TECHNICAL MANUAL

BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR

FOR

POL

EQUIPMENT

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HEADQUARTERS, DEPARTMENT OF THE ARMY

23 JUNE 1989

CHANGE

NO. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 26 FEBRUARY 1991

BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR FOR POL EQUIPMENT

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TM 5-3835-222-BD, 23 June 1989, is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages	Insert pages
3-7 through 3-10	3-7 through 3-10
4-3 through 4-6	4-3 through 4-6
5-1 and 5-2	5-1 and 5-2
5-9 and 5-10	5-9 and 5-10
6-5 and 6-6	6-5 and 6-6
8-7 and 8-8	8-7 and 8-8
8-23 and 8-24	8-23 and 8-24
8-27 and 8-28	8-27 and 8-28
C-1 and C-2	C-1 and C-2

2. Retain this sheet in front of manual for reference purposes.

By Order of the Secretary of the Army:

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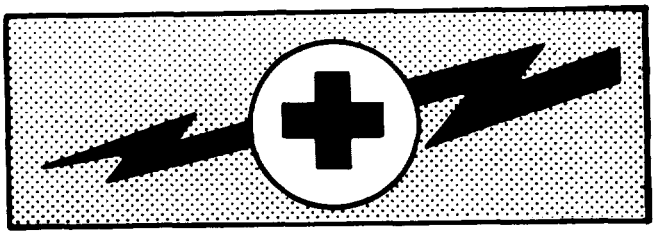
WARNING PAGE



W A R N I N G

H I G H V O L T A G E

is used in the operation of this equipment.

D E A T H O N C O N T A C T

may result if personnel fail to observe safety precautions.

Never work on electronic equipment unless there is another persons nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When the technician is aided by operators, he must warn them about dangerous areas.

Be careful not to contact high voltage connections of 115-volt ac input connections when installing or operating this equipment.

Whenever the nature of the operation permits, keep one hand away from the equipment as to reduce the hazard of current flowing through vital organs of the body.

WARNING

Do not be misled by the term "low voltage". Potentials as low as 50 volts may cause death under adverse conditions.

For Artifical Respiration, refer to FM 21-11.

WARNING

Drycleaning solvent, P-D-680, is used to clean parts is potentially dangerous to personnel and property. Avoid repeated and prolonged skin contact by wearing rubber or nonporous gloves when handling the solvent or wet material with drycleaning solvent. Wash hands immediately after exposure with soap and water and use a lanolin based skin cream to prevent skin drying. Do not use near open flame or excessive heat. Flash point of solvent is 100°F (38°C). Do not work with solvent in a closed room. Be sure there is good ventilation or the solvent vapors will build up in the air and become a poisonous mixture which can cause physical injury or even death.

WARNING

Extremely high pressure can occur during and after operation of certain equipment. If this pressure is not relieved before working on this equipment, serious injury or death may occur. Be sure to open all drains and vents before beginning any disassembly.

WARNING

Lifting or moving heavy equipment incorrectly can cause serious injury. Do not try to lift or move more than 50 pounds by yourself. Get an assistant. Bend legs while lifting. Do not support heavy weight with your back.

WARNING

Compressed air can blow dust into the eyes. Wear eye protection. Do not exceed 30 psig air pressure.

WARNING

Prolonged contact with liquid or mist can irritate eyes and skin. After any prolonged contact with skin, immediately wash contacted area with soap and water. If liquid contacts eyes, flush immediately with clear water. If liquid is swallowed, do not induce vomiting, get immediate medical attention. Wear rubber gloves when handling liquid. If prolonged contact with mist is likely, wear an appropriate respirator. When fluid is decomposed by heating, toxic gases are released.

WARNING

Dry ice is solid CO_2 at a temperature below -80°C (-112°F); it can burn. Wear temperature-resistant apron and gloves. CO_2 displaces oxygen; work in a well-ventilated area to avoid asphyxiation.

WARNING

Compressed air in airbrake system can blow dust into eyes. Do not work on airbrake system until air pressure is released. Wear eye protection. Open draincock on air reservoir slowly to avoid a sudden rush of air when releasing air pressure from airbrake system.

WARNING

Always use assistants during lifting operations. Use guide ropes to move hanging assemblies. Lack of attention or being in an improper position during lifting operations can result in serious injury or death. Pay close attention to movements of assemblies being lifted. Do not stand under lifted assembly or in a position where you could be pinned against another object. Watch your footing.

WARNING

Fuel line and tank repairs often involve handling of highly inflammable material. Mishandling can result in serious injury or death.

TECHNICAL MANUAL
NO. 5-3835-222-BD

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 23 June 1989

Technical Manual

for

BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR
FOR POL EQUIPMENT

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REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 to: Commander, U.S. Army Troop Support Command, ATTN: AMSTR-MCTS, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. A reply will be furnished directly to you.

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HOW TO USE THIS MANUAL

This manual is designed to help you accomplish your mission when your POL (Petroleum, Oil and Lubrication) equipment has sustained battlefield damage or is malfunctioning for any other reason during a combat situation.

Instructions are given in this manual for assessing damage to the POL equipment so that a decision can be made to continue operation without repair, to repair by replacement of parts from other or similar POL equipment, or to repair by means of the expedient procedures given in this manual.

If the decision to repair is made, this manual covers repairs for damage to POL equipment. A repair procedure index in the beginning of the chapter provides a quick locator for the paragraphs that cover repair for various types of damage. For each repair procedure, the manual gives the effect on performance of the repair, the estimated time required to make the repair, materials and tools required, and other options available to accomplish the repair or accomplish the mission without repair. Alternate procedures are provided, if applicable, to accomplish repair depending on materials available and the local situation.

CHAPTER I

GENERAL INFORMATION

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

1-1. Purpose.

a. This technical manual (TM) is for use by operators, unit and direct support/general support maintenance personnel. It provides procedures and guidelines for battlefield repairs on Petroleum, Oil and Lubrication (POL) and water distribution equipment under the forward support maintenance concept during combat.

b. The purpose of Battlefield Damage Assessment and Repair (BDAR) is to rapidly return disabled POL equipment to the operational commander by expediently fixing, by-passing, or jury-rigging components to restore the minimum essential systems required for the support of the specific combat mission or to enable the equipment 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 POL or water distribution equipment. Expedient repairs applicable to systems or sub-systems of a specific item are covered in system specific TM's.

b. Some POL equipment may require a vehicle for transportation. Many expedient repairtechniques 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. All possible types of combat damage and failure modes cannot be predicted nor are all effective field expedient repairs known. This TM provides guidelines for assessing and repairing battlefield failures of POL equipment and water distribution 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 rapidly repair equipment in a combat crisis.

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 a battlefield environment. Standard maintenance procedures will provide the most effective means of returning a damaged item to ready status provided that adequate time, replacement parts, and necessary tools are available. BDAR procedures. are only authorized for use 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. If full functional capacity can be restored expediently with a limited expenditure of time and assets, this should be done.

c. Some of the special techniques in this manual, if applied, may result in shortened life or damage to components of the equipment. The Commander must decide whether the risk of having one less item 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. The following terms specific to BDAR are used in this TM.

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

b. Repair Procedures. The term "repair" or "fix" in this manual includes any expedient action that returns a damaged part or assembly to a full or an acceptable degraded operating condition including:

(1) Short cuts in parts removal or installation.

(2) Installation of components from other POL equipment that can be modified to fit or interchange with components on the equipment.

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

(4) Bypassing of non-critical 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. "Damage assessment" is a procedure to rapidly determine what is damaged, whether it is repairable, what assets are required to make the repair, who can do the repair (i.e., unit or direct or general support) 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. Fully Mission Capable. The term "fully mission capable" (FMC) means that the equipment meets the minimum functional combat capability (MFCC) requirements. Refer to system specific TM's for each item's specific MFCC.

e. Combat Capable. The term "combat capable" means that the equipment meets the minimum functional combat capability requirements.

f. Combat Emergency Capable. The term "combat emergency capable" means that the equipment meets the needs for the specific mission; however, all systems are not functional. Also, additional damage due to the nature of an expedient repair may occur to the equipment if it is used. The Commander must decide if these limitations are acceptable for that specific emergency situation.

g. Cannibalization. The term "cannibalization", as used in this TM, means any use of repair parts or components obtained from another equipment, either damaged or of lower priority, to the immediate mission. In this TM, the term is used to include controlled exchange.

h. Equipment Triage. The term "equipment triage" means a system of deciding in which order battlefield damaged equipment will receive repair, according to time, urgency, material, and personnel required to accomplish the repair.

1-5. Quality Deficiency Report/Equipment Improvement Recommendations (QDR/EIR).

If your POL equipment needs improvement, let us know. Send an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Put in on a SF 368 (Quality Deficiency Report). Mail it to us at: U.S. Army Troop Support Command, AMSTR-QX, 4300 Goodfellow Boulevard, St. Louis, MO, 63120-1798. We will send you a reply.

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 POL equipment which may subject maintenance personnel to imminent danger (such as fuel leaks). It should be stressed that ordinary precautions taken in hazardous occasions should only be waived at the discretion of the Commander.

1-8. Operating Characteristics. Because this manual is directed at a class of equipment, as opposed to an individual system, the appropriate equipment TM should be consulted to determine Minimum Functional Combat Capability (MFCC).

1-9. Training. The Commander should insure that an adequate number of members of his organization, including supervisors, are trained in BDAR procedures applicable to his equipment. Each equipment operator should be trained to perform initial battlefield damage assessment for his crew position. See Appendix E, BDAR Fixes Authorized For Training.

1-10. Environment. BDAR may be required in a chemically toxic environment or under other adverse conditions with severe limitations in personnel, facilities, equipment, and materials. Performance of repair tasks may be necessary while wearing protective gear.

1-11. Permanent Repair. Upon completion of the mission, or at the next practicable opportunity, the equipment will be recovered or evacuated to the appropriated maintenance facility for permanent standard repair as required.

Section III. TASKS AND RESPONSIBILITIES

1-12. General. BDAR 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 equipment to the combat ready condition required for continuation of the mission.

1-13. Commander and Crew.

a. The crew of the damaged equipment will make the first assessment immediately after damage has occurred. Crew members will provide the Commander with an initial damage assessment which will include identifying/tagging and reporting system failure on all major 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 available crew. Immediacy of the report is more important than how long it will take to achieve operability. The initial report, therefore, may omit repair time estimates. An initial out-of-action report to the Commander including these essentials, must be done:

(1) Equipment damaged (out-of-action or impaired).

(2) Location of equipment.

(3) Mobility status (where applicable).

(4) Current and anticipated enemy action (if under hostile fire).

b. Assessment Checks. Assessment checks include looking at the damaged parts, determining what system they belong to, and deciding how they can be expediently repaired to permit immediate operation (full or partial).

c. Safety Check. A safety check should be made for any obvious hazards.

(1) Have any combustibles, such as fuel, hydraulic fluid, or oil, accumulated?

(2) Does wiring appear to be safe? Could arcing occur to stored ammo or leaking combustibles?

d. Functional/Operational Test. A functional/operational test should be performed next on those systems which appear undamaged. For systems with a built-in self-test feature, this will be done. Only those systems found to be damaged or inoperative shall be identified.

e. Commander's BDAR Report. The crew shall report to the Commander the results of the crew's damage assessment, naming the major known causes of the equipment's failure. If repair by crew is possible, they shall report a total estimated repair time and what functions may be restored.

f. Crew Assistance. The Commander will respond with directives and if required, will call Direct Support (DS) to the location of the damaged equipment for assistance. If possible, sufficient information will be provided to enable DS to bring any needed repair parts or special tools.

g. Crew Repairs. The crew shall proceed to make any possible field expedient repairs to restore operability to the limit of their skills, materials, and tools available.

1-14. Unit Maintenance.

a. Unit maintenance members operate out of the company or battalion trains. The assessor performs his assessment and the repairs are completed if possible at the damage site. If the site is within direct fire, or under enemy observation, movement to a more secure site in defilade may be necessary. This is still considered "on-site."

b. If the equipment has been left unattended in the forward battle area, the immediate area of the equipment should be checked for mines, and the equipment checked for booby traps before starting the battle damage assessment. The assessor should also make the safety checks necessary.

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

d. If the damage exceeds the repair capability and time is available for DS on-site fix, DS shall be called.

e. If time for DS on-site fix is not available, but the equipment is repairable, the crew shall provide for recovery of the equipment to a designated collection point.

f. If the equipment is not repairable, the crew 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).

g. If the equipment is contaminated, mark the equipment with contamination markers and arrange for recovery to a decontamination site.

1-16. Direct Support/General Support (DSGS).

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

b. Damaged POL equipment removed to designated repair sites shall be selected for repair by GS in order of:

(1) Most essential to the completion of the mission.

(2) Least amount of repair time.

1-16. 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 elapsed time for all tasks required to restore the equipment. The time available at the selected repair site must equal or exceed the estimated time required to accomplish all tasks associated with the BOAR.

b. Determining where BDAR will take place should be based on the guidelines in Table 1-1. These are general rules which must be adjusted by the Commander based on his best estimate of how the most responsive maintenance support can be provided. He must consider the tactical situation, maintenance backlog, personnel, tools, Test, Measurement, and Diagnostic Equipment (TMDE), and repair parts available. The guidelines are based on a defensive scenario and can be extended when applied to the offense.

Table 1-1. Summary of BDAR Time Guidelines

Location	Elements Performing DBAR	Time Guidelines
Breakdown Site	1. Operator/Crew 2. Direct Support 3. General Support	2 Hours
Battalion Trains	1. Battalion Maintenance Platoon 2. Direct Support 3. General Support	6 Hours
Brigade Support Area	1. Forward Support Maintenance Company 2. Direct Support 3. General Support	24 Hours
Division Support Area	1. Maintenance Battalion 2. General Support	36 Hours
Corps Support	1. General Support	96 Hours

1-17. Recording BDAR Repairs. All BDAR repairs must be recorded and the record properly processed.

a. All components of equipment which are repaired using BDAR, or other expedient techniques, shall be marked with a tag, DD Form 1577, or a similar conspicuous tag. It is not necessary to fill out the form. The purpose of marking an item which has been repaired using BDAR techniques is to quickly enable mechanics to recognize these parts when the equipment is subsequently returned for authorized permanent repair.

(1) Securing the tag. Since it is impractical to attach tags to expediently repaired components located on the outside of the equipment, the fix shall be noted on DD Form 1577 or a similar tag, and the tags will be stored in the compartment normally reserved for the equipment log book

(2) Degraded capability record. A tag should also be placed conspicuously on the equipment control panel when a BDAR procedure has resulted in a degraded operating capability. This tag should be marked “BDAR” and noted with its specific limitations or cautions.

(3) Cannibalization record. When a component is cannibalized from repairable equipment, a tag should be attached in the space created by the missing part to alert downstream repair personnel quickly that the part has been removed.

b. Permanent Repair Records.

(1) Recovery record. When the equipment is recovered/evacuated for permanent standard repair, and DA Forms 2404 and 2407 are used, the notation “BDAR” shall be added in the space provided for description of deficiencies.

(2) Forms disposition. DA PAM 738-750 provides for disposition of DA Form 2404 and copy number 3 of DA Form 2407. When ”BDAR” is noted on these forms, they shall be mailed to: Commander, US Army Troop Support Command, 4300 Goodfellow Boulevard, AMSTR-MES, St. Louis, MO 63120-1798. The information on these forms will provide data for designing POL equipment to be less susceptible to combat damage and easier to repair when damaged.

CHAPTER 2

ASSESSING BATTLEFIELD DAMAGE

BDAR FIZES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

2-1. Scope. This chapter provides guidelines used to assess battlefield. It directs you to an expedient repair procedure, or to the standard system TM if an expedient repair procedure for your problem does not 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 equipment operation. This chapter contains a table designed for POL equipment as a class (Table 2-1). This table will refer the user to the appropriate chapter. Each chapter has a Repair Procedure Index.

2-3. Application. Perform the following steps to find and fix battlefield damages:

a. Do the Preventive Maintenance Checks and Services (PMCS) in the TM and LO. At the same time, look for obvious damage to the equipment.

b. If applicable, do the troubleshooting/repair recommended by the specific TM.

c. If you find the problem, determine its effect of the operation of the equipment.

d. If you cannot fix the problem using the PMCS and procedures in the TM and LO, use Table 2-1 and fix the problem.

e. If the problem does not affect equipment operation, the Commander will decide whether to attempt to fix the problem or continue with the mission.

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

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

(2) Replace the bad part/assembly with a substitute, if one exists.

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

g. After repairing the damaged system, replace all lost fluids and/or lubricants. If the ones specified by LO or TM are not available, refer to Appendix D for a possible substitute.

Section II.

GENERAL FAULT ASSESSMENT TABLE

2-4. This section provides an overall table that refers the user to a specific chapter. In the chapter, there will be a Repair Procedure Index.

Table 2-1. Reference Table.

Engine Problems?	Go to Chapter 4
Fuel Supply System Problems?	Go to Chapter 5
Cooling System Problems?	Go to Chapter 6
Electrical System Problems?	Go to Chapter 7
Hydraulic Problems?	Go to Chapter 8
High Pressure Pipe or Hose Problems?	Go to System Specific TM
Fabric Tank Information?	Go to Fabric Tank TM

For any other problem not described here, refer to the Table of Contents or Index.

2-5. Assessment Process. The assessment procedures are shown in each chapter.

a. Procedure Sequence. All assessment procedures follow the sequence:

(1) visually inspect (repair, if necessary),

(2) functionally test (repair, if necessary), and

(3) assess the performance.

The field fixes will enable the crew to continue operations in some cases, but will usually be most useful for scheduling and accomplishing fix-forward repairs and assessing combat capabilities for reporting to the Commanders.

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

(1) The first assessment is extent and kind of damage, and how it affects equipment operation and capabilities.

(2) The second is whether the damage needs to be repaired.

(3) The third is assessment of where and how to repair the damage.

c. Assessment Levels. Assessments of damage may be made in turn by operator/crew and assessors.

(1) Extent and kind of damage is readily assessable.

(2) Whether or not to repair the damage may be readily assessable. However, whether to attempt repair and when and how to repair the damage may be judgement calls. No procedure can take all possible situations into account. Assessment of whether the damage needs to be repaired will be made by the Mission Commander as the equipment is evaluated for further operation or recovery.

(3) Assessment of where and how to repair the damage will be made with some suggestions by crew/operator. Decision may be redirected or changed.

CHAPTER 3
GENERAL REPAIR

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

3-1. Scope. This chapter describes quick-fix procedures for those items common to engines and functional elements of POL equipment.

3-2. Assessment Procedure. Visually inspect damaged components to determine the extent of damage and repair required.

NOTE

Procedures boxed in this index can be used for training purposes.

3-3. Repair Procedure Index.

Section II. GASKETS

3-4. General. Gaskets may become damaged causing 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. When some metal surfaces are bolted together a compressable 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 fluid leaking does not constitute a fire hazard or does not leak at a rate which will deplete the required lubrication.

Limitations:

- Frequent inspections required.

Personnel/Time Required:

- 1-2 soldiers - 1.0-6.0 hrs.

Materials/Tools:

- Leather
- Card board
- Tool Kit
- Gasket (appendix C, section II, item 13)
- Tape, Teflon (appendix C, section II, item 43)
- Gasket Sealer (Silicone) (appendix C, section II, item 15)
- Permatex (appendix C, section II, item 22)

Procedural Steps:

Option 1: Manufactured gasket.

a. Cut leather, cardboard or other material to fit the mating surfaces.

(1) Hold gasket against mating surface and mark an outline of the component, cut the material with a knife or shears.

(2) Hold material against mating surface. Tap the gasket material with a ballpeen hammer along the edges of the mating surfaces to remove unwanted gasket material.

b. Coat the gasket with a sealing compound.

c. Join components and bolt.

Other Options:

- Continue operation, refilling fluids as required.

Option 2: Used gaskets.

a. Coat mating surface with sealing compound.

b. Place used gasket or sections of broken gasket onto mating surface.

c. Coat other mating surface with gasket sealer.

d. Join components and bolt.

Option 3: Gasket sealer.

a. Remove old gasket material and residue.

b. Coat mating surfaces with silicone gasket sealer.

c. Allow silicone sealer to form a skin (10 to 15 minutes).

4. Joine components and bolt.

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

3-6. Gaskets, Engine. Engine cylinder head gaskets seal both compression and fluid galleries. Leakages 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

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 speeds should be reduced.

Limitations:

- Degraded power output.

Personnel/Time Required:

- 1-2 soldiers - 2.0 - 6.0 hrs.

Materials/Tools:

- Epoxy (appendix C, section II, item 11)
- Wire, Copper (appendix C, section II, item 50)
- Gasket Sealer (Hardening) (appendix C, section II, item 14)

Procedural Steps:

Option 1: Gasket sealer.

a. Remove cylinder head.

b. Locate leaking area.

c. Liberally coat leaking area with hardening gasket sealer.

d. Replace cylinder head, tighten mounting bolts or studs.

e. Check engine operation.

