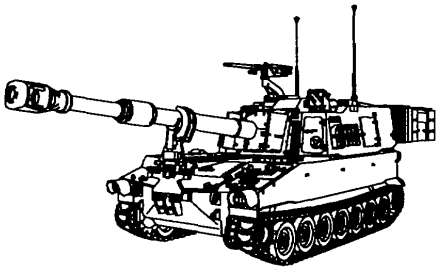
TECHNICAL MANUAL

OPERATOR'S, UNIT,
AND DIRECT
SUPPORT MAINTENANCE



BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR

FOR

HOWITER, MEDIUM,
SELF-PROPELLED:
155MM, M109A6
(NSN 2350-01-305-0028)
(EIC:3FC)

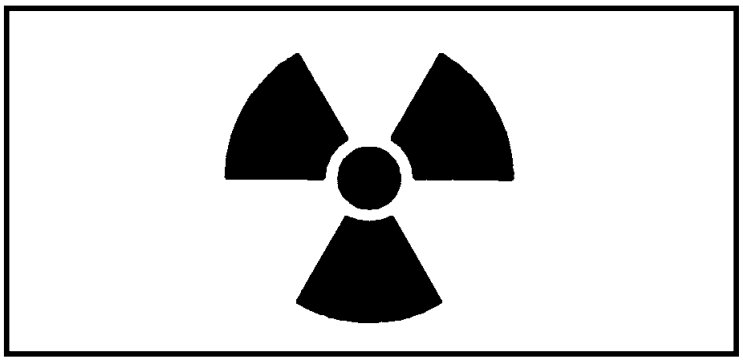
HEADQUARTERS, DEPARTMENT OF THE ARMY
25 MARCH 1994

WARNING

This technical manual contains nonstandard maintenance procedures. All normal safety procedures should be observed when the tactical situation permits. Extra care will be taken when the tactical situation requires performing maintenance with ammunition up-loaded and when fuels and lubricants are spilled in hull and cab.

WARNING

RADIOACTIVE MATERIAL(S)



TRITIUM (HYDROGEN-3) GAS

Handle with care in the event the radioluminous source is broken, cracked or there is no illumination, immediately wrap device in plastic bag (item 3, Appendix C) and notify the local Radiation Protection Officer (RPO). Contact the base safety office for the name and telephone number of your local RPO.

LOCAL RPO _____ TELEPHONE. _____

SAFETY PROCEDURES FOR NUCLEAR REGULATORY COMMISSION
(NRC) TRITIUM FIRE CONTROL DEVICES

1. **Purpose**: To implement mandatory license requirements for use and maintenance of tritium radioluminous fire control devices used on howitzers, mortars, tanks, and rifles.

2. **Scope**: This procedure is applicable to all personnel working with tritium devices, including unit, direct support, general support maintenance, and operator's levels.

3. **Radiological hazard**: The beta radiation emitted by tritium presents no external radiation hazard. However, if taken internally, it can damage soft tissue. If a capsule is broken, the tritium gas will dissipate into the surrounding air and surfaces near the vicinity of the break may become contaminated. Tritium can be taken into the body by inhalation, ingestion, or percutaneous (skin) absorption/injection.

4. **Safety precautions**.

   a. Check for illumination prior to use or service in low light or darkroom. If not illuminated, do not repair . Wrap the entire device in plastic bag (item 3, Appendix C) and notify the local RPO.

   b. No eating, drinking, or smoking will be allowed in tritium device work areas.

5. **Emergency procedures**: If a tritium source breaks, inform other personnel to vacate the area or move upwind. If skin contact is made with any area contaminated with tritium, wash immediately with

nonabrasive soap and water. Report the incident to the local RPO. Actions below will be taken under supervision or direction of the local RPO.

a. Personnel handling the device should wear rubber or latex gloves (item 32, Appendix C). Device must be immediately double wrapped in plastic, sealed (item 64, Appendix C) packaged (item 4, Appendix C), and evacuated to depot. Outside package must be identified as "Broken Tritium Device - Do Not Open." Dispose of used gloves as radioactive waste, per instructions from local RPO and wash hands well.

b. Personnel who may have handled the broken tritium should report to health clinic for tritium bioassay. Optimum bioassay sample is at least 4 hours after exposure.

c. Broken tritium sources indoors may result in tritium contamination in the area, such as work bench or table. The area must be cordoned off, restricted until wipe tests indicate no contamination.

6. Further information.

a. Requirements for safe handling and maintenance are located in TM 9-254, General Maintenance Procedures for Fire Control Materiel.

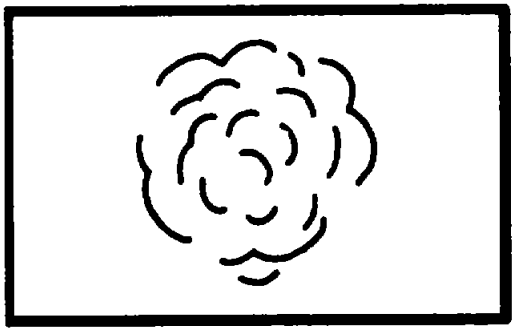
b. If assistance is needed, contact your local or major command (MACOM) safety office (s) for information on safe handling, shipping, storage, maintenance, or disposal of radioactive devices.

c. The AMCCOM RPO/licensee may be contacted by calling DSN 793-2965/2969/2995, Commercial (309) 782-2965/2969/2995. After duty hours contact the Staff Duty Office through the operator at DSN 793-6001, Commercial (309) 782-6001. The following rules and regulations are available from HQ, AMCCOM, ATTN AMSMC-SFS. Rock Island, IL 61299-6000. Copies may be requested, or further information obtained by contacting the AMCCOM Radiation Protection Officer (RPO).

(1) 10 CFR Part 19 - Notices, Instructions, and Reports to Workers.

(2) 10 CFR Part 20- Standards for Protection Against Radiation.

(3) NRC License, License Conditions, and License Application.



WARNING

CARBON MONOXIDE POISONING IS DEADLY

Carbon monoxide is a colorless, odorless, deadly poisonous gas, which, when breathed, deprives the body of oxygen and causes suffocation. Exposure to carbon monoxide produces headache, dizziness, loss of muscular control, drowsiness, and coma. Permanent brain damage or death can result from severe exposure.

Carbon Monoxide occurs in the exhaust of fuel-burning heaters and internal-combustion engines and becomes dangerously concentrated under conditions of inadequate ventilation. The following precautions must be observed to ensure the safety of personnel whenever the personnel heater, main, or auxiliary engine of any vehicle is operated for maintenance purposes or tactical use.

THE BEST DEFENSE AGAINST CARBON MONOXIDE POISONING IS ADEQUATE VENTILATION

1. DO NOT operate heater or engine of vehicle in an enclosed area unless it is ADEQUATELY VENTILATED.

2. DO NOT idle engine for long periods without maintaining adequate ventilation in personnel compartments.

3. DO NOT drive any vehicle with inspection plates, cover plates, or engine compartment doors removed unless necessary for maintenance purposes.

4. BE ALERT at all times during vehicle operation for exhaust odors and exposure symptoms. If either are present, IMMEDIATELY VENTILATE personnel compartments. If symptoms persist, remove affected personnel from vehicle and treat as follows: Expose to fresh air, keep warm, do not permit physical exercise; if necessary, administer artificial respiration. For detailed first aid instruction consult FM 21-11, First Aid for Soldiers

WARNING

NOISE HAZARD

Excessive noise levels are present any time the equipment is operating. Wear hearing protection while operating or working around equipment while it is running. Failure to do so could result in damage to your hearing. Seek medical aid should you suspect a hearing problem (ref FM 21-11).

WARNING

FALLING EQUIPMENT HAZARD

Never crawl under equipment when performing maintenance unless equipment Is securely blocked. Keep clear of equipment when it is being raised or lowered. Do not allow heavy components to swing while suspended by lifting device. Exercise extreme caution when working near a cable under tension. In case of personnel injury, seek medical aid Immediately (ref FM 21-11).

WARNING

FIRE HAZARD

Diesel fuel and combustible materials are used in operation and maintenance of this equipment. Do not smoke or allow open flames or sparks in areas where diesel fuel and combustible materials are used or stored. DEATH or severe injury may result if personnel fall to observe this precaution. If you are burned, seek medical aid immediately (ref FM 21-11).

WARNING

STEAM UNDER PRESSURE

When the engine is hot, remove radiator cap slowly to relieve pressure before complete removal. Failure to follow this procedure could cause SEVERE INJURY. If you are scalded by steam, seek medical aid immediately (ref FM 21-11).

WARNING

DO NOT USE MINERAL SPIRITS OR PAINT THINNER TO CLEAN THE HOWITZER.

Mineral spirits, paint thinners are highly toxic and combustible. Prolonged breathing can cause dizziness, nausea, and even death (ref FM 21-11).

DO NOT USE THESE MATERIALS

WARNING

DRY-CLEANING SOLVENT

Dry-cleaning solvent (PD-680) used to clean parts, is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Do not use near open flame or excessive heat. Do not smoke when using solvent. Failure to do so could cause SERIOUS INJURY. If you become dizzy while using cleaning solvent, get fresh air immediately, and if necessary, get medical attention. If contact with skin or clothes is made, flush thoroughly with water. If the solvent contacts your eyes, wash with water immediately, and obtain medical aid (ref FM 21-11).

WARNING

FLAMMABLE

Battery gases can explode. Do not smoke, have an open flame, or create sparks around a battery, especially if the caps are off. SEVERE INJURY may result if you fall to heed this warning. Seek medical aid immediately should explosion occur (ref FM 21-11).

WARNING

BURN HAZARD

Batteries contain sulfuric acid which can cause severe burns. Avoid contact with skin, eyes, or clothing, and remove all metal or jewelry. If battery electrolyte is spilled, stop its burning effects immediately (ref FM 21-11).

WARNING

ELECTRICAL HAZARD

Be certain MASTER power switch Is off when working on the electrical system to prevent injury due to electrical shock (ref FM 21-11)

WARNING

NBC HAZARD

If Nuclear Biological Chemical (NBC) exposure is suspected, all air filter media must be handled by personnel wearing full NBC protective equipment (ref FM 21-11).

WARNING

ROTATION HAZARD

Installed or removed, the rotation of the radiator cooling fans creates a hazard during maintenance on a running engine. Exercise care to prevent injury, especially to fingers and hands, during maintenance operations on a running engine (ref FM 21-11).

WARNING

FALLING EQUIPMENT/ROLLING VEHICLE HAZARD

Unless otherwise specified, perform all maintenance procedures with all equipment lowered to the ground, transmission in neutral, parking/emergency brake applied, and the engine stopped to prevent possible injury to personnel due to falling equipment or rolling vehicle (ref. FM 21-11).

WARNING

EXPLOSION HAZARD

Cylinders containing compressed gases must not be dropped, struck, or subjected to any temperature above +140°F (+60°C). This could result in an explosion and injury to personnel (ref FM 21-11).

WARNING

TOXIC MATERIAL

Phosphorus material on inside of night viewer is toxic if tube is broken. Be careful not to inhale or allow contact with open skin wounds or with mouth.

WARNING

BDAR team personnel must be made aware of the provisions of TB 9-1300-278, guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor which contain Depleted Uranium. Incorrect handling, storage and transporting can result in serious injury or death to personnel.

Technical Manual
TM 9-2350-358-BD

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington D.C., 25 March 1994

OPERATOR, UNIT, AND DIRECT SUPPORT MAINTENANCE

BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR

FOR

HOWITZER, MEDIUM, SELF-PROPELLED:

155MM M109A6 (NSN 2350-01-305-0028)

REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistake or if you know of a way to improve the procedures, please let us know Mall your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2, located in the back of this manual, directly to Commander, US Army Armament, Munitions, and Chemical Command, ATTN AMSMC-MAS, Rock Island, IL 61299-6000 A reply will be furnished to you.

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HOW TO USE THIS MANUAL

Use this TM for expedient repairs or fixes on the M109A6 howitzer in battlefield environment. The repairs or fixes in this manual are not permanent nor are they normal maintenance procedures. When conditions allow, make normal repairs.

WARNINGS

Review warning pages prior to performing any procedure. Warnings in text are abbreviated ORGANIZATION.

ORGANIZATION

This manual contains general fault assessment tables in Chapter 2. These tables are organized by major howitzer system and direct you to detailed assessment procedures in other chapters. The detailed assessment procedures isolate the problem and lead to an expedient repair procedure, if one exists.

WHERE TO START

You must first determine which system, such as, engine, fuel, or cooling, has been damaged before beginning an expedient repair procedure in this manual. After you have identified the system, go to the table of contents, which will identify the chapter for the damaged system. Proceed to the appropriate fault assessment table to determine the fault, which in turn will direct you to the procedure to repair it, if it exists. If you do not know what your problem is, use the assessment procedures described in Chapter 2.

HOW TO USE AN EXPEDIENT REPAIR PROCEDURE

You will find all the information you need to perform the procedure on the first page.

All of the information blocks are described in the following paragraphs.

GENERAL INFORMATION. You will find a brief description of what can happen when a given component is damaged and/or a general idea of what the expedient repair will accomplish.

APPLICABILITY. The data under this heading identifies whether or not the procedure is applicable to a specific model or component if the procedure is applicable to all models or components, this heading will not be listed.

LIMITATIONS. Operational limitations caused by the repair action that could cause further damage/degradation to the howitzer are listed here.

PERSONNEL/TIME REQUIRED. The estimated number of soldiers needed and estimated time required to complete the repair are listed here.

MATERIALS/TOOLS. If materials and/or tools, other than those commonly available to the crew, Maintenance Team (MT), and Maintenance Support Team (MST) are needed, they are listed in this manual. If the listed items are not available, you are requested to improvise. Virtually anything that will do the job is acceptable.

