductor to maintain tensile strength.

(2) Twist conductor once over and under conductor to form the first loop in the tie.

(3) Twist conductor once over and under conductor to form the second loop of the square knot tie.

(4) Pull the knot tight, but leave a quarter of an inch space between the knot and the insulation (Figure 6-17, Chapter 6, FM 24-20).

d. Remove the last 2-inch section of insulation from conductor and separate the three steel strands from the copper strands by flexing both wire strands (copper strands will remain bent when flexed).

e. Cut steel strands flush with the ends of the insulation and form an "X" over square knot by crossing the left-hand end of the copper strands under and over the right side of the square knot (Figure 6-18, Chapter 6, FM 24-20).

f. Wrap several tight turns over the bare portion of the right-hand conductor from the end of knot until two turns have been made on the insulation.

g. Cut the excess ends of the copper strands and repeat the same procedures on the right-hand end of the copper strands.

h. All splices are taped to waterproof the conductors.

(1) With the electrical insulation tape, start taping at the center of the splice.

(2) Using a steady pull, tape about 1 1/2 inches beyond the insulation at one end of square knot and back over the knot to about 1 1/2 inches beyond the insulation on the opposite side of square knot (Figure 6-19, Chapter 6, FM 24-20).

(3) Work the tape back again to the center of the splice to complete the taping with electrical insulation tape.

i. Start taping with friction tape to protect the electrical insulation tape from either end of square knot, about 1/2-inch beyond the electrical insulation tape.

j. Continue taping to a point 1/2-inch beyond the electrical insulation tape on the opposite ends.

k. Always test wire line for faults after splicing.

Learning Event 3:

VISUALLY INSPECT WIRE LINE.

1. Fault location calculation can be verified by visual inspection. Each field wire splice and insulation should be carefully inspected.

2. Inspect wire with your hands and eyes, by looking and feeling for damaged insulation or where splice is poorly made (Chapter 11, FM 24-20).

3. Check wire line in areas where wire is exposed to much wear from traffic and where wires rub against posts (Chapter 11, FM 24-20).

4. When you find a splice, if the splice appears good, and the conductors are even in length, the splice should be given a strong, hard pull.

5. If conductors of field wire splice are not of equal length, the splice should be cut out and the wire respliced. A short conductor at a splice may break in an overhead road crossing span.

6. Wire should be carefully inspected and pulled for tensile strength. Tape not firmly adhering to the wire must have the splice cut out, wire tested, and wire respliced.

7. When damaged insulation or poorly made splice is found, more time and labor is saved by cutting the line before and after the exposed wire and splice wire than retaping old splice.

8. Test wire line in both directions after line is cut.

9. If one side still doesn't answer, there is still another problem in the line section you are checking.

10. Splice each cut end of wire and continue searching wire line until fault is cleared.

11. If wire conductors are not damaged, just tape the exposed conductor section.

12. Use judgment in frequency of testing wire line, until fault is found (Chapter 11, FM 24-20).

13. When several damaged points exist on a short length of wire, cut out the bad section and splice the good section together.

LESSON 2

PRACTICE EXERCISE

(PERFORMANCE/TEST VERSION 1)

TASK: Locate field wire trouble.

CONDITIONS: Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, gloves, a predetermined site, using simulated tactical scenario narrations and discussions, and with a qualified supervisory OJT monitor's assistance.

STANDARDS: Correctly test wire line to identify trouble without error, within one out of two attempts, and within 30 minutes, under a simulated tactical scenario environmental condition.

(This objective supports SM Task Number and title 113-588-0005, Troubleshoot Field Wire WD-1( )/TT.)

	1st Attempt			2d Attempt		
	GO	NO-GO	SOJT MONITOR'S INITIALS	GO	NO-GO	SOJT MONITOR'S INITIALS
1. Localize trouble.						
a. Check the condition of line.						
b. Determine the nature of the fault.						
c. Locate the fault.						
2. Splice wire line.						
a. Remove insulation.						
b. Connect conductors.						
c. Complete the splice.						
d. Tape splice.						
e. Test wire line for faults.						
3. Visually inspect wire line.						
a. Check wire line for damage.						
b. Test all splices in the line.						
c. Continue above procedure until fault is cleared.						

LESSON 2

PRACTICE EXERCISE

(PERFORMANCE-ORIENTED/TEST VERSION 2)

TASK: Locate field wire trouble.

CONDITIONS: Given Lesson 2 material, pencil, paper, FM and TM extracts, and without supervision.

STANDARDS: Demonstrate competency of the task skills and knowledge by correctly responding to 80 percent of the multiple-choice test covering locating field wire trouble.

In each of the following questions, select the one answer which BEST completes the statement or answers the question. Indicate your response by circling the correct letter below.

1. When localizing trouble, why is the circuit opened at the first splice from the nearest terminal?

   a. Check cord connection.

   b. Test trouble.

   c. Replace dial.

   d. Check connection cable.

2. When localizing trouble, where is the connection for the wire on the test telephone?

   a. Hookswitch.

   b. EXT-INT switch.

   c. Receptacle connector.

   d. Line binding posts.

3. When trouble is not found on the terminal side, how is the fault side of the line checked?

   a. By moving test telephone to halfway of wire section.

   b. By making routine test.

   c. By visual inspection.

   d. By performing circuit test.

4. When splicing wire line, how is the wire cut after the ends are cut equal?

   a. 4 inches.

   b. 6 inches.

   c. 8 inches.

   d. 2 inches.

5. When splicing wire line, what tool is used in splicing the wire?

   a. MK-356/G splicing kit.

   b. TL-582 splicing tool.

   c. TL-29 knife.

   d. TL-13A pliers.

6. When splicing wire line, space is left between the knot and what?

   a. Conductor.

   b. Insulation.

   c. Steel strands.

   d. Copper strands.

7. When splicing wire line, how is the copper strand separated from the steel strands?

   a. Cutting strands flush with insulation.

   b. Twisting wire together.

   c. By flexing wire strands.

   d. By folding back stripped wire.