Option 2: Wire and sealer.

a. Remove cylinder head.

b. Remove gasket or O-rings.

c. Lay soft copper wire around each cylinder bore and trim to eliminate any overlap.

d. Reinstall old gasket coated with gasket sealer, varnish or paint.

e. Reinstall cylinder head, tighten mounting bolts or studs.

Other options:

- Continue operations.

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

3-7. Gaskets, Environmental. Inspect for water or foreign matter in compartments or areas that should be sealed. Rubber weatherstripping 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 but may not provide adequate Nuclear Biological & Chemical (NBC) Warfare, protection.

Limitations:

- None.

Personnel/Time Required:

- 1-2 soldiers - 20 - 60 minutes

Materials/Tools:

- Hose, Rubber
- Poncho
- Wire, Copper (appendix C, section II, item 50)
- Weatherstripping, Rubber (appendix C, section II, item 47)
- Inner Tube (appendix C, section II, item 16)
- Adhesive (appendix C, section II, item 1)
- Tarp, Canvas (appendix C, section II, item 44)
- Epoxy (appendix C, section II, item 11)

Procedural Steps:

a. Locate leak, remove component or cover.

b. Remove defective gasket and clean the sealing surfaces.

c. Obtain material to fabricate sealing gasket.

d. Cut gasket to fit.

e. Apply available adhesive, follow instructions on container.

f. Place gasket in proper location.

g. Reinstall component or cover.

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

Section III. BELTS

3-8. General. V-Belts provide direct drive and can be substituted or replaced if the basic factors about each belt is considered. Substitute belts must be wide enough to prevent bottoming in the pulley “V" and of the correct length to maintain tension. Inspect width and length of the belt. Smaller, narrower belts may be substituted or V-belts may be taken from one equipment if there are twin belt drives. Direct equipment-to-equipment removal and installation is a simple method of replacing missing belts.

3-9. V-Belt - Missing or Broken. Some vehicle subsystems are driven by V-belts. Many liquid cooling system coolant pumps and fans for moving air over or through a radiator require V-belts. Worn or frayed V-belts can slip or break causing the system to fail. V-belts can be replaced or substituted to restore system functions. Frequent adjustment may be required for substitute V-belts.

Limitations:

- Degraded output.

Personnel/Time Required:

- 1 soldier - 15 - 60 minutes

Materials/Tools:

- Link V-Belts, Adjustable
- Rope (appendix C, section II, item 26)
- Wire (appendix C, section II item 49)

Procedural Steps:

Option 1:

a. Rope or wire can also be used, but thin wire must be braided to ensure the needed friction is provided.

b. Assemble the rope or wire as close as possible to the original length of the correct belt.

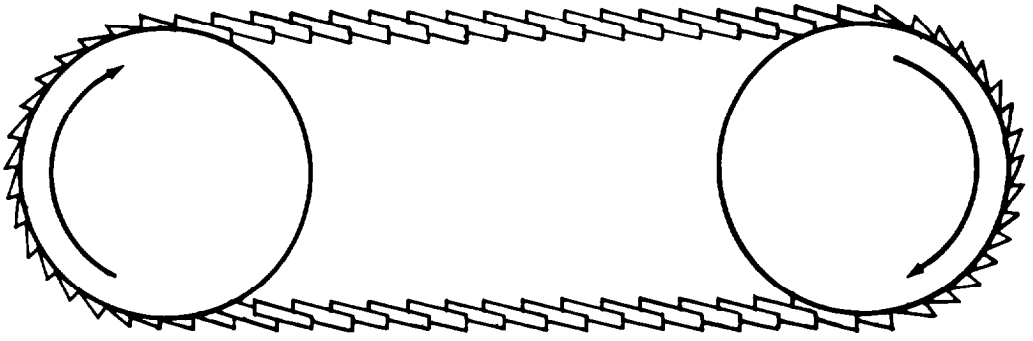
c. Adjust with the tensioner assembly.

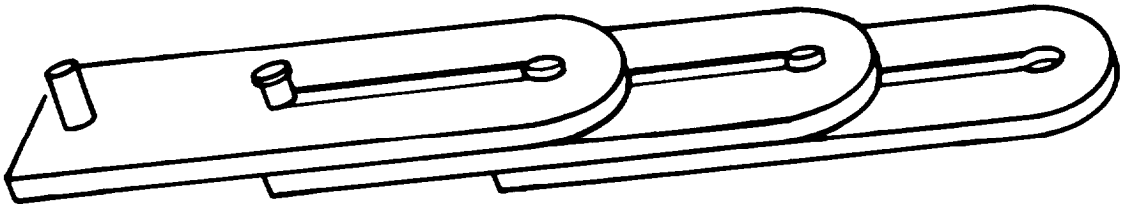
Option 2:

a. Separable-link belts can be used, if available.

b. Assemble the belting as close as possible to the original length of the correct belt and adjust with a vehicle belt tensioner.

c. Install the belt as shown. This prevents undue strain on the belt links.





ADJUSTABLE LINK BELTING, V

SIZE	NSN	U/I
A SIZE	3030-00-224-8358	FT
B BELTING	3030-00-233-9126	FT

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

Section IV. HOUSINGS, CASTINGS, PLATES

3-10. General. Castings or plates may be servicable even with holes or cracks providing the internal 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 of the structure can be allowed, but fatigue failures from crack growth cannot be predicted, and service life will depend on the extent of damage.

3-11. Engine Housing Damage. Small cracks or holes may develop in a cylinder head, block or engine housing, caused by vibrations, overheating, or explosive shocks. 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. Frequent fluid level checks must be performed.

Limitations:

- Degraded output.

Personnel/Time Required:

- 3 soldiers - 2.0 - 24.0 hrs.

Materials/Tools:

- Fiberglass Kit
- Lift
- Sandpaper (appendix C, section II, item 30)
- Epoxy (appendix C, section II, item 11)
- Deleted.
- Deleted.
- Permatex (appendix C, section II, item 22)

Procedural Steps:

Option 1:

a. Remove all paint from around the crack

b. Cover the crack and 1/4 inch or more of the surrounding area with quick-drying epoxy plastic.

c. Allow the epoxy to harden before running an engine. Use heat (heat lamp) to speed up curing of epoxy.

Option 2: Repair of small crack or hole.

a. Remove all paint from around the area where metal plate is to be positioned.

b. Cover the area with a plate from any available metal large enough to cover the crack or hole. Seal the edges of the plate with quick-drying epoxy.

c. Allow epoxy to harden before running engine.

Option 3: Repair of a small crack or hole.

a. Clean damaged area.

b. Fill small crack or holes in low stress area either with permatex, fiberglass, or epoxy.

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

Section V. BRACKETS AND WELDMENTS

3-12. General. Brackets are used on some POL equipment to mount or store items. Brackets are mounted to the item by bolting or welding in place and are subject to damage through vibrations, impact or explosive forces. Repairs must be made to restore the brackets needed for restoring essential equipment functions.

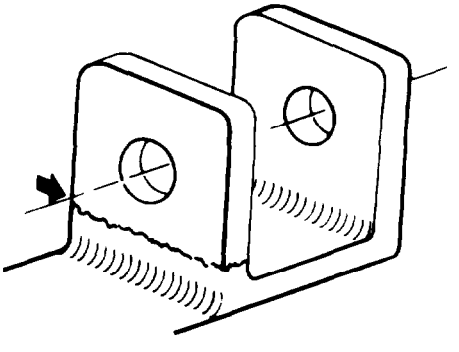
3-13. Bracket Broken. Equipment mounting brackets welded to the frame sometimes will break due to vibrations or collisions with obstacles. Brackets are needed to mount components and devices in locations or positions where they can be used to perform their required functions. Bolted brackets should be remounted using bolts if possible; their removal may be required to gain access to other components.

Personnel/Time Required:

- 2 soldiers - 1.0 hr.

Materials/Tools:

- Welding Equipment
- Cords, Elastic, Bungee (appendix C, section II, item 9)
- Wire, Commo (appendix C, section II, item 49) or Rope (appendix C, section II, item 26)
- Straps, Tiedown (appendix C, section II, item 38)



Procedural Steps:

Option 1: If bracket is broken off at the base metal, with component mounting holes unaffected, reweld in place. Mounting holes may be elongated to compensate for misalignment of attaching items.

Option 2: If the bracket mounting holes cannot be used due to stripped threads, or if broken bolts cannot be removed, weld the bracket to the location.

Option 3: If brackets cannot be welded or bolted, tie the component in place using rope, commo wire, bungee cords or straps.

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

Section VI.

HARDWARE, MECHANICAL LINKAGES, CABLES AND PULLEYS

3-14. General. Various elements of hardware and linkages are used throughout POL equipment to transfer the control actions from the control panel to the components being controlled. Damage can occur to the mounting hardware or the rods, cables, and levers in the mechanical linkage systems. Pins can become lost, linkages can bend or break, which will disable or hamper the equipment operation. This section will give various procedures that may be used to repair or restore needed functions.

3-15. Forcing Mismatched Threading. The proper bolts may not always be available to make repairs. Mismatched bolts can be used to make BDAR repairs, but care must be taken so as not to break bolts by forcing them too far. Coarse threaded bolts may be used in holes with fine threads. Forced threads will not hold as much stress as standard threads, but will provide a limited operational capability.

3-16. Thread Clean-Up. Damaged threads decrease the load bearing capability of bolts. Damaged threads can be repaired or cleaned up using a thread file or a triangular shaped file. The threads must be cleaned to remove any dirt or metal particles which might cause further damage to threaded holes. Use a wire brush and a nail or scribe to remove stuck metal particles. Damaged threads must have burrs removed. Cross-threaded bolts must have the torn metal removed where they connect between threads. Turning a hardened steel nut onto the bolt can help realign damaged threads.

3-17. Hardware Mounting. Brackets and components can be connected or mounted without proper bolts. An iron rod or stud can be inserted through the connecting holes and peened over on each side. The mushroomed ends will keep the components together. A stud can be screwed onto 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 peen the stud end to hold the nut in place. Linkages can also be connected by inserting a rod or bolt and peening the ends to keep it from dropping out of position.

3-18. Push/Pull Rod Damaged. Mechanical linkage rods can bend or break from explosive shock, impact or binding components. Rods can be repaired or improvised to regain usage of the system involved. The cause of breakage must be determined and corrected. Rods or shafts that are bent must be straightened. Place the rod/shaft on a hard flat surface and hit with a hammer to bend it straight. Broken rods/shafts can be splinted using scrap metal.

Limitations:

- Possible degraded output.

Personnel/Time Required:

- 1-2 soldiers - 1.0 - 2.0 hrs.

Materials/Tools Required:

- Welding Equipment
- Drill
- Hacksaw
- Deleted.

Procedural Steps:

Option 1: Welding equipment available.

a. Determine if damaged rod is made of steel or aluminum alloy.

b. Measure rod length between connecting points.

c. Remove rod and weld.

d. Remove all metal fragments which would hinder rod operation.

Option 2: Welding equipment is not available.

a. Cut needed material from bussle rack or hand rails to split rod.

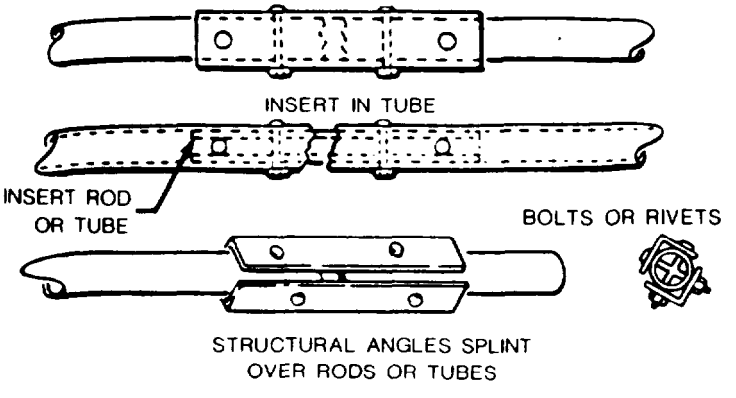
b. Measure rod length and drill holes through reinforcement and rod.

c. Rivet or bolt reinforcement to damaged rod.

Other Options:

- When push/pull rod damage is beyond repair, a substitute may be manufactured from plate stock.

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



3-19. Pully Damaged. When cable pulleys are damaged beyond use, a replacement may be cannibalized from other equipment, or the damaged pulley may be welded or wedged into position. A spacer, bolt and two flat washers can be used as an improved pulley to guide the cable.

3-20. Cable, Mechanical, Broken. 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:

Personnel/Time Required:

- 1 soldier - 1.0 - 2.0 hrs.

Materials/Tools:

- Nicropress Sleeves And Installation Tool Or Cable Clamp
- Vise
- Vise Grips
- Cable (appendix C, section II item 8)

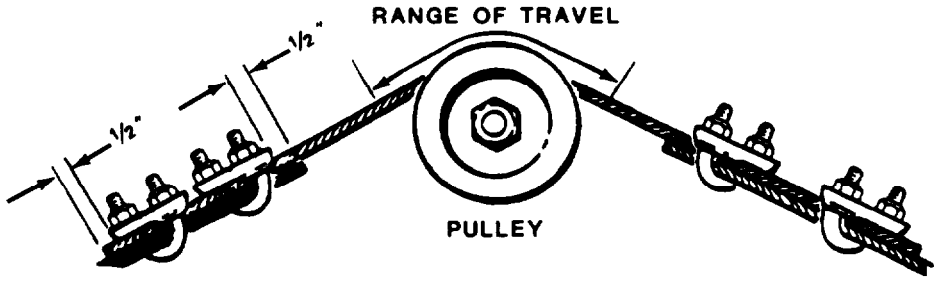
Other Options:

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

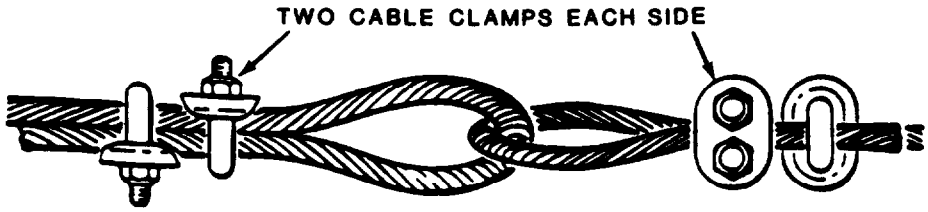
Procedural Steps:

a. Loosen the cable.

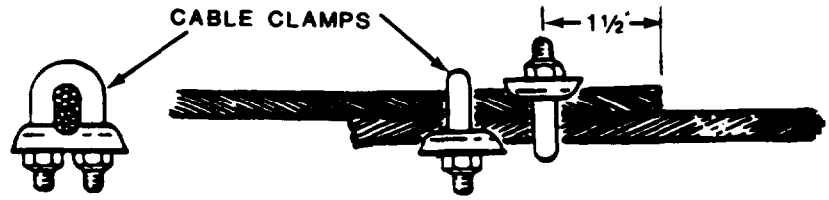
b. Select a length where the cable splices will not restrict the range of cable travel and splice cable using one of the methods shown.



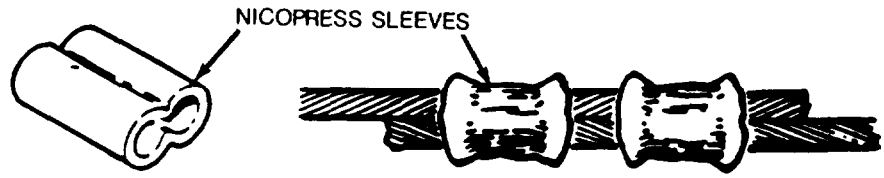
(1) Make a loop at the end of one cable, thread the other cable end through the loop, and make another loop. Secure both loops as shown.



(2) Splice cable with two clamps. The end of the cable should extend at least 1/2 inch beyond the clamp as shown.



(3) Splice the cable with two nicropress sleeves. Swage the sleeves on the cables with installation tool, a vise, or a hammer.



c. Adjust cable to its proper tension.

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

3-21. Pin Alignment, Clevis, Cotter, Dowels, Quick Release, Etc. Most linkages have retainer devices, cotter keys, lacing wire or safety pins to keep the connecting bolts or pins in place. During BDAR repairs, small pins may become lost or forgotten which will cause linkage or component failure. Repairing the equipment by securing connecting bolts or pins can be accomplished using wire, welding rod, bolts or nails. Place the item through the hole and bend the ends to keep it from falling out. Castelated nuts can also be retained using this method. Alignment pins or dowels can be replaced with cut bolts. Use a bolt that is a tight fit in the hole, tap the bolt in and cut to proper length.

CHAPTER 4

ENGINE COMPONENTS

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

4-1. Scope. Engines used with POL equipment can be diesel or gasoline powered. Repair procedures on a diesel engine therefore might not apply to a gasoline engine and vice versa. Engine damage can be detected by several different methods:

a. abnormal oil pressure or temperature readings or warning lights

b. abnormal noises

c. abnormal amounts or coloration of exhaust smoke

d. sudden loss of power or excessive fuel consumption

This chapter gives various expedient fixes which can restore the equipment's output in event of engine system failure.

4-2. Assessment Procedure.

a. Visually Inspect	Damage found to:	
	-Air Intake/Exhaust System	Go To Section III, IV
	-Lubrication	Go To Section V
	-Fuel System	Go To Chapter 5
	-Cooling System	Go To Chapter 6
	-Electrical System	Go To Chapter 7
	-Hydraulic Power Distribution . . .	Go To Chapter 8
b. Attempt To Start	Will not start:	
	Check Air/Intake /Exhaust System	Go To Section III, IV
	-Check Fuel System	Go To Chapter 5
	-Check Electrical Starting System	Go To Chapter 7

c. Observe Operation	Damage Detected When Operating Or System Not Working:
	-Internal Engine Failures . . . . . Go To Section II
	-Cooling System Failures . . . . . Go To Chapter 6
	-Lubrication System Failures . . . . Go To Section V

NOTE:
Procedures boxed in this index can be used for training purposes.

4-3. Repair Procedure Index.

Section II. ENGINE FAILURE

4-4. General. Basic engines on certain vehicles are identical to equipment engines. Motor supports, manifolds, exhaust or cooling systems may require different brackets to interchange. Accessories and brackets must be swapped from the unserviceable equipment or vehicle to make the replacement engine fit another application.

4-5. Engine Interchangeability. Availability of engines may become restricted to those found on damaged equipment. Military Standard engines from other equipment can be modified to fit military standard equipment sets requiring another engine. Commercial equipment sets engines cannot be be exchanged unless the equipment is absolutely identical.

NOTE

There are several engine procedures which vary depending on the equipment being repaired; therefore, the operator should refer to the specific TM for detailed instructions.

Section III. ENGINE AIR INTAKE SYSTEMS

4-6. Engine Air Intake For Normally Aspirated Engines. Normally aspirated engines require that the first cycle piston movement is downward to create a vacuum drawing air into the intake system. The key to avoiding damage to this type of system is to 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 are securely attached to prevent them being sucked into the engine intake manifold cylinder.

4-7. Engine Air Intake For Turbocharged Engines. Turbocharged engines use exhaust gases to drive the turbocharger to compress air and force it into the cylinder under pressure. The engine air intake system is therefore vacuum and pressure. Assessment and repairs to turbocharged air system should therefore be based on the rules above for the system up to the turbocharger inlet. For the outlet, the repairs should seal so that the air pressure does not escape. Because the turbocharger is driven by exhaust gases, repair of the drive system must seal the exhaust gases to prevent depressurization.

4-8. Engine Air Intake For Supercharged or Tubosupercharged 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 that turbocharged engines require 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.

4-9. Blower Drive Shaft Broken. The blower provides pressurized air to the engine air box. The blower is driven by a drive shaft (quillshaft) 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:

- Blower may be damaged.

Personnel/Time Required:

- 1 soldier - 1.0 hr.

Materials/Tools:

- Welding Equipment
- Deleted.

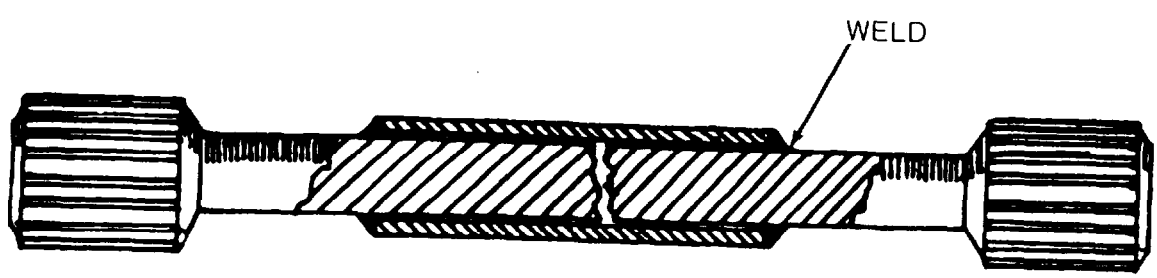
Procedural Steps:

a. Gain access to the drive shaft and remove both broken ends.

b. Use heavy steel tubing, or machine a sleeve so that the proper length is maintained.

c. Install sleeve or tube on shaft. Ensure that the proper length is maintained.

d. Weld ends of sleeve to shaft.



e. Reinstall blower drive shaft.

