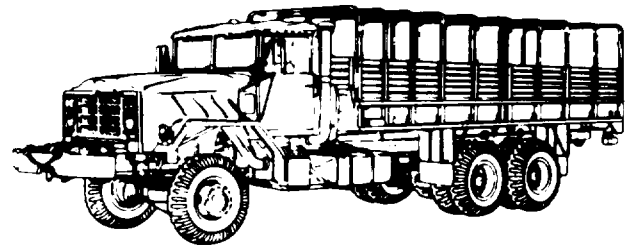


TM 9-2320-356-BD

TECHNICAL MANUAL

OPERATORS ORGANIZATIONAL  
DIRECT SUPPORT AND  
GENERAL SUPPORT MAINTENANCE



# BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR

FOR  
TACTICAL  
WHEELED  
VEHICLES

CHAPTER 1 INTRODUCTION

CHAPTER 2 ASSESSING BATTLEFIELD DAMAGE

CHAPTER 3 GENERAL AUTOMOTIVE COMPONENTS

CHAPTER 4 SELF-RECOVERY

CHAPTER 5 ENGINE

CHAPTER 6 FUEL SUPPLY SYSTEMS

CHAPTER 7 COOLING SYSTEM

CHAPTER 8 ELECTRICAL SYSTEM

CHAPTER 9 TRANSMISSION SYSTEMS

CHAPTER 10 AXLES AND DRIVE LINES

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TM 9-2320-356-BD

C1

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HEADQUARTERS  
DEPARTMENT OF THE ARMY  
Washington D. C., 14 December, 1989

**TECHNICAL MANUAL**  
**OPERATORS, ORGANIZATIONAL**  
**DIRECT SUPPORT AND**  
**GENERAL SUPPORT MAINTENANCE**  
  
**BATTLEFIELD DAMAGE**  
**ASSESSMENT AND REPAIR**  
  
**FOR**  
**TACTICAL WHEELEDVEHICLES**

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**WARNING**

This technical manual contains nonstandard maintenance procedures. All normal safety procedures should be observed when the tactical situation permits. Extra care shall be taken when maintenance is required in a hostile environment.

**WARNING**

Before assessing and handling communications equipment, turn off the power to all components of the communications system. Damaged equipment can cause severe shock to personnel and additional damage to equipment.

Technical Manual

9-2320-356-BD

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
Washington, D.C. 18 December 1987OPERATOR'S, ORGANIZATIONAL  
DIRECT SUPPORT AND GENERAL SUPPORT  
MAINTENANCEGENERAL BATTLEFIELD DAMAGE  
ASSESSMENT AND REPAIR  
FOR  
TACTICAL WHEELED VEHICLES

## REPORTING OF ERRORS

You can help improve this manual by calling attention to errors and by recommending improvements. Your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), and/or DA Form 2028-2 (Recommended Changes to Equipment Technical Manuals) may be used. Copies of DA Form 2028-2 are attached in the back of the manual for your use. Please mail your recommended changes directly to: Commander, US Army Tank-Automotive Command, ATTN: AMSTA-MB-BDAR, Warren, MI 48397-5000. A reply will be furnished directly to you.

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This manual provides procedures that may be applied to the following list of vehicles. Even though your vehicle may not be listed, some of the procedures in this manual may apply or provide ideas of what you can do to your vehicle.

COMMERCIAL UTILITY CARGO VEHICLE (CUCV)

Truck, Cargo  
2320-01-123-6827  
Truck, Cargo  
2320-01-123-2671  
Truck, Utility  
2320-01-123-2665  
Truck, Ambulance  
2310-01-123-2666  
Truck, Shelter Carrier  
2320-01-127-5077  
Truck, Chassis  
2320-01-133-5368  
Truck, Shelter Carrier  
2320-01-158-0820

GOER VEHICLE

M520 Truck, Cargo  
2320-00-873-5422  
M520 Truck, Cargo  
2320-00-191-1310  
M553 Truck, Wrecker  
2320-00-873-5426  
M559 Truck, Tanker, Fuel  
Servicing, 2500 gal.  
2320-00-873-5420  
M559 Truck, Tanker, Fuel  
Servicing, 2500 gal.  
2320-00-445-7250  
M877 Truck, Cargo, w/material  
handling crane  
2320-01-010-4956  
M877 Truck, Cargo, w/material  
handling crane  
2320-01-010-4957

HEAVY EXPANDED MOBILITY TACTICAL TRUCK (HEMTT)

M977 Truck, Cargo  
2320-01-099-6426  
M977 Truck, Cargo  
2320-01-097-0260  
M978 Truck, Tanker  
2320-01-097-0249  
M978 Truck, Tank  
2320-01-100-7672

HEAVY EXPANDED MOBILITY TACTICAL TRUCK (HEMTT) (cent)

M983 Truck, Tractor  
2320-01-097-0247  
M983 Truck, Tractor  
2320-01-099-6421  
M983E1 Truck, Tractor  
N/A  
M984 Truck, Wrecker  
2320-01-097-0248  
M984E1 Truck, Wrecker  
N/A  
M985 Truck, Cargo  
2320-01-100-7673  
M985 Truck, Cargo  
2320-01-097-0261  
M985E1 Truck, Cargo  
N/A

HET 70 HEAVY EQUIPMENT TRANSPORTER MODEL

M746 (NSN 2320-00-089-7264)

HIGH MOBILITY MULTI-PURPOSE WHEELED VEHICLE (HMMWV)

Truck, Utility, Cargo  
2320-01-107-7155  
Truck, Utility, Cargo  
2320-01-107-7156  
Truck, Utility, Tow Carrier  
2320-01-107-7153  
Truck, Utility, Tow Carrier  
2320-01-146-7191  
Truck, Utility, Tow Carrier  
2320-01-146-7188  
Truck, Utility, Armament Carrier  
2320-01-128-9551  
Truck, Utility, Armament Carrier  
2320-01-128-9552  
Truck, Utility, Armament Carrier  
2320-01-146-7190  
Truck, Utility, Armament Carrier  
2320-01-146-7189  
Truck, Utility, Shelter Carrier  
2320-01-146-7193



# HIGH MOBILITY MULTI-PURPOSE WHEELED VEHICLE HMMWV) (cent)

Truck, Utility, Shelter Carrier  
2320-01-146-7187  
Truck, Ambulance  
2310-01-111-2275  
Truck, Ambulance  
2310-01-111-2274  
Truck, Ambulance  
2310-01-146-7194

## M.A.N. VEHICLE SYSTEM

Truck, Tractor  
2320-12-191-5422  
Truck, Wrecker  
2320-12-191-5423  
Truck, Tractor  
2320-12-191-5424  
Truck, Tractor  
2320-12-191-5425

## M35 SERIES 2-1/2-TON VEHICLES

M35A2 Truck, Cargo  
2320-00-077-1616  
M35A2 Truck, Cargo  
2320-00-077-1617  
M35A2C Truck, Cargo  
2320-00-926-0873  
M35A2C Truck, Cargo  
2320-00-926-0875  
M35E8 Truck, Cargo  
2320-00-542-5635  
M36A2 Truck, Cargo, Dropside  
2320-00-077-1618  
M36A2 Truck, Cargo  
2320-00-077-1619  
M44A1 Truck Chassis  
2320-00-973-4145  
M44A2 Truck Chassis  
2320-00-077-1620  
M44A2 Truck Chassis  
2320-00-077-1621  
M44A2 Chassis, Truck  
2320-00-973-2229  
M45A2 Chassis, Truck  
2320-00-077-1622  
M45A2 Truck Chassis  
2320-00-077-1623  
M46A2 Chassis, Truck  
2320-00-077-1628

# M35 SERIES 2-1/2-TON VEHICLES (cent)

M46A2C Chassis, Truck  
2320-00-077-1629  
M46A2C Truck Chassis  
2320-00-077-1630  
M49A1C Truck Tank  
2320-00-077-1632  
M49A1C Truck, Tanker, Fuel, 1200  
Gal.  
2320-00-440-3349  
M49A2C Truck, Tanker, Fuel, 1200  
Gal.  
2320-00-077-1631  
M50A2 Truck, Tanker, Water, 1000  
Gal.  
2320-00-077-1633  
M50A2 Truck Tank  
2320-00-077-1634  
M50A3 Truck, Tanker, Water, 1000  
Gal.  
2320-00-937-4036  
M50A3 Truck Tank  
2320-00-937-5264  
M109A1 Truck, Van  
2320-00-706-2224  
M109A1 Truck, Van, Shop  
2320-00-690-8365  
M109A2 Truck, Van, Shop  
2320-00-440-8313  
M109A2 Truck, Van  
2320-00-440-8308  
M109A3 Truck, Van  
2320-00-077-1636  
M109A3 Truck, Van  
2320-00-077-1637  
M185A1 Truck, Shop, Instrument  
Repair  
4940-00-973-3995  
M185A2 Truck, Shop, Instrument  
Repair  
4840-00-987-8799  
M185A2 Inst Rep Shop Truck  
4940-00-987-8800  
M185A3 Truck, Shop, Instrument  
Repair  
4940-00-077-1638  
M185A3 Inst Rep Shop Truck  
4940-00-077-1639  
M275A2 Truck, Tractor  
2320-00-077-1640  
M275A2 Truck Tractor  
2320-00-077-1641

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M35 SERIES 2-1/2-TON VEHICLES (cont)

M292A2 Truck, Van, Expansible  
 2320-00-077-1642  
 M292A3 Truck, Van, Expansible  
 2320-00-699-3546  
 M292A5 Truck, Van, Expansible  
 2320-00-699-3746  
 M342A2 Truck, Dump  
 2320-00-077-1643  
 M602 Truck, Cargo  
 2320-00-446-7514  
 M607 Truck, Tractor  
 2320-00-695-9457  
 M609A1 Truck, Van  
 2320-00-688-9899  
 M610 Truck, Tanker, Water, 1000  
 Gal.  
 2320-00-973-4211  
 M611 Truck, Tanker, Gasoline,  
 1200 Gal.  
 2320-00-973-4213  
 M611C Truck, Tanker, Gasoline,  
 1200 Gal.  
 2320-00-696-0488  
 M613 Truck, Shop, Instrument  
 Repair  
 4940-00-691-5083  
 M614 Truck, Dump  
 2320-00-688-9897  
 M621 Truck, Cargo  
 2320-00-920-7593  
 M622 Truck, Tanker, Fuel, 1200  
 Gal.  
 2320-00-920-7598  
 M623 Truck, Van  
 2320-00-920-7596  
 M624 Truck, Dump  
 2320-00-920-7595  
 M751A2 Truck, Bolster  
 2320-00-937-0840  
 M756A2 Truck, Pipeline Construction  
 2320-00-904-3277  
 M763 Truck, Maintenance, Telephone  
 2320-00-937-5979  
 V17A/MTG Truck, Maintenance  
 2320-00-498-8377  
 V18A/MTG Truck, Maintenance  
 2320-00-498-8378

M39 SERIES 5-TON VEHICLES

M51A1 Truck, Dump  
 2320-00-045-7131  
 M51A1 Truck, Dump  
 2320-00-045-7132  
 M51A2 Truck, Dump  
 2320-00-055-9263  
 M51A2 Truck, Dump  
 2320-00-055-9262  
 M51A2 Truck, Dump  
 2320-00-055-9263  
 M52A1 Truck, Tractor  
 2320-00-086-7479  
 M52A1 Truck, Tractor  
 2320-00-086-7480  
 M52A2 Truck, Tractor  
 2320-00-055-9260  
 M52A2 Truck, Tractor  
 2320-00-073-8476  
 M52A2 Truck, Tractor  
 2320-00-055-9261  
 M54A2 Truck, Cargo  
 2320-00-055-9265  
 M54A2 Truck, Cargo  
 2320-00-055-9266  
 M54A2C Truck, Cargo  
 2320-00-926-0874  
 M54A2C Truck, Cargo  
 2320-00-761-2854  
 M55A2 Truck, Cargo  
 2320-00-055-9259  
 M61A2 Chassis, Truck  
 2320-00-965-0321  
 M61A2 Chassis, Truck  
 2320-00-055-9264  
 M63A2 Chassis, Truck  
 2320-00-285-3757  
 M63A2 Chassis, Truck  
 2320-00-226-6251  
 M63A2C Chassis, Truck  
 2320-00-969-4113  
 M246A2 Truck, Tractor  
 2320-00-073-8251  
 M291A1 Truck, Van  
 2320-00-880-4642  
 M291A1C Truck, Van  
 2320-00-880-4646

M39 SERIES 5-TON VEHICLES (cent)

M291A1D Truck, Van  
2320-00-880-4647  
M291A2 Truck, Van  
2320-00-907-0706  
M291A2C Truck, Van  
2320-00-907-0707  
M291A2D Truck, Van  
2320-00-907-0708  
M328A2 Truck, Stake  
2320-00-087-2317  
M543A2 Truck, Wrecker  
2320-00-055-9258  
M748A1 Truck, Bolster  
2320-00-880-4615  
M748A2 Truck  
2320-00-930-0023

M123 SERIES VEHICLES

M123A1C Truck, Tractor, 10-Ton, 6x6  
2320-00-226-6081

M151 SERIES

Truck, Utility, 1/4 Ton, 4 x 4  
M151A1  
2320-00-763-1092  
M151A1C  
2320-00-763-1091  
Truck, Ambulance, Frontline  
M151A2  
2320-00-177-9258  
M718A1  
2310-00-177-9256

M561 SERIES

M561 Truck, Cargo  
2320-00-873-5407  
M792 Ambulance  
2310-00-832-9907

M656 SERIES

M656 Truck, Cargo  
2320-00-903-0883  
M656 Truck, Cargo  
2320-00-999-8418  
M757 Truck, Tractor  
2320-00-937-1445  
M757 Truck, Tractor  
2320-00-937-1846

M656 SERIES (cent)

M791 Truck, Van, Expansible  
2320-00-832-5620  
M791 Truck, Van, Expansible  
2320-00-832-5610

M876 TELEPHONE MAINTENANCE TRUCK

2320-01-000-0114

M880 SERIES

M880 Truck, Cargo  
2320-00-579-8942  
M881 Truck, Cargo  
2320-00-579-8943  
M882 Truck, Cargo  
2320-00-579-8957  
M883 Truck, Cargo  
2320-00-579-8959  
M884 Truck, Cargo  
2320-00-579-8985  
M885 Truck, Cargo  
2320-00-579-8989  
M886 Ambulance  
2310-00-579-9078  
M887 Chassis  
2320-00-579-9080  
M888 Truck, Telephone Maint  
2350-01-044-0333  
M890 Truck, Cargo  
2320-00-579-8991  
M891 Truck, Cargo  
2320-00-579-9046  
M892 Truck, Cargo  
2320-00-579-9052  
M893 Ambulance  
2310-00-125-5679

M911 TRUCK, TRACTOR, HEAVY EQUIPMENT  
TRANSPORTER, COMMERCIAL (C-HET) 8X6,  
NSN 2320-01-0263-3733

M915 SERIES VEHICLES

M915 Line Haul Tractor  
2320-01-028-4395  
M916 Light Equipment Transporter  
2320-01-028-4396  
M917 20-Ton Dump Truck  
3805-01-028-4389  
M918 Bituminous Distributor  
3895-01-028-4390

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M915 SERIES VEHICLES (cont)

M919 Concrete Mobile  
3895-01-028-4391  
M920 Medium Equipment Transporter  
2320-01-028-4397

M915A1 VEHICLE

M915A1 Line Haul Tractor  
2320-01-125-2640

M939 SERIES

M923 Truck, Cargo  
2320-01-050-2084  
M925 Truck, Cargo  
2320-01-047-8769  
M927 Truck, Cargo, XLWB  
2320-01-047-8771  
M928 Truck, Cargo, XLWB  
2320-01-047-8770  
M929 Truck, Dump  
2320-01-047-8756  
M930 Truck, Dump  
2320-01-047-8755  
M931 Truck, Tractor  
2320-01-047-8753  
M932 Truck, Tractor  
2320-01-047-8752  
M933 Truck, Tractor  
2320-01-047-8768  
M934 Van, Expansible  
2320-01-047-8750  
M935 Van, Expansible, WHLG  
2320-01-047-8751  
M936 Truck, Wrecker  
2320-01-047-8754  
M939 Truck, 5-Ton, PIP  
2320-01-048-2450  
M940 Truck, Chassis  
2320-01-047-8743  
M941 Truck, Chassis  
2320-01-048-8742  
M945 Truck, Chassis  
2320-01-050-4894

809 SERIES VEHICLES

M809 Chassis  
2320-00-050-8841  
M809 Chassis  
2320-00-050-8842

809 SERIES VEHICLES (cont)

M809A1 Chassis  
2320-00-050-8941  
M810 Chassis  
2320-00-051-0585  
M810 Chassis  
2320-00-051-0586  
M811 Chassis  
2320-00-050-8985  
M811 Chassis  
2320-00-050-8986  
M811A1 Chassis  
2320-00-050-8989  
M811A2 Chassis  
2320-00-050-9005  
M812 Chassis  
2320-00-050-9011  
M812A1 Chassis  
2320-00-050-9040  
M813 Truck, Cargo  
2320-00-050-8890  
M813 Truck, Cargo  
2320-00-050-8902  
M813A1 Truck, Cargo  
2320-00-050-8905  
M813A1 Truck, Cargo, Dropside  
2320-00-050-8913  
M814 Truck, Cargo  
2320-00-050-8988  
M815 Truck, Bolster  
2320-00-050-8927  
M816 Truck, Wrk  
2320-00-051-0489  
M817 Truck, Dump  
2320-00-051-0589  
M817 Truck, Dump  
2320-00-050-8970  
M818 Truck, Tractor  
2320-00-050-8978  
M818 Truck, Tractor  
2320-00-050-8984  
M819 Truck, Tractor, Wrecker  
2320-00-050-9004  
M820 Truck, Van, Exp  
2320-00-050-9006  
M820A1 Truck, Van, Exp  
2320-00-050-9007  
M820A2 Truck, Van, Exp  
2320-00-050-9010  
M821 Truck, Stk Brg, Trans  
2320-00-050-9015

## CHAPTER 1

## INTRODUCTION

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. INTRODUCTION

## 1-1. PURPOSE

a. This technical manual (TM) is for use by operators and by organizational and direct support/general support maintenance personnel. It provides procedures and guidelines for battlefield repairs on tactical vehicles under the forward support maintenance concept during combat.

b. The purpose of battlefield damage assessment and repair (BDAR) is to rapidly return disabled tactical wheeled vehicles to the operational commander by expediently fixing, bypassing, or jury-rigging components to restore the minimum essential systems required for the support of the specific combat mission or to enable the vehicle to self-recover. These repairs may be temporary and may not restore full performance capability.

## 1-2. SCOPE

a. This TM describes BDAR procedures of a general nature applicable to all tactical wheeled vehicles. Expedient repairs applicable to systems or subsystems of a specific tactical vehicle are covered in system specific TM's.

b. Many expedient repair techniques helpful in preparing a vehicle for recovery are included in FM 20-22, Vehicle Recovery Operations. Details of such procedures are not duplicated in this TM, although certain quick-fix battlefield operations which would, in some cases, prepare the vehicle for recovery or self-recovery will be described. Users of this manual should refer to FM 20-22 for further recovery-associated expedient repairs.

c. Not all possible types of combat damage and failure modes can be predicted, nor are all effective field expedient repairs known. This TM provides guidelines for assessing and repairing battlefield failures of tactical vehicles and is not intended to be a complete catalog of all possible emergency repairs. The repairs described here will serve as guidelines and will stimulate the experienced operator or mechanic to devise expedients as needed to repair equipment rapidly in a combat crisis.

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### 1-3. APPLICATION

a. The procedures in this manual are designed for battlefield environments and should be used in situations where standard maintenance procedures are impractical. These procedures are not meant to replace standard maintenance practices, but rather to supplement them strictly in battlefield environment. Standard maintenance procedures will provide the most effective means of returning a damaged vehicle to ready status, provided that adequate time, replacement parts, and necessary tools are available. BDAR procedures are authorized for use only in an emergency situation in a battlefield environment and only at the direction of the commander.

b. BDAR techniques are not limited to simple restoration of minimum functional combat capability. Restore full functional capability if it can be done expediently and with a limited expenditure of time and assets.

c. Some of the special techniques in this manual, if applied, may result in shortened life or damage to components of tactical vehicles. The commander must decide whether the risk of having one less vehicle available for combat outweighs the risk of applying the potentially destructive expedient repair technique. Each technique gives appropriate warnings and cautions and lists systems limitations caused by this action.

### 1-4. DEFINITIONS

a. Battlefield Damage includes all incidents which occur on the battlefield and which prevent the vehicle from accomplishing its mission such as combat damage, random failures, operator errors, accidents, and wear-out failures.

b. Repair or Fix in this manual includes any expedient action that returns a damaged part or assembly to a full or an acceptably degraded operating condition including:

(1) Shortcuts in parts removal or installation.

(2) Installation of components from other vehicles that can be modified to fit or interchanged with components on the vehicle.

(3) Repair using parts that serve a noncritical function elsewhere on the same vehicle for the purpose of restoring a critical function.

(4) Bypassing of noncritical components in order to restore basic functional capability.

(5) Expeditious cannibalization procedures.

(6) Fabrication of parts from kits or readily available materials.

(7) Jury-rigging.

(8) Use of substitute fuels, fluids, or lubricants.

c. Damage Assessment is a procedure to determine rapidly what is damaged; whether it is repairable; what assets are required to make the repair; who can do the repair, i.e., crew, maintenance team (MT), or maintenance support team (MST); and where the repair should be made. The assessment procedure includes the following steps:

- (1) Determine if the repair can be deferred or if it must be done.
- (2) Isolate the damaged areas and components.
- (3) Determine which components must be fixed.
- (4) Prescribe fixes.
- (5) Determine if parts or components, materials, and tools are available.
- (6) Estimate the manpower and skill required.
- (7) Estimate the total time (clock-hours) required to make the repair.
- (8) Establish the priority of the fixes.
- (9) Decide where the fix shall be performed.
- (10) Decide if recovery is necessary and to what location.

d. Maintenance Team (MT) consists of organizational mechanics who may be trained in assessing battle damage and field repair procedures. An MT is called to out-of-action vehicles to supplement (or confirm) the crew's original damage assessment. MT assessment determines if field repairs will be conducted or if recovery is required. Depending on available time, the MT will assist the crew in restoring the vehicle to mission capability.

e. Maintenance Support Team (MST) consists of direct support/general support mechanics and technical specialists who are trained in assessing battle damage in addition to their speciality. The MST is called by the MT when vehicle damage exceeds MT assessment capability or organizational repair capability.

f. MT/MST Assessor is a senior member of the forward MT/MST. He is a systems mechanic/technician trained in BDAR techniques. He must know:

- (1) The unit's mission and the commander's requirements.
- (2) The maintenance capability of the unit, including the available skills, tools, repair parts, and materials.
- (3) How to detect contamination and effect decontamination of equipment.
- (4) The unit's maintenance workload.
- (5) The maintenance capability of all accessible rally and maintenance collection points.



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g. Fully Mission Capable (FMC) means that the vehicle can perform all its combat missions without endangering the life of the crew. To be FMC, the vehicle must be complete and fully operable with no faults listed in the "Equipment is not ready/available if" column of the operator's Preventive Maintenance Checks and Services (PMCS) .

h. Combat Capable means that the vehicle can operate in a combat environment with some limitations but meets the minimum functional capability requirements. (Refer to paragraph 1-8.)

i. Combat Emergency Capable means that the vehicle meets the needs for specific tactical maneuver; however, not all systems are functional. Also, additional damage due to the nature of an expedient repair may occur to the vehicle if it is used. The commander must decide if these limitations are acceptable for that specific emergency situation.

j. Self-Recovery Capable means that the vehicle meets the needs for recovery under self-power. It could include hazardous equipment conditions such as partial brakes or limited steering.

k. Cannibalization, as used in this TM, means the use of repair parts or components obtained from another tactical vehicle either damaged or of lower priority to the immediate mission. In this TM, the term is used to include controlled exchange.

#### 1-5. BDAR RECOMMENDATIONS AND QDR/EIR

a. Personnel originating new BDAR procedures should forward them directly to Commander, US Army Tank-Automotive Command, ATTN: AMSTA-MB-BDAR, Warren, MI 48397-5000. Personnel are encouraged to develop and report new BDAR ideas, techniques, and procedures.

b. Equipment Improvement Recommendations (EIR's) may be submitted by anyone who knows of an unsatisfactory condition with equipment design or use. You do not have to show a new design or list a better way to do a procedure; just tell why the design is unfavorable or why a procedure is hard. EIR's may be submitted on SF 368, Quality Deficiency Report. Mail these directly to Commander, US Army Tank-Automotive Command, AMSTA-MT, Warren MI 48397-5000. A reply will be sent directly to you.



## Section II. STANDARDS AND PRACTICES

### 1-6. BDAR CHARACTERISTICS

BDAR capability requires simplicity, speed, and effectiveness. Some BDAR procedures include repair techniques that violate standard peacetime maintenance practices. In a combat emergency situation, greater risks are necessary and acceptable.

### 1-7. WAIVER OF PRECAUTIONS

Under combat conditions, BDAR may be performed on vehicles which are fueled and/or armed. Other similar precautions may be waived at the discretion of the commander. Refer to paragraph 1-11e.

### 1-8. SERVICEABILITY AND OPERABILITY (OPERATING CHARACTERISTICS)

As an example, the Minimum Functional Capability criteria for trucks are given below.

#### NOTE

These criteria may be waived for recovery or if the tactical situation demands otherwise.

- a. Vehicle must have operational wheels and tires on both sides of the truck.
- b. Drive train must be functional and must be capable of reverse and at least one forward gear.
- c. Power train performance degradation cannot exceed that level which would cause the truck to be incapable of traveling 15 miles per hour on a level, unimproved road.
- d. Vehicle must be capable of braking/stopping from 15 mph.
- e. Vehicle steering system must be operational.

### 1-9. PERMANENT REPAIR

At the earliest practicable opportunity, the vehicle will be recovered or evacuated to the appropriate maintenance facility for permanent standard repair as required.

### Section III. RESPONSIBILITIES AND TASKS

#### 1-10. GENERAL

Battlefield damage assessment and repair procedures are applicable at all levels from crew through general support maintenance, depending on the extent of the damage; the time available; the skills required; and the parts, components, tools, and materials available. Within these limits, each maintenance level will rapidly take whatever action is necessary and possible to restore the vehicle to combat-ready condition required for continuation of the mission.

#### 1-11. COMMANDER AND CREW

a. The crew of the damaged vehicle will make the first assessment immediately after damage has occurred. Crew members will provide the vehicle commander with an initial damage assessment which will include notice of system failure and all major vehicle systems visibly damaged, inoperative, or impaired. If possible, all systems will be checked at the same time by different crew members. If the failure is due to hostile fire, the report will include the location of impact and the manning status. Immediacy of the report is more important than how long it will take to get back into action. The initial report, therefore, may omit repair time estimates. The vehicle commander must make an initial out-of-action report to the platoon leader including these essentials:

- (1) Vehicle damage (out-of-action or impaired)
- (2) Location of vehicle
- (3) Firepower status (if applicable)
- (4) Mobility status
- (5) Manning status
- (6) Current and anticipated enemy action

b. If communication capability is damaged, the vehicle commander should approach the nearest friendly radio and make his report.

c. In the forward battle area, it is imperative that the crew attempt to move the vehicle to a covered or concealed position to prevent additional combat damage. This is the first priority. If the vehicle is not capable of self-movement, use any vehicle to recover the vehicle or to move it to a concealed area.

d. Battlefield Damage Assessment/Repair assessment checks include looking at the damaged parts, determining what system they belong to, and deciding how they can be fixed or jury-rigged to permit immediate operation (full or partial).

- e. A safety check should be made for any obvious hazards.

#### NOTE

Correct any safety faults/hazards before proceeding.

- (1) Have any combustibles such as fuel, hydraulic fluid, or oil accumulated?
- (2) Does wiring appear to be safe? Could arcing occur to stored ammunition or leaking combustibles?
- (3) Is the fire extinguisher operational?

f. A functional/operational test should be performed next on those systems which appear undamaged. Refer to vehicle PMCS table before proceeding. Self-test shall be performed on those systems with a built-in self-test feature. Only those systems found to be damaged or inoperative shall be identified.

g. The vehicle commander shall report to the platoon leader the results of the crew's damage assessment, naming the major known causes of the vehicle's immobility. If repair by crew is possible, the vehicle commander shall report a total estimated repair time and what functions may be restored.

h. The platoon leader will respond with directives and, if required, will call an MT to the location of the damaged vehicle for assistance. If possible, sufficient information will be provided to enable the MT to bring needed repair parts or special tools.

i. The crew shall proceed to make field expedient repairs to restore communications and/or vehicle mobility as directed by platoon leader.

#### 1-12. ORGANIZATIONAL MAINTENANCE AND MAINTENANCE TEAMS (MT)

a. The organizational maintenance team (MT) and assessor operate out of the company or battalion trains. The MT assessor performs his assessment and the maintenance team completes repairs at the damage site if possible. If the site is within direct fire or under enemy observation, movement to a more secure site away from fire may be necessary. This is still considered "on-site".

b. If the vehicle has been left unattended in the forward battle area, the immediate area of the vehicle should be checked for mines, and the vehicle should be checked for booby traps before starting the battle damage assessment. The MT should also make the safety checks listed in paragraph 1-he.

c. The MT assessment will be more thorough than the crew's, using organizational maintenance support tools and equipment as needed. MT assessment includes:

- (1) Reviewing the crew's out-of-action report, if available.
- (2) Interviewing commander and crew, if available.
- (3) Visually inspecting damaged parts and systems.

(4) Making tests with organizational test equipment, if required.

(5) Performing additional vehicle operational tests, as necessary.

d. Using this information and following the steps of paragraph 1-4c, the MT will:

(1) Determine what must be repaired or replaced.

(2) Determine sequence and priority of repair actions.

(3) Estimate repair times for each repair task.

(4) Total the repair task times and determine if the repairs can be performed in the time available.

(5) Determine repair location and, if other than on-site, arrange for recovery of the vehicle to the repair site.

e. If all critical repairs can be made within the available time with the skills, materials, tools, and equipment at hand, the MT, assisted by the crew, will proceed with the on-site repair.

f. If the damage exceeds the repair capability of the MT, and the time is available for an MST on-site fix, the MST shall be called.

g. If time for an MST on-site fix is not available, but the vehicle is repairable, the MT shall provide for recovery of the vehicle to a designated collection point.

h. If the vehicle is not repairable, the MT shall provide for one of the following:

(1) Recovery to a maintenance collection point for evacuation to the rear.

(2) On-site stripping (if approved by commander, coordinated with support maintenance).

(3) Abandonment/destruction (if directed by commander).

Vehicles should never be abandoned if recovery/evacuation is possible because vehicles can almost always be rebuilt, no matter how badly damaged they are. If the vehicle is damaged catastrophically and evacuation is not possible, remove items in the following order:

(1) Needed spares on-site.

(2) Sensitive, high value, limited size items.

(3) Other needed spares or repair parts.

j. If the vehicle is contaminated, the MT shall mark the vehicle with contamination markers and arrange for recovery to a decontamination site. Refer to FM 21-40 NBC (Nuclear, Biological, and Chemical) Defense.

#### 1-13. DIRECT SUPPORT/GENERAL SUPPORT MAINTENANCE TEAM

a. The MST shall assist the MT as needed, using direct support maintenance tools and equipment. MST assessment and repair procedures are the same as those of the MT except at a higher maintenance level. If possible, the MT will tell the MST what tools and spare parts are needed to perform the repairs. While waiting for the MST to arrive, the crew, under the supervision of the MT, will open up the vehicle and make it ready for the MST to perform the assessment and repair.

b. Damaged vehicles removed to designated repair sites shall be selected for MST repair as directed by the company commander.

#### 1-14. TIME LIMITS FOR REPAIRING DAMAGE

a. In combat, the time available for BDAR is limited. One of the factors to be considered in the selection of a repair site is the amount of time available at the site based on the tactical situation. Every assessment must include an estimate of total time required to restore the vehicle. The time available at the selected repair site must equal or exceed the estimated time required to accomplish all tasks associated with the BDAR.

b. Determination of where BDAR will take place should be made by the commander.

#### 1-15. RECORDING BATTLEFIELD DAMAGE REPAIRS

a. Record shall be made of repairs to components of a tactical vehicle by BDAR or other expedient techniques in order to enable mechanics to determine authorized permanent repair. All expedient repairs and operational limitations must be recorded on DA Form 2404 (Operator's Daily).

b. DA PAM 738-750, the Army Maintenance Management System (TAMMS), describes preparation and disposition of DA Form 2404 and DA Form 2407. When BDAR is noted on DA Form 2407, a copy shall be mailed to: Combat Data Information Center, AFFDL/FES/CDIC, Wright Patterson AFB, Ohio 45433. The information on these forms will provide data for designing vehicles to be less susceptible to combat damage and easier to repair when damaged.

## CHAPTER 2 ASSESSING BATTLEFIELD DAMAGE

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

### Section I. GENERAL

#### 2-1. SCOPE

This chapter provides guidelines to use to assess battlefield damage. It directs you to an expedient repair procedure, or to the standard system TM if an expedient repair procedure for your problem doesn't exist.

#### 2-2. GENERAL

Use this TM in conjunction with the operator's technical manual (TM) and Lubrication Order (LO) . This chapter explains how to use this manual to assess and fix battlefield damage that prevents moving and/or communicating. This chapter contains the general fault assessment tables and general troubleshooting and maintenance instructions including combat damage report forms. General fault and specific fault assessment tables and detailed assessment procedures are used to locate the damage; and an expedient repair procedure tells how to fix the damage. An index of the expedient repair procedures is located in each chapter. If you don't know or aren't sure of exactly what your problem is, you should use the assessment tables and procedures to find the fault.

#### 2-3. APPLICATION

Use the following steps to find and fix battlefield damages:

- a. Do the Preventive Maintenance Checks and Services (PMCS) in the TM and the L O . At the same time, look for obvious damage to the vehicle.
- b. Do the troubleshooting/repair recommended in the TM, if applicable.
- c. If you find the problem, determine its effect on the operation (mobility or communication) of the vehicle.
- d. If you can't fix the problem using the PMCS table and the procedures in the TM and the LO, use chart 2-1 to assess and fix the problem.
- e. If the problem does not affect vehicle operation, the commander will decide whether to attempt to fix the problem or continue with the mission.

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f. If the damage does affect vehicle operation, do one of the following:

(1) Replace the bad part/assembly with a good one (from supply or other vehicle).

(2) Replace the bad part/assembly with a substitute that is interchangeable.

(3) Use the expedient repair procedures in this manual to repair the damage.

g. After repairing the damaged system, replace lost fluids and/or lubricants in accordance with specific LO. If those specified by the LO or TM are not available, refer to appendix D for a possible substitute.

## Section II. ASSESSING BATTLEFIELD DAMAGE

### 2-4. GENERAL

a. This section provides an overall damage assessment procedure to evaluate the mobility and communication functions of individual vehicles.

b. The assessment procedures are designed to ensure that all necessary aspects of vehicle capability are evaluated during the assessment process. The procedures refer you to:

- (1) procedures in this manual if a quick-fix is possible,
- (2) the vehicle TM when BDAR is not possible, or
- (3) a higher maintenance level if access to devices or materials to do the quick-fix are available only at those levels.

c. Each procedure:

- (1) contains general information about the problem,
- (2) lists materials and/or tools required other than those commonly available to the crew, MT, and MST (If the listed items are not available, anything that will do the job is acceptable.),
- (3) lists the estimated number of soldiers needed and the estimated time required to complete the repair,
- (4) states the operational limitations caused by the repair action before experiencing further damage/degradation to the vehicle, and
- (5) provides other expedient options that can be used, depending on the availability of personnel, materials, tools, and/or time. (This does not include standard maintenance procedures or recovery.)

d. Following each assessment procedure is an index of the procedures contained in that chapter. If you know exactly what your problem is, you can use the index to find the proper expedient repair procedure.

e. Additional data is contained in the appendixes.

(1) Appendix B lists special or fabricated tools used in performing BDAR repairs.

(2) Appendix C lists alternate sources of supply to include foreign ownership of US combat vehicles and expendable supplies which are recommended for use to implement various BDAR repairs.

(3) Appendix D lists substitutes for the petroleum, oil, and lubricants (POL).



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## 2-5. ASSESSMENT PROCESS

a. Assessments of damage may be made in turn by operator/crew, MT, and MST personnel. The assessment procedures are as follows:

- (1) Inspect.
- (2) Functionally test.
- (3) Assess the performance.

b. There are three kinds of assessments performed on damaged equipment:

- (1) The first is assessment of the extent and kind of damage and how it affects vehicle operation and capabilities.
- (2) The second is assessment of whether the damage needs to be repaired.
- (3) The third is assessment of where and how to repair the damage.

## 2-6. OVERALL VEHICLE ASSESSMENT PROCEDURE

a. This procedure can be used by the crew, but it will be of more use to an MT or MST assessor working to quick-fix vehicles for the completion of a mission or self-recovery. The procedure provides for assessing the kind of damage and determining:

- ( 1 ) the effect of the damage and if it needs to be fixed,
- (2) if the damage can be fixed using BDAR or if only regular maintenance operation can fix it, and
- (3) how long it will take to fix it.

b. This is accomplished by structuring this manual in rank order, from the vehicle two-function overview down to the specific. Each major function (move and communicate) and each subsystem of that function has a stand-alone assessment procedure. This makes it easier to identify each significant problem encountered in battlefield damaged equipment.

c. As an example, presume a 2-1/2-ton truck is down with a bad fuel pump. Fuel pumps are essential for even the lowest level of limp-home self-recovery. The vehicle/system assessment table, as part of its engine evaluation, tells the reader to visually and functionally check the engine. If it doesn't work, the assessor can then visually and functionally check the engine subsystems if time permits. The assessor would visually and functionally check the fuel subsystem and discover that the pump was inoperative. The fuel subsystem assessment table directs the reader to a specific page where BDAR suggestions for alternate fuel supply systems can be considered for use.

d. At any point on each of the assessment levels, the assessor can abort the procedure and direct recovery, evacuation, or other actions if the tactical situation dictates.

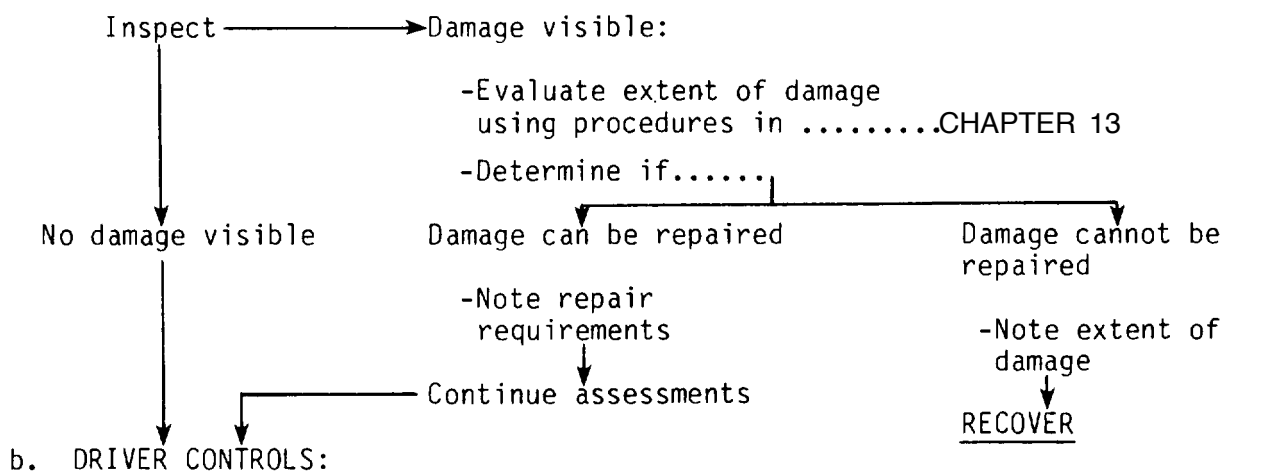
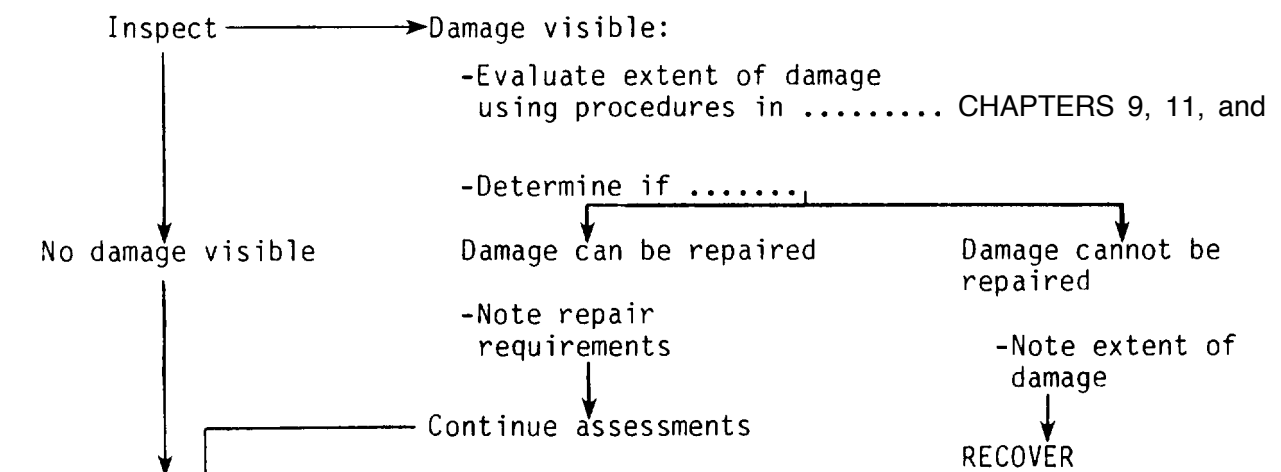
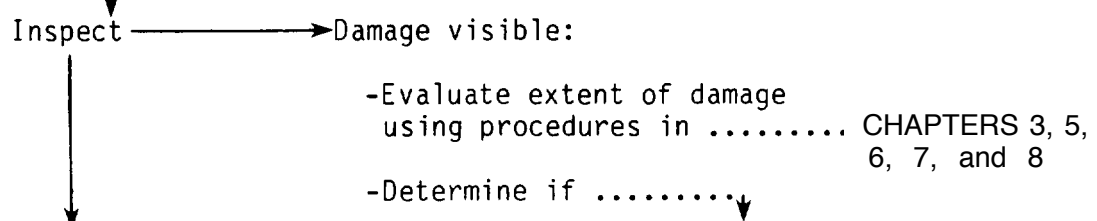
e. Refer to chart 2-1 to begin the assessment process.

Chart 2-1. Vehicle/System Assessment.

<u>ITEM/ACTION</u>	<u>FAULT ISOLATION</u>	<u>BDAR REFERENCE</u>
--------------------	------------------------	-----------------------

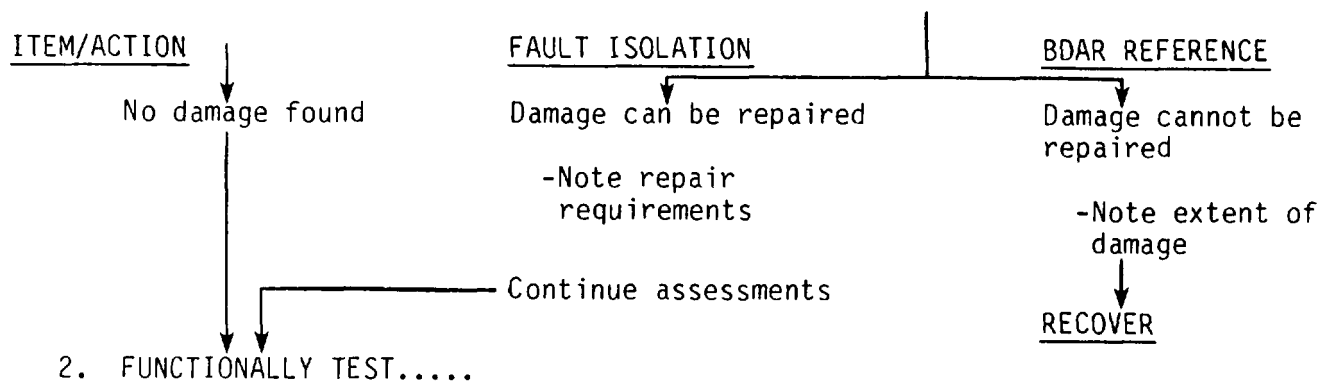
**NOTE**

Items checked in this procedure must work to provide minimum functional tactical capability. Even if all systems work, the vehicle may be unsafe and may not satisfy normal required operating capabilities or may not receive mission-essential maintenance.

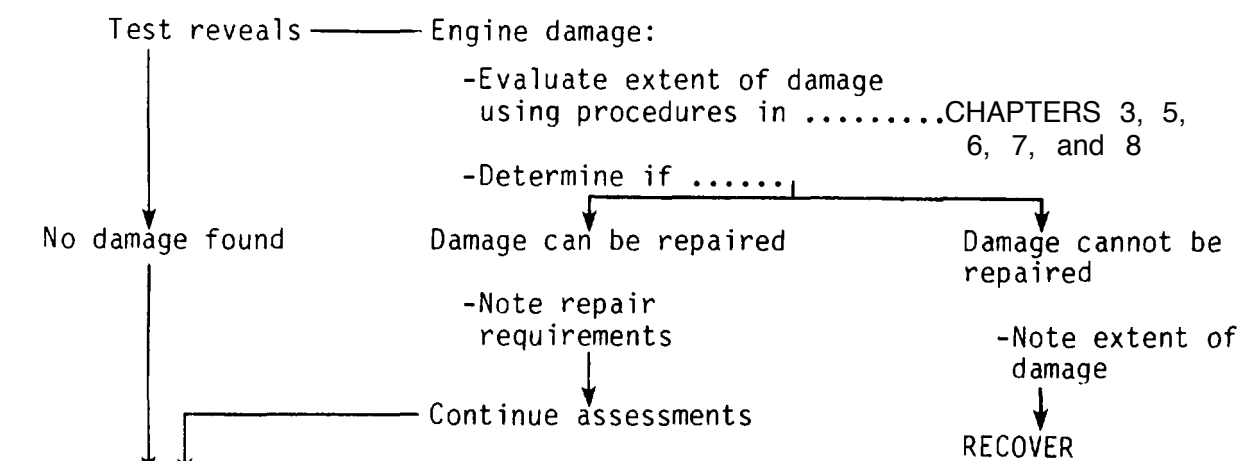
**A. MOBILITY ASSESSMENT.****1. INSPECT....****a. FRAME AND SUSPENSION:****b. DRIVER CONTROLS:****c. ENGINE:**

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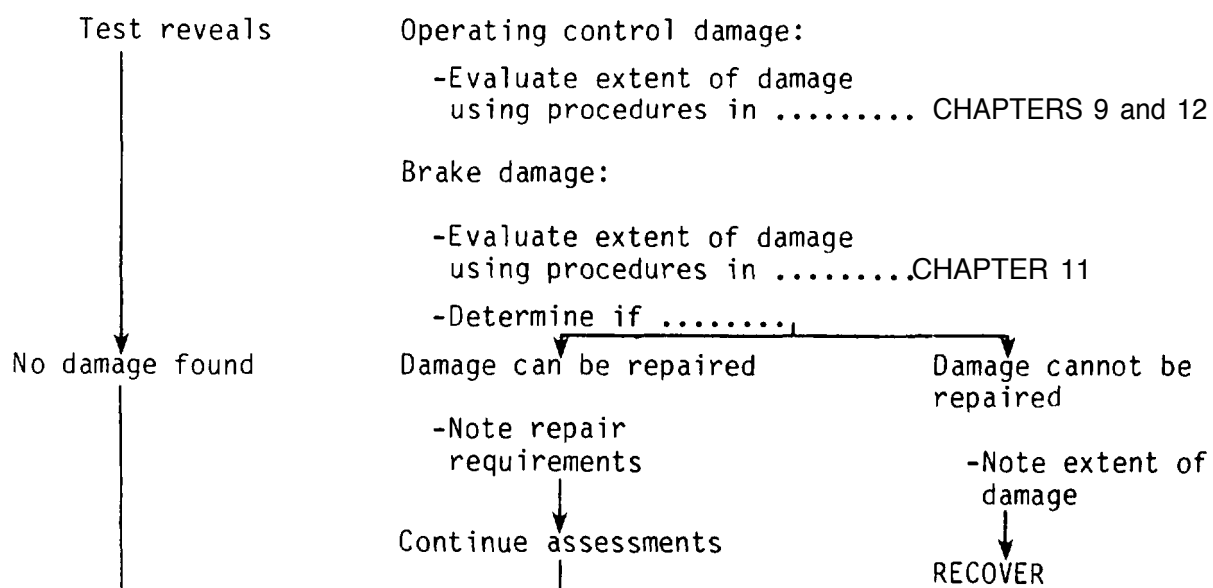
Chart 2-1. Vehicle/System Assessment (Cent).



## a. ENGINE:



## b. DRIVER'S CONTROLS:



This completes the mobility assessments. Continue with assessment of communication system if required. After systems are operational, prepare to report.

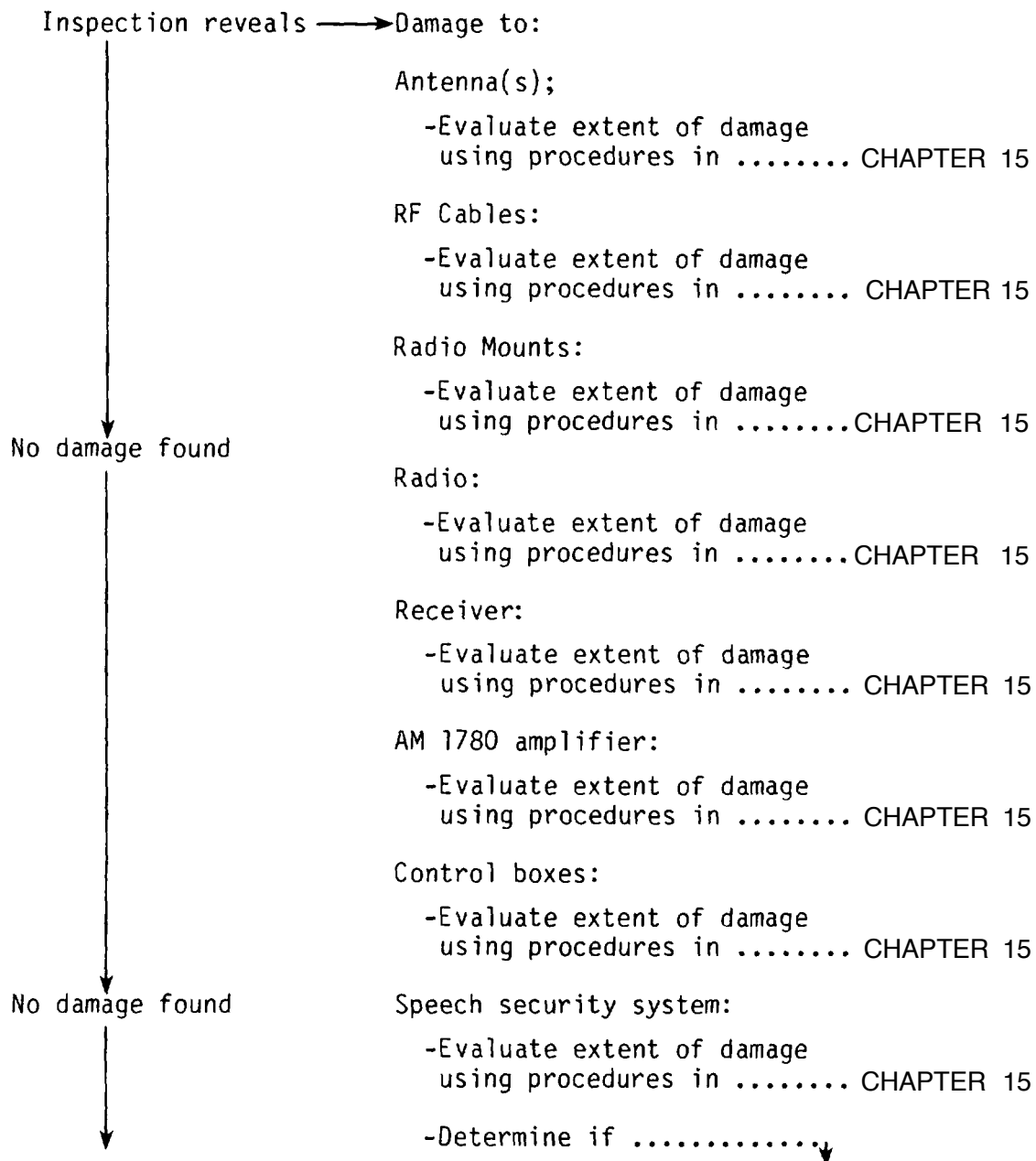
**Chart 2-1. Vehicle/System Assessment (Cent).**B. COMMUNICATIONS ASSESSMENTS.

<u>ITEM/ACTION</u>	<u>FAULT ISOLATION</u>	<u>BDAR REFERENCE</u>
--------------------	------------------------	-----------------------

1. INSPECT .....		
------------------	--	--

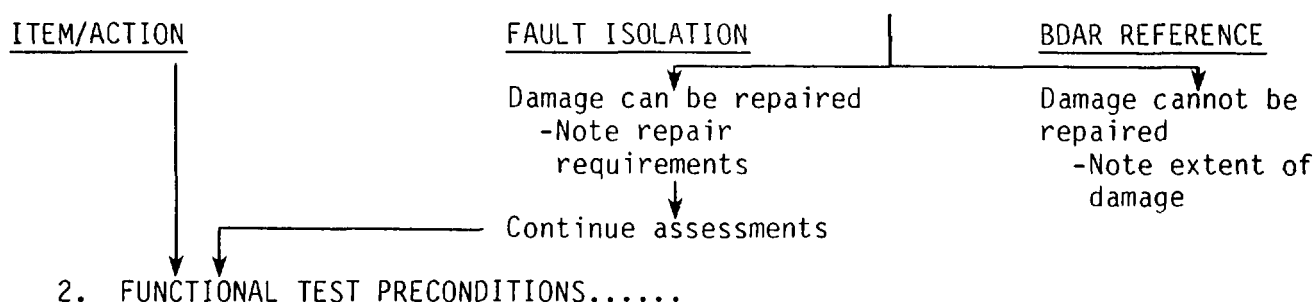
**WARNING**

Before assessing and handling communications equipment, turn off the power to all components of the communications system. Damaged equipment can cause severe shock to personnel and additional damage to equipment.



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Chart 2-1. Vehicle/System Assessment (Cent).

**NOTE**

Ensure that no current-conducting wires will short out to each other or to ground when power to equipment is turned on.

**NOTE**

Turn on power to each communication system as it is functionally tested.

## 3. SELF-TEST AND FUNCTIONAL CHECKS.....

## a. RADIO:

Functional test  
reveals

Radio does not work

No damage found

-Evaluate cause of malfunction  
using procedures in .....CHAPTER 15

## b. AUXILIARY RECEIVER:

Functional test  
reveals

Auxiliary receiver does not work

No damage found

-Evaluate cause of malfunction  
using procedures in .....CHAPTER 15

## c. SPEECH SECURITY SYSTEM:

Functional test  
reveals

Speech security system does not

No damage found

-Evaluate cause of malfunction  
using procedures in .....CHAPTER 15

-Determine if .....

Damage/malfunction  
can be repaired

Damage cannot be  
repaired

-Note cause and  
repair requirements

-Note cause and  
extent of damage

This completes assessment of the communication systems. Summarize assessment findings, and prepare to report assessment findings in move/communicate order to commander for vehicle status/disposition determination.

## CHAPTER 3

## GENERAL AUTOMOTIVE COMPONENTS

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

## 3-1. GENERAL

This chapter describes quick-fix procedures for those automotive items common to automotive systems and functional elements of a tactical vehicle.

## 3-2. ASSESSMENT PROCEDURE

Inspect damaged components to determine the extent of damage and the repair required.

## 3-3. BDAR PROCEDURE INDEX

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## Section II. GASKETS

## 3-4. GENERAL

Damaged gaskets may cause leakage from components. Procedures are available to make or repair gaskets if standard replacements are not available. Lift capability may be required to gain access to the gasket. Heat and pressure should be considered when selecting gasket materials.

## 3-5. GASKETS LEAKING

## General Information:

When some metal surfaces are bolted together, a compressible gasket is required to reduce or eliminate the leakage of fluids or lubricants. Gaskets are also used to seal systems against fuel leakage or to keep contaminants from entering. Leaks can be tolerated if the leaking fluid does not constitute a fire hazard or does not leak at a rate which will deplete the required lubrication.

## Limitations:

- o Frequent inspections required

## Personnel/Time Required:

- o 1-2 soldiers
- o 1-6 hours

## Materials/Tools:

Gasket material such as:

- o Leather
- o Used gasket
- o Cardboard
- o Teflon tape
- o Silicone gasket sealer
- o Hardening type sealer

## Other Options:

- o Continue operation, refilling fluids as required.

## Procedural Steps:

## Option 1: Manufactured Gasket.

1. Cut leather, cardboard, or other material to fit the mating surfaces.
  - a. Hold gasket against mating surface and mark an outline of the component. Cut the material with a knife or shears.
  - b. Hold material against mating surface. Tap the gasket material with a ball-peen hammer along the edges of the mating surfaces and holes to remove unwanted gasket material.

2. Coat the gasket with a sealing compound.
3. Join components and bolt together.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Used Gaskets.

1. Coat mating surface with sealing compound.
2. Place used gasket or sections of broken gasket onto mating surface.
3. Coat other mating surface with gasket sealer.
4. Join components and bolt together.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Gasket Sealer.

1. Remove old gasket material and residue.
2. Coat mating surfaces with silicone gasket sealer.
3. Allow silicone sealer to form a skin (10 to 15 minutes).
4. Join components and bolt together.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### 3-6. ENGINE HEAD GASKET FAULTY

#### General Information:

Engine cylinder head gaskets seal cylinders and fluid passages. Leakage can be detected through:

- a. lack of power,
- b. rough, uneven engine operation,
- c. abnormal pressure in crankcase or cooling system,
- d. contaminants in oil or cooling system, or
- e. engine might not start.