8. When taping splice, how far does the friction tape go beyond the electrical insulation tape?

   a. 1/2 inch.

   b. 1 1/2 inch.

   c. 1/4 inch.

   d. 1 1/4 inch.

9. When inspecting wire line, where is wire damage likely to occur?

   a. At aerial construction and splices.

   b. Where exposed to traffic and rubbing against posts.

   c. At splice and equipment.

   d. At surface construction and ties.

10. When inspecting wire line, if bare conductors are found but are not damaged, what is done to the wire?

   a. Test line.

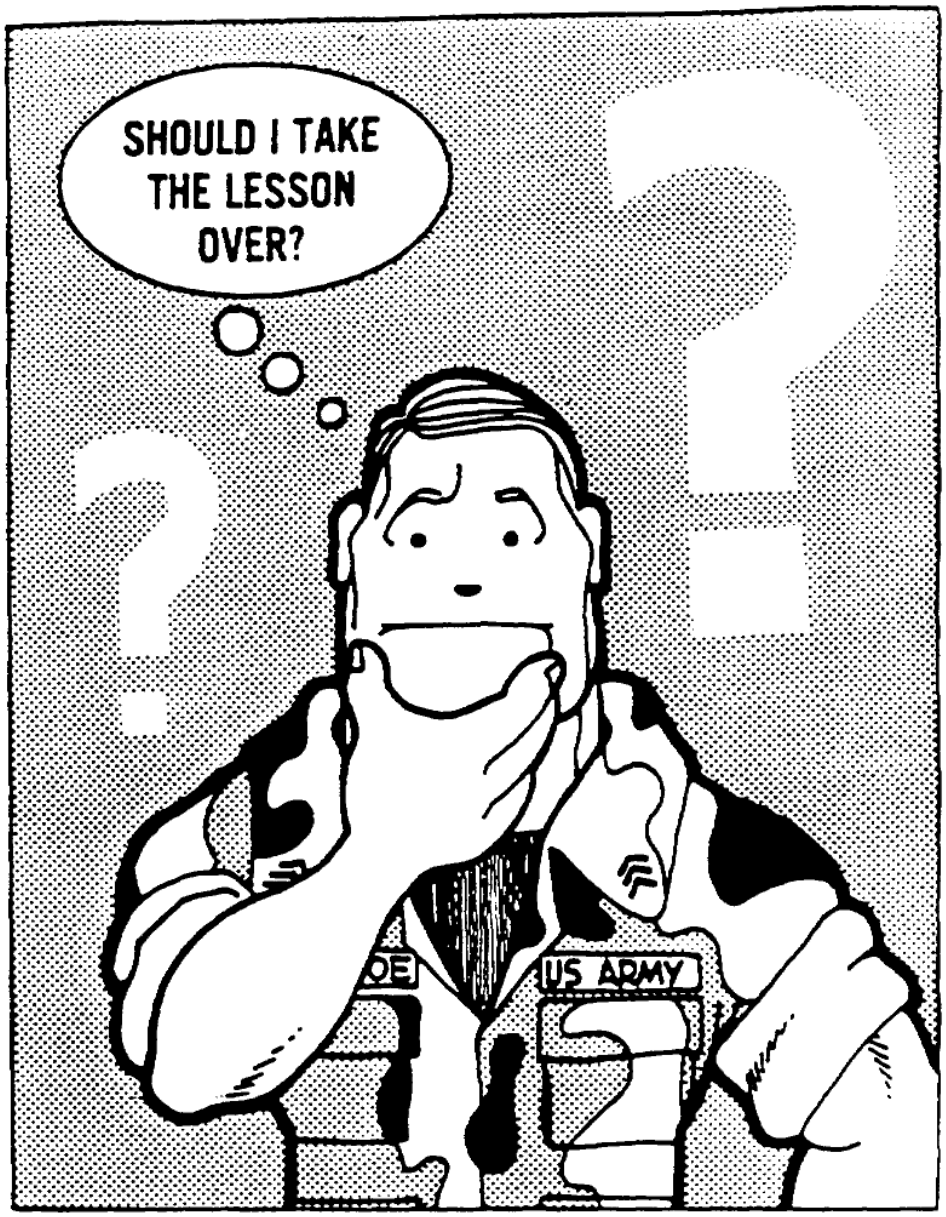
   b. Splice ends together.

   c. Tape the bare section only.

   d. Replace exposed section.

LESSON 2

LOCATE FIELD WIRE TROUBLE



ANSWERS TO PERFORMANCE-ORIENTED PRACTICE EXERCISES
(SOLUTION SHEET)

Answers	Reference (Learning event ___, para ___, page ___)			
Lesson 1:				
1. c	1	5		2
2. b	1	6	c	2
3. c	1	6	d	2
4. b	2	5		3
5. d	2	4		3
6. d	2	10		3
7. d	2	13	b	4
8. d	2	2	h(1)	13
9. b	2	2	a	13
10. c	2	2	c(1)	13
Lesson 2:				
1. b	1	3	a,	12
2. d	1	3	b	12
3. a	1	4		12
4. b	1	2	a	13
5. d	2	2	a	13
6. b	2	2	c(4)	13
7. c	2	2	d	13
8. a	2	2	h(3)	14
9. b	3	3		14
10. c	3	7		14

Field Wire Splice—Expedient Method

To make an expedient field wire splice (figure 6-13), follow these four essential steps:

- Cut the wires to stagger the lengths; remove the insulation of each conductor.
- Tie a square knot to retain the tensile strength of the conductors.
- Seize the square knot to provide good conductivity.
- Tape the splice to insulate the conductors and to protect the splice against abrasion and weather.