OTHER OPTION(S). This lists other options you can use depending on availability of personnel, material, tools, and/or time. This does not include standard maintenance procedures or recovery. This list is not all inclusive, therefore other means of repair may be available, but not included in this manual. Anything that you can do to effect a repair is acceptable.

HOW TO USE THIS MANUAL - CONTINUED

APPENDIXES

At the back of this manual, you will find Appendixes A thru E. Following is a list of these appendixes and a brief description.

APPENDIX A - REFERENCES Lists publications referenced in this manual.

APPENDIX B - SPECIAL OR FABRICATED TOOLS. Lists peculiar tools, fabricated tools, and test equipment.

APPENDIX C - EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST. Lists supplies and materials available for BDAR fixes.

APPENDIX D - SUBSTITUTE MATERIALS/PARTS. Lists repair parts which can be taken from other systems and used on the M109A6 howitzer, other countries with U S. combat vehicle, and substitutes for POL (petroleum, oils, and lubricants) used for the M109A6 howitzer.

APPENDIX E - BDAR FIXES AUTHORIZED FOR TRAINING. Lists BDAR fixes that have been approved for training. Training procedures are shown boxed in the index at the front of each chapter.

LIST OF ABBREVIATIONS/ACRONYMS

AFCS	Automated Fire Control System
ASTM	American Society of Testing and Measurements
AWG	American Wire Gage
BD	Battlefield Damage
BDA	Battlefield Damage Assessment
BDAR	Battlefield Damage Assessment and Repair
BDR	Battlefield Damage Repair
CAGE	Commercial and Government Entity
CC	Combat Capable
CEC	Combat Emergency Capable
CLP	Cleaner, Lubricant Preservative
CTA	Common Table of Allowances
CVC	Communications Vehicular Crewman
DA	Department of the Army
DD	Department of Defense
DOD	Department of Defense
EIR	Equipment Improvement Recommendation

LIST OF ABBREVIATIONS/ACRONYMS - CONTINUED

FM	Field Manual
FMC	Fully Mission Capable
GAA	Grease, Automotive and Artillery
GGP	Grease, General Purpose
GMD	Grease, Molybdenum Disulfide
GO	Lubricating Oil, Gear
JP	Jet Petroleum
LED	Light Emitting Diode
LO	Lubrication Order
LOMD	Lubricating Oil, Molybdenum Disulfide
LRU	Line Replaceable Unit
MCS	Microclimate Conditioning System
METT-T	Mission, Enemy, Terrain, Troops and Time
MFCC	Minimum Functional Combat Capability
MPH	Miles Per Hour
MST	Maintenance Support Team
MT	Maintenance Team
NATO	North Atlantic Treaty Organization
NIIN	National Item Identification Number
NBC	Nuclear, Biological, or Chemical
NSN	National Stock Number
OEA	Lubricating Oil, Internal Combustion Engine, Arctic
OE/HDD	Hydraulic Fluid Petroleum Base, Aircraft Missle and Ordnance
OHT	Hydraulic Fluid, Petroleum Base Preservative, Hydraulic Equipment
OMCP	Organizational Maintenance Command Post
ORS	O-ring Seal
O-156	Lubricating Oil, Aircraft Turbine Engine
PLS	Lubricating Oil, General Purpose, Preservative
PMCS	Preventive Maintenance Checks and Services

LIST OF ABBREVIATIONS/ACRONYMS - CONTINUED

POL	Petroleum, Oil, and Lubricant
QDR	Quality Deficiency Report
RBC	Rifle Bore Cleaner
RF	Radio Frequency
RFI	Radio Frequency Interference
RPO	Radiological Protection Officer
SF	Standard Form
SRC	Self-Recovery Capable
TAMMS	The Army Maintenance Management System
TM	Technical Manual
TMDE	Test, Measurement, and Diagnostic Equipment
U/I	Unit Of Issue
Vdc	Voltage Direct Current

CHAPTER 1

GENERAL INFORMATION

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

1-1. PURPOSE

a. This Technical Manual (TM) is for use by operators, unit, and direct support maintenance personnel. It provides procedures and guidelines for battlefield repairs on the M109A6 howitzer under the forward support maintenance concept during combat.

b. The purpose of Battlefield Damage Assessment and Repair (BDAR) is to rapidly return disabled combat equipment to the operational commander by expediently repairing, bypassing, or jury-rigging components to restore the minimum essential systems required for the support of a combat mission or to enable the howitzer to self-recover. These repairs are temporary, and may not restore full performance capability, and must be replaced with standard repairs at the first opportunity. For further Information on doctrine and guidance, see FM 20-30.

1-2. SCOPE

a. This TM describes BDAR procedures applicable specifically to M109A6 howitzers. For further information on expedient repairs of a general nature applicable to systems or subsystems common to more than one combat vehicle, see TM 9-2350-276-BD.

b. Many repair techniques helpful in preparing a howitzer 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. For further information on recovery-associated expedient repairs, see FM 20-22.

c. All possible types of combat damage and failure modes cannot be predicted, nor are all effective field repairs known. This TM provides guidelines for assessing and repairing battlefield failures of the M109A6 howitzer and is not intended to be a complete catalog of all possible emergency repairs. The repairs described here serve as a guideline and are intended to stimulate the experienced mechanic to devise methods, as needed, to rapidly repair equipment in a combat crisis.

d. Use this TM in conjunction with the M109A6 howitzer system TM's (TM 9-2350-314 series) and Lubrication Order (LO 9-2350314-12). A complete listing of TMs is contained in Appendix A.

1-3. APPLICATIONS

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 in a battlefield environment. Standard maintenance procedures will provide the most effective means to return a damaged vehicle 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 or in training, and only at the direction of the commander.

1-3. APPLICATIONS - CONTINUED

b. BDAR techniques are not limited to simple restoration of minimum functional combat capability. If full functional capability 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 M109A6 howitzers. The commander must decide whether the risk of having one less howitzer available for combat outweighs the risk of applying the potentially destructive repair technique. Each technique gives appropriate warnings and cautions, and lists system limitations caused by this action.

1-4. DEFINITIONS

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

b. Battlefield Damage Assessment (BDA) 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, 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 at once.
(2) Isolate the damaged areas and components.
(3) Determine which components must be fixed.
(4) Prescribe fixes.
(5) Determine if parts of 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.

c. Battlefield Damage Repair (BDR) in this manual includes any expedient action that returns a damaged part or assembly to a full or an acceptably degraded operating condition, including:

(1) Short cuts in parts removal or installation.
(2) Installation of components from other vehicles that can be modified to fit or interchange with components on the M109A6 howitzer.
(3) Repair using M109A6 howitzer parts that serve a non-critical function elsewhere on the same howitzer 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.

1-4. DEFINITIONS - CONTINUED

d. Maintenance Teams (MT) consist of unit level mechanics, who may be trained in BDAR procedures MTs are called to out-of-action vehicles to supplement (or confirm) the crew's original damage assessment. MT assessment determines if field repairs will be conducted or if recovery is required. Depending on available time, the crew will assist the MT in restoring the vehicle to mission capability.

e. Maintenance Support Teams (MST) consist of direct support mechanics and technical specialists, who are trained in assessing battle damage in addition to their specialty. MSTs are called by the MT when vehicle damage exceeds MT assessment capability or unit repair capability.

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

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

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

h. Combat Capable (CC) means that the howitzer meets the Minimum Functional Combat Capability (MFCC) requirements (para 1-8).

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

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

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

l. Scavenge means to salvage components from other vehicles that are damaged and/or unserviceable.

1-5. QUALITY DEFICIENCY REPORT/EQUIPMENT IMPROVEMENT RECOMMENDATIONS (QDR/EIR)

If your howitzer needs improvement, let us know Send us an Equipment Improvement Recommendation (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 do not like the design. Put it on an SF 368 (Quality Deficiency Report). Mall it to us at Commander, U S. Army Armament, Munitions and Chemical Command, ATTN AMSMC-QAD, Rock Island, IL 61299-6000. We will send you a reply.

SECTION II. STANDARDS AND PRACTICES

1-6. BDAR CHARACTERISTICS

BDAR 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 M109A6 howitzers which are fueled or armed. Other similar precautions may be waived at the discretion of the commander.

1-8. OPERATING CHARACTERISTICS

The Minimum Functional Combat Capability (MFCC) criteria for the M109A6 howitzer are as follows:

NOTE

These criteria may be waived for recovery or if the tactical situation demands otherwise (combat emergency capable).

a. Armament and Fire Control.

(1) Main gun must have recoil mechanism, equilibrator, and cannon assembly.

(2) Must have an operational fire control device (primary or secondary).

b. Mobility.

(1) Must have operational track on both sides of the howitzer.

(2) May be missing roadwheels with the following stipulations.

(a) May not be missing more than a total of two individual roadwheels on each side.

(b) The first, second, and last roadwheel stations must each have complete sets of roadwheels.

(c) There must be a complete set of roadwheels between any two incomplete roadwheel stations.

(3) Drive train must be functional and must be capable of reverse and at least one forward gear.

(4) Power train performance degradation cannot exceed that level which would cause the howitzer to be incapable of traveling 10 miles per hour (mph) on a level, unimproved road.

(5) Must be capable of normal braking/stopping from 10 mph and brakes must hold on a 30 percent slope.

(6) Vehicle steering system must be operational.

c. Communications. Must have intercom between chief-of-section and driver.

1-9. TRAINING

The Unit Commander must ensure that an adequate number of members of his organization, including supervisors, are trained In BDAR procedures applicable to his equipment. Each howitzer crewman should be trained to perform initial battle damage assessment for his crew position. The BDAR procedures which are contained within boxes on the BDAR procedure index at the beginning of each chapter are those authorized for training purposes. A summary listing of these training procedures is also presented in 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 limitation in personnel, facilities, equipment, and materials. Performance of repair tasks may be necessary while wearing protective gear. For further information on decontamination procedures, see FM 3-5.

1-11. PERMANENT REPAIR

Upon completion of the mission, or at the next practicable opportunity, the howitzer will be recovered or evacuated to the appropriate maintenance facility for permanent standard repair as required.

SECTION III. TASKS AND RESPONSIBILITIES

1-12. GENERAL

a. BDAR procedures are applicable at all levels, from crew through direct 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 or possible to restore the howitzer to the combat-ready condition required for continuation of the mission.

b. Battlefield damage repair items consist of essential tools, substitute parts, and expendable supplies and can be carried on board each howitzer to enable the crew to rapidly fix the simplest and most common types of damage/failure. (Refer to Appendix B (Special or Fabricated Tools), Appendix C (Expendable/ Durable Supplies and Materials List), and Appendix D (Substitute Materials/Parts)).

1-13. TAGGING/IDENTIFYING BDAR REPAIRS

a. All components of a vehicle, which are repaired using BDAR or other techniques, shall be reported on DA Form 2404, DD Form 1577, or similar conspicuous tag. The purpose of marking an item which has been repaired using BDAR techniques is to quickly enable mechanics to recognize these parts when the vehicle is subsequently returned for permanent standard repair.

b. Since it is impractical to attach tags to expediently repaired components located on the outside of the vehicle, the fix shall be reported on DA Form 2404, DD Form 1577, or similar tag.

c. A tag should also be placed conspicuously in the chief-of-section’s position 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.

d. When a component is cannibalized from a repairable vehicle, 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.

1-14. CHIEF-OF-SECTION AND CREW

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

(1) Howitzer damaged (out-of-action or impaired)

(2) Location of Howitzer

(3) Firepower status

(4) Mobility status

(5) Manning status

(6) Current and anticipated enemy action

b. If communication capability is damaged, the chief-of-section should approach the nearest friendly radio and make his report.

c. In the forward battle area, it is imperative that the crew attempt to move the howitzer to a covered or concealed position to prevent additional combat damage. This is the first priority. If the howitzer is not capable of self movement, use any vehicle, including other howitzers, to recover the vehicle or to get concealment. If this is not possible, then the turret should at least be turned in the direction of engaging fires in order to limit damage and to possibly return fire.

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

e. The following safety checks should be made for any obvious hazards.

(1) Is there an ammunition round in the tube?

(2) Are any ammunition rounds critical due to shock, fire, or physical damage?

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

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

(5) Is the fixed fire extinguisher system operational and are portable fire extinguishers serviceable? Crew members should be stationed inside and outside the howitzer with portable fire extinguishers and be prepared to manually actuate the fixed fire extinguisher system.

f. A functional/operational test should be performed next on those systems which appear undamaged. Only those systems found to be damaged or inoperative shall be identified.

g. The chief-of-section shall report to the executive officer the results of the crew's damage assessment, naming the major known causes of the vehicle's immobility and/or lack of fire power. If repair by the crew is possible, he shall report a total estimated repair time and what functions may be restored.

1-14. CHIEF-OF-SECTION AND CREW - CONTINUED

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

i. The crew shall proceed to make any possible field expedient repairs to restore fire power, communications, and/or vehicle mobility to the limit of their skills and available materials and tools.

1-15. MAINTENANCE TEAMS (MT)

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

b. If the howitzer has been left unattended in the forward battle area, the immediate area of the howitzer should be checked for mines, and the howitzer should be checked for booby traps before starting the battle damage assessment. The MT should also make the safety checks listed in paragraph 1-14e.

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

(1) Reviewing the crew's out-of-action report, if available.

(2) Interviewing commander and crew, if available.

(3) Visually inspecting damaged parts and systems.

(4) Performing a self-test.

(5) Making tests with unit test equipment, if required.

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

d. Using this information and following the steps in paragraph 1-15c, the MT will:

(1) Determine what must be repaired or replaced.