BDAR procedures are more difficult to perform on cylinder head gaskets, but limited operation can be restored. Frequent checks must be made for leakage and temperature changes. Engine rpm should be reduced.



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Limitations:

- o Reduced vehicle speed

Personnel/Time Required:

- o 1-2 soldiers
- o 2-6 hours

Materials/Tools:

- o Epoxy
- o Copper wire
- o Hardening gasket sealer
- o Sandpaper or emery cloth

Other Options:

- o Continue operations.

Procedural Steps:

Option 1: Gasket Sealer.

1. Remove cylinder head.
2. Locate leaking area.
3. Liberally coat leaking area with hardening gasket sealer.
4. Replace cylinder head and tighten mounting bolts or studs.
5. Check engine operation.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Wire and Sealer.

1. Remove cylinder head.
2. Remove damaged gasket or O-rings.
3. Clean the head and the engine head surface with sandpaper or emery cloth.
4. Lay soft copper wire around each cylinder bore and trim to eliminate any overlap.
5. Install old gasket coated with gasket sealer, varnish, or paint.
6. Install cylinder head and tighten mounting bolts or studs.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### 3-7. ENVIRONMENTAL GASKET LEAKING

#### General Information:

Inspect for water or foreign matter in compartments or areas that should be sealed. Rubber weather stripping from civilian vehicles or any rubber hose securely glued and sealed will stop leaks. Canvas or rubber inner tubes will also seal the system. These seals will prevent excessive water and air leaks.

#### Limitations:

- o None

#### Personnel/Time Required:

- o 1-2 soldiers
- o 20-60 minutes

#### Materials/Tools:

- o Rubber hose
- o Rubber weather stripping
- o Inner tubes
- o Adhesive
- o Canvas tarp
- o Epoxy
- o Tape

#### Procedural Steps:

1. Locate leak and remove component or cover.
2. Remove defective gasket and clean the sealing surfaces.
3. Obtain material to fabricate sealing gasket.
4. Cut gasket to fit.
5. Follow instructions on container and apply available adhesive.
6. Place gasket in proper location.
7. Install component or cover.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## Section III. BELTS

## 3-8. GENERAL

V-Belts provide direct drive and can be substituted or replaced if the basic factors about each belt are considered. Substitute belts must be the correct length to maintain tension and wide enough to prevent bottoming in the pulley V. Inspect width and length of the belt. Smaller, narrower belts may be substituted or V-belts may be taken from another vehicle if there are twin belt drives. Direct vehicle-to-vehicle removal and installation is a simple method of replacing missing belts.

## 3-9. V-BELT MISSING OR BROKEN

## General Information:

Some vehicle subsystems such as water pumps and radiator fans are driven by V-belts. Power generation is also belt driven. Worn or frayed V-belts can slip or break causing the system to fail. V-belts should be replaced or substituted to restore system functions. Frequent adjustment may be required for substitute V-belts.

## Limitations:

- o Frequent stops for belt adjustment
- o Possible engine overheating

## Personnel/Time Required:

- o 1 soldier
- o 15-60 minutes

## Materials/Tools:

- o Adjustable link V-belts
- o Rope
- o Wire

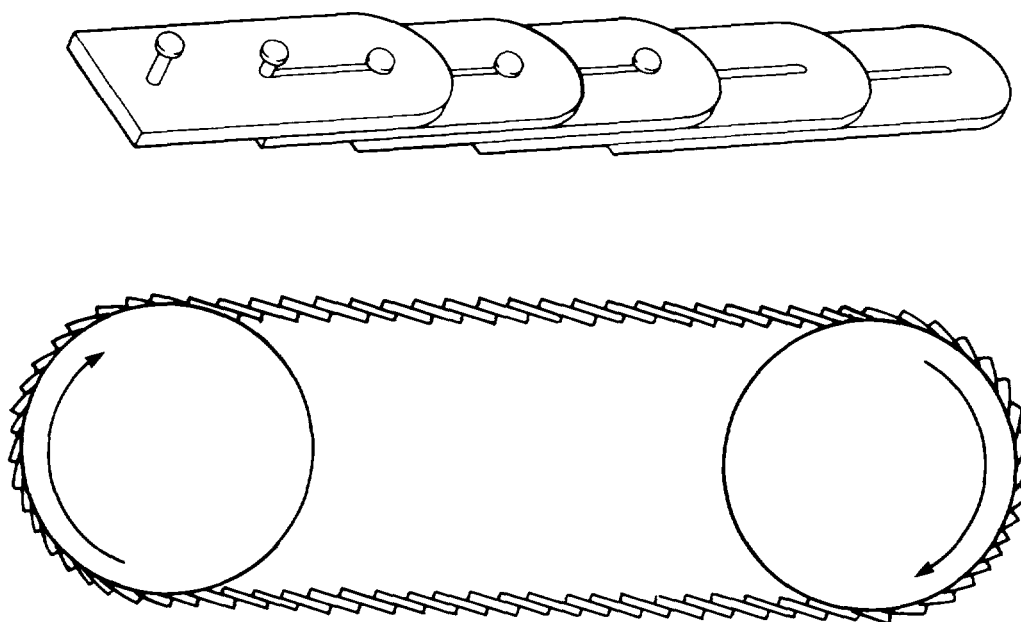
## Procedural Steps:

## Option 1: Rope or Wire.

1. Rope or wire can also be used, but thin wire must be braided to ensure the needed friction is provided.
2. Adjust the tensioner assembly for minimum belt length.
3. Assemble the rope or wire as close as possible to the minimum belt length.
4. Tighten with the tensioner assembly.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 2: Separable-Link Belts.

1. To remove link, hold one of the links with pliers and pry the next link off with a screwdriver.
2. Adjust the tensioner assembly for minimum belt length.
3. Assemble the belting as close as possible to the minimum belt length and snap links together with pliers.
4. Install the belt as shown. This prevents undue strain on the belt links.



DIRECTION OF ROTATION

5. Tighten with the vehicle belt tensioner.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## Section IV. HOUSINGS, CASTINGS, AND PLATES

## 3-10. GENERAL

Castings or plates may be serviceable, even with holes or cracks, provided the structure is not significantly weakened. Internal structures, such as crankshaft bearing journal webs, are necessary to distribute loads within the casting. Some damage to these elements can be allowed, but fatigue failures from crack growth cannot be predicted. Service life will depend on the extent of damage.

## 3-11. ENGINE/TRANSMISSION HOUSING DAMAGED

## General Information:

Small cracks or holes caused by vibrations, overheating, or explosive shocks may develop in a cylinder head, block, or transmission housing. Cracks that do not harm the structural strength of a housing can be deferred, but cracks that allow coolant or oil to escape must be repaired. Large holes or cracks will require exchange of the component. Depending on the extent and location of the damage, frequent fluid level checks may be necessary. In some cases, the engine or transmission may have to be removed. Use one of the following options to repair a small crack or hole.

## Limitations:

- o Reduced mobility

## Personnel/Time Required:

- o 2 to 3 soldiers
- o 2-24 hours

## Materials/Tools:

- o Sandpaper
- o Epoxy
- o Plastic steel
- o Metal plate
- o Bulk issue fiberglass or epoxy kit
- o Hardening sealer
- o Lift capability

## Procedural Steps:

## Option 1: Repair of Small Crack.

1. Remove all paint from around the crack.
2. Cover the crack and 1/4 inch or more of the surrounding area with quick-drying epoxy.
3. Allow epoxy to harden before running an engine. Use heat to speed up curing the epoxy.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Repair of Small Crack or Hole.

1. Remove paint from around the area where metal plate is to be positioned.
2. Cover the area with a plate from any available metal large enough to cover the crack or hole.
3. Seal the edges of the plate with quick-drying epoxy.
4. Allow epoxy to harden before running engine. Use heat to speed up curing the epoxy.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Repair of Small Crack or Hole.

1. Clean damaged area.
2. Fill small crack or holes in low-stress area either with hardening sealer, fiberglass, or epoxy.
3. Allow filler to harden before running engine.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## Section V. BRACKETS AND WELDMENTS

## 3-12. GENERAL

Brackets are used on all vehicles to mount or store items. Brackets are attached to the vehicle by bolting or welding and are subject to damage through vibrations, impact, or explosive forces. Repairs must be made to restore the brackets necessary for essential vehicle functions.

## 3-13. BRACKET BROKEN

## General Information:

Equipment mounting brackets on the frame will break sometimes due to vibrations or collision. Bolted brackets should be remounted using bolts if possible. Their removal may be required to gain access to other components.

## Limitations:

- o None

## Personnel/Time Required:

- o 2 soldiers
- o 1 hour

## Materials/Tools:

- o Welding equipment
- o Elastic cords
- o Wire or rope
- o BII tiedown straps

## Procedural Steps:

## Option 1: Weld.

1. If a bracket is broken off at the base, but component mounting holes are unaffected, reweld in place.
2. Elongate mounting holes to compensate for misalignment of attaching items.

3. Bolt components to bracket.

4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Weld in Place.

1. If the bracket mounting holes cannot be used because of stripped threads or if broken bolts, weld the bracket in place.

2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Tie Component.

1. Tie the component in place using rope, wire, elastic cords, or BII straps if brackets cannot be welded or bolted.

2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



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## Section VI. HARDWARE, MECHANICAL LINKAGES, CABLES, AND PULLEYS

## 3-14. GENERAL

Various types of hardware and linkages are used throughout tactical vehicles to transfer the control actions from the crew to the components being controlled. Damage can occur to the mounting hardware or the rods, cables, and levers in mechanical linkage systems. Pins can become lost or linkages can bend or break, disabling or hampering vehicle operation. This section will give various procedures that may be used to repair or restore needed functions.

## 3-15. FORCING MISMATCHED THREADS

Mismatched bolts can be used to make BDAR repairs if proper bolts are not available. Care must be taken not to break bolts by forcing them too far. Forced threads will not hold as much stress as standard threads but will provide a limited operational capability.

## 3-16. THREAD CLEANUP

Damaged threads can be repaired using a thread file or a triangular file. Turning a hardened steel nut onto the bolt can also help realine damaged threads. The threads must be cleaned to remove dirt or metal particles which might cause further damage to threaded holes. Use a wire brush, nail, or scribe to remove stuck metal particles.

## 3-17. MOUNTING HARDWARE USING IMPROPER BOLTS

Brackets and components can be connected or mounted using an iron rod or stud inserted through the connecting holes. Swaging or bending each end will keep the components together. A stud can be screwed into a threaded hole and a nut used to hold the component. If the proper size nut is not available, use a nut larger than the stud threads and flatten the stud end to hold the nut in place. Linkages also can be connected by inserting a nut or bolt and flattening the ends to keep it from dropping out of position.

## 3-18. GEARSHIFT LEVER BROKEN

## General Information:

Binding shift linkage can cause the transmission range selector lever to break, resulting in the loss of shifting control. Binding linkages must be repaired to allow shifting without excess strain on the mechanism. A temporary shift lever can be fabricated to provide selection of the transmission gear ranges.

## Limitations:

- o None

**Personnel/Time Required:**

- o 1 soldier
- o 1-30 minutes

**Materials/Tools:**

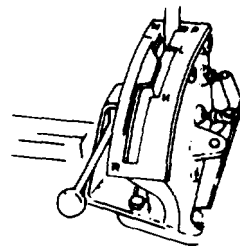
- o Vise grips
- o Channel locks

**Other Options:**

- o If the shift lever is hollow, insert a screwdriver into the remaining section to allow shifting.

**Procedural Steps:**

1. Remove shifting gate to gain access to the shift linkage shaft.



2. Clamp vise grips onto the remaining portion of the shift lever.
3. Move shift lever to determine range of movement.
4. Adjust to allow reverse and one forward gear as a minimum.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**3-19. PUSH/PULL ROD DAMAGED****General Information:**

Mechanical linkage rods can bend or break from explosive shock, impact, or binding components. Rods can be repaired to regain use of the system. The cause of binding must be determined and corrected. Rods or shafts that are bent can be straightened by placing the rod/shaft on a hard, flat surface and hitting it with a hammer. Broken rods/shafts can be splinted using scrap metal.

**Limitations:**

- o Possible degraded mobility

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Personnel/Time Required:

- o 1-2 soldiers
- o 1-2 hours

Materials/Tools:

- o Welding equipment
- o Drill
- o Hacksaw
- o Plate stock

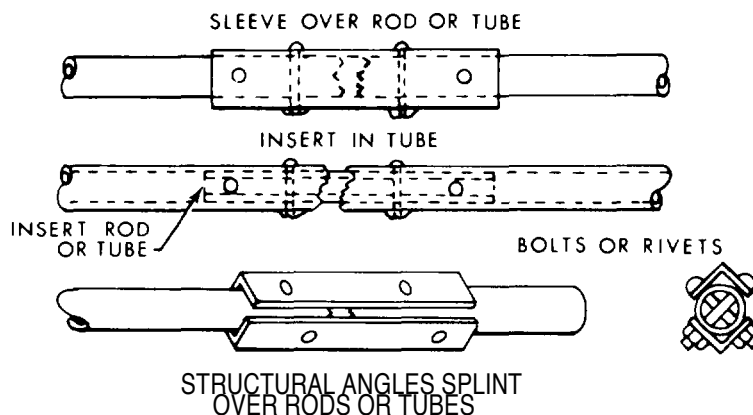
Procedural Steps:

Option 1: Weld.

1. Determine if damaged rod is made of steel or aluminum alloy.
2. Remove rod and weld ends together.
3. Remove metal fragments which would hinder rod operation.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Splint with Angle Iron.

1. Cut reinforcement from angle iron or hand rails to splint the rod.
2. Measure rod length and drill holes through reinforcement and rod.
3. Rivet or bolt reinforcement to damaged rod.



4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 3: Weld and Splint.

1. Measure rod length.
2. Cut off both end portions of the damaged rod.
3. Cut a piece of tubular stock that will make the length the same as the original when the end portions are added to it.
4. Weld the end portions.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 3-20. PULLEY DAMAGED

## General Information:

When cable pulleys are damaged, a replacement may be cannibalized from another vehicle or the damaged pulley may be welded or wedged into position. A spacer, bolt, and two flat washers can be used as an improvised pulley to guide the cable.

## 3-21. MECHANICAL CABLE BROKEN

## General Information:

Cables may break, causing a system to become inoperative. Cables may be repaired by splicing. When replacement cable is not available, prepare cable for splicing as follows.

## Limitations:

- o Range of movement may be limited

## Personnel/Time Required:

- o 1 soldier
- o 1-2 hours

## Materials/Tools:

- o New or reclaimed cable
- o Cable clamp or metal sleeves and installation tool
- o Vise
- o Vise-grips

## Other Options:

- o Damaged cable may be replaced with braided wire, commo wire (5 to 7 strands), or rope where the cable function will permit.

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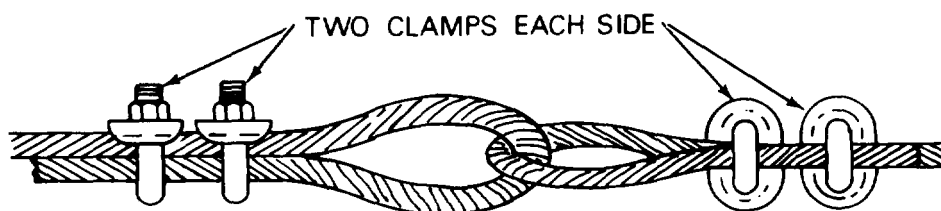
## Procedural Steps:

### NOTE

Be sure to select a length where the cable splices will not restrict the range of cable travel.

#### Option 1: Loop and Cable Clamp.

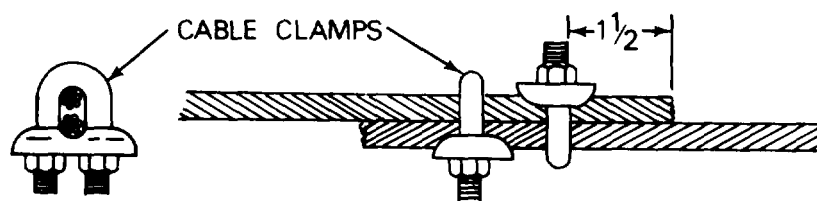
1. Make a loop at the end of one cable.
2. Thread the other cable end through the loop, and make another loop.
3. Secure both loops as shown.



4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Cable Clamps.

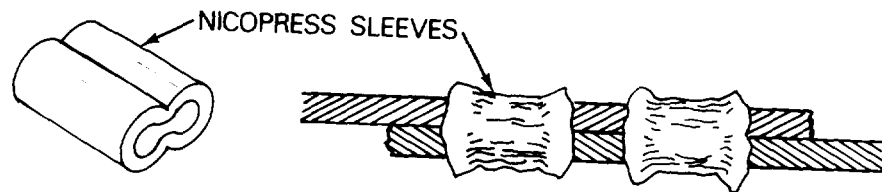
1. Splice cable with two clamps.
2. Connect the other cables by looping through the tie. The end of the cable should extend at least 1/2 inch beyond the clamp as shown.



3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 3: Swage Sleeves.

1. Splice the cable with two metal sleeves.
2. Swage the sleeves on the cables with installation tool, a vise, or a hammer.



3. Adjust cable to its proper tension.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### 3-22. CLEVIS, COTTER, DOWEL, QUICK-RELEASE, OR ALIGNMENT PIN MISSING

Most linkages have retainer devices, cotter keys, lacing wire, or safety pins to keep the connecting nuts, bolts, or pins in place. During BDAR repairs, wire, welding rod, bolts, or nails can be used to secure connecting nuts, bolts, or pins. Place the item through the hole and bend the ends to keep it from falling out. Alignment pins or dowels can be replaced with cut bolts. Use a bolt that is a tight fit in the hole, wedge the bolt in, and cut to proper length.

## Section VII. HYDRAULIC SYSTEMS

## 3-23. GENERAL

BDAR for a hydraulic system is generally confined to component replacement, expedient line repairs, or bypassing damaged lines. If a hydraulic circuit cannot be repaired, it may be necessary to isolate it (cut it off) from the system to permit operation of some other hydraulic functions. Damage to the hydraulic system usually requires replenishment of lost fluids. A list of-substitute-fluids can be found in appendix D.

**WARNING**

Bring hydraulic system to zero pressure before making repairs.

## 3-24. ASSESSMENT PROCEDURES

No specific assessment procedures are needed to locate leaks and ruptured lines. System specific TM's must be checked before isolation is performed.

## Section VIII. FLUIDS AND SEALS

## 3-25. GENERAL

Hydraulic circuits use fluids under pressure to activate, regulate, or drive mechanisms in the vehicle. To contain the pressure within the hydraulic system, all moving parts are sealed with gaskets, packing, and O-rings. Leakage at any of these, or at hydraulic devices or the lines that connect them, will render the entire system useless until the leak has been stopped.

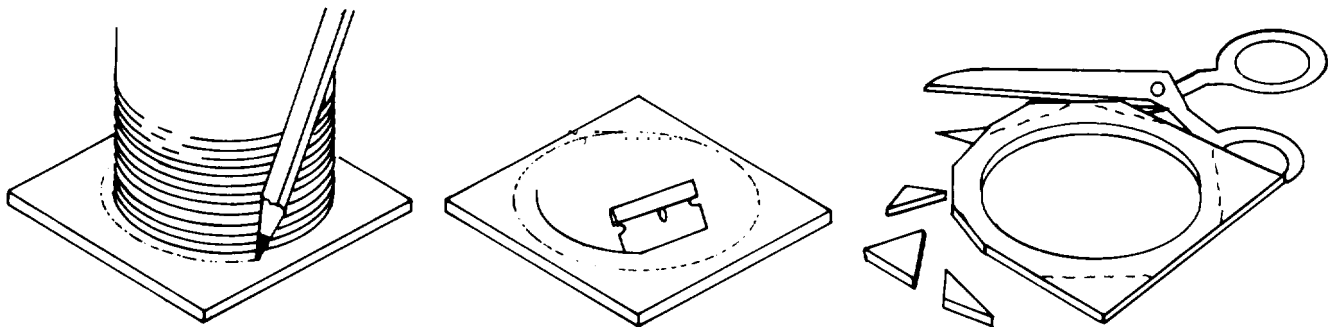
## 3-26. HYDRAULIC FLUID SUBSTITUTION

If the original fluid is lost and standard replacement is not available, a substitute fluid must be used. Check appendix D for a compatible fluid.

## 3-27. O-RING LEAKAGE

The following fixes could be used:

- a. A damaged O-ring could be repaired using plastic rubber. Apply the plastic rubber to the damaged area and press out air pockets. Allow to cure 1 hour (overnight for best results) before installation.
- b. Use a sharp tool such as a razor blade and cut a section of rubber having the same size as the damaged O-ring.





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## Section IX. METAL TUBING

## 3-28. GENERAL

To operate some of the vehicle mechanisms, a considerable amount of energy must be exerted. Hydraulic power is used to perform these high-energy tasks. High-energy requirements (or high-speed tasks) are usually met with high-pressure hydraulic lines or tubing made of metal. There are also metal low-pressure lines, usually used when heat is a consideration or shape is critical. This section covers expedient repairs on metal tubing.

## 3-29. METAL TUBE BENDING

Bending may be required to make tubing repairs. Dry sand can be poured into the tube to be bent. The ends must be plugged to keep the sand from falling out. Soft metal tubes can be sealed with finger pressure, but harder lines should have a plug inserted. After bending the tube, flush the sand from the tubing with a liquid to ensure removal of all particles.

## 3-30. HYDRAULIC LOW-PRESSURE METAL TUBING REPAIR

## General Information:

Damaged low-pressure metal hydraulic lines can be replaced with other available lines (high-pressure, metal, or rubber hoses).

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 30-120 minutes

## Materials/Tools:

- o AN/MS fittings
- 0 Hacksaw
- 0 Hand file
- 0 Beading tool
- 0 Wire
- 0 String
- 0 Sealant
- 0 Shrink tubing
- 0 Tube cutter

## Other Options:

- o Refer to chapter 5.

### Procedural Steps:

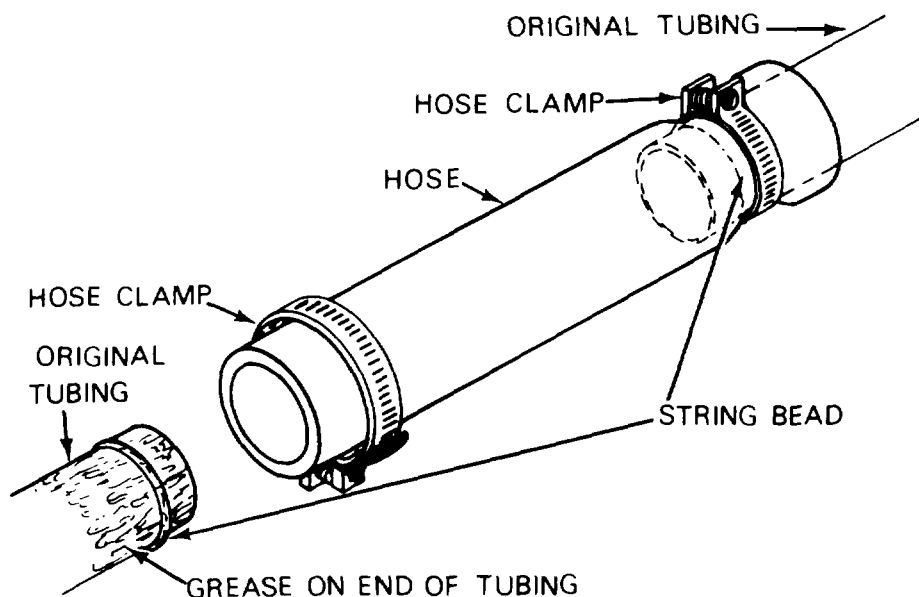
#### Option 1: Replacement of a Short Damaged Tube Section.

1. Cut out and square the damaged portion of the tubing.
2. Deburr and clean the ends.

#### NOTE

If a beading tool is not available, make an improvised head by wrapping string or wire around the tube. Coat the string or wire with sealant or hardening epoxy.

3. Bead the tubing 1/2 inch from the ends.
4. Select a length of medium- or high-pressure hose with an inside diameter equal to the outside diameter of the tube. Cut the length 4 inches longer than the removed piece of tubing.
5. Coat string and hose with sealant.
6. Slide the hose ends over the ends of the tubing. Use grease or system fluid to aid in sliding the hose over the tubing, particularly the bead.
7. Secure the hose with two hose clamps. Position clamp screws 180 degrees to each other. Pressure test the assembly.

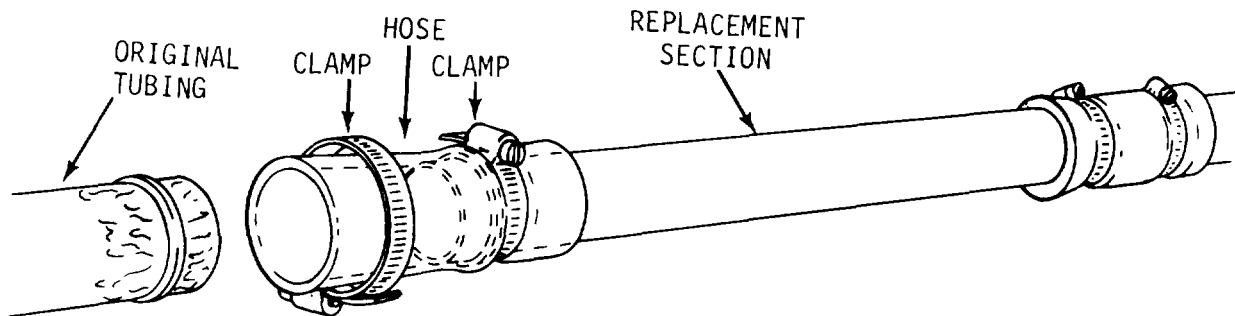


8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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Option 2: Replacement of Long Damaged Tube Section.

1. A long damaged section of metal tubing should be replaced with a new section of metal tubing. Use a piece of rubber hose and two hose clamps at each end to install the replacement section.



2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Heat Shrink Tubing (Short Damaged Lengths).

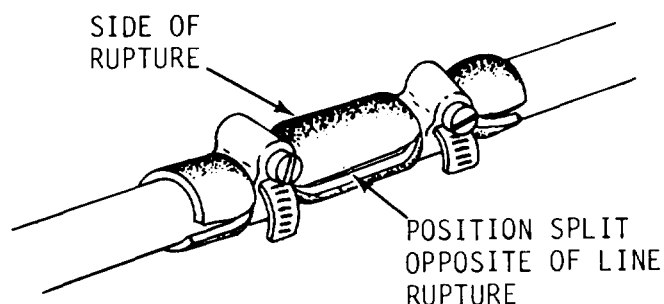
1. Cut out damaged section of tubing; deburr and clean ends.
2. Select a piece of shrink tubing with inside diameter equal to the outside diameter of the tube. Cut shrink tubing 2 inches longer than the piece of removed tubing.
3. Slip the shrink tubing 1 inch over each end of the cut installation.
4. Heat the portion of the heat-shrink tubing that is over the metal tubing and seal the connection.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 4: Tube Patch.

**NOTE**

If a rubber hose is not available, use a piece of patch material, rubber (piece of inner tube), gasket, or poncho material. If a hose clamp is not available, use tape, lacing wire, or copper wire. Check system fluid level frequently.

1. Use a piece of reinforced hose with an inside diameter equal to the outside diameter of the tube.
2. Split the hose lengthwise.
3. Coat the inside of the hose with sealant, if available. Install hose over the leak with the split opposite the leak.
4. Secure with a hose clamp directly over the leaking area.



5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**3-31. HYDRAULIC HIGH-PRESSURE METAL TUBING REPAIR****General Information:**

The following options are offered for the repair/replacement of high-pressure metal lines.

**Limitations:**

- o None

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Personnel/Time Required:

- o 2 soldiers
- o 30-90 minutes

Materials/Tools:

- o Tubing
- o Hose
- o Hose clamps
- o AN fittings
- o MS fittings
- o Tube cleaner
- o Coupling
- o Tube cutter
- o Hacksaw
- o Swage tool
- o Hand file
- o Tube flaring kit

Procedural Steps:

Option 1: Use Larger or Smaller Tubing.

1. Remove the damaged line.
2. Bend a larger or smaller line to conform to the damaged one.
3. Cut new line to length.
4. Install fittings on the new line that can be reduced or enlarged to adapt to the damaged line.
5. Flare the ends with swage or flaring tool.
6. Install new line.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

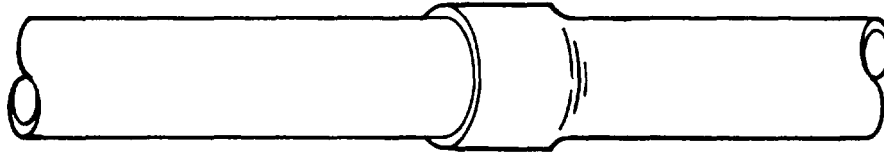
Option 2: Substitute with High-Pressure Hose.

1. Use a high-pressure hose to replace the damaged line. The temporary hose may follow a different path than the original line. Clamp the hose to hard supports at convenient intervals to secure the hose.
2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Swage and Solder Tubing.

1. Cut damaged area from tubing.
2. Square off tubing ends.
3. Swage one end of the tubing with swage tool.
4. Insert the other end of the tubing into the swaged end.

5. Solder the tubing at the swaged joint.
6. Operate the system and check for leaks.



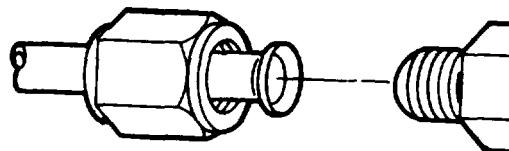
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 4: Nonflared Tube Coupling.

**WARNING**

Make sure coupling meets the psi requirement of the system. A coupling that breaks apart can damage equipment and injure personnel.

1. Cut damaged area from tubing.
2. Square off tubing ends.
3. Install a compression coupling into damaged line. If line is too short to repair, add a new piece of tubing to make up the distance and use two compression couplings.
4. Operate the system and check for leaks.



5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

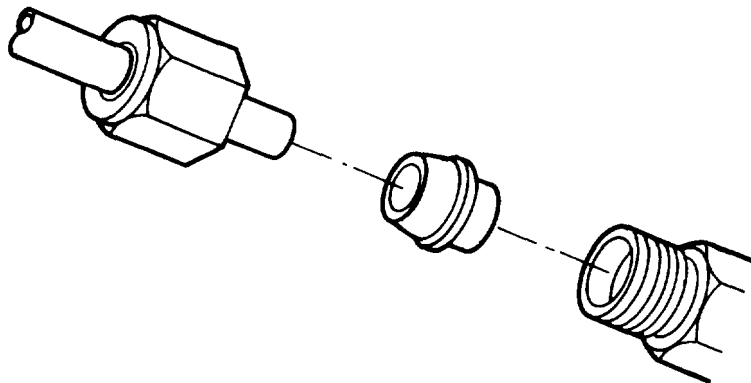
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Option 5: Flare Tube Coupling.

**NOTE**

Make sure the flaring kit is for 37-degree JIC fittings.

1. Cut damaged area from tubing.
2. Square off tubing ends.
3. Install the coupling nuts on the tube.
4. Flare both ends of tubing and connect tubing ends.
5. If the tube is too short to be coupled, flare a short piece of tubing on one end. Add the coupling nuts and flare the remaining end.
6. Connect the two couplings.
7. Operate the system and check for leaks.



8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section X. HYDRAULIC LINE REPAIR

## 3-32. GENERAL

This section provides expedient repair procedures for the hydraulic system. Procedures cover different methods of repair for high- and low-pressure tubes and hoses.

## 3-33. HYDRAULIC TUBE AND HOSE REPAIR

## General Information:

These procedures tell how to repair damaged hydraulic tubes and hoses. Use the following options to repair any damaged hydraulic tube or hose. To repair high-pressure lines use only the high-pressure options recommended. High-pressure procedures also may be used for low-pressure line fixes if the situation calls for it.

## Personnel/Time Required:

- o 1 soldier
- o 25 to 40 minutes

## Materials/Tools:

- o Correct size hydraulic hose or tubing
- o Hose clamps
- o Sealing compound
- o Adhesive tape
- o Hacksaw
- o Nipples

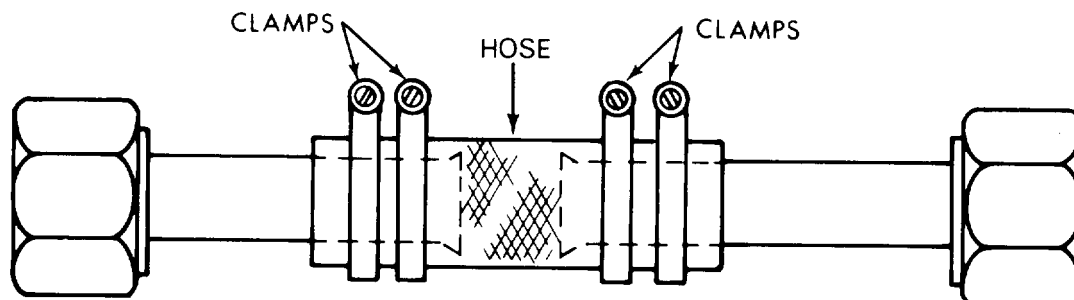
## Option 1: Tube Repair with a Rubber Hose.

## Limitations:

- o Not recommended for pressure above 70 psi

## Procedural Steps:

1. Squarely cut each end of damaged tube. Flare each end of damaged tube, if possible, and remove burrs.
2. Measure and record distance between cut ends of damaged tube.
3. Cut a length of correct diameter rubber hose 6 inches longer than distance measured.
4. Spread a light coat of sealing compound inside rubber hose.
5. Position hose between flared tube ends and secure each end with two clamps.



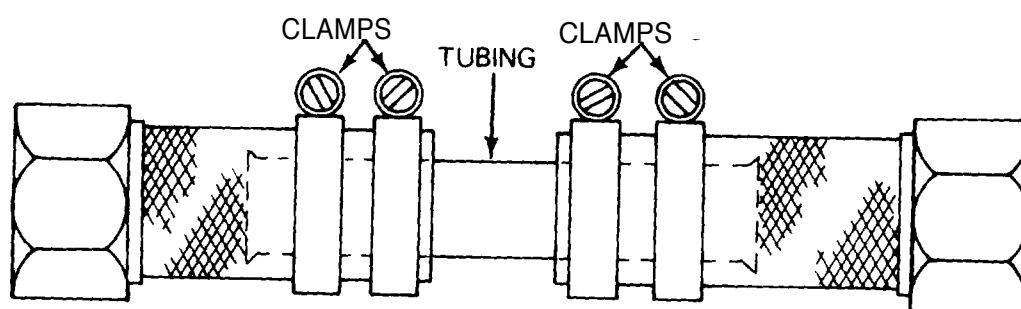


6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Hose Repair with Tubing.

##### Procedural Steps:

1. Use tape and wrap end of hose to be cut. Squarely cut each end of damaged hose. Clean loose particles from ends of rubber hose.
2. Measure and record distance between cut ends of damaged hose.
3. Cut length of correct diameter tubing 6 inches longer than distance measured.
4. Flare each end of tube, if possible, and remove burrs.
5. Spread a light coat of sealing compound around each end of tube.
6. Position tube inside each end of cut hose and secure each end with two clamps.

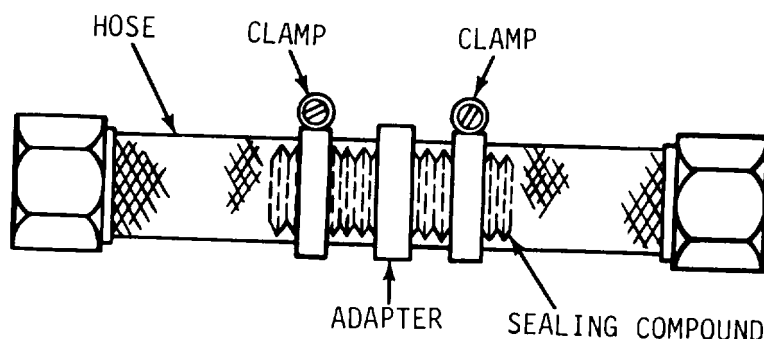


7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 3: High-Pressure Hose Repair with an Adapter.

##### Procedural Steps:

1. Use tape and wrap each end of hose to be cut. Squarely cut each end of damaged hose. Clean loose particles from ends of hose.
2. Spread a light coat of sealing compound on threads of adapter.
3. Install adapter or tube into each end of hose.
4. Secure hose and adapter with clamps.

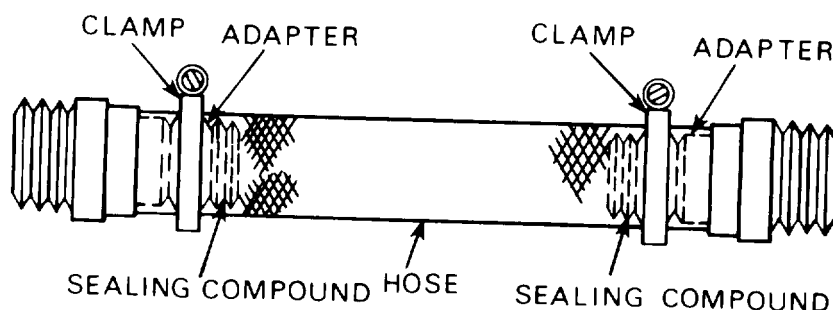


5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 4: High-Pressure Hose Repair (Same Size Hose Ends).

##### Procedural Steps:

1. Use tape and wrap each end of hose to be cut. Cut section of hose to length required. Be sure each end is squarely cut.
2. Spread a light coat of sealing compound on threads of one end of adapter.
3. Install end with sealing compound into hose. Secure with clamps.



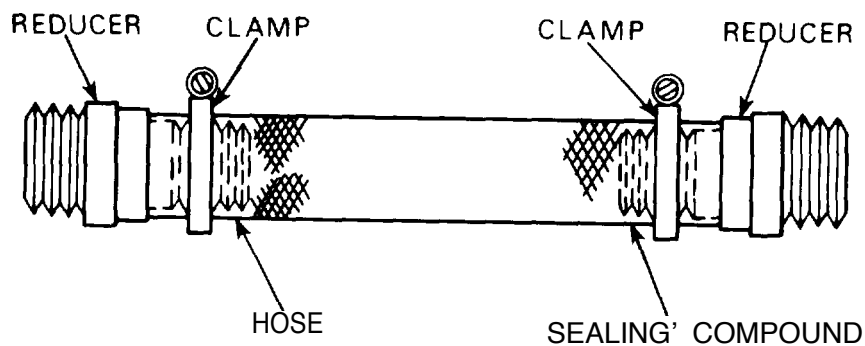
4. Repeat steps 2 and 3 for other end of hose.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 5: High-Pressure Hose Repair (Different Size Line Ends).

##### Procedural Steps:

1. Use tape and wrap each end of hose to be cut. Cut section of hose to length required. Be sure each end is squarely cut.
2. Spread a light coat of sealing compound on threads of one end of reducer.
3. Install end of reducer with sealing compound into hose. Secure with clamp.

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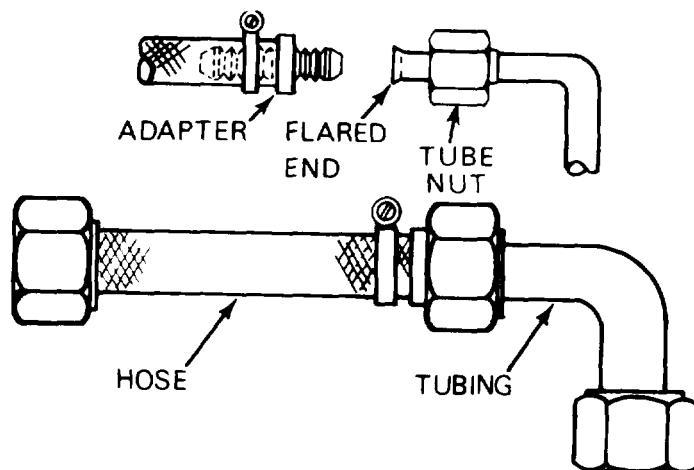
4. Repeat steps 2 and 3 for other end of hose.

5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 6: High-Pressure Line Repair (Hose and Tube Splice).

##### Procedural Steps:

1. Install adapter in hose. Refer to option 3 or 5.
2. Squarely cut end of tubing. Slide tube nut over tube,
3. Flare end of tube and remove burrs.
4. Connect hose and tube.

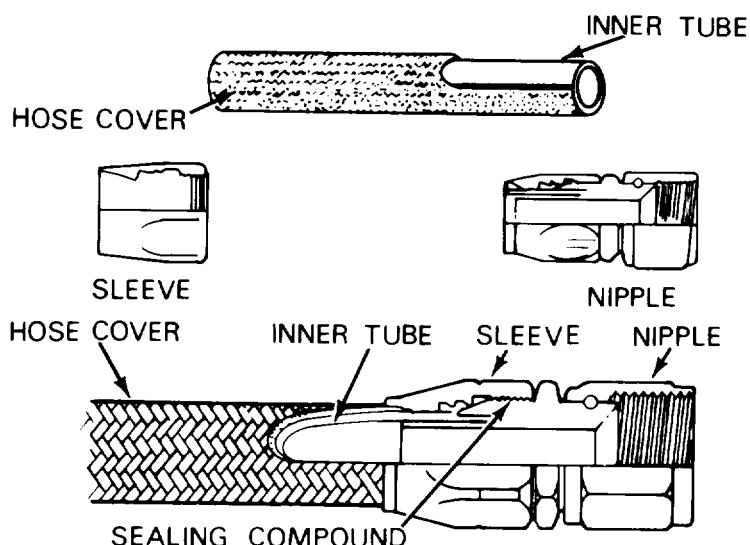


5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 7: High-Pressure Line Repair (Same Size Line End).

#### Procedural Steps:

1. Measure desired length of hose. Tape and mark area to be cut.
2. Squarely cut hose and remove loose particles and tape.
3. Install sleeve over hose cover.
4. Apply light coat of sealing compound on threads of nipple. Install nipple between hose cover and inner tube.
5. Install sleeve on nipple and tighten.



6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### 3-34. HYDRAULIC TUBE AND HOSE ISOLATION

#### General Information:

These procedures tell how to isolate damaged hydraulic tubes and hoses. Use the following options to plug or seal a damaged hydraulic circuit so that the rest of the system can operate without losing fluid.

#### Option 1: Low-Pressure Hose Isolation.

#### Limitations:

- o Not recommended for pressure above 70 psi

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Personnel/Time Required:

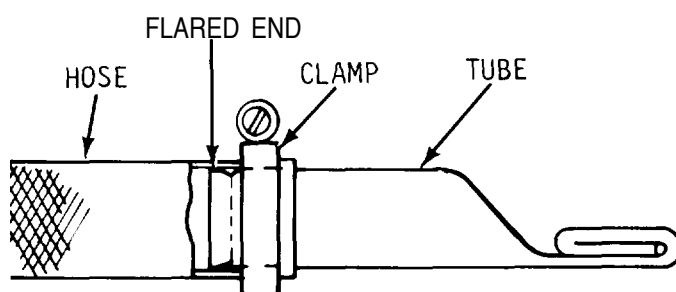
- o 1 soldier
- o 30 minutes to 2 hours

Materials/Tools:

- o Correct size tubing
- o Clamps
- o Adhesive tape
- o Sealing compound
- o Pipe plug
- o Tube pipe fitting kit
- o Hexagon-head screw

Procedural Steps:

1. Wrap tape around area to be cut. Squarely cut end of hose and remove loose particles.
2. Flatten about 4 inches of one end of tubing. Fold flat end over twice.



3. Flare other end of tubing, if possible, and remove burrs. Apply light coat of sealing compound around flared end of tube.
4. Slide flared end of tube inside hose and secure with clamp.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

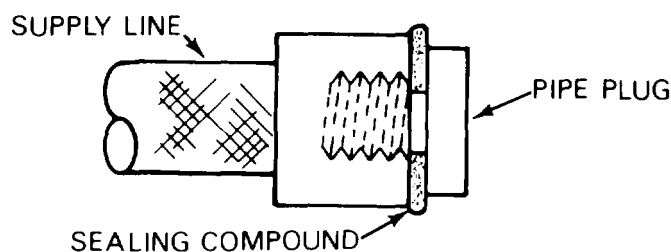
Option 2: High-Pressure Line Repair Using Plugs.

Limitations:

- o None

Procedural Steps:

1. Disconnect broken hose at source.
2. Coat threads of pipe plug with sealing compound.
3. Insert pipe plug in place of hose.

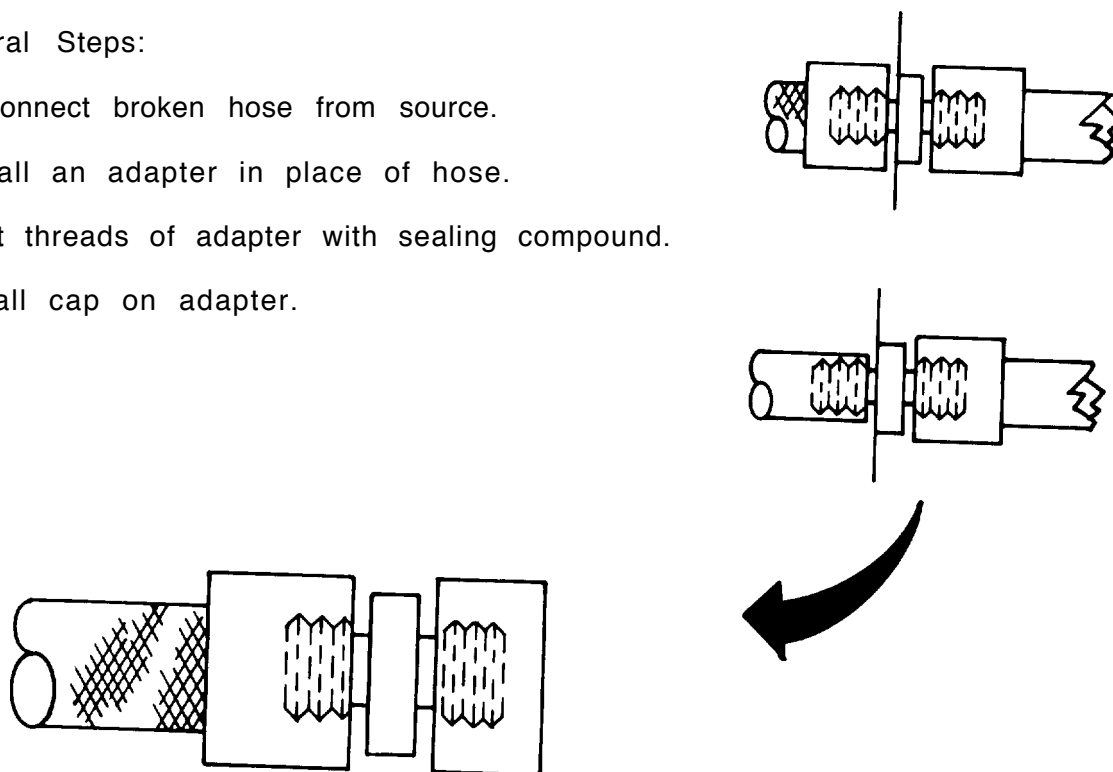


4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 3: High-Pressure Line Repair with a Cap.

## Procedural Steps:

1. Disconnect broken hose from source.
2. Install an adapter in place of hose.
3. Coat threads of adapter with sealing compound.
4. Install cap on adapter.

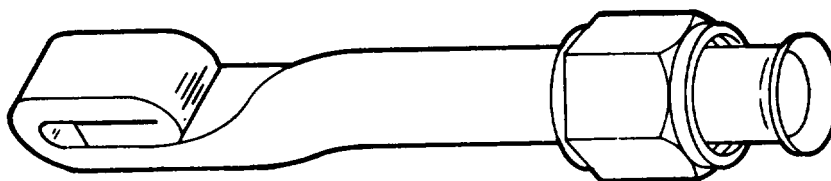


5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 4: High-Pressure Line Repair Using Flattened Tube End.

## Procedural Steps:

1. Remove broken tube, if necessary.
2. Flatten about 6 inches of tubing near break.
3. Fold flattened portion of tube over twice.



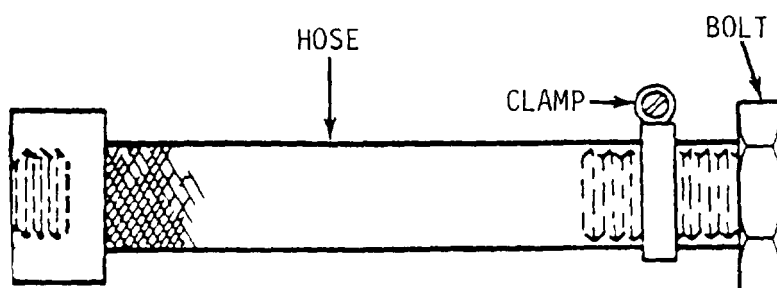
4. Install repaired tube if removed.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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### Option 5: High-Pressure Line Repair Using a Bolt.

#### Procedural Steps:

1. Wrap tape around area to be cut. Squarely cut end of hose and remove loose particles.
2. Install long hexagon-head screw inside hose.
3. Secure with clamps.



4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 4

### SELF-RECOVERY

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED

#### 4-1. GENERAL

Self-recovery is the ability to recover a vehicle that is immobile because of terrain and/or weather conditions. This chapter will deal with vehicles that are mired but not damaged by combat or equipment failure.

#### 4-2. ASSESSMENT CHART

- a. Preconditions: Vehicle must be in all-wheel drive.
- b. Inspect  $\longrightarrow$  Will not move:
  - $\downarrow$
  - ~All tires buried in mud; . . . . . go to paragraph 4-4
  - ~Front tires stuck in a ditch; . . . . . go to paragraph 4-5
  - ~Vehicle off road due to mud and/or snow; . go to paragraph 4-6

#### 4-3. BDAR PROCEDURE INDEX

	Para
All Tires Buried in Mud . . . . .	4-4
Front Tires in a Ditch . . . . .	4-5
Vehicle Off Road Due to Mud and/or Snow . . . . .	4-6



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#### 4-4. ALL TIRES BURIED IN MUD

##### General Information:

A mired dual-wheel vehicle without a winch may be able to free itself by using the rear wheels as a winch. A suitable anchor is required to aid in the recovery because mud has a suction effect on mired objects.

##### Limitations:

- o None

##### Personnel/Time Required:

- o 2 soldiers
- o 1 - 4 hours

##### Materials/Tools:

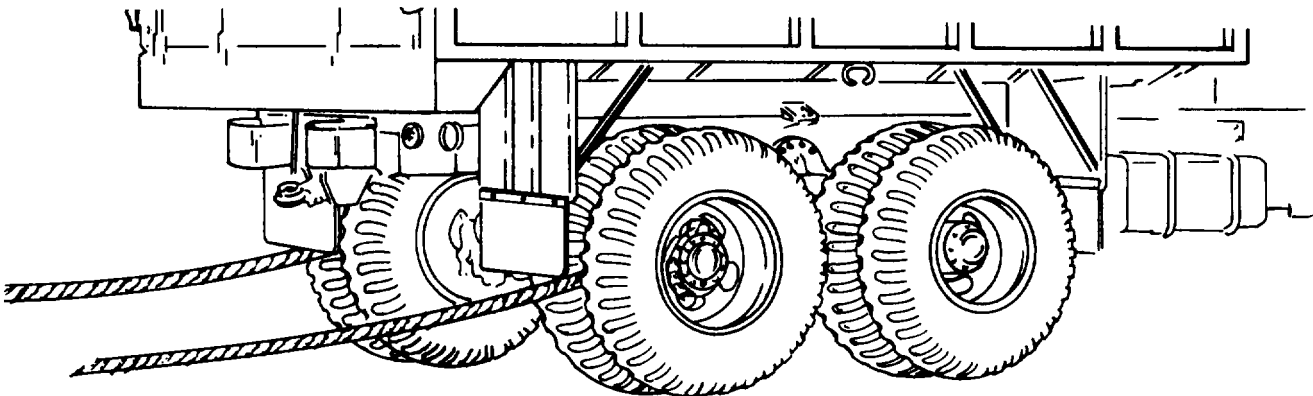
- o Rope
- o Timber (5 feet minimum)
- o Cable

##### Procedural Steps:

##### WARNING

All personnel not involved in the recovery operation shall be no closer to the vehicles than the longest cable used. Death or serious injury can result if the cable breaks.

1. String a rope or cable between the tires on each rear dual.
2. Feed rope or cable through one of the holes in the wheel.
3. Fasten rope or cable to wheel hub.
4. Anchor the other end of rope or cable (para 4-6).
5. Use reverse gear and let the rope/cable wind between the dual wheels to give the same action as a winch.
6. If damage is sustained during recovery, repair vehicle using BDAR or standard procedures as necessary.



#### 4-5. FRONT TIRES IN A DITCH

##### General Information:

Frequently a truck will become nosed in a shell hole or narrow ditch where both lifting and pulling forces are required to make the recovery. If the nosed truck is equipped with a winch, use the winch to supply the pulling force and an A-frame for the lifting force.

##### Limitations:

- o None

##### Personnel/Time Required:

- o 2 to 3 soldiers
- o 1-4 hours

##### Materials/Tools:

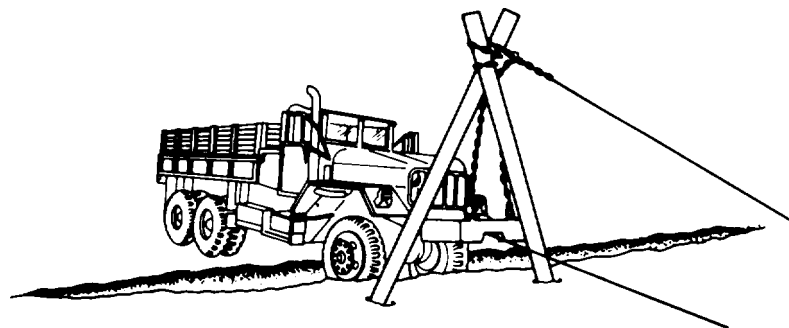
- o Timbers, 8 to 10 feet minimum
- o Tow chain, 20 feet

##### Procedural Steps:

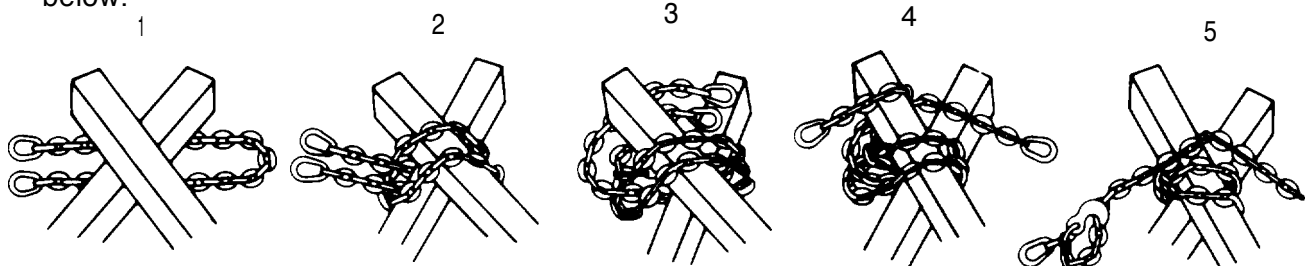
##### WARNING

All personnel not involved in the recovery operation shall be no closer to the vehicles than the longest cable used. Death or serious injury can result if the cable breaks.

1. Build an A-frame with two poles long enough to clear the front of the truck once it is raised.



2. Lash the poles together at the top with a figure-eight or girth hitch as shown below.



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3. Place the lower end of the poles in the ground, 10 to 12 inches deep, to prevent them from sliding when the power is applied.
4. Lay the upper end of the A-frame against the front of the vehicle and attach the chain to the bumper.
5. Secure the end of the winch cable to the apex of the A-frame and wind in winch. This will lift and pull the truck forward.
6. Fill the ditch with rocks, dirt, or other material so that the vehicle can be driven in either direction.
7. If damage is sustained during recovery, repair vehicle using BDAR or standard procedures as necessary.

#### 4-6. VEHICLE OFF ROAD DUE TO MUD AND/OR SNOW

##### General Information:

Vehicles with a winch can usually recover themselves if an anchor can be found or made. Vehicles with dual wheels can use the winching procedure in paragraph 4-4. A vehicle without a winch can be recovered with the help of another vehicle. If no other vehicle is available, the following procedure will help to recover light-duty vehicles.

##### Limitations:

- o None

##### Personnel/Time:

- o 2 soldiers
- o 30 minutes - 6 hours

##### Materials/Tools:

- o Rope
- o Wooden pickets (minimum 5 feet long and 3 inches thick)
- o Tow chain

##### Procedural Steps:

#### **WARNING**

All personnel not involved in the recovery operation shall be no closer to the vehicles than the longest cable used. Death or serious injury can result if the cable breaks.

##### Single-axle vehicles w/o winch

1. Find a natural anchor such as a tree or a large embedded rock within reach of the tow chain or rope. If no trees are readily available, use a piece of timber that is buried at least 3 feet in the ground.
2. Use block and tackle or a come-along to winch vehicle onto the road.
3. If damage is sustained during recovery, repair vehicle using BDAR or standard procedures as necessary.