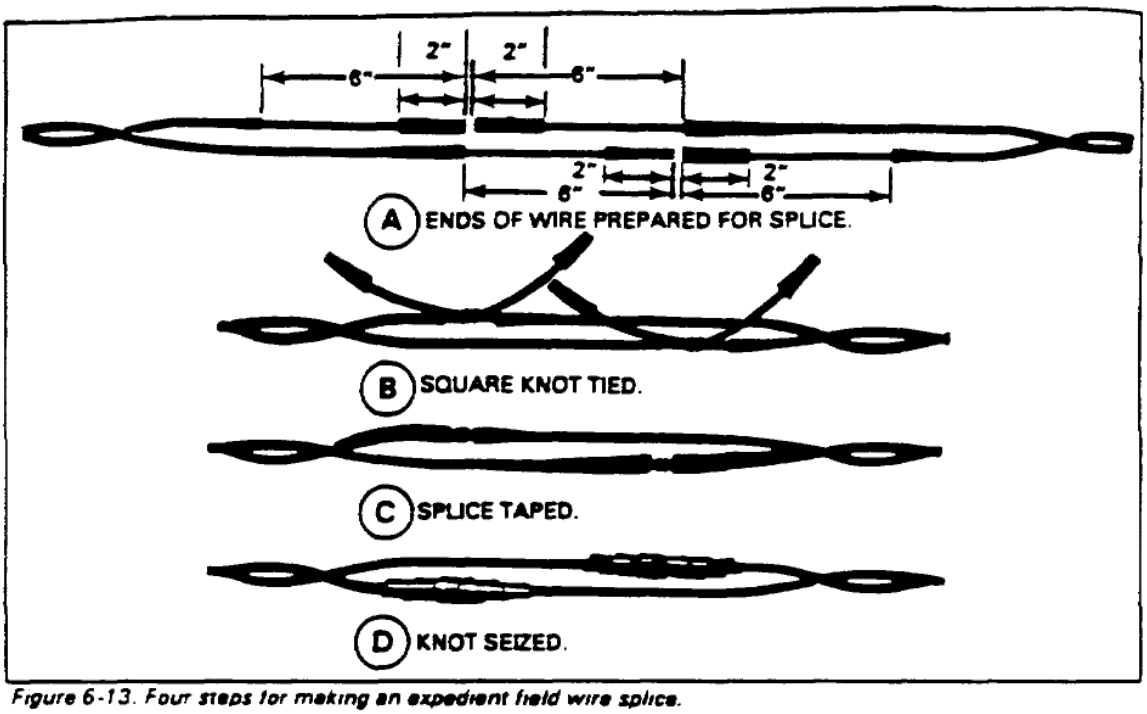


Figure 6-13. Four steps for making an expedient field wire splice.

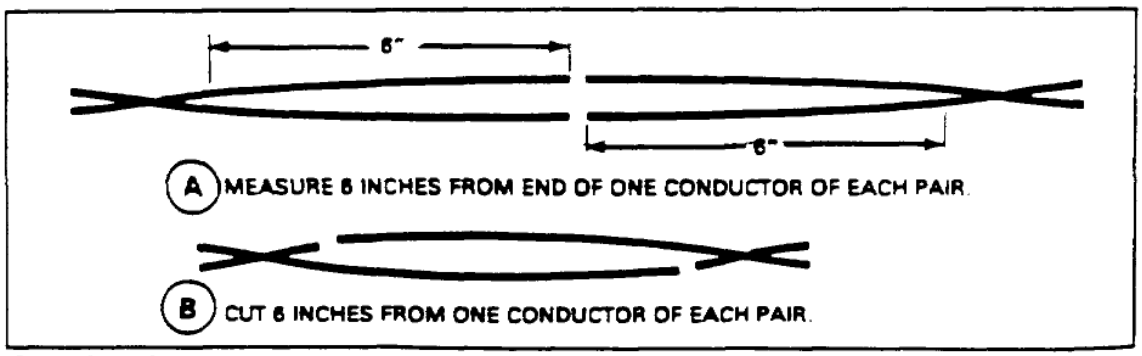


Figure 6-14. Conductors staggered for splicing.

To stagger the conductors of a field wire pair:

□ Snip off the ends of the pair of wires to ensure both conductors are equal length.

□ Cut one conductor of each pair 6 inches (or one plier's length) from the end (figure 6-14). (For WD-1A/TT, separate conductors first.)

To remove the insulation to bare the conductors for splicing (figure 6-15):

□ Use the cutting edge of Pliers TL-13-A to remove 6 inches (2 inches at a time) of both nylon jacket and inner insulation. Pull the third 2-inch section of the insulation only to the end of the conductor. This will keep the wire strands together during the next step of the splice.

□ Carefully clean the strands of the remaining insulation with Knife TL-29.

To tie the square knot, join the end of the long conductor of one pair and the end of the short conductor of the other pair after restoring the normal twist of the conductors. (For WD-1A/TT, twist conductors where they were separated.) Twist conductor 1 over and under conductor 2 to form the first loop (A, figure 6-16). Twist conductor 1 over and under conductor 2 to form the second loop of the square knot (B, figure 6-16). Pull the knot tight, but leave a 1/4-inch space between the knot and the insulation (B, figure 6-16).

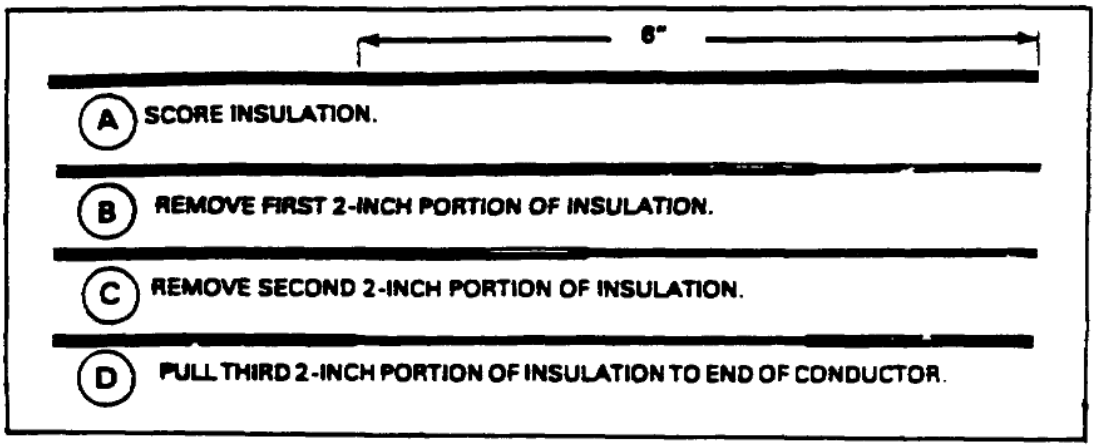


Figure 6-15. Removing insulation from field wire conductors.