(2) Determine sequence and priority of repair actions.

(3) Estimate repair times for each repair task.

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

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

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

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

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

1-15. MAINTENANCE TEAMS (MT) - CONTINUED

h. If the howitzer is not repairable, the MT shall provide for one of the following:
(1) Recovery to a maintenance collection point for evacuation to the rear.
(2) On-site stripping (if approved by commander coordinated with support maintenance).
(3) Abandonment destruction (if directed by commander).

i. Combat vehicle hulls should never be abandoned if recovery/evacuation is possible because hulls can almost always be rebuilt, no matter how badly damaged they are. If the howitzer is damaged catastrophically and evacuation is not possible, remove items in the following order.
(1) Needed spares on-site.
(2) Sensitive, high value, limited size items.
(3) Other needed spares.

j. If the vehicle is contaminated, the MT shall mark the vehicle with contamination markers and arrange for recovery to a decontamination site.

1-16. MAINTENANCE SUPPORT TEAMS (MST)

a. The MST shall assist the MT, as needed, using direct support maintenance tools and equipment. If possible the MT will tell the MST what tools and spare parts are needed to perform the repairs. While waiting for the MST to arrive, the crew, under the supervision of the MT, will open up the vehicle and make it ready for the MST to perform the BDAR when it arrives.

b. Damaged howitzers removed to designated repair sites shall be selected for repair by the MST in order of.
(1) Most essential to the completion of the mission.
(2) Can be repaired in the least amount of time.

1-17. 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 howitzer. The time available at the selected repair site must equal or exceed the estimated time required to accomplish all tasks associated with the BDAR. Times listed in this BDAR are for the specific BDAR task only.

b. Determining where BDAR will take place should be based on the guidelines in Table 1-1. Times are very flexible and depend on mission, enemy, terrain, troops, and time available (METT-T). They should not be considered restrictive. 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 BDAR	Time Guidelines
Breakdown Site	1. Operator/Crew 2. Battalion Maintenance Team 3. Maintenance Support Team from Forward Support Maintenance Company	2 Hours
Battalion Trains *(OMCP)	1. Battalion Maintenance Platoon 2. Maintenance Support Team from Forward Support Maintenance Company 3. Maintenance Support Team from Maintenance Battalion	6 Hours

*Organizational Maintenance Command Post

1-18. REPORTS

a. When the vehicle 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.

b. 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: WL/FIVS-SURVAC, BLDG 45, 2130 8th Street, Suite I, Wright Patterson AFB, Ohio 45433-7542. The Information on these forms will provide data for designing vehicles to be less susceptible to combat damage and easier to repair when damaged.

c. The battlefield damage assessment/repair forms used are listed in Chapter 2.

CHAPTER 2

ASSESSING BATTLEFIELD DAMAGE

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

2-1. SCOPE

This chapter provides guidelines to assess battlefield damage to the M109A6 howitzer and directs you to an expedient repair procedure, if one exists.

2-2. GENERAL

This chapter explains how to use this manual to assess and fix battlefield damage that prevents the M109A6 howitzer from moving, shooting, and/or communicating General fault assessment tables are contained in this chapter. Specific fault assessment tables, detailed assessment procedures, repair procedures, and repair procedure indexes are located in the following chapters. If you do not know or are not sure of exactly what your problem is, refer to the General Fault Assessment Tables 2-1 and 2-2 in Section II.

2-3. APPLICATION

Use the following steps to find battlefield damages:

a. Perform the Preventive Maintenance Checks and Services (PMCS) in the Operator's Manual. At the same time, look for obvious damage to the howitzer.

b. If applicable, do the troubleshooting/repair recommended in the Operator's Manual.

c If you find the problem, determine its effect on the operation (mobility, firepower, or communication) of the howitzer.

d. If you can't identify and fix the problem using the PMCS and procedures in the Operator's Manual, use General Fault Assessment Tables 2-1 and 2-2 to assess and fix the problem.

e. If the problem does not affect the howitzer's operation, the commander will decide whether to attempt to fix the problem or continue with the mission.

f. If the damage does affect the howitzer's operation, do one of the following:

(1) Replace the bad part/assembly with a good one from supply or scavenge from available source.
(2) Replace the bad part/assembly with a substitute, if one exists.
(3) Bypass the damaged component.
(4) Use the expedient repair procedures in this manual to repair the damage.

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

2-4. ASSESSMENT PROCESS

a. All assessment procedures follow the sequence:

(1) Visual Inspection (repair, if necessary),
(2) Operational inspection (repair, if necessary), and
(3) Evaluation of performance capability.

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

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

(1) The first assessment is the extent and kind of damage and how it affects the howitzer's capabilities.
(2) The second is if the damage needs to be repaired.
(3) The third is assessment of where and how to repair the damage.

c. Assessments of damage may be made in turn by crew, MT, and MST assessors.

(1) Extent and kind of damage that is readily assessable.
(2) Whether or not to repair damage that is readily assessable. However, whether to attempt repair, and when and how to repair the damage, may be a judgement call. No procedure can take all possible situations into account. Assessment of damage needed to be repaired will be made jointly by the MT and chief-of-section as they evaluate the howitzer for further operation or recovery.

(3) Assessment of where and how to repair the damage will be made by the MT, usually with some suggestions by crew MSTs may redirect or change the MT's decision.

2-5. ASSESSMENT PROCEDURE

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

(1) The effect of the damage and if it needs to be fixed.
(2) If the damage can be fixed using BDAR or if only regular maintenance operations can fix it.
(3) How long it will take to fix it. This is only an estimate based on the technical knowledge of the person performing the assessment.

This is accomplished by structuring this manual according to the major systems and subsystems which provide the howitzer's movement, firepower and communication functions. Each system that makes up a part of providing movement, firepower and communication, has a stand alone assessment procedure to make it easier to qualify each significant problem encountered in battlefield damaged equipment.

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

(1) Procedures in this manual if a quick-fix is possible,
(2) The standard TM if the best repair is covered in the system TM, or
(3) A higher maintenance level if access to devices or materials to do the quick-fix are available only at those levels.

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

2-5. ASSESSMENT PROCEDURE - CONTINUED

d. Each repair:

(1) Contains general information about the problem.

(2) Lists materials and/or tools required other than those commonly available to the crew, MT, and MST (if the items listed are not available, improvise. Anything that will do the job is acceptable).

(3) Lists the estimated number of soldiers needed and the estimated time required to complete the repair.

(4) States the operational limitations caused by the repair action before experiencing further damage/degradation to the howitzer.

(5) Provides other options you can use depending on the availability of personnel, materials, tools, and/or time (this does not include standard maintenance procedures or recovery).

e. Additional data is contained in the appendixes.

(1) Appendix A lists Referenced Publications used for repair of the M109A6 howitzer.

(2) Appendix B lists Special or Fabricated Tools.

(3) Appendix C lists Expendable/Durable Supplies and Materials.

(4) Appendix D lists Substitute Materials/Parts.

(5) Appendix E lists BDAR Fixes Authorized for Training.

f. As an example, presume that the engine coolant is overheating, only at high engine speeds. There is no apparent damage to the cooling system and fluid is present BDAR assessment procedures function as follows:

(1) General Fault Assessment Table 2-1 directs the reader to visually inspect each major system of the howitzer. The reader inspects the engine and fuel system before determining that there is damage in the cooling system. The reader is referred to Table 6-1 to perform a visual inspection of the coolant subsystems for which BDAR fixes are available. Damage to the coolant hose is found, affecting the water pump. The reader must determine whether the damage is repairable by assessing resources available and listed in the repair procedure paragraph (para 6-12). If damage cannot be repaired, the reader is directed to note repair requirements and recover the howitzer. The assessment would then be complete. Assuming repair is possible, however, the reader would note repair requirements, complete visual inspection of coolant subsystems (Table 6-1), and return to Table 2-1 to complete visual inspection of the howitzer's major subsystems. Once all major subsystems have been visually inspected, the reader is directed to perform all noted repair requirements and begin operation observation (Table 2-2).

(2) General Fault Assessment Table 2-2 directs the reader to damage affecting operation of major systems, subsystems, and components in the same way as the visual inspection. If recovery becomes necessary, the assessment ends. If not, repair requirements are noted and performed only after the howitzer operation of all major systems have been observed In this example, restored water pressure is observed following repair of the collapsed hose. The reader is then directed to perform all final damage assessment, (Table 2-3).

(3) General Fault Assessment Table 2-3 directs the reader to evaluate the howitzer's performance capability. In order to determine its mission readiness. The performance of the howitzer in this example is evaluated to be near normal, so the howitzer is either FMC or combat capable. All damage assessment is complete and this howitzer is ready for use at the commander's direction.

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

2-5. ASSESSMENT PROCEDURE - CONTINUED

h. Refer to Table 2-1 to begin the assessment process.

i. The battle damage assessment/repair forms in Section II are used in battlefield damage assessment. The forms are designed to assist commanders in rapidly assessing battlefield damaged equipment, systematically assessing equipment to determine which subsystem(s) are affected, and the time, personnel, and material required to effect repair. These forms will also assist in performing vehicle assessment. Vehicle assessment is defined as 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. The forms Illustrated are to be used in assessing battlefield damage.

NOTE

These forms are locally reproducible and should be reproduced in necessary quantities to support local needs.

The battlefield damage assessment/repair forms are designed to ensure that all necessary aspects of combat capability are evaluated during the assessment process.

All assessment procedures follow the sequence, (1) visual inspection (repair if necessary), (2) operation observation (repair if necessary), and (3) evaluation of performance capability. The net assessment and field fixes will enable the vehicle to continue the mission or self-recover, but will typically be more useful to the MT/MST for scheduling and accomplishing both BDAR quick-fixes and fix-forward repairs. Battlefield damage assessment will also provide the commander with the necessary information for timely decisions as to whether to continue to fight-the-vehicle or recover it at the appropriate level.

Reporting of battlefield damage should be accomplished in accordance with local Standard Operating Procedures (SOP).

There are three forms to be used when assessing battlefield damage, System Summary, Hull Damage Assessment and Repair, and Cab Damage Assessment and Repair. These forms can be used by the crew, an MT, or an MST.

(1) System Summary:

Can the vehicle move, shoot, and communicate?

What major system is affected?

Is the damage repairable?

If repairable, what are the limitations?

Estimated time to repair?

Estimated number of personnel to effect repair?

What are the materials required?

Recover status (recovery vehicle required or self-recovery)?

What expendable supplies/replacement parts are required?

What parts are cannibalized/exchanged?

2-5. ASSESSMENT PROCEDURE - CONTINUED

(2) Hull and Cab Damage Assessment and Repair address specific systems and subsystems. These forms are designed to assist the assessor to rapidly determine the appropriate BDAR fix. The portion of this which addresses parts should be filled out only when the tactical situation permits. Where possible these forms should follow the damaged equipment or be sent to the rear as a record of what damage occurred and what repairs were effected and where.

SECTION II. GENERAL FAULT ASSESSMENT TABLES AND BATTLE DAMAGE ASSESSMENT/REPAIR FORMS

NOTE

Subsystem, and components assessed through this assessment process must work to provide minimum functional combat capability (para 1-8). Even if all systems work, the vehicle may be unsafe and may not satisfy normal required operating capabilities or may not receive mission-essential maintenance.

Table 2-1. Visual Inspection

ITEM/ACTION	FAULT ISOLATION	BDAR REFERENCE
Engine Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 4, Table 4-1.
No damage found		
Fuel System Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 5, Table 5-1.
No damage found		

Table 2-1. Visual Inspection - Continued

ITEM/ACTION	FAULT ISOLATION	BDAR REFERENCE
Cooling System Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 6, Table 6-1.
No damage found		
Electrical System Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 7, Table 7-1.
No damage found		
Powertrain/Steering Visually Inspect	Damage visible -Evaluate extent of damage using procedure in	Chapter 8, Table 8-1.
No damage found		
Brakes Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 9, Table 9-1.
No damage found		
Wheels and Tracks Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 10, Table 10-1

Table 2-1. Visual Inspection - Continued

ITEM/ACTION	FAULT ISOLATION	BDAR REFERENCE
No damage found		
Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 11, Table 11-1.
No damage found		
Cannon and Mount Visually Inspect	Damage visible -Evaluate extent of damage using procedure in	Chapter 12, Table 12-1.
No damage found		
Communication System Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 13, Table 13-1.
No damage found		
Auxiliary Equipment Visually inspect	Damage visible: -Evaluate extent of damage using procedure in	Chapter 14, Table 14-1
No damage found		

Visual inspection is complete. Perform all noted repair requirements. After completing repair requirements, perform the operation observation in Table 2-2.