## CHAPTER 5

## ENGINE

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

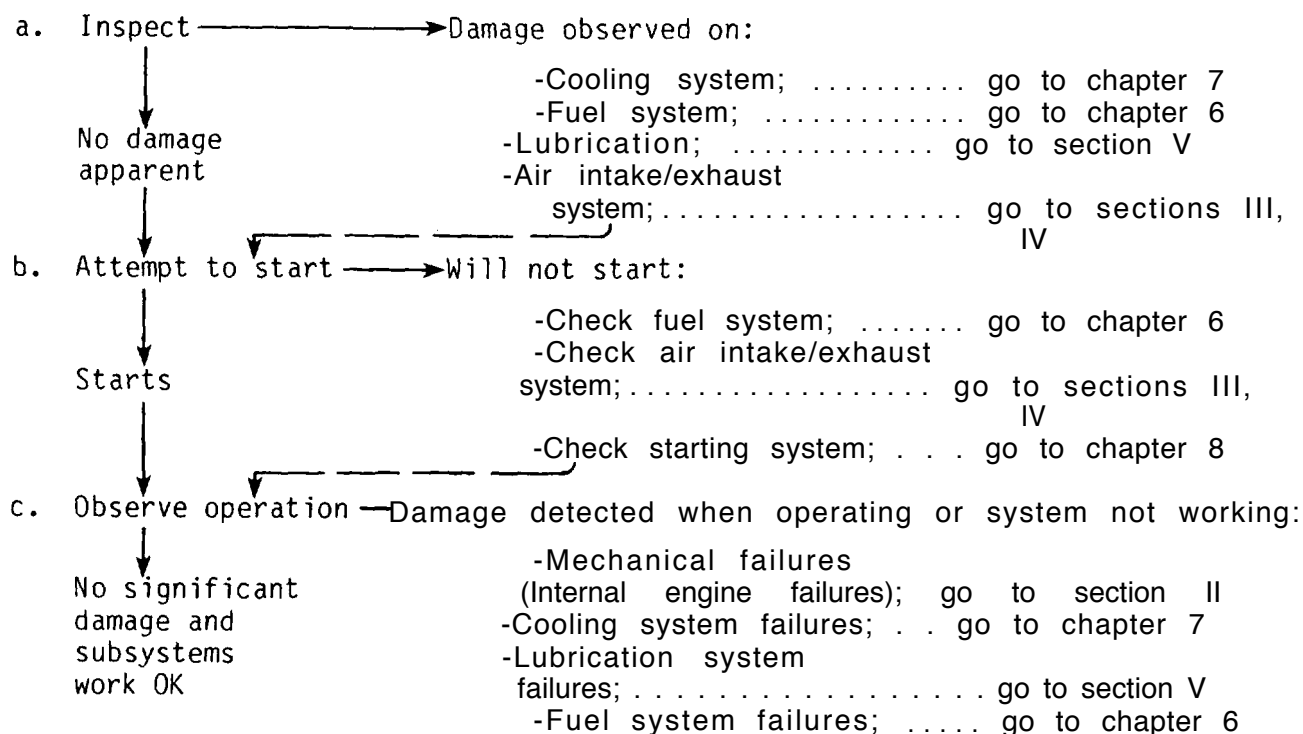
## 5-1. GENERAL

Most current tactical vehicles are powered by diesel fuel engines. Engine condition is monitored by sending units transmitting impulses to dash-mounted gages and warning lights. Engine malfunctions can be detected by:

- a. Abnormal oil pressure or temperature readings
- b. Abnormal noises
- c. Abnormal amounts or coloration of exhaust smoke
- d. Sudden loss of power or excessive fuel consumption
- e. Warning lights

This chapter gives various expedient fixes which can restore the vehicles mobility in the event of engine system failure.

## 5-2. ASSESSMENT CHART



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5-3. BDAR PROCEDURE INDEX	Para
Engine Interchangeability .....	5-5
Engine Air Intake for Naturally Aspirated Engines . . . . .	5-6
Engine Air Intake for Turbocharged Engines . . . . .	5-7
Engine Air Intake for Supercharged or Turbosupercharged Engines .....	5-8
Blower Drive Shaft Broken .....	5-9
Air Cleaner Clogged .....	5-10
Air Cleaner Damaged/Leaking .....	5-11
Intake Manifold or Other Castings or Containers Damaged .....	5-12
Exhaust Manifolds Damaged .....	5-14
Lubrication System Pump Failure .....	5-16
Oil Level Low .....	5-17
Hole in Oil Pan .....	5-18

## Section II. ENGINE FAILURE

## 5-4. GENERAL

Basic engines in tactical vehicles of a single family are the same but engine supports, manifolds, and exhaust or cooling systems require different brackets to fit a particular vehicle. Accessories and brackets must be swapped from the unserviceable engine to make the replacement engine fit another application.

## 5-5. ENGINE INTERCHANGEABILITY

## General Information:

Replace engine with any engine that can be converted and installed. Availability of engines may become restricted to those found in damaged vehicles. Basic engines from other vehicles can be modified or reconfigured to fit the vehicle needing the engine. Internal engine components may be interchanged, giving increased or decreased engine performance. The proper engine should be obtained as soon as possible to normalize vehicle operation. The following tables give some interchangeability information for Cummins, Detroit Diesel, and multifuel engines.

Table 5-1. Cummins Engine to Vehicle Model

		ENGINE MODEL					NTC 400 BIC CAM I	NTC 400 BIC CAM III
		V265	V300	VT903 V903C	NHC 250	NTC 290	NTC 380	
V E H I C L E  M O D E L	M939 series truck				x			
	M809 series truck				x			
	M290							
	10-ton Wrecker		x					
	M915 series							x
	M915A1							
	Navy 10-ton truck					x		
	M9 Earthmover							
	Erie Crane	x						
	M2 Infantry Fighting Vehicle							XT
	M3 Cavalry Fighting Vehicle							XT

x - Indicates the proper engine for each vehicle.

XT - Indicates turbo.

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Table 5-2. Detroit Diesel Engine to Vehicle Model/Equipment

		ENGINE MODEL								
		3-53	4-53	6V-53	3-71	6-71	6V-71T	8V-71T	12V-71T	8V-92TA
V E H I C L E  O R  E Q U I P M E N T	M561	x								
	LTV					x				
	Generator	x								
	6,000-lb RT Forklift		x							
	Mobile Assault Bridge									
	Ingersol Rand Air Compressor 750 CFM									
	M113									
	20-Ton Truck									
	LVS MK48									x
	6,000-lb RT Forklift									
	M730 Lance Carrier									
	M108 SP How							x		
	M109 SP Hiow							XT		
	M578 Rec Veh							XT		
	HEMTT									x
	M911									x
	45 kW Stuart Stevens Generator									
	30 kW Hogar Generator	x								

x - Indicates the proper engine for each vehicle.  
 XT - Indicates a turbocharged engine.

Table 5-3. Multifuel Engine to Vehicle Model

		Engine Model					
		465-1	LD 465-10	LDS 465-1A	LDS 465-2	LDT 465-10	LDS 427-2
v	M35	x	x			x	x
EM	2-1/2-Ton						
HO							
I D	M39			x			
CE	5-Ton						
L L							
E	M656				x		
	5-Ton						

X- Indicates the proper engine for each vehicle.

Table 5-4. Detroit Diesel Engine Injector\*

	ENGINE MODEL											
	3-53	4-53	6V-53	3-71	6-71	6V-71	12V-71	4-71	8V-71	8V-92TA	12 V-71T	8V-71T 6-71T
40	x	x	x									
45	x	x	x									
50			x									
I												
N 55				x	x	x	x	x	x			
J												
E 60				x	x	x	x	x	x			
c												
T 65									x			
0												
R 70				x	x		x	x	x	x	x	x
s												
75										x	x	x
80				x	x			x		x	x	x
90										x		x
9200										x		

X- Indicates the proper injector for each engine.

\*Most Detroit Diesel engines can physically be fitted with any of the listed injectors. Degraded running of the engine will be noticed, but no damage will occur by using a smaller or larger volume injector.



Table 5-5. Cummins Engine to Injector\*

		Engine Model				NTC290	NTC380
		V265	V300	V903C	NHC250		
E N G I N E  M O D E L	BM75976	x					
	BM97421		x				
	3007461						
	AR51271				x		
	3013738					x	
	AR40118					x	
	BM92584						x

x - Indicates the proper injector for each engine.

\*Most Cummins engines can physically be fitted with any of the listed injectors. Degraded running of the engine will be noticed, but no damage will occur by using a smaller or larger volume injector.

Table 5-6. Cumins Engine Interchangeability

		ENGINE MODEL						NTC 400 BIC CAM I	NTC 400 BIC CAM 111
		V265	V300	VT903 V903C	NHC 250	NTC 290	NTC 380		
E N G I N E  M O D E L	V265	x							
	V300		x						
	VT903			x					
	V903C			x					
	NHC250				x	x*	x*		
	NTC290				x	x	x*		
	NTC380				x*	x*	x		
	NTC400 BIG CAM I							x	x*
	NTC400 BIG CAM III							x*	x

X - Indicates complete interchangeability.

X\* - Indicates interchangeability with minor exterior component changes.

Table 5-7. Detroit Diesel Engine Interchangeability

		ENGINE MODEL									
							6V-71	8V-71	12V-71	8V-92	
		3-53	4-53	6V-53	3-71	6-71	6V-71T	8V-71T	12V-71T	8V-92T 8V-92TA	
ENGINE MODEL	3-53	x									
	4-53		x								
	6V-53										
	3-71				x						
	6-71					x					
	6V-71						x				
	6V-71T						x				
	8V-71							x			
	8V-71T							x			
	12V-71								x		
	12V-71T								x		
	8V-92									x	
	8V-92T									x	
	8V-92TA									x	

x - Indicates engine and internal component interchangeability.

Table 5-8. Multifuel Engine Interchangeability

		Engine Model					
		465-1	465-1C	LDS 465-1A	LDS 465-2	LDT 465-1C	LDS 427-2
E N G I N E	LD465-1	x	x	x	x	x	X*
	LD465-1C	x	x	x	x	x	X*
	LDS465-1A	x	x	x	x	x	
M O D E L	LDS465-2	x	x	x	x	x	
	LDT465-1C	x	x	x	x	x	x*
	LDS427-2	X*	X*			X*	x

x - Indicates interchangeability with minor exterior component changes.

x\* - Indicates that a complete engine must be interchanged.

## Section III. ENGINE AIR INTAKE SYSTEMS

## 5-6. ENGINE AIR INTAKE FOR NATURALLY ASPIRATED ENGINES

Naturally aspirated engines require a downward piston movement to create a vacuum, drawing air into the intake system. To avoid damage to this type of system, prevent drawing unfiltered air into the engine. Repairs to this system should always be done with materials that do not block the air flow and that are securely attached to prevent them from being sucked into the engine through the intake manifold.

## 5-7. ENGINE AIR INTAKE FOR TURBOCHARGED ENGINES

Turbocharged engines use exhaust gases to drive the turbocharger, compressing the air and forcing it into the cylinder; therefore, the engine air intake system is vacuum and pressure. Assessment and repairs to turbocharged air systems, should, therefore, be based on the rules above for the system up to the turbocharger inlet. Repairs should seal the outlet so that the air pressure does not escape. Because the turbocharger is driven by exhaust gases, repair to the drive system must seal the exhaust gases to prevent depressurization.

## 5-8. ENGINE AIR INTAKE FOR SUPERCHARGED OR TURBOSUPERCHARGED ENGINES

Supercharged engines use a mechanical system to drive the air intake compressor. The supercharger is usually mounted directly on the intake manifold or engine block. Some Detroit Diesel models are turbosupercharged. Damage assessment and repair to these engines require the same techniques and precautions as turbocharged engines for the vacuum and pressurized parts of the air intake system. Because superchargers are mechanically driven, repairs to the drive system will usually require repair parts.

## 5-9. BLOWER DRIVE SHAFT BROKEN

## General Information:

The blower provides pressurized air to the engine air box. The blower is driven by a drive shaft (quill shaft) which acts as the fuse for the supercharger system. The shaft shears when it is overloaded to protect the blower from damage. The shaft can be repaired if a new part is not available.

## Limitations:

- o Blower may be damaged

## Personnel/Time Required:

- o 1 soldier
- o 1 hour

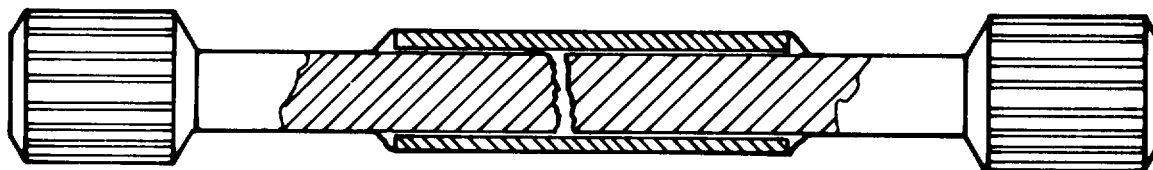
## Materials/Tools:

- o Tubing or sleeve
- o Welding equipment
- o Shop van/lathe

### Procedural Steps:

#### Option 1: Weld using Tubing or a Sleeve.

1. Gain access to the drive shaft and remove both broken ends.
2. Use heavy steel tubing or machine a sleeve that will fit the broken shaft.
3. Install sleeve or tube on shaft. Ensure that the proper length is maintained.
4. Weld ends of sleeve to shaft.



5. Install blower drive shaft.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Weld Without a Sleeve.

#### NOTE

Try to determine the length of the shaft before turning it on a lathe.

1. Record the length of the shaft. Use a lathe to square off and chamfer each half of the broken shaft.
2. If the shaft is damaged but not broken, cut through the damaged area and perform step 1.
3. Center and drill each half with the proper size drill to tap each half the same size, approximately 1/4 to 3/8 inch in diameter.
4. Tap each side approximately 1 inch deep.
5. Cut off a bolt with the same thread size as the shaft halves and that matches the proper tapped length.
6. Screw the two halves together as close to the overall length of a new shaft. Check by inserting the shaft in the blower housing.

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7. After the proper length has been determined unscrew the two halves. Find and insert a spacer (e.g., washer or nut) that will allow the two shafts to be screwed together tight for proper length.
8. Screw both halves together tight.
9. Chuck the newly made shaft into a lathe.
10. Put a rotating center into the tailstock of the lathe. Adjust the tailstock to align the shaft.
11. Turn the lathe by hand and check the shaft for straightness. Tap with a light hammer if necessary.

**CAUTION**

Tack the two halves together at four different points to help keep the shaft true. Excess heat can cause warpage and damage to the shaft.

12. Weld the shaft together while the shaft is still locked in the lathe. Rotate and check the shaft after every tack and every weld.
13. Bathe the shaft in clean SAE 30 motor oil to cool.
14. Install blower drive shaft.
15. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

5-10. AIR CLEANER CLOGGED

General Information:

The air cleaner is essential for keeping dirt and dust from getting into the engine. Under heavy dust conditions the filter can become clogged and restrict the air flow. Lack of air will result in incomplete fuel combustion, resulting in reduced power and excessive exhaust smoke. Dirt should be blown out of the filter with compressed air directed from the inside of the filter element. The filter element may be tapped to dislodge dirt.

Limitations:

- o None

Personnel/Time Required:

- o 1 soldier
- o 15 minutes

Materials/Tools:

- o Rubber hose  
(Part of B11)

**Other Options:**

- o Use vacuum cleaner
- o Gently tap filter against hard surface

**Procedural Steps:**

1. Remove air cleaner elements.
2. Clean filters using one of the following methods:
  - a. Dismount a blower motor (such as dust exhausters), connect to power source with long leads, and blow dirt from air cleaner.
  - b. Disconnect exhaust hoses from all but one blower. Connect hoses together using tape to gain sufficient length to reach outside. Start engine and blower and blow dirt deposits from filters.
  - c. Use air from a disabled wheeled vehicle's tires. Remove valve stem and connect rubber hose to valve and blow out filters.
  - d. Use brake air tank from wheeled vehicle by connecting rubber hose, or place filter directly under air flow from valve.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**5-11. AIR CLEANER DAMAGED/LEAKING****General Information:**

The air cleaner must filter incoming air for the engine. Damage or leaks that cause the air cleaner to be ineffective must be repaired. Leaks in the filter housing or duct work can be taped over or covered by a rag that will filter air coming through the leak. Sealing the leak is preferred. Only as a last resort should the air cleaner be bypassed or eliminated. Damage will occur as the engine ingests the dirt and dust from unfiltered air. If the only option is to eliminate the air filter, this procedure will allow a minimum amount of air filtration.

**Limitations:**

- o Possible degraded mobility

**Personnel/Time Required:**

- o 1 soldier
- o 30 minutes

**Materials/Tools:**

- o Duct or electrical tape
- o Section cut from blanket or shirt
- o Hose
- o Clamp
- o Wire



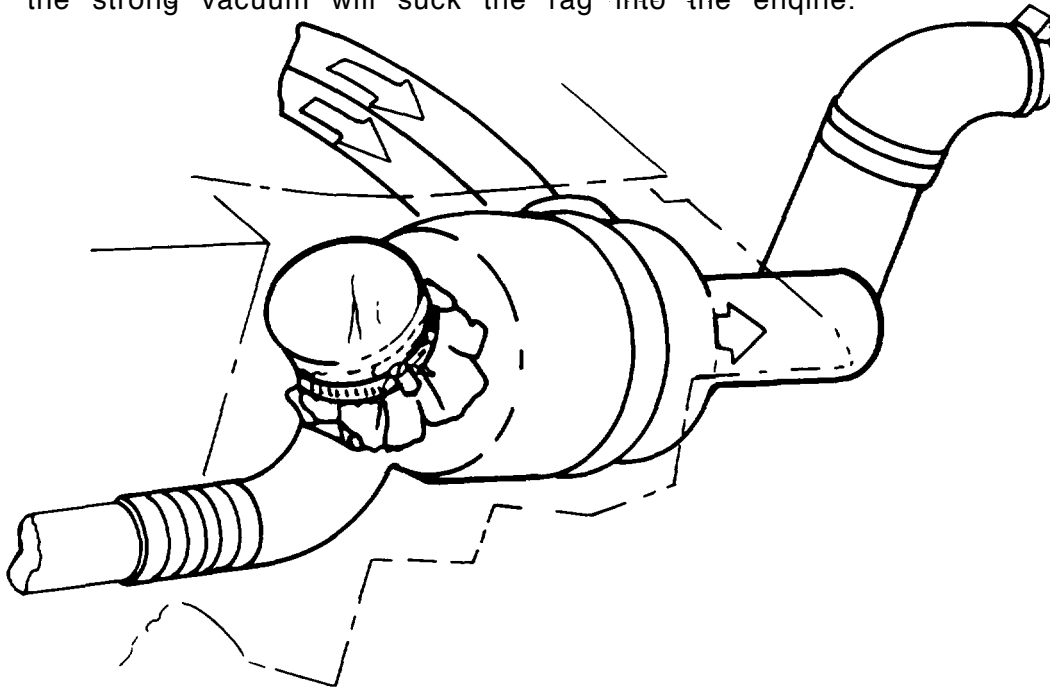
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Other Options:

- o Bypass or eliminate air cleaner

Procedural Steps:

1. Disconnect the air hose at the attachment to the engine.
2. Cover the air inlet with a clean rag (use a shirt or blanket if no rags are available). Clean the rag whenever it gets dirty.
3. Anchor the cloth tightly to the air intake with a hose clamp or wire; otherwise, the strong vacuum will suck the rag into the engine.



4. Record the DAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

5-12. INTAKE MANIFOLD OR OTHER CASTINGS OR CONTAINERS DAMAGED

General Information:

Intake manifolds are difficult to repair. Auto body fillers, epoxies, or gasket sealers can seal cracks. Holes will require welding because of irregular surfaces. Tape will provide a temporary seal on unpressurized air intake portions but has minimal value for pressurized systems without metal or wire reinforcement. Epoxy kits will make an almost permanent repair, if time is available for curing. Follow the individual kit directions.

## Section IV. ENGINE EXHAUST SYSTEMS

## 5-13. GENERAL

The engine exhaust system consists of the exhaust manifold, muffler, and pipes to route the gases out of the vehicle. Turbocharged engines have the exhaust gases routed through the turbocharger to drive the vanes. Damage to the muffler or pipes (not including the ducting for the turbocharger drive circuit) is inconvenient, but the vehicle can still be operated. Care must be taken, however, to keep carbon monoxide out of the crew compartments. Turbocharger drive circuits must be repaired or engine performance will be degraded.

## 5-14. EXHAUST MANIFOLDS DAMAGED

## General Information:

Damaged manifolds are indicated by loud noises. Damage to the exhaust manifolds ahead of the turbocharger will degrade vehicle operation. Continued engine operation may set the fuel lines on fire.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 15-30 minutes

## Materials/Tools:

- o Sheet metal
- o Clamps
- o Asbestos sheet
- o Sealing material

## Other Options:

- o Weld or braze the manifold.

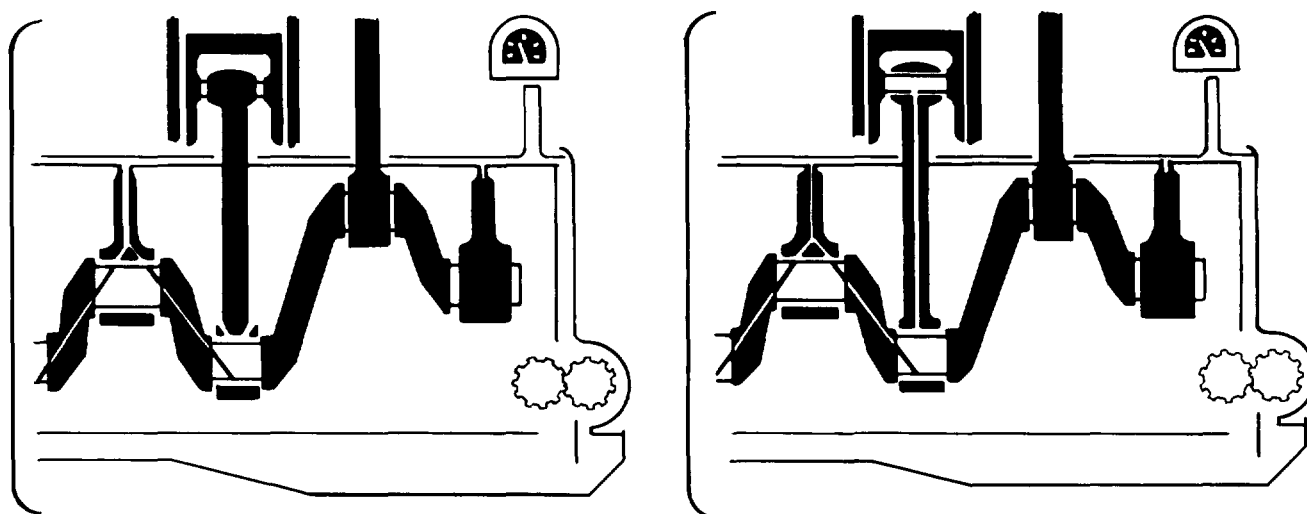
## Procedural Steps:

1. Gain access to the damaged manifold.
2. Obtain a sealing material (asbestos sheet preferred) and cut sheet to cover the hole or leak.
3. Use hose clamps and secure the sheet in place.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section V. ENGINE LUBRICATION SYSTEMS

## 5-15. GENERAL

Engine lubrication is essential for moving components; crankshaft bearings and diesel engine piston crowns are especially critical. The pressure lubrication of the bearings and the cooling spray to the piston crowns are examples of the dual purpose of the engine lubricant. Bypassing or rendering any portion of the lubrication system inoperative will degrade the length of engine life.



Force-Feed Lubrication System

Full Force-Feed Lubrication System

Figure 5-1. Typical Lubrication Systems.

## 5-16. LUBRICATION SYSTEM PUMP FAILURE

## General Information:

The oil pump is needed to provide lubrication to engine components. A warning light or low or no reading of gage indicates a problem. The main and rod bearings as well as a minimal splash lubrication of the pistons is possible by overfilling the crankcase with oil. However, components such as blower, blower drive gears, or turbocharger will not receive any lubrication from overfilling. Valve train components will also lack lubrication but can operate for short time periods. Overfilling the crankcase with oil is a last resort option which should be used only to move under cover. Engine failure will occur if used for normal or limited operation.

## Limitations:

- o Severely degraded mobility
- o Engine destruction likely within 5 minutes

## Personnel/Time Required:

- o 1 soldier
- o 15-20 minutes

## Materials/Tools:

- o Cooking oil
- o Engine oil
- o Transmission oil
- o Diesel fuel

## Procedural Steps:

1. Check oil level.
2. Obtain enough engine or substitute oil to overfill crankcase.
3. Overfill the crankcase.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 5-17. OIL LEVEL LOW

## General Information:

Oil levels can become low because of leakage or burning the oil through normal engine operation. If oils prescribed by the LO are not available, use substitutes listed in appendix D. Oils other than those designed for use in engines will provide limited lubrication. When using diesel fuel, do not dilute the lubrication oil more than approximately three parts diesel fuel to one part engine oil except in extreme emergencies. Keep engine rpm low. Do not dilute lubricating oil with gasoline.

## 5-18. HOLE IN OIL PAN

## General Information:

The oil pan is located at the bottom of the crankcase and serves as an oil reservoir for the engine. In rough terrain, the pan can be punctured very easily because of its location.

## Limitations:

- o Engine failure

## Personnel/Time Required:

- o 1 soldier
- o 2-4 hours

## Materials/Tools:

- o Hardening epoxy
- o Wire screen (fine mesh)
- o Aluminum can
- o Sandpaper

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Procedural Steps:

1. Clean the hole thoroughly.
2. Smooth out sharp edges.
3. Sandpaper the edges of the hole.
4. Cut a piece of screen 1 inch larger than the hole.
5. Apply a thin coat of epoxy to the edges of the hole.
6. Lay the screen over the hole and add another layer of epoxy around the edges. Let it dry approximately 20 to 30 minutes.
7. Cut a patch the same size as the screen from an aluminum can.
8. Coat the entire screen with epoxy and lay the metal patch over the screen.
9. Apply epoxy over the patch.
10. Let dry for 2 to 3 hours.
11. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 6

## FUEL SUPPLY SYSTEM

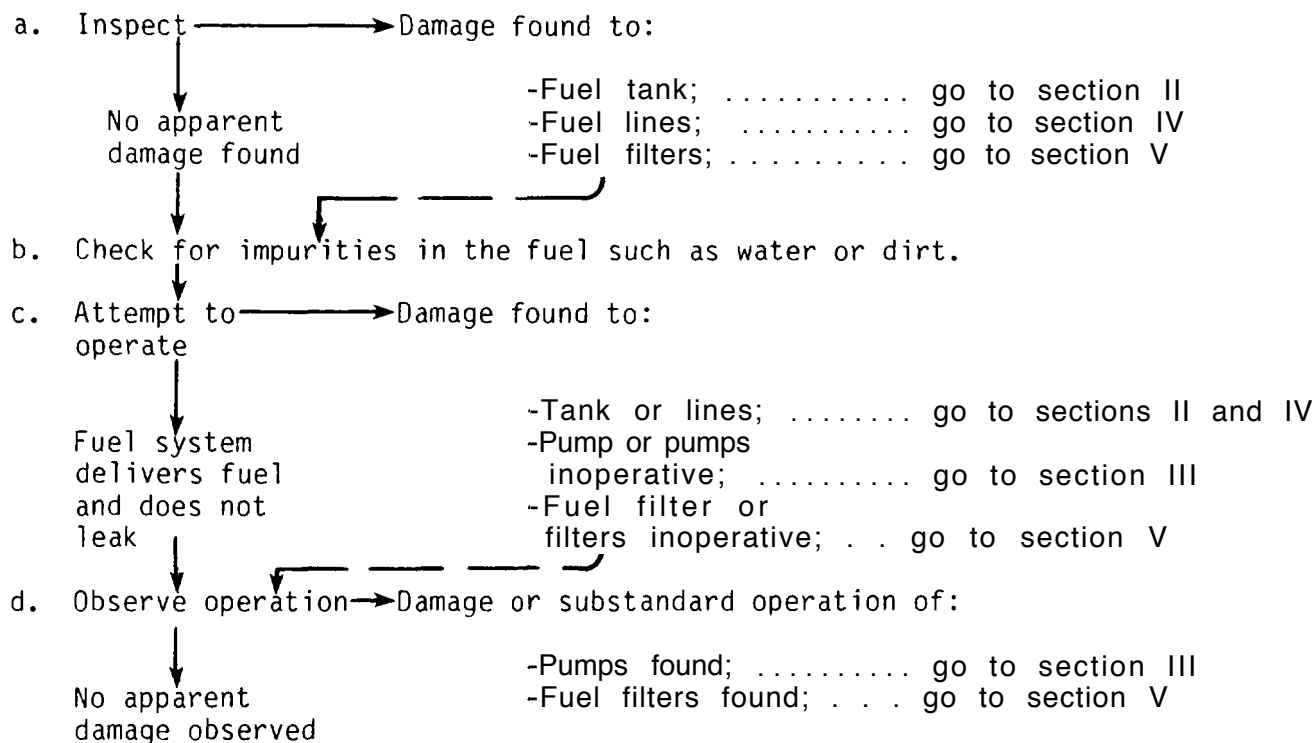
**BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.**

## Section I. GENERAL

## 6-1. GENERAL

Fuel supply systems consist of fuel storage tanks, fuel pumps, filters, and the tubes and hoses needed to route the fuel to the engine. Some systems use electrical pumps located in the tanks and a mechanized, engine-mounted pump to move the fuel. Other systems mount the fuel storage tank in a location which allows gravity flow of the fuel to the engine, assisted by an engine-mounted, mechanized pump. Two filters are mounted in series to provide a primary and secondary filtration system to trap dirt and other contaminants. Fuel filters must be checked for accumulations of dirt and water. A diesel engine can be severely damaged by using unfiltered fuels.

## 6-2. ASSESSMENT PROCEDURE



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6-3.	BDAR PROCEDURE INDEX	Para
	Fuel Tank Leaks .....	6-5
	Fuel Tank Substitute .....	6-6
	In-tank Fuel Pump Interchangeability .....	6-8
	Engine Fuel Pump Interchangeability .....	6-9
	Fuel System Seals Leak .....	6-11
	Fittings Leak .....	6-12
	Fuel Line (Low Pressure Rupture) .....	6-13
	Fuel Injector Line Rupture .....	6-14
	Fuel Filter Clogged or Frozen .....	6-16
	Bypassing Fuel Filter .....	6-17

## Section II. FUEL STORAGE SYSTEMS

### 6-4. GENERAL

Fuel storage systems may be enclosed metal containers, nylon-fiberglass tanks, or rubber reinforced fuel bladders installed in vehicle bulkheads. All systems are susceptible to contamination by dirt or water. Metal tanks are susceptible to corrosion which will contaminate the stored fuel. Draining and purging fuel tanks of contaminants are of major importance for long combat usage. Leakage caused by normal vibration or combat-induced damage must be repaired before the vehicle can be used for combat.

### 6-5. FUEL TANK LEAKS

#### General Information:

The repairs are dictated by the type of material from which the fuel tank, cell, or bladder is manufactured. Fuel leakage is an indication that a fuel storage container is damaged. Time required for repairs will vary with the fuel tank location and ease of access for repairs. The area surrounding the damage must be cleaned to make a good repair. Heat will hasten curing of fiberglass or epoxy.

#### Option 1: Aluminum Fuel Tanks.

#### Limitations:

- o None if welded

#### Personnel/Time Required:

- o 1-3 soldiers
- o 2-6 hours

#### Materials/Tools:

- o Patch material (sheet metal, sheet rubber, plexiglass, or plywood)
- o Sealer
- o Rivets or screws
- o Drill
- o Drill bits

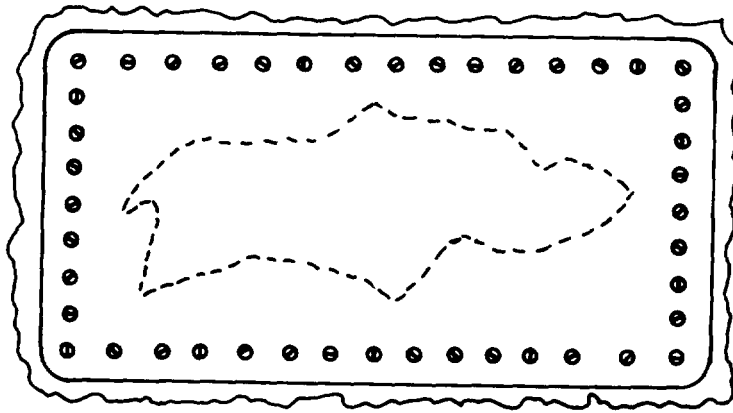
#### Other Options:

- o Use fiberglass repair or plug.

#### Procedural Steps:

1. Drain fuel.
2. Remove the fuel tank, if necessary.
3. Clean oil and residue from damaged area.
4. Cut patch material large enough to extend 1 to 2 inches over the hole edges.
5. Attach the patch to the tank.





6. Drill holes in plate and tank approximately 1 inch apart. Apply sealer to the patch and rivet or screw the plate to the fuel tank.

7. Install fuel tank, if removed.

8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Fiberglass Fuel Tanks.

Limitations:

- o None, if fiberglass kit is used

Personnel/Time Required:

- o 1-3 soldiers
- o 2-6 hours

Materials/Tools:

- o Epoxy
- o Fiberglass repair kit
- o Gasket sealer
- o Pop-rivets

Other Options:

- o Plug hole.

Procedural Steps:

1. Drain fuel tank.
2. Remove fuel tank, if necessary.
3. Clean oil and fuel residue from damaged area.
4. Rough up area around damage with sandpaper or a file.

5. Repair using one of the following:

- a. Apply fiberglass following kit instructions.
- b. Mix and apply epoxy following kit instructions.
- c. Cut patch material, drill tank and patch, and coat patch liberally with fuel-resistant gasket sealer. Attach patch, and secure with pop-rivets. Seal rivet heads with sealer.

6. Install fuel tank, if removed.

7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Plug Holes (Metal or Fiberglass Tanks).

Limitations:

- o None

Personnel/Time Required:

- o 1-3 soldiers
- o 1-3 hours

Materials/Tools:

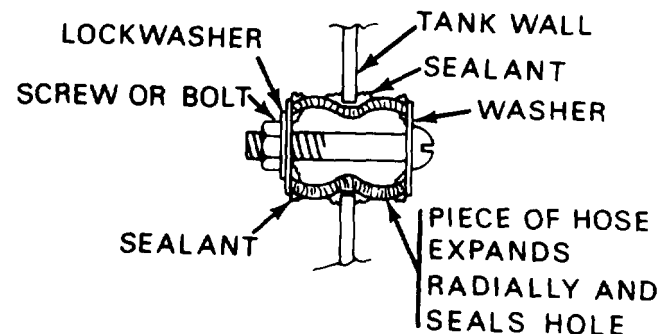
- o Rubber hose
- o Bolt and nut
- o Two large flat washers

Other Options:

- o Use fiberglass or epoxy.

Procedural Steps:

1. Drain fuel until level is below the hole.
2. If removal of the fuel tank is necessary, drain tank.
3. Obtain hose the approximate size of the hole.
4. Assemble the hose, bolt, nut, and washers as shown.



5. Coat the hose assembly with sealer to aid in the repair.
6. Insert the hose assembly into the hole.
7. Tighten the bolt and nut to make the hose expand and seal the fuel tank hole.
8. Install the fuel tank, if removed.
9. Record the DAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## 6-6. FUEL TANK SUBSTITUTE

### General Information:

Tactical operations may not allow sufficient time to make normal or expedient repairs to the vehicle's fuel tank. A more rapid repair can be improvised by installing a substitute fuel tank. The fuel tank should be mounted to avoid interfering with operating components. Use as large a container as possible. Frequent refueling will be required.

### Limitations:

- o Limited mobility (range)

### Personnel/Time Required:

- o 1 soldier
- o 30-60 minutes

### Materials/Tools:

- o Fuel container (5-gallon gas or oil can, 55-gallon drum, etc.)
- o Rubber fuel line
- o Hose clamp
- o Rope or straps

### Procedural Steps:

1. Locate a temporary fuel container.
2. Obtain a fuel line.
3. Connect fuel line to container.
4. Secure temporary fuel container to the outside of the vehicle in a position to allow gravity feed for the fuel.
5. Connect fuel line to the inlet side of the mechanical or electrical vehicle fuel pump.
6. Install return line to the temporary container.
7. Bleed the air from the fuel line.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Section III. FUEL PUMPS

#### 6-7. GENERAL

Tactical vehicles use electrical and mechanical fuel pumps. Fuel pumps can be repaired with instructions provided in respective equipment TM's. In a battlefield environment, replacement of a fuel pump is often the most expedient means to solve the problem. Fuel pumps on most tactical vehicles are interchangeable with fuel pumps on other vehicles. The multifuel engine needs a small in-tank fuel pump to supply fuel to the injection pump. Without an in-tank pump, the multifuel engine will not operate.

#### 6-8. IN-TANK FUEL PUMP INTERCHANGEABILITY

##### General Information:

In-tank fuel pumps on tactical vehicles can be interchanged with other vehicles. The difference in the pumps normally is in the brackets used to locate the electrical unit. The pump must be placed in the proper location for efficient fuel pickup. The electrical unit can normally be installed in the bracket for the vehicle being repaired.

The electrical unit can be clamped using the existing clamps (for example, an adjustable clamp from an air cleaner ducting system). Use a strip of rubber or a rubber hose to aid in holding the pump in position. The following vehicles have interchangeable fuel pumps:

M35/M44A2 Series, 2-1/2-Ton Truck  
M48/M60 Series Tank  
M88 Recovery Vehicle  
M109/M110 Self-propelled Howitzer  
M578 Recovery Vehicle  
M39A2 Series, 5-Ton Truck

#### 6-9. ENGINE FUEL PUMP INTERCHANGEABILITY

##### General Information:

Electric fuel pumps will not normally supply the fuel pressure required by the injector system if the mechanical fuel pump fails. However, operation in a degraded mode is possible by replacing the mechanical pump with an electric unit. Mechanical pumps within the same engine family are interchangeable. The heater fuel pump can also be used to provide fuel to the engine.

- a. Most Cummins fuel pumps are interchangeable. Minor fuel line adjustments might be necessary to attach lines to the pump.
- b. Detroit Diesel 3-53 thru 8V92TA fuel pumps are substitutable.
- c. Personnel heater fuel pumps may be substituted.
- d. Multifuel fuel pumps are interchangeable. Internal adjustments will differ.

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## Section IV. FUEL LINES AND VALVES

## 6-10. GENERAL

Fuel lines route the fuel from the storage tanks through the filters to the engine and back to the tanks. Lines are a combination of rubber hoses and metal tubes. Leaks and blockages are common failures. Clogged lines can be cleared by blowing compressed air through them. Broken or cracked lines must be repaired or bypassed. Various methods of repair are given in this section. Other line repairs are also listed in chapter 3, sections IX and X.

## 6-11. FUEL SYSTEM SEALS LEAK

## General Information:

O-rings are used in some systems to seal the fuel in the lines. BDAR as well as normal repairs will damage the O-rings. Fuel absorption will cause the O-rings to swell, causing installation problems since they no longer fit into the O-ring groove. Some repairs are possible if the O-ring is damaged. Swollen O-rings can be allowed to dry until they shrink enough to fit. Torn or cut O-rings can be replaced with a larger O-ring by cutting it to length. If an adhesive is available, glue the cut ends together. O-rings with small cuts can be coated with a silicone gasket sealer to stop the leakage caused by the cut, if the cut in the O-ring is not against a moving surface. Refer to paragraph 3-27.

## 6-12. FITTINGS LEAK

## General Information:

Flared fuel fittings will start to leak because of engine vibrations or overtightening. Leaking fittings should first be tightened to attempt to stop the leak. If tightening does not stop the leak, string can be used to push the flared tubing more firmly against the mating surface. Coating the string with a gasket sealing compound will aid in stopping leaks in a low-pressure fuel line.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 30-60 minutes

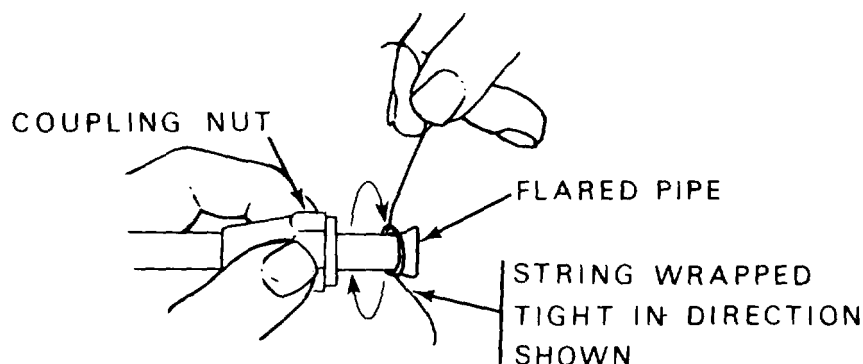
## Materials/Tools:

- o Fuel-resistant sealant  
(silicone, rubber, or similar material)
- o String or light tie cord

## Procedural Steps:

## Option 1: Teflon Tape or String to Seal Line.

1. Remove coupling flange nut.
2. Slide coupling flange nut away from flared end.
3. Clean grease, oil, and fuel from flared end.



4. Wrap string or Teflon tape around flared end of line.
5. Coat string liberally with fuel-resistant sealant.
6. Install line and tighten nut securely.
7. Check for leaks. If still leaking, repeat procedure using more string.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 2: Reflare Line.

## Procedural Steps:

1. Cut line.
2. Reflare line with flaring tool.
3. Install line, tighten nut, and check for leaks.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 6-13. FUEL LINE (LOW PRESSURE RUPTURE)

## General Information:

Low-pressure fuel lines can rupture or crack for various reasons such as frozen water in the lines, vibrations, rubbing against other components, or impact. Repairs can be performed to stop the leakage and continue the mission.

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### Limitations:

- o None

### Personnel/Time Required:

- o 1 soldier
- o 30-60 minutes

### Materials/Tools:

- 0 Rubber sheet (tire inner tube or similar material)
- 0 Tape
- 0 Wire
- 0 Rubber hose
- 0 Hose clamps
- 0 Sealant
- 0 Metal tubing (mirror arms, old hydraulic line, or similar material)
- 0 Thin sheet metal (coffee can or similar material)
- 0 Shell casing, 5.56 mm or 7.62 mm
- 0 Aluminum can
- 0 Nonhardening sealer
- 0 Epoxy

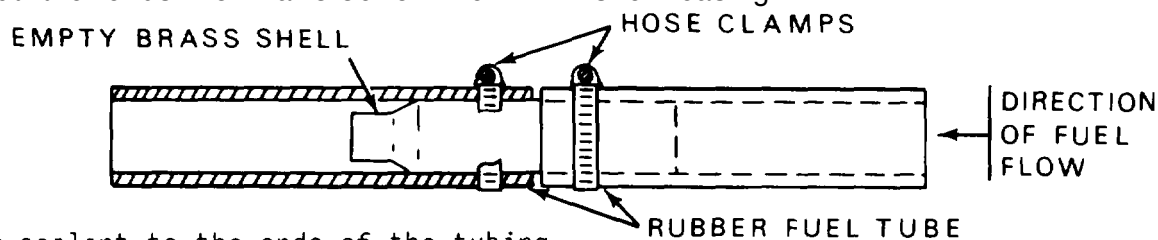
### Other Options:

- o Seal the crack with epoxy.

### Procedural Steps:

#### Option 1: Damaged Rubber Hose.

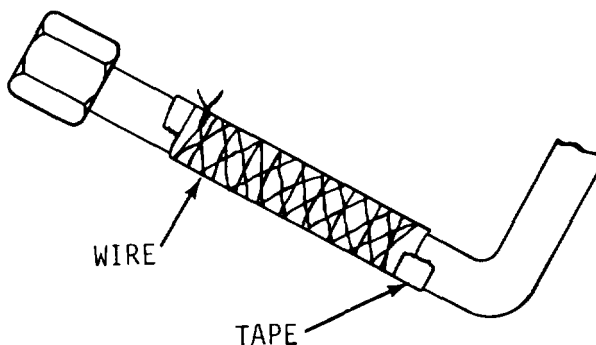
1. Cut out damaged portion of hose.
2. Cut a piece of metal tubing longer than the section removed. If tubing is not available, cut the ends from a 5.56 or 7.62 mm shell casing.



3. Apply sealant to the ends of the tubing.
4. Insert the metal tubing into the hose ends.
5. Clamp the hose ends with hose clamp or wrap tightly with wire and twist the wire ends together.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 2: Metal Tubing Cracked.

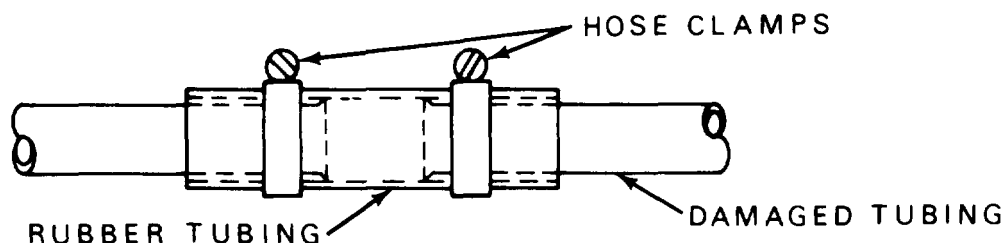
1. Clean dirt and grease from around the crack.
2. Coat the crack with sealant.
3. Wrap tubing with a sheet of fuel-resistant material.
4. Clamp the sheet directly over the crack.
5. If clamps are not available, wrap the tubing with tape.
6. Wrap wire around the tape as reinforcement.



7. Wrap an additional coating of tape over the wire.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 3: Holes in Metal Tubing.

1. Cut out damaged portion of metal tubing.
2. Clean both ends of tubing.
3. Cut a piece of rubber hose 2 inches longer than the section removed.
4. Apply sealant to both ends of tubing.
5. Insert the tubing ends 1 inch into the hose.
6. Secure with loose clamps or tightly twisted wire.



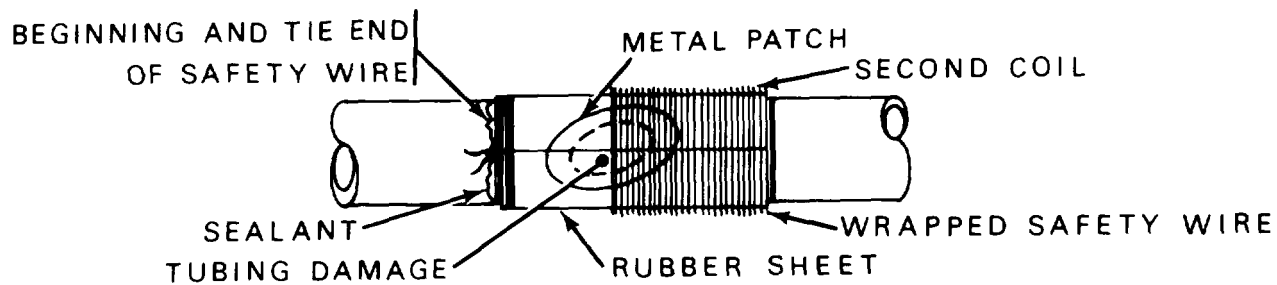
7. If the hose is too large, the tubing can be flared or sleeved to fit.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



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#### Option 4: Patch Large Metal Lines.

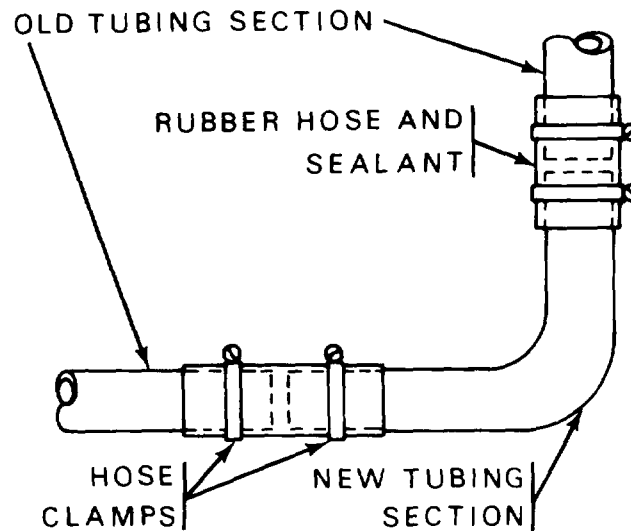
1. Smooth damaged area.
2. Clean dirt and oil from damaged area.
3. Cut a patch from thin sheet metal or an aluminum can.
4. Coat the metal patch and tubing with sealant and place over damaged area.
5. Cut a patch from rubber or other fuel -resistant material and coat with nonhardening sealer, if available.
6. Wrap over metal patch.
7. Wrap rubber patch with wire to equalize the pressure over the repair.



8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 5: Repair Damaged Bends.

1. Cut a bend from an old hydraulic line, mirror arm, or similar item.
2. Remove the damaged bend from the line.
3. Clean the cut tubing ends.
4. Apply sealant to tubing ends.
5. Use two 2-inch sections of rubber hose and install the replacement bend.
6. Clamp with hose clamps or tightly twisted wire.



7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 6-14. FUEL INJECTOR LINE RUPTURE

- a. If a high-pressure fuel line is damaged and there is no time for a better repair, cut the line and weld or crimp the injector pump side shut. The engine will run for a limited time on fewer cylinders.

- b. If a replacement line is not available, repair the defective line. Remove it from the vehicle and clean it. Braze pin holes closed. If the hole is too large for this procedure, cut out that section of line. Use a piece of slightly larger metal tubing as a sleeve, overlapping both cut ends of the injector line. The sleeve should fit tightly over the injector line; if it is too loose, crimp to get a tight fit. Then braze or silver solder both ends of the sleeve to the fuel line.

## Section V. FUEL FILTERS

## 6-15. GENERAL

Fuel filters remove dirt and water from the fuel. Dirt and water will cause damage to fuel system components. Fuel filters are normally mounted in series, making them primary and secondary filters. Some vehicles have a fuel filter and water separator as a single unit. Other vehicles have a separate fuel filter and water separator. Fuel filters should be bypassed only as a last resort.

## 6-16. FUEL FILTER CLOGGED OR FROZEN

## General Information:

The first indication of clogged or frozen fuel filters will be a failure of the engine to start or degraded performance because of insufficient fuel. Fuel filters, if drained daily, should not freeze. Clogged filters must be cleaned or changed to correct the problem.

## Limitations:

- o Possible internal engine damage if filters are bypassed

## Personnel/Time Required:

- o 1-2 soldiers
- o 15-30 minutes

## Material/Tools:

- o Fuel

## Other Options:

- o Remove filter elements.

## Procedural Steps:

1. Gain access to fuel filters.
2. Remove the fuel filter from the canister.
3. Rinse the filter in a pan of fuel or blow out with compressed air; if frozen, thaw it out.
4. Install and prime the fuel filter.
5. Start the engine.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 6-17. BYPASSING FUEL FILTER

### General Information:

Multifuel engines have two fuel filters located at the rear of the engine. There are two lines that have to be removed from the filter housing.

This paragraph will incorporate procedures for the CUCV, HEMTT, M939 series 5-ton, M35 series 2-1/2-ton, M39 series 5-ton, M911 and the M915 series engine fuel systems.

### Limitations:

- o A possible chance of a clogged injector
- o Degraded power

### Personnel/Time Required:

- o 1 soldier
- o 15-30 minutes

### Materials/Tools:

- o 3/8-inch pipe coupling
- o 3/8-inch pipe tee
- o Hacksaw
- o Clamps from compressor air intake line (2)
- o Hose

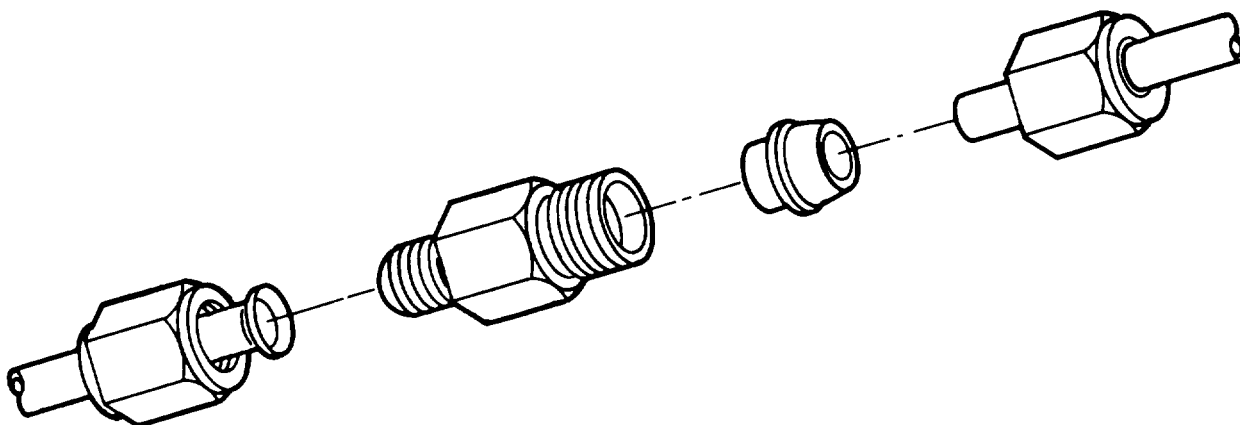
### Procedural Steps:

#### Option 1: Couple Fuel Lines for Multifuel Engines.

1. Disconnect the inlet and the outlet lines at fuel filters.
2. Disconnect the 3/8-inch fittings from the inlet and outlet lines.
3. Connect the 3/8-inch fittings to a coupling and connect the fuel lines to the coupling.

#### NOTE

Couplings may be either style.

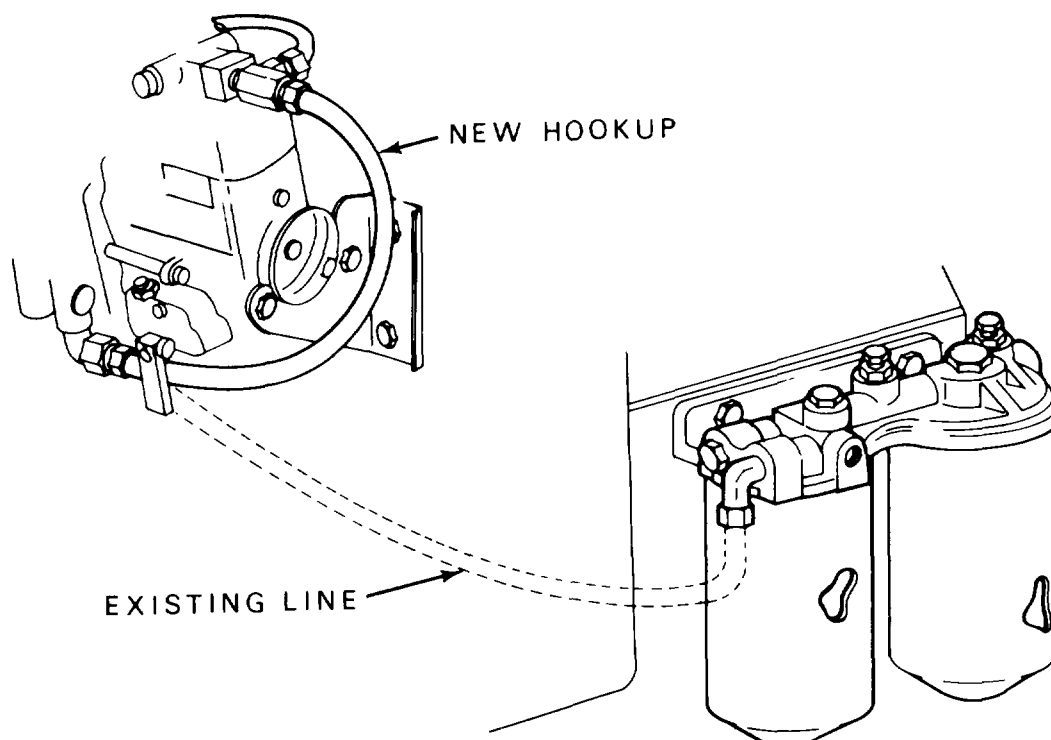


4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

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## Option 2: Direct Hookup of Fuel Lines for Multifuel Engines.

1. Remove the existing intake fuel line from the filters.
2. Remove existing line from back of fuel pump.
3. Attach the existing inlet fuel line to the back of the fuel pump.



4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

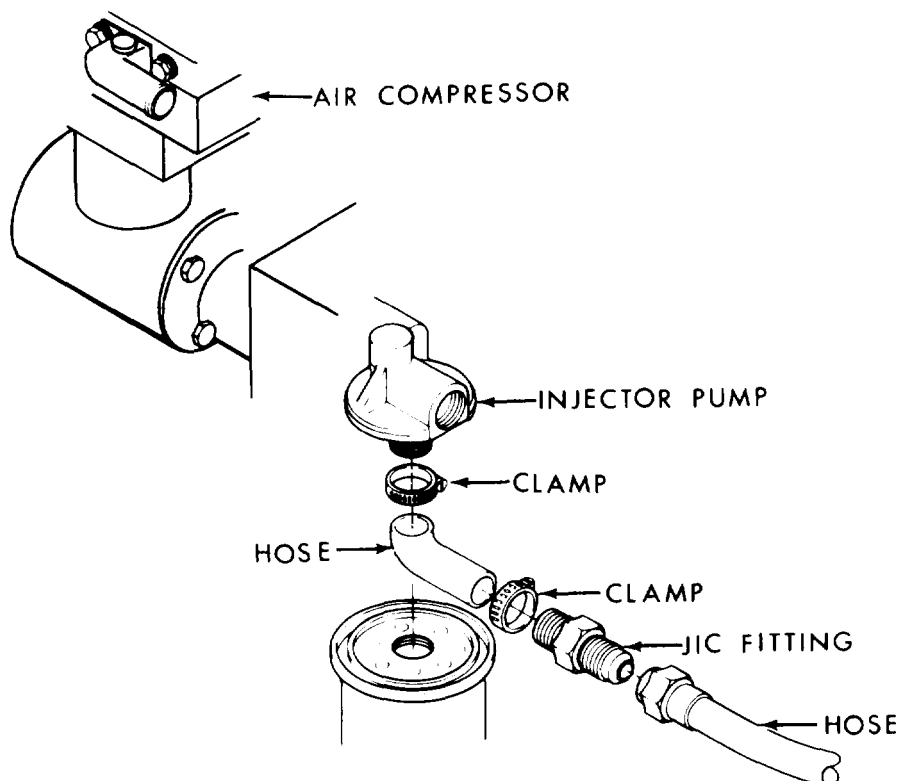
## Option 3: Bypass Fuel Filter for HEMTT and M911.

1. Disconnect the one inlet and two outlet lines.
2. Disconnect the 1/4-inch fittings from the inlet and outlet lines.

3. Connect the fittings and lines to a 1/4-inch tee.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 4: Bypass Fuel Filter for M915.