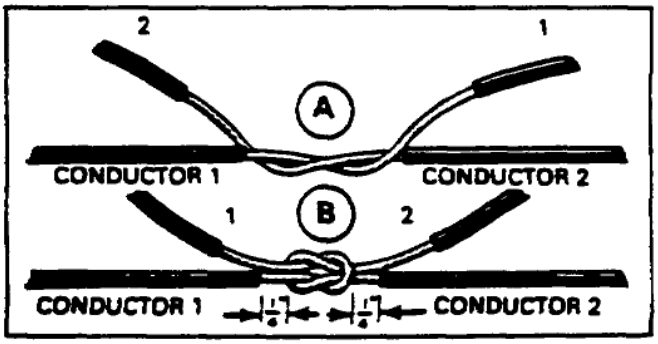


Figure 6-16. Tying square knot in field wire.

To seize the splice:

□ When seizing wire is available, insert a 6- to 8-inch length of seizing wire through the center of the square knot and tighten the knot (A, figure 6-17). Bend the seizing wire at its center. Use half of the wire for wrapping to the right. Take several close turns with the seizing wire, both to the left and to the right, to bind the square knot (B, figure 6-17). Cut the excess ends of the conductor flush with the insulation. Continue the seizing wire wrap, to the left and to the right of the square knot, until two turns are taken on the insulation. Cut the ends of the seizing wire, and press them down into the insulation (C, figure 6-17).

□ When seizing wire is not available, use the copper strands of the conductor to seize the square knot. After the knot has been tied and pulled tight, remove the 2-inch section of the insulation and separate the three steel strands from the copper strands (A, figure 6-18). (Copper strands will remain bent when

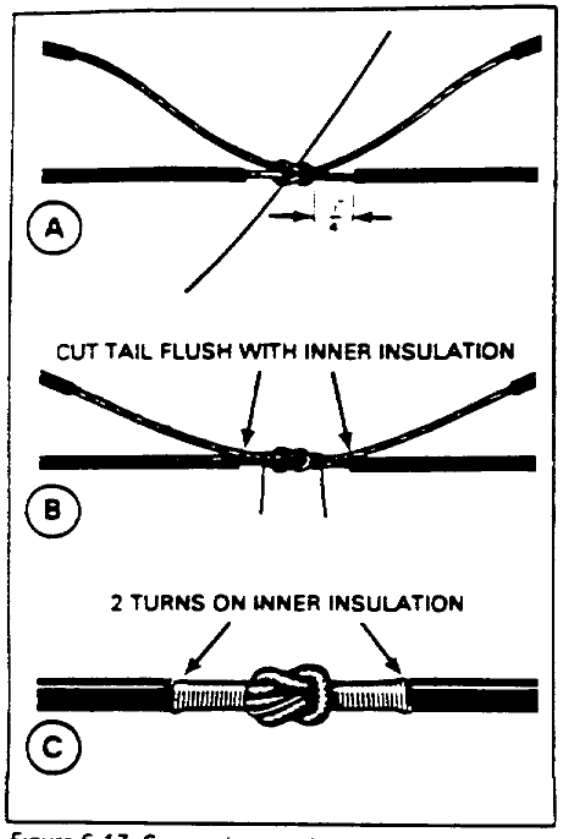


Figure 6-17. Square knot with seizing wire.

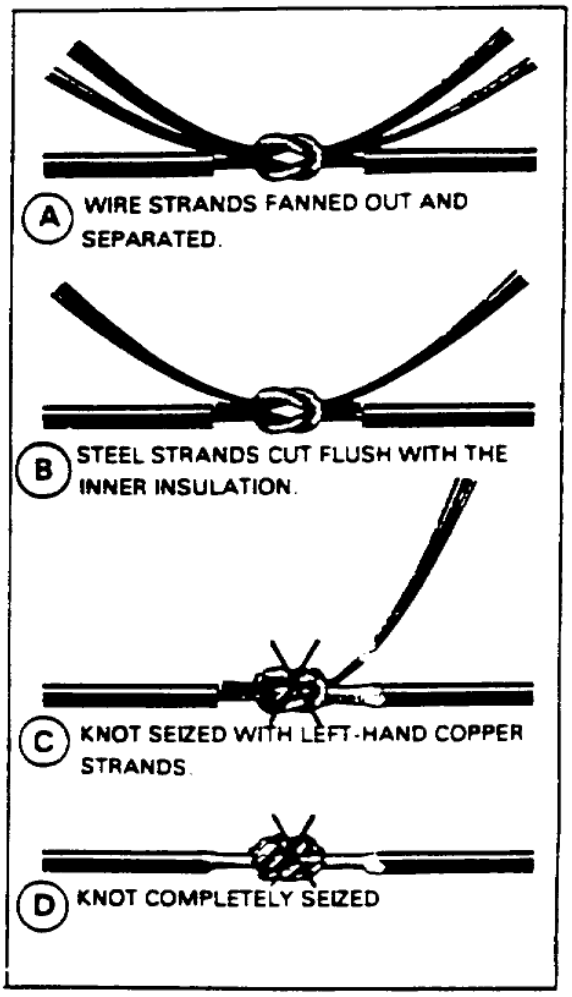


Figure 6-18. Square knot without seizing wire.

flexed.) Cut the steel strands flush with the ends of the insulation (B, figure 6-18). Form "X" over square knot with copper strands. Cross the left-hand end of the copper strands over the right side of the square knot (C, figure 6-18). Wrap several tight turns over the bared portion of the right-hand conductor from edge of knot. Continue wrapping until at least two turns have been made on the insulation. Cut the excess ends of the copper strands. Repeat the seizing operation with the right-hand end of the copper strands; again cross over the crest of the square knot and wrap two turns on the insulation of the left-hand conductor.