Table 2-2. Operation Observation

ITEM/ACTION	FAULT ISOLATION	BDAR REFERENCE
Engine Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 4, Table 4-2
↓ Operative		
Fuel System Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 5, Table 5-2
↓ Operative		
Cooling System Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 6, Table 6-2
↓ Operative		
Electrical System Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 7, Table 7-2
↓ Operative		
↓		

Table 2-2. Operation Observation - Continued

ITEM/ACTION	FAULT ISOLATION	BDAR REFERENCE
Powertrain/Steering Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 8, Table 8-2
↓ Operative		
Brakes Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 9, Table 9-2
↓ Operative		
Wheel and Tracks Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 10, Table 10-2
↓ Operative		
Hydraulic System Attempt operation →	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 11, Table 11-2
↓ Operative		

Table 2-2. Operation Observation - Continued

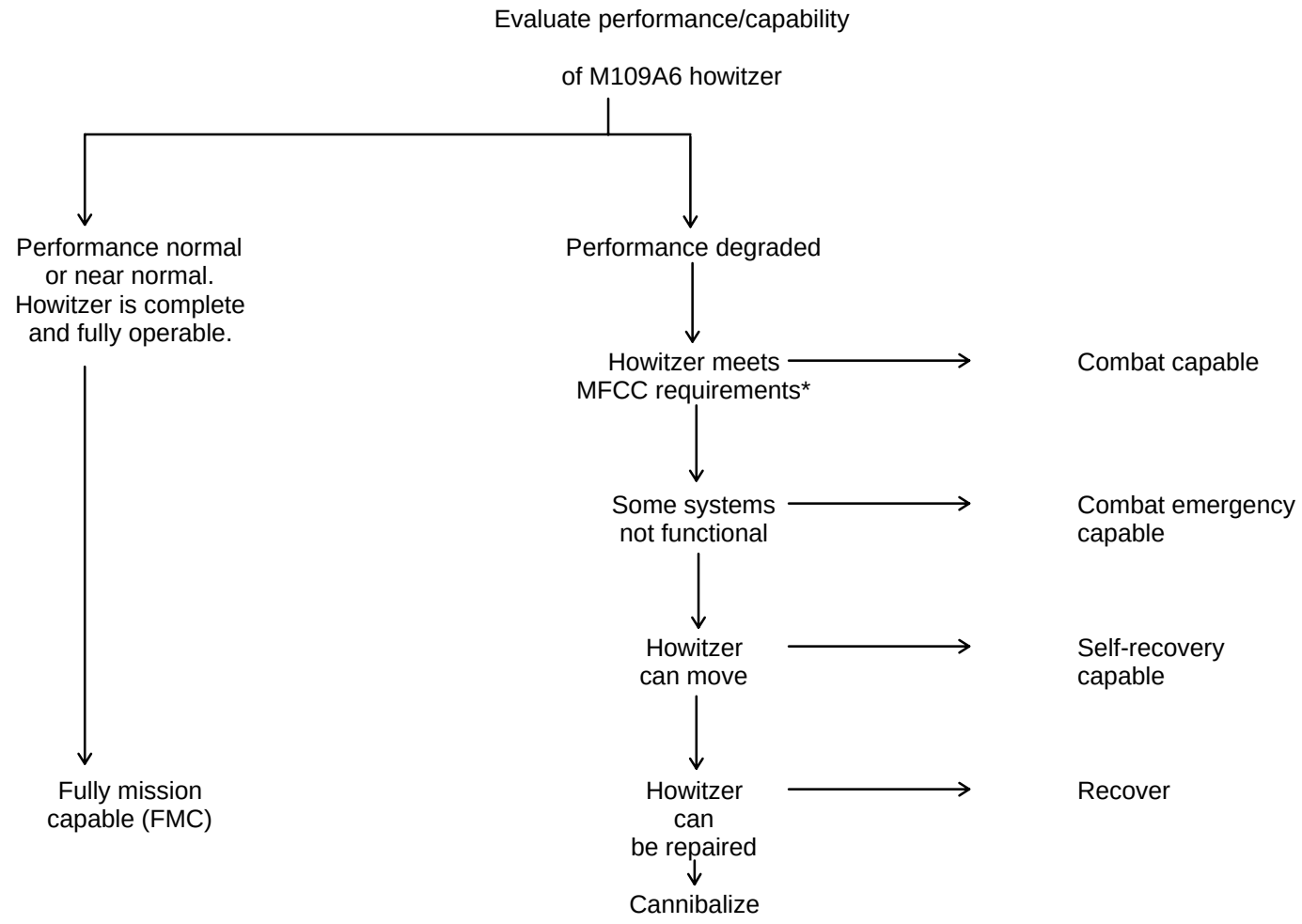
ITEM/ACTION	FAULT ISOLATION	BDAR REFERENCE
Cannon and Mount	Inoperative: -Evaluate extent of damage using procedure in	Chapter 12, Table 12-2.
Operative		
Communication System Attempt operation	Inoperative: -Evaluate extent of damage using procedure in	Chapter 12, Table 12-2.
Operative		
Auxiliary Equipment Attempt operation	Inoperative: -Evaluate extent of damage using procedure in.....	Chapter 13, Table 13-2.
No damage found		
Auxiliary Equipment Attempt operation	Damage visible: -Evaluate extent of damage using procedure in	Chapter 14, Table 14-2
Operative		

Operation observation is complete. Perform all noted repair requirements. After completing repair requirements, evaluate the howitzer's performance capability according to Table 2-3.

Table 2-3. Evaluation of Performance Capability

NOTE

See paragraph 1-4 for definitions/ requirements of performance capabilities.



*Refer to paragraph 1-8 for Minimum Functional Combat Capability (MFCC) criteria.

SYSTEM SUMMARY

Serial No. _____

Vehicle Status	Yes	No	Recovery Status	Yes	No
Can Howitzer be Repaired_____	☐	☐	Can be Recovered_____	☐	☐
Can Howitzer Move _____	☐	☐	Can Self-Recover _____	☐	☐
Can Howitzer Shoot_____	☐	☐	Can be Towed_____	☐	☐
Can Howitzer Communicate ___	☐	☐	Transportable _____	☐	☐

Major Systems	Repair	Recover	Limitations	Time	Personnel
Engine _____	☐	☐	_____	_____	_____
Fuel System_____	☐	☐	_____	_____	_____
Cooling System _____	☐	☐	_____	_____	_____
Hull Electrical System _____	☐	☐	_____	_____	_____
Powertrain/Steering _____	☐	☐	_____	_____	_____
Brakes _____	☐	☐	_____	_____	_____
Wheels and Tracks _____	☐	☐	_____	_____	_____
Cannon and Mount _____	☐	☐	_____	_____	_____
Cab Electrical System _____	☐	☐	_____	_____	_____
Loader Rammer_____	☐	☐	_____	_____	_____
Sighting Equipment _____	☐	☐	_____	_____	_____
AFCS_____	☐	☐	_____	_____	_____
MCS_____	☐	☐	_____	_____	_____
Hydraulic System_____	☐	☐	_____	_____	_____
Traverse Mechanism _____ ____	☐	☐	_____	_____	_____
Communications _____	☐	☐	_____	_____	_____
Other _____	☐	☐	Total	_____	_____

Remarks

_____

_____

_____

HULL DAMAGE ASSESSMENT AND REPAIR

Serial No. _____

Vehicle Status

	Yes	No
Can Howitzer be Repaired_____	☐	☐
Can Howitzer Move _____	☐	☐

Recovery Status

	Yes	No
Can be Recovered_____	☐	☐
Can Self-Recover _____	☐	☐
Can be Towed _____	☐	☐
Transportable _____	☐	☐

Major Systems

	Repair	Recover
Engine _____	☐	☐
Fuel System_____	☐	☐
Cooling System _____	☐	☐
Electrical System _____	☐	☐
Powertrain/Steering _____	☐	☐
Brakes _____	☐	☐
Wheels and Tracks _____	☐	☐
Other _____	☐	☐

Limitations	Time	Personnel
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
Total	_____	_____

Remarks

_____

_____

_____

_____

_____

_____

_____

HULL DAMAGE ASSESSMENT AND REPAIR - CONTINUED

COLUMN 1

Engine	Time	Personnel
1. Engine		
2. Exhaust System		
3. Oil Pan		
4. Injectors		
5. _____		
6. _____		
Total		

Fuel System	Time	Personnel
1. Fuel Tanks		
2. Fuel Pump		
3. Fuel Pumps (In-Tank)		
4. Fuel Lines		
5. Fuel Filters		
6. Throttle Controls		
7. _____		
8. _____		
Total		

Cooling System	Time	Personnel
1. Radiator		
2. Cooling Fans		
3. Water Pumps		
4. Hoses, Tubes, and Fittings		
5. _____		
6. _____		
Total		

Electrical System	Time	Personnel
1. Circuit Breakers		
2. Batteries		
3. Wiring Harnesses/Leads		
4. Voltage Regulator		
5. Relays		
6. Air Cleaner Blower Motor		
7. Starter		
8. Generator		
9. _____		
10. _____		
Total		

COLUMN 2

Powertrain/Steering	Time	Personnel
1. Shift Controls		
2. Transmission/Transfer		
3. Final Drive		
4. Quick Disconnects		
5. Parking Brakes		
6. Service Brakes		
7. Steering Linkage		
8. _____		
9. _____		
Total		

Brakes	Time	Personnel
1. Brake Linkage		
2. _____		
3. _____		
Total		

Wheels and Tracks	Time	Personnel
1. Road Arm Assemblies		
2. Roadwheels		
3. Shock Absorbers		
4. Track Adjusters		
5. Track Idler Wheels		
6. Final Drive Hubs		
7. Track Assemblies		
8. _____		
9. _____		
Total		

Initial Vehicle Assessment and Recovery	Time	Personnel
1. Vehicle Recovery Procedures		
2. Vehicle Self-Recovery Procedures		
3. _____		
4. _____		
Total		

HULL DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

Total Assessment	Time	Personnel
Column 1	_____	_____
Column 2	_____	_____
Total	_____	_____

Remarks

HULL DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

	Expendable Supplies/Replacement Parts	NSN
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

HULL DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

	Cannibalized/Exchanged Parts	NSN
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

CAB DAMAGE ASSESSMENT AND REPAIR

Serial No._____

Vehicle Status

	Yes	No
Can Howitzer be Repaired_____	☐	☐
Can Howitzer Move _____	☐	☐

Recovery Status

	Yes	No
Can be Recovered_____	☐	☐
Can Self-Recover _____	☐	☐
Can be Towed_____	☐	☐
Transportable _____	☐	☐

Major Systems

	Repair	Recover
Cannon and Mount _____	☐	☐
Electrical System _____	☐	☐
Loader Rammer_____	☐	☐
Sighting Equipment _____	☐	☐
AFCS_____	☐	☐
MCS_____	☐	☐
Hydraulic System_____	☐	☐
Transverse Mechanism _____	☐	☐
Communications _____	☐	☐
Other _____	☐	☐

Limitations	Time	Personnel
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
Total	_____	_____

Remarks

_____

_____

_____

_____

_____

_____

_____

CAB DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

COLUMN 1

Cannon and Mount	Time	Personnel
1. Barrel Assembly		
2. Breech Mechanism		
3. Gun Mount		
4. _____		
5. _____		
Total		

Electrical System	Time	Personnel
1. Circuit Breakers		
2. Wiring Harness/Leads		
3. Relays		
4. Slip Ring		
5. Brush Blocks		
6. Hydraulic Compartment Fan		
7. Hydraulic Pump Motor		
8. Hydraulic Control Box		
9. Transverse Limit Switch		
10. _____		
11. _____		
Total		

Loader Rammer	Time	Personnel
1. Loader Rammer Assembly		
2. Control Valve		
3. _____		
4. _____		
Total		

Sighting Equipment	Time	Personnel
1. M145 Linkage Assembly		
2. Connecting Link Assembly		
3. Telescope Cover		
4. M145 Alignment Device Mount		
5. _____		
6. _____		
Total		

COLUMN 2

Automatic Fire Control System	Time	Personnel
1. Wiring Harnesses		
2. Control Unit		
3. Display Unit		
4. Power Conditioner Unit		
5. Communication Processor		
6. Ballistic Computer/ Weapons Controller		
7. Backup Batteries		
8. Azimuth Tachometer		
9. Elevation Tachometer		
10. Tube Temperature Sensor		
11. Hull Naviation Components		
12. Cab Naviation Components		
13. _____		
14. _____		
Total		

Microclimate Conditioning System	Time	Personnel
1. Air Duct, Hoses, and Connectors		
2. Control Panel		
3. M3 Heaters		
4. MCS Pack Components		
5. Wiring Harnessess/Leads		
6. _____		
7. _____		
Total		

CAB DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

COLUMN 3

Hydraulic System	Time	Personnel
1. Lines and Fittings	_____	_____
2. Fuzes and Manifold	_____	_____
3. Gunner's Control Handle	_____	_____
4. COS Control Handle	_____	_____
5. Equilibration Manifold	_____	_____
6. Equilibration Hand Pump	_____	_____
7. Elevation Equilibration Acumulator	_____	_____
8. Mode Selector Valve	_____	_____
9. Elevation Mechanism	_____	_____
10. Hydraulic Powerpack	_____	_____
11. Tranverse Servovalve	_____	_____
12. Tranverse Motor	_____	_____
13. Hydraulic Clutch Valve	_____	_____
14. Tranverse Limit Valve	_____	_____
15. Elevation Selector Valve	_____	_____
16. Manual Elevation Hand Pump	_____	_____
17. Manual Elevation Pump Accumulator	_____	_____
18. Hydraulic Fluid Filter Assembly	_____	_____
19. Traverse Selector Valve	_____	_____
20. _____	_____	_____
21. _____	_____	_____
Total	_____	_____

COLUMN 4

Traverse Mechanism	Time	Personnel
1. Traverse Mechanism Assembly	_____	_____
2. Traverse Lock Assembly	_____	_____
Total	_____	_____

Communications	Time	Personnel
1. Intercom Audio Amplifier	Connectors	_____
2. Intercom Control Boxes	_____	_____
3. Antennas and Mounts	_____	_____
4. Radio and Mount	_____	_____
5. Wiring Harnesses	_____	_____
6. _____	_____	_____
7. _____	_____	_____
Total	_____	_____

Total Assessement	Time	Personnel
Column 1	_____	_____
Column 2	_____	_____
Column 3	_____	_____
Column 4	_____	_____
Total	_____	_____

Remarks

CAB DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

	Expendable Supplies/Replacement Parts	NSN
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

CAB DAMAGE ASSESSMENT AND REPAIR - CONTINUED

Serial No._____

	Cannibalized/Exchanged Parts	NSN
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

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 components of the M109A6 howitzer.