1. Remove and discard damaged fuel filter.
2. Disconnect fuel line at injector pump.



3. Install JIC-to-pipe adapter fitting.
4. Connect JIC-to-pipe adapter fitting to fuel line.
5. Remove intake air hose and cable clamps from compressor.
6. Cut hose to length needed.
7. Install two clamps loosely on each end of hose.
8. Fit hose over fuel line and fuel filter inlet.
9. Tighten clamps.
10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

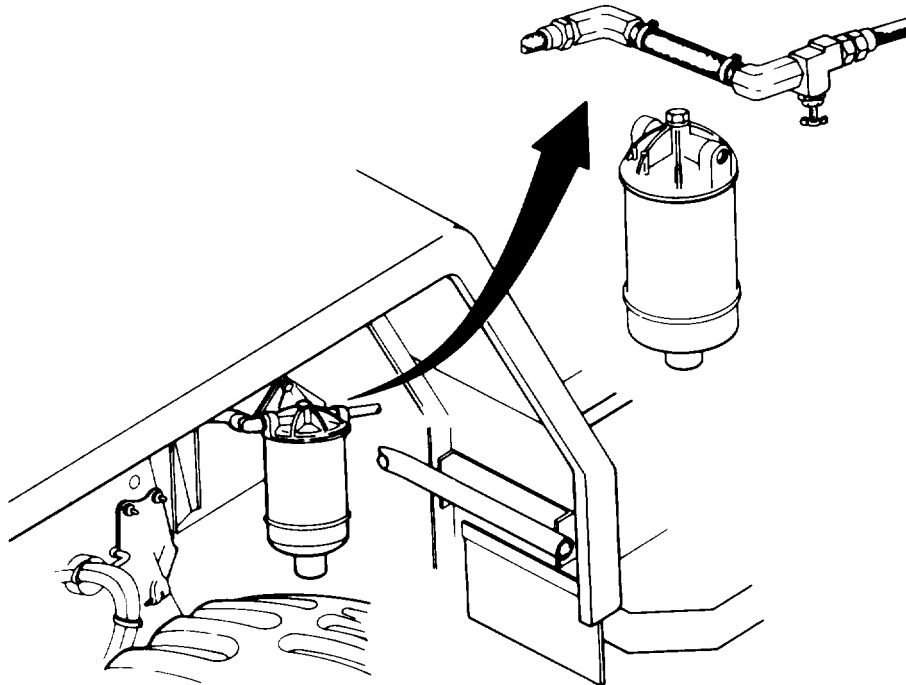
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Option 5: Bypass Fuel Filter for M939.

**NOTE**

The fuel filter on M939 series trucks is located under the front fender on the driver's side of the truck.

1. Disconnect the inlet and outlet fuel lines from the filter.
2. Connect the two lines with a coupling.



3. If a coupling is not available, cut the fittings off the fuel lines.
4. Insert a copper tube in the lines and secure with hose clamps.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 7

## COOLING SYSTEM

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

## 7-1. GENERAL

Cooling system problems may be indicated by a variety of faults. Typically, the driver's indicator panel will show overheating.

## 7-2. ASSESSMENT CHART

## a. Air cooling system assessment.

## (1) Inspect ----→Damage found to:

No damage found	-Fans; .....	go to specific TM
	-Fan drive; .....	go to specific TM
	-Shrouds; .....	go to section 11
	-Ducts; .....	go to paragraph 5-11
	-Engine compartment seals; .....	go to paragraph 3-7

## (2) Start engine ----→Damage found to:

No damage found	-Fan air intake; .....	go to specific TM
	-Fan drive; .....	go to specific TM
	-Engine compartment seals; .....	go to paragraph 3-7

## b. Liquid cooling system assessment.

(1) Visually ----→Damage found to:  
inspect

No damage found	-Hoses, hose clamps; .	go to section III
	-Gaskets; .....	go to paragraph 3-4
	-Radiator; .....	go to section III
	-V-belts; .....	go to paragraph 3-9



(2) Start engine -----Damage found to:

No damage found	-Head gasket; . . . . .	go to paragraph 3-6
	-Internal engine	
	water jackets; . . . . .	go to paragraph 3-5
	-Thermostat; . . . . .	go to section III
	-Coolant flow/water	
	pump; . . . . .	go to section III
	-Cooling fan; . . . . .	go to specific TM
-Air flow through		
radiator; . . . . .	go to section II	

### 7-3. BDAR PROCEDURE INDEX

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## Section II. AIR COOLING SYSTEMS

### 7-4. GENERAL

Cooling system failures can result in engine failure and therefore must be repaired if the engine is expected to operate for any length of time. Cooling system problems most often are indicated on the driver's instrument panel. While temporary overheating indications may result from excessive workload on the engine, repeated or constant indication of overheating is almost always followed by a major cooling problem.

### 7-5. AIR COOLING SHROUDS DAMAGED

Shrouds are used to direct the cooling air over the hot engine. Bent or torn shrouds will upset the flow of air and cause hotspots to occur which can cause internal engine failures. Torn shrouds can be bent back into shape and patched with sheet metal, epoxy, or tape to restore the proper air flow. At a minimum, they must be bent away from contact with moving components. If the existing shrouds cannot be repaired, new shrouds must be fabricated.

### Section III. LIQUID COOLING SYSTEMS

#### 7-6. COOLANT SUBSTITUTE

A liquid-cooled engine cannot operate for long without coolant. When normal coolants are not available, a substitute may be used. Any liquid, except gasoline or jet fuels, can be used; but some liquids will deteriorate the cooling system's rubber components. Petroleum products will not transfer the heat as efficiently as water-based coolant, but will work if nothing else is available. Old engine oil or fluids drained from damaged vehicles, transmission oil, or hydraulic fluids may be a possible source of fluids. The cooling system must be drained and flushed as soon as possible if petroleum-based fluids are used.

#### 7-7. THERMOSTAT STUCK

The thermostat regulates the engine operating temperature by controlling coolant flow through the engine. When the thermostat is stuck in the closed position, it prevents coolant from circulating and causes engine overheating. BDAR repair is to remove the thermostat and operate the vehicle. If the thermostat is stuck in the open position or removed, it may degrade engine performance and increase fuel consumption.

#### 7-8. ENGINE COOLANT FROZEN

##### General Information:

During cold weather, inadequate antifreeze protection will cause the coolant to freeze. Care must be taken when thawing the cooling system that damage is avoided. The water pump may be unable to turn, which will damage drive belts as well as the pump itself. The thawing procedure must include frequent inspections for leaks which will indicate cracked or broken components. Engine temperature must also be monitored to prevent damage due to overheating.

##### Limitations:

- o None, if engine is left running or antifreeze protection is upgraded

##### Personnel/Time Required:

- o 2 soldiers
- o 30-60 minutes

##### Other Options:

- o Route air from fuel-operated vehicle heater over the radiator.
- o Route another vehicle's exhaust gases over the radiator.

### Procedural Steps:

1. Gain access to radiator and engine.
2. Inspect for ice and obvious cracks in coolant system components.
3. If coolant is solid, remove or disengage the water pump drive belts.
4. Start the engine and allow to warm up. Do not allow engine to overheat.
5. Shut down the engine and allow the heat to melt the ice.
6. Attempt to turn water pump pulley.
7. When the water pump pulley can be turned, install the drive belts.
8. Start the engine and allow to warm up. Do not allow engine to overheat.

### 7-9. RADIATOR LEAKAGE

#### General Information:

Radiator leakage may be detected by low coolant levels. Obvious wet areas or overheating will indicate that the coolant level must be checked. The following procedures provide options to stop or stop or reduce the leakage rate.

Option 1: Small Hole.

#### Limitations:

- o None

#### Personnel/Time Required:

- o 1 soldier
- o 15-30 minutes

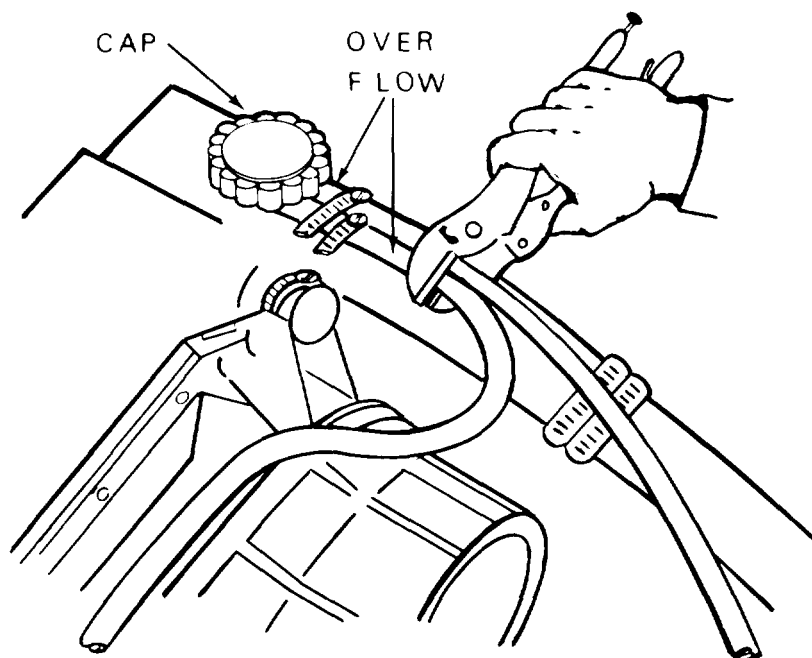
#### Materials/Tools:

- o Stop leak chemical
- o Cigarette tobacco
- o Pepper
- o Eggs
- o Oatmeal
- o Farina (cream of wheat)
- o Corn meal

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#### Procedural Steps:

1. Remove radiator cap and start engine.
2. Add coolant to bring coolant to the proper level.
3. Sprinkle or pour one of the materials listed into the coolant.
4. Inspect the hole for evidence of reduced or eliminated leakage.
5. Add more material if leak has not stopped or been reduced to an acceptable limit.
6. Leave radiator cap loose.



7. Plug overflow lines on surge tank coolant systems if so equipped.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Radiator Inlet or Outlet Tube Leak.

##### Limitations:

- o None

##### Personnel/Time Required:

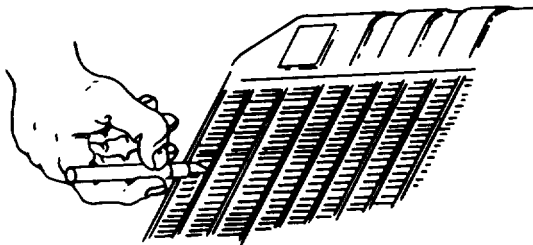
- o 1 soldier
- o 1-4 hours

##### Material/Tools:

- o Wire brush
- o Solvent
- o Epoxy

### Procedural Steps:

1. Gain access to radiator.



2. Inspect the radiator and pinpoint the leak.
3. Drain the coolant.
4. Clean the leak area with solvent or available cleaner.
5. Scrape or rough up the damaged surface with a wire brush or knife.
6. Mix epoxy according to kit instructions and fill the hole with the mixture. Work the epoxy well into the crack.
7. Allow epoxy to cure. Heat will speed the curing.
8. Refill coolant and check for leaks.
9. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### 7-10. CORE PUNCTURED

#### General Information:

A punctured core can be repaired without epoxy or solder. The size of the hole(s) may cause the engine temperature to rise beyond the normal operating range. Check the coolant level periodically.

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Limitations:

- o Possible reduced cooling

Personnel/Time Required:

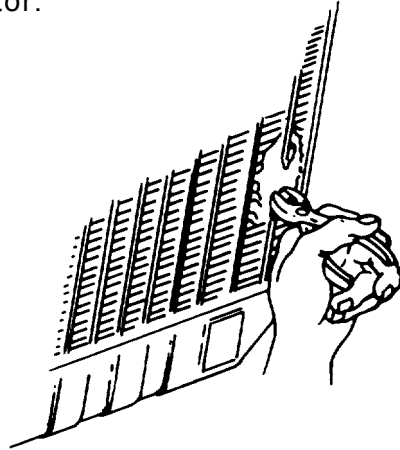
- o 1 soldier
- o 30-60 minutes

Materials/Tools:

- o Side cutters
- o Epoxy or solder

Procedural Steps:

1. Gain access to radiator.



2. Inspect the radiator to pinpoint the leak.
3. Drain the coolant.
4. Use side cutters and cut or break away the cooling fins from the coolant tubes, 1 to 2 inches each side of the leak.
5. Cut the coolant tube at the leak, taking care not to tear or puncture the other tubes.
6. Squeeze the tube ends together and fold each end over on itself approximately 1/2 inch.
7. If epoxy or solder is available, seal the coolant tube ends.
8. If no epoxy or solder is available, fold the tube once more, 1/2 inch, to restrict the coolant leaks.
9. Refill the coolant and check for leaks.
10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 7-11. HOSE CLAMP BROKEN

## General Information:

A broken hose clamp will allow the hose to leak coolant and cause engine overheating. The clamp must be replaced or a substitute improvised to regain a sealed cooling system. If a replacement clamp is not available, wire can be used as a substitute. Care must be taken that the wire does not loosen.

## Limitations:

- o None

## Personnel/Time Required

- o 1 soldier
- o 5-10 minutes

## Materials/Tools:

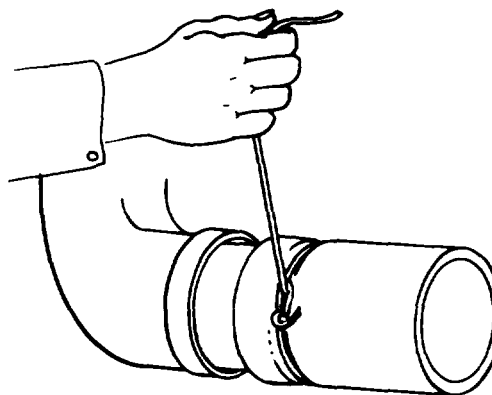
- o Wire, safety (lacing) or communication
- o Rope
- o Belt
- o Stick
- o Tape

## Other Options:

- o Wrap the hose with wire. Use a stick and twist wire ends together like a tourniquet. Tape ends of stick to hose.

## Procedural Steps:

1. Make a loop in one end of a wire. Twist the wire so that a permanent loop is formed.
2. Loosely wrap the wire once around the hose and pull the other end through the loop.





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3. Press the loop tightly against the hose and pull the wire through the loop as tight as possible. Bend the wire back on itself, crimping it, so that the wrap will be tight and secure.
4. Secure the loose end by making one more wrap, opposite direction of the first.
5. Pull the wires through the loop again as tight as possible.
6. Crimp the wire in the opposite direction.
7. Secure loose end of wire and cut off.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 7-12. HOSE LEAKAGE

##### General Information:

A leaking hose can be detected by obvious wet areas or engine overheating. Weak hoses feeling soft and spongy should be reinforced with metal if repaired. The soft, spongy feeling indicates the rubber is deteriorated and will not withstand normal cooling system pressures. Option 1, below, provides procedures for repairing a small leak in a hose. Option 2 shows how to correct a larger split in a hose.

##### Limitations:

- o Reduced mobility

##### Personnel/Time Required:

- o 1 soldier
- o 30 minutes

##### Materials/Tools:

- o String or wire
- o Nonporous material (rubber, raincoat)
- o Thin sheetmetal
- o Gasket sealer
- o Clamps
- o Tape

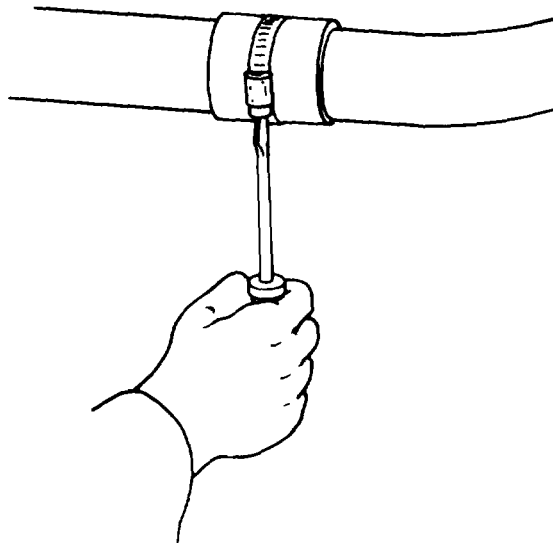
##### Other Options:

- o Use a pneumatic tire repair kit.

##### Procedural Steps:

##### Option 1: Small Leak.

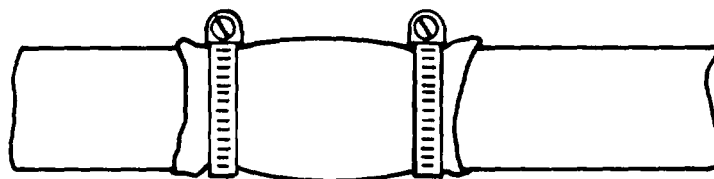
1. Gain access to leaking hose.
2. Clean dirt and oil from damaged hose.
3. Coat the damaged area with gasket sealer.



4. Wrap a nonporous material (raincoat, rubber mat) over the leak.
5. Secure the material with a clamp.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Large Leak.

1. Gain access to leaking hose.
2. Clean dirt and oil from damaged area.
3. Coat the damaged area with gasket sealer.
4. Cut a metal patch from a tin can or other thin metal.
5. Bend the metal into a cylindrical shape the size of the damaged hose and coat the inside with sealer.
6. Wrap the metal patch over the damaged hose.
7. Secure the patch with adjustable clamps or tape.
8. Check for leaks.



9. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## 7-13. HOSE COLLAPSE

## General Information:

When the rubber in the coolant hoses starts to deteriorate, it becomes soft and has a spongy feeling. Overheating problems that occur only at high engine speeds are normally from collapse of a deteriorated hose on the suction side of the water pump. The hose can be reinforced by inserting a rigid hollow object like a can or coiled wire to prevent the hose from collapsing.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 15-60 minutes

## Materials/Tools:

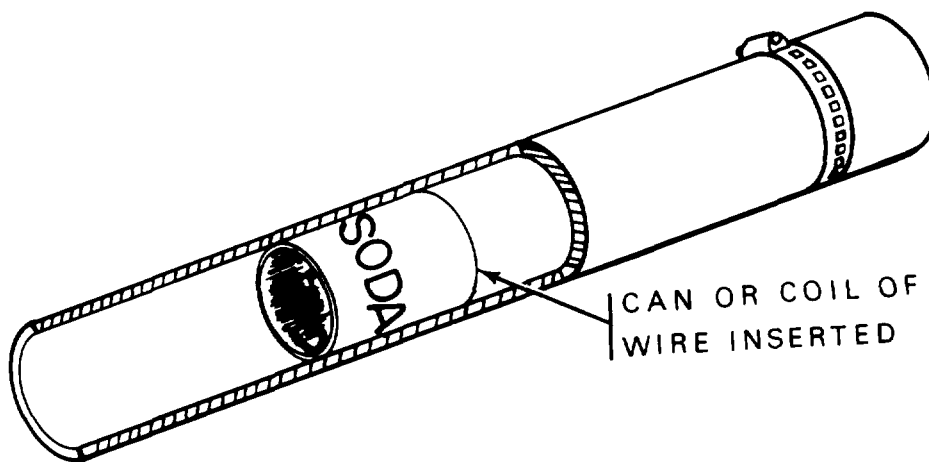
- o Tin can
- o Stiff wire (coat hanger, welding rod)

## Other Options:

- o Operate at reduced engine speed.

## Procedural Steps:

1. Gain access to hose.
2. Drain coolant.
3. Loosen and remove clamp from one end of the hose. Disconnect hose.
4. Insert a can, with ends removed, or bent wire into the hose.
5. Connect and tighten the hose.



6. Refill coolant to proper level.
7. Check for leaks.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 7-14. HOSE IMPROVISATION (LOW PRESSURE)

##### General Information:

Coolant hose or tube damage will sometimes be such that a patch will not stop the leak. The damaged portion must be removed and replaced with a substitute. Several repairs can be made using one of the following procedures.

##### Limitations:

- o None

##### Personnel/Time Required:

- o 1 soldier
- o 15-60 minutes

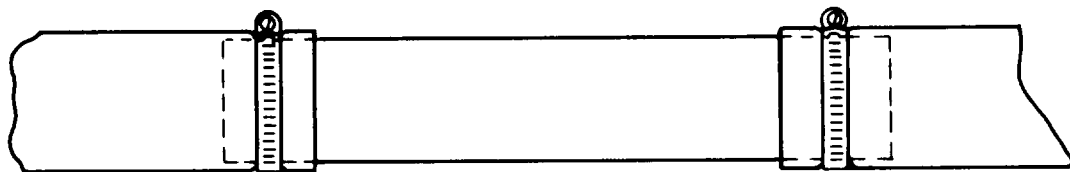
##### Materials/Tools:

- o Gasket sealer
- o Garden hose, heater hose
- o Pipe
- o Clamps or wire
- o Hacksaw

##### Procedural Steps:

##### Option 1: Pipe Insert.

1. Cut out damaged hose section.
2. Cut a piece of pipe longer than the damaged hose section.
3. Coat the pipe ends with gasket sealer.

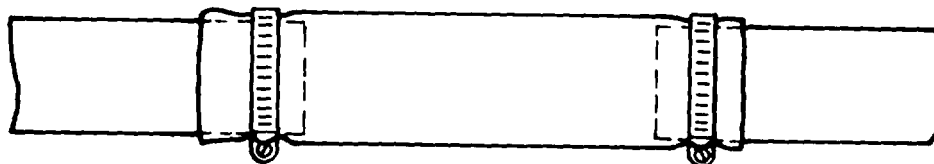


4. Insert the pipe into the damaged hose ends.
5. Secure the hose ends with clamps or twisted wire.
6. Fill coolant to proper level and check for leaks.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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### Option 2: Another Hose.

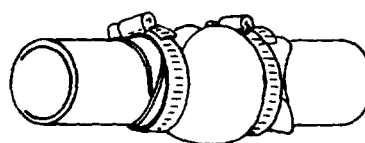
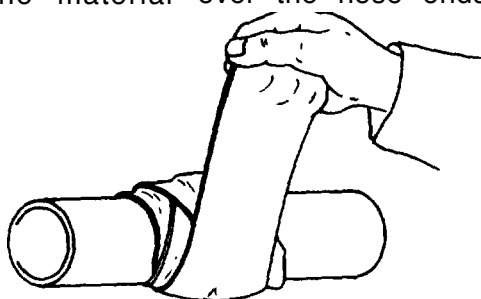
1. Remove the damaged section of hose.
2. Cut a section of substitute material longer than the removed section.
3. Coat ends of damaged hose with gasket sealer.



4. Slip the hose over the ends of the damaged hose.
5. Secure the hose with clamps or twisted wire. Do not overtighten and restrict the coolant flow.
6. If the damaged hose inside diameter equals the outside diameter of the substitute hose, the hose can be inserted into the damaged hose and secured.
7. Fill coolant and check for leaks.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 3: Short-Hose Fabrication.

1. Cut a short section of inner tube or rubber sheet to required length.
2. Coat the hose ends with sealant.
3. Slip the material over the hose ends.



4. Wrap the inner tube as tightly as possible on the hose.
5. Use hose clamps or tightly wound wire and secure the inner tube.
6. Fill coolant to proper level and check for leaks.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 8

## ELECTRICAL SYSTEM

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

## 8-1. GENERAL

Electrical systems on tactical vehicles are 12- and 24-volt, negative ground, direct current (dc) systems. Electrical current storage for starting and standby circuits is provided by batteries. The batteries are connected in a series-parallel configuration to provide 12 and 24 V dc. All electrical power to circuits can be turned off by a main power switch.

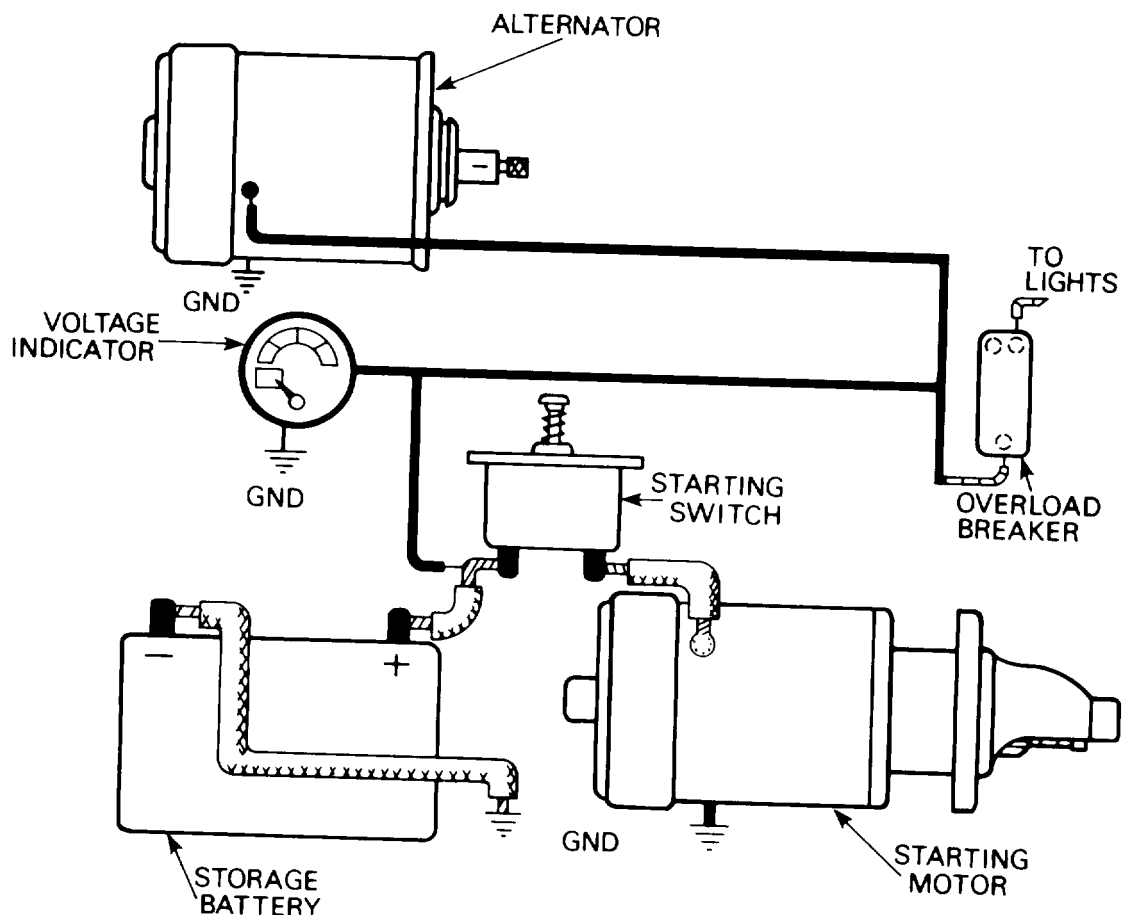


FIGURE 8-1. Basic vehicle electrical system.

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## 8-2. ASSESSMENT CHART

## a. Inspect-----Damage found to:

No damage found Start engine	-Batteries; . . . . .	go to section VI
	-Switches; . . . . .	go to section II
	-Fuses; . . . . .	go to section II
	-Circuit breakers; . . .	go to section II
	-Voltage regulator; . .	go to specific vehicle TM
	-Alternator; . . . . .	go to specific vehicle TM
	-Wiring; . . . . .	go to section IV

## b. Observe operation----Damage or trouble found in:

No damage or trouble found	-Starting engine; . . . .	go to sections II, IV, V and VI
	-Alternator output function; . . . . .	go to specific vehicle TM
	-Voltage regulator function; . . . . .	go to specific vehicle TM
	-Circuit breakers; . . . .	go to section 11

Evaluate system performance:

Charging System Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self-Recovery Capable	Recover
-Charging system works OK	X	X	X	X	
-Charging system works marginally		X	X	X	
-Charging system does not work			X	X	X

## 8-3. BDAR PROCEDURE INDEX

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## Section II. ELECTRICAL COMPONENTS

### 8-4. GENERAL

Electrical circuits contain switches and protection devices. Bypassing a failed switch or protective device is a rapid repair but may create more damage. The circuit must be checked for shorts before bypassing a protective device.

### 8-5. NEUTRAL SAFETY SWITCH DEFECTIVE

#### General Information:

Engine starter will not energize. This procedure will allow the engine to be started with the shifting lever in any position.

#### Limitations:

- o None

#### Personnel/Time Required:

- o 1 soldier
- o 15 minutes

#### Materials/Tools:

- o Electrical tape
- o Duct tape
- o Bandaid
- o Shoelace

#### Procedural Steps:

1. Locate neutral safety switch.
2. Disconnect both wires.
3. Slide protective insulation boots back on the wires to expose the electrical connectors.
4. Wrap the two electrical connectors together with tape or shoelace.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



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## 8-6. STARTER SWITCH INOPERATIVE

### General Information:

#### **CAUTION**

Bypassing the starter switch for more than 30 seconds may cause damage to the glow plug and the combustion chamber of the CUCV and HMMWV engine.

If the engine will not crank, bypass the starter switch and jump the starter terminals.

### Limitations:

- o None

### Personnel/Time Required:

- o 1 soldier
- o 15 minutes

### Materials/Tools:

- o Piece of wire
- o Tape

### Procedural Steps:

#### Option 1: Bypass Starter Switch.

1. Locate the starter switch.
2. Remove the wire from the starter switch.
3. Use a jumper wire or touch the wires removed in step 2 together.
4. After engine starts, disconnect jumper or leads.
5. Insulate lead with tape.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Jump Starter Terminals.

1. Gain access to starter.
2. Use a piece of wire or suitable object and connect the main power terminals to the solenoid terminal.
3. After engine starts, disconnect jumper.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 8-7. FUSE OR CIRCUIT BREAKER FAILURE

### General Information:

A short or overload in a circuit will cause the fuse to burn out or the circuit breaker to trip, i.e., the circuit becomes inoperative. A temporary repair can be made by bypassing the protection device with straight wiring or by replacing the fuse with tinfoil, wire, ballpoint pen spring, or similar conductor. Use of solder will provide some amount of circuit protection.

### **CAUTION**

Damage to the equipment can occur when the circuits are not properly fused.

Record the BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

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## Section III. SHIELDED CABLES

## 8-8. GENERAL

Some high-voltage or high-current electrical circuits are shielded to prevent the circuit from inducing a current in a parallel circuit. The shield is connected to ground which will stop current from escaping or entering the conductor from any source other than its own circuit. Shielded cables should be replaced whenever possible. Communications cables are covered in chapter 15.

## 8-9. SHIELDED CABLE DAMAGED

## General Information:

Repairs are possible if replacement cables are not available. Care must be taken so the shield is not connected to the conductor.

## Limitations:

- o Possible radio frequency interference (RFI)

## Personnel/Time Required:

- o 1 soldier
- o 20 - 40 minutes

## Materials/Tools:

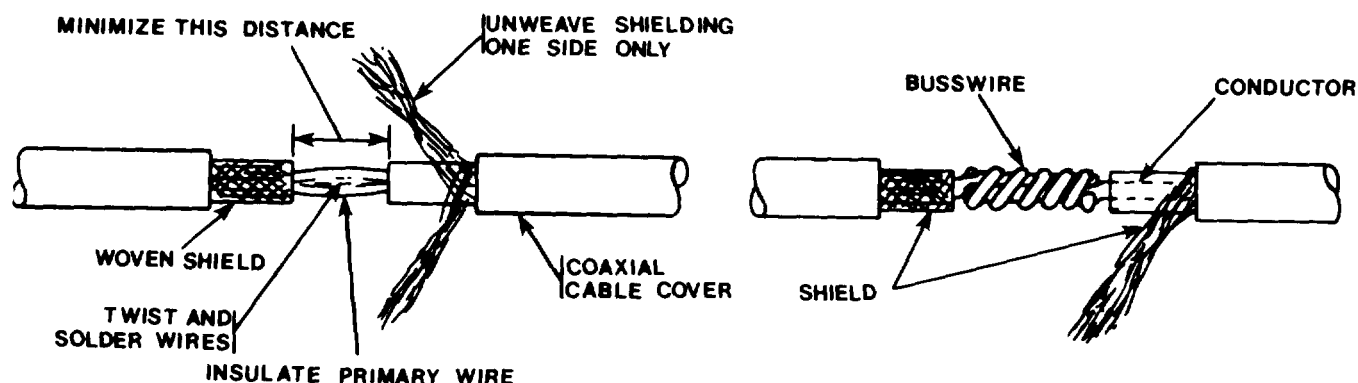
- o Solder, rosin-core
- o Tape
- o Soldering iron

## Procedural Steps:

## Option 1: Coaxial Cable.

1. Cut back coaxial cable cover 3 inches from each wire end.
2. Cut back woven shield and inner conductor insulation on one wire 2 inches from the end.
3. On the other wire, unweave the shielding and remove the inner conductor insulation 2 inches from the end.
4. Splice the broken wires by twisting and soldering. If soldering iron is not available, lay wires side by side and wrap with a busswire.

5. Insulate wire splice with several layers of tape.



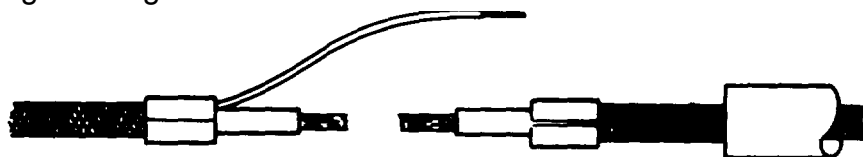
6. Lay the unwoven shielding over the insulated splice and make contact with the woven shield on the other side. Distribute the unwoven shielding carefully around the diameter of the wire and solder or wrap with busswire.
7. Cover the entire splice with several layers of tape.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Shrink Tube Insulation.

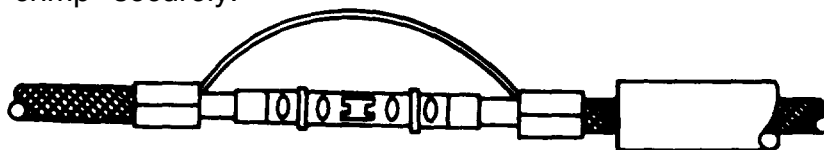
1. Prepare the severed ends of the cable as shown.



2. Slide shrinkable or flexible transparent tubing over the splice. The sleeve must be long enough to extend beyond the two ground sheath connectors.
3. Attach a grounding sheath connector to one end of the severed wire and crimp.



4. Install a grounding sheath connector to the other side of the break. Do not crimp this one yet.
5. Use a permanent splice to join the severed inner conductor or use the barrel of a terminal lug when a permanent splice is not available. A ballpoint pen refill will work as a terminal splice; crimp onto wires. Insulate from the shielding.
6. Push the free end of the grounding wire into the uncrimped grounding sheath connector and crimp securely.



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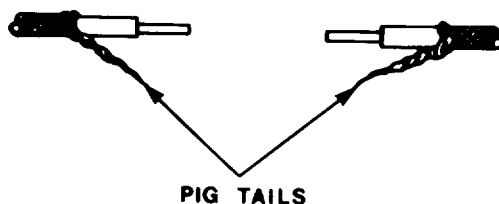
7. Slide outer insulating sleeve into place. If flexible tubing is used, tie both ends with nylon braid or cord.



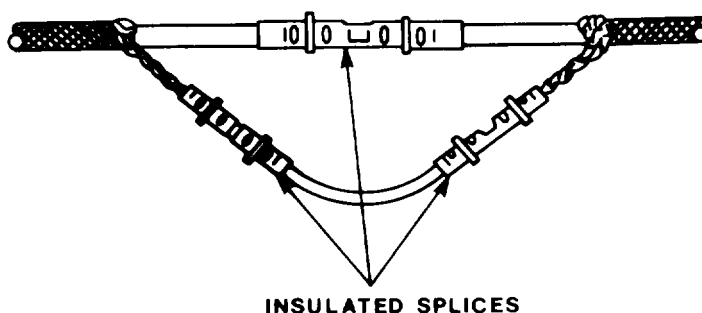
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 3: Insulated Crimp Splices.

1. Prepare the severed ends of the cable for pigtail method of shield termination.



2. Use the insulated splice connector to join the inner conductors.



3. Use two splice connectors to add a short length of insulated wire as an extension to complete the shield connection.



4. Cover area with tape or vinyl sleeve.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section IV. WIRING HARNESSES

## 8-10. GENERAL

Wiring harnesses are normally replaced when extensive damage occurs. Because of improvements or different configurations, replacement harnesses from other vehicles of the same vehicle family may use some different style connectors. Try to obtain harnesses from an identical model; however, connectors can be exchanged with the damaged harness. The same procedure is followed to change a complete connector or to splice a complete harness. If a wire is damaged but the fault cannot be located, it should be replaced with a jumper wire.

## 8-11. WIRING HARNESS DAMAGED

## General Information:

Wire harness repairs are generally a series of single-wire repairs. Establishing circuit continuity in a bundle of wires is difficult because individual wires are not color coded. Wires must be identified before they are connected. Essential electrical functions can be rapidly restored by using jumper wires.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 1 - 2 hours

## Materials/Tools:

- o Wire
- o Splices
- o Electrical tape
- o Soldering iron
- o Plastic ties

## Procedural Steps:

## Option 1: Wire Bundle Repairs.

1. Splice the first wire and tape. Leave the tape hanging from the repair.
2. Splice the next wire, lay it on top of the first repair.
3. Continue wrapping with electrical tape.
4. Repeat these steps as often as necessary to repair the wire bundle without cutting or breaking the tape until the repair has been completed.

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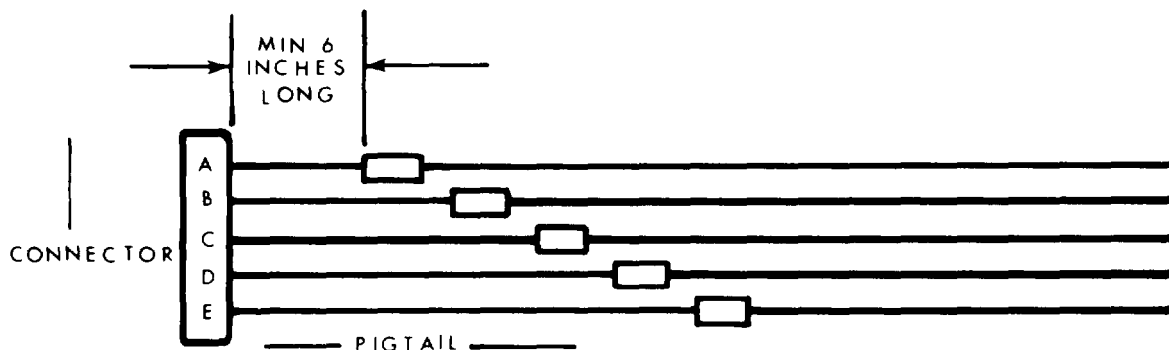
5. Stagger splices, when possible, at least one splice length.
6. Ensure that essential cable clamps have been replaced.
7. Clamp cushion can be replaced by tape.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Jumper Wire.

1. Identify the connector pin at each end of the harness.
2. Cut off the end of the defective wire.
3. Thread the jumper wire along the path of the cable harness, passing the wire through the clamps.
4. Attach the jumper wire.
5. Tape the jumper wire securely to the harness at intervals that will provide protection from vibration or sagging.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 8-12. CONNECTOR PIN DAMAGED (BROKEN OR MISSING)

If the pins are too small, or time is insufficient, the entire connector should be replaced. A replacement connector, complete with a pigtail removed from another vehicle, can be spliced to the vehicle wiring harness as shown. If the connector is attached to shock-mounted equipment, the wires should be long enough to ensure free movement of the equipment on its shock mounts. Procedures are the same as for repairing a wire bundle. (Refer to para 8-11. )



Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 8-13. WIRES BROKEN

## General Information:

Broken wires can be spliced several different ways to restore an electrical circuit. Soldered connections conduct current best and should be used whenever possible.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 10 - 20 minutes

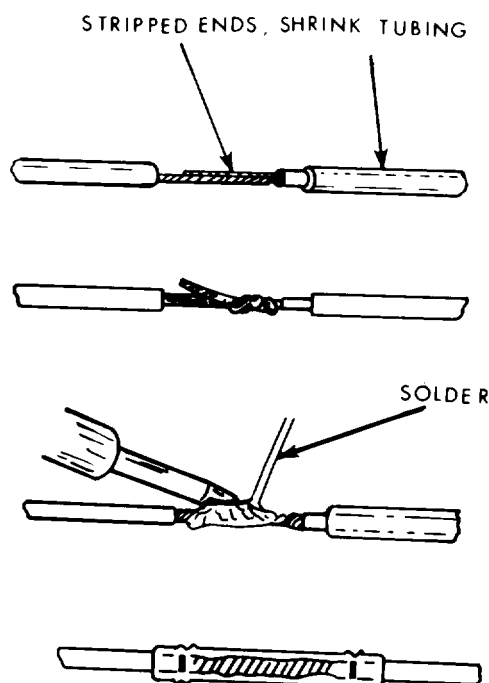
## Materials/Tools

- o Crimping tool
- o Solder, rosin-core
- o Wire splice
- o Heat shrink tubing
- o Soldering iron

## Procedural Steps:

## Option 1: Solder Wire.

1. Strip ends of broken wires.
2. Slide a section of plastic sleeving or shrink tubing, if available, over one end of the broken wire.



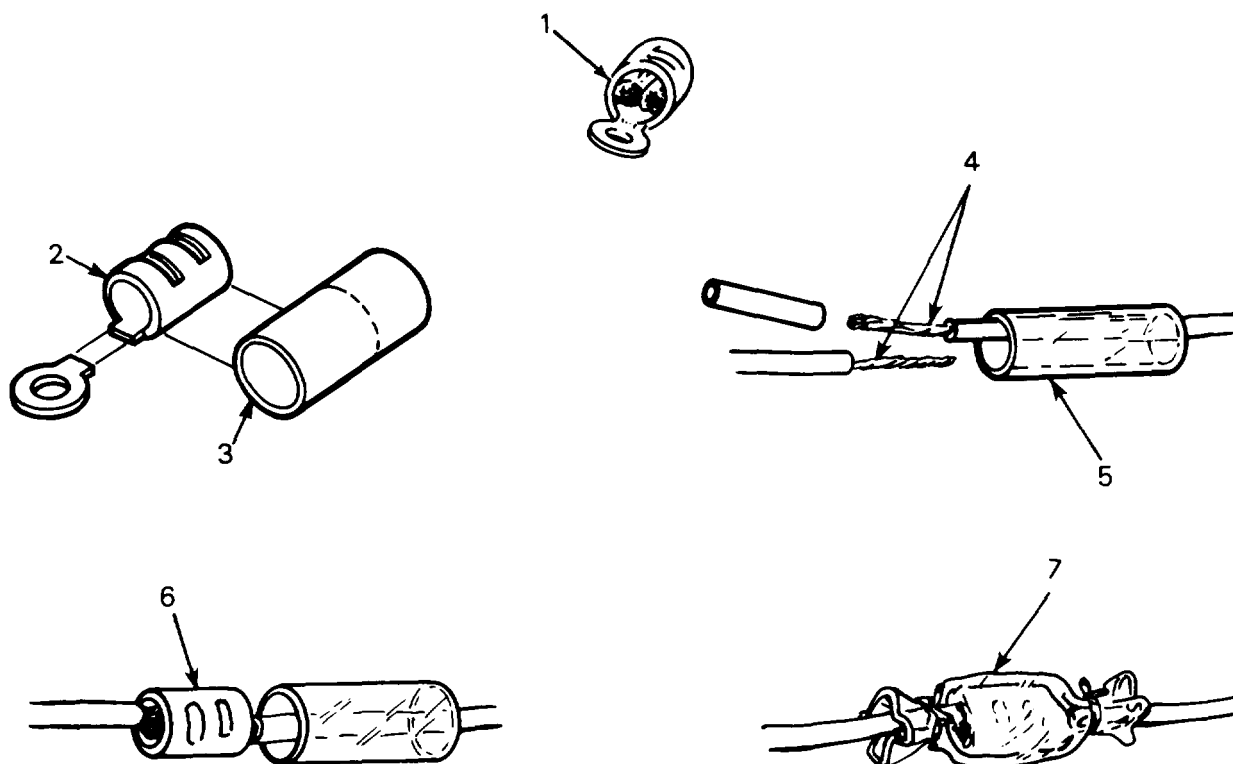


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3. Lay the stripped ends side by side.
4. Twist the wire ends together.
5. Use rosin-core solder and solder wires together.
6. Slide sleeve or tubing over the soldered wires, or apply tape to insulate the conductor.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Wire Splice.

1. If terminal lug barrel is used for splicing, select barrel diameter large enough to accept both wires.
2. Cut off terminal flush with pre-insulation.

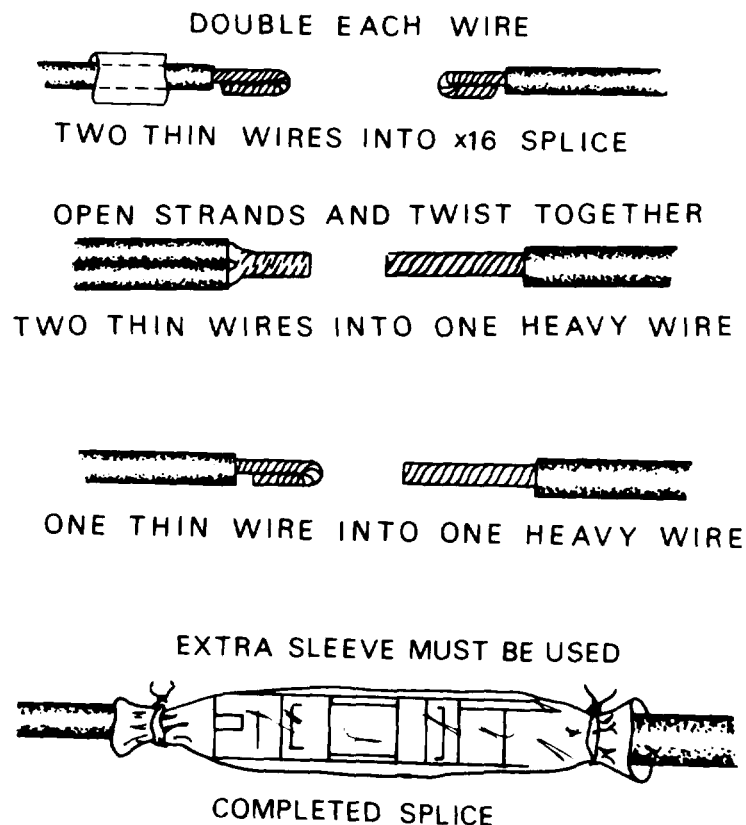


3. Cut insulating sleeve 1 inch longer than the barrel.
4. Strip broken ends of wires.
5. Slide insulating sleeve or shrink tubing, if available, over one end of broken wire.

6. Insert wires into the prepared splice barrel and crimp to secure the wires. Use crimp tool matching the size of the barrel.
7. Slide the sleeve or tubing over the splice or use tape to insulate the conductor. Apply heat to shrink tubing. Ends of nonshrink sleeve must be tied.
8. Record the BDAR action taken. When mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 3: Different Size Wire Splices.

1. Strip broken wire ends, stripping enough insulation to allow the smaller wire to be doubled as shown.
2. Slide plastic sleeve or shrink tubing, if available, over one end of broken wire.
3. Connect wires by using a splice or terminal lug prepared as in Option 2.
4. Crimp splice or lug to secure the wires.
5. Slide the sleeve or tubing over the splice or use tape to insulate the conductor.



6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## 8-14. HEAVY-DUTY CABLE DAMAGED

## General Information:

Heavy electrical cables are more difficult to repair than small wires; however, they can be repaired using several different methods. Splicing procedures can be used to repair a break.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 soldier
- o 15 - 60 minutes

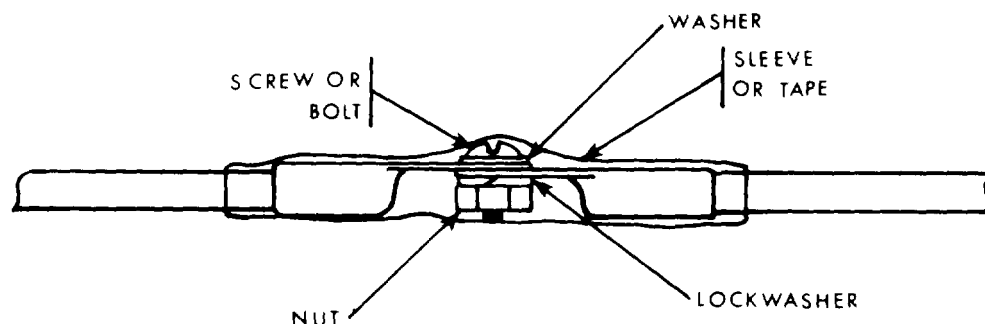
## Materials/Tools:

- o Terminal lugs, screw clamp, or small hole clamp
- o Insulating sleeve or electrical tape
- o Soldering iron or torch and solder
- o Safety wire
- o Clamp cable
- o Heat shrink tubing

## Procedural Steps:

## Option 1: Splice with Terminal Lug.

1. Clean area to be repaired.
2. Trim the broken ends of the wire and slide an insulating sleeve or shrink tubing over one end of the wire.
3. Strip wire and crimp an insulated terminal lug to each wire end.



4. Bolt the terminal lugs together using short bolt with nut.
5. Slide the sleeve or tubing over the connection or use tape to insulate the conductor. Apply heat to shrink tubing. Ends of nonshrink sleeve must be tied.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 2: Splice Stranded Cable.

1. Remove 2 inches of insulation from each end of broken wire.
2. Split the ends of cable into manageable strands and joint the two ends by twisting like strands together.



3. Bend the twisted end parallel to the cable and insulate with tape.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### Option 3: Splice with Clamp.

1. Remove 1 inch of insulation from each end.
2. Separate the strands on each end.
3. Ram the two ends together as far as possible so that the strands intermesh.
4. Solder the intermeshed wires together. If a soldering iron is not available, the two intermeshed ends may be secured with a screw clamp, cable clamp, or safety wire.
5. Insulate with tape.

6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

## Section V. ELECTRICAL MOTORS

## 8-15. GENERAL

Repair on automotive motors should be restricted to relays, solenoids, and brushes. Damage to casings and windings cannot be expediently repaired.

## 8-16. ELECTRICAL ALTERNATOR/MOTOR BRUSH WORN

## General Information:

Electrical motors and alternators use a carbon composition brush to transfer electrical energy to or from the armature commutators. The transfer of energy creates an electrical arc which will burn the brushes. Arcing and normal friction will cause the brushes to become worn and inefficient for electrical power transfer. The brushes can be substituted with the carbon core from a BA30 or BA31 flashlight battery. Care must be taken when opening the battery; the contents are corrosive. Brush retaining springs can be used to transfer the energy or to hold the old brush wires in place.

## Limitations:

- o Shorter motor/alternator life

## Personnel/Time Required:

- o 1 to 3 soldiers
- o 1 to 8 hours

## Materials/Tools:

- o BA30 or BA31 battery
- o Hacksaw
- o Sandpaper

## Other Options:

- o Modify and use other electrical brush sets.

## Procedural Steps:

1. Gain access to motor or alternator.
2. Remove electrical brush plate.
3. Obtain a BA30 or BA31 battery.

**WARNING**

The fibrous material of a battery is corrosive and could cause injury to eyes and damage to clothing.

4. Use a hacksaw or other available tool and split the battery open, taking care not to damage the carbon core.
5. Clean and cut the carbon core to fit the brush plate receptacles.

6. Insert the core into the brush plate and position the old brush wires under the retaining springs to ensure electrical continuity.
7. Seat the brushes:
  - a. Cut a strip of sandpaper slightly wider than the commutator surface.
  - b. Tape the sandpaper strip over the commutator.
  - c. Install the brush plate.
  - d. Rotate the armature in the normal direction of rotation until the carbon core face conforms to the armature surface curvature.
  - e. Remove sandpaper and blow out dust and sand.
8. Assemble motor/alternator and test operation.
9. Install motor/alternator.
10. Record BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 8-17. STARTER SOLENOID DEFECTIVE (DELCO-REMY ONLY)

##### General Information:

With uneven wear of the solenoid plunger shaft, a lip will form on one side of the shaft and the engine starter will not engage. Temporary repair can be made by removing solenoid and rotating solenoid plunger shaft 180 degrees.

##### Limitations:

- o Shorter starter solenoid life

##### Personnel/Time Required:

- o 1 - 2 soldiers
- o 30 - 60 minutes

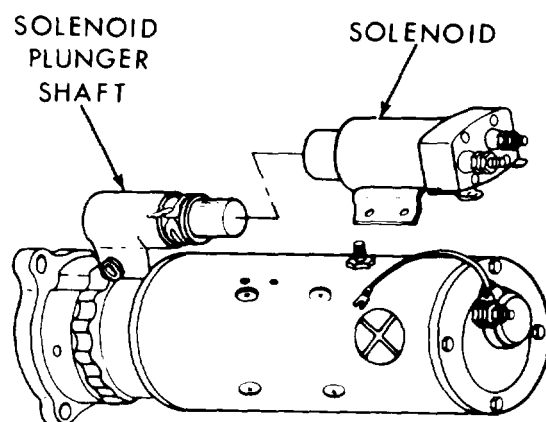
##### Materials/Tools:

- o None

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Procedural Steps:

1. Disconnect power at negative battery terminal.
2. Gain access to engine starter; remove if necessary.
3. Remove solenoid from starter.
4. Rotate solenoid plunger shaft 180 degrees.



5. Install solenoid on starter.
6. Install starter, if removed.
7. Connect power.
8. Test starter operation.
9. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section VI. BATTERIES AND BATTERY CABLES

## 8-18. GENERAL

The batteries store electrical energy to start the vehicle engine and to supply energy for accessory systems to operate without requiring engine operation. The batteries also act as a buffer for the electrical charging system. Without a battery in the circuit, the charging system will charge at its maximum rate and rapidly burn out. Battery configuration is a minimum of two 12-volt batteries connected in series to give a 24 V dc output.

## 8-19. BATTERY TERMINAL POST BROKEN

## General Information:

Battery terminal posts can be repaired if they are broken. The stub can be built back up with lead. If melting facilities or tools are not available, a post can be secured with a self-tapping screw or bolt. The battery should be replaced as soon as possible if the post is only screwed or bolted in place.

## Limitations:

- o Less starting power

## Personnel/Time Required:

- o 1 soldier
- o 10 - 30 minutes

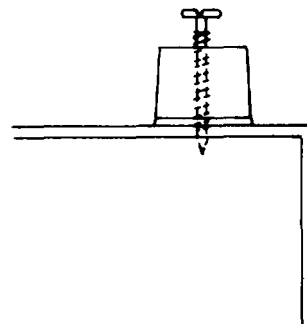
## Materials/Tools:

- o Hose clamp
- o Self-tapping screw
- o Drill and small drill bits
- o Lead
- o Solder
- o Acetylene torch
- o M59 cooking unit

## Procedural Steps:

## Option 1: Repair with Screw.

1. Drill a small hole (1/8 to 3/16 inch) through the terminal post.
2. Screw the broken post to the battery.



3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



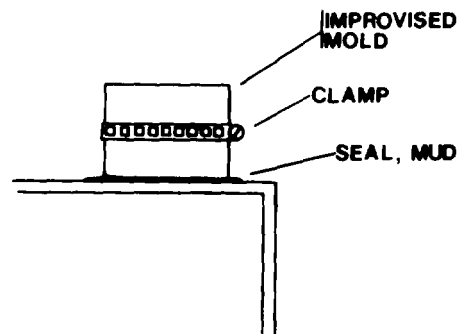
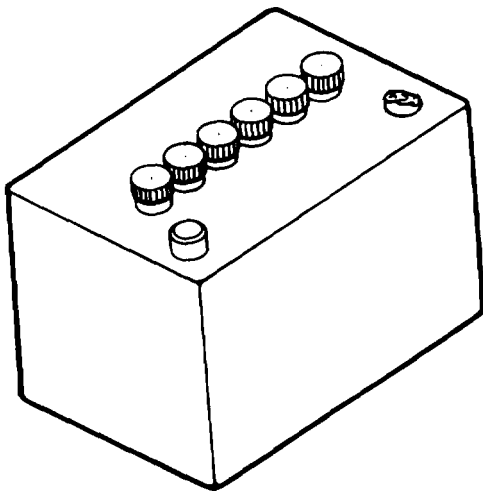
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Option 2: Connect Cable to Broken Post.

1. File down broken battery post.
2. Drill a small hole (1/8 to 3/16 inch) through the filed terminal post.
3. Connect cable terminal with large washer and screw.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Mold a Lead or Solder Post.

1. Disconnect cable clamp and clean the damaged terminal post.
2. File the post round in diameter and flat on top.
3. Install a self-tapping or sheet metal screw into the top of the post.
4. Cut a 1 X 8-inch strip from an aluminum can.
5. Form a mold with the strip of aluminum around the damaged post and secure it with a hose clamp or a piece of wire.



6. Melt approximately 6 oz of lead or solder in a metal can or cup and pour it into the improvised mold.
7. Remove aluminum molding.
8. File the new post so the battery cable clamp will mate securely with the post.
9. Connect cable clamp.
10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

## 8-20. BATTERY CRACKED

### General Information:

Batteries can become cracked from vibrations, impact, or freezing. Cracks can be repaired or sealed until replacements can be obtained. Batteries which are cracked from freezing must be inspected for internal shorts or broken plates. Most epoxy will not shrink and is resistant to acid. Epoxies make a semi-permanent repair and should be used as a first option.

### Limitations:

- o None

### Personnel/Time Required:

- o 1 soldier
- o 1 - 2 hours

### Materials/Tools:

- o Bulk issue fiberglass
- o Epoxy
- o Hardening sealer

### Procedural Steps:

1. Drain battery below the crack.
2. Clean damaged area.
3. Fill crack with either hardening sealer, fiberglass, or epoxy.
4. Fill battery to proper level.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 8-21. BATTERY CABLE DAMAGED

### General Information:

Battery cables and cable ends may be repaired if damaged. If splicing is not possible because of the amount of cable damage, a new cable may be fabricated.