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

4-10. Air Cleaner Clogged. The air cleaner is essential for keeping dirt and dust from getting into the engine. Under heavy dust conditions it 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 should not be hit to dislodge dirt as this can deform the sealing element and let dirt into the engine causing internal damage.

Personnel/Time Required:

- 1 soldier - 15 minutes

Procedural Steps:

a. Remove air cleaner elements.

b. Clean filters using one of the following possibilities:

(1) Dismount a blower motor (such as dust exhausters), connect to power source with long leads, and blow dirt from air cleaner.

(2) Disconnect exhaust holes from all but one blower. Connect hoses together using tape to gain sufficient length to reach outside. Start engine and blower, blow dirt deposits from filters.

(3) Use air from a disabled wheeled vehicle's tires. Remove valve stem and connect rubber hose to valve and proceed to blow out filters.

(4) Use brake air tank from wheeled vehicle by connecting rubber hose or place filter directly under air flow from valve.

Other Options:

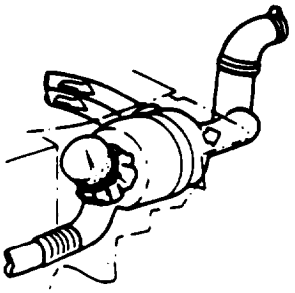
- Use vacuum cleaner.
- Gently tap filter against hard surface.

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

4-11. Air Cleaner Damaged/Leaking. The air cleaner must filter all incoming air for the engine. Damage or leaks that cause the air cleaner to be ineffective must be repaired. Any leaks in the filter housing or duct work can be taped over or covered by a rag that will filter any air coming through the leak. Sealing the leak is preferred. Only as a last resort should the air cleaner bypassed or eliminated. Damage will occur as the engine ingests the dirt and dust in unfiltered air. If the only option is to eliminate the air filter this procedure will allow a minimum amount of air filteration.

Limitations:

- Possible degraded output.



Personnel/Time Required:

- 1 soldier - 30 minutes

Materials/Tools:

- Blanket or Shirt
- Tape, Duct (appendix C, section II item 40) Or Tape, Electrical (appendix C, section II, Item 41)

Procedural Steps:

a. Disconnect the air hose at the attachment to the engine.

b. Cover the air inlet with a clean cloth (such as a shirt or blanket). Clean the cloth whenever It gets dirty.

c. Anchor the cloth tightly to the air intake with a hose clamp or wire, otherwise the strong vacuum will suck the cloth into the engine.

Other Options:

- Bypass or eliminate air cleaner.

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

4-12. Intake Manifold Or Other Castings Or Containers Damaged. Intake manifolds are difficult to repair. Autobody 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

WARNING

This can cause personal injury or possibly even death. Care must be taken, to keep carbon monoxide away from the operator.

4-13. The engine exhaust system consists of the exhaust manifold, muffler and pipes to route the gases to the muffler and 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, are inconvenient, but the equipment can still be operated. Turbocharger drive circuits must be repaired or engine performance will be degraded.

CAUTION

Continued engine operation with damaged exhaust manifolds may set the fuel lines on fire.

4-14. Exhaust Manifolds Damaged. Damaged manifolds are indicated by loud noises. Any damage to the exhaust manifolds upstream of the turbocharger will degrade engine operation.

Personnel/Time Required:

- 1 soldier - 15 - 30 minutes

Materials/Tools:

- Hose Clamps
- Deleted.

Procedural Steps:

a. Gain access to the damaged manifold.

b. Obtain a sealing material (asbestos sheet preferred), cut sheet to cover the hole or leak.

c. Secure the sheet in place using hose clamps.

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

Section V. ENGINE LUBRICATION SYSTEMS

4-15. General. Engine lubrication is essential for all moving components; however, crankshaft bearings and diesel engine piston crowns are 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 inoperative lubrication system will degrade the length of the engine life.

4-16. Lubrication System Pump Failure. The oil pump is needed to provide lubrication to engine components. Low or no reading of gage or warning lights indicates a problem. The main and rod bearings, as well as a minimal splash lubrication of the pistons, is possibly done by overfilling the crankcase with oil. However, components such as a 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 only be used in case of emergency. Engine failure will occur if use for normal or limited operation.

Limitations:

- Severely degraded operation.

Personnel/Time Required:

- 1 soldier - 15 - 20 minutes

Materials/Tools:

- Cooking oil
- Oil, Engine (appendix C, section II, item 20)
- Oil, Transmission (appendix C, section II, item 21)
- Fuel, Diesel (appendix C, section II, item 12)

Procedural Steps:

1. Check oil level.

2. Obtain enough engine oil or substitue to overfill crankcase.

3. Overfill the crankcase.

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

WARNING

DO NOT dilute lubricating oil with gasoline. Personal injury or death or death may occur.

4-17. Oil Level Low. 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 only limited lubrication. When using diesel fuel, do not dilute the lubrication oil more than approximately 3 parts diesel fuel to 1 part engine oil except in extreme emergencies. Operate at a slower engine speed to prevent damage to the engine.

CHAPTER 5

FUEL SUPPLY SYSTEM

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

CAUTION

A diesel engine can be severely damaged by using unfiltered fuels.

Section I. INTRODUCTION

5-1. Scope. Fuel supply system consist of fuel storage tanks, fuel pumps, filters, tubes and hoses needed to route the fuel. Some engines use electrical fuel pumps located in the tanks and a mechanized engine mounted fuel 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 mechanical 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.

5-2. Assessment Procedure.

a. Visually inspect — Damage found to:
- -Fuel Tank . . . . . Go To Section II
- -Fuel Lines . . . . . Go To Section IV
- -Fuel Filters.. . . . . Go To Section V

b. Check for impurities in the fuel such as water or dirt.

c. Attempt To Operate — Damage found to:
- -Tank Or Lines . . . . . Go To Sections II or IV
- -Pump lnoperative . . . . . Go To Section Ill
- -Fuel Filters Inoperative. . . . . Go To Section V

d. Observe Operation — Damage Or Substandard Operation Of:
- -Pumps Found . . . . . Go To Section Ill
- -Fuel Filters . . . . . Go To Section V

NOTE:
Procedures boxed in this index can be used for training purposes.

5-3. Repair Procedure Index.

Section II. FUEL STORAGE SYSTEM

5-4. General. Fuel storage systems may be enclosed in metal containers, nylon fiberglass tanks or rubber reinforced fuel bladders. All systems are susceptible to contamination from 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 usage. Leakages caused by normal vibration or actual combat damage must be repaired before the equipment can be used.

5-5. Fuel Tank Leaks. Fuel tank leaks are difficult to repair in a battlefield environment. The repairs are also dictated by the type of material from which the fuel tank, cell or fuel bladder is manufactured. Fuel leakage is an indication that a fuel storage container is damaged. Time is 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 curling of fiberglass epoxies.

Option 1: Aluminum fuel tanks:

Limitations:

- None if welded.

Personnel/Time Required:

- 1-3 soldiers - 2.0 - 6.0 hrs.

Materials/Tools:

- Welding Equipment
- Rivets Or Screws
- Deleted.

Procedure Steps:

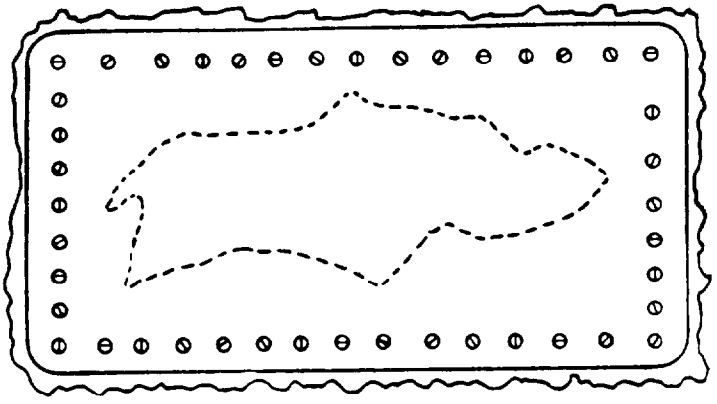
a. Gain access to the damaged area (on the fuel tank.)

b. Drain and vent fuel tank. (Purge the tank using vehicle exhaust gases.)

c. Cut an aluminum patch large enough (to extend 1-2 inches over the hole edges.)

d. Attach the patch to the tank.

(1) MIG or TIG weld the patch to the fuel tank.



(2) Drill holes in plate and tank approximately one inch apart. Apply sealer to the patch and rivet or screw the plate to the fuel tank.

e. Reinstall fuel tank, if removed.

Option 2: Fiberglass Fuel Tanks.

Limitations:

- None if fiberglass repair kit is used.

Personnel/Time Required:

- 1-3 soldiers - 2.0 - 6.0 hrs.

Materials/Tools:

- Fiberglass Repair Kit
- Pop-Rivets
- Epoxy (appendix C, section II, item 11)
- Gasket, Sealer (Hardening) (appendix C, section II, item 15)

Other Options:

- Plug hole.

Procedural Steps:

a. Gain access to fuel tank.

b. Drain fuel tank

c. Clean oil and fuel residue from damaged area.

d. Rough up area around damage with sandpaper or a file.

e. Repair using one of the following:

(1) Apply fiberglass following kit instructions.

(2) Mix and apply epoxy following kit instructions.

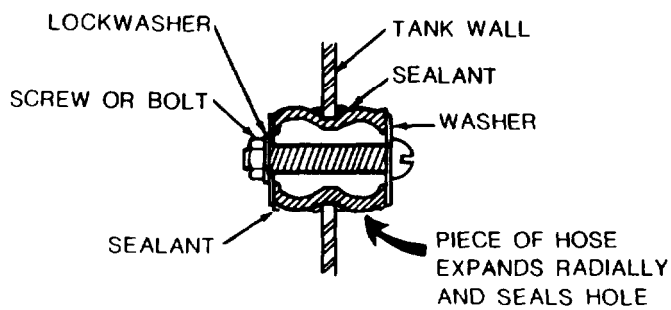
(3) Cut sheet metal patch, drill tank and patch, coat patch liberally with fuel resistant gasket sealer. Attach patch with pop-rivets, seal rivet heads with sealer.

f. Reinstall fuel tank, if removed.

Option 3: Plugging holes, metals or fiberglass tanks.

Personnel/Time Required:

- 1-3 soldiers - 1.0 - 3.0 hrs.



Materials/Tools:

- Hose, Rubber
- Bolt And Nut
- Flat Washers

Procedural Steps:

a. Gain access to fuel tank hole.

b. Drain fuel until level is below the hole.

c. Obtain hose the approximate size of the hole.

d. Using a round file, file the hole to a size equal to the hose diameter.

e. Assemble the hose, bolt, nut and washers as shown.

f. Coat the hose assembly with sealer to aid in the repair.

g. Insert the hose assembly into the hole.

h. Tighten the bolt and nut to make the hose expand and seal the fuel tank hole.

i. Reinstall the fuel tank, if removed.

Other Options:

- Use fiberglass or epoxy.

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

5-6. Bladder Cell Leakage. Bladder type fuel cells can be repaired similar to patching tire inner tubes. Repairs can be placed inside or outside of the bladder depending on access to the damage.

Personnel/Time Required:
- 1-2 soldiers - 1.0 - 2.0 hrs.

Materials/Tools:

- Adhesive (appendix C, section II, item 1) or Rubber Cement (appendix C, section II, item 27)
- Inner Tube (appendix C, section II, item 16)
- Rubber Liner Sheet (appendix C, section II, item 29)

Procedural Steps:

a. Gain access to damaged area.

b. Smooth the damaged area out.

c. Clean and lightly buff an area slightly larger than the patch.

d. Fabricate a patch from rubber liner sheet, or other available material, that extends sufficiently in all directions past the damaged area.

e. Apply the patch with available rubber cement or adhesive.

f. After curing, check the patch for leakage.

g. Reinstall the fuel bladder, if removed.

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

5-7. Fuel Tank Substitute. Tactical operations may not allow sufficient time to make normal or expedient repairs to the engine'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. If fittings will not go with jury rigged tank, fill base with fuel and insert the end into the tank. Be sure the fuel tank is higher than the auxilary fuel connection point to facilitate siphoning.

Limitations:

- Limited operating time.

Personnel/Time Required:

- 1 soldier - 30 minutes - 1.0 hr.

Materials/Tools:

- Fuel Container
- Hose Clamp
- Rubber Fuel Line (appendix C, section II, item 28)
- Rope (appendix C, section II, item 26) Or Straps, Tiedown (appendix C, section II, item 38)

Procedural Steps:

a. Locate a temporary fuel container.

b. Obtain a fuel line.

c. Connect fuel line to container.

d. Secure temporary fuel container to the outside of the equipment in a position to allow gravity feed for the fuel.

e. Connect fuel line to the inlet side of the mechanical or electrical equipment fuel pump.

f. Bleed the air from the fuel line.

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

Section III. FUEL PUMPS

5-8. General. It would be a tremendous duplication of effort to give procedures for changing fuel pumps in all equipment configurations. These procedures are adequately described in the respective unit TM. What is not given in these TM's is a list of alternate sources of supply for each respective fuel pump in case a spare is unavailable. See Appendix D for a list of alternate sources of supply.

5-9. Fuel Pump, In-Line Interchangeability. In-line fuel pumps on POL equipment can be interchanged with other POL equipment and sometimes generators. The difference in the pumps is normally the brackets are used to locate the electrical unit. The electrical unit can be dismounted from the brackets and installed in the bracket for the equipment being repaired. The electrical unit can be clamped using the existing clamps or using 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.

5-10. Fuel Pump Failure. Electric fuel pumps will not normally supply the fuel pressure required by the injector system if the mechanical fuel pump fails. However, limited operation in a degraded mode is possible by replacing the mechanical pump with an electrical unit. Mechanical pumps are substitutable with adequate operational capabilities within the same engine family. Some heater fuel pumps can be used to provide fuel to the engine.

NOTE

If fuel is not reaching the engine, and the electric fuel pump is making an audible clicking sound, the problem may simply be a poor ground. Connect a piece of wire from the ground post of the battery to the frame of the equipment. This may correct the problem.

Section IV. FUEL LINES AND VALVES

5-11. General. Fuel lines route the fuel from the storage tanks to the filters and the engine fuel system. Lines are a combination of rubber hoses and metal tubes. Leaks and fuel line blockages are common failures. Clogged lines can be cleared by blowing compressed air through them. Broken or cracked lines must be repaired or bypassed.

5-12. Seals, Fuel System, Leak. 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 reinstallation problems since they no longer fit into the O-ring groove. Some repairs are possible if the O-ring is damaged. Swelled O-rings can be allowed to dry until they shrink in size

enough to fit. Torn or cut O-rings can be replaced using a larger O-ring and 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 seal the leakage caused by the cut, if it is not sealing against overtightening. Leaking fittings should first be tightened to attempt an easy repair.

5-13. Fittings Leaking. Flared fuel fittings will start to leak because of engine vibrations or overtightening. Leaking fittings should first be tightened to attempt stopping the leak If tightening does not stop the leak, string can be used to push the flared tubing more firmly against the connecting surface. Coating the string with a gasket sealing compound will aid in stopping leaks in a low pressure fuel line.

Personnel/Time Required:

- 1 soldier - 30 minutes - 1.0 hr.

Materials/Tools:

- Sealant, Fuel Resistant
- String (appendix C, section II, item 39) Or Cord, Light Tie (appendix C, section II, item 10)

Procedural Steps:

a. Remove coupling flange nut.

b. Slide coupling flange nut up, away from flared end.

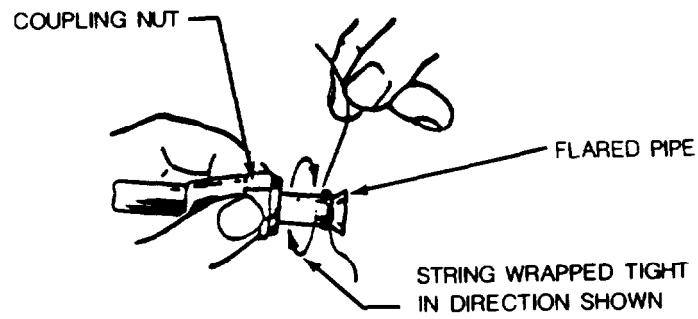
c. Clean grease, oil and fuel from flared end.

d. Wrap string around flared end of line.

e. Coat string liberally with fuel resistant sealant.

f. Reinstall line and tighten nut securely.

g. Check for leaks. If still leaking, repeat procedure using more string.



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

5-14. Fuel Line (Low-Pressure Rupture). Low pressure fuel lines can rupture or crack for various reasons. Frozen water in the lines, vibrations, rubbing against other components or impact can all cause the line to rupture or crack. Repairs can be performed rapidly to stop the leakage and continue the mission.

Personnel/Time Required:

- 1 soldier - 30 minutes - 1.0 hr.

Materials/Tools:

- Tape
- Wire
- Hose, Rubber
- Hose Clamps
- Rubber Liner Sheet (appendix C, section II, item 29)
- Sealant (appendix C, section II, item 31)
- Tubing (appendix C, section II, item 45)
- Sheet Metal (appendix C, section II, item 32)
- Deleted.

Other Options:

- Seal the crack with epoxy.

Procedural Steps:

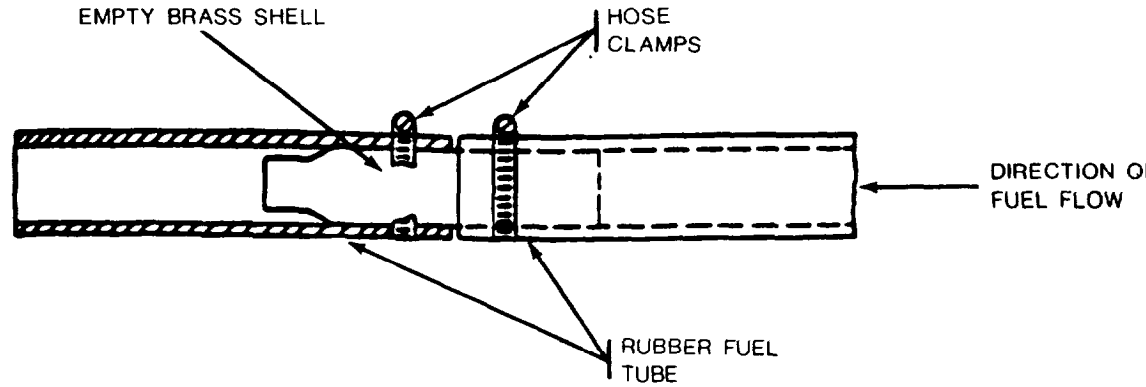
Option 1: For damaged rubber hose:

a. Cut out damaged portion of hose.

b. Cut a piece of metal tubing longer than the length of the hose section removed. If tubing is not available, cut the ends from a 7.62 mm shell casing.

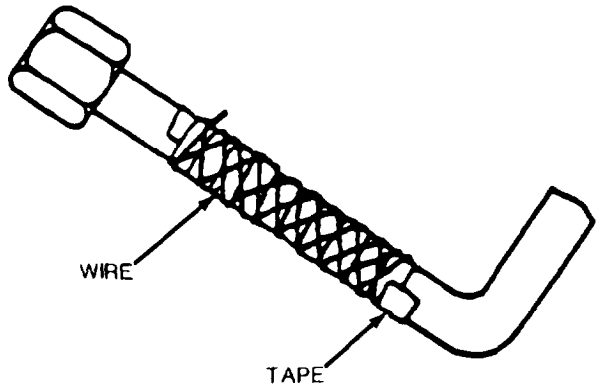
c. Apply a sealant to the ends of the tubing.

d. Insert the metal tubing into the hose ends.



e. Clamp the hose end with hose clamps or wrap tightly with wire and twist the wire ends together.

Option 2: For metal tubing cracks:



a. Clean all dirt and grease from around the crack

b. Coat the crack with sealant.

c. Wrap tubing with a sheet of fuel resistant material.

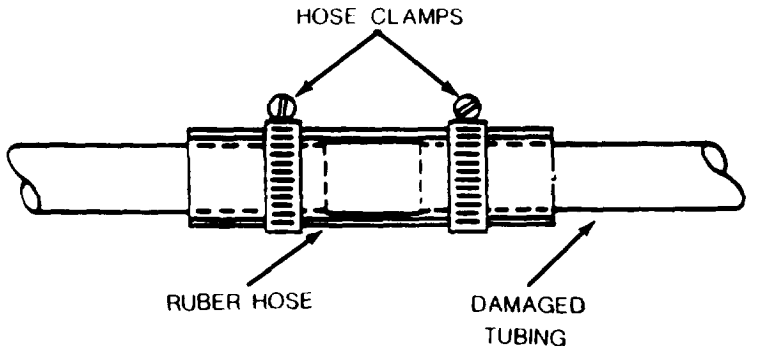
d. Clamp the sheet directly over the crack

e. if clamps are not available, wrap the tubing with tape.

f. Wrap wire around the tape as reinforcement.

g. Wrap an additional coating of tape over the wire.