3-2. ASSESSMENT PROCEDURE

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

3-3. REPAIR PROCEDURE INDEX

SECTION II. BRACKETS

3-4. GENERAL

Brackets are used on all vehicles to mount or store items. Brackets are mounted to vehicles by bolting or welding in place and are subject to damage through vibration, impact, or explosive forces. Repairs must be made to restore the brackets needed for recovering essential vehicle functions.

3-5. BRACKET (BOLTED), BROKEN

Bolted brackets should be remounted using bolts if possible. Their removal may be required to gain access to other components. Mount bolted brackets by using any available larger threaded bolt, wire, or by welding.

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.3 hour

Materials/Tools:

Bolt (scavenge from available source)

Procedural Steps:

1. Remount bracket using any available larger threaded bolts Refer to missing bolts (para 3-24).

2. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

Bolt or nail (scavenge from available source), steel rod (item 60, Appendix C), or rod, welding (item 51, Appendix C) or wire, safety (item 80, Appendix C or scavenge from available source).

Procedural Steps:

1. Remount bracket using wire, welding rod, steel rod, nail, or bolt through both bracket holes, if both sides of mounting holes are accessible.

2. Bend or peen both ends of welding rod, steel rod, nail, or bolt to secure bracket.

3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-6. BRACKET (WELDED), BROKEN

Equipment mounting brackets welded to the hull sometimes break due to vibration or collision with obstacles. Brackets are needed to mount components and devices in locations or positions where they can be used to perform their required function. Mount bracket into place and secure by welding.

Limitations:

None

Personnel/Time Required:

- 2 soldiers
- 1.0 hour

Materials/Tools:

- Rod, welding (item 51, Appendix C)
- Welding equipment

Procedural Steps:

1. Set broken portions of bracket in original position.
2. Weld bracket in place.
3. Elongate holes or slots in bracket to compensate for misalignment.
4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. WIRING HARNESSES

3-7. GENERAL

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

3-8. WIRING HARNESS, DAMAGED

Wiring harness repairs are generally accomplished using a series of single wire splices. 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.

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

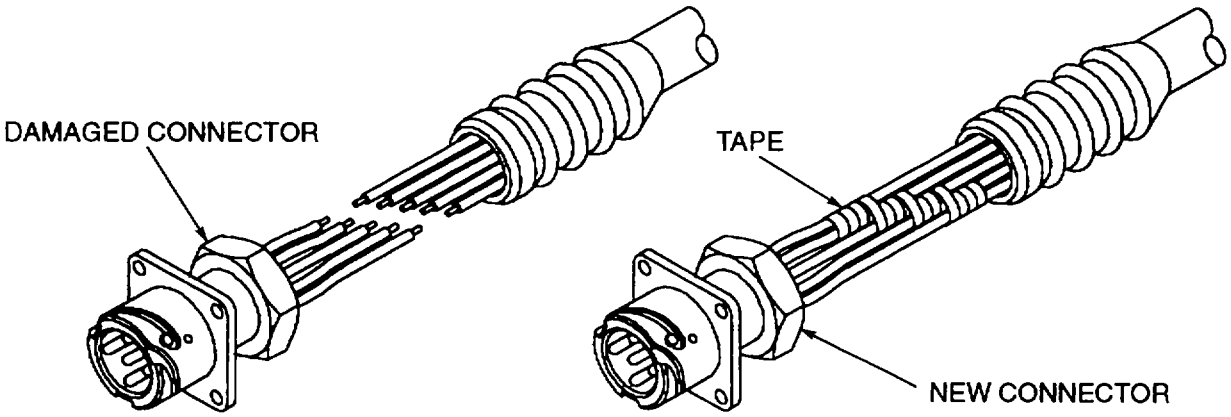
3-8. WIRING HARNESS, DAMAGED - CONTINUED

Materials/Tools:

- Serviceable connector (scavenge from available source)
- Tape, insulation, electrical (item 63, Appendix C)

Procedural Steps:

1. Turn off MASTER rower switch.



2. Cut wires, as shown, to remove damaged connector.
3. Splice corresponding wires (para 3-10).
4. Wrap tape around first splice and leave hanging.
5. Cut and splice next corresponding wire, approximately 1 inch from first splice
6. Wrap tape around second splice without breaking tape from first splice.
7. Repeat these steps until all spices are completed.
8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

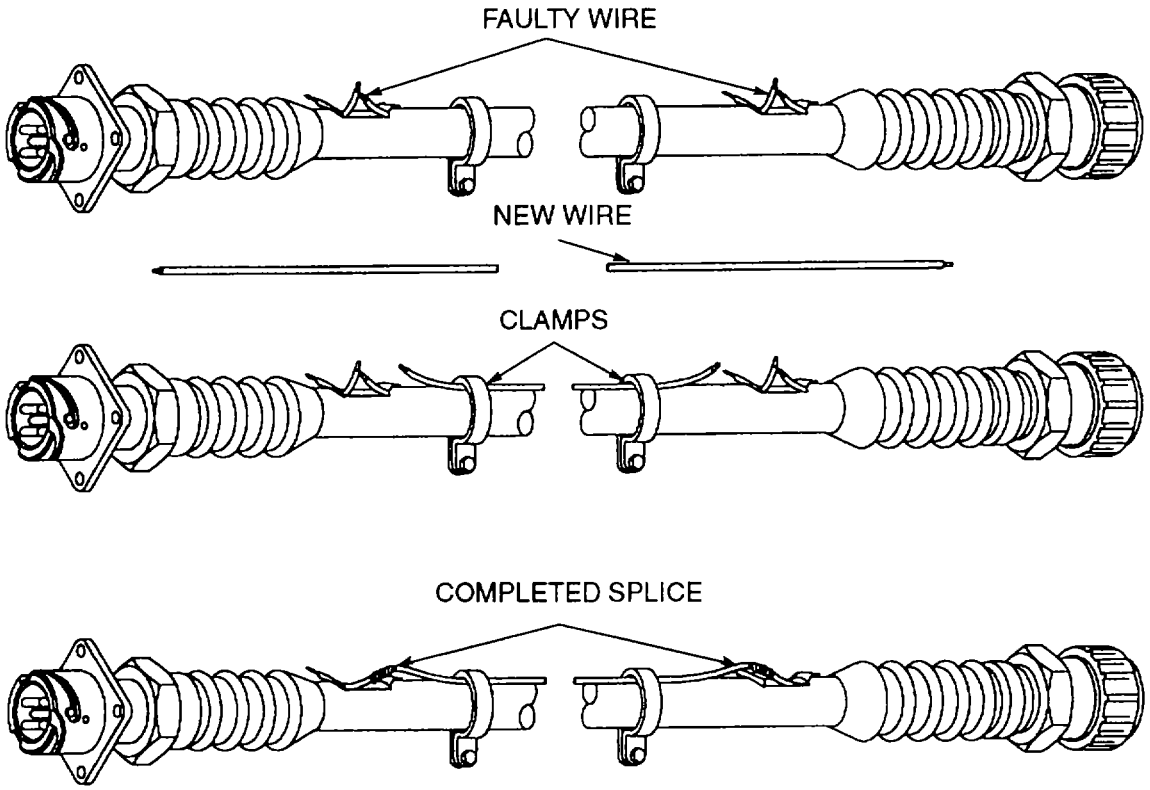
Materials/Tools:

- Tape, insulation, electrical (item 63, Appendix C)
- Wire, electrical, 20 AWG (American Wire Gage) (item 78, Appendix C)

3-8. WIRING HARNESS, DAMAGED - CONTINUED

Procedural Steps:

1. Turn off MASTER power switch.



2. Identify connector pin at each end of harness.

NOTE

Leave 1 inch of wire on connector.

3. Cut off both ends of defective wire.

4. Strip 1 inch off both ends of electrical wire, 20 AWG.

5. Thread wire along path of cable harness passing wire through clamps.

6. Splice and tape wire at both ends.

7. Tape wire securely to harness at intervals to provide protection from vibration or sagging.

8. Record BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-9. CONNECTOR PIN, BROKEN, DAMAGED, OR MISSING

Connector pins can be bypassed when broken, damaged, or missing. Connect wire to both ends of the connection wires.

Option 1

Limitations:

None

Personnel/Time Required:

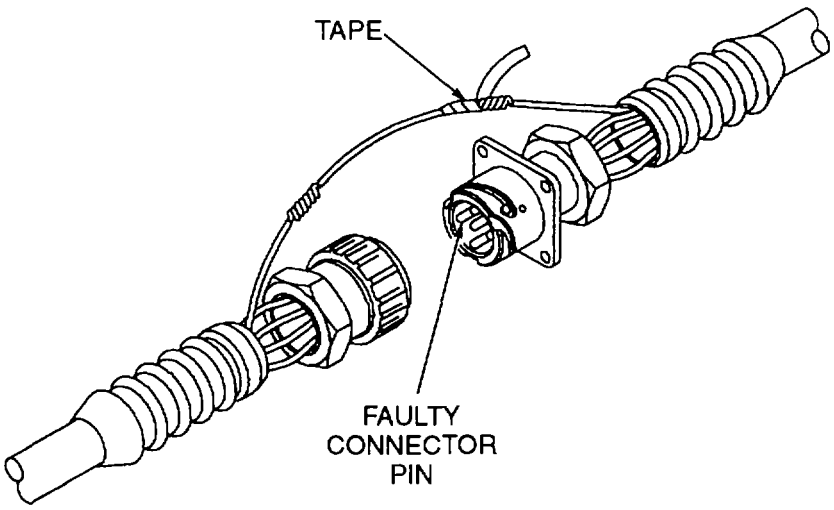
- 1 soldier
- 0.3 hour

Materials/Tools:

- Tape, insulation, electrical (item 63, Appendix C)
- Wire, electrical, 20 AWG (item 78, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch.



2. Identify faulty connector pin and wire at both ends of connector.

NOTE

If connector is attached to shock-mounted equipment, the wires should be long enough to ensure free movement of the equipment on its shock mounts.

3. Cut wires at both ends of connector.

4. Strip both ends of electrical wire, 20 AWG.

5. Connect electrical wire to both ends of wires, not connected to the faulty connector.

3-9. CONNECTOR PIN, BROKEN, DAMAGED, OR MISSING - CONTINUED

6. Splice and tape wire at both ends (para 3-10).

7. Secure loose wire to connector with tape.

8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

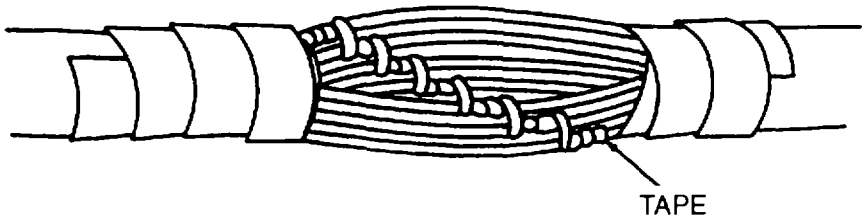
- 1 soldier
- 0.5 hour

Materials/Tools:

Tape, insulation, electrical (item 63, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch.



2. Cut wires to remove damaged connectors.

3. Splice corresponding wires (para 3-10).

4. Wrap tape around first splice and leave hanging.

5. Cut and splice next corresponding wire, approximately 1 inch from first splice.

6. Wrap tape around second spice without breaking tape from first splice.

7. Repeat these steps until all splices are complete.

8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-9. CONNECTOR PIN, BROKEN, DAMAGED, OR MISSING - CONTINUED

Option 3

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

Nail, paper clip, or welding rods (dependent upon diameter of pin replacement being made) (scavenge from available source)

Procedural Steps:

CAUTION

Due to high amperage in some electrical circuits, arcing may occur. This procedure could cause further damage to equipment. Use this procedure as a last resort.

1. Turn off MASTER power switch.
2. Identify connector pin damaged.
3. Remove damaged pin, if necessary.
4. Cut required material to length as needed.
5. Insert material in female end of connector.
6. Ensure replacement pin is in alignment and not touching other pins and reconnect connector.
7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-10. 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.

3-10. WIRES, BROKEN - CONTINUED

Option 1

Limitations:

None

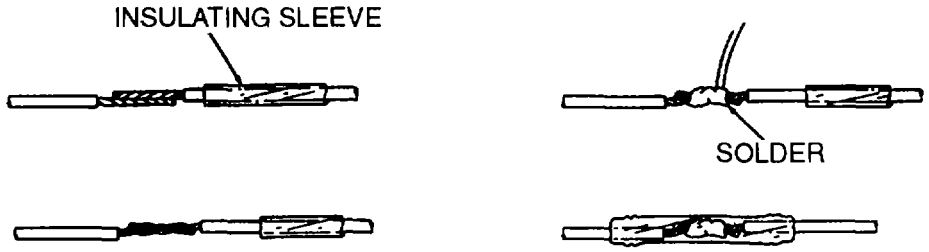
Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage

Materials/Tools:

- Crimping tool, terminal (found in M2/3 generic BDR kit, Section III, Appendix C)
- Insulation sleeving, electrical (item 37, Appendix C)
- Solder, lead-tin alloy (item 58, Appendix C)
- Tape, insulation, electrical (item 63, Appendix C)

Procedural Steps:



1. Strip end of broken wires.
2. Install a section of insulation sleeving over one end of broken wire.
3. Lay stripped ends side by side.
4. Twist wire ends together.
5. Solder wires together using lead-tin alloy solder.
6. Insulate by sliding sleeve over soldered wires and crimp or wrap tape around soldered wires.
7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

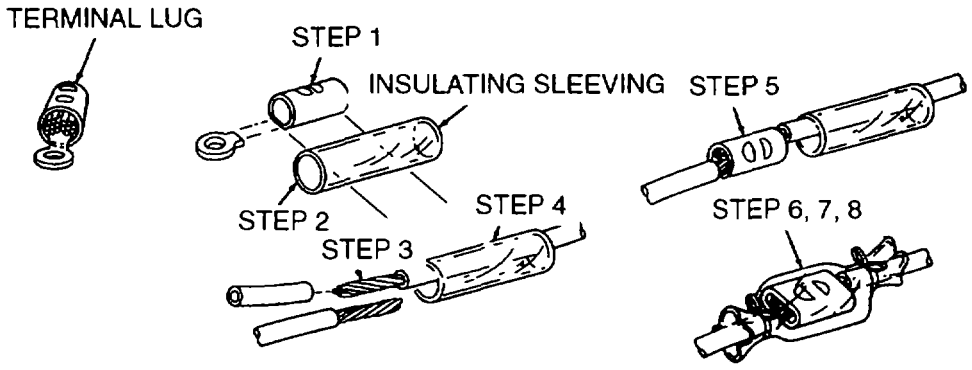
- 1 soldier
- Time determined by location and amount of damage.