### Limitations:

- o Less starting power

### Personnel/Time Required:

- o 1 soldier
- o 30 - 45 minutes

### Materials/Tools:

- o Cable clamps
- o Small hose clamps
- o Commo wire
- o Electrical tape
- o Wire cutters or pocket knife
- o Vise grips

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#### Procedural Steps:

1. Cut approximately 75 pieces of commo wire 3 inches longer than the damaged cable area.
2. Remove insulation.
3. Remove 1-1/2 inches of insulation from existing battery cable ends.
4. Twist commo wire to form a large cable approximately the same size (diameter) as battery cable.
5. Use cable clamps or hose clamps to hold commo wire to battery cable ends. If no clamps are available, use vise grips to hold cable in place.
6. Wrap exposed wire with electrician's tape.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 8-22. INDEXING STARTERS

##### General Information:

Most of the starters used on tactical wheeled vehicles are basically the same. The integral parts of a starter are arranged in different positions so that the starters can be adapted to different engines and engine configurations. Indexing the position of the starter solenoid to the drive gear housing will allow the starter to be used on a variety of engines.

##### Limitations:

- o None

##### Personnel/Time Required:

- o 1 soldier
- o 30 - 60 minutes

##### Materials/Tools:

- o Adjustable wrench
- o Pliers

#### Procedural Steps:

##### NOTE

The same starter assembly is used on the LDS-465, LDT-465 and LD-465 engines. The pinion housing is positioned differently for certain engine applications. FIGURE 8-I-A illustrates positions for LDS-465-1 and LDS-465-1A engines; FIGURE 8-I-B illustrates positions for LD-465-1, LD-465-1C, and LDT-465-1C engines; and FIGURE 8-I-C illustrates position for LDS-465-2 engine.

1. Remove starter.

2. Remove pinion housing assembly.
3. Remove spacer (if model contains one).
4. Adjust position of pinion housing assembly to particular engine according to engine and position (refer to FIGURES 8-1-A, 8-1-B, and 8-1-C).

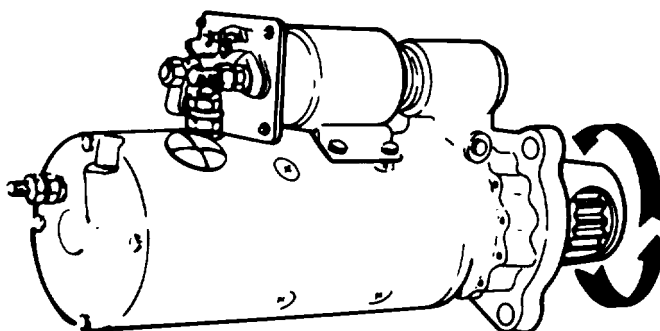


FIGURE 8-1-A. Pinion housing position for LDS-465-1 and LDS-465-1A engine applications.

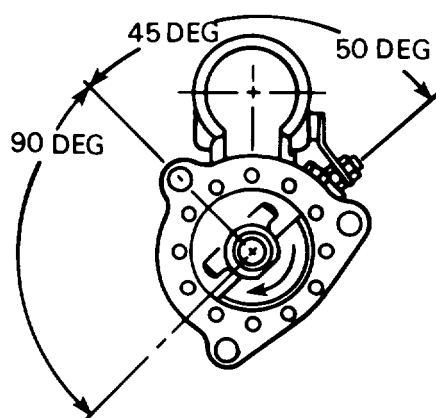


FIGURE 8-1-B. Pinion housing position for LD-465-1 and LD-465-1C, and LDT-465-1C engine applications.

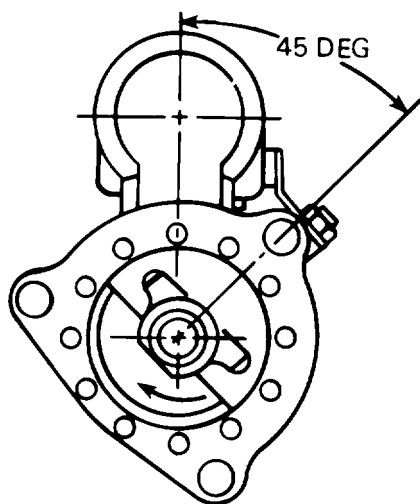
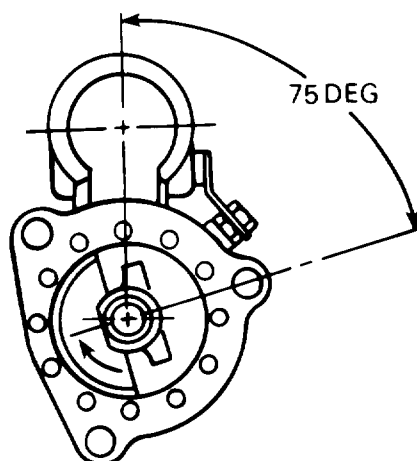


FIGURE 8-I-C. Pinion housing position for LD-465-2 engine applications.

5. Install pinion housing assembly and spacer if necessary.
6. Install starter assembly on engine.



7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 8-23. STARTER SWITCH DEFECTIVE

### General Information:

Starter switches vary in size and mechanical operation. The newer light-duty vehicles and the CUCV series trucks have steering column key switches. If they are inoperative, the steering wheel is locked and steering is impossible. The 5- and 2-1/2-ton trucks have pushbutton and on-off type switches. Most tactical wheeled vehicles do not need a key to start the engine.

### Limitation:

- o None

### Personnel/Time Required:

- o 1 soldier
- o 10 minutes

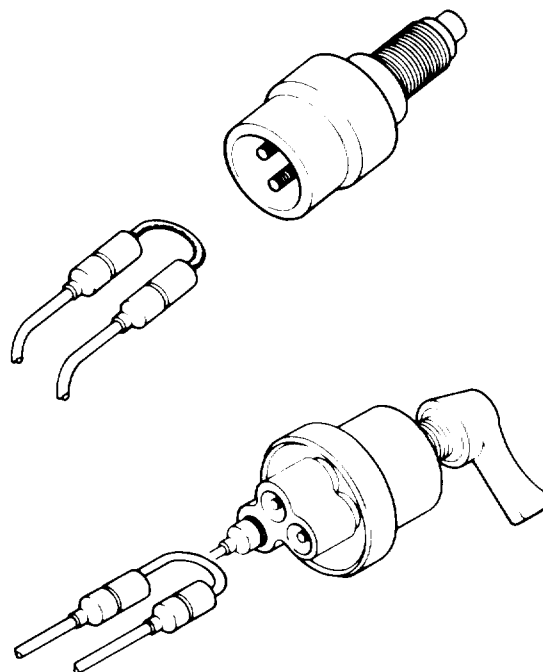
### Materials/Tools:

- o Electrical wire
- o Knife
- o Adjustable wrench

### Procedural Steps:

#### Option 1: Jumper the Switch.

1. Remove the wires from the switch.
2. Cut a piece of electrical wire 6 inches long and remove 1/4 inch of insulation from each end.
3. Insert the jumper wire into the ends of switch wires.
4. Remove jumper wire after engine starts.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



#### Option 2: Isolate the Switch.

1. Cut both wires from the switch.
2. Remove insulation from the cut ends.
3. Attach the two wires together to make an electrical connection.
4. Separate the wires after the engine starts.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 9

## TRANSMISSION SYSTEMS

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. MANUAL TRANSMISSION

## 9-1. GENERAL

A manual transmission with internal problems most likely would have to be repaired in a maintenance shop. Manual transmissions are designed according to the number of forward gears and the measured distance between centerlines of the mainshaft and the counter gear.

## 9-2. ASSESSMENT CHART

- a. Preconditions: Vehicle brakes should be in working condition. The vehicle engine must run to assess the power train using this procedure.

Damage found to:

- Housing; . . . . . go to paragraphs 9-4 and 9-5
- Fluid; . . . . . go to paragraph 9-8
- Linkages; . . . . . go to paragraph 9-9

Damage found to:

- Forward gears; . . . go to specific TM
- Reverse gears; . . . go to specific TM

performance:

## Manual Transmission Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-All gears normal	x	x	x		
-Reverse and two forward gears		x	x	x	
-Reverse and one forward gear			x	x	x
-One gear only			x	x	x
-No gears					x

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## 9-3. BDAR PROCEDURE INDEX

Para

Cracks or Holes in the Housing ..... 9-4

## 9-4. CRACKS OR HOLES IN THE HOUSING

## General Information:

Repair of cracks or holes in the transmission housing can be attempted without removing the transmission. Cracks or holes in the housing may be repaired with epoxies and sealers if the hole or crack is accessible for cleaning.

## Limitations:

- o None

## Personnel/Time Required:

- o 1 to 2 soldiers
- o 1 to 3 hours

## Material/Tools:

- o Cleaning solvent
- o Rags
- o Hardening or silicone sealer
- o Nonhardening sealer
- o Screen (fine mesh)
- o Aluminum cans
- o Sandpaper
- o Wooden peg
- o Gear lubricant
- o Epoxy

## Procedural Steps:

## Option 1: Hardening Sealer.

1. Clean area around holes or cracks with sandpaper.
2. Cut a piece of screen 1 inch larger than the hole.
3. Apply a thin coat of hardening sealer to the edges of the hole.
4. Lay the screen over the hole and add another layer of hardening sealer around the edges. Let sealer dry approximately 20 to 30 minutes.
5. Cut a patch from an aluminum can the same size as the screen.
6. Apply hardening sealer to the entire screen and lay the metal patch over the screen.
7. Coat the patch with hardening sealer.
8. Let dry for 2 to 3 hours.

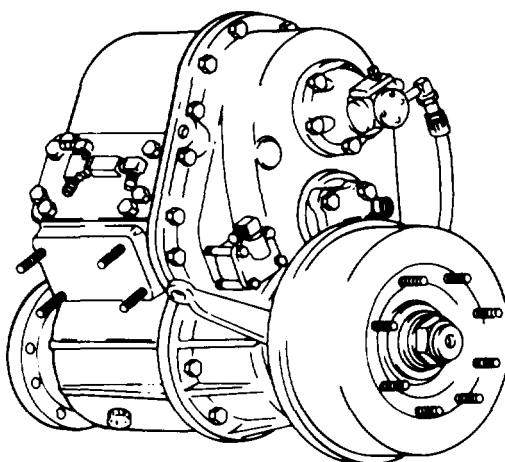


9. Add gear lubricant if necessary.

10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Nonhardening Sealer.

1. Cut a wooden peg approximately the same size as the hole if hardening sealant is not available.
2. Clean area around hole or cracks with sandpaper
3. Cover the peg with nonhardening or silicone sealer and insert peg into hole.

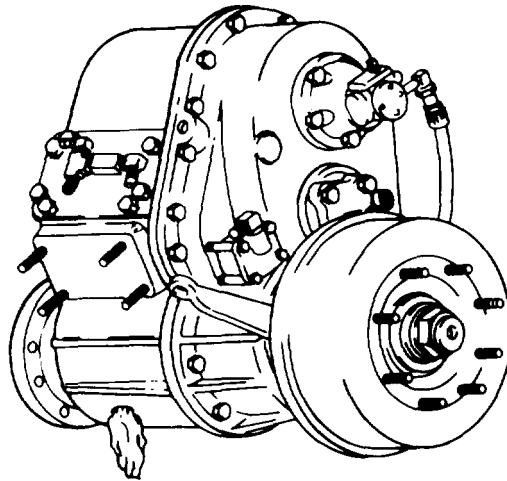


4. Apply sealer around peg to ensure secure seal.
5. Let dry at least 1 hour.
6. Add gear lubricant if necessary.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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Option 3: Epoxy and Rags.

1. Clean area around hole or crack with sandpaper.
2. Fill hole or crack with silicone sealer, epoxy, or any metal filler available.
3. Coat the rag with sealer and insert in the hole.



4. Let dry for at least 1 hour.
5. Add gear lubricant if necessary.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section II. AUTOMATIC TRANSMISSION

## 9-5. GENERAL

An automatic transmission with internal problems most likely would have to be repaired in a maintenance shop. Holes and cracks in the housing and linkage problems can be repaired in the field in an expedient manner. Fluid loss due to holes and cracks and linkage damage are the most frequent external causes of automatic transmission malfunctions.

## 9-6. ASSESSMENT CHART

- a. Preconditions: Vehicle brakes should be in working condition. The vehicle engine must run to assess the power train using this procedure.
- b. Inspect → Damage found to:
- Housing; . . . . . go to paragraph 9-4
  - Drives; . . . . . go to section III
  - Fluids; . . . . . go to paragraph 9-8
  - Linkages; . . . . . go to paragraph 9-9
- No damage found ↓
- c. Start engine, operate transmission, and observe operation → Damage found to:
- Forward gears; . . . . . go to specific TM
  - Reverse gears; . . . . . go to specific TM
- No damage found ↓
- Check power train performance:

Automatic Transmission Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-All gears normal	x	x	x		
-Reverse and one forward gear		x	x	x	
-One gear only			x	x	
-No gears					x

## 9-7. BDAR PROCEDURE INDEX

Para

Fluids .....	9-8
Linkage .....	9-9

## 9-8. FLUIDS

## General Information:

Fluid loss will most likely be caused by cracks or holes in the housing, oil cooler, and oil lines. Refer to paragraph 9-4 for cracks or holes in the housing. Refer to section IX of chapter 3 for metal tube repair. POL substitutes are located in appendix D.

## 9-9. LINKAGE

## General Information:

If the gear-shifting control linkages are damaged, emergency transmission range selection can be performed under the vehicle.

## Limitations:

- o Degraded mobility

## Personnel/Time Required:

- o 2 soldiers
- o 5 to 10 minutes

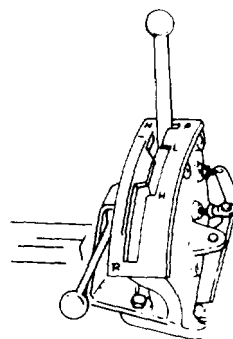
## Materials/Tools:

- o Vise grips
- o Cutting torch

## Procedural Steps:

## Option 1: Manual Shift from Under Vehicle.

1. Remove damaged linkage.



2. Move shift arm to the neutral or park position so the vehicle can be started.
3. One soldier starts the vehicle and keeps the brakes engaged while another soldier crawls under the vehicle and moves shift arm into gear position. After determining gear positions, select proper gear and remove vise grips.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Manual Shift from Inside Vehicle.

1. Cut a hole in the floorboard in the general area of the shifting arm of the transmission.
2. Remove damaged linkage.
3. Use vise grips and move shift arm to the neutral or park position so the vehicle can be started.
4. Start the vehicle.
5. Determine gear position and select proper gear.
6. Record the bar action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section III. TRANSFER ASSEMBLIES

## 9-10. GENERAL

The transfer assembly is essentially a two-speed auxiliary unit which is driven by the transmission. Power is transmitted by the transfer assembly through propeller shafts to each of the driving axles.

## 9-11. ASSESSMENT PROCEDURES

- a. Preconditions: Vehicle brakes should be in working condition. The vehicle engine must run to assess the power train using this procedure.
- b. Inspect → Damage found to:
- Housing; . . . . . go to paragraph 9-4
  - Linkages; . . . . . go to paragraph 9-9
- No damage found ↓
- c. Start engine  
Operate transfer  
assembly and  
observe operation → Damage found to:
- Low-range gears; . . . . . go to specific TM
  - High range gears; . . . . . go to specific TM
- No damage found ↓
- Evaluate system  
performance:

Transfer Assemblies Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-All gears normal	x	x	x		
-Low gears only		x	x	x	
-High gears only		x	x	x	
-No high- or low- range gears					x

## 9-12. BDAR PROCEDURE INDEX

Para

Transfer Interchangeability . . . . .	9-13
Cracks or Holes in the Housing . . . . .	9-14

### 9-13. TRANSFER INTERCHANGEABILITY

#### General Information:

Transfer failure can have a multitude of causes. Availability of replacement transfers may become a problem that can be solved only by removal from other damaged equipment.

An alternate source of supply for transfers is foreign-owned equipment (refer to app C).

### 9-14. CRACKS OR HOLES IN THE HOUSING

#### General Information:

Repair of cracks or holes in the transfer housing can be attempted without removing the transfer.

#### Limitations:

- o None

#### Personnel/Time Required:

- o 1 to 2 soldiers
- o 1 to 3 hours

#### Material/Tools:

- o Cleaning solvent
- o Rags
- o Hardening sealer
- o Nonhardening sealer
- o Gear lubricant
- o Wooden peg
- o Aluminum can

#### Procedural Steps:

##### Option 1: Hardening Sealer.

1. Clean area around holes or cracks with sandpaper.
2. Cut a piece of screen 1 inch larger than the hole.
3. Apply a thin coat of hardening sealer to the edges of the hole.
4. Lay the screen over the hole and add another layer of hardening sealer around the edges. Let sealer dry approximately 20 to 30 minutes.
5. Cut a patch from a aluminum can the same size as the screen.
6. Apply hardening sealer to the entire screen and lay the metal patch over the screen.

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7. Coat the patch with hardening sealer.
8. Let dry for 2 to 3 hours.
9. Add gear lubricant if necessary.
10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: Nonhardening Sealer.

1. Cut a wooden peg approximately the same size as the hole if hardening sealant is not available.
2. Clean area around hole or cracks with sandpaper.
3. Cover the peg with nonhardening sealer and insert peg into hole.
4. Apply sealer around peg to ensure secure seal.
5. Let dry at least 1 hour.
6. Add gear lubricant if necessary.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



## CHAPTER 10

## AXLES AND DRIVE LINES

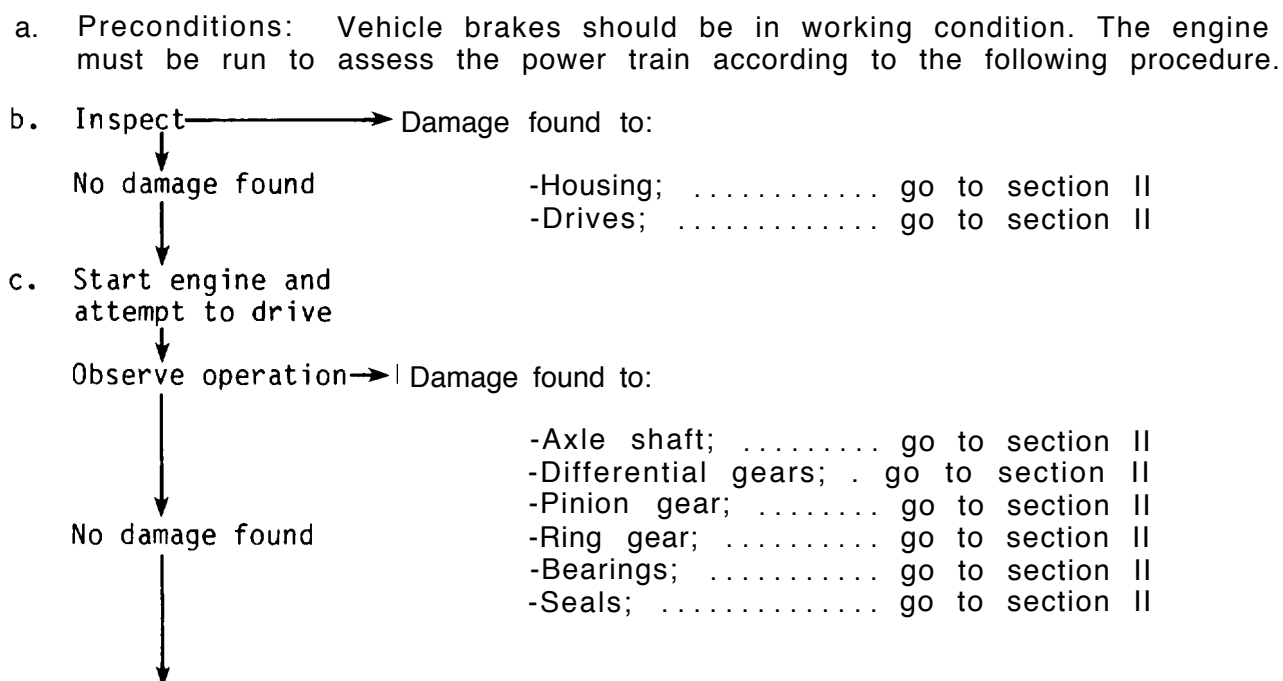
BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

## 10-1. GENERAL

Tactical wheeled vehicles need their axles and drive lines to be in good running condition to perform a combat mission at full capacity. Broken or damaged axle shafts and drive lines are the most frequent causes of running gear and axle malfunctions. Carrier or third member failure is not as likely to happen; but if it does, the rear axle carriers on the 5-ton trucks and 2-1/2-ton trucks are interchangeable within the same series. If 100% efficiency is not needed, the following procedures will explain how to isolate a damaged axle, carrier, axle shaft, or drive line so that the vehicle can be used in a degraded capacity.

## 10-2. ASSESSMENT CHART



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Check rear axle  
Performance:

### Axle and Drive Line Assessment

-Unit operates normally  
-Operates, seal leaks  
-We axle on either FR or RR Unserviceable  
-Axle on FR and RR unserviceable  
-Differential on FR unserviceable  
-Differential on RR unserviceable  
-FR and RR axles and housings Unserviceable

Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self-Recovery Capable	Recover
x	x	x		
	x	x	x	
	x	x	x	
	x	x	x	
	x	x	x	
	x	x	x	
			x	x

## Section II. FRONT AND REAR AXLES

10-3.	BDAR PROCEDURES INDEX	Para
	Axle shaft in front rear axle damaged .....	10-4
	Axle shaft in front rear and rear rear axles damaged .....	10-5
	Axle housing leaks (front rear or rear rear) .....	10-6
	Carrier on front rear or rear rear axle damaged .....	10-7
	Axle shafts and carrier damaged on front rear and rear rear axles. . . . .	10-8
	Front axle damaged I.....	10-9
	Drive line damaged I.....	10-10

## 10-4. AXLE SHAFT IN FRONT REAR AXLE DAMAGED

**NOTE**

The axle lock switch must be engaged.

## General Information:

A broken left or right axle shaft will cause the axle to lose its ability to drive the vehicle. The vehicle can still be propelled by the rear rear axle and the front axle.

## Limitations:

- o Degraded mobility (and terrain capability)

## Personnel/Time Required:

- o 1 soldier
- o 30 minutes

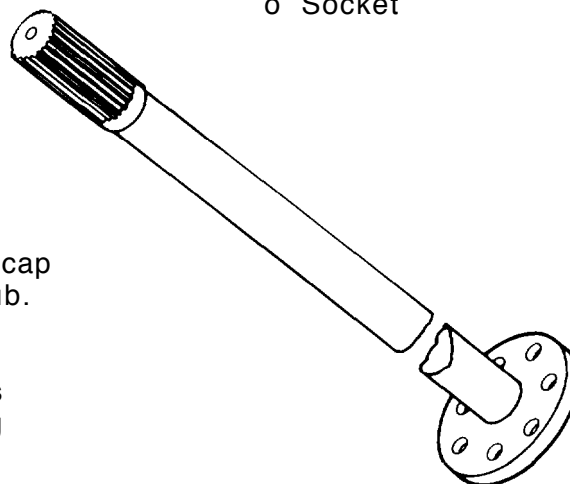
## Materials/Tools:

- o Rags
- o Cardboard
- o Cutting torch
- o Washers
- o Ratchet
- o Socket

## Procedural Steps:

## Option 1: Install Cap.

1. Remove damaged axle shaft.
2. Cut the axle as close to the cap as possible. Install cap on the hub.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



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Option 2: Cardboard Cap.

1. Remove damaged axle shaft.
2. Insert rags in hub.
3. Make a cap from cardboard and install on hub.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 10-5. AXLE SHAFT IN FRONT REAR AND REAR REAR AXLES DAMAGED

General Information:

If both rear axles have axle shaft damage, most tactical wheeled vehicles will operate after some of the drive train to the rear axles has been removed. This will allow the vehicle to use the front axle and perform.

Limitations:

- o Degraded mobility, terrain capability, and load capacity

Personnel/Time Required:

- o 2 soldiers
- o 30 minutes to 2 hours

Materials/Tools:

- o Ratchet and socket

Procedural Steps:

1. Remove the propeller shaft between the transfer case and the front rear axle.

#### NOTE

Some transfers must be in the locked position.

2. Attempt to move vehicle.
3. If vehicle is inoperative, remove propeller shaft between front rear axle and rear rear axle.
4. Attempt to move vehicle.
5. If vehicle is inoperative, refer to paragraph 10-4.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 10-6. AXLE HOUSING LEAKS (FRONT REAR OR REAR REAR)

General Information:

Repair of axle housing leakage due to cracks or holes can be attempted without removing either of the rear axle housings.

**Limitations:**

- o None

**Personnel/Time Required:**

- o 1-2 soldiers
- o 1-2 hours

**Materials/Tools:**

- o Cleaning solvent
- o Rags
- o Hardening sealer
- o Nonhardening sealer

**Procedural Steps:**

1. Clean area around holes or cracks and fill them with silicone, epoxy sealant, or any metal filler available.
2. If the hole is too large to be filled, make a wooden peg, coat the peg with sealer, and place it in the hole.
3. Apply sealer around peg to ensure secure seal.
4. Fill the axle housing to the proper oil level.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**10-7. CARRIER ON FRONT REAR OR REAR REAR AXLE DAMAGED****General Information:**

Carrier damage to either of the rear axles will render the vehicle inoperative.

**Limitations:**

- o Severe mobility restrictions

**Personnel/Time Required:**

- o 2 soldiers
- o 1 to 4 hours

**Materials/Tools:**

- o Gasket material
- o Cardboard

**NOTE**

The carriers in the rear axles of the M939, M809, and M39 series 5-ton trucks are the same. The carriers in the rear axles of all 2-1/2-ton trucks are the same.

**Procedural Steps:****Option 1. Front rear axle carrier damaged.**

1. Remove the axle shafts and the damaged carrier.

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2. Remove the axle shafts and carrier from the rear rear axle housing.
3. Install the rear rear carrier into front rear axle housing.
4. Install axle shafts into both housings.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2. Rear rear axle carrier damaged.

1. Remove both axle shafts.
2. Remove propeller shaft.
3. Make cardboard cover and install on hub.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 10-8. AXLE SHAFTS AND CARRIER DAMAGED ON FRONT REAR AND REAR REAR AXLES

General Information:

With no rear axles in working condition, the vehicle must drive off the front axle only.

Limitations:

- o Degraded speed
- o Terrain restrictions

Personnel/Time required:

- o 2 soldiers
- o 2-4 hours

Materials/Tools:

- o Cardboard

Procedural steps:

1. Remove all axle shafts.
2. Remove propeller shaft.
3. Make a cardboard cover and install on hub.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 10-9. FRONT AXLE DAMAGED

### General Information:

The front axle is necessary for a vehicle to have a 100% load carrying and pulling capability. If the axle shafts or the gears in the third member are damaged, the vehicle can still be used.

### Limitations:

- o Degraded mobility and terrain capability

### Personnel/Time required:

- o 1 soldier
- o 30-45 minutes

### Materials/Tools:

- o Various open-end box wrenches

### Procedural steps:

Option 1: 2-1/2- and 5-ton.

1. Disconnect the hub on the front drums.
2. Disconnect the propeller shaft from axle to transfer case.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 2: CUCV.

1. Put front hubs in free position.
2. Remove propeller shaft from axle to transfer case.
3. Shift transfer case into two-wheel mode.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 10-10. DRIVE LINE DAMAGED

### General Information:

The drive line or propeller shaft in a vehicle must be straight and free of any damage to perform at full load capacity. Most tactical wheeled vehicles utilize more than two drive lines to drive the different axles. Removal of a damaged drive can greatly decrease the capability of the vehicle. A combat damaged drive line can be repaired using the following procedure.

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Limitations:

- o Possible vibration at higher speeds

Personnel/Time required:

- o 1 soldier
- o 1-3 hours

Materials/Tools:

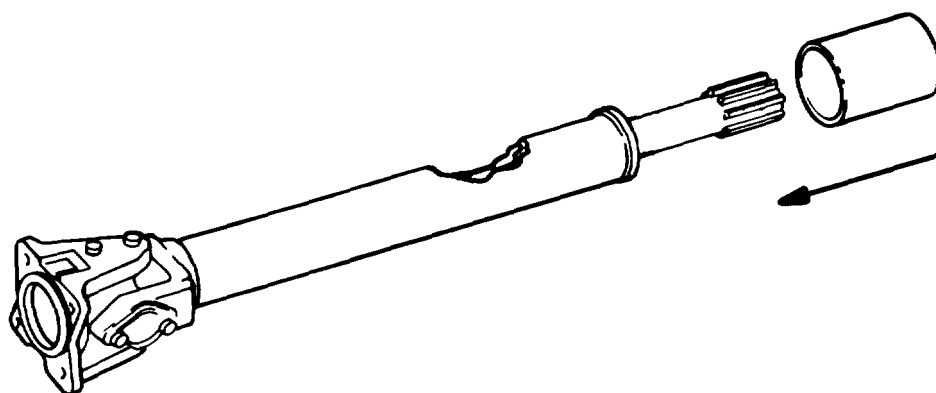
- o Crowbar
- o Steel pipe
- o Acetylene cutting torch with welding tips
- o Arc welder (if available)
- o Assorted sizes of combination wrenches

Procedural steps:

1. Remove damaged drive line.

NOTE

The diameter of a pipe can be determined by measuring the circumference of the pipe and dividing that distance by 3.1415.



2. Measure the outside diameter of the drive line.
3. Obtain a piece of steel pipe that has an inside diameter no more than 1/2 inch larger or smaller than the diameter of the drive line.
4. Cut the pipe a little longer than the damaged area of the drive line.
5. If the pipe is too small in diameter, cut a slit in the pipe and use a crowbar or wedge to enlarge the pipe so it will slide over the drive line.
6. Remove jagged edges and pound down any protrusions that would keep the pipe sleeve from sliding over the drive line. Slide pipe over damaged area.



7. If the pipe sleeve is a little larger, use screwdrivers or wedges (small rocks, sticks, etc) to keep the pipe sleeve centered on the drive line.

**CAUTION**

Drive line will warp if a large amount of heat is applied in one area. Weld in 1/2-inch passes on opposite sides.

8. Gas weld or arc weld the pipe to the drive line in 1/2-inch passes.
9. Install drive line in vehicle.
10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 11

## BRAKES AND WHEELS

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

## 11-1. GENERAL

- a. Brake systems are classified in different categories depending upon how they are actuated or assisted. There are air hydraulic, vacuum assist, hydraulic assist, and air or hydraulic brake systems. Every system except the straight air system uses hydraulic lines to all wheels, wheel cylinders, hydraulic reservoirs, and master cylinders.
- b. Wheel failure can have a multitude of causes. Availability of replacement wheels may become a problem that can be solved only by removal from other damaged equipment. An alternate source of supply for wheels is foreign-owned equipment (refer to appendix C).

## Section II. HYDRAULIC BRAKES

## 11-2. GENERAL

The common result of hydraulic brake system failure is the loss of fluid. The system must be sealed or leakage reduced. Some holes in the hydraulic system can be repaired using procedures provided in chapter 3 of this manual. Tubing or hose leaks can be repaired using methods shown in chapters 6 and 7.

## 11-3. ASSESSMENT CHART

- a. **Assessment Preconditions:** Before testing the vehicle brakes, clear the immediate area; or, if in a restricted area, restrain the vehicle to be tested with chains or cables connected to a restraining vehicle. The brakes can be tested either by using the vehicle's own power or by being towed up a slight grade by the restraining vehicle.
- b. Check fluid level
- c. . Inspect → Damage found to:
- Pedal and linkage; ..... go to paragraph 11-5
  - Hydraulic brake lines; . go to paragraph 11-6
  - Brake cylinders; ..... go to paragraph 11-7
- No damage found
- ↓
- Operate or tow → Damage found to:
- Parking brakes; ..... go to paragraph 11-8
- the vehicle up a slight grade and check brake operation effectiveness.
- ↓
- Evaluate system performance:

Brake Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-Brakes normal	x	x	x		
-Brakes degraded		x	x	x	
-Brakes severely degraded			x	x	
-No brakes			x	x	x

## 11-4. BDAR PROCEDURE INDEX

	Para
Pedal and Linkage Damage .....	11-5
Hydraulic Brake Line Damage .....	11-6
Brake Cylinder Failure .....	11-7
Parking Brake Locked .....	11-8
Brake Malfunction, Hydraulic Fluid Loss .....	11-9

## 11-5. PEDAL AND LINKAGE DAMAGE

## General Information:

If the brake pedal linkage is broken, the only BDAR fix would be to weld the broken parts. Some bent or damaged parts may need to be straightened with heat.

## Limitations:

- o Severely degraded brakes
- o Reduced speed
- o No brakes

## Materials/Tools:

- o Arc welder
- o Acetylene torch
- o 2-lb hammer
- o Bench vise

## Personnel/Time Required:

- o 1 soldier
- o 2 hours

## Other Options:

- o Cannibalize parts from similar vehicle.

## Procedural Steps:

1. Remove damaged or broken linkage.
2. Heat and reshape damaged parts or weld if necessary.
3. Replace repaired part or parts.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 11-6. HYDRAULIC BRAKE LINE DAMAGE

## General Information:

BDAR for a hydraulic system is generally confined to component replacement, expedient line repairs, or bypassing damaged lines. If a hydraulic circuit cannot be repaired, it may be necessary to isolate it, cutting it off from the system to permit operation of some other hydraulic functions. Damage to the hydraulic brake system requires replenishment of lost fluids.

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Limitations:

- o Degraded braking
- o Reduced speed
- o Uneven braking

Personnel/Time Required:

- o 1 soldier
- o 30 minutes

Materials/Tools:

- o Tie wire
- o Tubing cutter
- o Hacksaw
- o Sidecut pliers
- o Visegrip pliers

Procedural Steps:

**NOTE**

Refer to chapter 3 for repair procedures for hydraulic lines.

1. Find the split or break in the line.
2. Cut the line in front of the break.
3. Fold 2 inches of the line back and crimp it together.
4. Fold the crimped portion in half and crimp it again.
5. Wire the line to the nearest stationary place.
6. Check fluid level in the reservoir. If brake fluid is not available, refer to paragraph 11-9 for substitute fluids.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

11-7. BRAKE CYLINDER FAILURE

General Information:

The wheel cylinder, mounted on the backing plate assembly at both ends of each axle assembly, consists of two opposed rubber cups and pistons enclosed in a cast housing. The fluid forced from the air hydraulic cylinder enters the wheel cylinder at a point between the rubber cups and pistons. This causes the cups and pistons to move outward to exert pressure through the push rods on the upper ends of the brakeshoes. Fluid leakage around the pistons and cups is the biggest factor in brake cylinder failure. This will cause erratic braking due to fluid contamination of the brakeshoe linings.

**Limitations:**

- o Degraded braking
- o Reduced speed
- o Uneven braking

**Personnel/Time Required:**

- o 1 or 2 soldiers
- o 30 to 60 minutes

**Material/Tools:**

- o Wire
- o Visegrip pliers

**Procedural Steps:**

1. Remove hydraulic line from the backing plate if necessary.
2. Fold 2 inches of the line back and crimp it together.
3. Fold the crimped portion in half and crimp it again.
4. Wire the line to the nearest stationary place.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**11-8. PARKING BRAKE LOCKED****General Information:**

Parking brakes are cable operated. Most malfunctions are caused by the cable not releasing the parking brake. Some parking brakes are fixed to the transfer case, and others are part of the rear axle brake system. In most cases, the parking brake handle will not release, causing the brakes to remain applied. Disconnecting the linkage will release the brakes.

**Limitations:**

- o No parking brakes

**Personnel/Time Required:**

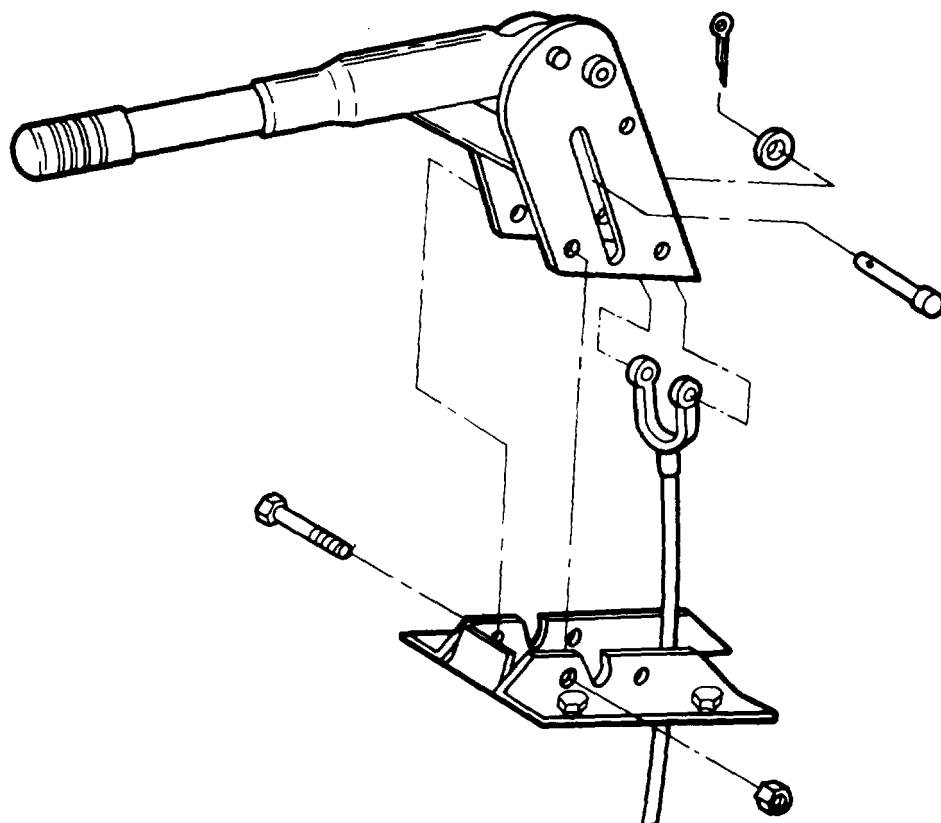
- o 1 soldier
- o 5 minutes

**Materials/Tools:**

- o Pliers
- o Adjusting wrench

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## Procedural Steps:



1. Locate the parking brake handle.
2. Remove cable from parking brake handle and bracket.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 11-9. BRAKE MALFUNCTION, HYDRAULIC FLUID LOSS

## General Information:

If BDAR fixes have been applied to brake components to reduce fluid loss, lost brake fluid must be replaced to make hydraulic brake action possible. If brake fluid is not available, the following fluids will work as emergency substitutes:

- (1) Hydraulic fluid
- (2) Ethylene glycol (antifreeze)
- (3) Diesel fuel
- (4) Water
- (5) Petroleum-based fluids
- (6) Alcohol

Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Section III. AIRBRAKES


## 11-10. GENERAL

The basic characteristic of this system is that the brakes are applied by compressed air. Compressed air provides sufficient braking force to control even the heaviest vehicles. The fundamental units and descriptions of their functions are listed in 1 thru 8 below:

1. Air compressor, driven directly from engine crankshaft or from one of the auxiliary shafts to furnish compressed air for brake operation.
2. Governor, to limit pressure produced by compressor within a predetermined range.
3. Reservoir, to receive air from compressor and store it for use in the braking system. Two or more reservoirs are usually used.
4. Airbrake valve, to control brake operation by directing flow of air from reservoir to brake chambers when brakes are applied, and from brake chambers to atmosphere when brakes are released.
5. Brake chambers, one for each wheel, to convert pressure of compressed air into mechanical force for applying brakes.
6. Quick-release valve, to speed up exhaust of brake chambers not close to brake valves so that all the brakes may be quickly released.
7. Relay valve, used on trailers and trucks with long wheelbases to speed operation of rear wheel brakes. On trucks with short wheelbases, the shorter length of brake lines permits rapid rear brake action without aid of a relay valve.
8. Slack adjusters, provide a means of adjusting the brakes to compensate for wear in linings.

## 11-11. ASSESSMENT CHART

- a. Assessment Preconditions: Before testing the vehicle's brakes, clear the immediate area or, if in a restricted area, restrain the vehicle to be tested with chains or cables connected to a restraining vehicle. The brakes can be tested either by using the vehicle's own power or by being towed up a slight grade by the restraining vehicle.
- b. Start the engine and check air pressure for a 60-psi minimum.
- c. Inspect and check-+ Damage found to:  
     brake operation  
     effectiveness
 



- Air compressor; ..... go to paragraph 11-13
  - Air governor; ..... go to paragraph 11-14
  - Reservoir; ..... go to paragraph 11-15



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↓  
 No damage found  
 ↓  
 Evaluate System  
 performance:

-Brake chamber; . . . . . go to paragraph 11-16  
 -Quick-release valve; . go to paragraph 11-17  
 -Relay valve; . . . . . go to paragraph 11-18  
 -Slack adjusters; . . . . . go to paragraph 11-19

## Brake Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-Brakes normal	x	x	x	x	
-Brakes degraded		x	x	x	
-Brakes severely degraded			x	x	x
-No brakes			x	x	x

## 11-12. BDAR PROCEDURE INDEX

	Para
Air Compressor Failure . . . . .	11-13
Air Governor Failure . . . . .	11-14
Air Reservoir Damage . . . . .	11-15
Brake Chamber Damage or Failure . . . . .	11-16
Quick-Release Valve Failure . . . . .	11-17
Relay Valve Failure . . . . .	11-18
Slack Adjuster Damage or Failure . . . . .	11-19

## 11-13. AIR COMPRESSOR FAILURE

## General Information.

Air compressor failure on vehicles with airbrakes will render the vehicles inoperable. There are some fixes and bypasses that will allow limited vehicle operation.

## Limitations:

- o Very degraded stopping capability,
- o Decreased speed
- o Decreased number of stops
- o Increased stopping distance
- o Decreased traveling distance

## Personnel/Time Required:

- o 1-2 solders
- o 1-3 hours

## Materials/Tools:

- o Argon
- o Nitrogen
- o 1/4-inch air hose (10-15 ft)
- o Assortment of 1/2-inch tubing fittings
- o Copper tubing, 6 inches

## Procedural Steps:

**WARNING**

Driving a vehicle without brakes could cause damage to the vehicle and injury to personnel. Operate only in lowest gear. Use this procedure as a last resort.

## Option 1: No Brakes.

1. Shift transfer case into low range.
2. Back off caging bolts located in the center of the rear axle fail-safe brake chamber assembly.
3. Use the lowest gear on transmission so that a safe speed without brakes can be maintained.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 2: Insert Gas Substitute.

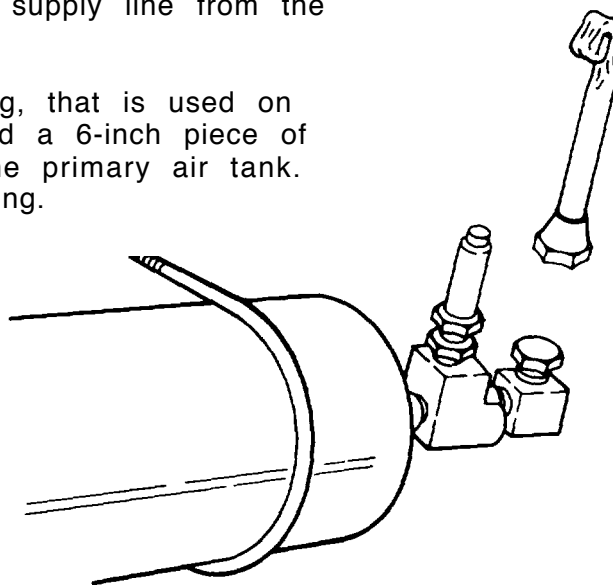
**WARNING**

Do not use compressed oxygen as a pressure medium. Air compressor systems have a slight amount of oil that seeps into the air lines. Oxygen will explode when oil is present in a pressurized system, resulting in death or serious injury.

1. Obtain a bottle of nitrogen or argon with a regulator. The bottle should be at least one-half full (1000 psi).
2. Secure bottle in the vehicle for easy access.
3. Locate one of the emergency air lines on the rear of the vehicle.

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4. Adjust the regulator to zero pressure by turning adjustment knob fully counterclockwise.
5. Adapt a 1/4-inch air hose from the nitrogen or argon bottle to the emergency air line on the rear of the truck.
6. Disconnect the main air supply line from the primary air tank.
7. Use the same size fitting, that is used on the main air supply line, and a 6-inch piece of copper tubing to plug off the primary air tank. Double crimp the copper tubing.



8. Open the valve on the bottle.
9. Adjust the regulator for 100 psi.
10. Check air gage in the vehicle for a pressure reading.
11. Drive the vehicle a short distance and check braking.
12. Periodically check pressure in the nitrogen or argon bottle.
13. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 11-14. AIR GOVERNOR FAILURE

The governor maintains air pressure in the reservoir between the desired maximum and minimum values by controlling the compressor unloading mechanism. If the governor failed, maintaining a constant working air pressure would be impossible.

#### Limitations:

- o None

#### Personnel/Time Required:

- o 1 soldier
- o 1 hour

#### Materials/Tools:

- o Pipe plug
- o New or used replacement governor

**Procedural Steps:****Option 1: Replace Governor.**

1. Locate and remove damaged governor.
2. Install new or used governor.
3. If new or used part is not available, try a governor from another vehicle with an air system.
4. Start the vehicle and check that the air pressure minimum is high enough to supply the braking operation of the vehicle.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**Option 2: Isolate Governor.**

1. Locate damaged governor. Some are located on the firewall and others near the compressor.
2. Remove the two largest air lines.
3. Plug the lines with a pipe plug or crimp the copper lines and double them over.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**11-15. AIR RESERVOIR DAMAGE****General Information:**

The reservoir stores air that it receives from the compressor. Reservoir leaks can be detected by listening for escaping air or by pouring water over the reservoir and watching for air bubbles. Repairs normally are made by welding the reservoir; but if welding equipment is not available, and the hole is small, a repair can still be made using this procedure.

**Limitations:**

- o None

**Personnel/Time Required:**

- o 2 soldiers
- o 1 to 2 hours

**Materials/Tools:**

- o Arc welder
- o Sandpaper or file
- o Epoxy
- o Wood
- o Sheet metal screws
- o Leather boot
- o Rubber from tire or tube
- o Large diameter washer

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#### Procedural Steps:

##### Option 1: Weld.

1. Locate leak and remove reservoir if necessary.
2. Clean the hole(s) with sandpaper or file.
3. Form-fit a piece of similar metal over damaged area.
4. Weld a two-pass bead around the patch metal.
5. Install reservoir.
6. Start engine and check for leaks.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

##### Option 2: Epoxy and Self-Tapping Screw.

1. Locate leak and remove reservoir.
2. Clean area around hole with sandpaper.
3. Fill holes with available material such as self-tapping sheet metal screw, and cover with a quick-drying epoxy plastic; or force a sheet metal screw through a makeshift washer (leather or rubber). Use a washer, if available, to back up the rubber or leather. Install into hole. Tighten securely.
4. Install reservoir.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

##### Option 3: Use One Reservoir; Isolate Damaged One.

1. Disconnect the air line from the damaged air reservoir.
2. Remove the line connecting both reservoirs.
3. Attach air line from compressor to the good reservoir.
4. Plug holes in reservoir to be used with appropriate size pipe plugs.
5. Start engine and check for leaks.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 4: Bypassing Damaged Air Reservoirs.

1. Disconnect air lines from both damaged air reservoirs.
2. Determine which line comes from the compressor and which one goes to the air hydraulic cylinder. Attach the lines together.
3. Plug lines needed to maintain air pressure.
4. Start engine and check for leaks.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 11-16. BRAKE CHAMBER DAMAGE OR FAILURE

##### General Information:

The brake chamber is an air device that operates the brakeshoes of a vehicle. When the chamber is damaged or fails, the brakes will automatically lock up and stop the vehicle.

If one or more of the brakes will not release, the following procedure will allow the vehicle to move.

##### Limitations:

- o Reduced braking ability
- o Reduced speed

##### Personnel/Time Required:

- o 1 soldier
- o 30 to 60 minutes

##### Material/Tools:

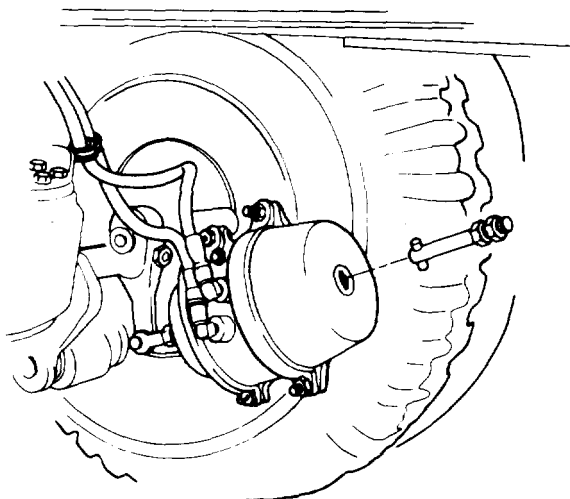
- o Adjustable wrench
- o Caging tool

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## Procedural Steps:

### NOTE

When the brake is manually released, that brake will not have any braking capability.



1. Use a caging bolt tool and turn in a direction that will retract the pushrod and compress the power spring in the brake chamber.
2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 11-17. QUICK-RELEASE VALVE FAILURE

### General Information:

The quick-release valve is provided to reduce the time required to release the air pressure from the brake chambers.

Quick-release valve can have a multitude of failures. Availability of replacement parts may become a problem that can be solved only by removal from other damaged equipment.

There are two valve failures that would cause the vehicle to be inoperable. One would be when the valve exhausts all the time, and the second would be when the valve will not exhaust.

### Limitations:

- o Reduced braking ability
- o Reduced speed

### Personnel/Time Required:

- o 2 soldiers
- o 15 to 60 minutes

### Materials/Tools:

- o Lockwire
- o Hose clamps
- o Assorted size bolts or capscrews

## Procedural Steps:

### NOTE

Each rear axle of a tandem or triple set has its own quick-release valve.

#### Option 1: Isolate Chamber.

1. Remove the main air line to the brake chamber.
2. Plug the main line if fittings are available.
3. If no fittings are available, kink the air line by doubling it over, and tie it with wire.
4. Check for leaks.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Plug Main Air Line.

1. Cut the main air line.
2. Use a bolt of equal or close diameter and screw it into the line. Lock-wire the line in two places.
3. Check for leaks.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 11-18. RELAY VALVE FAILURE

### General Information:

The relay valve is controlled by the brake valve, and speeds up application and release of the rear wheel brakes for long wheelbase vehicles. It reacts quickly to slight changes in air pressure from the brake valve. Repair can be done only by replacement with a serviceable valve.

## 11-19. SLACK ADJUSTER DAMAGE OR FAILURE

### General Information:

Slack adjusters function as adjustable levers and provide a means of adjusting the brakes to compensate for wear of linings. During brake operation, the entire slack adjuster rotates with the brake camshaft, which is connected to the slack adjuster through the splined central hole. For brake adjustment, the worm moves the gear, changing the position of the lever arm with respect to the camshaft. Repair can be done only by replacement with a serviceable adjuster.



## Section IV. WHEELS

## 11-21. WHEEL INTERCHANGEABILITY

## General Information:

Wheel interchangeability among different vehicles can be successfully accomplished by using table 11-1 at the end of this section. The chart lists an X in the box where bolt patterns are the same. This does not mean that the tires on the wheels will be the same size. Some of the newer vehicle series use a low-profile, extra-wide tire. Some still use duals on the rear axles. Some single-wide tires can be used in place of duals as long as the weight capacities are close and clearance can be maintained. The following is a list of trailers that have the same size wheel for all 2-1/2-ton trucks.

2-1/2-ton drop-axle trailer  
 M353 3-1/2-ton trailer  
 M104A2 1-1/2-ton trailer  
 M532 3-1/2-ton trailer  
 M105A2 1-1/2-ton trailer  
 M532 Laundry unit  
 M200A1 2-1/2-ton generator trailer

## Limitations:

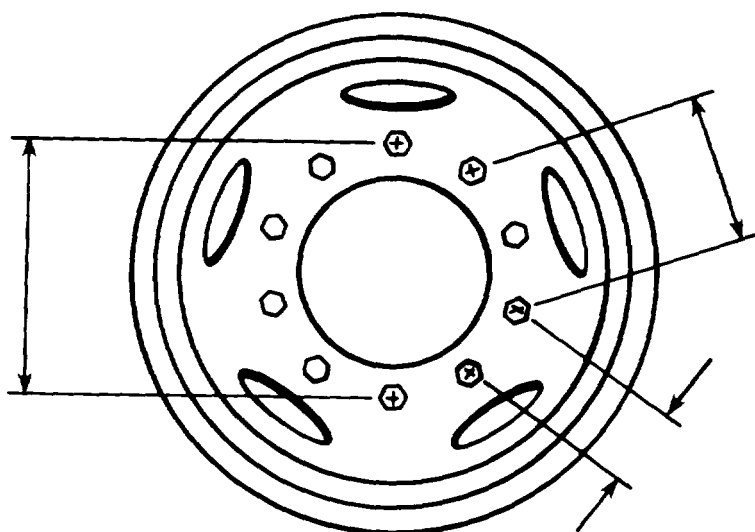
- o Reduced speed
- o Degraded mobility

## Materials/Tools:

- o Tape measure
- o String
- o Cutting torch

## Procedural Steps:

Option 1: Measure Lug Nut Pattern.



**NOTE**

Ten-bolt wheel lug nut patterns are identical on many of the tactical wheeled vehicles. The 2-1/2-ton series wheels all interchange. The Dodge 880 and the HMMWV 8-lug wheel will fit all the CUCV'S that have 8-lug wheels, but the CUCV wheel will not fit the rear axle of the Dodge or any hub on the HMMWV.

1. Measure the lugs on the hub or the holes in the wheel for similar patterns.
2. Measure the center hole in the wheel for hub clearance.
3. Make sure that tire size is correct so that tire will not hit or rub the vehicle.
4. Remove damaged wheel and replace the wheel and tire from another vehicle.
5. Make sure to keep like-size tires on the rear.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**Option 2: CUCV as a Substitute.**

1. If CUCV wheels are the only wheels available for a Dodge 880 or a HMMWV, use a cutting torch and cut the center hole about 1/8 inch larger.
2. Install the wheels on vehicle.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**Option 3: Rear Wheel.**

1. Use one of the dual rear wheels to replace a front wheel.
2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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Table 11-1. Wheel Interchangeability

VEHICLE												
		M561	M880	M1008		M939	M35	M809	M39		M915	
WHEEL	M151	Gamma	Dodge	M1009		5-ton	2-1/2	5-ton	5-ton	M977	Line	M911
	Jeep	Goat	Truck	CUCV	HMMWV	Truck	-Ton	Truck	Truck	HEMTT	Haul	C-HET
M151 Jeep	X											
M561 Gamma Goat		X										
M880 Dodge Truck			X	X	X*							
M1008, M1009 CUCV			X*	X	X*							
HMMWV			X	X	X							
M939 5-Ton Truck						X		X	X			
M35 2-1/2-Ton Truck							X					
M809 5-Ton Truck						X		X	X			
M39 5-Ton Truck						X		X	X			
M977 HEMTT										X	X	
M915 Line Haul Truck											X	
M911 C-HET												X
M746 22.5-Ton Tractor											X	

\* Refer to option 2 of paragraph 11-21.

## CHAPTER 12

## STEERING SYSTEM

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

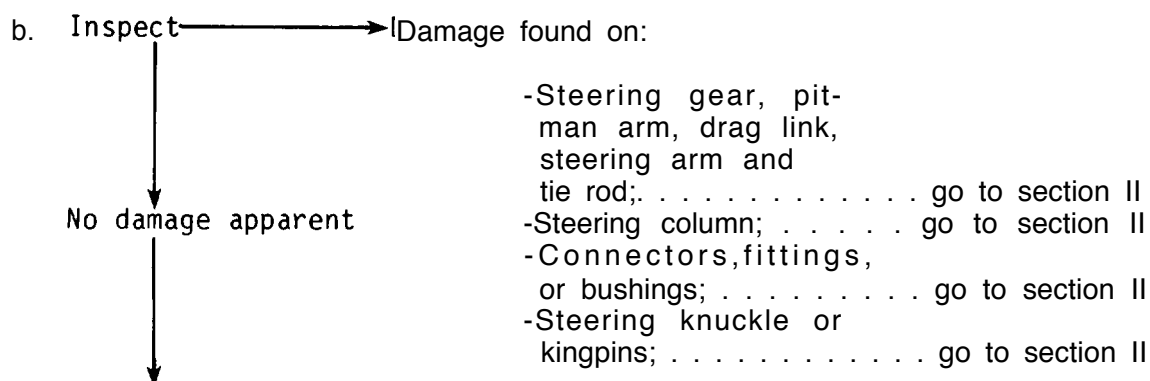
## 12-1. GENERAL

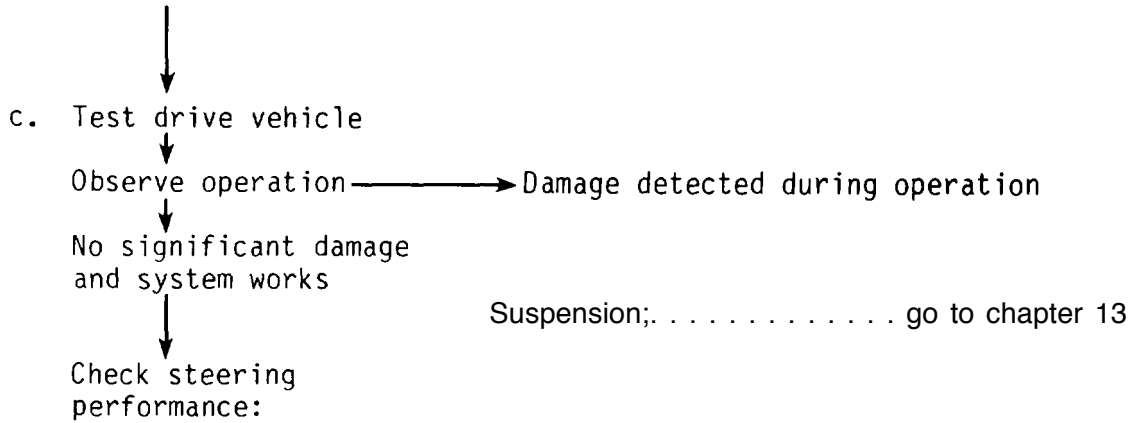
The steering systems consist of steering wheels, steering columns, steering gear assemblies, hydraulic pumps, linkage such as tie rods and idler arms, kingpins, steering arms and knuckles, connectors, fittings, and bushings. These parts must be adjusted, aligned, and lubricated to ensure the operator proper control of the wheeled vehicle. Steering malfunctions can be detected by:

- a. Abnormal darting to the left or right without any steering wheel movement.
- b. Excessive pulling on the wheel to the left or right.
- c\* No control at all.
- d. Abnormal noises.
- e. Front end chatter and erratic steering wheel movement.