Option 3: For holes in metal tubing:



a. Cut out damaged portion of metal tubing.

b. Clean both ends of tubing.

c. Cut a piece of rubber hose two inches longer than the length of removed tubing.

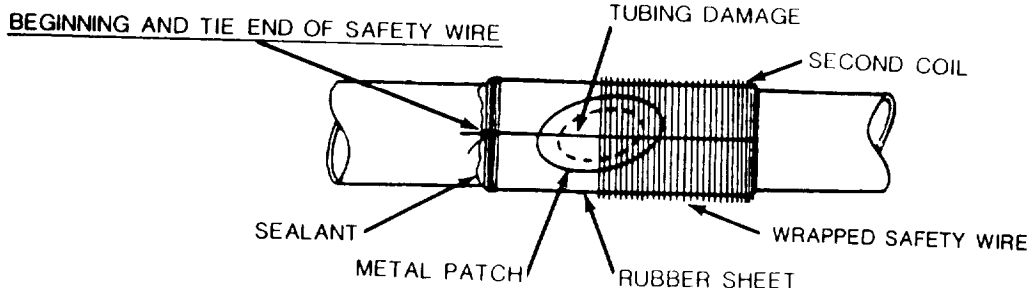
d. Apply sealant to both ends of tubing.

e. Insert the tubing ends one inch into the hose.

f. Secure with hose clamps or tightly twisted wire.

g. If the hose is too large, the tubing can be flared or sleeved to fit.

Option 4: Patching large metal lines:



b. Clean dirt and oil from damaged area.

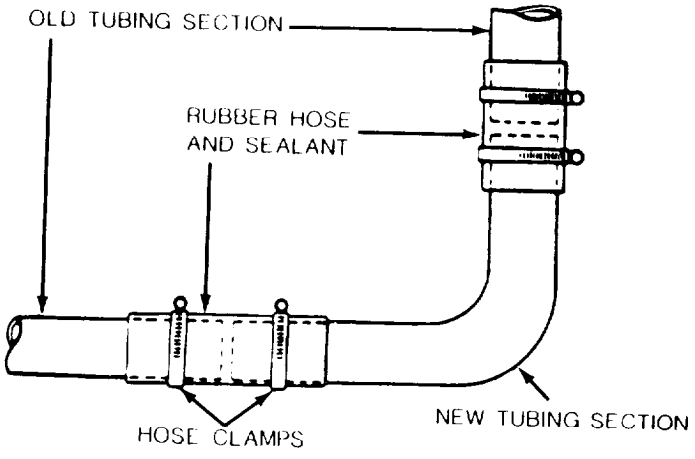
c. Cut a metal patch from sheet metal.

d. Coat the metal patch and tubing with sealant and place over damaged area.

e. Cut a patch from rubber or other fuel resistant material and wrap over metal patch.

f. Wrap rubber patch with wire to equalize the pressure over the repair.

Option 5. Repairing damaged bends:



a. Cut a bend from an old hydraulic line, mirror arm or similar material.

b. Remove the damaged bend from the line.

c. Clean the cut tubing ends.

d. Apply sealant to tubing ends.

e. Using two, 2-inch sections of rubber hose, install the replacement bend.

f. Clamp with hose clamps or tightly twisted wire.

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

5-15. Fuel injector Line, Rupture.

a. If a high pressure fuel line is damaged and there is not time for a better repair, cut the line and weld or crimp shut the injector pump side. 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 equipment and clean it. Braze pin holes closed. If the hole is too large for this procedure, cut out the section of line. Use a piece of slightly large 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

5-18. General. Fuel filters are needed to remove dirt and water from the fuel. Dirt and water will cause damage to the fuel injectors if fuel is not filtered. Fuel filters are normally mounted in series, a primary and a secondary filter. Fuel filters should only be bypassed as a last resort.

5-17. Fuel Filter Clogged or Frozen. The first indication of clogged or frozen fuel filters will be a failure of the engine to start or degraded performance due to insufficient fuel. Fuel filters, if drained periodically, should not freeze. Clogged filters must be cleaned or changed to correct the problem.

Limitations:

- Possible engine internal damage if filters are bypassed.

Personnel/Time Required:

- 1-2 soldiers - 15 - 30 minutes

Other Options:

- Remove filter elements.

Procedural Steps:

Option 1: Cleaning filters.

a. Gain access to fuel filters.

b. Remove the fuel filter from the cannister.

c. Rinse the filter in a pan of fuel or blow out with compressed air; if frozen thaw out.

c. Reinstall the fuel filter.

e. Start the engine.

Option 2: Bypassing the filters.

a. If the engine will not start, disconnect the fuel inlet line.

b. Disconnect the fuel outlet line and reconnect it to the fuel inlet line.

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

CHAPTER 6
COOLING SYSTEM

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

6-1. Scope. Cooling system problems may be indicated by a variety of faults. Typically the operator's indicator panel will show overheating.

8-2. Assessment Procedure.

a. Air cooling system assessment:

(1) Visually inspect — Damage Found To:
- -Fans . . . . . Go To Specific TM
- -Fan Drive . . . . . Go To Specific TM.
- -Shrouds . . . . . Go To Para 6-5.
- -Ducts . . . . . Go To Para 4-11.
- -Engine Compartment Covers . . . . Go To Para 4-11.
- -Engine Compartment Seals . . . . . Go To Para 3-7.

(2) Start engine — Damage Found To:
- -Fan Air Intake . . . . . Go To Specific TM
- -Fan Drive . . . . . Go To Specific TM.
- -Engine Compartment Covers . . . . Go To Para 4-11.
- -Engine Compartment Seals . . . . . Go To Para 3-7.

b. Liquid Cooling Systems Assessment:

(1) Visually Inspect — Damage Found To:
- -Hoses, Hose Clamps . . . . . Go To Section Ill.
- -Gaskets . . . . . Go To Section II, Chapter 3.
- -Radiator . . . . . Go To Section Ill.
- -V-Belts . . . . . Go To Para 3-9.

(2) Start Engine — Damage Found To:

-Head Gasket ..... Go To Para 3-6.
-Internal Engine Water Jacket ... Go To Para 3-5.
-Thermostat ..... Go To Section III.
-Coolant Flow/Water Pump ..... Go To Section Ill.
-Cooling Fan ..... Go To Specific TM.
-Air Flow Through Radiator ..... Go To Section II.
-Fuel Filters ..... Go To Section II.

NOTE:
Procedures boxed in this index can be used for training purposes.

6-3. Repair Procedure Index.

Section II. AIR COOLING SYSTEMS

6-4. General. Cooling system failures can result in engine failure and therefore must be dealt with if the engine is expected to operate for any length of time. Cooling system problems most often are indicated on the operator'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.

6-5. Shrouds, Air Cooling 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 kits or tape to restore the proper air flow. At minimum, they must be bent to prevent contact with moving compartments. If the existing shrouds cannot be repaired, new shrouds must be fabricated from sheet metal.

Section Ill LIQUID COOLING SYSTEM

6-6 General. During performance of repairs, or as a result of leakage, the coolant may become lost. 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 as a substitute, but some liquids will deteriorate the cooling system rubber components. Petroleum products will not transfer the heat as efficiently as a water-based coolant, but will work if nothing else is available. Old engine oil or fluids drained from damaged vehicles, transmission oil, or hydraulic systems 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.

6-7. Thermostat Stuck. The thermostat regulates the engine operating temperature, from 180 to 195 degrees farenheit, 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 equipment. If the thermostat is stuck in the open position or removed, it may degrade engine performance and increase fuel consumption.

6-8. Engine Coolant Frozen. During cold weather, inadequate antifreeze protection will cause the coolant to freeze. Care must be taken when thawing the cooling system so that further 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 overheating damage.

Limitations:

- None if engine is left running or antifreeze protection is upgraded.

Personnel/Time Required:

- 2 soldiers - 30 minutes - 1.0 hrs.

Procedural Steps:

a. Gain access to radiator and powerpack.

b. Inspect for amount of ice and obvious cracks in coolant system components.

c. If coolant is solid, remove or disengage the water pump drive belts.

d. Start the engine and allow to warm up, but not get hot.

e. Attempt to turn water pump pulley.

f. Shut down the engine and allow the heat to radiate into and melt the ice.

g. When the water pump pulley can be turned, reinstall the drive belts.

h. Restart the engine and allow to warm up, but not overheat.

Other Options:

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

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

6-9. Radiator Leaking. Radiator leaking may be detected by low coolant levels. Obvious wet areas or overheating will indicate that the coolant level must be checked. The repair procedure used is dependent on the size of the hole(s) causing the leak. The following procedures provide options to stop or reduce the leakage rate.

Option 1: Small Hole:

Personnel/Time Required:

- 1 soldier - 15 - 30 minutes

Materials/Tools:

- Cirgarettes Or Tobacco
- Pepper
- Eggs
- Oatmeal
- Farina (Cream Of Wheat)
- Corn Meal
- Stop Leak Chemical (appendix C, section II, item 37)

Procedural Steps:

a. Remove radiator cap and start engine,

b. Add coolant to bring coolant to the proper level.

c. Sprinkle or pour one of the materials listed above into the coolant.

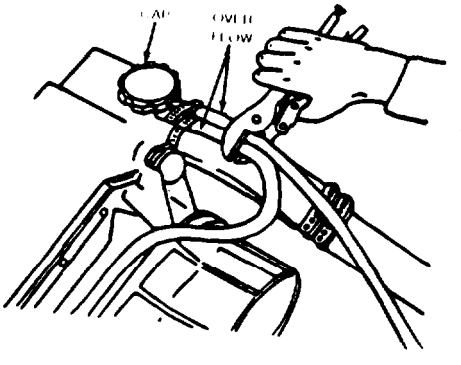
d. Inspect the hole for evidence of reduced or eliminated leakage.

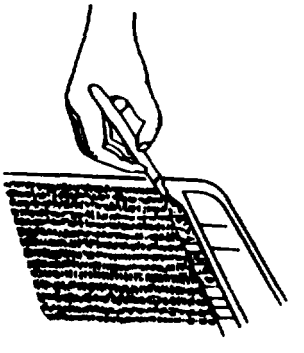
e. Add more material if leak has not stopped or been reduced to an acceptable limit.

f. Leave radiator cap loose.

g. Plug overflow lines on surge tank equipped coolant systems.

Option 2: Tubing to Heater Joint, Leak





Personnel/Time Required:

- 1 soldier - 1.0 - 4.0 hrs.

Materials/Tools:

- Wire Brush
- Solvent (appendix C, section II, item 35)
- Epoxy (appendix C, section II, item 11)

Procedural Steps:

a. Gain access to radiator.

b. Inspect the radiator and pinpoint the leak location.

c. Drain the coolant.

d. Clean the leak area with solvent or available cleaner.

e. Scrape or rough up the damaged surface with a wire brush or knife as shown.

f. Mix epoxy according to kit instructions and fill the hole with the mixture. Work the epoxy well Into the crack

g. Allow epoxy to cure. A heat lamp will speed the curing.

h. Reinstall coolant and check for leaks.

Option 3: Core Punctured.

Limitations:

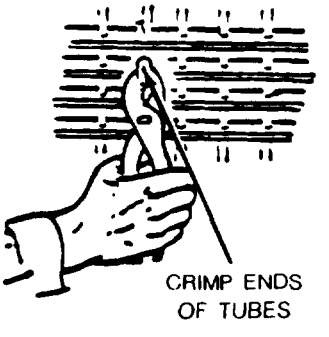
- Possible reduced cooling.

Personnel/Time Required:

- 1 soldier - 30 minutes - 1.0 hr.

Materials/Tools:

- Side Cutters
- Epoxy (appendix C, sect ion II, item 11) Or Solder (appendix C, section II, item 33)



Procedural Steps:

a. Gain access to radiator.

b. Inspect the radiator and pinpoint the leak location.

c. Drain the coolant.

d. Using side cutters, cut or break away the cooling fins from the coolant tubes, 1 to 2 inches each side of the leak

e. Cut the coolant tube at the leak location, taking care not to tear or puncture the other tubes.

f. Squeeze the tube ends together and fold over on itself approximately ½ inch.

g. If epoxy or solder is available, seal the coolant tube ends.

h. If no epoxy or solder is available, fold the tube once more H-inch to restrict the coolant leaks.

i. Reinstall the coolant. Inspect radiator for leaks.

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

6-10. Hose Clamp Broken. A broken hose clamp will allow the hose to leakcoolant 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.

Personnel/Time Required:

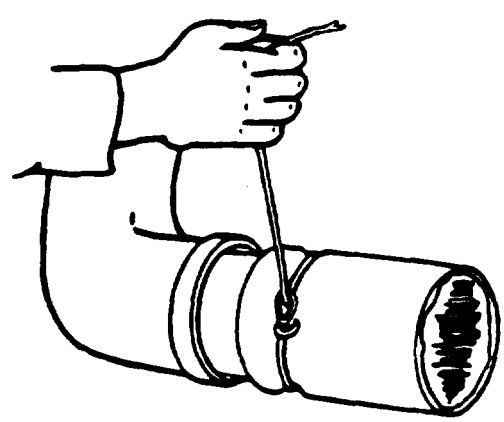
- 1 soldier - 5 - 10 minutes

Materials/Tools:

- Deleted.

Procedural Steps:

a. Make a loop in one end of a wire. Twist the wire so that a permanent loop is formed.



b. Loosely wrap the wire once around the hose and pull the other end through the loop.

c. While pressing the loop tightly against the hose, 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.

c. Secure the loose end by making one more wrap, opposite direction of the first.

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

Other Options:

- Wrap the hose with wire. Using a stick, twist wire ends together like a tourniquet. Tape ends of stick to hose.

WARNING

Fluids in an overheating engine can scald or burn causing serious injury.

6-11. Hose Leakage. 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 two procedures for repairing a small leak in a hose. Option 2 shows how to correct a larger split in a hose.

Limitations:

- Limited output.

Personnel/Time Required:

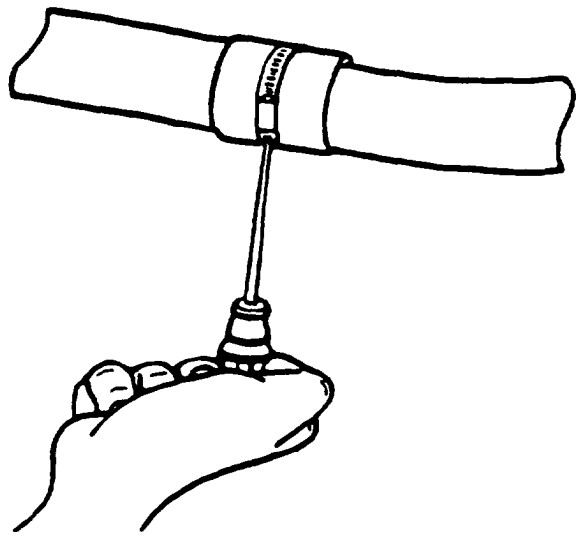
- 1 soldier - 30 minutes

Materials/Tools:

- Clamps
- String (appendix C, section II, item 39)
- Rubber Liner Sheet (appendix C, section II, item 29)
- Sheet Metal (appendix C, section II, item 32)
- Gasket Sealer (Hardening) (appendix C, section II, item 14)
- Tape, Duct (appendix C, section II, item 40) or Tape, Electrical (appendix C, section II, item 41)

Procedural Steps:

Option 1: Hose, Small Leak



a. Gain access to leaking hose.

b. Clean dirt and oil from damaged hose.

c. Coat the damaged area with gasket sealer.

d. Wrap a non-porous material (poncho or rubber mat) over the leak.

e. Secure the material with a clamp.

Option 2: Hose, Small Leak

a. Gain access to leaking hose.

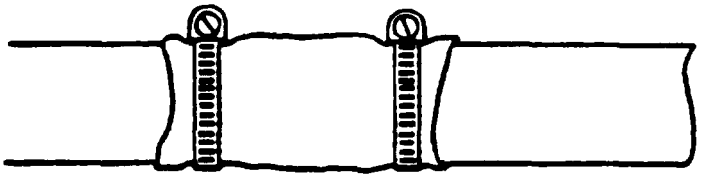
b. Clean dirt and oil from damaged hose.

c. Cover the damage with a rubber mat section.

d. Wrap the patch with electrical or duct tape.

e. Reinforce the patch with wire or string to distribute the patch sealing pressure evenly over the damaged area.

Option 3: Hose, Large Leak



a. Gain access to leaking hose.

b. Clean dirt and oil from damaged area.

c. Coat the damaged area with gasket sealer.

d. Cut a metal patch from a tin can or other thin metal.

e. Bend the metal into a cylindrical shape the size of the damaged hose and coat the inside with sealer.

f. Wrap the metal patch over the damaged hose.

g. Secure the patch with adjustable clamps or tape.

h. Check for leaks.

Other Options:

- Use a Tire Patch Repair Kit.

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

6-12. Hose Collapse. 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 a deteriorated hose on the suction side of the water pump collapsing. The hose can be reinforced by inserting a rigid hollow object, like a can or wire coiled, to prevent the hose from collapsing. The inserted item will help the hose remain open even though the suction is trying to close it.

Personnel/Time Required:

- 1 soldier - 15 minutes - 1 hr.

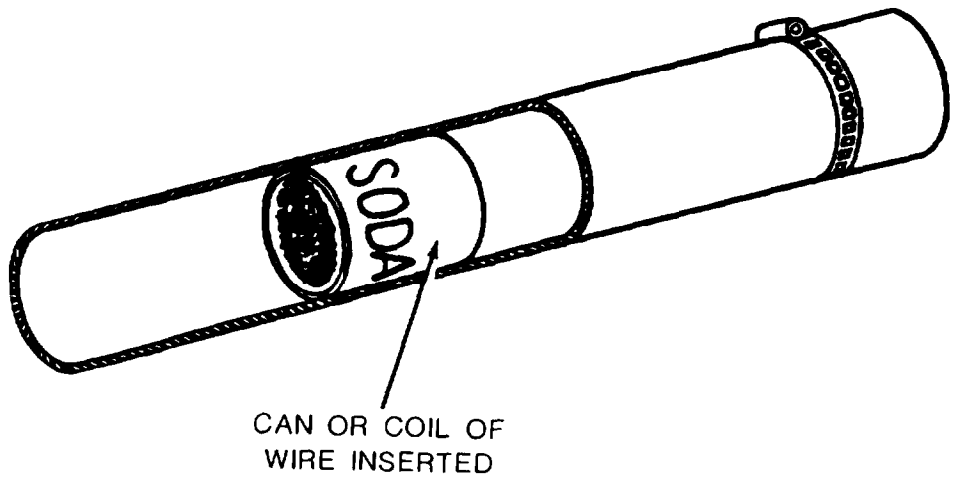
Materials/Tools:

- Tin Can
- Wire, Stiff (coat hanger or welding rod)

Other Options:

- Operate at reduced engine speed.

Procedural Steps:



a. Gain access to hose.

b. Drain coolant.

c. Loosen and remove clamp from one end of the hose.

d. Insert a can with ends removed or bent wire into the hose.

e. Reconnect and tighten the hose.

f. Refill coolant to proper level.

g. Check for leaks.

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

6-13. Hose improvisation (Low Pressure): 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.

Personnel/Time Required:

- 1 soldier - 15 minutes - 1 hr.

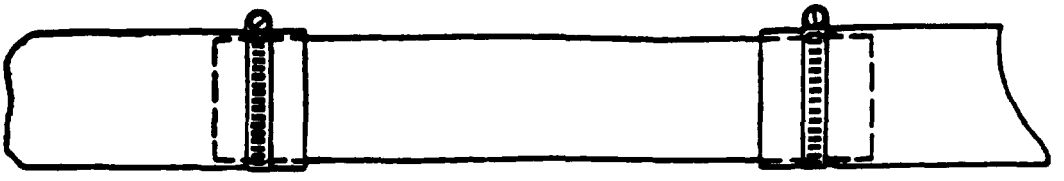
Materials/Tools:

- Hose, Garden Or Hose, Heater
- Pipe
- Clamps Or Wire
- Hacksaw
- Gasket Sealer (Hardener) (appendix C, section II, Item 14)

Procedural Steps:

Option 1: Pipe Insert:

a. Cut out damaged hose section.



b. Cut a section of pipe longer than the removed hose.

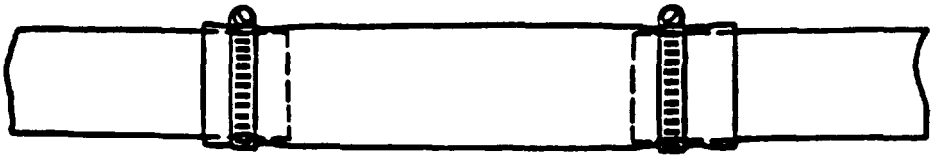
c. Coat the pipe ends with gasket sealer.

d. Insert the pipe into the damaged hose ends.

e. Secure the hose ends with clamps or twisted wire.

f. Refill coolant to proper level and check for leaks.

Option 2: Other Hose.



a. Cut out damaged hose section.

b. Cut a section of substitute material longer than the removed section.

c. Coat ends of damaged hose or tube with gasket sealer.