3-10. WIRES, BROKEN - CONTINUED

Materials/Tools:

- Crimping tool, terminal (found in M2/3 generic BDR kit, Section III, Appendix C)
- Gun, thermal
- Insulation sleeving, electrical (item 37, Appendix C)
- Tape, insulation, electrical (item 63, Appendix C)
- Terminal, lug, crimp style (item 67, Appendix C)

Procedural Steps:



NOTE

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

1. Cut terminal lug flush with barrel.
2. Cut insulation sleeve 1 inch longer than barrel.
3. Strip ends of broken wires.
4. Install insulation sleeve over one end of broken wire.
5. Insert wires into prepared splice barrel and crimp to secure wires.
6. Slide sleeve over splice or use tape to insulate conductor.
7. Apply heat to shrink material.
8. Tie off ends of non-shrink sleeve.
9. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3

Limitations:

None

3-10. WIRES, BROKEN - CONTINUED

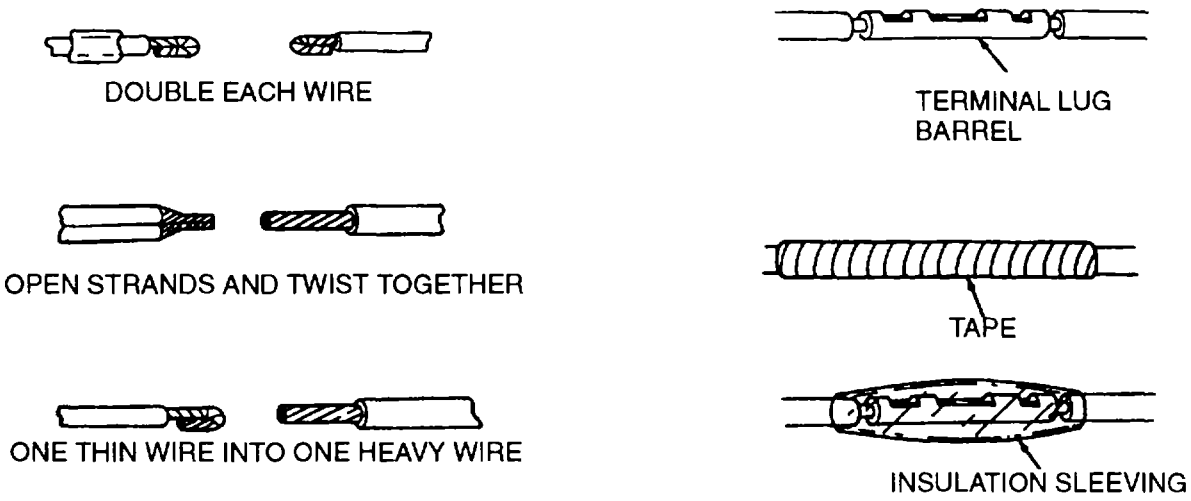
Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools

- Crimping tool, terminal (found in M2/3 generic BDR kit, Section III, Appendix C)
- Insulation sleeving, electrical (item 37, Appendix C)
- Tape, insulation, electrical (item 63, Appendix C)
- Terminal, lug, crimp style (item 67, Appendix C)

Procedural Steps:



1. Strip enough insulation from broken wire to allow small wire to be doubled as shown.

2. Install insulation sleeving over one end of broken wire.

3. Connect wires by using a spice or terminal lug barrel as in Option 2.

4. Crimp splice or lug to secure wires.

5. Slide sleeve over spice or tape spice to insulate.

6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. ELECTRICAL CABLES

3-11. GENERAL

Heavy duty and shielded cables can be severed or damaged in battlefield conditions. Cables should be replaced when damaged. Repairs are possible if replacement cables are not available.

3-12. HEAVY DUTY CABLES, BROKEN

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

3-12. HEAVY DUTY CABLES, BROKEN - CONTINUED

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

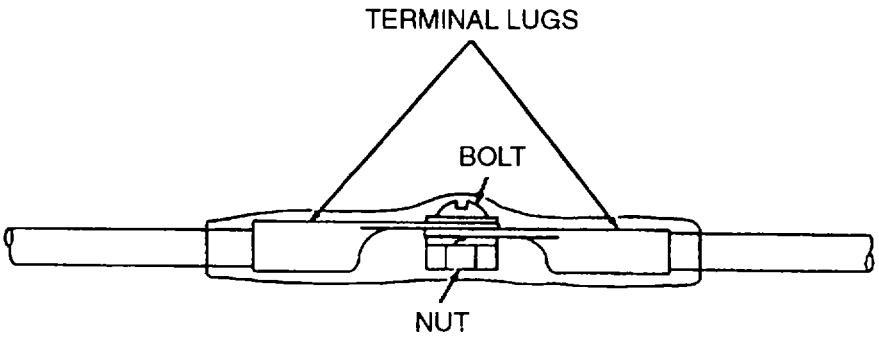
Materials/Tools:

- Crimping tool, terminal (found in M2/3 generic BDR kit, Section Ill, Appendix C)
- Gun, thermal
- Short bolt with matching nut (scavenge from available source)
- Tape, insulation, electrical (item 63, Appendix C) or insulation sleeving, electrical (item 34, Appendix C)
- Terminal lug, crimp style, two required (item 67, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch.

2. Clean area to be repaired.



3. Trim ends of broken wire.

4. Install an insulating sleeve over one end of broken wire.

5. Strip wire and crimp an insulated terminal lug to each end of broken wire.

6. Bolt terminal lugs together using short bolt with nut.

7. Slide insulating sleeve over connection and either heat-shrink or tie securely at each end. Tape may be used.

8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-12. HEAVY DUTY CABLES, BROKEN - CONTINUED

Option 2

Limitations:

None

Personnel/Time Required:

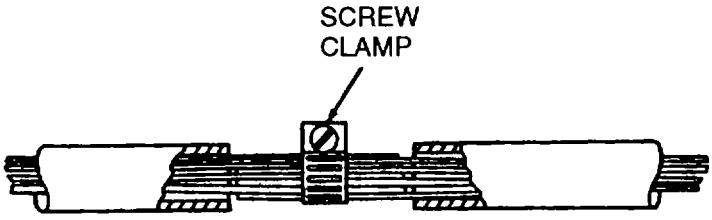
- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

- Clamp, screw (item 9, Appendix C)
- Solder, lead-tin alloy (item 58, Appendix C)
- Tape, insulation, electrical (item 63, Appendix C)
- Wire, safety (item 80, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch.



2. Remove 1 inch of insulation from each end of broken wire.

3. Fan out strands on each end.

4. Push two ends together as far as possible, so that strands intermesh.

NOTE

If solder is not available, the two intermeshed ends may be secured with a screw clamp, cable clamp, or safety wire.

5. Solder intermeshed wires together.

6. Insulate with tape.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-12. HEAVY DUTY CABLES, BROKEN - CONTINUED

Option 3

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.4 hour

Materials/Tools:

Tape, insulation, electrical (item 63 Appendix C) or insulation sleeving, electrical (item 34, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch.
2. Remove 2 inches of insulation from each end of broken wire.
3. Split ends of cable into manageable strands.
4. Join two ends by twisting corresponding strands together.
5. Bend twisted end parallel to cable and insulate with tape.
6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.5 hour

Materials/Tools:

Tape, insulation, electrical (item 63, Appendix C)

3-12. HEAVY DUTY CABLES, BROKEN - CONTINUED

Procedural Steps:

1. Turn off MASTER power switch.

2. Cut and splice corresponding wires (para 3-10).

3. Wrap insulating tape around first splice and leave hanging.

4. Cut and splice next corresponding wire, approximately 1 inch from first splice.

5. Wrap tape around second splice without breaking tape from first splice.

6. Repeat steps 2-5 until all splices are complete.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-13. SHIELDED CABLES, DAMAGED

Some high-voltage or high-current electrical circuits are shielded to prevent the circuit from inducing a current in a parallel circuit. The shield is connected to a ground which will stop current from escaping or entering the conductor from any source other than its own circuit. Shielded cables should be replaced. Repairs are possible if replacement cables are not available. Splicing wires is a quick fix for damaged shielded wires.

Option 1

Limitations:

Radio Frequency Interference (RFI) may be induced.

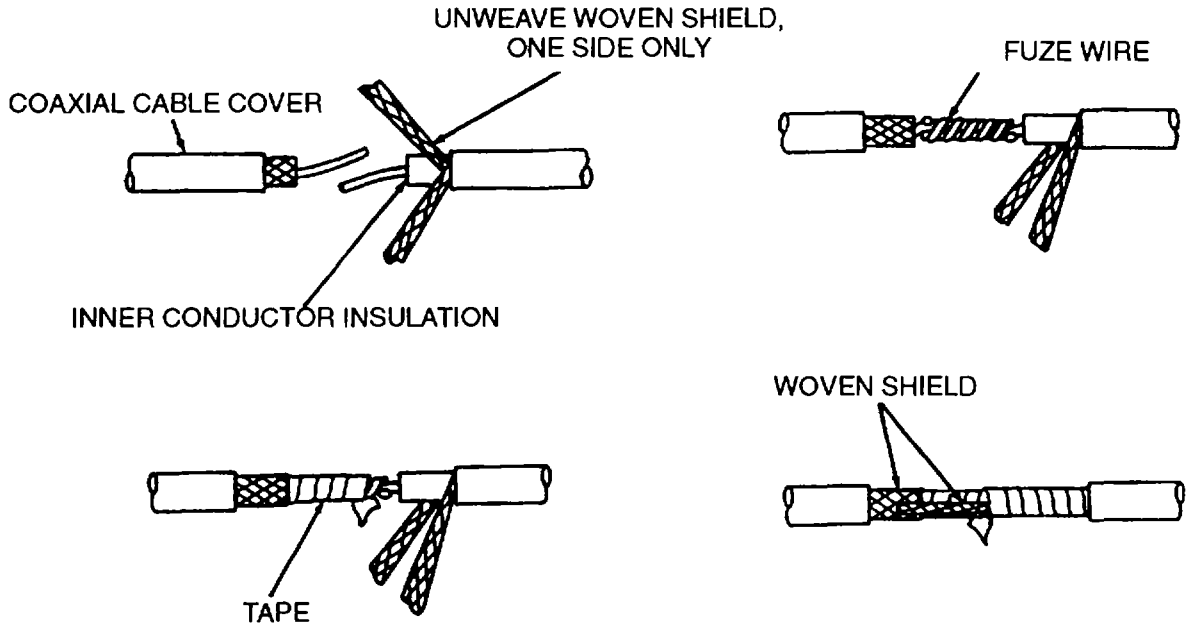
Personnel/Time Required:
- 1 soldier
- 0.5 hour

Materials/Tools:

- Solder, lead-tin alloy (item 58, Appendix C)
- Tape, insulation, electrical (item 63, Appendix C)
- Wire, fuze (item 79, Appendix C)

3-13. SHIELDED CABLES, DAMAGED - CONTINUED

Procedural Steps:



1. Cut back coaxial cable cover 3 inches from each wire end.
2. Cut back woven shield and inner conductor insulation on one wire 2 inches from end.
3. Unweave woven shield and remove inner conductor insulation 2 inches from end of other wire.

NOTE
If solder is not available, lay wires side by side and wrap with fuze wire as shown.

4. Splice broken wire by twisting and soldering.
5. Insulate splice with several layers of tape.
6. Lay unwoven shield over insulated splice and make contact with woven shield on other side of splice.
7. Cover entire splice with several layers of tape.
8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

RFI (radio frequency interference) may be induced.