## 12-2. ASSESSMENT PROCEDURE

- a. Preconditions: Vehicle brakes should be in working condition. The vehicle must be capable of movement to assess the power train using this procedure.





## Steering System Assembly Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-Steering normal	x	x	x		
-Steering degraded		x	x	x	
-Steering severely degraded			x	x	x
-No steering					x

## 12-3. BDAR PROCEDURE INDEX

## Para

Steering Gear, Pitman Arm, Drag Link, Steering Arm, Cross Tube Arm, Tie Rod Ends, Tie Rod Cross Tube, and Alinement Damage . . . . .	12-5
Steering Column Damage . . . . .	12-6

## Section II. STEERING COMPONENTS

### 12-4. GENERAL

Steering components are, for the most part, hydraulically assisted. The hydraulic system does not need to be intact to operate a vehicle. The linkage arms can be repaired if bent or damaged. Reduced vehicle speed will be necessary for control.

### 12-5. STEERING GEAR, PITMAN ARM, DRAG LINK, STEERING ARM, CROSS TUBE ARM, TIE ROD ENDS, TIE ROD CROSS TUBE, AND ALINEMENT DAMAGE

#### General Information:

Vehicle will not steer straight. This procedure will allow the vehicle to be driven without the risk of total tire damage due to misalignment.

#### Limitations:

- o Reduced speed and maneuverability

#### Personnel/Time Required:

- o 2 soldiers
- o 6 hours

#### Materials/Tools:

- o Replacement parts new or used
- o Wire
- o Tape measure or stick longer than axle width
- o Pry bar, tree limb, or string

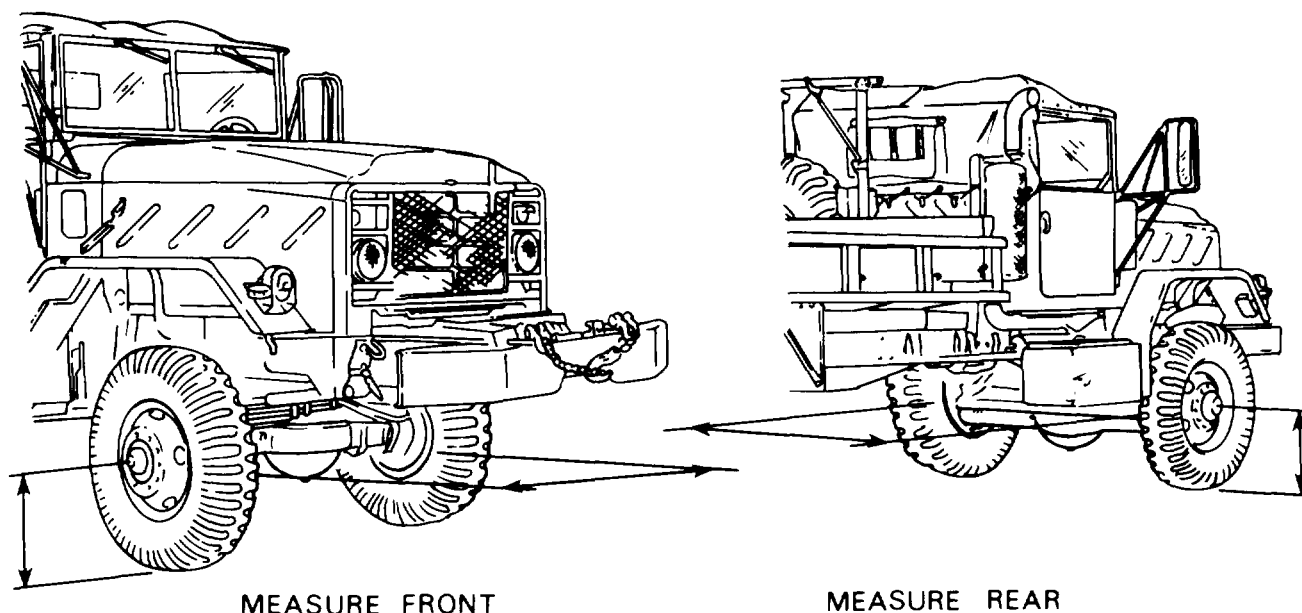
#### Procedural Steps:

1. Remove linkage parts that are damaged and replace with new or used parts.
2. If parts are not available, proceed as follows:
  - a. Wire joint or socket connections that are a part of the tie rod end, cross tube arm, tie rod cross tube, and steering arm.
  - b. If tie rod cross tube is bent, straighten with pry bar or tree limb.

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3. Measure inside distance between front tires with a tape measure, string, or piece of wood as follows:

- a. Place front wheels in straight-ahead position.
- b. Measure the distance from the center of the front hub to the ground.
- c. Mark the inner tire side walls the same distance as measured in step b on the front and the rear of the tires.



- d. Measure and record distance between marks. The front measurement should be 1/4 inch shorter than the rear.

- e. Adjust tie rod ends and repeat step d and e until properly aligned.

4. Record the BDAR action taken. When mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 12-6. STEERING COLUMN DAMAGE

### General Information:

Repair can be accomplished by using replacement parts. An alternate source of supply for steering columns is foreign-owned equipment (see appendix C). Record the BDAR action, taken. When mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 13

## FRAME AND SUSPENSION

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section 1. GENERAL

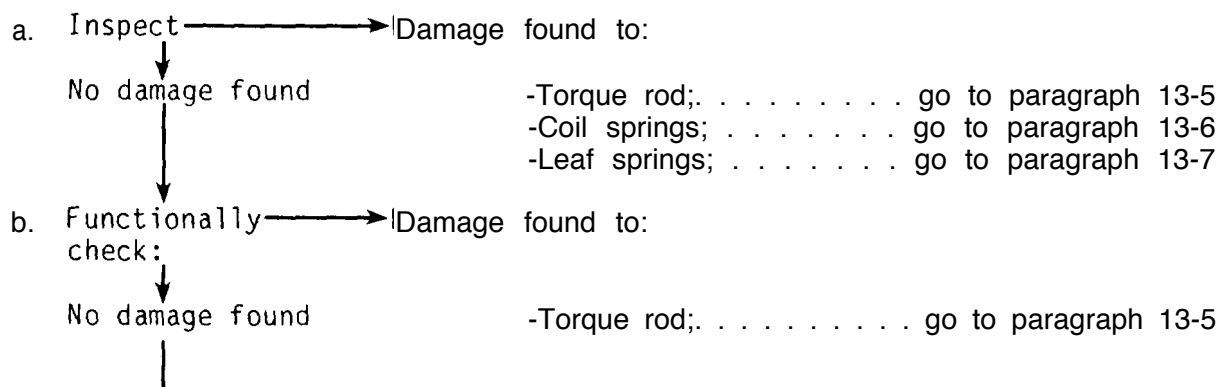
## 13-1. GENERAL

The frame consists of those parts which support the vehicle and tie the various units together. The frame consists of left and right side members which are pressed steel channel sections. The crossmembers, gussets, brackets, reinforcements, and rear engine mounts are riveted to these sections. The rear suspension assembly of a tandem setup uses six torque rod assemblies, two upper and four lower. The load is equalized between axles by full-floating springs oscillate on a cross shaft. Axles are kept in place by spring guide brackets on axle housings. Driving and braking forces are transmitted to the frame by the six torque rod assemblies which also maintain correct vertical position of axles and prevent weight transfer between axles.

The front suspension system is more complex than the rear suspension system. The front suspension system must allow the wheels to move up and down and must also allow the wheels to pivot from side to side so that the vehicle can be steered. In smaller vehicles, the front suspension is basically the same as in larger ones. The rear suspension differs because the smaller vehicle has only one axle, while the larger vehicles have two or more.

There are three basic types of springs: leaf, coil, and torsion bar. Most small vehicles use coil or torsion bar springs at the front wheels. Some vehicles use coil springs at the rear wheels, but most use leaf springs. Spring damage is the single most frequent cause of suspension failure.

## 13-2. ASSESSMENT CHART





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Evaluate system  
status:

## Frame and Suspension Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-All components of suspension operational	X	X	X		
-Frame, front suspension operational, left or right rear inoperable			X	X	
-Front or rear suspension inoperable					X
-Frame, front, or rear suspen- sion inoperable					X

## Section II. FRAME AND SUSPENSION

13-3.	BDAR PROCEDURE INDEX	Para
	Front and rear suspension interchangeability .....	13-4
	Torque Rod Damage .....	13-5
	Coil Spring Damage .....	13-6
	Leaf Spring Damage .....	13-7

## 13-4. FRONT AND REAR SUSPENSION INTERCHANGEABILITY

## General Information:

Replacement parts may not be available through normal channels. Replacements can be modified if obtained from other vehicles in the same family of vehicles. Most parts will be usable without modification or improvised mounting. Suspension repairs vary with vehicle and suspension configuration and are covered in more detail in specific vehicle TM's.

## 13-5. TORQUE ROD DAMAGE

## General Information:

Each torque rod assembly consists of a torque rod and two ball assemblies. Torque rods are attached to each rear axle and transmit driving and braking forces to the frame.

## Limitations:

- o Reduced speed
- o Degraded mobility
- o Reduced vehicle capacity

## Personnel/Time Required:

- o 2 soldiers
- o 30 minutes

## Materials/Tools:

- o Pry bar
- o 6- to 8-lb hammer
- o Chain
- o Large adjustable wrench

## Procedural Steps:

1. Remove locknuts.
2. Remove damaged torque rod.
3. Chain axle to the frame.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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### 13-6. COIL SPRING DAMAGE

#### General Information:

The coil spring is made of a length of steel rod wound into a coil. The coils are heat treated to make them elastic and to give them strength. A damaged coil that has been severed cannot be repaired by welding the broken area. Heating the coil removes the temper and the elasticity from the coil and it will collapse with any weight or force on it.

#### Limitations:

- o Reduced speed in rough terrain
- o Reduced vehicle capacity

#### Personnel/Time Required:

- o 2 soldiers
- o 1 to 2 hours

#### Materials/Tools:

- o Arc welder
- o Acetylene and oxygen
- o C-clamp
- o Steel rods (minimum 1/2 inch thick)

#### Procedural Steps:

1. Raise the vehicle with a jack or a wrecker so that vehicle is level.
2. Measure the length of the coil spring.
3. Cut three pieces of steel rod the same length as the spring.
4. Weld the steel rods to the spring at approximately equal distances apart.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

### 13-7. LEAF SPRING DAMAGE

#### General Information:

Leaf springs are made of heat-treated carbon steel for elasticity and strength. Welding broken or damaged leaf springs will remove the temper from the spring and it will bend with any weight or pressure on it. Welding can be used as a temporary fix if care is taken to weld a small amount at a time. The following procedures will work only if no more than three leaf springs are broken on large vehicles and no more than two on small vehicles.

#### Limitations:

- o Reduced speed in rough terrain
- o Reduced vehicle capacity

**Personnel/Time Required:**

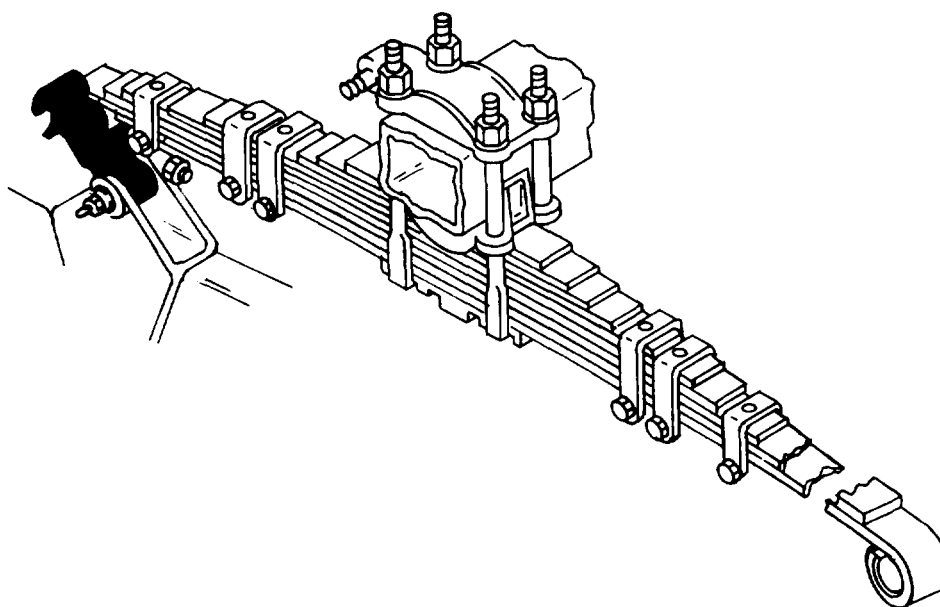
- o 2 soldiers
- o 1 to 2 hours

**Materials/Tools:**

- o Arc welder
- o Acetylene and oxygen
- o C-clamp
- o Disc grinder
- o Jack stands or blocks

**Procedural Steps:**

1. Jack up the vehicle so it can be held by the frame with jack stands and blocks.
2. Jack the axle housing directly under the broken spring just enough to support the weight of the axle housing.
3. Remove entire spring assembly and disassemble it.



4. Weld the broken leaf springs with 1/4-inch passes. Allow each pass to cool. Keep alternating the welding process until all broken springs are welded.
5. Grind welds so the springs mate, and assemble the spring assembly.
6. Install spring assembly in the vehicle.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## CHAPTER 14

## WRECKER AND CRANE ASSEMBLIES

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

## Section I. GENERAL

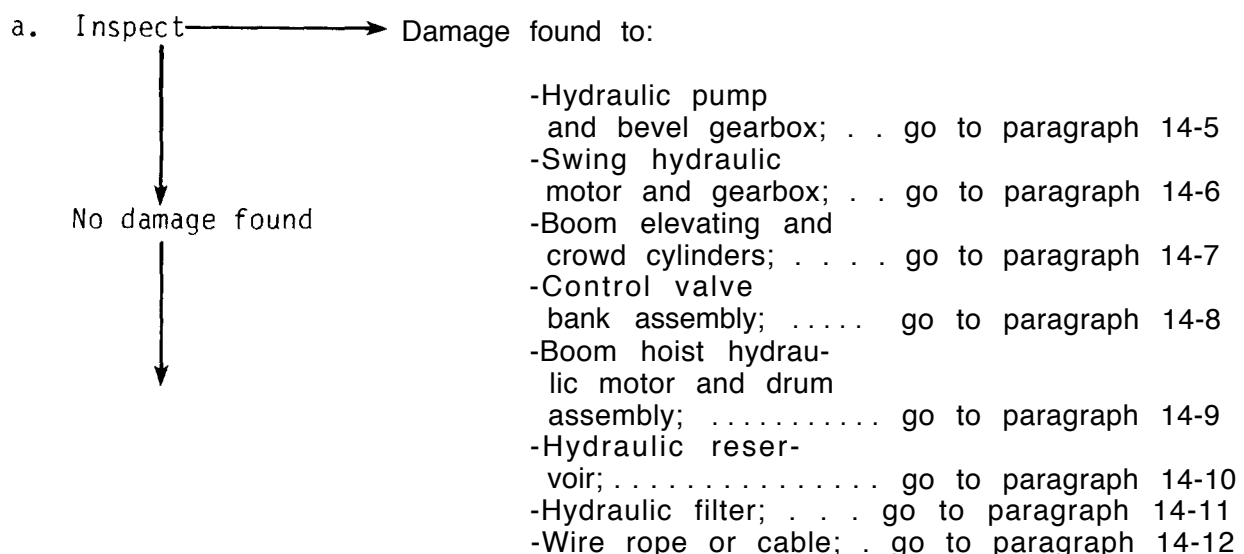
## 14-1. GENERAL

The wrecker crane consists of the wrecker unit that is mounted above the truck chassis, with the exception of the rear-mounted winch. The various functions of the wrecker crane are dependent on all of the hydraulic and mechanical units built into the crane. The power for the wrecker crane is supplied by the truck engine through a bevel gearbox hydraulic pump. This pump forces fluid to each of the hydraulically actuated units. The control of the various functions is in the control valve bank. From there the fluid is directed under high pressure to operate any of the following: the elevating cylinders for raising or lowering the boom, the boom crowd cylinder for extending or retracting the boom, the swing motor for revolving the crane, and the hoist motor for winding and unwinding the hoist cable. A special cone-type worm and drive gear transmits the power for turning the hoist drum and revolving the crane. The following procedures deal with the M543, M816, and M936 5-ton wrecker components.

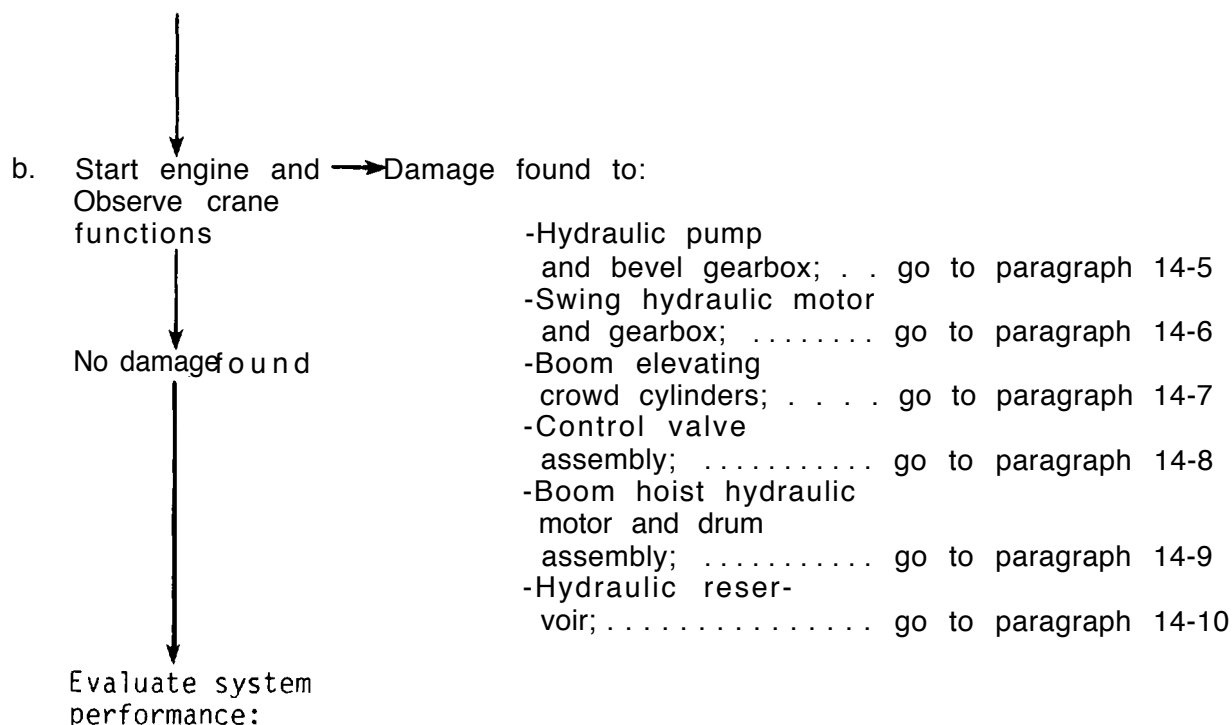
## 14-2. ASSESSMENT CHART

## NOTE

The engine must be operational to assess the hydraulic system.



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## Crane and Wrecker System Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable
-All components operational	X	X	X
-Swing hydraulic motor and gearbox unserviceable		X	X
-Boom assembly elevating cylinders operational, extension cylinders unserviceable		X	X
-Hydraulic reservoir leaks		X	X
-Boom assembly extension cylinder operational, elevating cylinders unserviceable		X	X
-Control valve inoperative			X
-Boom hoist hydraulic motor and drum assembly damaged or inoperative			X
-Main hydraulic pump and bevel gearbox inoperative			X

14-3.	BDAR PROCEDURE INDEX	Para
	Hydraulic Pump Damaged or Inoperative .....	14-5
	Swing Hydraulic Motor and Gearbox Defective or Damaged .....	14-6
	Boom Elevating or Crowd Cylinders Inoperative .....	14-7
	Control Valve Bank Assembly Damaged or Defective .....	14-8
	Boom Hoist Hydraulic Motor and Drum Assembly Inoperative or Damaged .	14-9
	Hydraulic Reservoir Damaged .....	14-10
	Hydraulic Filter Damaged or Defective .....	14-11
	Wire Rope or Cable Damaged .....	14-12
	Wire Rope Attachments .....	14-13
	High-Pressure Hose Substitution and Isolation (M543, M816, and M936).	14-14
	High-Pressure Tube Substitution and Isolation (M543, M816, and M936).	14-15

## Section II. HYDRAULIC COMPONENTS

## 14-4. GENERAL

The hydraulic components that will be discussed in this section will be the hydraulic pump, motors, control valve, high-pressure hoses and tubes, and reservoir and filter. BDAR for a hydraulic system is generally confined to component replacement, expedient line repairs, or bypassing damaged lines. If a hydraulic circuit cannot be repaired, it may be necessary to isolate it (cut it off) from the system to permit operation of some other hydraulic functions. Damage to the hydraulic system usually requires replenishment of lost fluids.

**WARNING**

Hydraulic fluid under pressure can cause death or injury to personnel. Bring hydraulic system to zero pressure before making repairs.

## 14-5. HYDRAULIC PUMP DAMAGED OR INOPERATIVE

## General Information:

Hydraulic pumps can have a multitude of failures. Repairs can be accomplished only by replacement with a serviceable part. An alternate source of supply for the pump is foreign-owned equipment (refer to appendix C).

## 14-6. SWING HYDRAULIC MOTOR AND GEARBOX DEFECTIVE OR DAMAGED.

## General Information:

If the hydraulic swing motor becomes inoperative, the wrecker crane can still be used to perform most of its functions. The crane will not have its side-to-side lift capability. The swing motor may have to be isolated if there are leakage problems. Swing motor failure can have a multitude of causes. Repairs can be accomplished only by replacement with a serviceable part.

## Limitations:

- o No side-to-side rotation

## Personnel/Time Required:

- o 1 soldier
- o 20 to 30 minutes

## Materials/Tools:

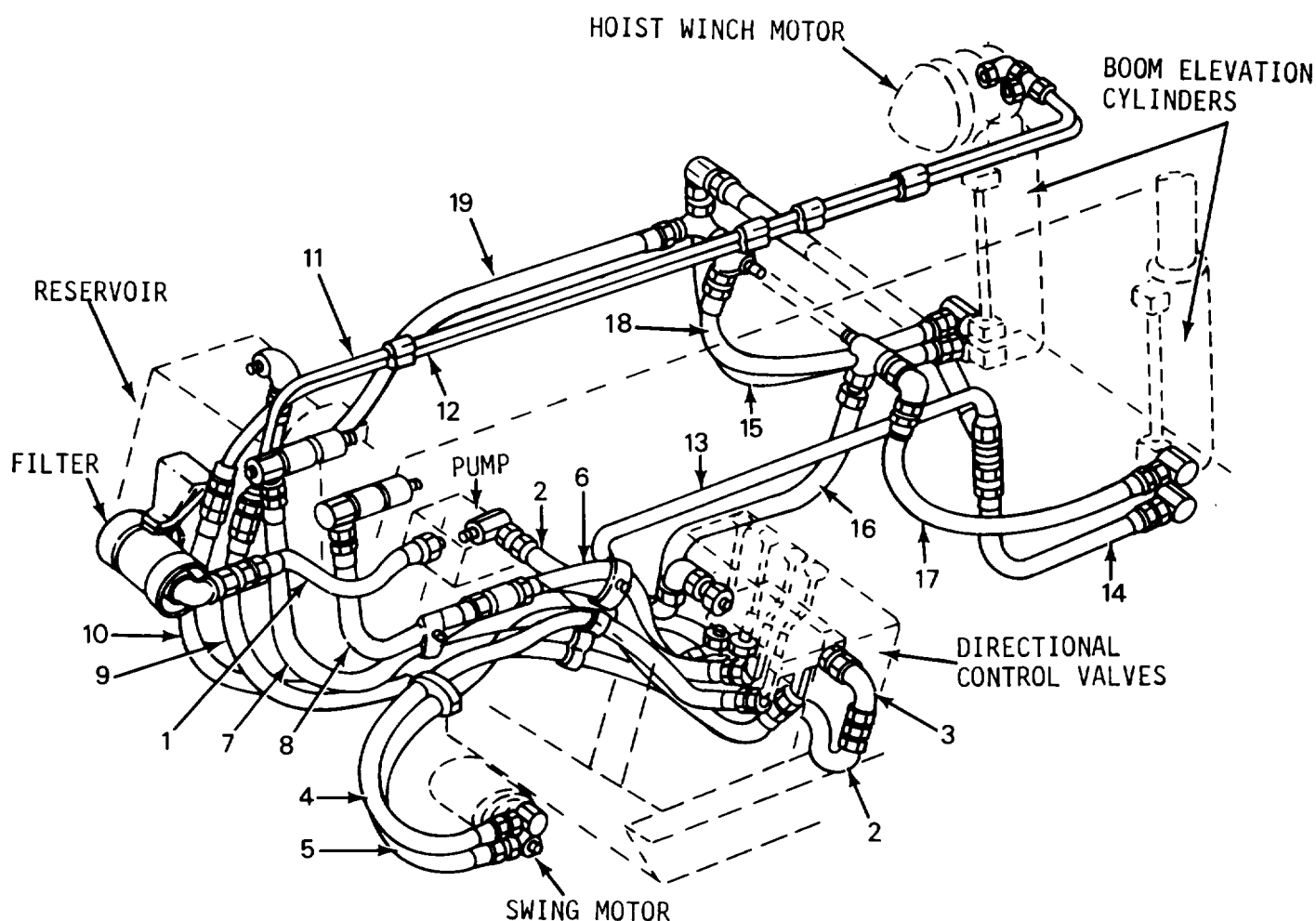
- o Adjustable wrench
- o Plugs



## Procedural Steps:

## Option 1: Isolate and Plug.

1. Remove hoses 4 and 5 from swing motor. Refer to figure below.
2. Plug hoses with an appropriate fitting.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



## Option 2: Isolate without Plugs.

1. Remove hoses 4 and 5 from swing motor and control valve. Refer to figure above.
2. Remove handle from control valve.
3. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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#### 14-7. BOOM ELEVATING OR CROWD CYLINDERS INOPERATIVE

##### General Information:

Most hydraulic cylinder failure is caused by faulty seals

A hydraulic cylinder consists of a cylinder body, a movable piston, and a piston rod attached to the piston. End caps are attached to the cylinder body barrel by threads, keeper rings, tie rods, or a weld. (Industrial cylinders use tie rods.)

As the cylinder rod moves in and out, it is guided and supported by a removable bushing called a rod gland.

The side through which the rod protrudes is called the head. The opposite side without the rod is termed the cap. Inlet and outlet ports are located in the head and cap.

For proper operation, a positive seal must exist across a cylinder's piston as well as at the rod gland. Cylinder pistons are sealed by using lipseals or cast iron piston rings.

Rod gland seals come in several varieties. Some cylinders are equipped with a V-shaped or cup-shaped primary seal made of leather, polyurethane, nitrile, or viton, and a wiper seal which prevents foreign materials from being drawn into the cylinder.

One popular type of rod gland seal consists of a primary seal with serrated edges along its inside surface. The edges contact the rod continuously and scrape it clean of fluid. A second wiper seal catches fluid which may get by the primary seal and also wipes the rod of foreign material when the rod retracts.

##### Limitations:

- o Degraded load capacity

##### Personnel/Time Requirement:

- o 1 soldier
- o 1 to 2 hours

##### Materials/Tools:

- o Pump packing
- o String
- o Rope
- o Candles or paraffin-base wax
- o Lip protection balm

### Procedural Steps:

#### Option 1: String or Rope Seal.

1. Remove damaged or worn rod gland seal.
2. Saturate string or rope, depending upon size of packing, with wax or lip balm.
3. Install substitute packing around cylinder rod and cut to make a snug fit.
4. Tap the new packing with a blunt tool to form a tight seal around the cylinder rod.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Pump Packing.

1. Remove damaged or worn rod gland seal.
2. Install pump packing around cylinder rod and cut to make a snug fit.
3. Tap packing with a blunt tool to form a tight seal around the cylinder rod.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures."

### 14-8. CONTROL VALVE BANK ASSEMBLY DAMAGED OR DEFECTIVE

#### General Information:

A directional control valve consists of a body with internal passages which are connected and disconnected by a movable part. In directional valves, the movable part is a spool. Spool valves are by far the most common type of directional valve used in hydraulics.

A directional valve consists of a pump passage, tank passages, and two actuator passages. This valve is known as a 4-way valve because it has four distinct passages within its body.

The function of a 4-way directional valve is to cause the reverse motion of a cylinder or hydraulic motor. To perform this function, the spool directs flow from the pump passage to one actuator passage when it is in one extreme position. At the same time, the spool is positioned so that the other actuator passage is exhausted to tank.

Repair can be accomplished only by replacement with a serviceable part.

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#### 14-9. BOOM HOIST HYDRAULIC MOTOR AND DRUM ASSEMBLY INOPERATIVE OR DAMAGED

##### General Information:

The boom hoist motor and drum assembly are an integral part of the wrecker. With either the motor or the drum damaged or inoperative, the lifting capability of the wrecker would be minimal. The drum and hoist motor are necessary to operate the in-and-out movement of the hoist cable and hook. The hook movement is one of the most important aspects of wrecker efficiency.

##### Limitations:

- o Degraded lifting

##### Personnel/Time Required:

- o 2 soldier
- o 30 to 60 minutes

##### Materials/Tools:

- o Acetylene torch
- o Cable clamp

##### Procedural Steps:

1. Place the boom in the down position and cut the cable or wire rope to a length that is twice the distance from the ground to the boom.
2. Attach the cut end of the cable to boom where the cable originally is anchored with a cable clamp or by interweaving the cables. Refer to paragraph 14-12 or 14-13 to attach cable. The block and hook should be hanging at about ground level.
3. Use the boom elevating control and the crowd cylinder control to raise and lower the hook.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 14-10. HYDRAULIC RESERVOIR DAMAGED

##### General Information:

The hydraulic reservoir tank supplies fluid to the main hydraulic pump. Damage to the hydraulic reservoir may vary, depending on the various types and degree of damage sustained during a combat situation. This paragraph describes quick-fix procedures for repair options according to the degree of damage.

##### Assessment Procedure:

Inspect damaged component to determine extent of damage and the repair required.

##### Limitations:

- o Degraded mobility

**Personnel/Time Required:**

- o 2 soldier
- o 1 to 2 hours

**Materials/Tools:**

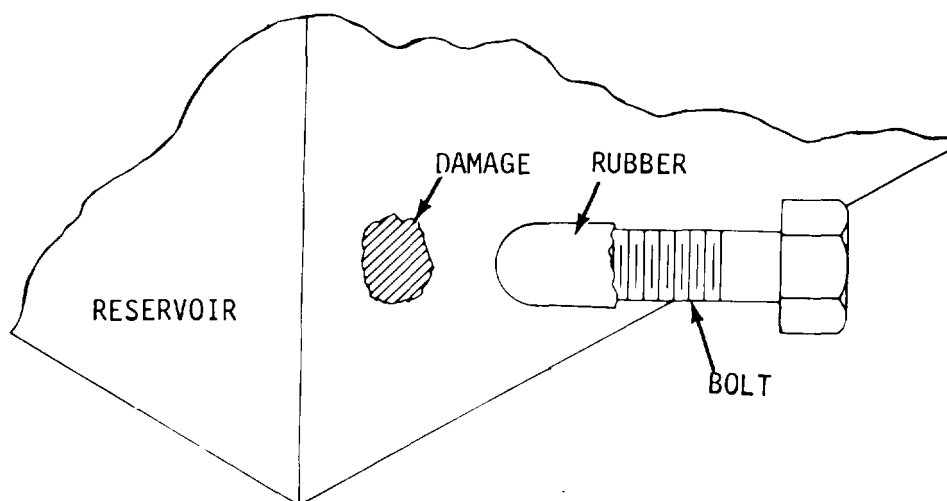
- |   |                                      |
|---|--------------------------------------|
| o Bolt or stick                           | o Cleaning solvent                   |
| o Piece of thin rubber                    | o Heavy-gage can (or similar object) |
| o Oil drainage container                  | o Nylon rope                         |
| o Clean barrel or tank (20 to 55 gallons) | o Metal bar                          |
| o Clean rags                              |                                      |
| o Welding equipment                       |                                      |
| o Wrenches                                |                                      |

**Procedural Steps:****NOTE**

Repair small holes in the hydraulic reservoir housing without removing the housing, if location is accessible. If damaged area is not accessible, refer to option 3.

**Option 1: Bolt and Rubber Patch.**

1. Wrap a piece of rubber around bolt or stick that is approximately the same size as the hole.
2. Insert rubber-covered bolt or stick into hole.



3. Insert slivers of wood if necessary to help ensure a better seal.

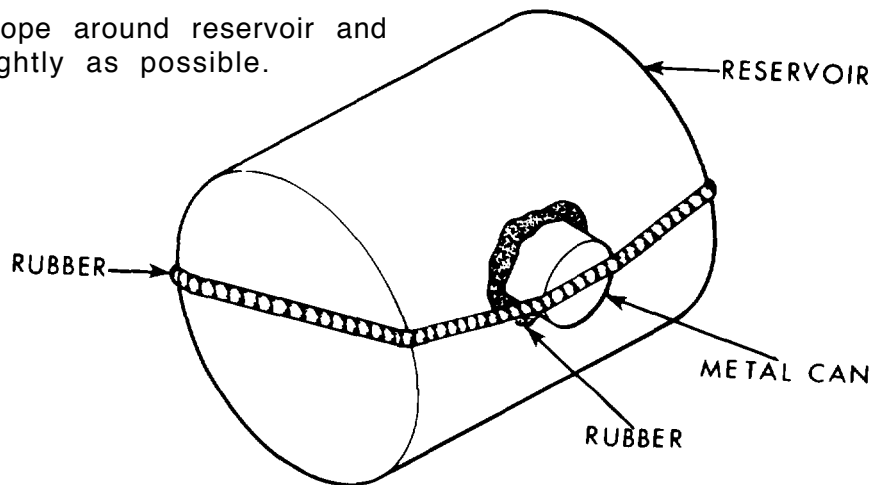
**CAUTION**

Care must be taken to ensure debris or foreign particles are removed from hydraulic fluid. It may be necessary to strain fluid with cheesecloth or a clean rag.

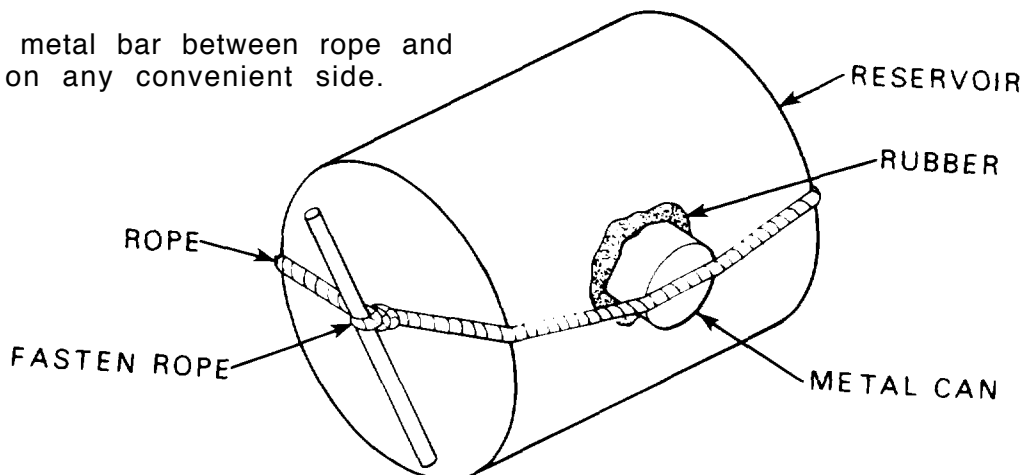
4. Check fluid level. Refer to appendix D for compatible replacement fluids, if necessary.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**Option 2: Damage on Flat Surface.**

1. Clean area around holes or cracks.
2. Flatten protruding reservoir material.
3. Place piece of rubber over damaged area.
4. Place heavy-gage can over rubber so that it completely covers hole.
5. Tie nylon rope around reservoir and over can as tightly as possible.



6. Insert metal bar between rope and reservoir on any convenient side.



7. Twist metal bar to tighten rope until fluid stops leaking.
8. Secure metal bar to prevent unwinding.

**CAUTION**

Care must be taken to ensure debris or foreign particles are removed from hydraulic fluid. It may be necessary to strain fluid with cheesecloth or a clean rag.

9. Check fluid level. Refer to appendix D for compatible replacement fluids, if necessary.
10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Option 3: Inaccessible Area Repair.

**CAUTION**

When disconnecting hydraulic lines and hoses, plug openings with clean rags to prevent dirt from entering and causing damage to internal parts.

**CAUTION**

Care must be taken to ensure debris or foreign particles are removed from fluids. It may be necessary to strain fluid with cheesecloth or clean rag.

1. Remove fittings from reservoir and repair damaged area.
2. Remove damaged reservoir from vehicle.
3. If substituting reservoir, cut holes in the substitute container at locations appropriate for connecting existing hoses. If necessary, cut a hole in an appropriate area for a new filler hole. Use a clean rag as a new cap.
4. Weld old fittings into holes of the substitute reservoir.
5. Flush substitute reservoir with hydraulic fluid to remove debris.
6. Reconnect hydraulic lines to substitute reservoir.
7. Secure new reservoir to vehicle and fill reservoir with hydraulic fluid. Refer to appendix D for compatible replacement fluids, if necessary.
8. Operate hydraulic system slowly.

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9. As air bleeds from the system, fill reservoir with hydraulic fluid or compatible replacement fluid.

10. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### **14-11. HYDRAULIC FILTER DAMAGED OR DEFECTIVE**

##### **General Information:**

The hydraulic fluid filter is designed to keep the oil clean and free of dirt and other foreign particles or contaminants. Contamination affects the performance of the hydraulic components. Sticking and sluggish action can occur or passages may become plugged. Dirt can prevent valves from seating, resulting in leakage, loss of control, and damage to the crane.

##### **Assessment Procedure:**

Inspect damage components to determine extent of damage and the repair required.

##### **Option 1: Remove Filter Element**

Limitations:

- o Degraded usage with time

##### **Personnel/Time Required:**

- o 1 soldier
- o 30 minutes

##### **Materials/Tools:**

- o Adjustable wrench

##### **Procedural Steps:**

1. Remove filter element.
2. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

##### **Option 2: Remove Filter Assembly.**

Limitations:

##### **Personnel/Time Required:**

- o 1 soldier
- o 30 minutes

##### **Materials/Tools**

- o Adjustable wrench
- o 14- or 18-inch pipe wrench
- o 2-inch pipe nipple
- o 2-inch, 90-degree elbow



**Procedural Steps:**

1. Remove filter assembly from reservoir.
2. Install nipple and elbow on reservoir.
3. Connect hose to elbow.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

**14-12. WIRE ROPE OR CABLE DAMAGED****General:**

A wire rope or cable is the most important single item in vehicle recovery. The most common use in military units is for winch cables. Wire rope is made of many wires twisted together to make a strand. The strands are then twisted together around the core, making a rope. If wire becomes untwisted or frayed and special fittings are unavailable, the seizing method is recommended.

One of the simplest and quickest eye splices for field use is the Flemish eye or Molly Hogan, sometimes referred to as the rolled-in eye splice. It is especially applicable to preformed wire rope.

**Assessment Procedure:**

Inspect damaged component to determine extent of damage and the repair required.

**Limitations:**

- o Degraded weight capacity

**Personnel/Time Required:**

- o 1-2 soldiers
- o 30-60 minutes

**Materials/Tools:**

- o Wire rope cutter
- o Copper wire
- o Electrical tape

**WARNING**

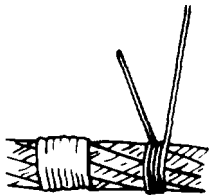
Wire ropes or cables can cause serious injury to personnel. Wear protective gloves when handling wire ropes or cables.

**Procedural Steps:****Option 1: Wire Bind.**

1. Bind the wire rope or cable with wire 1/4 inch beyond both sides of the damaged area.
2. Make cable taut while winding wire on the rope by hand. Keep the coils tight.

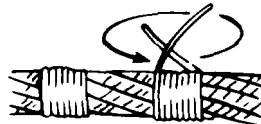
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3. When the damaged area is covered, twist the ends of the wire counterclockwise. Tighten the twist to remove slack.
4. Twist with pliers to tighten coils.
5. Pry the twist to tighten coils even more.
6. Repeat twist for secureness.
7. Cut off ends and bend twisted portion down against rope.

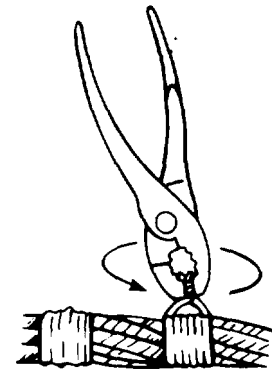


1 WRAP WITH SMALL WIRES

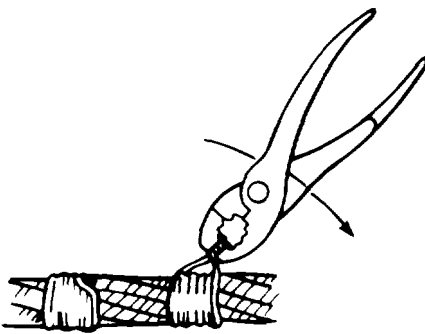
TWIST PORTION  
NEAR MIDDLE



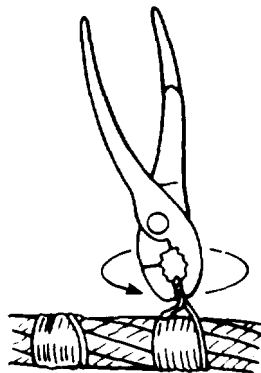
2 TWIST ENDS TOGETHER COUNTERCLOCKWISE



3 TIGHTEN TWIST WITH PLIERS



4 PRY TWIST TO TIGHTEN



5 REPEAT TWIST

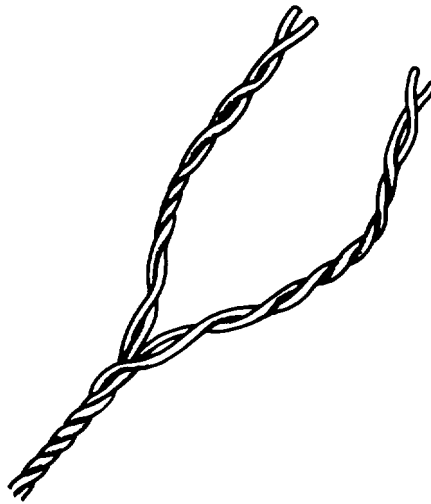


6 BEND TWISTED PORTION DOWN AGAINST ROPE

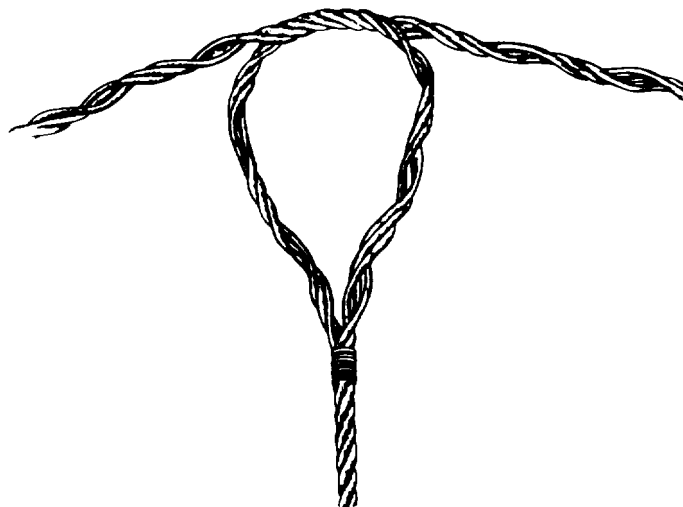
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### Option 2: Rolled-In Eye Splices.

1. Bend the rope from the end at a distance equal to the length of loop desired, plus an additional length approximately 10 times the rope diameter. Split the rope by separating three adjacent strands, leaving the other strands and core intact.

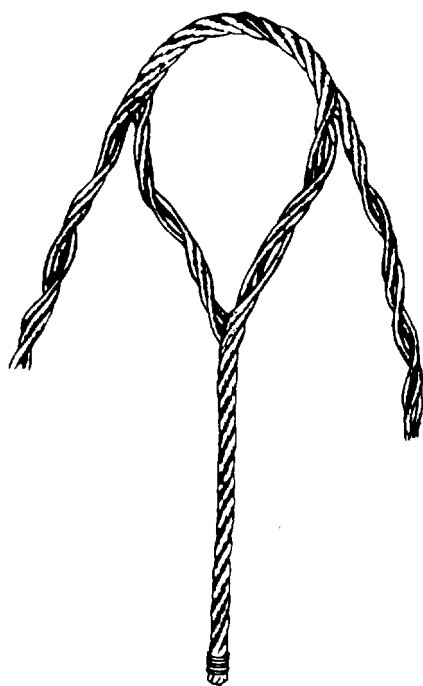


2. Bend the sets of strands into the desired loop, crossing over with one set in the same manner you would make a simple overhand knot. The two sets of strands will lock together.

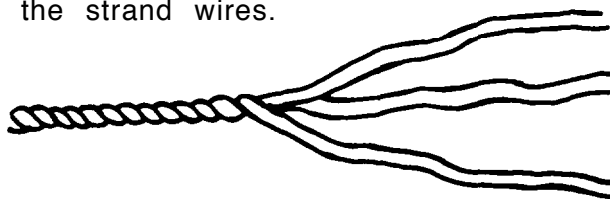


3. Start laying the strand sections alternately back into the rope grooves, continuing until sections are laid as deep into the throat as possible, allowing the six strands and core to project past the throat of the loop.

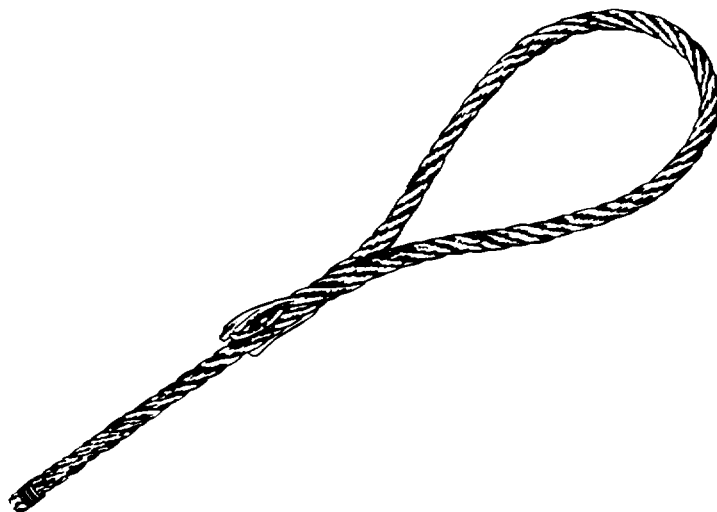
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4. Unlay or broom out all the strand wires.



5. Trim the wires to make a tapered end for wrapping the wires tight against the rope body with seizing strand, or wrap with copper wire or friction tape to safety-cover the exposed wire.



6. Record the BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

## 14-13. WIRE ROPE ATTACHMENTS

### General Information:

Fittings or end attachments for wire rope vary with use. The standard fittings for field use are thimbles and clips. If damage is shearing, breakage, or excessive wear, these attachment may be used as a source of repair.

### Assessment Procedure:

Inspect damaged component to determine extent of damage and the repair required.

### Limitations:

- o Shorter cable

### Personnel/Time Required:

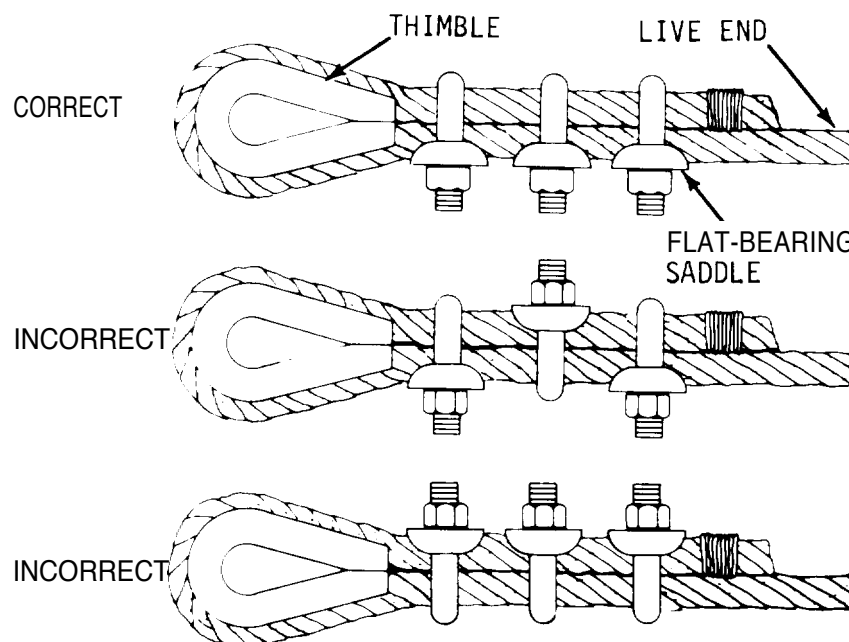
- o 1 soldier
- o 15-30 minutes

### Materials/Tools:

- o Thimble
- o Clips
- o Wrench

### Procedural Steps:

1. Determine the number of clips needed by using three times the rope diameter in inches, plus one. Use the next largest whole number if total results in a fraction.
2. Wrap the rope around the thimble.
3. Space clips six rope diameters apart for best holding power. Nuts should be tightened once rope has been in service under tension.



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4. Place all the V-bolts on the short, or dead, end of the rope.
5. Place the flat-bearing saddle or base against the live end.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

#### 14-14. HIGH-PRESSURE HOSE SUBSTITUTION AND ISOLATION (M543, M816, AND M936)

##### General Information:

High-pressure hose failure or damage to a vital system on the wrecker can be fixed by removing a hose from a system that will not affect the particular task to be performed. The following procedures and tables will help to make the proper decision as to the system from which to remove or to isolate so the crucial system can be utilized.

Refer to table 14-1 for hose size, length, location, and function performed. Refer to figure in paragraph 14-6 that will show physical location and hose numbers that interchange with those in table 14-1.

##### Limitations:

- o Loss of a hydraulic function
- o Extended recovery time

##### Personnel/Time Required:

- o 1 soldier
- o 15 to 60 minutes

##### Material/Tools:

- o Adjustable wrench

##### Procedural Steps:

1. Locate and remove the damaged hose on the wrecker.
2. Refer to table 14-1 and identify the hose.
3. Select a function that will not be needed or whose loss will not affect the mission. Make sure that the substitute hose is as long as or longer than the damaged hose. Remove good hose and substitute it for the damaged one.
4. Remove the handle from the valve that controls the missing function. This will prevent oil loss due to accidental activation.
5. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## 14-15. HIGH-PRESSURE TUBE SUBSTITUTION AND ISOLATION (M543, M816, AND M936)

## General Information:

High-pressure tube damage on a wrecker can be repaired by substituting and isolating another tube from the wrecker's hydraulic system. If a vital function of the crane is inoperative due to a damaged high-pressure tube, refer to table 14-1 for the size, length, location, and function of other tubes of approximately the same length. Refer to the figure in paragraph 14-6 that will show physical location and hose numbers that interchange with those in table 14-2.

## Limitations:

- o Loss of a hydraulic function
- o Extended recovery time

## Personnel/Time Required:

- o 1 soldier
- o 15 to 60 minutes

## Material/Tools:

- o Adjustable wrench

## Procedural Steps:

1. Locate and remove damaged high-pressure tube.
2. Refer to table 14-1 and identify the tube.
3. Select a function that will not be needed or whose loss will not affect the mission. Make sure that the substitute tube is longer than the damaged tube. Remove the tube.
4. Isolate the hydraulic function that is not needed and remove the handle from the control valve.

**CAUTION**

Do not kink tubing when bending it. A kink will weaken the tubing.

5. Bend the substitute tube in the appropriate places to fit and install the tube.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

Table 14-1. Tube and Hose Specifications

**NOTE**

High-pressure tube and hose repairs may be used to fix low-pressure conduits.

Number	Pressure requirements	Conduit size inches	Conduit length inches	Damage result	Location
1	Hose, high-pressure	2.0 ID	44.0	Immediate loss of entire system power	Reservoir to pump
2	Hose, high-pressure	1.0 ID	38.0	Immediate loss of entire system power	Pump to gondola
3	Tube, high-pressure	1.0 OD	15.0	Immediate loss of entire system power	Gondola to directional control valves
4	Hose, high-pressure	1.0 ID	68.0	Immediate traverse power loss. No effect if not operated.	Swing motor to traverse control valve
5	Hose, high-pressure	1.0 ID	68.0	Immediate traverse power loss. No effect if not operated.	Swing motor to traverse control valve
6	Hose, high-pressure	1.0 ID	22.0	Immediate boom extension power loss. No effect if not operated.	Extension control valve to side of gondola
7	Hose, high-pressure	1.0 ID	80.0	Immediate boom extension power loss. No effect if not operated.	Extension cylinder to extension control valve
8	Hose, high-pressure	1.0 ID	48.0	Immediate boom extension power loss. No effect if not operated.	Side of gondola to extension cylinder
9	Hose high-pressure	1.0 ID	77.0	Immediate loss of winch power. No effect if not operated.	Winch control valve to crane hinge
10	Hose, high-pressure	1.0 ID	77.0	Immediate loss of winch power. No effect if not operated.	Winch control valve to crane hinge



Table 14-1. Tube and Hose Specifications (Cent)

Number	Pressure requirements	Conduit size inches	Conduit length inches	Damage result	Location
11	Tube, high-pressure	1.0 OD	108.0	Immediate loss of winch power. No effect if not operated.	Winch motor to crane hinge
12	Tube, high-pressure	1.0 OD	107.0	Immediate loss of winch power. No effect if not operated.	Winch motor to crane hinge
13	Tube, high-pressure	1.0 OD	40.0	Immediate loss of boom elevation power. No effect if not operated.	Elevation control valve to elevation crossover tee
14	Hose, high-pressure	1.0 ID	29.0	Immediate loss of boom elevation power. No effect if not operated.	Left elevation cylinder to crossover tee
15	Hose, high-pressure	1.0 ID	29.0	Immediate loss of boom elevation power. No effect if not operated.	Right elevation cylinder to crossover tee
16	Hose, high-pressure	1.0 ID	35.0	Immediate fluid loss. Rapid loss of entire system power.	Directional control valves to left reservoir tee.
17	Hose, high-pressure	1.0 ID	17.0	Immediate fluid loss. Rapid loss of entire system power.	Left elevation cylinder to left reservoir tee
18	Hose, high-pressure	1.0 ID	17.0	Immediate fluid loss. Rapid loss of entire system power.	Right elevation cylinder to right reservoir tee
19	Hose, high-pressure	1.25 ID	20.0	Immediate fluid loss. Rapid loss of entire system power.	Right reservoir tee to reservoir

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Table 14-2. Interchangeability of Hydraulic Hoses and Tubes

Hose/ tube No.	Location	Vehicle					
		M936	M816	M543A2	M543A1	M543	M62 M62A2
1.	Reservoir to pump		x	x	x	x	x
2.	Pump to gondola		x	x	x	x	x
3.	Gondola to directional control valves		x	x	x	x	x
4.	Traverse motor to traverse control valve	x	x	x	x	x	x
5.	Traverse motor to traverse control valve	x	x	x	x	x	x
6.	Extension control valve to gondola	x	x	x	x	x	x
7.	Extension cylinder to control valve	x	x	x	x	x	x
8.	Gondola to extension cylinder	x	x	x	x	x	x
9.	Control valve to hinge	x	x	x	x	x	x
10.	Control valve to hinge	x	x	x	x	x	x
11.	Winch motor to hinge	x	x	x	x	x	x
12.	Winch motor to hinge	x	x	x	x	x	x
13.	Control valve to crossover tee	x	x	x	x	x	x
14.	Left elevation cylinder to crossover tee	x	x	x	x	x	x
15.	Right elevation cylinder to crossover tee	x	x	x	x	x	x
16.	Control valve to left reservoir tee	x	x	x	x	x	x
17.	Left elevation cylinder to reservoir tee	x	x	x	x	x	x
18.	Right elevation cylinder to reservoir tee	x	x	x	x	x	x
19.	Right reservoir tee to reservoir	x	x	x	x	x	x

## CHAPTER 15 COMMUNICATIONS SYSTEM

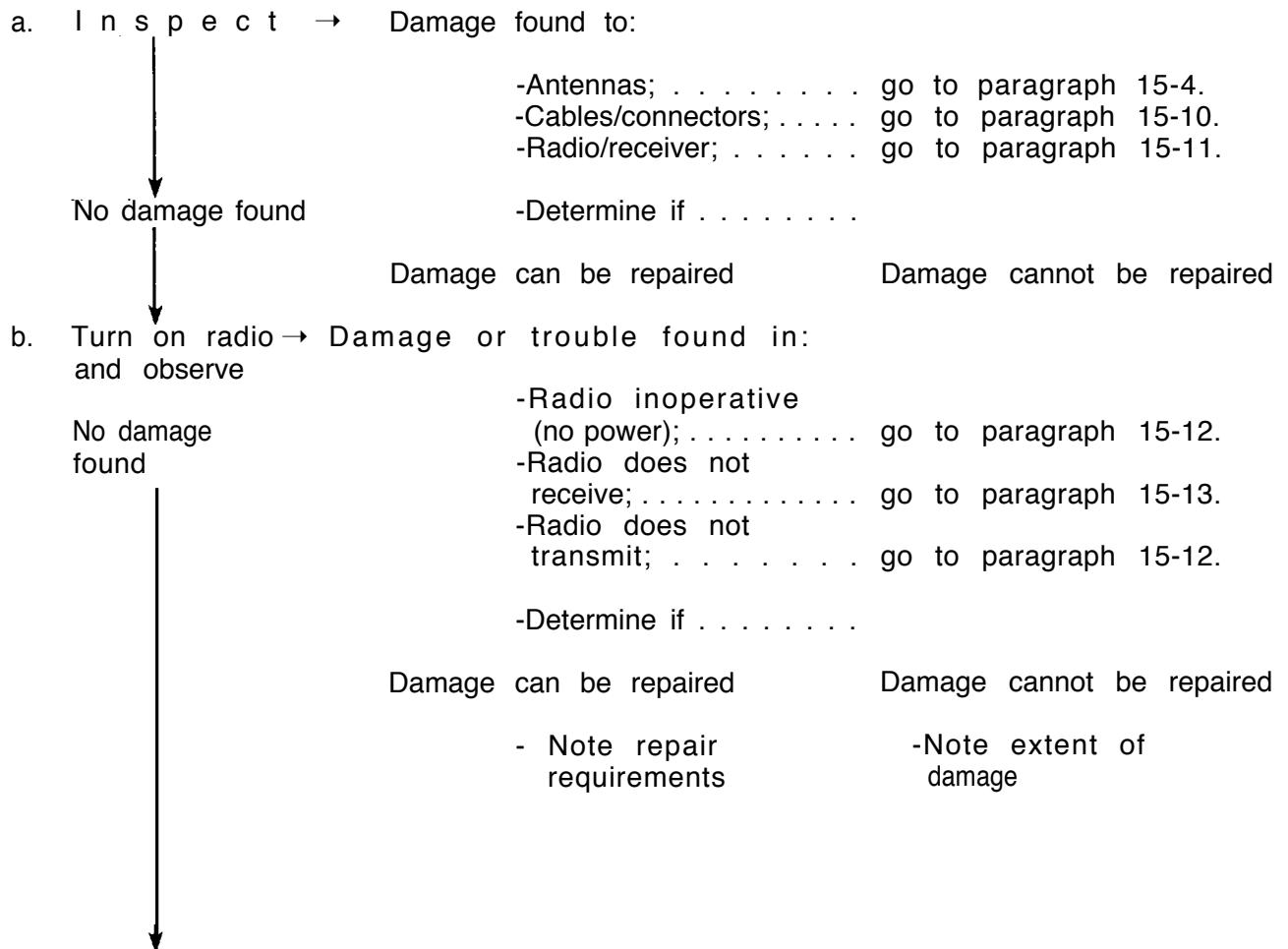
BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

### Section I. INTRODUCTION

#### 15-1. GENERAL

This chapter contains the fault assessment and expedient repair procedures available to find and repair battlefield damage to the communications system of tactical vehicles. Examine for dented surfaces or holes, torn insulation, severed cables, or other evidence of damage. Check component boxes for unusual odors. After obvious damage has been repaired, attempt to operate the communications system to check for damage that is not obvious.