To tape the splice with electrical insulation tape, start taping at the center of the splice (A, figure 6-19). Use a steady pull and tape about 1 1/2 inches beyond the insulation at one end. Work the tape back over the knot to about 1 1/2 inches beyond the insulation on the opposite side. Finally, work the tape back again to the center of the splice.

When taping the splice with friction tape, start at either end about 1/2 inch beyond the electrical insulation tape. Continue the taping to a point about 1/2 inch beyond the electrical insulation tape on the opposite end (B, figure 6-19).

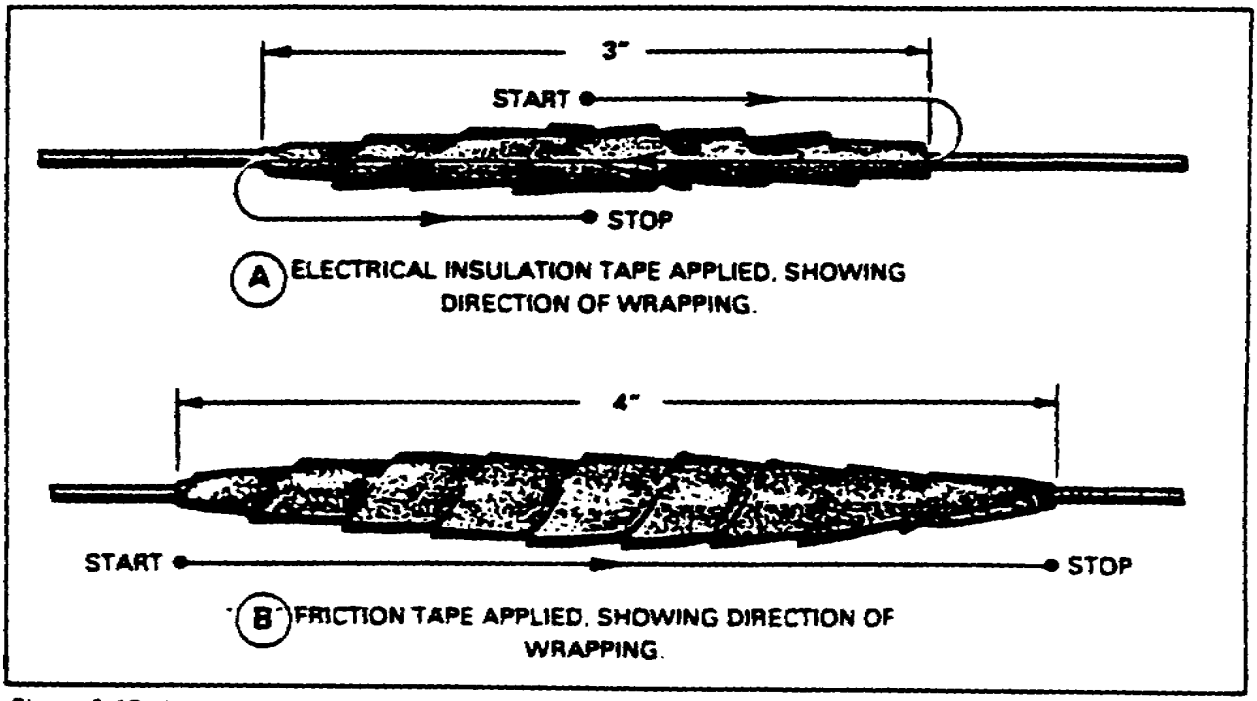


Figure 6-19. Applying electrical insulation tape and friction tape.

Combination Splice

The combination splice (figure 6-20) is used to splice an insulated stranded conductor to an insulated solid conductor. It is made as follows:

□ Remove 6 inches of insulation from the end of each wire and scrape the wire clean.

□ Tie an overhand knot (first half of square knot) in the stranded wire within 1/8 inch of the insulation.

□ Slip the knotted wire over the solid conductor to within 1/2 inch of the solid conductor wire insulation (A, figure 6-20).

□ Wrap the stranded wire around the solid conductor up to the insulation (B, figure 6-20). Cut the excess stranded wire.

□ Bend the end of the solid wire back at the knot, and wrap it around the stranded wire until two turns are made on the insulation (C, figure 6-20).

□ Wrap the solid wire in the opposite direction to the wrapping of the stranded wire. Cut off excess solid wire, and press the cut end down into the insulation.

□ Tape the splice as described previously.