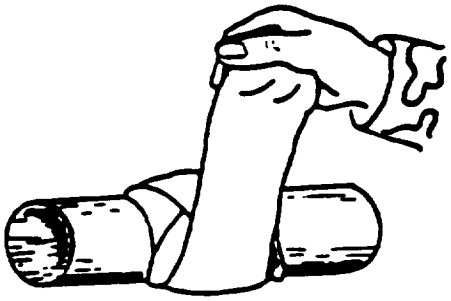
d. Slip the hose over the ends of the damaged hose or tube.

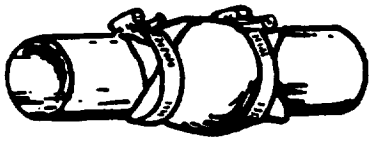
e. Secure the hose with clamps or twisted wire; do not overtighten and restrict the coolant flow.

f. If the damaged hose inside diameter equals the outside diameter of the hose, the hose can be inserted into the damaged hose and secured. This, however, will not work with tubing.

g. Refill coolant to proper level and check for leaks.

Option 3: Short Hose Fabrication:





a. Use a short section of inner tube or rubber sheet cut to required length,

b. Coat the tubing ends with sealant.

c. Slip the material over the tubing ends.

d. Wrap the innertube as tightly as possible on the tubing.

e. Secure the innertube using hose clamps or tightly wound wire.

f. Refill coolant to proper level and check for leaks.

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

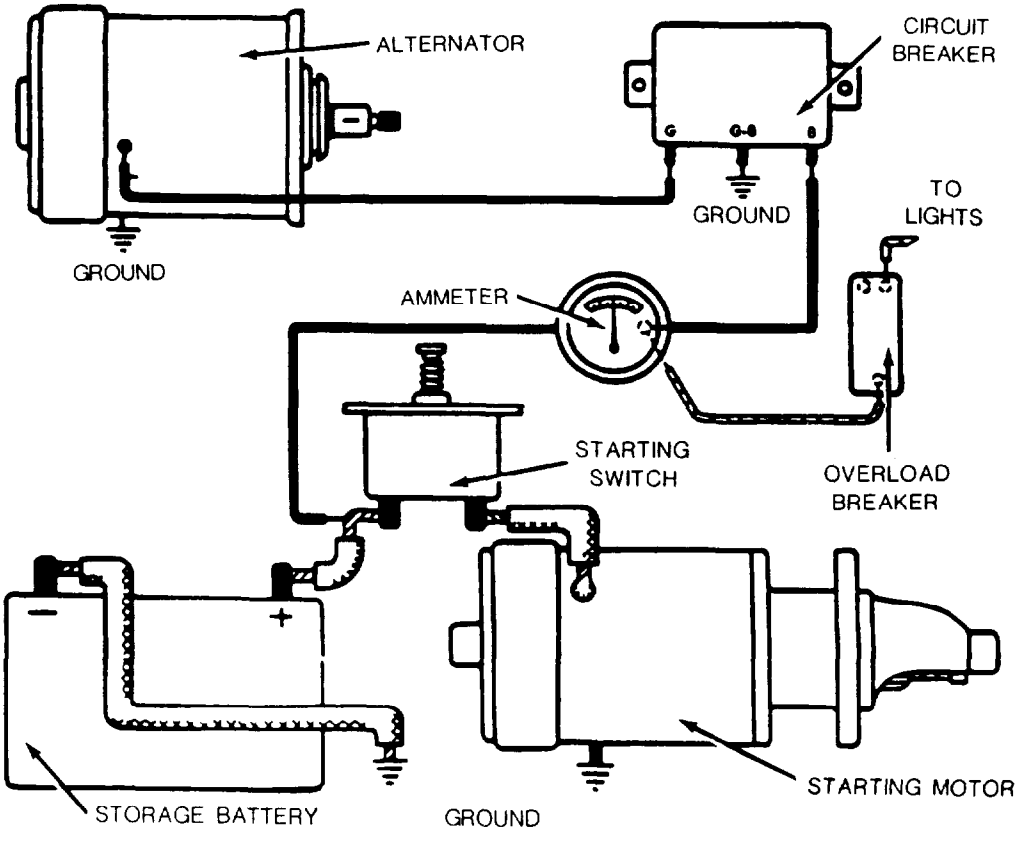
CHAPTER 7

ELECTRICAL SYSTEM

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E). IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

7-1. Scope. Electrical systems on most POL equipment are 24 volt negative ground, direct current systems. Electrical storage for starting and standby circuits is provided by batteries. The batteries are connected in a series-parallel configuration to provide 24vDC current. In most of the larger POL equipment, there are many safety circuits to prevent accidential damage to the equipment through mechanical failure. For example, if the oil pressure drops too low, a safety circuit will shut down the equipment.



7-2. Assessment Procedure:

a. Visually Inspect — Damage Found To:

-Switches . . . . . Go To Section II.
-Fuses . . . . . Go To Section II.
-Circuit Breakers . . . . . Go To Section II.
-Batteries . . . . . Go To Section V.
-Voltage Regulator . . . . . Go To Specific TM.
-Alternator . . . . . Go To Specific TM.

b. Observe Operation — Damage Or Substandard Operation Of:

-Alternator Output Function . . . . . Go To Specific TM.
-Voltage Regulator Function . . . . . Go To Specific TM.
-Circuit Breakers . . . . . Go To Section II.

Evaluate System Performance

Charging System Assessment

	Fully Mission Capable	Corn bat Capable	Corn bat 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	X

7.3 Repair Procedure index. NOTE: Procedures boxed in this index can be ued for training purposes.

Section II. ELECTRICAL COMPONENTS

7-4. General. Electrical circuits contain switches and protection devices. Bypassing a failed switch or protection device is a rapid repair but may create more damage. The circuit must be checked for shorts before bypassing a protection device.

7-5. Switch Defective. Engine starter will not energize due to cutoff by safety circuit. This procedure will allow the equipment to operate until ultimate possible destruction from damage related to the particular safety circuit.

Personnel/Time Required:

- 1 soldier - 15 minutes

Materials/Tools:

- Tape, Electrical (appendix C, section II, item 41)
- Tape, Duct (appendix C, section II, item 40)
- Bandaids
- Shoelaces

Procedural Steps:

a. Locate switch.

b. Disconnect both wires.

c. Slide protective insulation boots back on the wires to expose the electrical connectors.

d. Lay the two connectors side by side and secure with tape.

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

7-6. Switch, Starter, inoperative. If the engine will not crank, bypass the starter switch and jump the starter terminals.

Personnel/Time Required:

- 1 soldier - 15 minutes

Materials/Tools:

- Wire
- Tape

Procedural Steps:

Option 1: Bypass starter switch.

a. Locate the starter switch.

b. Remove the wire from the starter switch.

c. Use a jumper wire or touch the wires, removed in step b, together.

d. After engine starts, disconnect jumper or leads.

e. Insulate lead with tape.

Option 2: Jump starter terminals.

a. Gain access to engine starter.

b. Using a piece of wire or suitable object, connect the main power terminal to the solenoid terminal.

c. After engine starts, disconnect jumper.

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

CAUTION

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

7-7. Fuse or Circuit Breaker Failure. A short or overload in a circuit will cause the fuse to burn out or the circuit breaker to trip. 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.

Section III. WIRING HARNESSES

7-8. General. Wiring harnesses are normally replaced when extensive damage occurs. Because of improvements or different configurations, replacement harnesses from other POL equipment of the same 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 splice a completed harness. If a wire is damaged but the fault cannot be located, it should be replaced with a jumper wire.

7-9. Wiring Harness Damage. 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. Most essential electrical functions can be rapidly restored by using jumper wires. An alphanumeric code is imprinted onto the outer insulating jacket of each wire. A point to point run of each wire can be determined from the troubleshooting diagram plate and the alphanumeric code.

Personnel/Time Required:

- 1 soldier - 1.0 - 2.0 hrs.

Materials/Tools:

- Wire
- Splices
- Soldering Iron
- Plastic Ties
- Tape, Electrical (appendix C, section II, item 41)

Procedural Steps:

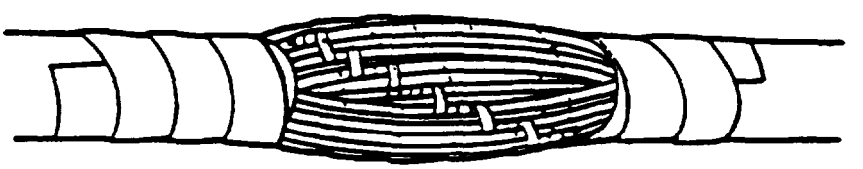
Option 1: Wire Bundle Repairs.

a. Repair the first wire and tape. Leave the tape hanging from the repair.

b. Repair the next wire, lay it on top of the first repair.

c. Continue wrapping with electrical tape.

d. Repeat these steps as often as necessary to repair the wire bundle without cutting or breaking the tape until the repair has been completed.



e. Stagger splices, when possible, at least one splice length.

f. Ensure that minimum essential cable clamps have been replaced.

g. Clamp cushions can be replaced by tape.

Option 2: Jumper Wire:

a. Identify the connector pin at each end of the harness.

b. Cut off the end of the defective wire.

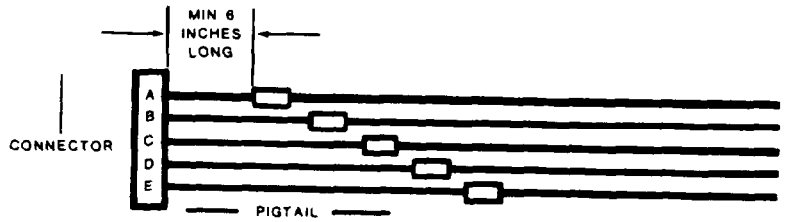
c. Thread the jumper wire along the path of the cable harness passing the wire through the clamps.

d. Attach the jumper wire.

e. Tape the jumper wire securely to the harness at intervals that will provide protection from vibration or sagging.

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

7-10. 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 equipment can be spliced to the equipment 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 repairing a wire bundle.



7-11. Wires Broken. Broken wires can be spliced several different ways to restore an electrical circuit. The available tools and materials will determine the method used. Soldered connections conduct current the best and should be used whenever possible.

Personnel/Time Required:

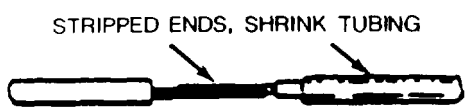
- 1 soldier - 10 - 20 minutes

Materials/Tools:

- Crimping Tool
- Soldering Iron
- Solder, Rosin-Core (appendix C, section II, item 34)
- Wire, Splice (appendix C, section II, item 52)
- Tubing, Heat Shrunk (appendix C, section II, item 46)

Procedural Steps:

a. Strip end of broken wires.



b. Install a section of plastic sleeving or shrink tubing, if available, over one end of the broken wire.

c. Lay the stripped ends side by side.

d. Twist the wire ends together.

e. Solder wires together using rosin-core solder.

f. Slide sleeve or tubing over the soldered wires or tape to insulate the conductor.

Option 2: Wire Splice Method:

a. If terminal lug barrel is used for splicing, select barrel diameter large enough to accept both wires.

b. Cut off terminal flush with pre-insulation.

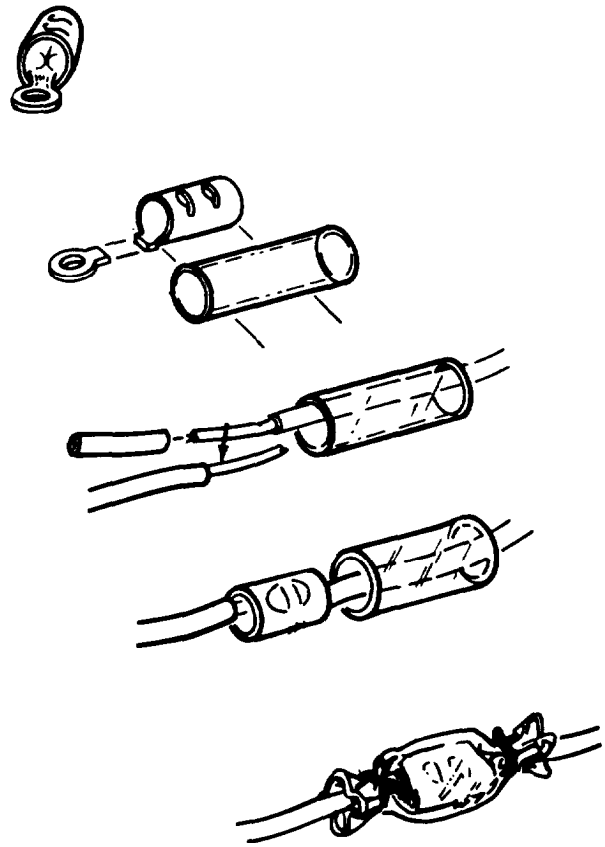
c. Cut insulating sleeve one inch longer than the barrel.

d. Strip end of broken wires.

e. Install insulating sleeve or shrink tubing, if available, over one end of broken wire.

f. Insert wires into the prepared splice barrel and crimp to secure the wires. Use crimp tool matching the size of the barrel.

g. Slide sleeve or tubing over the splice or use tape to insulate the conductor and apply heat to shrink material. Ends of non-shrink sleeve must be tied.



Option 3: Splicing Different Size Wires:

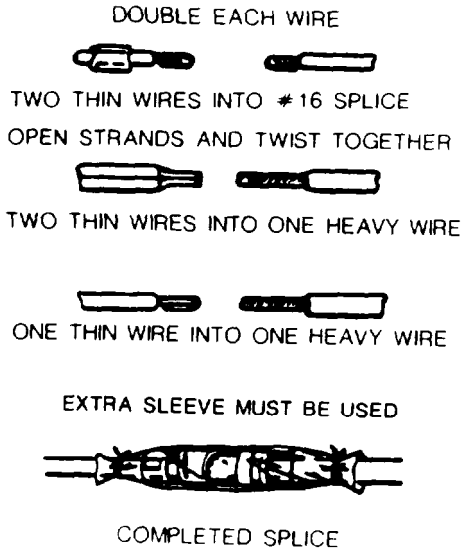
a. Strip broken wire ends, strip enough insulation to allow the smaller wire to be doubled as shown.

b. Install plastic sleeve or shrink tubing, if available, over one end of broken wire.

c. Connect wires by using a splice or terminal lug prepared as in Option 2.

d. Crimp splice or lug to secure the wires.

e. Slide the sleeve or tubing over the splice or tape to insulate the conductor.



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

7-12. Cable, Heavy Duty, Damaged. Heavy electrical cables are more difficult to repair than small wires and they Can be repaired using several different methods. Splicing procedures can be used to repair a break

Personnel/Time Required:

- 1 soldier - 15 - 60 minutes

Materials/Tools:

- Bolt, Short With Matching Nut
- Lugs, Terminal, Screw Clamp, or Clamp, small hole
- Cable Clamp and Solder (appendix C, section Ii, item 33)
- Soldering Iron Or Torch and Soder (appendix C, section II, item 33)
- Insulting Sleeve, Or Tape, Electrical (appendix C, section II, item 41)
- Wire, Safety (appendix C, section II, item 51)

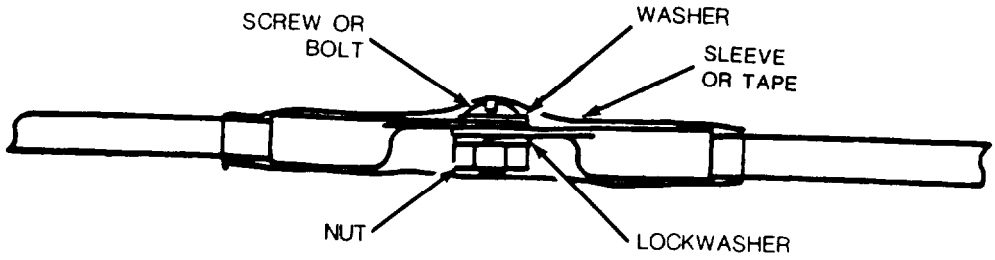
Procedural Steps:

Option 1: Splicing cable with terminal lugs:

a. Clean area to be repaired.

b. Trim the broken ends of the wire and install an insulating sleeve over one end of the wire.

c. Strip wire and crimp an insulated terminal lug to each wire end.



d. Bolt the terminal lugs together using short bolt with nut.

e. Slide the insulating sleeve over the connection and either heat-shrink or tie securely at each end. Tape may be used in place of sleeve.

Option 2: Splicing stranded cable:

a. Remove two inches of insulation from each end of broken wire.

b. Split the ends of cable into manageable strands and join the two ends by twisting like strands together.

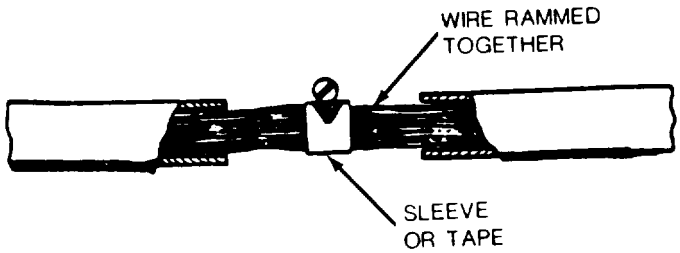
c. Bend the twisted end parallel to the cable and insulate with tape.

Option 3: Clamp. Splicing:

a. Remove one inch in insulation from each end.

b. Fan out the strands on each end.

c. Ram the two ends together as far as possible, so that the strands intermesh.



d. 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.

e. Insulate with tape.

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

Section IV. ELECTRICAL MOTORS

7-13. General. Repair on electric motors should be restricted to relays, solenoids and brushes. Damage to casings and winding cannot be expediently repaired.

7-14. Brush, Electrical, Alternator/Starter-Motor, Worn. Many electrical motors use a carbon compositon 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 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:

- Shorter motor life.

Personnel/Time Required:

- 1-3 soldiers - 1.0 - 8.0 hrs.

Materials/Tools:

- Hacksaw
- Battery (BA30) (appendix C, section II, item 4) or (BA31) (appendix C, section II, item 5)
- Sandpaper (appendix C, section II, item 30)

Other Options:

- Modify and use other electrical brush sets.

Procedural Steps:

a. Gain access to motor.

b. Remove electrical brush plate.

c. Obtain a BA30 or BA31 battery.

d. Using a hacksaw or other available tool, split the battery open taking care not to damage the carbon core.

e. Clean and cut the carbon core to fit the brush plate receptacles.

f. Insert the core into the brush plate and position the old brush wires under the retaining springs to ensure electrical continuity.

g. Seat the Brushes:

(1) Cut a strip of sandpaper slightly wider than the commutator surface.

(2) Tape the sandpaper strip over the commutator.

(3) install the brush plate.

(4) Rotate the armature in the normal direction of rotation until the carbon core conforms to the armature surface curvature.

(5) Remove sandpaper and blow out dust and sand.

h. Reassemble motor and test operation.

i. Reinstall motor.

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

7-15. Starter Solenoid Defective, Delco-Remy Only. 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 the solenoid and rotating solenoid plunger shaft 180 degrees.

Limitations:

- Starter solenoid life is shorter than new part.

Personnel/Time Required:

- 1-3 soldiers - 1.0 - 6.0 hrs.

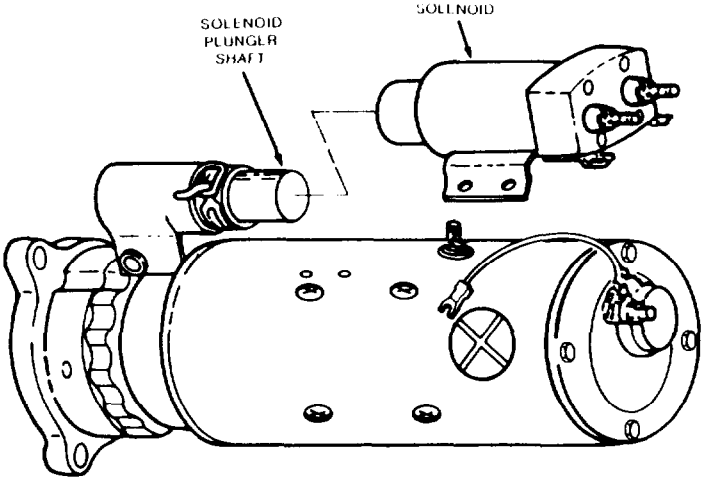
Procedural Steps:

a. Disconnect power. (Unhook negative battery terminal.)

b. Gain access to engine starter; remove if required.

c. Remove solenoid from starter.

d. Rotate solenoid plunger shaft 180 degrees.



e. Install solenoid on starter.

f. Reconnect power.