#### 15-2. ASSESSMENT CHART



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↓  
Evaluate system  
performance:

## Communications System Assessment

	Fully Mission Capable	Combat Capable	Combat Emergency Capable
-Communications systems works	x	x	x
-Communications systems works marginally	x	x	x
-Communications systems does not work		x	x

## 15-3. BDAR PROCEDURE INDEX

**WARNING**

Do not touch bare wires on expedient antennas with the radio keyed. You could get burned and/or shocked.

**CAUTION**

Field expedient antennas are fragile and will not take much abuse. The continued use of expedient antennas may result in damage to receiver/transmitter.

	Para
Metallic Whip Antenna Broken .....	15-5
Reception Antenna Substitutes .....	15-6
Vertical Dipole Antenna Substitute .....	15-8
Transmission Antenna Substitutes .....	15-9
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Foreign Equipment Interchangeability (AN/VRC-12 Series) .....	15-13
Foreign Equipment Interchangeability (Allied Radios) . . . . .	15-14
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## Section II. RECEPTION ANTENNAS

## 15-4. GENERAL

An antenna is a metal rod or tubing which transmits and receives radio signals. A broken antenna will lessen the efficiency of the communication system. Any 9-foot antenna (e.g., CB antenna) can be adapted for use. Expedient reception antennas can be made using commo or electrical wire.

## 15-5. METALLIC WHIP ANTENNA BROKEN

## General Information:

This procedure gives instructions for the repair of a metallic whip antenna.

## Limitations:

- o Reduction in range

## Personnel/Time Required:

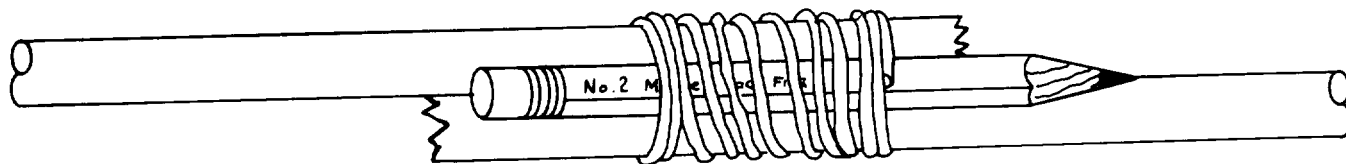
- o 1 soldier
- o 20 minutes

## Materials/Tools:

- o Stick, 4- to 6-inch length
- o Wire, commo or electrical, 1-foot length

## Procedural Steps:

1. Scrape 3 to 6 inches of paint from the broken ends of the antenna with sand, rock, metal, sandpaper, or a knife.
2. Wipe scraped areas clean.
3. Strip the insulation from the 1-foot length of wire.
4. Overlay the cleaned ends of the broken antenna.
5. Place a stick on top of the antenna ends and wrap tightly together with wire.
6. If time and equipment are available, solder the connection.



7. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

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## 15-6. RECEPTION ANTENNA SUBSTITUTES

## General Information:

A substitute antenna for reception only can be made using one of the options below. The total length of wire and antenna stub should not exceed 9 feet.

## Limitations:

- o No transmission capability

## Personnel/Time:

- o 1 soldier
- o 30 minutes

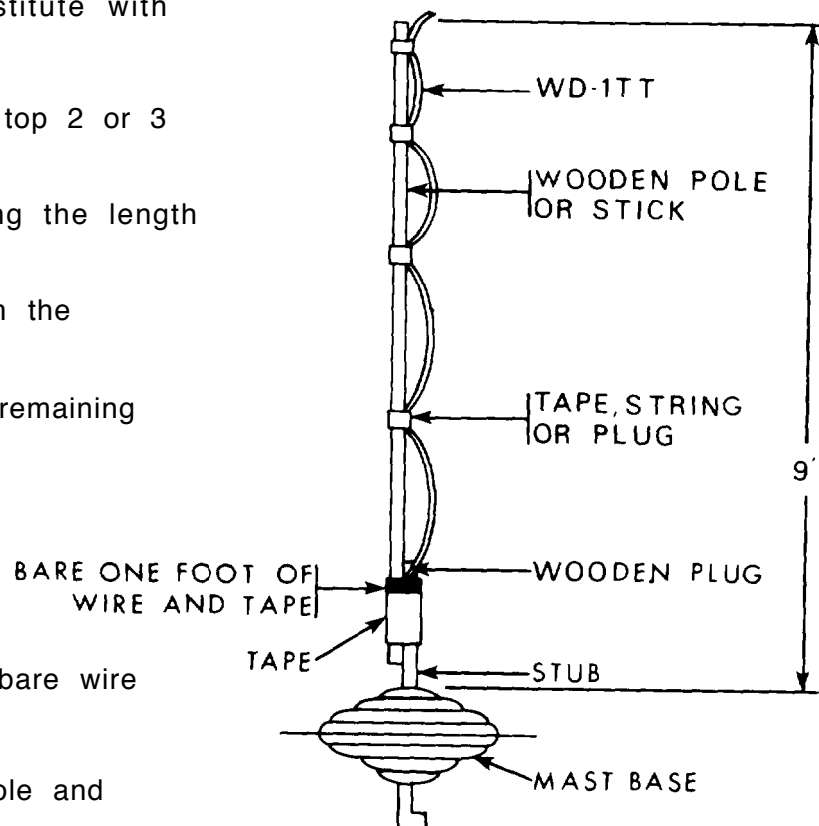
## Materials/Tools:

- o Pole or stick, 10-foot length
- o Tape, string, or rope
- o Wire, commo or electrical, 10-foot length

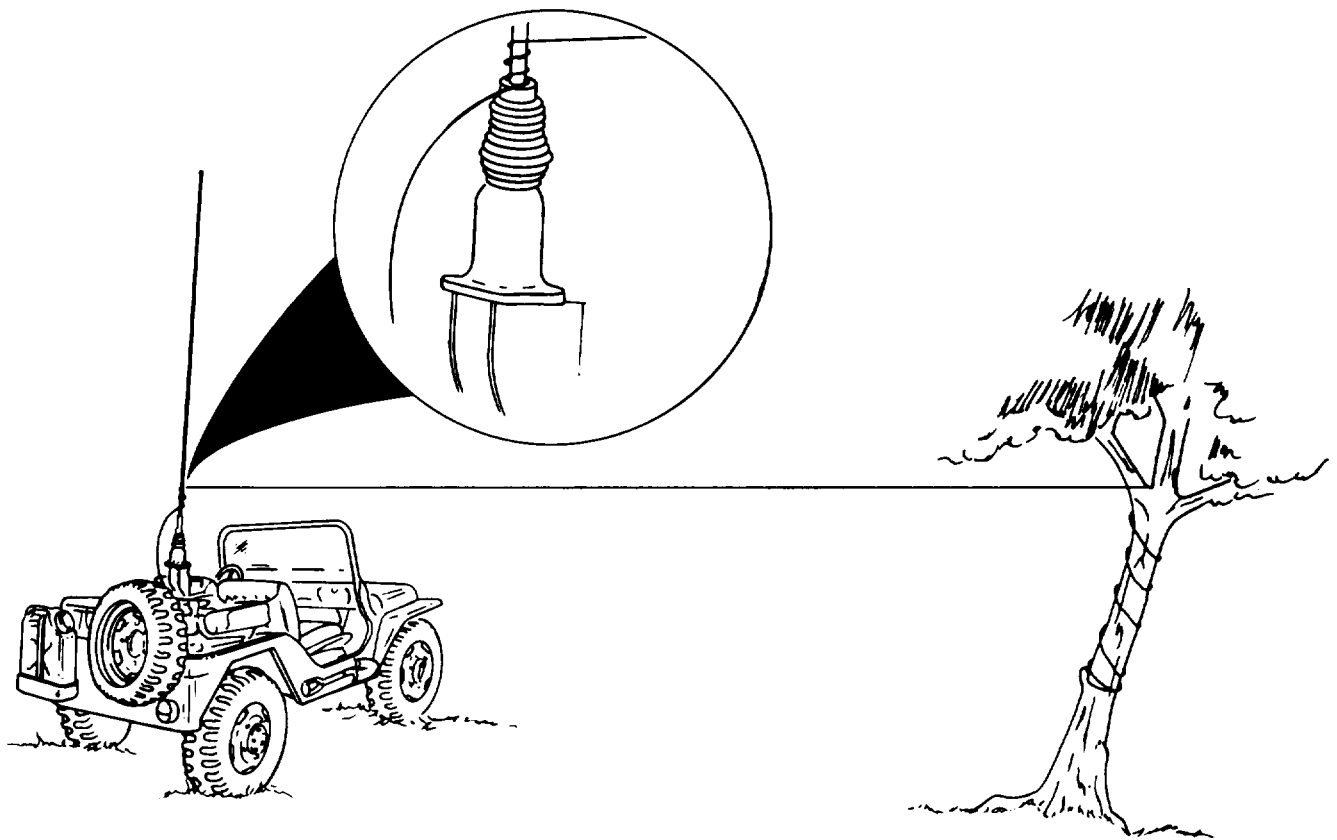
## Procedural Steps:

## Option 1: Vertical Wire Substitute with Wooden Pole.

1. Scrape the paint from the top 2 or 3 inches of the antenna stub.
2. Attach 9 feet of wire along the length of the pole with tape.
3. Remove the insulation from the remaining 1 foot of wire.
4. Hold the pole beside the remaining antenna section and base.
5. Wrap the bare 1-foot section of wire tightly around the scraped portion of the broken antenna and the pole.
6. Lay the short end of the bare wire on top of the stub.
7. Push wire into the stub hole and jam in place with a peg.
8. Tape peg to stub.
9. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.



Option 2: Long Wire Antenna.



1. Strip approximately 2 inches of insulation from one end of the wire.
2. Attach the bare lead to the center of the antenna connection on the receiver by jamming it into the hole.
3. Tape or tie wire to the antenna connector to prevent it from being pulled or vibrated out of the hole.
4. Stretch out wire and tie an improvised insulator to the opposite end. Place a rope or wire on the opposite side of the insulator and tie off the slack to tree or pole to create as near vertical an antenna as possible.
5. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

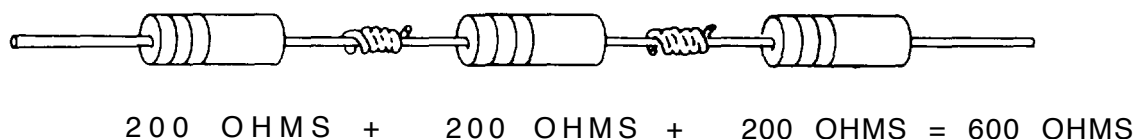
## Section III. TRANSMISSION ANTENNAS

## 15-7. GENERAL

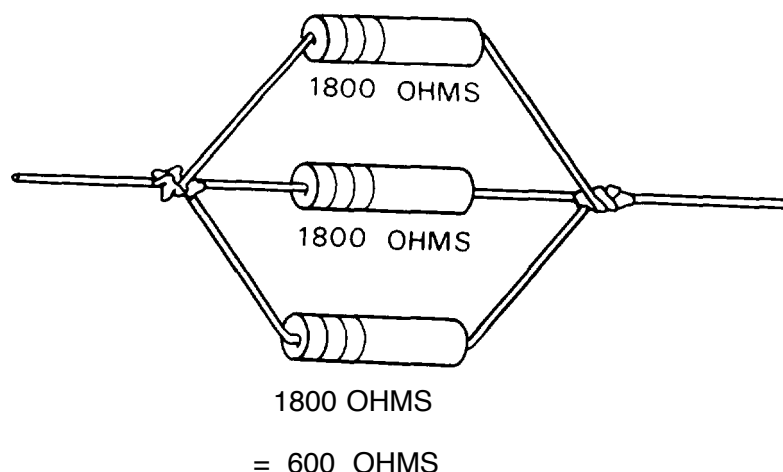
Antennas for transmitting have properties different from receiving-only antennas. Any 9-foot antenna (e.g., CB antenna) can be adapted for use.

Frequency sensitive lengths and resistances must be adjusted using exact length wires (elements) or a matching unit. Antenna resistance also affects the direction of transmission and the loading of the transmitter final stages.

Resistance requirements can be met by connecting lower resistance value resistors, end-to-end (in series), until the desired resistance value is obtained.



Wattage requirements can be met by connecting lower wattage resistors side-by-side (in parallel ) until the desired wattage is obtained.



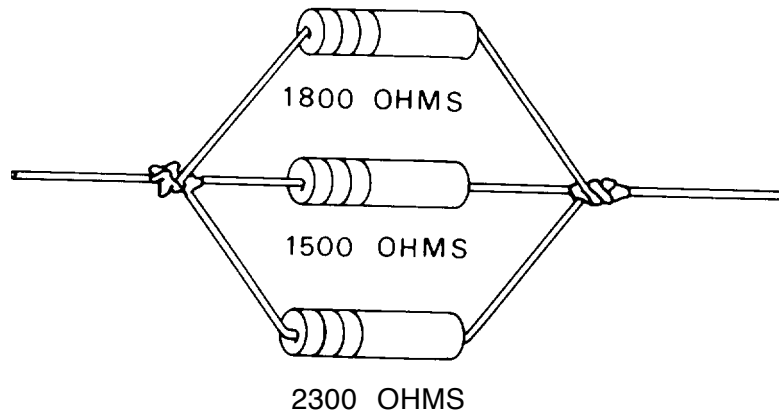


When the resistors are hooked in parallel, the resistance is reduced by the number of equal-value resistors in parallel.

If unequal resistors are used, the following formula must be used to compute the resistance for best operation:

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \text{etc.}$$

$$\begin{aligned} \text{Total Resistance (R}_t\text{)} \\ 1/R_t &= 1/1800 + 1/1500 + 1/2300 \\ R_t &= 604 \text{ ohms} \end{aligned}$$



#### 15-8. VERTICAL DIPOLE ANTENNA SUBSTITUTE

##### General Information:

A vertical dipole will provide transmission capability while mobile. The length of the transmitting antenna must be carefully selected because a matching unit will not be used. For quick reference, wire lengths for the following frequencies are given for each leg of the completed antenna:

- a. 30.00 MHz (MC) = 7 ft 9 in.,
- b. 40.00 MHz (MC) = 5 ft 8 in.,
- c. 50.00 MHz (MC) = 5 ft 0 in.,
- d. 60.00 MHz (MC) = 3 ft 11 in., and
- e. 70.00 MHz (MC) = 3 ft 4 in.

For best performance, the exact wire length for the frequency to be used can be calculated using this formula: length (feet) = 234 divided by the frequency in MHz (MC).

##### Limitations:

- o Possible reduced range
- o Must build a new antenna for every 10.00 MHz frequency change

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#### Personnel/Time Required:

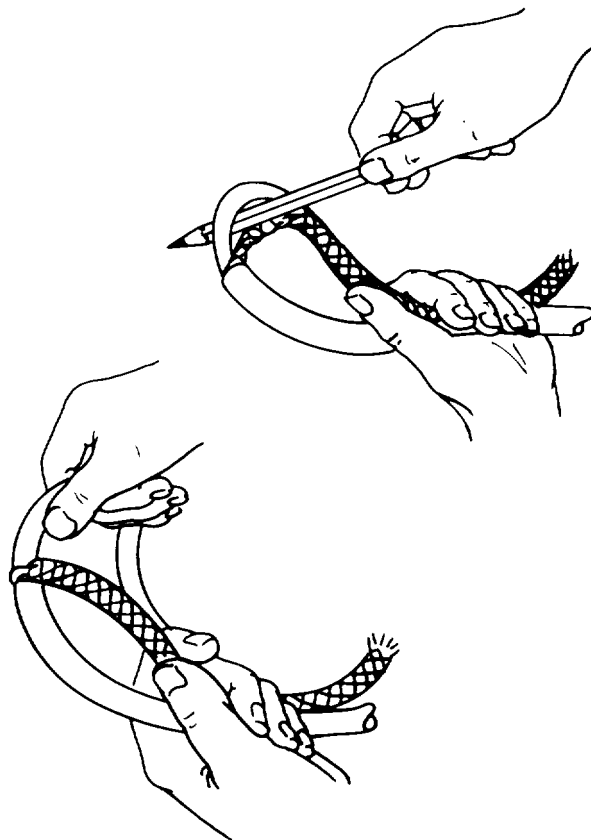
- o 1 soldier
- o 30 minutes

#### Materials/Tools:

- o Cable, coaxial, RG-8  
(NSN 6145-00-161-0887)  
or RG-58 (NSN 6145-00-161-0908)
- o Pole or stick
- o Tape or string

#### Procedural Steps:

1. Measure off and mark, but do not cut, the proper length of coaxial cable.
2. Strip the outer insulation from the cable, in 1-foot steps, to expose the braided shield wire. Do not cut the shield wire.
3. Bend the cable into a loop, holding it with one hand.
4. Carefully separate the braided shield from the insulated center conductor.
  - a. Work the pencil or nail between the shield wire and center conductor to form a hole.
  - b. Place a finger in the hole and slowly pull the center conductor out of the shield.
5. Twist the shield wire to form a conductor.
6. Tape or tie the center conductor to the top portion of the pole.
7. Tape or tie the braided shield wire to the bottom portion of the pole.
8. Secure the cable.
9. Fasten the pole to the antenna base.
10. Route the remaining coaxial cable to the radio.



11. If there is a BNC connector (twist-lock) on the cable, attach it to the radio antenna connector. If not, prepare and connect the coaxial cable as follows:

- a. Carefully strip the outer insulation from the coaxial cable to expose enough braided shield to reach a screw near the antenna connector on the radio case. Do not cut shielding.
- b. Use a pencil or nail and carefully separate the braided shield from around the center conductor insulation.
- c. Twist shield wire into a pigtail.
- d. Strip the center conductor insulation to expose enough wire to push into the antenna connector.
- e. Wedge the wire into the center of the antenna connector.
- f. Attach the pigtail to a screw on the radio case.

12. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

#### 15-9. TRANSMISSION ANTENNA SUBSTITUTES

##### General Information:

This procedure gives instructions for making a 1/4 wave ground plane antenna, long wire antenna, or a half rhombic antenna. The transmission range is greatly increased but cannot be used during mobile operations. The length of the 1/4 wave ground plane antenna elements must be selected because a matching unit will not be used. For quick reference, wire lengths for the following frequencies are given for each leg of the completed antenna:

- a. 30.00 MHz (MC) = 7 ft 9 in.,
- b. 40.00 MHz (MC) = 5 ft 8 in.,
- c. 50.00 MHz (MC) = 5 ft 0 in.,
- d. 60.00 MHz (MC) = 3 ft 11 in., and
- e. 70.00 MHz (MC) = 3 ft 4 in..

For best performance, the exact wire length for each frequency to be used can be calculated using this formula: length (feet) = 234 divided by the frequency in MHz (MC).

##### Limitations:

- o Not for mobile use
- o Long wire and half rhombic antennas are very directional
- o Must build a new antenna for every 10.00 MHz frequency change

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## Personnel/Time Required:

- o 1 soldier
- o 30 minutes

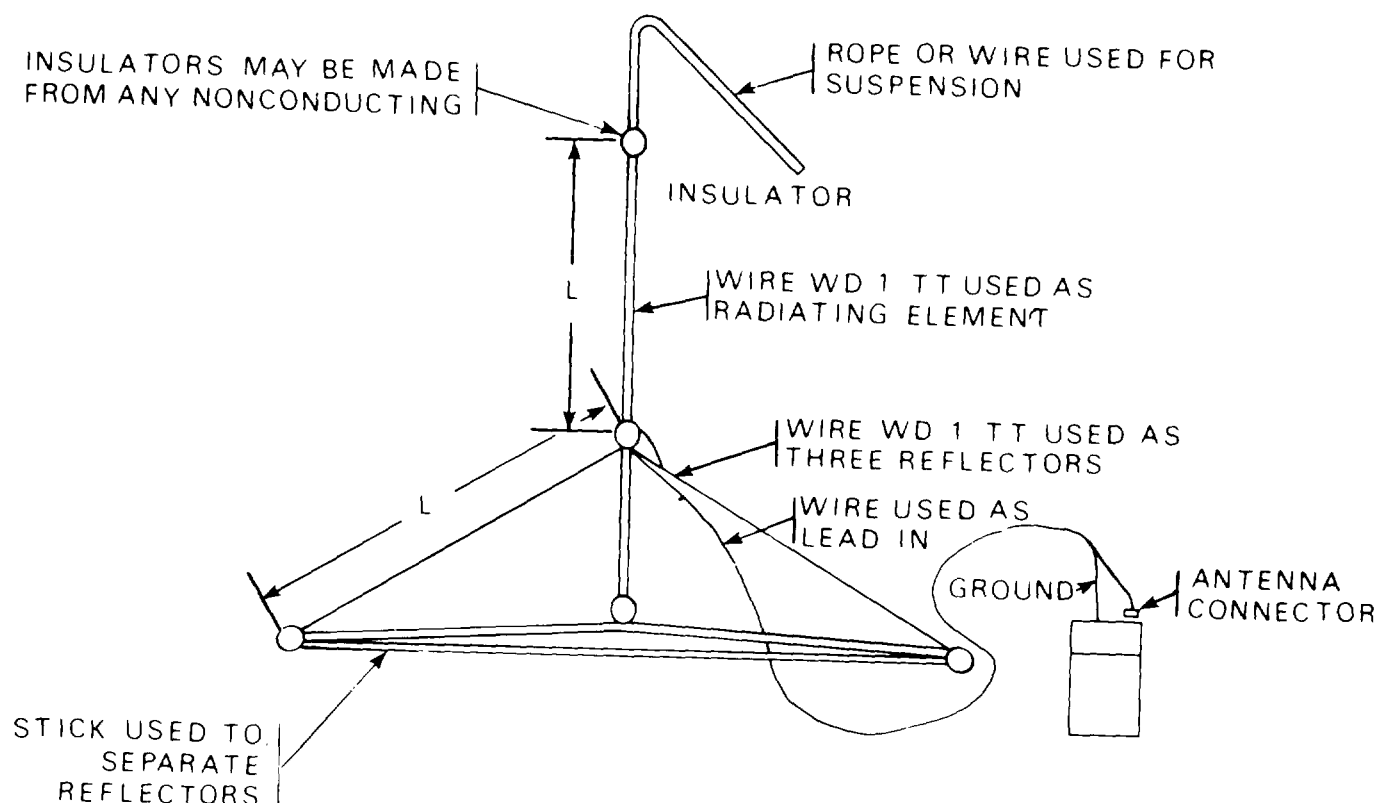
## Materials/Tools:

- o Wire, commo or electrical
- o Insulators (e.g., glass, plastic, leather, nylon, etc.), five each
- o Sticks or branches, 3-foot length (three required)

## Procedural Steps:

## Option 1: 1/4 Wave Ground Plane Antenna.

1. Calculate the length of wire needed for the radiating element.
2. Cut the required length radiating element from wire.
3. Cut three wires to use as reflector elements approximately the same length as the radiating element.
4. Strip the insulation from one end of the three reflector wires.



FIELD EXPEDIENT GROUND PLANE ANTENNA

5. Twist wire ends together and connect to an insulator.
6. Tie three sticks together, 3 feet in length, to form a triangular support for the lower end of the reflector element wires.
7. Use three insulators and connect the lower end of the reflector elements and triangular support.
8. Connect one end of the radiating element to an insulator at the upper end of the reflector elements.
9. Connect an insulator and a suspension rope or wire to the upper end of the radiating element.
10. Cut two pieces of wire long enough to reach from the radio to the desired height of the antenna.
11. Strip the insulation from one end of both wires.
12. Splice one wire to a bare section of the radiating element.
13. Mark the opposite end as antenna.
14. Splice the other wire to a bare section of the reflector wires.
15. Toss the suspension rope or wire over the limb of a tree or other support.
16. Pull the antenna up to the desired height.
17. Strip insulation from the other end of both wires.
18. Connect the wire marked as antenna to the center of the radio antenna connector.
19. Connect the other wire to a screw on the radio (ground).
20. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

Option 2: Long Wire Antenna.

1. Determine the direction of the desired station.
2. Select a support at least 15 feet high.

X  
You

X  
Support

X  
Distant  
Station

3. Move the vehicle approximately 100 feet from the support. Keep the support in line with and between you and the desired station.
4. Connect 100 feet of wire to an insulator.

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5. Attach the insulator approximately 15 feet up the support. Do not allow the wire to contact the support.
6. Pull the wire tight.
7. Tie the opposite end of the wire to a stake.
8. Strip 1/2 inch of insulation from the end of the wire.
9. Connect the bared wire to the center connection of the antenna connector on the radio.
10. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

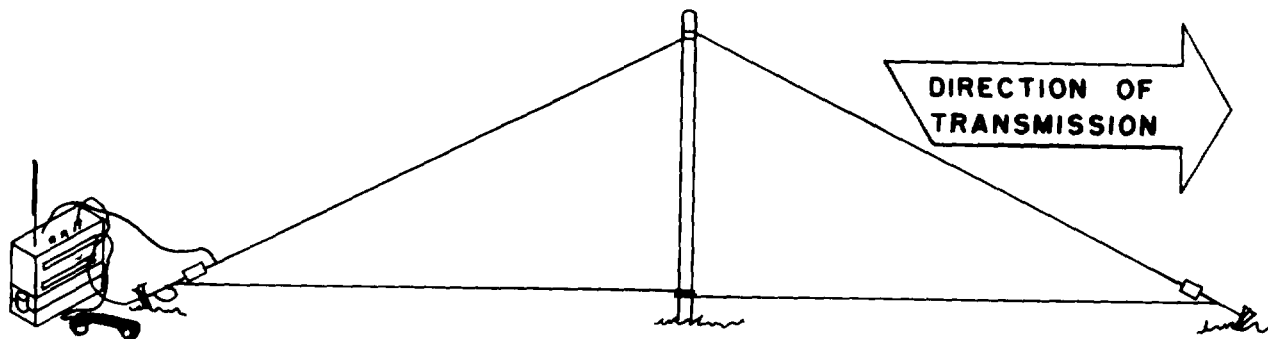
Option 3: Half Rhombic Antenna.

Materials/Tools:

- o Wire, commo or electrical
- o Insulators (e.g., glass, plastic, leather, nylon, etc), three each
- o 600-ohm carbon resistor or equivalent

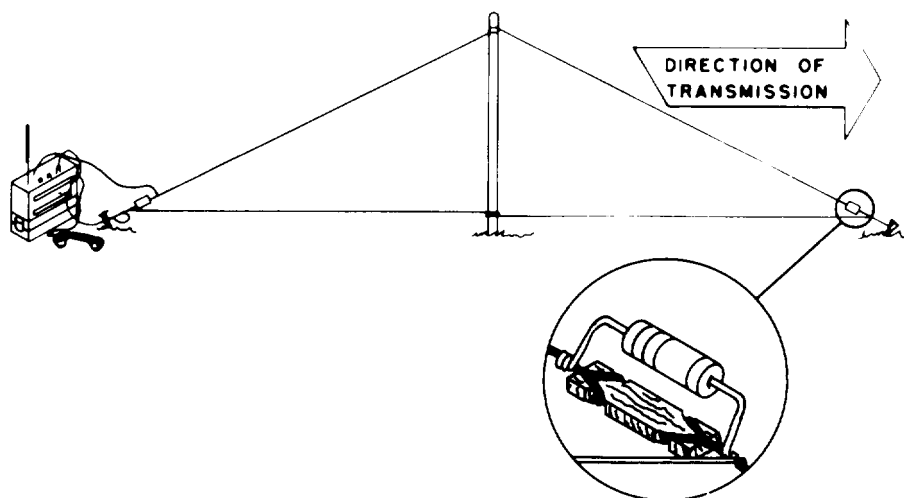
Procedural Steps:

1. Determine the direction of the desired station.
2. Select a support at least 30 feet high.



3. Move your vehicle approximately 50 feet from the support. Keep the support in line with and between you and the desired station.
4. Cut approximately 100 feet of wire for the antenna.
5. Cut approximately 91 feet of wire for a counterpoise.

6. Connect an insulator to each end of the wire used for the antenna.
7. Tie an insulator to the middle of the antenna wire to be used for elevating the antenna.
8. Connect tiedown wires to the outside of the insulators at the ends of the antenna wire.
9. Connect the counterpoise to the insulators at the same point as the tiedown wires.
10. Connect a long rope or wire to the outside of the insulator at the middle of the antenna wire.
11. Raise the center of the antenna up the support approximately 30 feet.
12. Stretch the antenna and counterpoise ends out in a straight line between you and in line with the vehicle and the desired station.
13. Drive stakes in the ground by each tiedown wire.
14. Stretch the antenna and counterpoise tight and tie to the stakes.
15. Connect a wire from the antenna to the center of the antenna connection on the radio.
16. Route a second wire, for ground, from any convenient screw on the radio case and connect it to the counterpoise wire.



17. Connect a 600-ohm carbon resistor across the insulator on the transmission end of the antenna. Refer to paragraph 15-7 for construction of a 600-ohm resistor.
18. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

## Section IV. CABLES

### 15-10. GENERAL

Interconnecting communications cables and connectors can normally be repaired using procedures contained in the electrical chapter.

Communications interconnecting cables normally have multiple wires. Put sufficient wraps of tape or insulation on the individual wires to prevent shorts or grounding.

RF cables are shielded cables. The shielding over the splice must make good contact with the shielding on the other side to prevent radio frequency interference (RFI). When sufficient shielding is not available, a repair can be made by using a conductive material (such as tubular copper braid, metal gauze, conductive foil from gum wrappers, cigarette packages, or common kitchen foil) over the repair.

Damaged connectors can be bypassed using a direct wiring procedure or by substituting unused connector wire pairs and wiring them to connect the appropriate circuits.



## Section V. RADIOS AND MOUNTS

## 15-11. GENERAL

There are no simple methods for constructing field expedient radios. However, signal flags, handsignals, flashlights, telephones, and messengers can be used in place of a radio. When the receiver/transmitter is damaged, an auxiliary receiver can be tuned to the proper frequency and used for reception.

## 15-12. RADIO INOPERATIVE/BREAKER WILL NOT RESET

## General Information:

The radio will receive but not transmit when the POWER switch is turned to OFF/BREAKER RESET and back to LOW or HIGH. This can be caused by problems in the matching unit antenna. Transmission can possibly be restored by disconnecting the power cable to the matching unit. A damaged or corroded matching unit will not allow the transmit circuit breaker to reset.

## Limitations:

- o Must manually set frequency on antenna matching unit

## Personnel/Time Required:

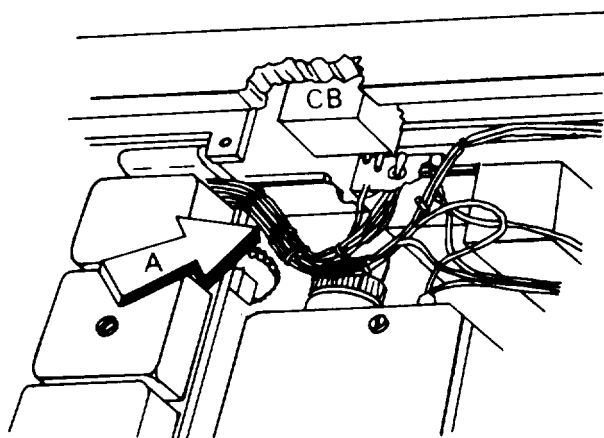
- o 1 soldier
- o 20 minutes

## Procedural Steps:

1. Turn POWER switch to OFF/BREAKER RESET.
2. Disconnect the CX-4722 power cable between the radio and the antenna matching unit.
3. Turn frequency control switch on the bottom of the antenna matching unit to the proper operating frequency.
4. Turn POWER switch to HIGH and then back to OFF/BREAKER RESET.
5. Turn POWER switch to desired operating power position.
  - a. If the radio will now transmit, resume normal operations with the matching unit power cable disconnected.
  - b. If radio does not transmit, proceed to step 6.
6. Turn POWER switch to OFF/BREAKER RESET.
7. Remove the radio from mount.
8. Remove the bottom cover from the radio.

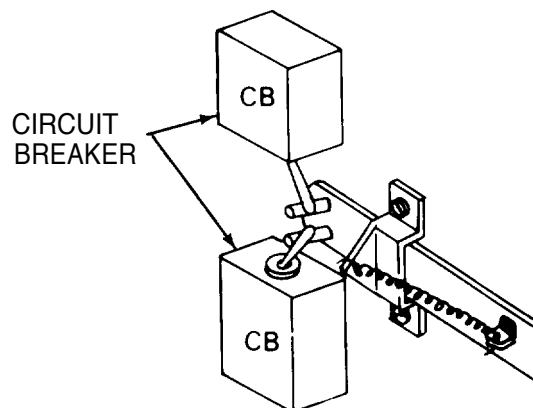
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9. Look into the radio and locate wiring harness A.
10. Move wiring harness A out of the way.



INSIDE RADIO

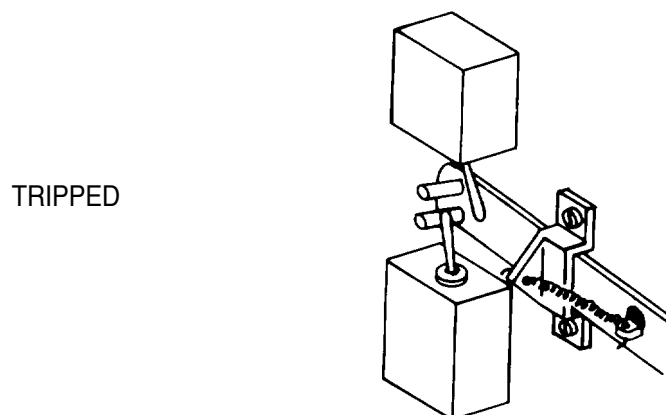
11. Locate the two circuit breakers mounted on the front panel .



ON

CIRCUIT BREAKERS

12. Turn the POWER switch to OFF/BREAKER RESET to move the circuit breaker levers to the ON position.



13. Turn the POWER switch to LOW position. Both of the circuit breaker levers should remain in the ON position.

14. Manually reset the circuit breaker lever if it does not remain in the ON position.

15. Replace the bottom cover of the radio.

16. Replace the radio in the mount.

17. Do not reconnect the power cable to the matching unit.

18. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

#### 15-13. FOREIGN EQUIPMENT INTERCHANGEABILITY (AN/VRC-12 SERIES)

##### General Information:

The following foreign countries use the standard American AN/VRC-12 series radio:

- a. Belgium,
- b. Israel,
- c. Korea,
- d. Netherlands,
- e. Spain, and
- f. Sweden

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## 15-14. FOREIGN EQUIPMENT INTERCHANGEABILITY (ALLIED RADIOS)

## General Information:

This procedure contains general installation instructions for Allied radio equipment. The countries listed below have agreed to utilize the same connectors for cables within the radio system. Power cable connectors should be the same.

Basic FM Radio & Country	Frequency Range (MHz)	Power Output (Watts)		Band width (kHz)	Range (km)	
		Min	Max		Min	Max
AN/VCR-12	30 to 75.95	3	35	50	8	30
PRC-351/352 (UK)	30 to 75.95	4	20	25/50	8	16
SE M-35/25 (FRG)	26 to 69.95	0.15	15	50	8	30
RV-3/13/V (Italy)	26 to 71.95		15	50		30
TR-VP-113/213 (France)	26 to 71.95		15	50		30
TRC-570 (France)	26 to 71.95	2	30	25/50	15	40

## Limitations:

- o Possible reduced range and limited frequencies

## Personnel/Time Required:

- o 1 soldier
- o 1 hour

## Procedural Steps:

1. Mark the cable connector which supplies power to the mount on the foreign vehicle.
2. Remove the radio and its accompanying mount from the foreign vehicle.
3. Take one foreign handset or CVC helmet for use if the US handset or CVC helmet will not adapt to the front of the foreign radio.
4. Remove the radio and its accompanying mount from the US vehicle.
5. Install the foreign radio and mount in the place vacated by the US radio.
6. Configure the US power cable end to fit the foreign mount power socket.
7. Connect the power cable to the foreign radio mount.
8. Record BOAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

15-18

## 15-15. FOREIGN EQUIPMENT INTERCHANGEABILITY (SOVIET RADIO R-123M)

## General Information:

Use enemy equipment only as a last resort. Frequency range of the Soviet R-123M radio is 20 to 51.5 MHz (MC). This covers only the low band frequencies of the US radio. Use of this radio will require modification to use US microphones, speakers, and handsets. Power and antenna hookups must also be changed.

Salvage as many of the connectors and accessories as possible (antenna cable with connectors, and chestplates with headsets). Use jumper wires to preserve the ability to use accessories with US equipment.

## Limitations:

- o Limited frequencies
- o Frequency must be set manually on the antenna matching unit

## Personnel/Time Required:

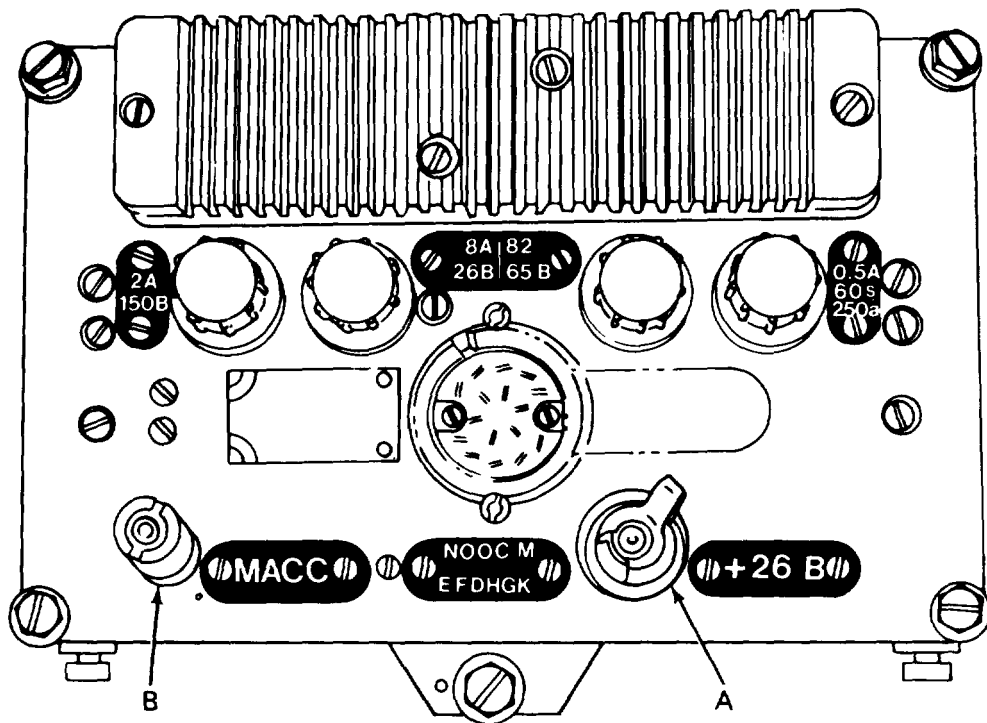
- o 1 soldier
- o 1 hour

## Materials/Tools:

- o Wire, commo or electrical
- o Tape
- o Handset, H-161/GR, H-189/GR, H-207/GR, H-250/GR or CVC helmet
- o M-80 microphone and 8-ohm speaker (if handset above is not available)
- o Chestplate, Soviet
- o Transceiver, Soviet, R-123M (with power supply)
- o Wire, 2-conductor, 12-gage (minimum size) , 3-foot length

## Procedural Steps:

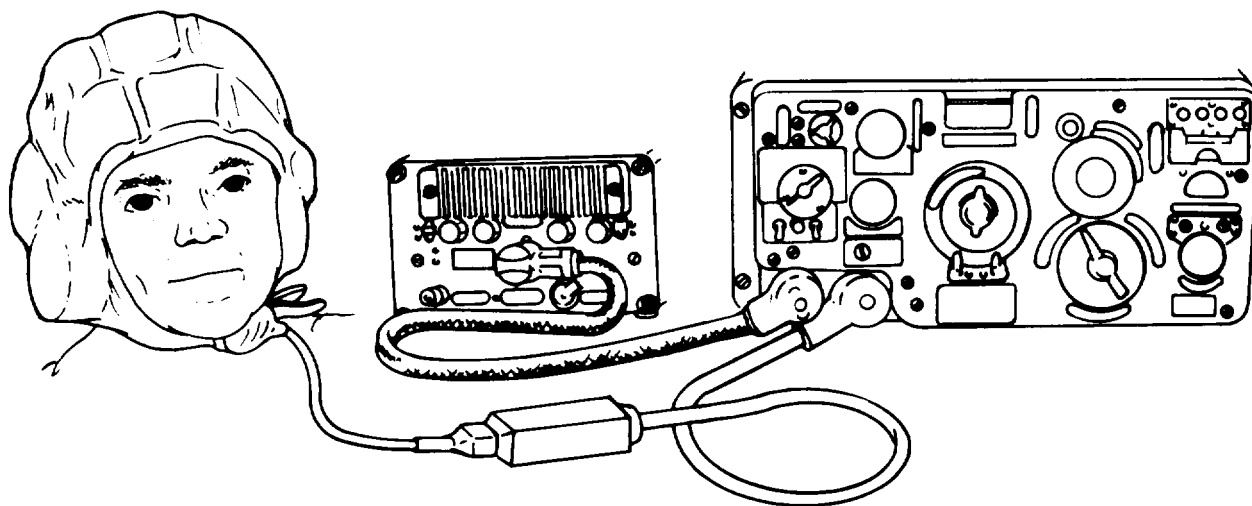
1. Disconnect battery ground.
2. Locate the cable that runs from the batteries to connection J-21 (power) on the bottom of the radio mount.
3. Disconnect this cable.
4. Strip back and remove approximately 4 inches of the outer insulation without removing the connector from the cable.
5. Remove approximately 1/4 to 1/2 inch of the inner insulation from each of the four wires in the cable.



6. Jumper the red and the white wires to the positive side of the Soviet power supply (Point A). Use a jumper cable of at least 12-gauge wire.
7. Jumper the black and the green wires to the negative side of the power supply (Point B). Use a jumper cable of at least 12-gauge wire.
8. Install the R-123M onto the mount and secure.
9. Splice the Soviet coaxial cable to the antenna coaxial cable.
10. Connect the coaxial cable to the antenna connection point located on the right side of the R-123M, immediately below the AHTEHHA sign.
11. Connect a microphone and speaker to the radio using one of the following options:

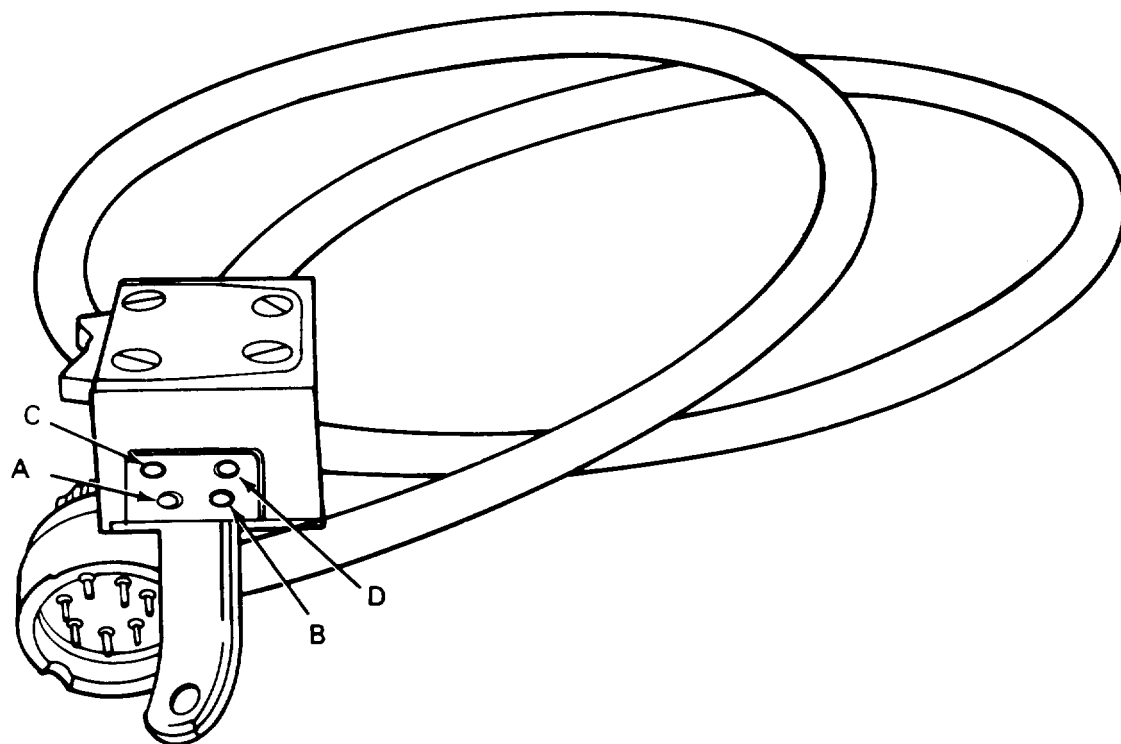
### Option 1: Soviet Accessories.

Use the Soviet chestplate and headset without modification.



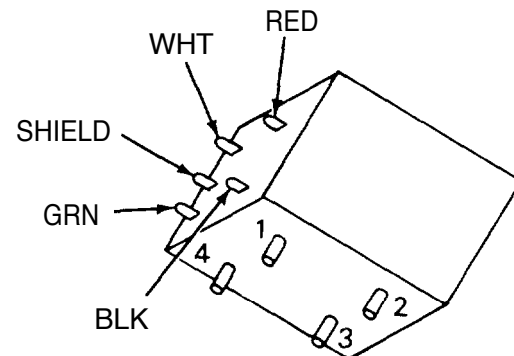
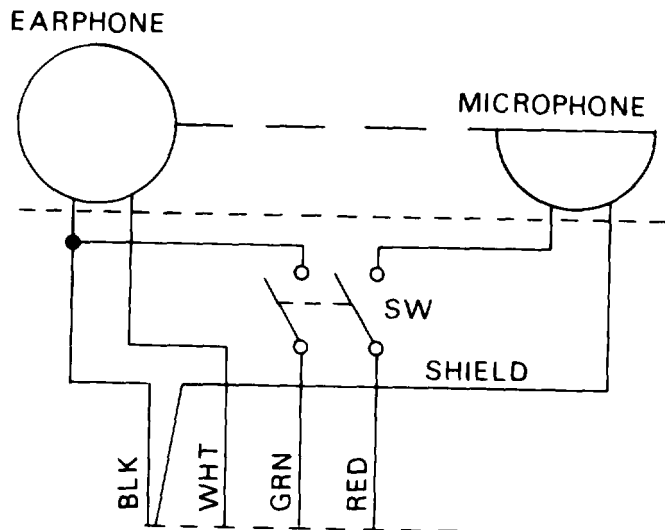
### Option 2: Soviet Chestplate (H161, H189, H207, or H250).

1. Remove handset switch plate.



SOVIET CHEST PLATE

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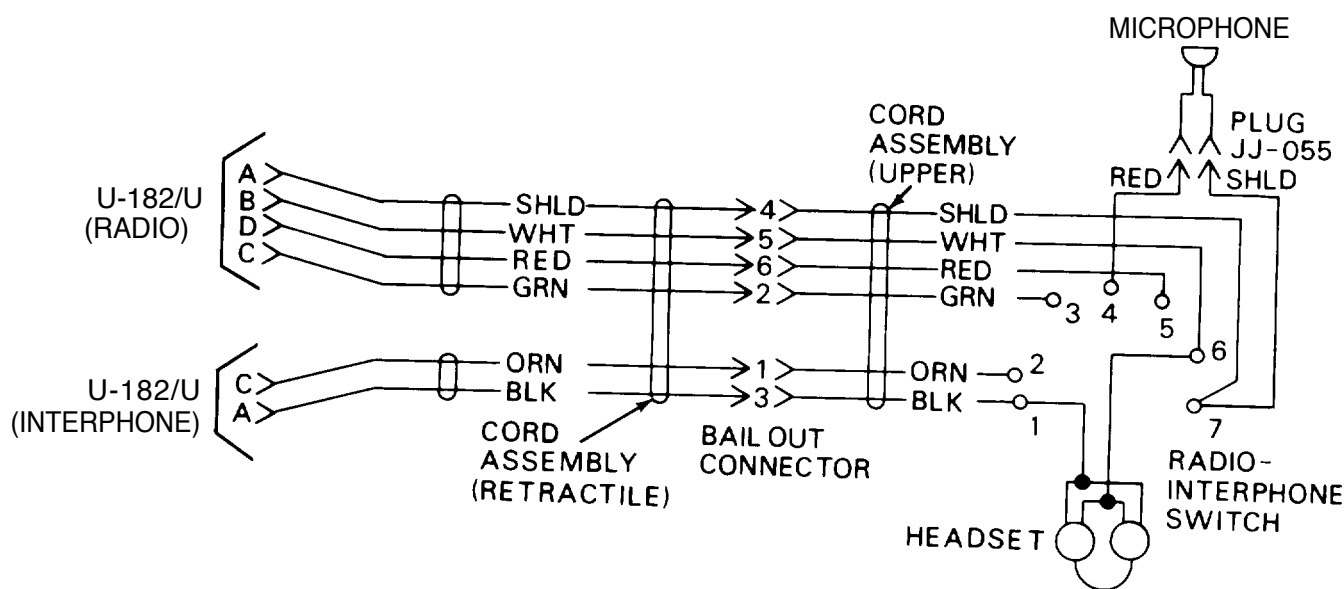
## HANDSET SWITCH PLATE

2. Connect four wires, 2 feet long, to the black, white, green, and red wire connections on the handset switch.
3. Connect the jumper wire from the black wire to one of the inside jacks (point A) on the Soviet chestplate.
4. Connect the jumper wire from the white wire to the other inside jack (point B).
5. Connect the jumper wire from the green wire to one of the outside jacks (point C).
6. Connect the jumper wire to the other outside jack (point D).
7. Reverse the jumper wires at points C and D on the Soviet chestplate if you can receive but not transmit.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.



## Option 3: CVC Helmet to Soviet Chestplate.

1. Remove CVC helmet plastic earphone cushion and receiver retainer.



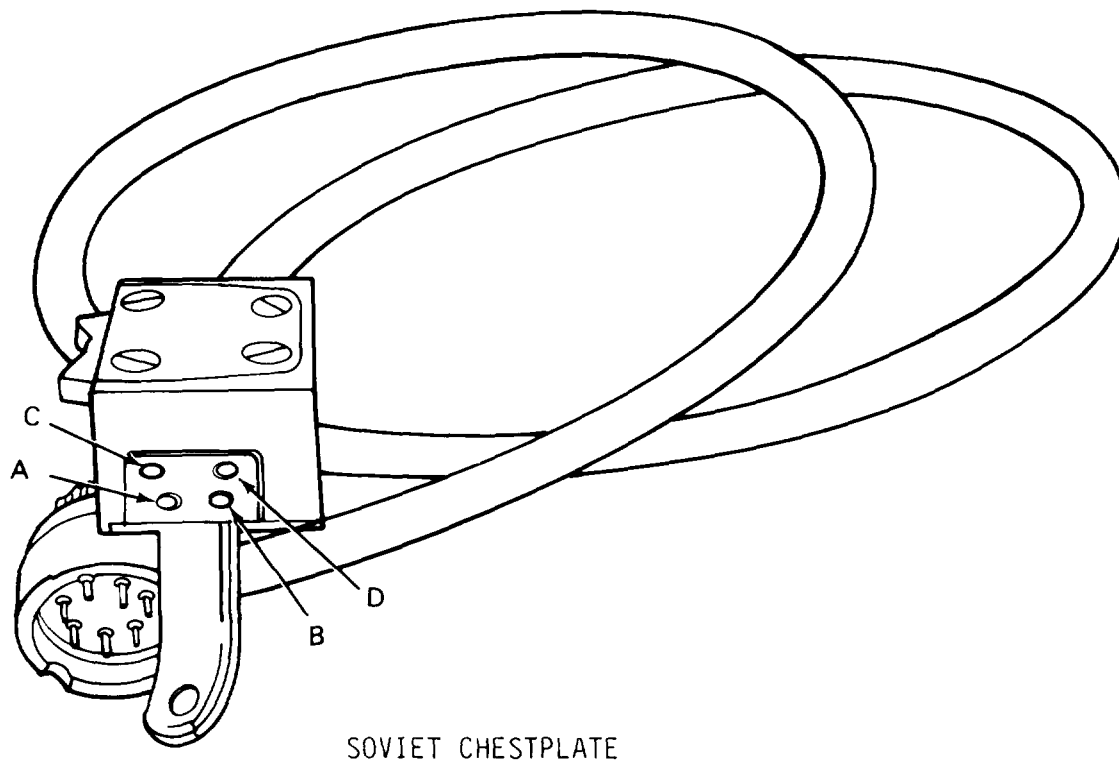
2. Connect four jumper wires, 12 feet long, to the white, black, red, and shield wire connections on the CVC helmet switch.
3. Connect the jumper wire from the white wire to point A on the soviet chestplate.
4. Connect the jumper wire from the black wire to point B on the soviet chestplate.
5. Connect the jumper wire from the shield wire to point C on the soviet chestplate.
6. Connect the jumper wire from the red wire to point D on the soviet chestplate.
7. Assemble the CVC helmet.
8. Reverse the jumper wires at points C and D on the soviet chestplate if you can receive but not transmit.
9. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## Option 4: M-80 Microphone and 8-Ohm Speaker to Soviet Chestplate.

1. Remove microphone switch cover plate.
2. Connect two jumper wires, 2 feet long, to the red and green wire connections on the switch.

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3. Connect the jumper wire from the red wire connection to one of the outside jacks (point C) on the Soviet chestplate.
4. Connect the jumper wire from the green wire connection to the other outside jack (point D).
5. Connect a jumper wire, 2 feet long, to the ground (-) side of an 8-ohm speaker (RT-524, for example).
6. Connect a jumper wire, 2 feet long, to the positive (+) side of the speaker.
7. Connect the jumper wire from the ground side of the speaker to one of the inside jacks (point A) on the soviet chestplate.
8. Connect the jumper wire from the positive side of the speaker to the other inside jack (point B).



9. Hook the soviet chestplate to the intercom connection on the front of the soviet radio.
10. Connect battery ground.
11. Test radio operation. Refer to paragraph 15-16.
12. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

## 15-16. SOVIET RADIO R-123M TUNING AND

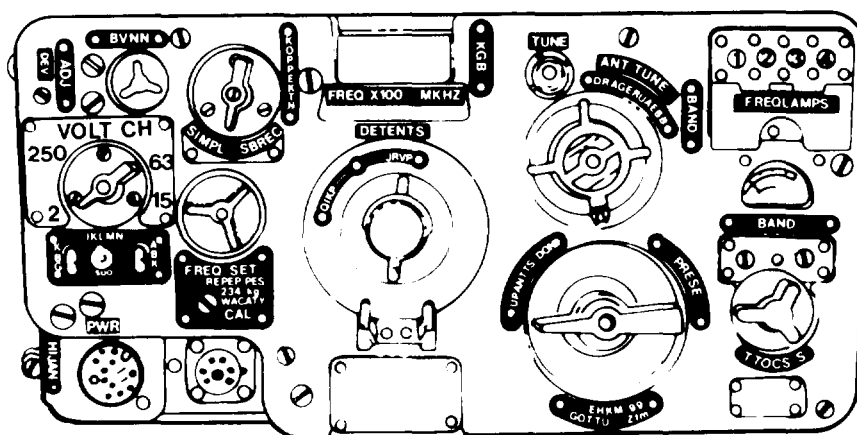
## General Information:

This procedure gives tuning and operating instructions for the R-123M Soviet radio. Radio will overheat if a 3:1 transmit-to-receive ratio is not observed. The R-123M radio lists frequency in kilocycles (kc) times 100. For conversion to MHz (MC), add two zeros to right end of the figure displayed and place a decimal to the left of the third number from the right. ( i.e., 360 kc times 100 = 36.000 MHz. )

## Personnel/Time Required:

- o 1 soldier
- o 20 minutes

## Procedural Steps:



1. Turn power switch and dial light switch to the OFF (down) position.
2. Set mode selector switch to the SIMPL (left) position.
3. Tighten antenna loading control locking nut.
4. Turn squelch control knob counterclockwise (off).
5. Turn volume control knob all the way clockwise.
6. Turn voltage check/operate switch to 1,2B (approximately the 1-o'clock position).
7. Turn power switch and the dial light switch to the on (up) position. Frequency dial viewing window and indicator meter will light.