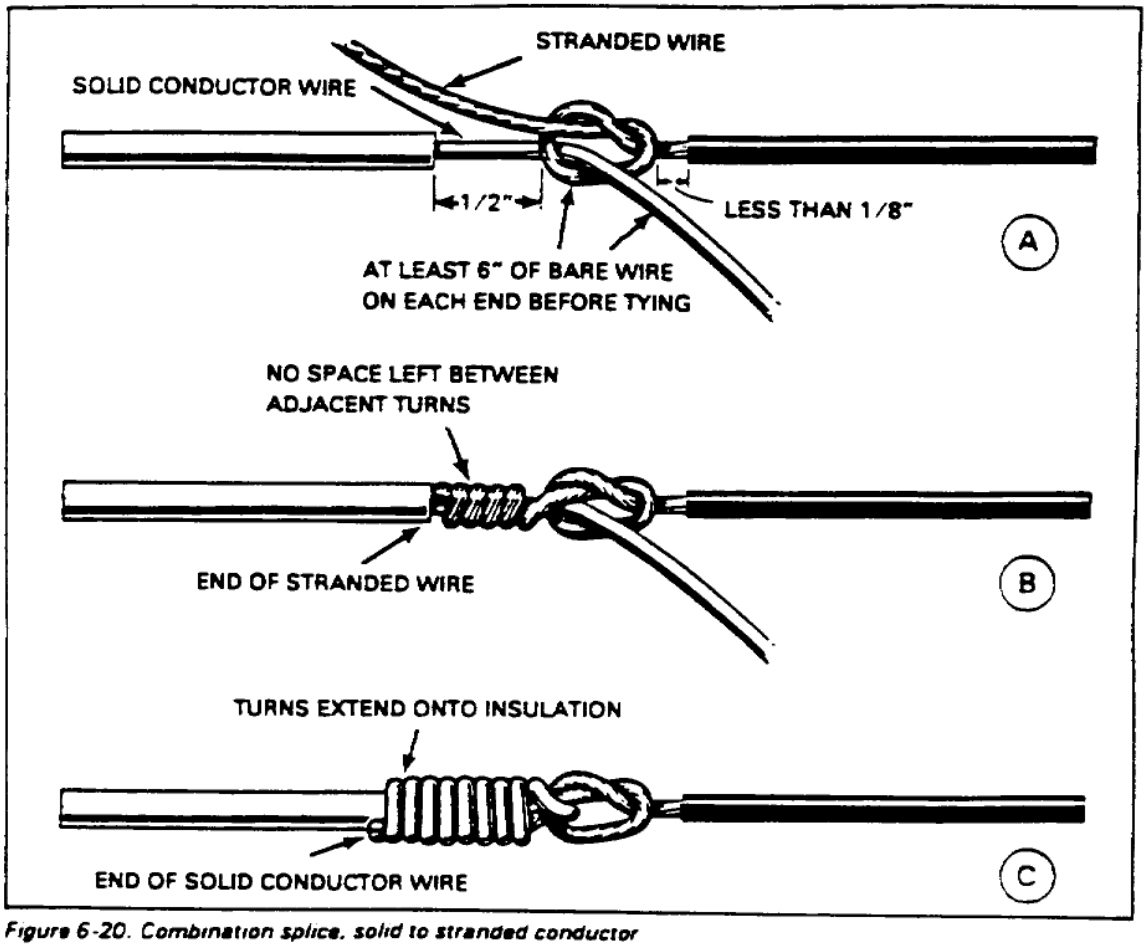


Figure 6-20. Combination splice, solid to stranded conductor

EXTRACTS OF FM 24-20

Chapter 11

Maintaining Field Wire Lines and Cable Lines

General

Maintenance of field wire lines includes both the prevention and the correction of circuit failures. Prevention of troubles on wire lines and equipment begins with careful planning and selection of wire routes, and continues with installation of a system that uses approved methods of construction. Troubles will occur, however, regardless of the care with which the circuits are installed. To efficiently diagnose and correct circuit failures, maintenance personnel should know troubles common to field wire lines and their effect on circuit quality and speech transmission.

Common Trouble of Field Wire Lines

Trouble can occur either in the wire line or in the terminal equipment connected to the line. Wire circuit failures include open circuits, short circuits, grounded circuits, crossed circuits, or combinations of these defects at one or more points in the circuit. These common troubles are shown in figure 11-1 and are defined as follows:

A short circuit, or short, occurs when the two conductors of a pair come in electrical contact. Shorts are usually the result of damaged or stripped insulation.

An open circuit, or open, is a break or cut in one or both conductors of a pair. It occurs most frequently on long-span aerial construction or at other stress points.

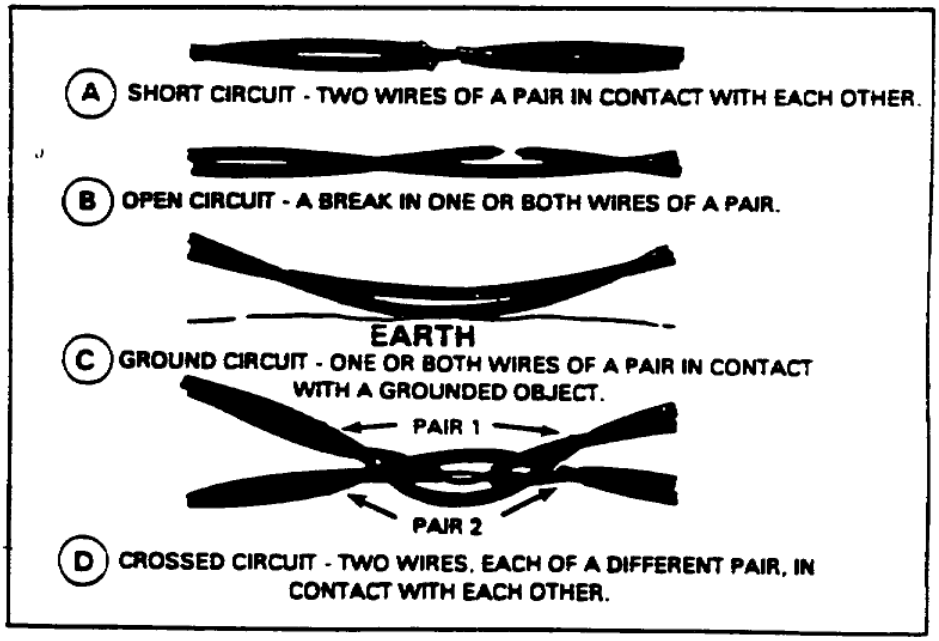


Figure 11-1. Common troubles in field wire lines.

A grounded circuit, or ground, occurs when one or both conductors of a circuit come in electrical contact with the ground or a grounded object. Grounds are the result of damaged insulation or poorly taped splices. They occur most frequently during rainy weather or when the line is installed in wet or damp areas.

A crossed circuit, or cross, exists when two conductors, each of a different circuit, are in electrical contact. It occurs most frequently in field wire cables supported on aerial spans or at points where multipair wire lines converge or are installed along the same route.

Symptoms of Trouble on Field Wire Lines

Field wire troubles can exist in various degrees of severity. For example, opens and shorts can cause intermittent troubles often difficult to locate. In this case, the wireman must utilize test instruments and logical troubleshooting procedures to determine the nature and location of the trouble.

An open disrupts communications completely. An intermittent open, caused by a poorly made splice or loose contact, introduces a high resistance in the circuit. It may be possible to communicate over a highly resistive circuit, but the transmission is usually weak and noisy.

A complete (low resistance) short will disrupt communications completely. A partial (high resistance) short usually causes weak transmission and signaling.

A ground on both sides of a circuit will produce the same effect as a short. Usually, a ground occurring on one side of a circuit will not interrupt communications; however, it will introduce hum or noise in the circuit.