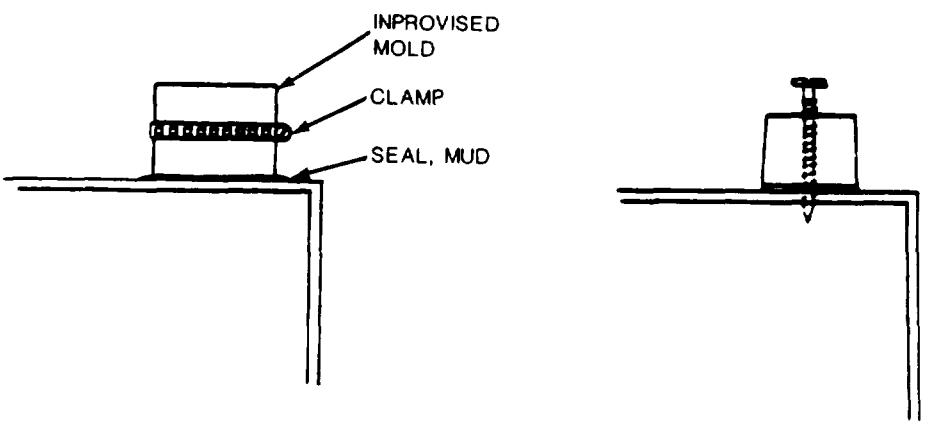
g. Test starter operation.

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

Section V. BATTERIES AND BATTERY CABLES

7-16. General. The batteries store electrical energy to start the 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 24v DC output. The battery cables' end terminals must be securely wrapped and taped with electrical insulating materials if they are not to be secured to the appropriate battery terminals.

7-17. Battery Terminal Post Broken. 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.



WARNING

Battery acid may burn and cause damage to the skin.

7-18. Battery Cracks. 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.

CHAPTER 8

HYDRAULIC POWER DISTRIBUTION

BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE', DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

8-1. Scope. 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 almost always requires replenishment of lost fluids.

WARNING

Bring hydraulic system to zero pressure before making repairs. If this pressure is not relieved before working on the equipment, serious injury or death may occur.

8-2. Assessment Procedures:

No specific assessment procedure is needed to locate leaks and ruptured lines. System specific TMs must be checked before any isolation is performed.

NOTE:
Procedures boxed in this index can be used for training purposes.

8-3. Repair Procedure Index.

8-4. Cannibalization. This section explains how to cannibalize hydraulic lines from other equipment or within the same equipment.

Limitations:

- Conduit cannibalization will limit hydraulic capabilities of the cannibalized equipment.

Personnel/Time Required:

- 1 soldier - 1.0 hr.

Materials/Tools:

- Tool Kit

WARNING

For Hoses Only: Replacement hoses for damaged high-pressure hoses must be of the high-pressure type. Low-pressure hoses may explode under high pressure causing equipment failure and/or operator injury.

Procedural Steps:

a. Determine the fitting type and length of the damaged line.

b. Locate an acceptable substitute for the damaged line. Make sure all size specifications for the replacement line match the damaged line exactly.

NOTE

For Hose and Tubes: Fitting types for a corresponding line must be of the exact same thread type as those of the damaged line.

WARNING

For Tubes Only: In most cases, it will be desirable to replace a damaged hydraulic tube with a hydraulic hose, due to the unique configuration of hydraulic tubes. Similar tubes, carefully bent so as not to crimp the tube, may be cannibalized to replace a damaged hydraulic tube or hose. If fitting types are identical, any compatible metal hydraulic tube (high- or low-pressure) may be used to replace any hydraulic tube (high- or low-pressure).

c. Check that the cannibalized line is long enough to replace the damaged line.

d. Using adjustable wrenches, remove both lines and replace the damaged line with the cannibalized line. Take extra caution that the line fittings are properly threaded. Tighten these fittings snugly.

e. Check that the hydraulic reservoir is at least the minimum operating level. If this level is low, refer to Para 8-13 and fill the reservoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir level again to ensure a sufficient hydraulic fluid level. If this level is low, refer to Para 8-13 and fill the reservoir as needed.

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

Section II. HOSES

8-5. Hose Repair. The following options explain how to repair damaged hydraulic hoses. Use one of the following options to repair a damaged hydraulic hose. Damaged high-pressure hoses require a high-pressure fix. Damaged low-pressure hoses may be repaired by either a high- or low-pressure fix; however, high-pressure fixes are preferred.

8-5.1 High-Pressure Hose Fabrication.

Limitations:

- High-pressure hose must be used for high-pressure repairs.

Personnel/Time Required:

- 1 soldier - 1.5 hrs.

Materials/Tools:

- Tool Kit
- Hose Fittings
- Hose, Hydraulic, High-Pressure
- Tape
- Saw
- Vise

Procedural Steps:

a. Remove the damaged hose.

b. Measure desired length of hose (see para 8-14) and cut to correct length (see para 8-15).

c. Attach fitting to each end of the replacement hose (see para 8-16).

d. Install assembled hose.

e. Check that the hydraulic reservoir level Is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

a. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-5.2 High-Pressure Hose Repair Using Splicer.

Limitations:

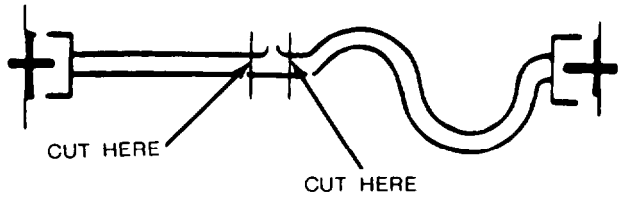
- High-pressure hose must be used for high-pressure repair.
- Removing damaged area and splicing hose may cause hose to be too short to be properly installed. One end of hose may need to be refabricated in order to achieve desired hose length.

Personnel/Time Required:

- 1 soldier - 50 minutes

Materials/Tools:

- Tool Kit
- Hose Splicer
- Hose Clamp(s)
- Tape
- Saw



Procedural Steps:

a. Determine if hose will be long enough to complete repair once the damaged section is removed and the splicer is inserted. If it is not, proceed to para 8-5.3.

b. Squarely cut each end of the damaged hose (see para 8-15).

c. Install the hose splicer (see para 8-19 or 8-20).

d. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

e. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

f. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-5.3. High-Pressure Hose Repair - Using Hose and Splicers.

Limitationa:

- High-pressure hose must be used for high-pressure repair.

Personnel/Time Required:

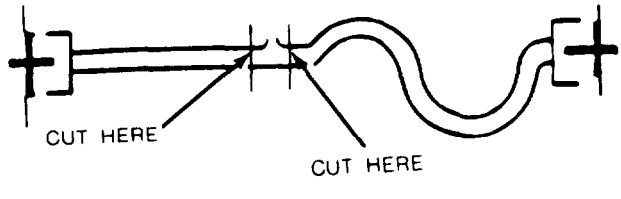
- 1 soldier - 1.0 hr.

Materials/Tools:

- Hose Splicer
- Hose Clamp(s)
- Hose, Hydraulic
- Tape
- Saw
- Tool Kit

Procedural Steps:

a. Squarely cut out section of damaged hose (see para 8-15).



b. Determine the necessary length of hose to make the repair.

c. Squarely cut each end of the replacement hose (see para 8-15).

d. Install the hose and hose splicers (see para 8-19 and 8-20.)

e. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-5.4. Low Pressure Hose Repair - Using Tube and Clamps.

Limitations:

Repair recommended for low-pressure repairs only.

Personnel/Time Required:

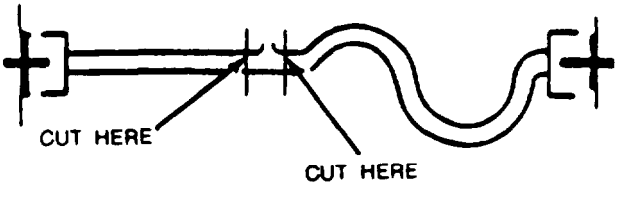
- 1 Soldier - .5 hr.

Materials/Tools:

- Tubing
- Hose Clamp(s)
- Tape
- Saw
- Tool Kit

Procedural Steps

a. Squarely cut out section of damaged hose (see para 8-15.)

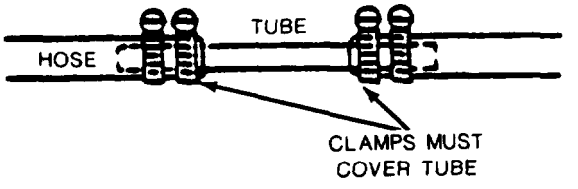


b. Cut piece of tubing of correct diameter four inches longer than the piece of damaged hose removed (see para 8-17).

c. Slide two hose clamps over each end of the hydraulic hose.

d. Insert the tube Into the hose ends. Make sure that the hose overlaps the tube by two Inches on both sides.

e. Move hose clamps over the tube Inside the hose and tighten them with a screwdriver or wrench.



f. Check that the hydraulic reservoir level Is at least at the minimum operating level. If this level Is low, refer to para 8-13 and fill the reservoir as needed.

g. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

h. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-5.5. Low-Pressure Hose Repair - Using Thin Neoprene and Clamps

Limitations

- This fix Is most effective for small punctures or small rips in low-pressure hoses.

Personnel/Time Required:

- 1 soldier - 30 minutes

Materials/Tools:

- Wire Snips, Small
- Hose Clamp(a)
- Tool Kit
- Deleted.

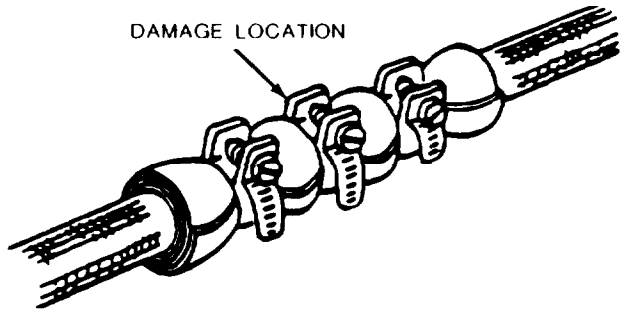
Procedural Steps:

a. Use wire snips to remove frayed wire protruding from the hose.

b. Wrap neoprene around the damaged area of the hose as tightly as possible.

c. Disassemble the hose clamps, wrap them around the neoprene piece, and reassemble.

d. Tighten the hose clamps directly over the damaged area of the hose with a screwdriver or wrench.



e. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-6. Hydraulic Hose Isolation. The following options explain how to isolate damaged hydraulic hoses. Before isolating a hose, determine what effect the isolation will have on the capabilities of the system. Use one of the following options to isolate a hydraulic hose. Determine if the damaged hose is a high-pressure or low-pressure hose. Damaged high-pressure hoses require high-pressure isolation. Damaged low-pressure hoses may be isolated by either high- or low-pressure isolation; however, high-pressure isolations are preferred.

8-6.1 High-Pressure Hose isolation - Using Plug or Cap.

Personnel/Time Required:

- 1 soldier - 25 minutes

Materials/Tools:

- Tool Kit
- Deleted.

Procedural Steps:

a. Remove the damaged hose with an adjustable wrench.

b. Install a plug or cap where the hose was previously connected.

c. Tighten the plug or cap with an adjustable wrench.

d. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

e. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

f. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-6.2 High-Pressure Hose Isolation - Using Bolt and Clamp.

Personnel/Time Required:

- 1 soldier - 50 minutes

Materials/Tools:

- Tape
- Saw

Bolt, One-Inch Long (to fit inside of hose)

- Hose Clamp(s)
- Tool Kit

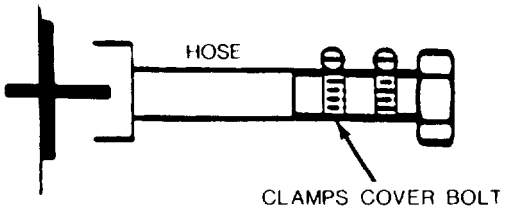
Procedural Steps:

a. Squarely cut each end of the damaged hose (see para 8-15).

b. Slide two hose clamps onto the hose. Leave them loose.

c. Screw the bolt into the hose in a clockwise direction.

d. Slide the clamps so they cover the bolt.



e. Tighten the clamps with a screwdriver or an adjustable wrench.

f. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

g. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

h. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid ‘level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-6.3. Low Pressure Isolation - Using Tubes and Clamps.

Limitations:

Isolation recommended for low-pressure hose repairs only.

Personnel/Time Required:

- 1 soldier - 50 minutes

Materials/Tools:

- Tape
- Saw
- Hose Clamp(s)
- Tool Kit
- Tubing (appendix C, section II, item 45)

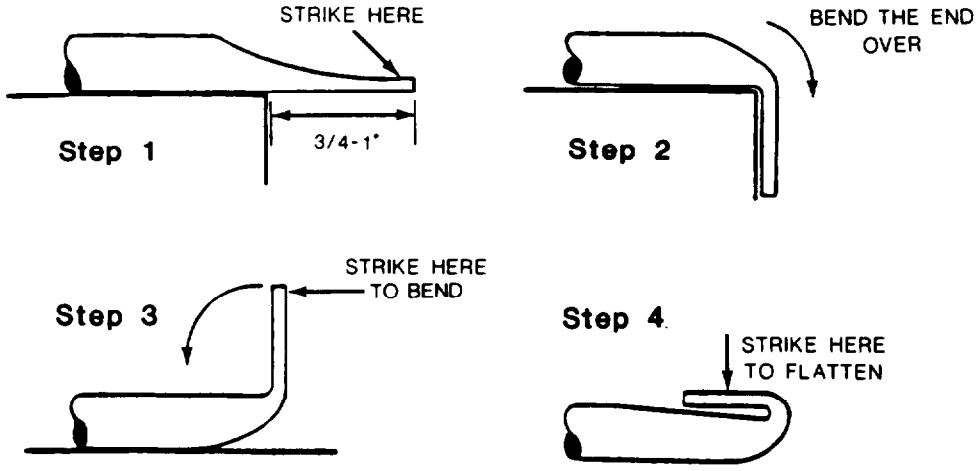
Procedural Steps:

a. Squarely cut the end of the damaged hose (see para 8-15).

b. Cut the ends of the tubing squarely (see para 8-17).

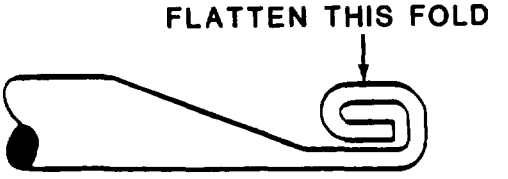
c. Flatten one end of the tubing six inches.

d. Crimp the tube using the four steps as shown below.



e. Repeat Steps a-d to develop another fold. This should also be flattened when the fold is made.

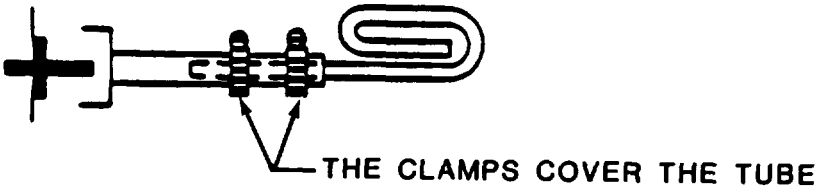
f. Slide two loosened hose clamps over the hose.



a- Insert the tubing four inches into the hose.

h. Slide the clamps so they cover the tube.

i. Tighten the clamps with a screwdriver or an adjustable wrench.



j. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

k. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

l. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

Section III. TUBES

8-7. Hydraulic Tube Repair. The following options explain how to repair damaged hydraulic tubes. Use one of the following options to repair a damaged hydraulic tube. Determine If the damaged tube is high-pressure or low-pressure. Damaged high-pressure tubes require a high-pressure fix. Damaged low-pressure tubes may be repaired by either **a** high- or low-pressure fix; however, high-pressure fixes are preferred.

8-7.1. High-Pressure Tube Repair - Using Hose Fabrication.

Limitations:

- High-pressure hose must be used for high-pressure repairs.

Personnel/Time Required:

- 1 soldier - 1.5 hrs.

Materials/Tools:

- Tool Kit
- Hose Fittings
- Hose, Hydraulic, High-Pressure
- Tape
- Saw
- Vise

Procedural Steps:

a. Remove the damaged tube.

b. Measure the desired length of hose (see para 8-14). Hose may follow a different path than the original tube and may be easier to install.

c. Squarely cut each end of the hose (see para 8-15).

d. Attach a fitting to each end of the replacement hose (see para 8-18).

e. Install the assembled hose.

f. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level low, refer to para 8-13 and fill the reservoir as needed.

g. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

h. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-7.2 High-Pressure Tube Repair - Permaswaging.

Personnel/Time Required:

- 1 soldier - 1.5 hrs.

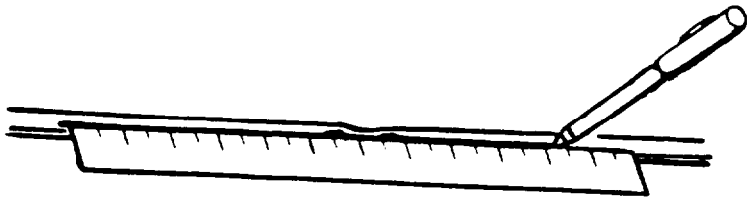
Materials/Tools:

- Tool Kit
- Ruler
- Pen
- Repair Kit, Tube

Procedural Steps:

a. Remove the tube with adjustable wrenches.

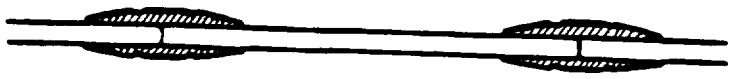
b. Using a pen and a ruler, draw a straight line on the tubing, starting in the undamaged area, through to the damaged section, into the other undamaged area.



c. Refer to the illustrations below to determine the repair method required.

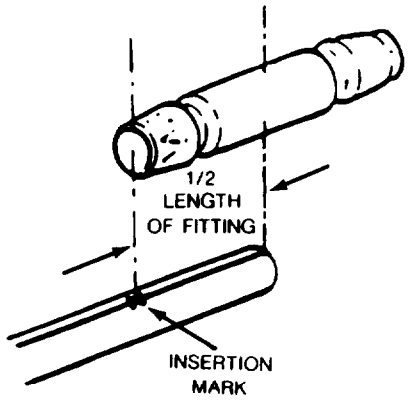
d. Make one or two cuts as necessary to enable removal of the damaged section. If the distance between the two cuts is less than 0.30 inches, use a repair similiar to the illustration below.

If the distance between the two cuts is greater than 0.30 inches, use a repair similar to the figure below.



e. Ends of tubing to be permaswaged must be centered inside the permaswage fitting. Use the permaswage marking tool and the centering/marking instructions supplied with the permaswage kit. Use the marking method below only if the marking tool is not available.

(1) Mark half of the overall length of the permaswage fitting on the tubing end.



(2) Repeat the marking procedure on the other end of the tubing to be swaged.

f. Slide permaswage fitting(s) all the way onto the undamaged tube ends.

g. Position the replacement section between the cut ends of undamaged tubing and slide pemaswage fittings over the gaps between tube ends.

h. Make sure insertion marks are visible on either side of the fitting. Also, rotate the fitting and replacement section until the long-axis marking aligns on the undamaged tube end.

i. Secure the nut of the end fitting “finger tight” to the adapter.

j. Position the permaswage tool to one side of the fitting and swage. Swage the other side of the fitting.

k. if a replacement section is used, repeat Steps h and i.

I. install the tube with adjustable wrenches.

m. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

n. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

o. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-7.3. High-Pressure Tube Repair - Using Hose Section Replacement.

Limitations:

- High-pressure hose must be used for high-pressure repairs.

Personnel/Time Required:

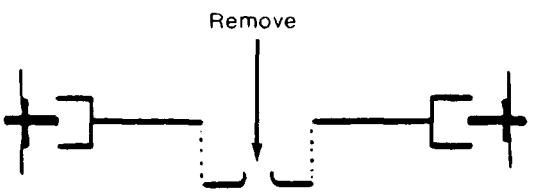
- 1 soldier - 1.5 hrs.

Materials/Tools:

- Hose Fittings (Male)
- Hose, Hydraulic, High-Pressure
- Tube Fittings (Female, Flareless)
- Tape
- Saw
- Tool Kit
- Vise

Procedural Steps:

a. Squarely cut out the damaged section of tube (see para 8-17).



b. Measure the correct length of replacement hose (see para 8-14) and cut to the correct length (see para 8-15).

c. Attach a male fitting to each end of the hose (see para 8-18).

d. Attach a female fitting to each tube end (see para 8-16).

e. install the assembled hose on the vehicle.

f. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

g. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. check carefully for fluid leaks. Tighten leaking fittings.

h. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 6-13 and fill the reservoir as needed.

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

8-7.4. High-Pressure Tube Repair - Using End Replacement.

Limitations:

- High-pressure hose must be used for high-pressure repairs.

Personnel/Time Required:

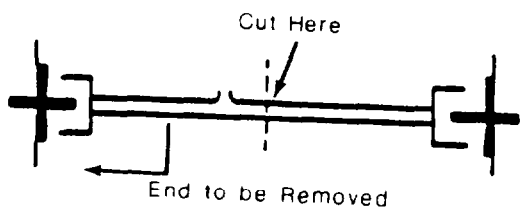
- 1 soldier - 1.5 hrs.