Personnel/Time Required:

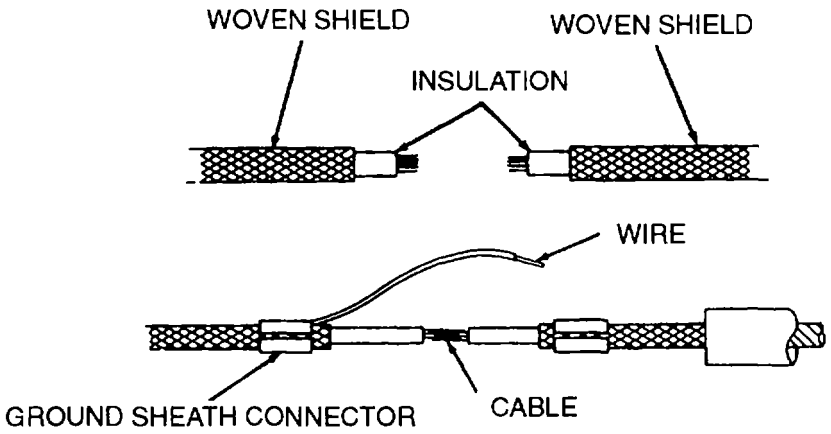
- 1 soldier
- 0.5 hour

3-13. SHIELDED CABLES, DAMAGED - CONTINUED

Materials/Tools:

- Crimping tool, terminal (found in M2/3 generic BDR kit, Section III, Appendix C)
- Ground sheath connector, two required (scavenge from available source)
- Gun, thermal
- Insulation sleeving, electrical (item 37, Appendix C)
- Permanent splice/barrel of a terminal lug (scavenge from available source)
- Shielding, material, two required (item 56, Appendix C or scavenge from available source)
- String (scavenge from available source)
- Tape, insulation, electrical (item 63, Appendix C)
- Wire, electrical. 18 AWG (item 77, Appendix C)

Procedural Steps:



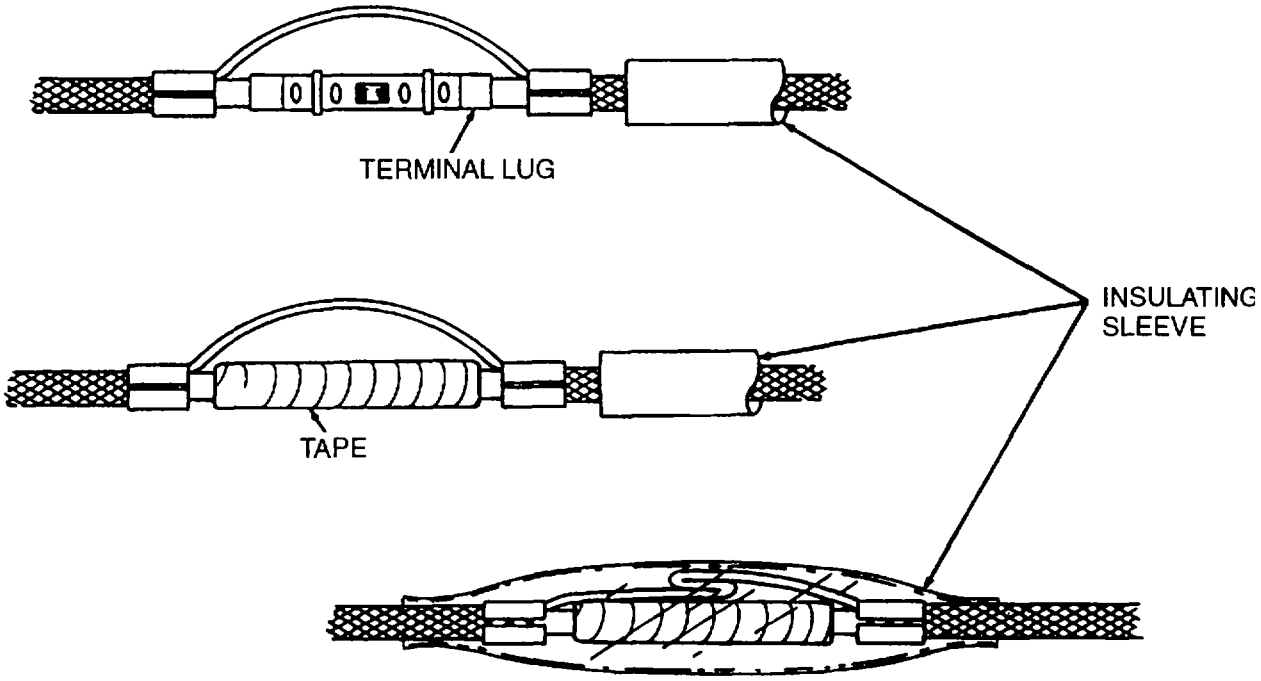
1. Remove approximately 1 1/2 inches of woven shield from both ends of severed cable.
2. Remove 1/2-inch of insulation from around conductor on both ends.
3. Slide insulating sleeve onto cable.

NOTE

Heat shrink tubing must be long enough to cover entire splice.

4. Place a ground sheath connector on cable.
5. Strip one end of electrical wire.
6. Place wire end into ground sheath connector.
7. Ensure ground sheath connector, wire, and shielding make contact.
8. Crimp ground sheath connector.
9. Slide second ground sheath connector onto other end of cable.

3-13. SHIELDED CABLES, DAMAGED - CONTINUED



10. Install permanent splice/barrel of a terminal lug over ends of severed inner conductor.

11. Insulate permanent splice from shielding with electrical tape.

12. Strip other end of small insulated wire and splice into second ground sheath connector, ensuring contact is made with shielding.

13. Crimp second ground sheath connector.

14. Slide insulation sleeve over entire spice.

15. Heat insulation sleeve or tie both ends of flexible tubing.

16. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3

Limitations:

RFI may be induced.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

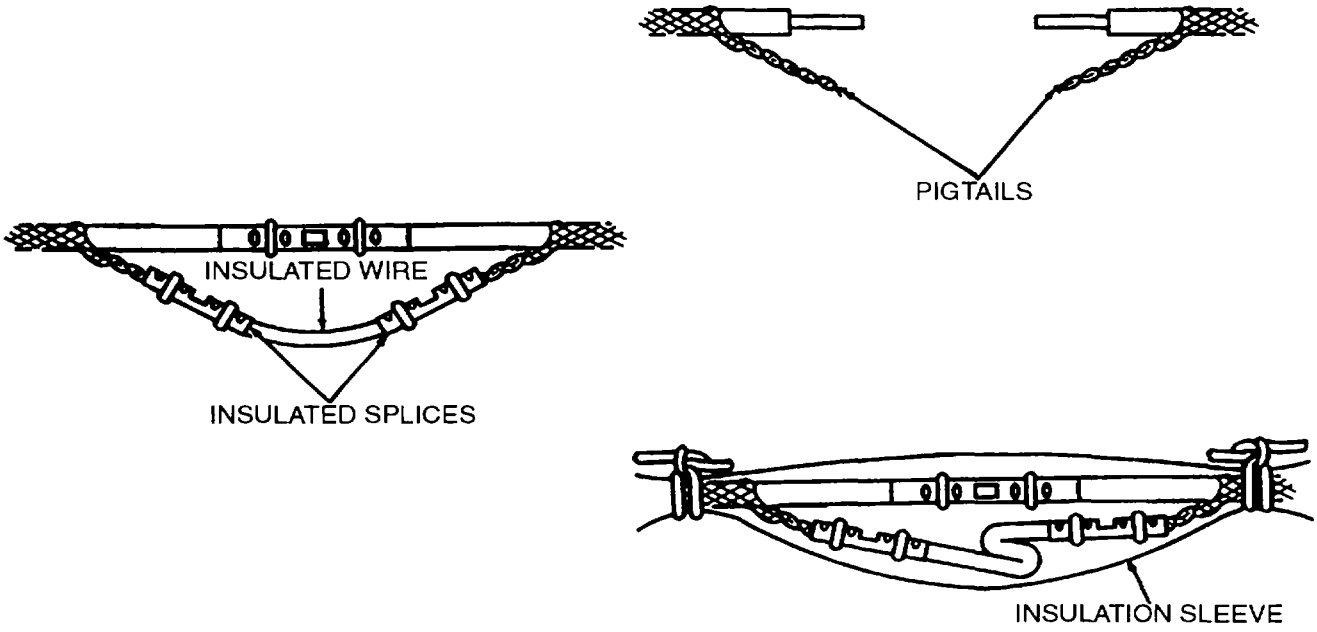
Materials/Tools:

- Connector, splice, three required (item 10, Appendix C)
- Crimping tool, terminal (found in M2/3 generic BDR kit, Section III, Appendix C)

3-13. SHIELDED CABLES, DAMAGED - CONTINUED

- Gun, thermal
- Insulation sleeving, electrical (item 37, Appendix C)
- Wire, electrical 18 AWG (item 77, Appendix C)

Procedural Steps:



1. Prepare severed ends of cable for pigtail method of shield termination.
2. Join inner conductors using insulated splice connector.
3. Add a short length of insulated wire as an extension to complete shield connection by using two splice connectors.
4. Cover area with tape or insulation sleeve.
5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION V. ELECTRICAL COMPONENTS

3-14. GENERAL

Electrical circuits contain switches and protection devices. Vibration, impact, or explosive forces can cause a switch to become inoperative. A short or overload in a circuit will cause the fuse to bum out or the circuit breaker to trip. The circuit becomes inoperative. A temporary repair can be made by bypassing the protection device or switch.

3-15. SWITCHES, DAMAGED

Inoperative circuit can be caused by a damaged switch. A temporary repair can be made by bypassing the switch with straight wiring.

Limitations:

Operation of switch is eliminated.

3-15. SWITCHES, DAMAGED - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.3 hour

Materials/Tools:

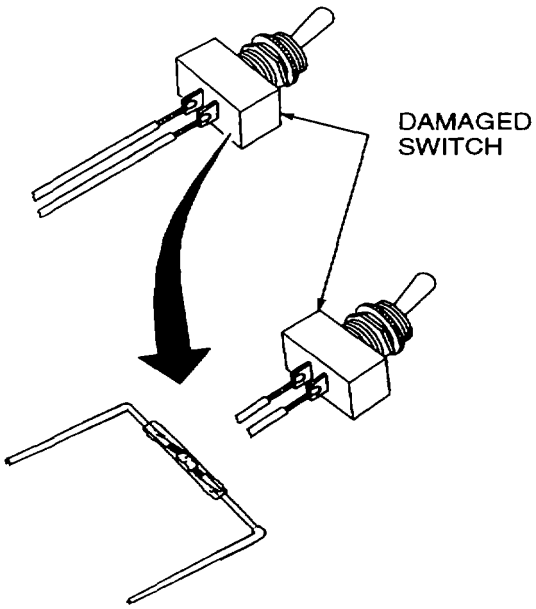
- Tape, insulation, electrical (item 63, Appendix C)
- Toggle switch, single-pole, single-throw (item 68, Appendix C)

Procedural Steps:

CAUTION

Do not use the following procedure on momentary switches. For example, starter switch, or further damage to equipment will occur.

1. Turn off MASTER power switch.



2. Remove or cut wires connected to damaged switch.
3. Splice wires together (para 3-10), bypassing switch.
4. Insulate and secure wires with electrical tape.
5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-16. CIRCUIT BREAKERS, DAMAGED

Bypassing a circuit breaker is a quick repair but may create more damage to the circuit. The circuit must be checked for shorts before bypassing a circuit breaker.

3-16. CIRCUIT BREAKERS, DAMAGED - CONTINUED

Limitations:

Protection offered by circuit breaker is eliminated.

Personnel/Time Required:

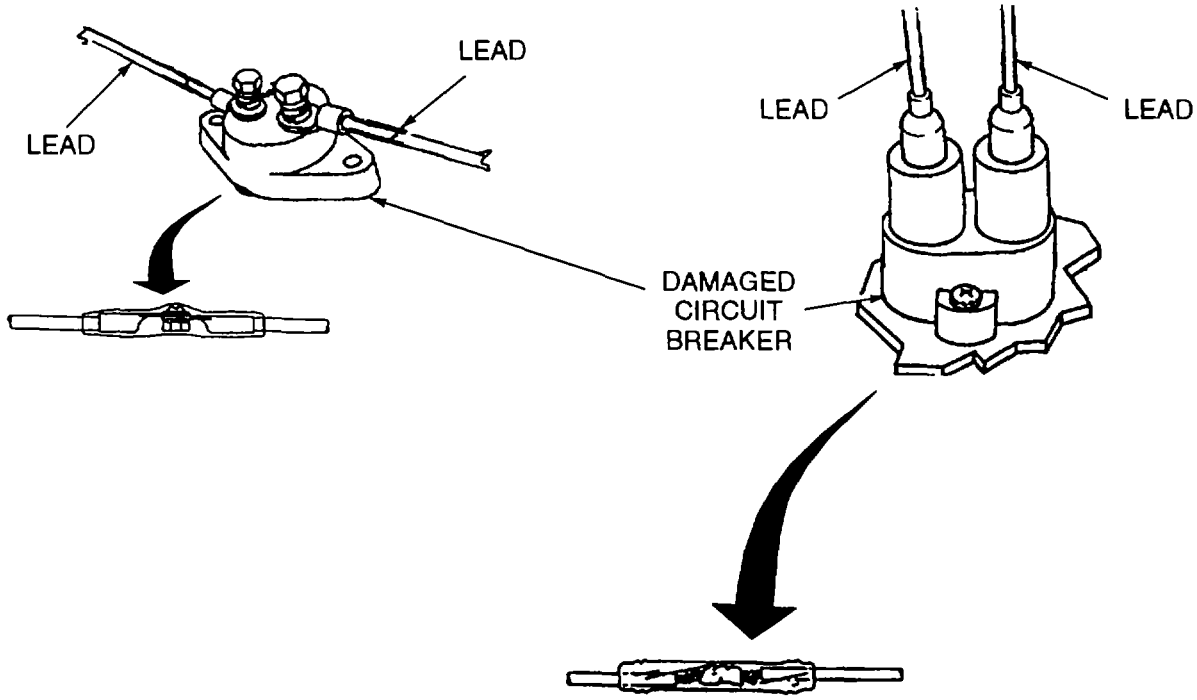
- 1 soldier
- 0.2 hour

Materials/Tools:

Tape, insulation, electrical (item 63, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch.



2. Remove wires from damaged circuit breaker.

NOTE

Use appropriate method of splicing, either for small wires (para 3-10) or for heavy-duty cable (para 3-12).