A cross usually causes cross talk or interference between the two crossed circuits. This cross talk or interference could make the separate conversations unintelligible.

Methods of Testing Field Wire Lines

Tests should be made on field wire lines before installation to determine condition and serviceability. While constructing a line, test at the end of each reel length and before connecting the line to the terminal equipment. Testing during construction will disclose troubles that have developed during the wire-laying operation.

Proper maintenance requires routine tests at regular intervals on all working circuits and equipment. The frequency of these tests will vary according to the nature and importance of the circuits, the equipment, the type of installation, the amount of traffic handled, and the amount of trouble experienced. Communications are never interrupted to make a routine test. Routine tests should be made by maintenance personnel during slack traffic periods. These tests must include all operating functions normally required of the circuit and equipment.

Tests are conducted when trouble is reported or detected on a circuit. The wireman must quickly analyze the fault, determine its location, and clear the trouble with the least possible interruption of service. High-priority circuits are rerouted, or spare lines, are put into service at patch panels or test points.

Tests are usually made from the construction center, test station, or switching center utilizing field wire test equipment. If no test equipment is available, a field telephone can be used to determine several types of trouble in field wire circuit and equipment, utilizing the following methods:

- To test for an open, connect the ends of the circuit to be tested to the line terminals of the test telephone, and turn the generator crank of the telephone rapidly. If the crank turns freely without drag, the circuit is open.
- To test for a short, follow the same procedures as for open and if the crank turns hard with a heavy drag and a jerky movement, a short exists on the circuit.

□ To test for a ground, connect both conductors of the circuit to the test telephone. Weak communications, noise, and weak reception usually indicate a ground on the circuit.

□ To test for a cross, cross talk and cross signaling indicate a cross on the circuit.

Locating and Clearing Trouble

After it is verified there is trouble on the line, it is necessary to test and localize the fault to the particular section of a circuit. Further tests are made within the section until the trouble is located. Before testing a line, always check the circuit to determine if it is in use. Never open a circuit that is in operation.

If tests indicate trouble is in the wire line, the wireman should determine nature and approximate location of the fault. Often, information such as the type of terrain, unusual troop activities, or shellfire in an area, will aid the repairman in locating the trouble.

Normally, a wire team physically inspects a line route with the required maintenance equipment. The wire line should be carefully examined with particular attention to:

- Condition of insulation and splices.
- Underground and aerial crossings.
- Ties on swaying trees
- Places where the wire has been run over or pulled out of place by vehicular traffic.

Damaged insulation, poorly made splices, and other possible trouble spots are repaired and tested along the route. If no obvious troubles are found, tests are made at frequent intervals along the line to the terminal testing point.

When possible, always open a circuit at a splice or at a test point nearest a terminal end. Tape all points where the insulation of the line was pierced or removed during a test. If each test proves that the line is serviceable toward the terminal testing point, the trouble exists farther out along the line. If the repairman cannot communicate with terminal test point, he has passed the trouble and, therefore, should work back along the line, dividing in half the distance between successive tests. Since a defective circuit could have trouble at more than one point, it is essential that the repairman make a complete circuit test after removing each trouble.

□ When checking for an open circuit, the test equipment can be connected across the circuit without cutting the wire line.

□ When checking for a ground or short, it will be necessary to cut the line.

Testing at too frequent intervals at the start of the troubleshooting procedure can delay detection of the line trouble. Considerable time is spent in splicing the circuit after tests are made for shorts and grounds. A visual inspection of the wire lines often will disclose the trouble sooner. However, if any long section of the line cannot be inspected visually, tests should be made at each end of that particular section.

If it is determined trouble is in the terminal equipment, tests are given according to procedures listed in the technical manuals on the specific equipment. Equipment repairs will be performed only by qualified personnel at the proper repair echelon.

In certain critical areas, the routine maintenance testing of a wire line is commonly supplemented by patrols that inspect sections of line most subject to damage. When possible, the wiremen who constructed a given section of a line should be assigned the mission of patrolling that section. Wire patrols repair trouble where needed, replace poor splices or sections of the line, tape any insulation abrasions, and generally improve the line construction.

Use of Test Stations in Testing Field Wire Lines

Test stations are installed on a wire line to simplify the testing and rearranging of circuits. A test station is usually given a geographic designation. The equipment used at these points is Terminal Strip TM-184 or Terminal Box TA-125/GT (figure 11-2). Test stations are usually located:

- At points where circuits diverge.
- At the end of a wire line that does not terminate in a switchboard.
- Near points where circuits are most exposed to damage.
- At probable future locations of command posts.
- At other convenient points along the line.

The site selected for a test station should afford concealment and cover from hostile observation and fire. Also, it should be readily accessible for testing purposes. A test station consists of one or more terminal strips fastened to a tree, fence post, or other support. The wire circuits at a test station are tagged and tied before being connected to the binding posts of the terminal strip. The circuits are connected in numerical order, beginning at the top with the lowest numbered circuit. A test station can be installed after initial installation of the wire lines, but this should be done without any interruption to communications service.

When a test station is to be abandoned, the usual practice is to leave the terminal strip connected. If the test station is removed, the

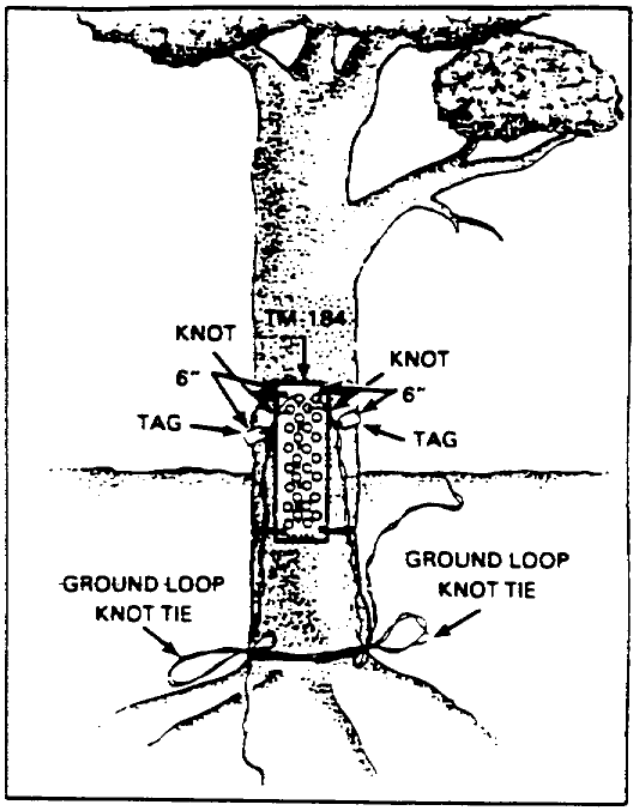


Figure 11-2. Terminal Strip TM-184 test station.

circuits must be spliced. The removal of test stations should be done without interrupting communications.