Materials/Tools:

- Hose Fitting(s) (Male)
- Hose Fitting(s) (Female)
- Hose, Hydraulic, High-Pressure
- Tube Fittings, Female, Flareless
- Tape
- Vise
- Tool Kit
- Saw (appendix B, section ii, item 14)

Procedural Steps:

a. Squarely cut off the damaged section of the tube that will be replaced by the hose (see para 8-17). Remove the tube to be replaced from the vehicle.



b. Assemble the flareless fitting (see para 8-18).

c. Measure the correct length of replacement hose (see para 8-14) and cut to the correct length (see para 8-14 and 8-15).

d. Assemble the male fitting on one end and the female fitting on the other end of the replacement hose (see para 8-16).

e. install the assembled hose on the vehicle.

f. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

g. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

h. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reervoir as needed.

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

8-7.5. High-Pressure Tube Repair - Using Hose and Union.

Limitations:

- High-pressure hose must be used for high-pressure repair.

Personnel/Time Required:

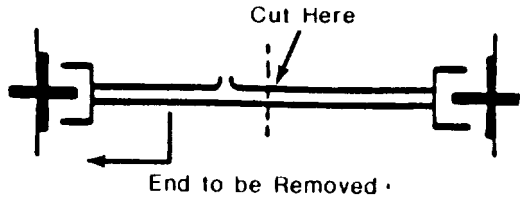
- 1 soldier - 1.5 hrs.

Materials/Tools:

- Tool Kit
- Hose Fitting(s) (Female)
- Hose, Hydraulic, High-Pressure
- Hex Union
- Tube Fitting(s), Female, Flareless
- Tape
- Saw
- Vise

Procedural Steps:

a. Squarely cut off the damaged section of the tube that will be replaced by the hose (see para 8-17). Remove the tube to be replaced.



b. Assemble the flareless fitting (see pare 8-16).

c. Measure the correct length of replacement hose (see para 8-14) and cut to the correct length (see para 8-15).

d. Assemble female fittings to both ends of the replacement hose (see para 8-16).

e. install the assembled hose on the vehicle.

f. Connect the union to the hose fitting.

g. Connect the tube end to the union.

h. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

i. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

j. Check the hydraulic reservoir level again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-7.8. Low-Pressure Tube Repair - Using Neoprene Hose and Clamps.

Limitations:

- Repair recommended for low-pressure tube repairs only.

Personnel/Time Required:

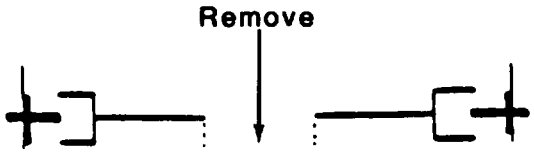
- 1 soldier - 50 minutes

Materials/Tools:

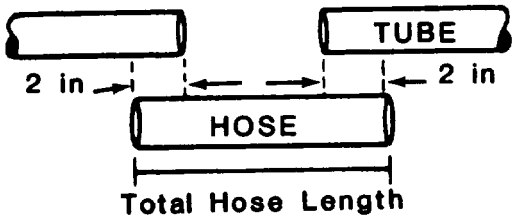
- Tool Kit
- Hose Clamp(s)
- Hose, Hydraulic
- Hacksaw
- Sandpaper (appendix C, section II, item 30)

Procedural Steps:

a. Squarely cut out the damaged section of the tube that will be replaced by the hose (see para 8-17).



b. Measure the replacement hose so that there are at least two inches of hose covering each end of the tube.



c. Cut the correct length of replacement hose (see para 8-15).

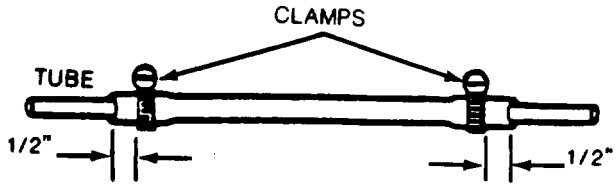
d. Attach the hose to the tube with clamps:

(1) Roughen the ends of the tube with coarse sandpaper.

(2) Slide the clamps to the middle of the hose.

(3) Slide the hose over the roughened area of the tube.

(4) Tighten the clamps over the area where the tube and hose connect.



e. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

f. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir level again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-7.7. Low-Pressure Tube Repair – Using Neoprene and Clamps.

Limitations:

• This fix is most effective for small punctures in low-pressure tubes.

Personnel/lime Required:

• 1 soldier – 30 minutes

Materials/Tools:

• Tool Kit

• Hose Clamp(s)

• Neoprene Mat (appendix C, section II item 18)

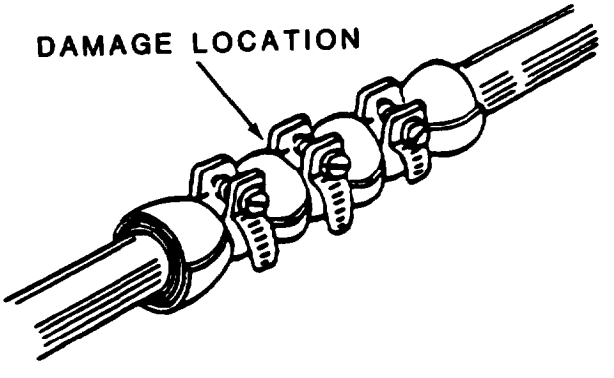
Procedural Steps:

a. Use pliers to carefully bend the protruding tubing back as close to the original position as possible.

b. Wrap neoprene around the damaged area of the tube as tightly as possible.

c. Disassemble the hose clamps, wrap them around the neoprene piece, and reassemble.

d. Tighten the hose clamps directly over the damaged area of the tube with a screwdriver or wrench.



e. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid leve. if this level is low refer to para 8-13 and fill the reservoir as needed.

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

8-8. Hydraulic Tube Isolation. The following options explain how to isolate damaged hydraulic tubes. Before isolating a tube, determine what effect the isolation will have on the capabilities of the system. Use one of the following options to isolate a hydraulic tube. Determine if the damaged tube is high-pressure or low-pressure tube. Damaged high-pressure tubes require high-pressure isolation. Damaged low-pressure tubes may be isolated by either high- or low-pressure isolation; however, high-pressure isolations are preferred.

8-8.1. High-Pressure Tube Isolation – By Cap Or Plug.

Personnel/Time Required:

- 1 soldier – 25 minutes

Materials/Tools:

- Tool Kit (appendix C, section ii, item 25)
- Plug (appendix C, section ii, item 25)

Procedural Steps:

a. Remove the damaged hose with an adjustable wrench.

b. install a plug or cap where the tube was previously connected.

c. Tighten the plug or cap with an adjustable wrench.

d. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

e. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

f. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-8.2. High-Pressure lube Isolation – By Crimping Damaged End.

Limitations:

- Not recommended for one-inch or larger tubes.

Personnel//Time Required:

• 1 soldier – .5 hr.

Materials/Tools:

• Tool Kit

• Hacksaw

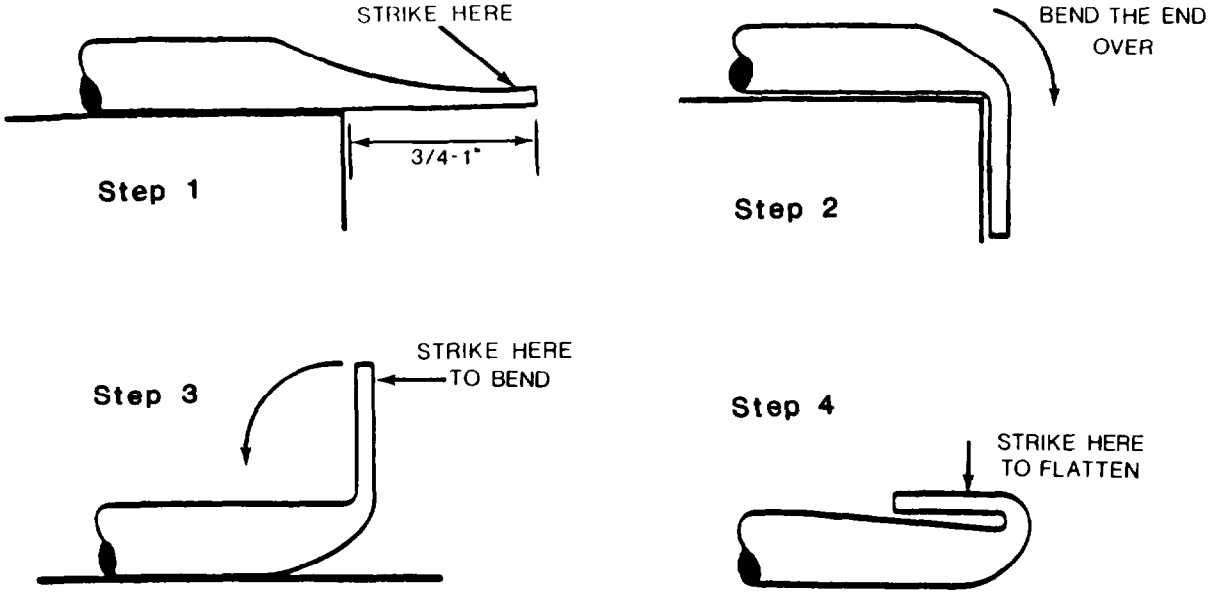
Procedural Steps:

a. Remove the tube from the vehicle.

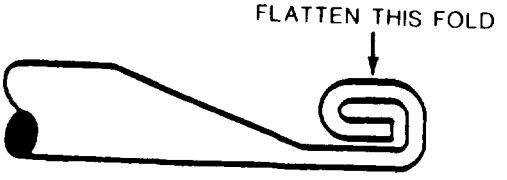
b. Cut the damaged section from the tube (see para 8-17).

c. Flatten the end of the remaining tube 5-6 inches from the end.

d. Crimp the tube using four steps as shown.



e. Repeat Steps 1-4 to develop another fold. This should also be flattened when the fold is made.



f. install the crimped tube on the vehicle.

g. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

h. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

i. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-8.3. Low-Pressure isolation – By Bullet Insertion

Limitations:

• Correct size bullet must be used.

Personnel/Time Required:

• 1 soldier – 1.0 hr.

Materials/Tools:

• Tool Kit

• Vise

• Blunt Punch

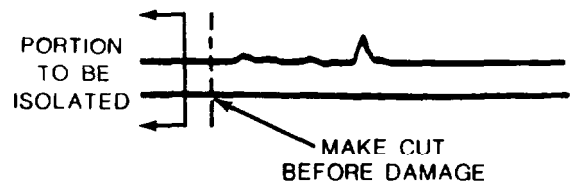
• Hacksaw

• Deleted.

WARNING

Extreme caution must be used when removing bullet from casing. Round detonation may cause serious injury or death.

Procedural Steps:



a. Remove the tube.

b. Cut the damaged end of the tube (see para 8-17).

c. Remove the bullet from the casing.

d. Plugging the end of the tube:

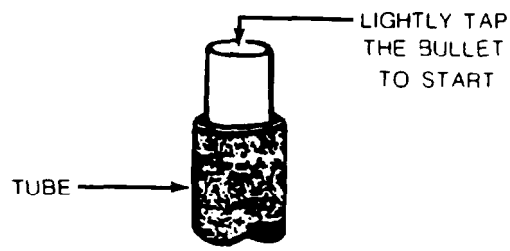
(1) insert the tube into a vise. Leave approximately 2½ inches of the tube protruding from the vise.

(2) Lubricate the bullet with oil or hydraulic fluid.

(3) Place the bullet in the tube with the pointed end in the tube.

NOTE

Make sure the bullet Is straight before hitting it.

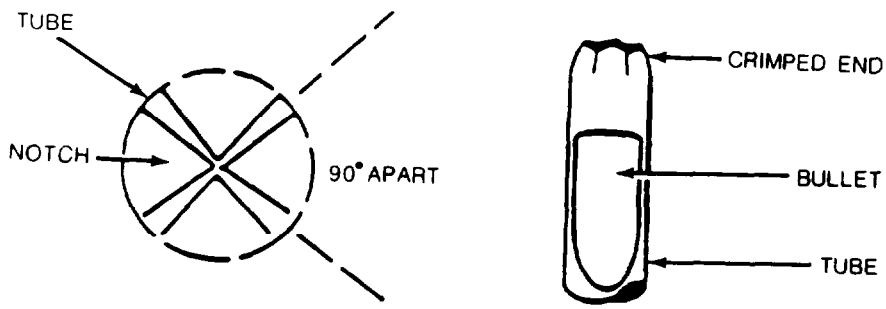


(4) Lightly tap the bullet to start it into the tube.

(5) Hammer the bullet until it is flush with the tube end.

(6) At this point, push the bullet farther into the tube with the hammer and blunt punch. Push it approximately ½ inch into the tube.

(7) Form a star crimp around the end of the tube with the hammer and blunt punch. The notches should be placed 90° apart.



e. install the plugged tube into the vehicle.

f. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

g. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

h. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid leve. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

Section IV. MASTER CYLINDER REPAIRS

8-9. O-Ring Fabrication (From Rubber).

Limitations:

• Repair may be ineffective for some O-ring configurations.

Personnel/Time Required:

• 1 soldier – 1.0 hr.

Materials/Tools:

• Pencil Or Pen

• Razor Blade Or Knife

• Neoprene Mat (appendix C, section II, item 18)

Procedural Steps:

a. Remove damaged O-ring.

b. Trace outline of damaged O-ring on replacement neoprene.

c. Cut the new O-ring from neoprene.

d. install the O-ring.

e. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the resevoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-10. Hydraulic Reservoir Repair. (Using Bolt or Stick and Neoprene).

Limitations:

• This repair is most effective with small holes.

Personnel/Time Required:

• 1 soldier – 20 minutes

Materials/Tools:

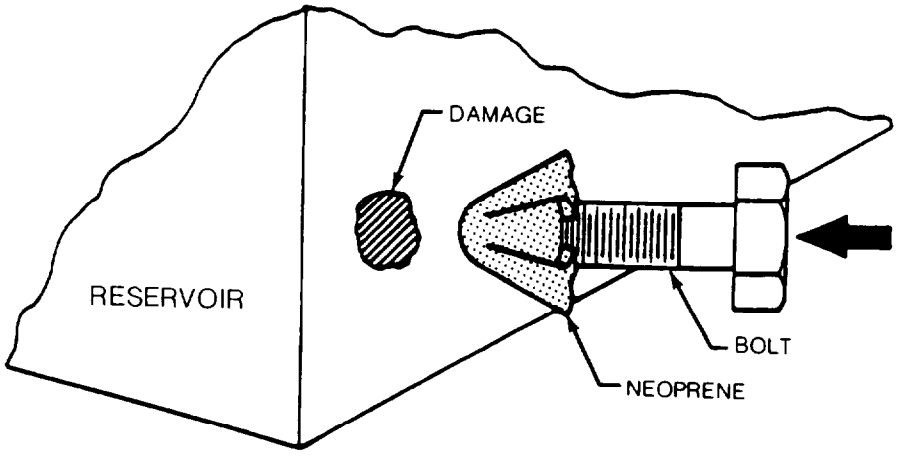
• Bolt

• Neoprene Mat (appendix C, section ii, item 18)

Procedural Steps:

a. Wrap the piece of neoprene around a bolt or stick.

b. insert the neoprene covered bolt or stick into the hole.



c. Additional bolts or sticks may be inserted to help assure a better seal.

d. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

e. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid teaks. Tighten leaking fittings.

f. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-11. Hydraulic Reservoir Replacement.

Limitations:

• This option permanently deforms the fittings used to connect the suction and return lines to the new reservoir.

Personnel/Time Required:

• 1 soldier – 2.0 hrs.

Materials/Tools:

• Tank

• Tool Kit

• Cutting Torch

• Weld (appendix C, section ii, item 48)

Procedural Steps:

a. Remove the damaged reservoir from the vehicle.

b. Remove the fittings from damaged reservoir.

c. Use a cutting torch to cut holes in the replacement reservoir in locations in which old reservoir fittings can be installed. if necessary, cut a hole in an appropriate area for a new filler hole. Use a cloth as a replacement cap.

c. Weld the old fittings into the holes of the new reservoir.

e. Flush the new reservoir with hydraulic fluid to remove much debris as possible.

f. Reconnect hydraulic lines to the new reservoir.

g. Secure the new reservoir to the vehicle with rope.

h. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

i. Operate ail hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

j. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. if this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-12. Hydraulic Cylinder Repair. For BDAR purposes, a damaged or inoperable hydraulic cylinder may be quickly repaired and made operable or partically operable, thus restoring the effectiveness of the equipment as a whole. Although some damage is irreversible, there are many cases where a fix-forward technique is feasible. This section provides useful information and procedures for several cylinder repairs.

8-12.1 Damaged Cylinder Body Repair – Using Weld.

Limitations:

- Piston seals will not seal properly over repaired area
- Hydraulic cylinder must be removed.

CAUTION

Caution must be used to prevent hydraulic fluid fire which could cause further damage to the equipment.

Personnel/Time Required:

- 2 soldiers – 2.0 hrs.

Materials/Tools:

- Tool Kit
- Welding Equipment
- Hoist
- Deleted.

Procedural Steps:

a. Relieve pressure of hydraulic System.

b. Remove cylinder.

c. Remove ail hydraulic fluid from cylinder.

d. Slide cylinder rod so that the piston is as far from damaged section as possible.

e. File any rough edges that are at the damaged point.

f. Weld steel plate over damaged area.

g. Install repaired cylinder.

h. Check that the hydraulic reservoir level is at least at the minimum operating level. if this level is low, refer to Para 8-13 and fill the reservoir as needed.

I. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

j. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to Para 8-13 and fill the reservoir as needed.

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

8-12.2 Repair of Piston Rod Damage to Prevent Rod Seal Destruction (Using File).

Limitation:

• Cylinder rod seals will not seal over damaged portion of rod, resulting in some leakage.

• Dirt may be carried into cylinder in damaged rod section, resulting in fluid damage.

• Rod may be weakened due to damage.

Personnel/Time Required:

• 1 soldier – 30 minutes

Materials/Tools:

• Sharpening Stone

• Tool Kit

Procedural Steps:

a. File down sharp edges at damaged point to original rod diameter.

b. Rub repaired area with cloth to check for snags and sharp points,

c. Repeat steps 1 and 2 until no snags occur.

d. Wash metal filings from rod using hydraulic fluid.

e. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

f. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

g. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-12.3 Repair of Piston Rod Damage to Prevent Rod Seal Destruction (Using Weld).

Limitations:

• Welding equipment is needed for this repair.

• Cylinder rod seals may not seal over repaired section of rod, resulting in some leakage.

• Dirt may be carried into cylinder at damaged rod section, resulting in fluid contamination.

• Rod may be weakened due to contamination.

CAUTION

Caution must be used to prevent hydraulic fluid fire which could cause further damage to the equipment.

Personnel/Time Required:

• 1 soldier – 1.0 hr.

Materials/Tools:

• Welding Equipment

• Tool Kit

• Sharpening Stone

Procedural Steps:

a. Remove all hydraulic fluid from around area to be welded.

b. Fill damaged area in rod with weld material.

c. File welded area down to original rod diameter.

d. Rub repaired area with cloth or rag to check for snags and sharp points.

e. Repeat steps c and d until no snags occur.

f. Wash metal filings from rod using hydraulic fluid.

g. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level Is low, refer to para 8-13 and fill the reservoir as needed.

h. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

i. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-12.4. Replace Damaged Piston Seals (Using Rubber Or Gasket Material).

Limitations:

- New seal may not be compatible with fluid.
- New seal may not hold high pressure.
- Some internal leakage may persist.
- Cylinder must be removed and disassembled.

Personnel/Time Required:

- 2 soldiers – 2.5 hrs.

Materials/Tools:

- Tool Kit
- Razor Blades
- Pencil Or Pen
- Hoist
- Neoprene Mat (appendix C, section II, item 18)

Procedural Steps:

a. Relieve pressure of hydraulic system.

b. Remove cylinder.

c. Remove bolts holding rod end of cylinder to cylinder body.

d. Carefully slide piston-rod end assembly out of cylinder body exposing piston seals.

e. Do not allow dirt to contaminate internal parts of the cylinder.

f. Remove damaged seal(s) from piston.

g. Trace outline of damaged seal(s) to neoprene mat or gasket material.

h. Cut the new seal(s) to neoprene mat or gasket material.

h. Cut the new seal(s) out carefully.

I. Install the new seal(s) on the piston.

j. Carefully slide piston-rod end assembly back into cylinder body.

k. Replace bolts holding rod end of cylinder to cylinder body and tighten.

I. Install repaired cylinder.

m. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

n. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

o. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

8-12.5. Replace Damaged Piston Seals (Using Rope or Twine)

Limitations:

- New seal may not be compatible with fluid.
- New seal may not hold high pressure.
- Some internal leakage may persist.
- Cylinder must be removed and disassembled.

Personnel/Time Required:

- 2 soldiers – 2.5 hrs.

Materials/Tools:

- Hoist
- Tool Kit
- Rope (appendix C, section II, item 26)

Procedural Steps:

a. Relieve pressure of vehicle hydraulic system.

b. Remove cylinder.

c. Remove bolts holding rod end of cylinder to cylinder body.

d. Carefully slide piston-rod end assembly out of cylinder body exposing piston seals.

e. Do not allow dirt to contaminate internal parts of the cylinder.

f. Remove damaged seal(s) from piston.

g. Wrap rope or twine around piston seal groove to find necessary length.

h. Cut the rope or twine to length.