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8. Allow the tubes to heat until a rushing noise is heard in the speaker/headset.
9. Adjust volume control knob for the desired volume level.

**CAUTION**

The receiver and transmitter are tuned simultaneously. Do not operate the transmitter without using an antenna. Transmitting without connecting an antenna will damage the transmitter portion of the radio.

10. Turn voltage check/operate switch clockwise to the 6, 3B position. The needle on indicator meter should be in the shaded portion of the scale.
11. Turn the voltage check/operate switch to the 150B position. The needle on the indicator meter should be in the shaded portion of the scale.
12. Check the power supply for bad fuses and replace or jumper any bad ones if the needle was not in the shaded area.
13. Turn the voltage check/operate switch to the 1,2B position on the scale (approximately the 7-o'clock position). Indicator meter should read in the shaded portion of the scale.
14. If the meter reading was not in the shaded portion of the scale, check the power supply for bad fuses and replace or jumper any bad ones.
15. Turn voltage check/operate switch to the 150B position.
16. Momentarily place the chest plate switch switch in the transmit position. The reading on indicator meter should be in the shaded portion of the scale.
17. Turn voltage check/operate switch to the 250B position.
18. Momentarily place the chest plate switch in the transmit position. The reading on indicator meter should be in the shaded portion of the scale.
19. If the meter reading was not in the shaded portion, check the power supply for bad fuses and replace or jumper any bad ones.
20. Turn voltage check/operate switch to the 600B position.
21. Momentarily press the switch to transmit. The reading should be in the shaded portion of the scale.
22. If the meter reading was not in the shaded portion, check the power supply for bad fuses and replace or jumper any bad ones.
23. Turn voltage check/operate switch to the PAboTA1 (operate) position.

24. Turn preset channel/continuous tune selector switch to the I or II position. Position I is used if the operating frequency is between 20 and 35.75 MHz. Position II is used if the operating frequency is between 25.8 and 51.5 MHz. Band selection is shown by band indicator lights.

25. Rotate frequency tuning knob to the frequency listed that is the closest to the operating frequency.

Band I: 22.050 MHz 28.350 MHz 34.650 MHz

Band II: 36.225 MHz 40.950 MHz 42.525 MHz 45.675 MHz 48.825 MHz

The frequencies are marked on the frequency dial with an extended graduation line capped by an arrowhead.

26. Turn mode selector switch to the SBREC (receive only) position.

27. Press and hold tone call button. A tone should be heard in the earphones.

28. Rotate frequency tuning knob. The tone heard should progress from a high pitch to a low pitch then to a high pitch again. The proper setting is the point between the high tones and the lowest pitch or when totally absent.

29. Note the positions of the index line and the frequency graduation line through frequency dial viewing window.

30. Release tone call button.

31. Perform the following adjustment if the index line is not within one-fifth of a graduation (5 KHz):

a. Remove index line adjustment plug.

b. Rotate the adjustment right and left with a screwdriver until the index line is aligned with the frequency graduation line.

c. Replace index line adjustment plug.

32. Return mode selector switch to the SIMPL position (left).

33. Turn preset channel/continuous tune selector switch to position I or II.

34. Open preset locking screw access cover on the front panel.

35. Release the preset locking screw with the special key (not shown) attached to the case of the radio by turning the screw 90 degrees counterclockwise. Use the special key (not shown) attached to the case and turn preset locking screw 90 degrees counterclockwise.

36. Turn frequency tuning knob to the desired frequency.

37. Hold frequency tuning knob and turn preset locking screw clockwise with the special key until the slot is pointed at the red dot.

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38. Loosen antenna loading control locking nut two or three turns.
39. Push the chestplate switch to the transmit position and hold.
40. Turn antenna loading control knob. Several peaks will be noted on indicator meter. Tune to the greatest peak.
41. Release the chestplate switch.
42. Hold antenna loading control knob and tighten antenna loading control locking nut.
43. Press the Soviet chestplate switch to transmit. Release to receive.
44. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.

#### 15-17. FIELD EXPEDIENT RADIO REMOTE

##### General Information:

This procedure gives instructions for the construction of a field expedient remote to replace the AN/GRA-39 if it is inoperative. Build the radio remote unit using the schematic.

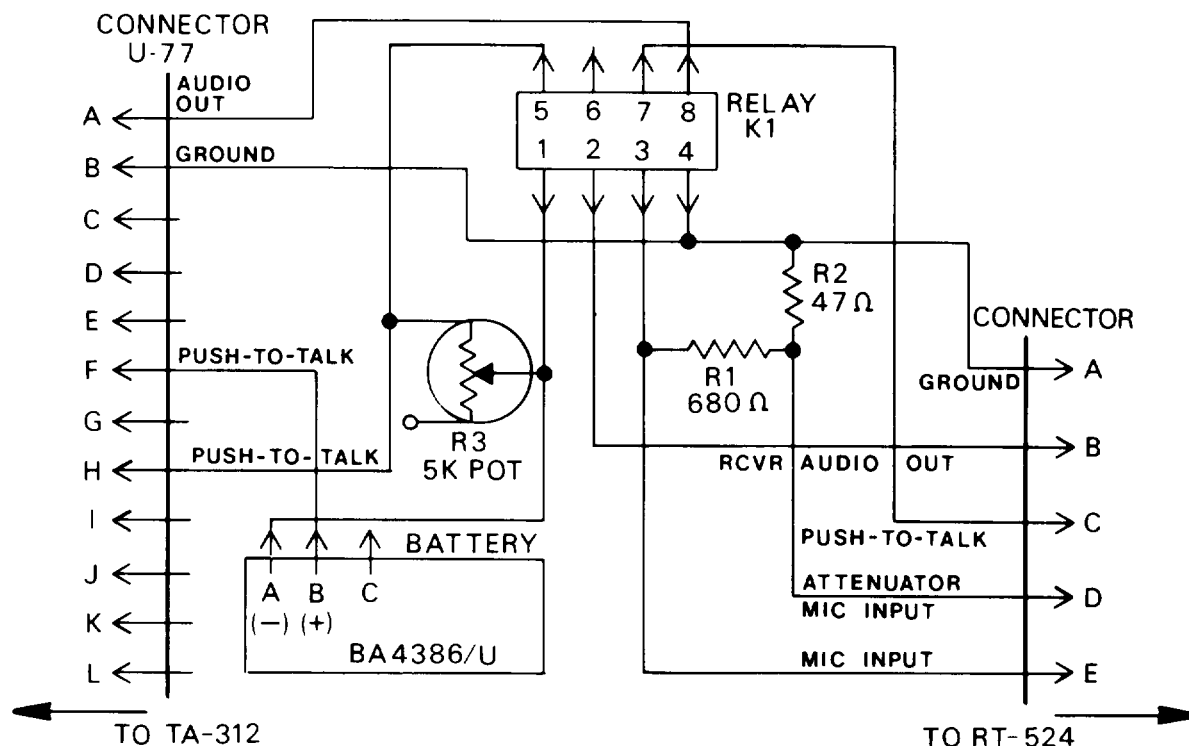
##### Personnel/Time Required:

- o 1 soldier
- o 1 hour

##### Materials/Tools:

- o 680-ohm resistor
- o 47-ohm resistor
- o 5000-ohm variable potentiometer
- o H-144/U handset (only cord and plug used)
- o M-80 microphone (only cord and plug used)
- o K-1 relay (28 V dc)  
(NSN 5945-00-951-6458)
- o BA-4386/U battery  
AN/PRC-77 battery)  
(NSN 6135-00-926-8322)
- o TA-312/PT field telephones  
(two each)
- o Electrical tape
- o 18- or 24-gage wire
- o Soldering iron and solder

## Procedural Steps:



1. Cut the cords (at the handset end) from the H-144 handset and the M-80 microphone.
2. Remove 6 inches of outer insulation from the cut end of each cord. Do not cut the inner wires.
3. Remove 1/2 inch of insulation from the end of each inner wire.
4. Use a multimeter or continuity tester to match the wires with the pins in the plug using reference letters.
5. Arrange components in order shown in the schematic.
6. Solder the two resistors together at one end.
7. Solder all other wires to points referenced.
8. Tape the R-3 (5000-ohm) potentiometer, K-1 relay, and 6A-4386 battery (AN/PRC-77 battery) solidly together.
9. Connect the 5-pin connector to the RT-524 jack marked RETRANSMIT R/W.
10. Connect the 10-pin connector to the jack on a TA-312.

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11. Connect the required length of commo wire (up to 15 miles) between the two telephones.
12. Set the selector switch S1 on both telephones to LB to enable DC switching from the push-to-talk switch.
13. Connect the dc plug from the remote unit into the 6A-4386 battery (AN/PRC-77 battery).
14. Turn on radio.
15. Adjust the 5000-ohm potentiometer so that the K-1 relay energizes when the push-to-talk switch on the remoted TA-312 is pressed.
16. Check operation.
17. Record BDAR action taken. When the mission is complete, as soon as practicable, repair using standard maintenance procedures.



## APPENDIX A

## REFERENCES

## A-1. PUBLICATION INDEX

The following index should be consulted frequently for latest changes or revisions and for new publications relating to material covered in this manual:

DA PAM 310-1	Consolidated Index of Army Publications and Blank Forms
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## A-2. FORMS

DA Form 2028	Recommended Changes to Publications and Blank Forms
DA Form 2404	Equipment Inspection and Maintenance Worksheet
DA Form 2407	Maintenance Request
DA Form 2408-9	Equipment Control Record
SF 368	Quality Deficiency Report

## A-3. TECHNICAL PUBLICATIONS

a. Bulletins (TB)

TB 9-2300-247-40	Tactical Wheeled Vehicles: Repair of Frames
TB 9-2300-422-20	Security of Tactical Wheeled Vehicles
TB 43-0142	Safety Inspection and Testing of Lifting Devices
TB 750-651	Use of Antifreeze Solutions and Cleaning Compounds in Engine Cooling Systems

b. Manuals (TM)

TM 3-4230-204-12&P	Operator's and Organizational Maintenance Manual Including Repair Parts and Special Tools List: Mask, Chemical-Biological , Special Purpose
TM 3-6665-225-12	Operator's and Organizational Maintenance Manual: Alarm, Chemical Agent, Automatic: Portable
TM 5-725	Rigging
TM 9-237	Operator's Manual for Welding Theory and Application
TM 9-238	Deepwater Fording of Ordnance Material

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TM 9-247	Materials used for Cleaning, Preserving, Abrading, and Cementing Ordnance Material and Related Materials Including Chemicals
TM 9-2610-201-14	Standards and Criteria for Technical Inspection and Classification of Tires (FSC 2610)
TM 750-244-6	Procedures for Destruction of Tank-Automotive Equipment to Prevent Enemy Use
TM 750-254	Cooling systems, Tactical Vehicles

#### A-4. FIELD MANUALS

FM 3-5	NBC Decontamination
FM 3-87 (HTF)	Nuclear, Biological, and Chemical (NBC) Reconnaissance and Decontamination Operations (How to Fight)
FM 5-36	Route Reconnaissance and Classification (How to Fight)
FM 9-207	Operation and Maintenance of Ordnance Materiel in Cold Weather ( 0 to -65°F)
FM 10-69	Petroleum Supply Point Equipment and Operations
FM 20-22	Vehicle Recovery Operations
FM 21-11	First Aid for Soldiers
FM 21-26	Map Reading
FM 21-40	NBC (Nuclear, Biological, and Chemical) Defense
FM 21-305	Manual for the Wheeled Vehicle Driver
FM 25-3	Training in Units
FM 31-70	Basic Cold Weather Manual
FM 31-71	Northern Operations
FM 90-6(HTF)	Mountain Operations (How to Fight)
FM 101-5-1	Operational Terms and Symbols

## A-5. ARMY REGULATIONS (AR)

AR 310-25	Dictionary of United States Army Terms
AR 310-50	Authorized Abbreviations and Brevity Codes
AR 385-40	Accident Reporting and Records
AR 600-55	Motor Vehicle Driver - Selection, Testing, and Licensing

## A-6. SUPPLY MANUALS

SC 4910-95-CL-A72	Shop Equipment, Automotive Maintenance and Repair: Organizational Maintenance
SC 4910-95-CL-A74-HR	Hand Receipt Manual Covering Content of Shop Equipment, Automotive Maintenance and Repair, Organizational Maintenance

## A-7. GENERAL PUBLICATIONS

DA PAM 738-750	The Army Maintenance Management System (TAMMS)
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## A-8. VEHICLE PUBLICATIONS BY SERIES NUMBER

TM 9-2320-206 series	M123A1C Series Truck, Tractor, 10-Ton
TM 9-2320-209 series	M35 Series Truck, 2-1/2-Ton
TM 9-2320-211 series	M39 Series Truck, 5-Ton
TM 9-2320-218 series	M151 Series Truck, Utility, 1/4-Ton, 4 X 4
TM 9-2320-242 series	M561 Series Truck, Cargo, 1-1/4-Ton
TM 9-2320-258 series	HET 70 Heavy Equipment Transporter
TM 9-2320-260 series	M809 Series Truck, 5-Ton
TM 9-2320-266 series	M880 Series Truck, Cargo, 1-1/4-Ton
TM 9-2320-270 series	M911 Truck Tractor, Heavy Equipment Transporter, Commercial (C-HET)
TM 9-2320-272 series	M939 Series Truck, 5-Ton
TM 9-2320-273 series	M915 Series Line Haul Tractor
TM 9-2320-279 series	Heavy Expanded Mobility Tactical Truck (HEMTT)
TM 9-2320-289 series	Commercial Utility Cargo Vehicle (CUCV)

## APPENDIX B

### SPECIAL AND FABRICATED TOOLS/WELDING EXPEDIENTS

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

#### Section I. GENERAL

##### B-1. SCOPE

This appendix lists items recommended for the support of the vehicle in a combat environment. The items listed may be required for battlefield damage assessment and repair at maintenance levels from crew thru DS. Also listed are expedient tools for performing BDAR repairs using nonstandard equipment.

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## Section II. TOOLS

### B-2. GENERAL

Tools listed in this appendix will enhance crew members and mechanics at all levels to accomplish battlefield damage and assessment repairs in a more expedient manner. Some tools listed may already be on hand in the unit.

The column marked Level indicates the maintenance level at which these items be stocked or carried. The unit commander may modify the items in the list and the maintenance levels carrying the items, based on current mission requirements and recent operational experience.

The items marked C (Crew) are recommended to be carried on the vehicle for use in combat emergencies at the discretion of the unit commander. Those items marked MT are recommended to be carried by each battlefield damage assessment and repair maintenance team (MT). Some of these items may already be available at organizational maintenance; however, additional items will be required to stock each MT. Those items marked O are recommended to be stocked at organizational and those marked MST are recommended to be carried by the DS maintenance support teams (MST).

## EXPENDABLE TOOLS

ITEM NUMBER	LEVEL	NSN	DESCRIPTION
1	C	5110-00-277-4591	Blade, hand hacksaw: 24 teeth per in., 10 in. lg
2	C	5110-00-927-1063	Blade, hacksaw, flat (tungsten)
3	MT	5120-00-203-6431	Clamp, C: 6 in. (two required)
4	MT	5120-00-278-2423	Crimping Tool: terminal, hand w/cutting pin, stipper
5	MT	5120-00-278-6520	Cutter, tubing, close quarters
6	C	5120-00-227-8074	Extension, socket wrench: 1/2 in. sq dr 10 in. lg
7	C	5110-00-241-9153 5110-00-241-9156	File, hand: half rnd, 10 in.
8	C	5110-00-234-6559	File, hand: rnd style
9	C	5110-00-289-9657	Frame, hand hacksaw, 10 in. and 12 in. blade accommodated
10	C	4940-00-561-1002	Gun, thermal: PN 8031088
11	C	5110-00-263-0349	Handle, file
12	C	5110-00-240-5943	Knife, pocket: w/clevis, screwdriver, wire scraper, and cutting blade
13	C	5120-00-221-1536	Knife, putty
14	C		Lifter, roadwheel arm
15	C	5120-00-239-8251	Pliers: lineman's, w/side cutter, 8 in.
16	C	5120-00-247-5177	Pliers: rnd nose w/cutter, 6 in.
17	C	5120-00-278-0352	Pliers, slip joint: angle nose, multiple tongue and groove, 10 in.
18	C	5120-00-624-8065	Pliers, slip joint: conduit, w/o hall, w/removable plastic inserts, 9 in. lg
19	C	5120-00-293-0448	Punch, alining: 3/16 in. pt, 8 in. lg, 3/8 in. dia

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## EXPENDABLE TOOLS (CONT)

ITEM NUMBER	LEVEL	NSN	DESCRIPTION
20	c	5120-00-595-9531	Punch, alining: 1/4 in. pt, 12 in. lg
21	c	5120-00-242-5966	Punch, drive pin: 1/8 in.
22	o	4931-01-119-7103	Repair kit, electrical connector: PN 12285360
23	MT	5120-00-017-2849	Riveter: blind, hand
24	c	5120-00-234-8913	Screwdriver, cross tip: No. 2
25	c	5120-00-221-7063	Scriber, machinist's: double point
26	c	5120-00-237-0982	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 3/8 in.
27	c	5120-00-189-7924	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 7/16 in.
28	c	5120-00-237-0984	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 1/2 in.
29	c	5120-00-189-7932	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 9/16 in.
30	c	5120-00-189-7946	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 5/8 in.
31	c	5120-00-235-5870	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 11/16 in.
32	c	5120-00-189-7985	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 3/4 in.
33	c	5120-00-189-7933	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 13/16 in.
34	c	5120-00-189-7934	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 7/8 in.
35	c	5120-00-189-7935	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 15/16 in.
36	c	5120-00-189-7927	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 1 in.
37	c	5120-00-242-3349	Socket, deepwell, 1/2 in. dr, 3/4 in.

## EXPENDABLE TOOLS (CONT)

ITEM NUMBER	LEVEL	NSN	DESCRIPTION
38	MT	5110-00-803-6339	Splitting tool, nut, 7/8 in. cap
39	MT	6625-01-102-6878	TA-1 continuity and test probe kit: PN 12303622
40	c	5140-00-498-8772	Tool box, portable: steel w/removable tray, 21 in. lg, 8-1/2 in. w, 7-3/8 in. h
41	MT	5120-01-128-5511	Tool set, supplement, organizational: PN 12310894
42	c		Web strap assembly, adjustable: PN 12273481
43	c	5120-01-121-4981	Wrench, plug, straight bar hex: PN 12284998
44	c	5120-00-240-5328	Wrench, adjustable: 8 in.
45	c	5120-00-277-4244	Wrench, plier: straight jaw, 8-1/2 in.
46	c	5120-00-148-7917	Wrench set, combination box with open end, 12 components, 5/16 in. - 1 in.
47	c	5120-00-148-7918	Wrench set, open end, fixed, 6 components 3/16 in. - 1-1/16 in.



## Section III. TEST EQUIPMENT

## B-3. FIELD EXPEDIENT TEST EQUIPMENT

## General Information:

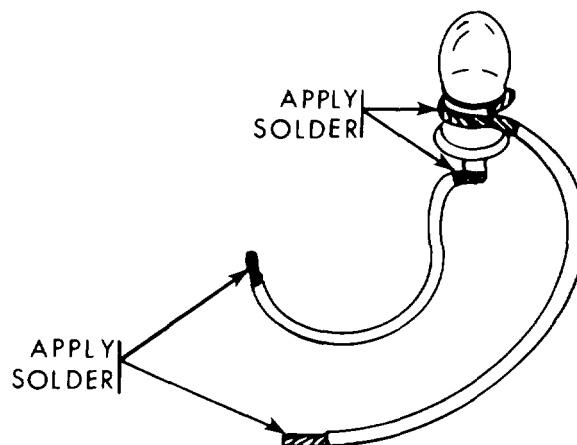
Sometimes, in the process of assessing the battlefield damage, it is necessary to make voltage and resistance measurements to determine where the fault is. Standard test equipment (voltmeter, ohmmeter, SWR meter, etc.) should be used whenever possible. If standard test equipment is not available, field expedient equipment can be fabricated using parts commonly found on the vehicle and in the forward maintenance areas. The following paragraph provides fabrication instructions for making a voltmeter, ohmmeter, and RF transmitter output test.

**NOTE**

Accurate measurements are not available. These are Go-No-Go meters.

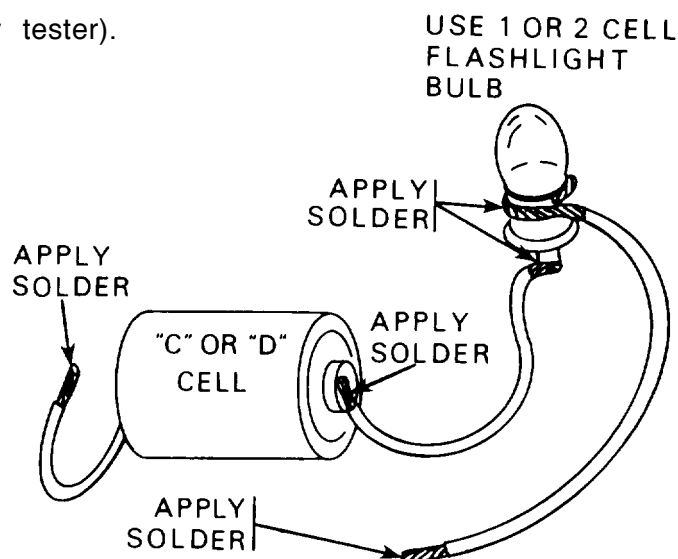
## 1. Making a Voltmeter.

A voltmeter can be made from a light bulb and two pieces of wire. The pieces of wire can be connected to the case and center terminal of the bulb by means of solder, twisting, or simply holding the wire ends against the bulb (see illustration). The voltage rating of the bulb should be close to the value of the expected voltage being measured. For voltages in the 18 to 30 vdc range, any light bulb on the driver's master panel, driver's instrument panel, gunner's panel, commander's panel, or gunner's primary sight can be used. For voltages of 5 vdc or less a two-battery cell flashlight bulb can be used. The presence of voltage will cause the bulb to glow. Polarity of dc voltage does not have to be observed; even ac voltage can be measured. Twist exposed wire ends together and apply solder, if available, and solder. Touch to voltage source when ready to make measurement.



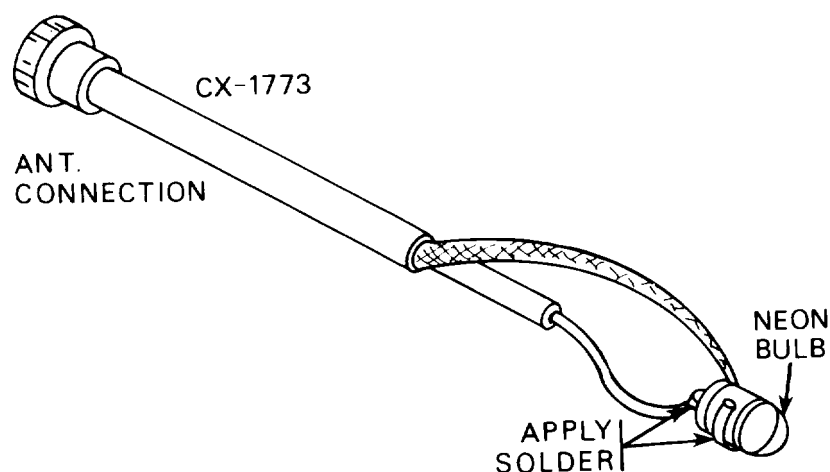
## 2. Making an ohmmeter (continuity tester).

An ohmmeter can be made from a flashlight bulb, flashlight battery, and three pieces of wire. When the free ends of the wires are touched to a circuit where continuity (or a short) exists, the bulb will glow. If a two-cell flashlight bulb is used with only one battery, the bulb will glow with one-half its normal brilliance.



## 3. Making an RF Transmitter Output Tester.

This device is used to determine if the radio is sending a signal to the antenna.



a. An RF transmitter output tester can be made from a neon light bulb and a piece of CG-1773 RF cable. Solder the bulb to the cable as shown in the illustration. Connect the cable to the ANT connection on the front of the radio. When the radio is keyed, the bulb will glow if RF power is present at the antenna connection (this does not verify transmitter frequency accuracy).

b. Another way to check for transmitter output is to hold a common (wooden) lead pencil tip 1/4 inch to 1/8 inch from the ANT connection. If RF power is present, a yellowish-white arc will jump from the connector to the pencil tip when the radio is keyed.

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## Section IV. WELDING EXPEDIENTS

## B-4. CONTROLLED AMPERAGE

## General Information:

Battlefield repairs requiring welding can be performed by using the auxiliary generator (Little Joe) from the M88 or generator recovery vehicle if a regular welder is not available.

## Limitations:

- o Possible degraded armor protection

## Personnel/Time Required:

- o 2-soldier
- o 1-2 hours

## Materials/Tools:

- o Auxiliary generator (24 V dc)
- o Control unit from a welder or similar control
- o Welders helmet and gloves
- o Welding rod, coat hangers, or barbed wire
- o Heavy-gage cable (2.0 gage or larger)
- o Vise grips or clamps
- o Fuel line

## Other Options:

- o Use uncontrolled amperage.
- o Weld using vehicle battery power.

## Procedural Steps:

1. Remove auxiliary generator from M88 recovery vehicle and place close to area to be welded. Connect heavy-gage cables to (+) and (-) output posts. Also connect control unit to (+) and (-) output posts. Tighten terminal securely.
2. Connect negative (-) cable to tank hull with clamp close to area to be welded. Connect welding rod to positive (+) cable with vise grips. Insulate vise grips with gloves, rags, or several layers of dry paper.

**WARNING**

Use welder's helmet to protect eyes and face from arc. Do not touch exposed cable or vise grips with bare hands; metal gets very hot. Do not perform this task in rain or on wet ground because of electrical shock hazard.

3. Start auxiliary generator, strike arc, and weld. Set control unit for amperage level required by the thickness of the metal.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## B-5. UNCONTROLLED AMPERAGE

## General Information:

Battlefield repairs requiring welding can be accomplished by using auxiliary generator (Little Joe) M88 recovery vehicle or a generator if a regular welder is not available. Welding will be difficult without amperage control.

## Limitations:

- o Possible degraded armor protection

## Personnel/Time Required:

- o 2 soldiers
- o 1-3 hours
- (24 V dc)
- o Heavy gage cable (2.0 gage minimum)
- o Vise grips or clamps
- o Fuel line
- o Welder helmet and gloves
- o Welding rod, coat hangers, or barbed wire

## Other Options:

Weld using the vehicle battery power

## Procedural Steps:

1. Remove auxiliary generator from M88 recovery vehicle and place close to area to be welded. Connect heavy gage cables (+) and (-) output posts and tighten securely.
2. Connect negative (-) cable to vehicle hull with clamp close to area to be welded. Connect welding rod to positive (+) cable with vise grip and insulate area against heat with gloves, rags, or several layers of dry paper.

**WARNING**

Use welder's helmet to protect eyes and face from arc. Do not touch exposed cable or vise grips with bare hands; metal will get very hot. Do not perform this task in rain or on wet ground because of possible electric shock hazard.

3. Start auxiliary generator, strike arc, and weld. Use small diameter welding rod for thin metal; use large welding rod for thick metal. Continue to weld until repair is satisfactory.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

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## Section V. CONTAINERS

### B-6. IMPROVISED CONTAINER

#### General Information:

Many repairs require the draining of the fluid systems (fuel, coolants, or oils). An improvised container can be used to catch the fluids.

#### Limitations:

- o None

#### Personnel/Time Required:

- o 2 soldiers
- o 20-30 minutes

#### Materials/Tools:

- o Large plastic sheet
- o Panels
- o Tarpaulin

#### Procedural Steps:

1. Dig a basin large enough to hold liquid.
2. Line the hole with a liner to hold the fluids.
3. Drive the vehicle over the hole.
4. Drain the liquid.
5. Dip the liquid from the hole using a steel helmet, can or canteen cup.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair using standard maintenance procedures.

## APPENDIX C

### ALTERNATE SOURCES OF SUPPLY

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

#### Section I. GENERAL.

##### C-1. GENERAL

This appendix lists alternate sources of supply to include foreign ownership of US combat vehicles and expendable supplies which may be utilized for repairs.

## Section II. FOREIGN OWNERSHIP OF US TACTICAL VEHICLES

## C-2. GENERAL

Repair parts are expected to be in short supply. Parts may be available from other nations involved in the immediate combat areas. Friendly nations owning US weapons systems may have stocks of repair parts or equipment available for cannibalization. The following tables identify nations owning American tactical vehicles.

Table C-1. US Tactical Vehicles Sold to Foreign Countries  
(Countries That Purchased Vehicles)

---

<u>M151 Series</u>	
Truck, Utility, 1/4-Ton, 4 x 4	
1. Argentina	29. Kuwait
2. Bahrain	30. Laos
3. Bolivia	31. Lebanon
4. Brazil	32. Liberia
5. Cambodia	33. Libya
6. Cameroon	34. Luxembourg
7. Canada	35. Morocco
8. Chad	36. Pakistan
9. Chile	37. Panama
10. China (Taipei)	38. Paraguay
11. Colombia	39. Peru
12. Denmark	40. Philippines
13. Dominican Republic	41. Portugal
14. Egypt	42. Saudi Arabia
15. El Salvador	43. Senegal
16. Ethiopia	44. Singapore
17. Fiji	45. Somalia
18. France	46. Spain
19. Ghana	47. Sudan
20. Greece	48. Thailand
21. Guatemala	49. Tunisia
22. Honduras	50. Turkey
23. Indonesia	51. United Kingdom
24. Iran	52. Uruguay
25. Israel	53. Venezuela
26. Jamaica	54. Vietnam
27. Jordan	55. Yemen (Sana)
28. Korea (Seoul)	56. Zaire

Table C-1. US Tactical Vehicles Sold to Foreign Countries  
(Countries That Purchased Vehicles) (Cent)

---

M880 Series

I-1/4-Ton, 4 x 4

- |            |                   |
|------------|-------------------|
| 1. Fiji    | 5. Pakistan       |
| 2. Israel  | 6. Saudi Arabia   |
| 3. Kuwait  | 7. China (Taipei) |
| 4. Lebanon | 8. Yemen (Sana)   |

Commercial Utility Cargo Vehicle (CUCV)

3/4-Ton, 4 x 4 - 1-1/4 Ton, 4 x 4

- |            |          |
|------------|----------|
| 1. Liberia | 2. Sudan |
|------------|----------|

High Mobility Multi-Purpose Wheeled Vehicle (HMMWV)

No sales as of Nov 85.

M939 Series

Truck, Cargo, 5-Ton, 6 x 6

- |                 |
|-----------------|
| 1. Saudi Arabia |
|-----------------|

M35 Series

Truck, Cargo, 2-1/2-Ton, 6 x 6

- |                   |                    |
|-------------------|--------------------|
| 1. Austria        | 16. Laos           |
| 2. Bolivia        | 17. Lebanon        |
| 3. Cambodia       | 18. Liberia        |
| 4. Chad           | 19. Morocco        |
| 5. Chile          | 20. Pakistan       |
| 6. Egypt          | 21. Panama         |
| 7. El Salvador    | 22. Philippines    |
| 8. Ethiopia       | 23. Saudi Arabia   |
| 9. Fiji           | 24. Sudan          |
| 10. Greece        | 25. Thailand       |
| 11. Guatemala     | 26. Turkey         |
| 12. Indonesia     | 27. Venezuela      |
| 13. Iran          | 28. Vietnam        |
| 14. Jordan        | 29. China (Taipei) |
| 15. Korea (Seoul) |                    |



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Table C-1. US Tactical Vehicles Sold to Foreign Countries  
(Countries That Purchased Vehicles) (Cent)

---

M809 Series

Truck, Cargo, 5-Ton 6 x 6

1. Australia	15. Lebanon
2. Brazil	16. Liberia
3. Cambodia	17. Morocco
4. Canada	18. New Zealand
5. Chile	19. Philippines
6. Colombia	20. Pakistan
7. Egypt	21. Portugal
8. Ethiopia	22. Saudi Arabia
9. Iran	23. Singapore
10. Israel	24. Thailand
11. Jordan	25. Tunisia
12. Korea (Seoul)	26. Turkey
13. Kuwait	27. Yemen
14. Laos	28. Zaire

M39 Sereis

Truck, Cargo, 5-Ton, 6 x 6

1. Argentina	19. Jordan
2. Austria	20. Korea (Seoul)
3. Belgium	21. Kuwait
4. Bolivia	22. Lebanon
5. Brazil	23. Liberia
6. Burma	24. Libya
7. Colombia	25. Morocco
8. Denmark	26. Netherlands
9. Ecuador	27. Nicaragua
10. Ethiopia	28. Norway
11. Germany	29. Pakistan
12. Greece	30. Paraguay
13. Guatemala	31. Peru
14. Honduras	32. Philippines
15. Indonesia	33. Spain
16. Iran	34. Turkey
17. Israel	35. China (Taipei)
18. Italy	36. Vietnam

M911 Series

Truck, Tractor, Heavy Equipment Transporter, Commercial (C-HET)

1. Sudan	3. Yemen
2. Thailand	

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## Section III. EXPENDABLE SUPPLIES

## C-3. GENERAL

a. This appendix lists items recommended for the support of combat vehicles in a combat environment. The list includes expendable supplies and materials which may be used to expedite BDAR repairs in a combat situation. The items listed may be required for battlefield damage assessment and repair at maintenance levels from crew through DS.

b. The column marked Level indicates the maintenance level at which it is recommended these items be stocked or carried. The unit commander may modify the items in the list and the maintenance levels carrying the items, based on current mission requirements and recent operational experience. The items marked C (Crew) are recommended to be carried on the vehicle for use in combat emergencies at the discretion of the unit commander. Those items marked MT are recommended to be carried by each Battlefield Damage Assessment and Repair maintenance team (MT). Some of these items may already be available at organizational maintenance; however, additional items will be required to stock each MT. Those items marked O are recommended to be stocked at organizational level, and those marked MST are recommended to be carried by the DS maintenance support team (MST).

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## EXPENDABLE SUPPLIES

ITEM NUMBER	LEVEL	NSN	DESCRIPTION	U/I
1	0	8040-00-831-3403	Adhesive, epoxy, 1 pt	kt
2	0	8040-00-828-7385	Adhesive/Sealant, silicone rubber, GE RTV 103	tu
3	0	8040-00-738-6429	Adhesive, epoxy	kt
4	MT	3030-00-224-8358	Belt, V, adjustable link, A size 1/2 in. width	ft
5	MT	3030-00-233-9126	Belt, V, adjustable link, B size 3/4 in. width	ft
6	MT	5999-00-661-0416	Cap, electrical: crimp style	pk
7	C	8030-00-159-5032	Cement, epoxy, Devcon F-2	kt
8	C	4730-00-289-5909	Clamp, hose: 3/8 to 1 in.	ea
9	C	4730-00-908-3193	Clamp, hose: 1-1/16 to 2 in.	ea
10	C	5350-00-192-5047	Cloth, abrasive: al-oxide 1/0 9 in. w, 11 in. lg (50 sheets)	pk
11	MT	5315-00-598-5916	Cotter pin assortment	at
12	MT	5940-00-296-5326	Ferrule, electrical: wristlock type, 22-14 wire size (10 in pkg)	pk
13	0	5330-00-291-1605	Gasket, cork, 1/32 in.	sh
14	0	5330-00-171-9134	Gasket, cork, 3/16 in.	sh
15	C	5330-00-467-3615	Gasket material, 1/32 in. (w. e.g. resistant)	sh
16	C	5330-00-223-5845	Gasket material, 1/64 in. (w. e.g. resistant)	sh
17	0	5330-00-467-3615	Gasket. material, 1/32 in. (w.o.g. resistant)	sh
18	0	4720-00-623-9178	Hose, nonmetallic, 1/4 in. inside diameter	ft
19	0	4720-00-169-5112	Hose, nonmetallic, 1/2 in. inside diameter	ft

## EXPENDABLE SUPPLIES (CONT)

ITEM NUMBER	LEVEL	NSN	DESCRIPTION	U/I
20	0	4720-00-288-9873	Hose, nonmetallic, 3/4 in. inside diameter	f t
21	0	8010-00-515-2487	Lacquer, insulating, electrical	p t
22	0	5310-00-297-3751	Nut assortment	a t
23	MT	5330-00-966-8657	Packing assortment (O-rings)	ea
24	0	9650-00-264-5050	Pig lead, 5 lb	l b
25	0	5410-00-793-2021	Repair kit, electronic equipment shelter (fiberglass)	ea
26	C	4020-00-968-1352	Rope, polypropylene (600-ft roll)	r l
27	MT	5320-01-004-0238	Rivet, pop, steel, SB4-2, 1/8 in. dia, 1/8 in. lg ( quantity 100)	hd
28	MT	5320-01-028-6621	Rivet, pop, steel, SB4-4, 1/4 in. dia, 1/4 in. lg (quantity 50)	bx
29	MT	5320-00-510-7823	Rivet, pop, aluminum, AB4-2A, 1/8 in. dia, 1/8 in. lg	ea
30	MT	5320-00-408-6073	Rivet, pop, aluminum, AB6-2A, 3/16 in. dia, 1/8 in. lg	hd
31	MT	8030-00-656-1426	Sealing compound, gasket, non-hardening	p t
32	0	5335-00-054-5273	Screen, wire mesh, 60 in. X 150 ft	r l
33	0	8030-00-935-1083	Sealant, asphalt base, 8-lb	cn
34	0	8030-00-965-2004	Sealant, synthetic rubber, 1 pt	k t
35	0	8030-00-881-5238	Sealant and puttying compound kit: kit no. 3 qt	k t
36	MT	5305-00-275-4073	Setscrew assortment	a t
37	MT	5940-00-840-0139	Splice, conductor: crimp style, wire size 10	ea
38	MT	5940-00-500-8723	Splice, conductor: crimp style, wire size 10	ea
39	C	5975-00-451-5001	Strap, tiedown (nylon)	hd

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## EXPENDABLE SUPPLIES (CONT)

ITEM NUMBER	LEVEL	NSN	DESCRIPTION	U/I
40	MT	5820-00-783-9035	Strap, clamp, perforated	f t
41	C	9905-000-537-8957	Tag, blank, white	bd
42	C	8030-00-889-3535	Tape, anti seizing pipe plug, Teflon 1/2 in. wide	ea
43	MT	5970-00-543-1005	Tape, electrical	r l
44	C	7510-00-802-8311	Tape, filament-reinforced: 3/4 in., 50 yd roll	r l
45	MT	5940-00-813-0698	Terminal, lug: crimp style, stud sz 6, wire sz 22-18	ea
46	MT	5940-00-577-3711	Terminal, lug: crimp style, stud sz 10, wire sz 16-14	hd
47	MT	5940-00-283-5280	Terminal, lug: crimp style, stud sz 6, wire sz 16-14	ea
48	MT	5940-00-143-4780	Terminal, lug: crimp style, stud sz 10, wire sz 16-14	ea
49	MT	5940-00-143-4794	Terminal, lug: crimp style, stud sz 10, unspec	ea
50	MT	5940-00-804-9185	Terminal, quick disconnect, wire sz 18	pk
51	MT	5940-00-804-9184	Terminal, quick disconnect, wire sz 14-16	pr
52	MT	5970-00-815-1295	Tubing, shrink, 1/4 in.	f t
53	MT	5970-00-812-2967	Tubing, shrink, 1 in.	f t
54	MT	5970-00-812-2968	Tubing, shrink, 1/6 in.	f t
55	MT	5970-00-812-2969	Tubing, shrink, 1/8 in.	f t
56	MT	5310-00-209-2312	Washer, lock, assortment	at
57	MT	5310-00-275-4290	Washer, flat, assortment	at
58	C	6145-00-152-6499	Wire, wire sz 14	f t
59	C	6145-00-435-8613	Wire, wire sz 18	f t
60	MT	5315-00-271-4251	Woodruff key assortment	at

## APPENDIX D POL SUBSTITUTES

BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.

### Section I. GENERAL

#### D-1. GENERAL

a. POL products available within the US and NATO military supply systems, commercial products, and captured products may be acceptable substitutes for POL shortages. Some POL will be destructive if used. This appendix provides tables on how to blend or mix good fuels with poor or nonfuels to increase the available quantity of fuel. This appendix also presents information on lubricants and hydraulic fluids. The tables divide POL products into three categories as follows:

- (1) Primary. The correct product for the system.
- (2) Alternate. A product that closely matches the primary but will result in reduced performance. Using the alternate POL will have no effect of the durability of the system. There are no restrictions on the duration of use.
- (3) Emergency or Expedient. A product that can be used for a short period of time only. These products are a last resort only and will result in a significant reduction in performance and in serious harm to the system with continued use.

b. POL products are usually identified by NSNs or part numbers which identify the product; however, specification numbers and product names may also be a means of identifying the product. Guidance provided is keyed to specification numbers, product names, application (automotive, aviation, marine), and the type of user (military, commercial, and foreign).

c. NATO products can usually be assumed to be direct replacements for US military products, but there are some products which do not meet the same user applications. The American Society of Testing and Measurements (ASTM) specifications relate to commercial products found in the US.

d. This section will list a few elementary characteristics of importance, although you will have no means of measuring or predicting them. You can use the basic fuels, as provided, in order of priority. It will tell you how to mix one or more fluids to produce a usable fuel and finally tell how to remove or flush a fuel from the system.

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e. Table D-1 identifies fuels or products that can be used as fuels. One of the best means to increase the available fuel is to use potential substitutes as extenders by mixing them with the primary fuels and not using them as the sole fuel source. This allows some products which could not ordinarily be burned (or pumped) to be used by diluting them. Because of the dangers of varying combustibility of fuels, increased by vaporization during filling, the blending process is very important. The most direct and expedient procedure to mix fuels is to add the two fuels at the same time from two separate fuel lines. If added directly to the vehicle fuel tanks as separate fuels there is not sufficient turbulence in filling or shaking by normal driving to provide a properly mixed fuel. In vehicles with more than one tank, you could end up with a distinct fuel type in each tank.

## D-2. FUEL BLENDING.

a. In following the blending procedure, it must be remembered that the basic fuel is the better of the two fuels and the extender is the poorer. The blending fuel is the extender. While you can use up to 50 percent (half and half) of the extender you should not use more than is needed to obtain the supply needed. Also, ensure a fuel tank or container is available to hold the quantity of fuel needed to perform the mixing operation.

b. The preferred location to accomplish blending is at a fuel dispensing site or in fuel dispensing vehicles that utilize their own pumps. The least desirable is using the vehicle's fuel tanks. Blending in vehicle fuel tanks should only be done as a last resort because it is imprecise and time consuming.

( 1 ) Blending in Fuel Dispensing Vehicles. Add the blending fuel to the fuel tank and mix by connecting the pump inlet hose to the vehicle and recirculating the fuel for a minimum of 15 minutes.

(2) Blending in 55-Gallon Drums. Add the blending fuel directly into a drum and mix by rolling the drum.

(3) Blending in Gravity Feed Tanks (Stationary) not Equipped With Fuel Transfer Pumps. Blending fuel can be added manually or by using the pump and meter of a fuel dispensing vehicle. Add the blending fuel and mix by recirculating from the tank outlet to the tank truck pump inlet.

### NOTE

Blending in the fuel tanks of using equipment and vehicles should be undertaken only as a last resort. Add both fuels to the fuel tank at the same time with dual nozzles, or from fuel cans.

c. If expedient fuels are not used completely during the operation, they should be drained or pumped out. Fill the vehicle fuel tanks with 10 to 15 gallons of an approved primary fuel and operate the engine for at least 1/2 hour. Operate the engine under a load or drive the vehicle a sufficient distance to bring the engine up to operating temperature.

### D-3. LUBRICANTS AND HYDRAULIC FLUIDS

a. This section lists a few elementary characteristics of importance, although there are no expedient means of measuring or predicting them. A list of basic fluids which can be used is provided in order of priority. Cautions on incompatible fluids are mentioned and a means suggested to flush the system.

Table D-2 provides a list of basic fluids which can be used as substitutes (alternate and expedient). It is structured around the vehicle lube order. Alternate products shown are NATO equivalents to the US specifications and can really be considered as primary fluids. There are no corresponding ASTM designators. The expedients are emergency only substitutions. They may cause three problems, either individually or in combination.

(1) They may not allow proper or efficient operations because of improper viscosity.

(2) They may cause high wear rate because of improper viscosity.

(3) They may cause seal damage or create deposits because of improper chemical composition.

c. There are no established time constraints on these expedients, but the shorter the time used the better.

### D-4. FLUSHING LUBRICANT AND HYDRAULIC SYSTEMS

a. Expedient lubricant and hydraulic fluids must be removed as soon as possible, and the system cleaned and inspected.

b. For those systems using oils, flushing involves draining; filling with the proper product; operating to ensure complete circulation and, when possible, stable operating temperature (this usually means at least 1/2 hour); a redrain; and fill. For the transmission and hydraulic system, a second period of operations and a third drain and refill are needed. Installation of new filters is desirable. Filters must as a minimum be removed and cleaned. Operate without filters only as a last resort. While systems should not be disassembled to inspect seals, maintenance organizations would be prepared to replace seals that show signs of leaking. Organizations must observe seals on these systems during subsequent operations.

c. For systems using grease, it is normally necessary to disassemble the system and wash the parts, especially the bearings, in a suitable solvent. The parts are then wiped dry, inspected for wear and pitting, replaced if needed, and packed with the proper product.



## Section II. Tables

Table D-1. Fuels and Substitute Fuels  
(Listed in Order of Priority)

---

Primary Fuels

1. VV-F-800 (Diesel Fuels) (DF-1, DF-2, DF-A)
2. NATO-F-54 (Diesel Fuel, Military)
3. ASTM-D-975 (Automotive Diesel) (I-D & 2-D)
4. NATO - 58 (Kerosene)
5. ASTM-D3699 (Kerosene)
6. Any blend of the above

Alternate Fuels

1. MIL-T-5624 (Aviation Turbine Fuel) (JP-4 & JP-5)\*
2. NATO-F-40 (Aviation Turbine Fuel)
3. ASTM-D-1655 (Aviation Turbine Fuel) (Jet B)
4. NATO-F-44 (Aviation Turbine Fuel)
5. MIL-T-83133 (Aviation Turbine Fuel) (JP-4)
6. NATO-F-34 (Aviation Turbine Fuel)
7. ASTM-D-1655 (Aviation Turbine Fuel ) (Jet A-1)
8. ASTM-D-2880 (Turbine Fuel) (0-GT, 1-GT, 2-GT, 3-GT, 4-GT)
9. MIL-F-16884 (Marine Diesel) (DFM)
10. NATO-F-76 (Navy Distillate Fuel)
11. MIL-F-815 (Navy Distillate Fuel) (F0-1 & F0-2)
12. NATO-F-75 (Navy Distillate Fuel) (Low Pour Point)
13. ASTM-D-396 (Fuel Oil ) (No. 1 & 2)

With Fuel Extenders (Blends up to half and half - 50 percent extender)

<u>Base</u>	<u>Extender</u>
14. Any primary fuel	Any alternate fuel
15. Any alternate fuel	Any alternate fuel
16. MIL-F-815	Any lighter primary or alternate fuel
17. NATO-F-76	Any lighter primary or alternate fuel
18. Any diesel fuel	PD-680 (Type I & II) (Drycleaning Solvent)
	ASTM-D-484 (K, I, II, III, IV) (D.C.S.)
	ASTM-D-235 (I thru IV) (Pet. Spirits)

\*Better than a 50 percent chance these will have acceptable cetane.

Table D-1. Fuels and Substitute Fuels (Cont)

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Expedient (Emergency) Fuel

Blends with other fuels or extenders (Note blend rates stated.)

<u>Base</u>	<u>Extender</u>
1. Any primary fuel	Any gasoline - up to 50%
2. Any alternate fuel	Any gasoline II - up to 25%
3. Any primary fuel	New engine oil - up to 50%
4. Any alternate fuel	New engine oil - up to 75%
5. Any primary fuel	Used engine oil
6. Any alternate fuel	Used engine oil
	Strained and filtered through charcoal or cloth. Any significant quantity of water must be removed.
1. MIL-G-3056 (Motor Gasoline) (Combat)	
2. NATO-F-46 (Auto Gasoline) (91 RON) (Military)	
3. NATO-F-49 (Auto Gasoline) (95 RON) (Military)	
4. NATO-F-50 (Auto Gasoline) (91 RON)	
5. VV-G-1690 (Auto Gasoline)	
6. ASTM-D-439 (Auto Gasoline) (Any Grade)	
7. MIL-G-53006 (Auto Gasoline)	
8. MIL-G-5572 (Aviation Gasoline) (100/130)	
9. NATO-F-18 (Aviation Gasoline) (100/130)	
10. ASTM-D-910 (Aviation Gasoline) (100)	
11. MIL-G-5572 (Aviation Gasoline) (115/145)	
12. NATO-F-22 (Aviation Gasoline) (115/145)	

---

Table D-2. Engine Oil Substitutes

Ambient temp range	Lube	MIL-SPEC	NATO equivalent	Acceptable products	Emergency substitute	Last resort
4 to -54°C 40 to -65°F	Oil Engine Arctic	MIL-L-46167	0-183	Soviet M6V, M6A, AS-3, AS-4, AS-5, AS-6		Automatic transmission fluid, tur- bine oil, cooking oil, gear lube diluted with diesel fuel, or any light oil
5 to -15°C 40 to 50°F	Oil Engine HD0-10W	MIL-L2104	0-237	Soviet M10V, M10A, AS-10	Aug 10W to 50 oil	
30 to -10°C 90 to 15°F	Oil Engine	MIL-L-2104	0-238	Soviet M-8A, M8V		
Above 30°C to 0°C Above 90°F to 30°F	Oil Engine HD0-40	MIL-L-2104	0-239	Soviet M8G1, M1091		
Above 30°C to -15°C Above 90°F to 5°F	Oil Engine HD0- 15W-40	MIL-L-2104				

Table D-3. Military and Commercial Automatic Transmission Fluid (ATF) Substitutes

The selection of an automatic transmission fluid for use in administrative fleet vehicles should be in accordance with the vehicle manufacturer's recommendation. The automatic transmission of General Motors Corporation's, Chrysler's, and American Motors Corporation's vehicles require the use of a transmission fluid that contains special friction modifying agents. In these vehicles, transmission fluids qualified under General Motor's DEXRON or DEXRON II specification should be used. Ford transmissions, however, have unique frictional requirements and therefore require the use of fluids corresponding to the Ford Type F specification. The Ford Type F fluid is not interchangeable with the DEXRON or DEXRON II fluids. Mixing of these two fluids will result in degraded transmission operation. Some Ford vehicles ( 1977 and later) are using ESP-M2C138-CJ fluid which is compatible with DEXRON II. Check the vehicle manufacturer's recommendation before any change in the transmission fluid is made.

Table D-3. Military and Commercial Automatic Transmission Fluid (ATF) Substitutes (Cent)

Lube	MIL-SPEC	NATO equivalent	Acceptable products	Emergency substitute	Last Resort for all Lubes
Engine Oil HD0-10	MIL-L-2104	3-6P-304	0EA-10 DEXRON DEXRON II	Any 10W to 30W oil	Brake fluid, turbine oil  Hydraulic fluid  Diesel fuel, cooking oil, or water

Table D-4. Gear Oil Substitutions

Reference rank	Alternate fluid	Grade	Nato equivalent	Viscosity related to basic fluid
Basic Fluid	MIL-L-2105	75W 80W/90 80/140	0-186 0-226 0-228	Same
1	VV-L-751	1 2 3	0-199 0-203 0-203	Lower
2	MIL-L-2104	30 50	0-238 0-239	Lower
3	MIL-L-21260	30 50	C-642 C-644	Lower
4	VV-L-765	80 90 140	NR NR NR	Same
5	MIL-L-46152	20W/40	NR	Lower
6	MIL-L-23699		0-156	Lower
7	MIL-L-7808	NR	0-148	Lower
8	MIL-L-9000	NR	0-278	Lower
9	MIL-L-46167	5W/20	0-183	Lower

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Table D-5. Hydraulic Fluid Substitutions

Preference rank	Alternate fluid	Seal compatibility	Viscosity related To basic fluid
Basic Fluid	MIL-L-2104C	Compatible	Same
1	SAE 10 motor oil	Compatible	Same
2	Dextron II	Compatible	Lower
3	MIL-L-46167 (OEA)	Compatible	Lower
4	MIL-L-2104C (OE/HDO-30)	Compatible	Higher
5	MIL-H-56170A	Compatible	Lower
6	MIL-H-6083B	Compatible	Lower
7	MIL-H-5606B	Compatible	Lower
8	MIL-L-23699A (Turbine Oil )	Moderate	Lower
9	MIL-L-7808A MIL-L-7808G (Turbine Oil )	Moderate	Lower
10	Ethylene Glycol (Anti-freeze)	Compatible	Lower
11	Ethylene Glycol and Water, 50-50 mix	Compatible	Lower
12	Water	Compatible	Lower
13	Diesel Fuel	Compatible	Lower

## APPENDIX E

## BDAR FIXES AUTHORIZED FOR TRAINING

BDAR TRAINING FIXES SHALL BE  
USED ONLY AT THE DISCRETION OF THE COMMANDER  
DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE  
PROCEDURES AS SOON AS PRACTICABLE

REPAIR PROCEDURE

## PARAGRAPH NO.

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REPAIR PROCEDURE

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By Order of the Secretary of the Army:

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## THE METRIC SYSTEM AND EQUIVALENTS

### LENGTH MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches  
 1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches  
 1 Kilometer = 1000 Meters = 0.621 Miles

### WEIGHTS

1 Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces  
 1 Kilogram = 1000 Grams = 2.2 lb.  
 1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

### LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces  
 1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

### SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches  
 1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet  
 1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

### CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches  
 1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

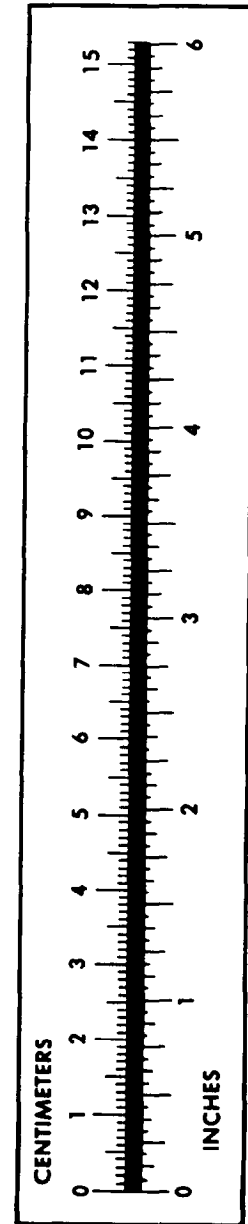
### TEMPERATURE

$5/9(^{\circ}\text{F} - 32) = ^{\circ}\text{C}$   
 212° Fahrenheit is equivalent to 100° Celsius  
 90° Fahrenheit is equivalent to 32.2° Celsius  
 32° Fahrenheit is equivalent to 0° Celsius  
 $9/5^{\circ}\text{C} + 32 = ^{\circ}\text{F}$

### APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches .....	Centimeters .....	2.540
Feet .....	Meters .....	0.305
Yards .....	Meters .....	0.914
Miles .....	Kilometers .....	1.609
Square Inches .....	Square Centimeters .....	6.451
Square Feet .....	Square Meters .....	0.093
Square Yards .....	Square Meters .....	0.836
Square Miles .....	Square Kilometers .....	2.590
Acres .....	Square Hectometers .....	0.405
Cubic Feet .....	Cubic Meters .....	0.028
Cubic Yards .....	Cubic Meters .....	0.765
Fluid Ounces .....	Milliliters .....	29.573
its .....	Liters .....	0.473
arts .....	Liters .....	0.946
allons .....	Liters .....	3.785
Ounces .....	Grams .....	28.349
Pounds .....	Kilograms .....	0.454
Short Tons .....	Metric Tons .....	0.907
Pound-Feet .....	Newton-Meters .....	1.356
Pounds per Square Inch .....	Kilopascals .....	6.895
Miles per Gallon .....	Kilometers per Liter .....	0.425
Miles per Hour .....	Kilometers per Hour .....	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters .....	Inches .....	0.394
Meters .....	Feet .....	3.280
Meters .....	Yards .....	1.094
Kilometers .....	Miles .....	0.621
Square Centimeters .....	Square Inches .....	0.155
Square Meters .....	Square Feet .....	10.764
Square Meters .....	Square Yards .....	1.196
Square Kilometers .....	Square Miles .....	0.386
Square Hectometers .....	Acres .....	2.471
Cubic Meters .....	Cubic Feet .....	35.315
Cubic Meters .....	Cubic Yards .....	1.308
Milliliters .....	Fluid Ounces .....	0.034
Liters .....	Pints .....	2.113
Liters .....	Quarts .....	1.057
ers .....	Gallons .....	0.264
ms .....	Ounces .....	0.035
ograms .....	Pounds .....	2.205
Metric Tons .....	Short Tons .....	1.102
Newton-Meters .....	Pounds-Feet .....	0.738
Kilopascals .....	Pounds per Square Inch .....	0.145
ometers per Liter .....	Miles per Gallon .....	2.354
ometers per Hour .....	Miles per Hour .....	0.621



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