Command posts are often established at a former test station location. When converting a test station into a telephone central, it is important that wire lines be placed aerially or buried, and that the switchboard be set up as near the test station as possible to simplify the cutover. The terminal strips which were used at the test station can be utilized as a main distributing frame for the switchboard or serve as part of a signal center for a switching central. When the transfer is completed, the operator should check the circuits and notify the units concerned that the conversion has been completed. Wire tags should be staggered to prevent one tag from covering another.

Cross-patching circuits at test stations or switching centrals frequently allow communications to be maintained during the troubleshooting period. For example, assume that two telephone centrals are connected by two circuits passed through a common test station; one circuit has trouble on the near side of the test station, and the other circuit has trouble on the far side. To reestablish one serviceable circuit, take the good section at each side of the test station and connect (cross-patch) the sections together. Restore the original connections after the repairs have been made.

Records Used for Troubleshooting

It is essential that installation and maintenance records be maintained. These records, which include line route maps, circuit diagrams, and traffic diagrams, must show all changes in a wire line throughout its operation. Also, trouble reports, test records, and work schedule rosters are maintained when necessary.

Cable Line Maintenance

Cable maintenance begins immediately after cable lines are installed. Maintenance teams inspect and police cable lines daily.

(4) Wrap the carrying strap around the support, and secure the free end to the upper ring on the carrying case.

(5) Wrap a length of field wire around the support and through the lower loop of the carrying case, and tie it securely in place.

c. Setting Selector Switch. Use a screwdriver to set the selector switch to the proper position for the service being used.

d. Connecting the Line.

(1) Strip approximately 1 inch of insulation from the ends of the two wires in the line to be connected. Scrape the stripped ends clear.

(2) Fold back the stripped wires about one-half inch from the end.

(3) Push down one of the LINE 1–2 binding posts. Insert the bare end of one wire into the binding post slot, and release the post. Check to see that the wire is securely clamped. Repeat the procedure with the other wire, in the other post.

e. Connecting External Batteries.

(1) Remove the BA–30's from the battery compartment.

(2) Connect a 3-volt battery source to the BAT binding posts on the panel.

CB and CBS Operation Using H–144(*)/U.

(1) Make sure that the H–60/PT is seated firmly in the retaining cradle.
(2) Operate the INT-EXT switch to EXT, and wait for the operator to answer.
(3) For CBS operation, press the press-to-talk switch to talk and release it to listen.
(4) For CB operation, the press-to-talk switch is not used.
(5) When the call is terminated, operate the INT-EXT switch to INT.

c. LB Operation Using H–60/PT.

(1) Operate the INT-EXT switch to INT.
(2) Make sure that the H–60/PT is seated firmly in the retaining cradle.
(3) Turn the handcrank rapidly a few turns.
(4) Remove the H–60/PT from the retaining cradle, and wait for the operator or called party to answer.
(5) Operate the press-to-talk switch to talk, and release it to listen.
(6) When the call is terminated, replace the H–60/PT in the retaining cradle and turn the handcrank rapidly a few turns. This will signal the switchboard that the call has been completed.

d. LB Operation Using H–144(*)/U.

(1) Make sure that the H–60/PT is firmly seated in the retaining cradle.

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PRACTICE EXERCISE

PERFORMANCE (HANDS-ON/WITH THE EQUIPMENT)
(ONLY IF YOU HAVE THE EQUIPMENT)

SUBCOURSE NO./TITLE: SS0437-7, Testing Wire Lines and Locating Faults (31L)

TASK: Test wire line and locating faults.

CONDITIONS: Given approximately 150 feet of installed field wire line with faults, telephone set TA-312/PT, BA-30 batteries, tool equipment TE-33, FM 24-20 and TM 11-5805-201-12 extracts, gloves, a predetermined site, using simulated tactical scenario narrations and discussions, and with a qualified supervisory OJT monitor's assistance.

STANDARDS: Correctly test wire line to identify trouble without error, within one out of two attempts, and within 30 minutes, under a simulated tactical scenario environmental condition.

(This objective supports SM Task Number and title 113-588-0005, Troubleshoot Field Wire WD-1()/TT.)

Lesson 1: Test Wire Line to Identify Trouble

	1st Attempt			2d Attempt		
	GO	NO-GO	SQJT MONITOR'S INITIALS	GO	NO-GO	SQJT MONITOR'S INITIALS
1. Connect wire to test telephone.						
a. Remove lines from terminating equipment.						
b. Insert lines into binding post of test telephone.						
2. Test wire to verify circuit trouble.						
a. Check condition of both conductors.						
b. Check for open, short, ground, and cross.						

Lesson 2: Locate Field Wire Trouble

	1st Attempt			2d Attempt		
	GO	NO-GO	SOJT MONITOR'S INITIALS	GO	NO-GO	SOJT MONITOR'S INITIALS
1. Localize trouble.						
a. Check the condition of the line.						
b. Determine the nature of the fault.						
c. Locate the fault.						
2. Splice wire line.						
a. Remove insulation.						
b. Connect conductors.						
c. Complete the splice.						
d. Tape splice.						
e. Test wire line for faults.						
3. Visually inspect wire line.						
a. Check wire line for damage.						
b. Test all splices in the line.						
c. Continue above procedure until fault is cleared.						