I. Wrap the rope or twine around the piston in the piston seal groove.

j. Carefully slide piston-rod end assembly back into cylinder body.

k. Replace bolts holding rod end of cylinder to cylinder body and tighten.

i. Install repaired cylinder.

m. Check that the hydraulic reservoir level is at least at the minimum operating level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

n. Operate all hydraulic subsystems (except those that may still be damaged) to remove air from the system. Check carefully for fluid leaks. Tighten leaking fittings.

o. Check the hydraulic reservoir again to ensure a sufficient hydraulic fluid level. If this level is low, refer to para 8-13 and fill the reservoir as needed.

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

Section V. OPERATIONAL PROCEDURES

8-13. Hydraulic Fluid Substitution. The following table lists emergency alternative fluids for the hydraulic system. Fluids are ranked in order of substitution preference (see Table 8-1).

Table 8-1. HYDRAULIC FLUID SUBSTITUTION

PREFERENCE BANK	ALTERNATIVE FLUID	SEAL COMPATIBILITY	VISCOSITY RELATIVE TO BASIC FLUID
Basic Fluid	MIL-H-6083B	Compatible	Same
1	DEXRON II	Compatible	Same
2	MIL-L-46167 (OEA)	Compatible	Same
3	MIL-H-5617OA	Compatible	Same
4	MIL-H-5606B	Compatible	Same
5	MIL-L-2140C (OE/HDO-30)	Compatible	Higher
6	MIL-L-2104C (OE/HDO-10)	Compatible	Higher
7	SAE 10 Motor Oil	Compatible	Higher
8	MIL-L-23699A (Turbine Oil)	Moderate	Same Same
9	MIL-L-7808A -7808G	Moderate	Same
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

8-14. Determining Hose and Length.

Procedural Steps:

a. Measure the overall length of the replacement hose assembly.

b. Use a string to closely trace the path (end to end) that the hose follows. Tracing the path will allow accurate measurement of all the curves that the hose follows.

c. Do not pull the string taut. This will give an incorrect reading.

8-15 Cutting Hose.

Personnel/Tie Required:

- 1 soldier – 10 minutes

Materials/Tools:

- Hacksaw
- Scissors
- Axe
- Sledgehammer
- Tape, Masking (appendix C, section II, item 42)
- Oil (appendix C, section II, item 19)

Procedural Steps:

Option 1: Use a hacksaw.

a. Wrap the area of the cut with masking tape (if available).

b. Make your cut perpendicular to the length of the hose.

c. Remove the tape (if used).

d. Flush the hose with clean oil to remove foreign particles. Do not reuse flushing oil.

Option 2: Use an axe and a sledgehammer.

a. Wrap the area of the cut with masking tape (if available),

CAUTION

Do not rest the hose on anything that could be damaged by the axe as it passes through the hose. (If possible, place the hose on a piece of wood.)

b. Rest the cutting edge of the axe on top of the hose so that the axe is perpendicular to the length of the hose.

c. Carefully strike the axe with the hammer until the hose is separated,

d. Remove the tape (If used).

e. Flush the hose with clean oil to remove foreign particles. Do not reuse flushing oil.

8-16. Assembling Hose With Fittings.

Personnel/Time Required:

• 1 soldier – 15 minutes

Materials/Tools:

• Vise

• Fluid, Hydraulic

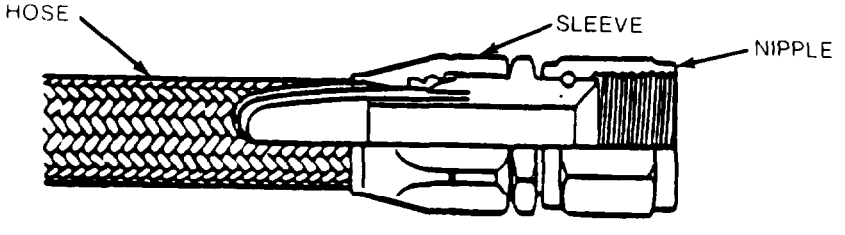
Procedural Steps:

a. Secure the outer sleeve in a vise with the small end facing out.

b. Dip the hose in hydraulic fluid or oil.

c. Turn the hose counterclockwise to screw the oiled end into the small end of the outer sleeve.

d. When the hose bottoms in the sleeve, remove the assembly from the vise.



e. Check to see that nothing has stopped the hose prematurely.

f. If the hose has bottomed, turn it clockwise ½ turn.

g. Remove the sleeve and hose from the vise. Place the large end of the sleeve facing up.

h. Dip the nipple end of the fitting hydraulic fluid or oil.

i. Turn the sleeve clockwise and apply downward pressure to screw the nipple into the sleeve.

j. Tighten the sleeve until the nipple hex makes contact with the sleeve.

8-17. Cutting The Tube.

Personnel/Time Required:

• 1 soldier – 5 minutes

Materials/Tools:

• Tube Cutter

• Oil (appendix C, section II, item 19)

NOTE

Make sure the tube is round after a cut. The fittings will not hold if the tube is not round.

a. Cut the tube with either a tube cutter or a hacksaw. Make the cut perpendicular to the length of the tube.

b. Deburr the ends of the tube, both internally and externally.

c. If a hacksaw is used, flush the tube with clean oil to clear it of metal filings. Do not reuse flushing oil.

8-18. Assembling Tube With Fittings.

Personnel/Time Required:

• 1 soldier – 15 minutes

Materials/Tools:

• Tool Kit

• Fitting, Flareless

• Fluid Hydraulic

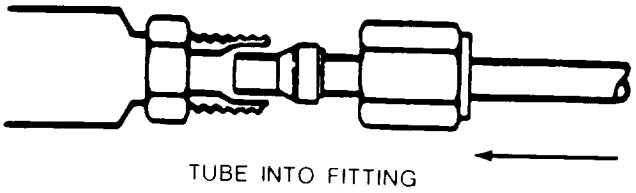
Procedural Steps:

a. Place the flareless fitting in a vise.

b. Lubricate the ends of the fitting with hydraulic fluid or oil.

c. Slide the nut and ferrule onto the tube.

d. Insert the tube and ferrule into the flareless fitting.



e. Screw the nut onto the fitting by hand until it Is “finger tight.”

f. Hold the tube against the shoulder of the fitting and tighten the nut with a wrench until it feels snug.

g. Tighten the nut one more turn.

h. Remove the nut.

i. Inspect the lead edge of the ferrule for a “correct bite” of ferrule onto the tube.

j. The tube with the ferrule and nut is now ready for assembly.

8-19. Installation of Hose Section With Hose Splice, For All Hose Sizes Smaller Than 1 Inch.

Personnel/Time Required:

• 1 soldier – 10 minutes

Materials/Tools:

• Tool Kit

• Clamp(s)

• Hose Splice Fitting

Procedural Steps:

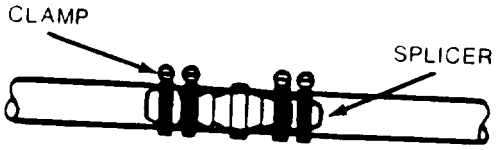
a. Slide two clamps onto the existing hose end. Do not tighten,

b. Push the hose splice into the end of the existing hose.

c. Slide two clamps onto the other hose end.

d. Push the hose splice into the end of the replacement hose.

e. Slide the clamps so they cover the hose splice on either side.



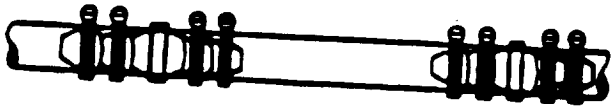
f. Tighten the clamps with a screwdriver.

g. Repeat Steps a-f for the other hose end.

8-20. Installation of Hose Section With Hose Splice, For All Hose Sizes 1 Inch or Longer.

Personnel/Tools Required:

• 1 soldier – 10 minutes



Materials/Tools:

• Tool Kit

• Clamp(s)

• Hose Splice Fitting

Procedural Steps:

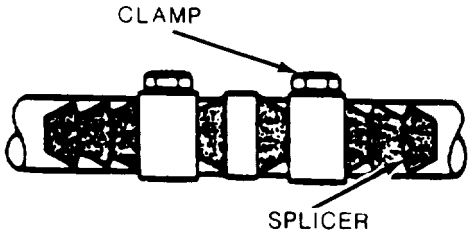
a. Place one heavy-duty hose clamp onto the existing hose. Do not tighten.

b. Push the hose splice into the end of the existing hose.

c. Slide one heavy-duty hose clamp onto the replacement hose.

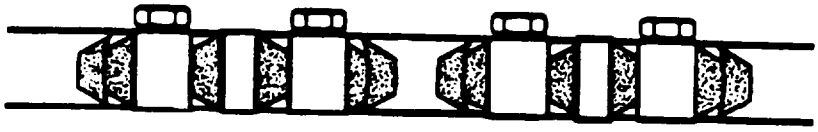
d. Push the hose splice Into the replacement hose section.

e. Slide the clamps so they cover the hose splice on either side.



f. Tighten the clamps with an adjustable wrench.

g. Repeat Steps a-f for the other end of the hose.



APPENDIX A
REFERENCES

Publication Number	Title
DA PAM 738-750	The Army Maintenance Management System
FM 20-22	Vehicle Recovery Operations
FM 21-11	Artificial Respiration

APPENDIX B

SPECIAL AND FABRICATED TOOLS

Not Applicable

APPENDIX C

EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST

Section I. INTRODUCTION

C-1. Scope.

This appendix equipment/system lists expendable/durable supplies and materials you will need to make BDAR fixes on POL equipment. Items are listed alphabetically by the item name shown in the description column. These items are authorized to you by CTA 5-970, Expendable/Durable Items (Except Medical, Class, V, Repair Parts, and Heraldic Items) or CTA 8-100.

C.2 Explanation of Columns (Section II).

a. Column (1) – Item Number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material.

b. Column(2)–National Stock Number (NSN). This is the National Stock Number assigned to the item; use it to request or requisition the item.

c. Column (3)–Description. Indicates the Federal item name, and if required, a description to identify the item. The last line for each item indicates the Commercial and Government Entity Code (GAGEC) in parentheses followed by the part number.

d. Column (4)–Unit of Issue (U/I). Is the abbreviation of the types of units under which material is issued.

Section II. EXPENDABLE/DURABLE SUPPLIES AND MATERIALS

NOTE

In Section II, Expendable/Durable Supplies and Materials, there are not NSNs or U/Ls listed. The Description will include the item name ***only.*** This information is not available because of the nature of the items and the BDAR itself.

ITEM NUMBER	NSN	DESCRIPTION	U/I
1	8040-01-063-7509	ADHESIVE	GL
2	6135-00-835-7211	BATTERY (BA30)	EA
3	6135-00-112-1699	BATTERY (BA31)	EA
4	4110-00-274-6831	CABLE	RL
5	4020-00-240-2146	CORD, ELASTIC BUNGEE	SL
6	5975-00-451-5001	CORD, LIGHT TIE	EA
7	8040-00-914-0720	EPOXY	KT
8	9140-00-286-5287	FUEL, DIESEL	GL
9	8030-00-220-6973	GASKET	BT
10	8030-00-247-2525	GASKET SEALER (HARDING)	TU
11	8040-00-145-0450	GASKET SEALER (SILICONE)	TU
12	2610-00-051-9204	INNER TUBE	EA
13	9150-00-402-4478	OIL	QT
14	9150-00-186-6681	OIL, ENGINE	QT
15	9150-00-754-2635	OIL, TRANSMISSION	GL
16	8040-00-826-3535	PERMATEX	BT
17	4020-00-068-7907	ROPE	CL
18	8040-01-248-6104	RUBBER CEMENT	CN
19	4720-01-279-3042	RUBBER, FUEL LINE	EA
20	8030-01-146-2654	RUBBER LINE (SHEET)	EA
21	5350-00-224-7230	SAND PAPER	PG
22	8030-00-965-2004	SEALANT	KT
23	3439-00-184-8960	SOLDER	RL
24	3439-00-243-1882	SOLDER, ROSIN-CORE	RL
25	6850-00-274-5421	SOLVENT	GL
26	6850-00-598-7311	STOP LEAK CHEMICAL	CN
27	5340-01-029-9085	STRAPS, TIE DOWN	EA
28	4020-00-233-5980	STRING	BL
29	7610-00-802-8311	TAPE, DUCT	RL
30	5970-00-543-1005	TAPE, ELECTRICAL	RL
31	7510-00-266-6711	TAPE, MASKING	RL
32	8030-00-889-3535	TAPE, TEFLON	RL
33	8340-00-205-3323	TARP, CANVAS	EA
34	5970-00-815-1269	TUBING, HEAT SHRUNK	MT
35	5680-00-794-0784	WEATHER STRIPPING	EA
36	3439-00-178-8594	WELD	BX
37	6145-00-226-8812	WIRE, COMMO	RL
38	6145-00-432-8613	WIRE, COPPER	RL
39	5940-00-840-0139	WIRE, SPLICE	EA

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APPENDIX D
POL SUBSTITUTES

BOAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING AT THE DISCRETION OF THE COMMANDER. (AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E.) IN EITHER CASE, DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.

Section I. INTRODUCTION

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 non-fuels 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:

Primary. The correct product for the system.

Alternate. A product that closely matches the primary but will result in reduced performance. Using the alternate POL will have no effect on the durability of the system. There are not restrictions on the duration of use.

Emergency or Expendient. 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 both 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 or 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.

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 combustability 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 no 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. ***Blending Procedure.*** 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 vehicles fuel tanks. Blending in vehicles 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 reconnecting the pump inlet hose to the vehicle and recirculating the fuel for a minimum of 15 minutes.

(2) ***B/ending 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 10-15 gallons of an approved primary fuel and run the engine for at least ½ 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 ued is provided in order or priority. Cautions on incompatible fluids are mentioned and a means suggested to flush the system.

b. Table D-1 provides a list of basic fluids which can be used as substitutes (alternate and expedient). It is structured around the vehicle lubrication order. Alternate products shown are NATO equivalents to the US specifications and can really be considered primary fluids. There are no corresponding ASTM designators. The expedients are emergency only substitutions. They may cause one of 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 costraints on these expedients, but the shorter the time used is better.

P 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, refilling with the proper product, operating to insure complete circulation and when possible stable operating temperature (this usually means at least ½ hour), a redrain and refill. 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. As a last resort only, operate without filters. While systems should not be disassembled to inspect seals, maintenance organizations should 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 repacked with the proper product.

Section II. TABLES

Table D-1. Fuels and Substitute Fuels

(Listed in Order of Priority)

Primary Fuels

1. W-F-800 (Diesel Fuels) (DF-1, DF-2, DF-A)
2. NATO-F-54 (Diesel Fuel, Military)
3. ASTM-D-975 (Automotive Diesel) (1-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) (Jet A-1)
8. ASTM-D-2880 (Turbine Fuel) (OGT, 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) (FO-1 & FO-2)
12. NATO-F-75 (Navy Distillate) (Low Pour Point)
13. ASTM-D-396 (Fuel Oil) (No. 1 & 2)

With Fuel Extenders (Blends up to half and half – 50 percent extender)

Base	Extender
14. Any Primary Fuel	Any Alternate Fuel
15. Any Alternate Fuel	Any Alternate Fuel
16. MIL-F-815	Any lighter primary or alternate
17. NATO-F-76	Any lighter primary or alternate
18. Any Diesel Fuel	P-D-680 (Type I & II) (Dry Cleaning 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 change these will have acceptable cetane.

Table D-1. FUELS AND SUBSTITUTE FUELS
(Continued)

Expedient (Emergency) Fuel

Blends with other fuels or extenders (note blend rates stated).

Base	Extender
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 Strained&filtered through
6. Any Alternate Fuel	Used engine oil charcoal or cloth. Any significant quality of water must be removed.

** Gasolines
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. W-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)

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.

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By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

WILLIAM J. MEEHAN, II
Brigadier General United States Army
The Adjutant General

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(qty rqr block no. 1171) Operator Maintenance requirements for Lubricating and Service Unit, Gas Driven, Trailer Mounted, 23 CFM Compressor (901-1765-1) (TM 5-4930-207 Series).

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(qty rqr block no. 1381) Operator Maintenance requirements for Pump, Centrifugal, Petroleum Pipeline, Gasoline, Skid Mounted, Model CE4P4 (TM 5-9222).

(qty rqr block no. 1384) Operator Maintenance requirements for Pump, Centrifugal, Pneumatic Sump, 210 GPM Model 251 (TM 5-4320-255-13).

(qty rqr block no. 1387) Operator Maintenance requirements for Pump, Centrifugal, Petroleum, Gas Driven, Skid Mounted, 500 GPM-555 FT Head, 1400 GPM/275 FT Head (PP113) (TM 5-4320-217 Series).

(qty rqr block no. 1390) Operator Maintenance requirements for Pump, Centrifugal, Self-priming, Gas Driven, Skid Mounted, 1120 GPM, 6 IN (K906EWA) (TM 5-4320-233 Series).

(qty rqr block no. 1393) Operator Maintenance requirements for Pump, Centrifugal, Gas Driven, Skid Mounted, 1120 GPM, 6 IN (K906MP) (TM 5-4320-240 Series).

(qty rqr block no. 1399) Operator Maintenance requirements for Pump, Centrifugal, Petroleum Pipeline, Gas Driven, Skid Mounted (GP75) (4-INUSPL) (CE4P-4) (TM 5-4320-225 Series).

(qty rqr block no. 1402) Operator Maintenance requirements for Pump, Centrifugal, Petroleum, Trailer Mounted, 350GPM, 275 FT Head, 4 IN (0412-MVG4D, 04A12B-MVG4D) (TM 5-4320-218 Series).

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(qty rqr block no. 1420) Operator Maintenance requirements for Pump, Reciprocating, Diaphragm, Gas Driven, Wheel Mounted, 100 GPM, 10 FT Lift, 4 IN (4D-327) (TM 5-4320222 Series).

(qty rqr block no. 1423) Operator Maintenance requirements for Pump, Reciprocating, Diaphragm, Gas Driven, Power Driven, Wheel Mounted, 100 GPM (4D-2A016) (TM 5-4320-251 Series).

(qty rqr block no. 1426) Operator Maintenance requirements for Pump, Reciprocating, Diaphragm, Gas Driven, Power Driven, Wheel Mounted (US40CDG) (TM 5-4320-275-13&P).

(qty rqr block no. 2449) Operator Maintenance requirements for Pump Unit, Centrifugal, Water (13213E2578) (TM 5-4320-302 Series).

(qty rqr block no. 2455) Operator Maintenance requirements for Pump Unit, Centrifugal (A52109H) (TM 5-4320-304 Series.

(qty rqr block no. 2458) Operator Maintenance requirements for Pumping Assembly, 600 GPM (TM 5-4320-305 Series).

(qty rqr block no. 2461) Operator Maintenance requirements for Pumping Assembly, 1250 GPM (TM 5-4320-306 Series).

(qty rqr block no. 2464) Operator Maintenance requirements for Pumping Assembly, QM2D (76910CA) (TM 5-4320-308 Series).

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PFC JOHN DOE
COA, 3d ENGINEER BN
FT. LEONARDWOOD, MO. 63108

DATE SENT

PUBLICATION NUMBER	PUBLICATION DATE	PUBLICATION TITLE
TM 5-3835-222-BD	23 June 1989	Battlefield Damage Assessment and Repair

BE EXACT. . .PIN-POINT WHERE IT IS

PAGE NO	PARA-GRAPH	FIGURE NO	TABLE NO
6	2-1 a		
B1		4-3	
125	line 20		

IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:

In line 6 of paragraph 2-1a the manual states the engine has 6 Cylenders. The engine on my set only has 4 Cylenders. Change the manual to show 4 Cylenders.

Callout 16 on figure 4-3 is pointing at a bolt. In key to figure 4-3, item 16 is called a shim - Please correct one or the other.

I ordered a gasket, item 19 on figure B-16 by NSN 2910-00-762-3001. I got a gasket but it doesn't fit. Supply says I got what I ordered, so the NSN is wrong. Please give me a good NSN

PRINTED NAME, GRADE OR TITLE, AND TELEPHONE NUMBER
JOHN DOE, PFC (268) 317-7111

SIGN HERE John Doe
JOHN DOE

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DEPARTMENT OF THE ARMY

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COMMANDER
U S ARMY TROOP SUPPORT COMMAND
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4300 GOODFELLOW BOULEVARD
ST. LOUIS, MO 63120-1798

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Commander
U.S. Army Troop Support Command
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U S ARMY TROOP SUPPORT COMMAND
ATTN: AMSTR-MCTS
4300 GOODFELLOW BOULEVARD
ST. LOUIS, MO 63120-1798

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 = .35 ounce grams
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measures

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*TO*	*Multiply by*	*To change*	*TO*	*Multiply by*
inches	centimeters	2.540	ounce-inches	newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	newton-meters	1.356	metric tons	short tons	1.102
pound-inches	newton-meters	.11296			

Temperature (Exact)

°F Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C