3. Splice wires together, bypassing circuit breaker.

4. Insulate and secure wires with electrical tape.

5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION VI. GASKETS

3-17. GENERAL

Gaskets may become damaged due to vibration, heat, or explosive force. Procedures are available to make or repair gaskets. If standard replacements are not available. Lift capacity may be required to gain access to the gasket. Heat and pressure should be considered when selecting gasket materials.

3-18. GASKETS, LEAKING

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

Option 1

Limitations:

- Possible reduced Nuclear, Biological, or Chemical (NBC) protection.
- Possible reduced system pressure.
- Seam may still leak at a reduced rate.
- Frequent inspections are required.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

- File folder, TM cover, cardboard, or suitable material (scavenge from available source)
- Sealer, permatex (item 54, Appendix C)
- Gasket, material (item 31, Appendix C)

Procedural Steps:

1. Separate two items where gasket is to be installed.

2. Scrape mating surfaces clean.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Coat gasket maternal with sealer.

4. Install gasket material on one mating surface.

3-18. GASKETS LEAKING - CONTINUED

5. Join two items where gasket has been installed.

6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

- Possible reduced NBC protection.
- Possible reduced system pressure.
- Seam may still leak at a reduced rate.
- Frequent inspections are required.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

- Sealer, permatex (item 54, Appendix C)
- Used or broken gasket (scavenge from available source)

Procedural Steps:

1. Separate two items where gasket is to be installed.
2. Scrape mating surfaces clean.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin-and clothing. To avoid Injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Coat one mating surface with sealer.

4. Install used gasket, or sections of broken gaskets, onto mating surface.

5. Coat other mating surface with sealer.

6. Join two items where gasket has been installed.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-18. GASKETS LEAKING - CONTINUED

Option 3

Limitations:

- Possible reduced NBC protection.
- Possible reduced system pressure.
- Seam may still leak at a reduced rate.
- Frequent inspections are required.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

Adhesive (item 1, Appendix C)

Procedural Steps:

1. Separate two items where gasket is leaking.

2. Scrape mating surfaces clean.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Coat mating surfaces with adhesive.

4. Allow adhesive to form a skin (10 to 15 minutes).

5. Join two items where adhesive has replaced gasket.

6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION VII. PREFORMED PACKINGS

3-19. GENERAL

Preformed packings are used to seal lines, connections between lines, and containment areas. After a packing is installed, it absorbs a small amount of the fluid within the line and expands to prevent leaking. In repair of lines and components damaged in battle, it may become necessary to remove and install saturated preformed packings. A procedure is available to recondition used preformed packings if standard replacements are not available.

3-20. PREFORMED PACKINGS, SATURATED

When preformed packings are saturated with fuel or oil for an extended period of time they will expand or swell. In most cases it is nearly impossible to install a used preformed packing in the same place it was removed. If a preformed packing is cut or pinched, it should not be reused.

Limitations:

Lines may leak at a reduced rate.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

Used preformed packing (scavenge from available source) or packing, preformed (item 45, Appendix C)

Procedural Steps:

NOTE

If preformed packing is known to be in short supply, perform the following procedure if packing is not damaged or cut.

1. Inspect preformed packing when removed from fuel system.
2. Remove as much fuel as possible from preformed packing with clean rag.
3. Place preformed packing on clean, dry, flat, warm surface to dry and shrink.

CAUTION

Heat will speed drying time, but too much heat will damage preformed packing.

4. Reuse preformed packing when packing shrinks to original size.
5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION VIII. FUEL, OIL, AND/OR HYDRAULIC LINES

3-21. GENERAL

Use this procedure to implement temporary repairs to fuel, oil, and/or hydraulic fluid lines affected by damage or wear. This fix can also be used to reroute lines past damaged equipment.

3-22. FUEL, OIL, AND/OR HYDRAULIC FLUID LINES, DAMAGED

General Information:

Temporary repairs can be made depending on the type and amount of damage and the tactical situation.

3-22. FUEL, OIL, AND/OR HYDRAULIC FLUID LINES, DAMAGED - CONTINUED

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

- Fitting kit, tube-pipe (found in M2/3 generic BDR kit, Section III, Appendix C))
- Tube, fitting kit 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 69, 70, 71, 72, 73, Appendix C)
- Nipple, tube straight 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 40, 41, 42, 43, 44, Appendix C)
- Packing, preformed kit (item 45, Appendix C)
- Tool, deburring (found in M2/3 BDR kit, Section III, Appendix C)

Procedural Steps:

1. Cut out damaged section of tube.
2. Clean and deburr ends of damaged tube.
3. Install tube pipe fitting using kit instructions.
4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

Repair may continue to leak at a reduced rate.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

- Clamp, hose (item 7, Appendix C or scavenge from available source)
- Hose, nonmetallic (item 35, Appendix C or scavenge from available source)
- Tape, antiseizing, pipe plug, teflon, 1/2-inch (item 61, Appendix C)
- Tool, deburring (found in M2/3 BDR kit, Section III, Appendix C)

Procedural Steps:

1. Clean and deburr ends of damaged tube.

3-22. FUEL, OIL, AND/OR HYDRAULIC FLUID LINES, DAMAGED - CONTINUED

NOTE

- **Use hose that fits over the damaged sections as tightly as possible without crimping tube**
- **Use at least two hose clamps per side, more if available**

2. Place clamps on hose, do not tighten, and push hose over damaged tube ends.

3. Move clamps over tube inside of hose and tighten (equal number of clamps per side).

4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3

Limitations:

Repair may continue to leak at a reduced rate.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

- Clamp, hose (item 7, Appendix C or scavenge from available source)
- Tube (scavenge from available source)

Procedural Steps:

1. Trim ends of hose

NOTE

- **Use hose that fits inside damaged sections as tightly as possible without crimping tube.**
- **Use at least two hose clamps per side; more if available.**

2. Place clamps on hose, do not tighten, and push tube into hose ends.

3. Move clamps over tube inside of hose and tighten (equal number of clamps per side).

4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IX. HARDWARE, CABLES, AND PULLEYS

3-23. GENERAL

Various elements of hardware and linkages are used throughout combat vehicles to transfer the control actions from the crew to the components being controlled. Damage can occur to mounting hardware, or rods, cables, and levers in mechanical linkage systems. Pins can become lost or linkages can bend or break which will disable or hamper the vehicle operation.

3-24. BOLTS, MISSING

Similar hardware can be scavenged from non-essential equipment within the vehicle. 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 rods or studs can also be used to make BDAR repairs.

Option 1

Limitations:

Limited operational stress capability

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

Bolt (scavenge from available source)

Procedural Steps:

CAUTION

Bolts may break if over tightened too far.

1. Force mismatched bolt into threaded hole.

2. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

Limited operational stress capability.

Personnel/Time Required:

- 1 soldier
- 0.2 hour

3-24. BOLTS MISSING - CONTINUED

Materials/Tools:

- Iron rod (scavenge from available source)
- Iron stud (scavenge from available source)

Procedural Steps:

1. Insert iron rod or stud through connecting holes of components or brackets being remounted or connected.

2. Peen iron rod or stud on each side of holes.

3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3

Limitations:

Limited operational stress capability.

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

- Threaded rod (scavenge from available source)
- Nut (scavenge from available source)

Procedural Steps:

1. Install rod into threaded connector hole.

NOTE

A nut larger than the rod threads can be used for BDAR repair if a nut of proper size is not available

2. Tighten nut onto rod to hold component in place.

3. Slide nut over end of rod and peen rod end to hold nut in place.

4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-25. BOLT THREADS, DAMAGED

Damaged threads decrease the load-bearing capability of bolts. Damaged threads can be repaired or cleaned using thread file or triangular shaped file. The threads must be cleaned to remove any dirt or metal particles which might cause further damage to threaded holes. In the event that bolt threads are damaged beyond repair and proper bolts are not available, refer to BDAR procedures (para 3-24) that address missing bolts.

Limitations:

Possible decrease in load-bearing capability.

3-25. BOLT THREADS, DAMAGED - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

- Nail or scnbe (scavenge from available source)
- Nut (scavenge from available source)

Procedural Steps:

CAUTION

Dirt or metal particles on threads may further damage threaded hole.

NOTE

Turning hardened steel nut onto bolt can help realign damaged threads.

1. Clean threads to remove dirt and metal particles using thread file or triangular-shaped file.
2. Remove stuck metal particles using wire brush and nail or scribe.
3. Remove burrs.
4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-26. MECHANICAL LINKAGE 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.

Option 1

Limitations:

Possible degraded mobility

Personnel/Time Required:

- 1-2 soldiers
- Time determined by location and amount of damage.

Materials/Tools:

- Plate stock (scavenge from available source)
- Rod, welding (item 51, Appendix C)

3-26. MECHANICAL LINKAGE ROD, DAMAGED - CONTINUED

Procedural Steps:

NOTE

If welding capability is not available go to option 2.

1. Remove damaged rod.
2. Measure distance between connecting points.

NOTE

Rod length should equal distance measured in step 2.

3. Cut required length of plate stock.
4. Weld rod.
5. Remove any excess metal that would hinder operation.
6. Install rod.
7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

Possible degraded mobility

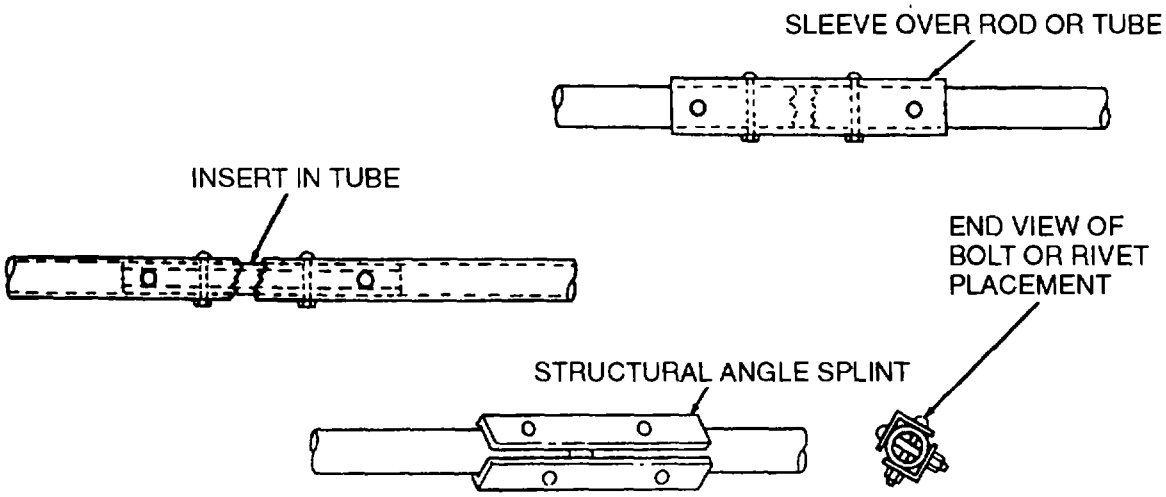
Personnel/Time Required:

- 1-2 soldiers
- Time determined by location and amount of damage.

Materials/Tools:

- Bolts, two required (scavenge from available source)
- Rod or tube (scavenge from available source)

Procedural Steps:



3-26. MECHANICAL LINKAGE ROD, DAMAGED - CONTINUED

1. Remove damage rod.
2. Measure distance between connecting points.
3. Measure rod or tube length.

NOTE

Rod length should equal distance measured in step 3.

4. Cut required length of reinforcement rod or tube.

5. Drill holes through reinforcement and rod.

6. Rivet or bolt reinforcement to damaged rod.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-27. PULLEY, DAMAGED

When cable pulleys are damaged beyond use, the damaged pulley may be welded, wedged into position, or replaced with a bolt.

Option 1

Limitations:

Cable life will be decreased.

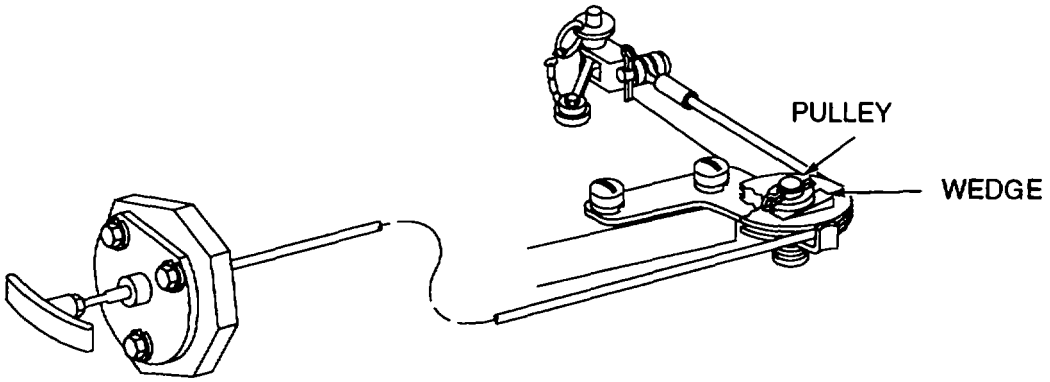
Personnel/Time Required:

- 1-2 soldiers
- Time determined by location and amount of damage

Materials/Tools:

- Grease, aircraft (item 33, Appendix C)
- Wedging material, wood or metal (scavenge from available source)

Procedural Steps:



1. Place wedge between pulley and support.

3-27. PULLEY, DAMAGED - CONTINUED

2. Grease cable and place on pulley.
3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

Cable life will be decreased.

Personnel/Time Required:

- 1-2 soldiers
- Time determined by location and amount of damage

Materials/Tools:

- Bolt (scavenge from available source)
- Flat washers, two required (scavenge from available source)
- Grease, aircraft (item 33, Appendix C)

Procedural Steps:

1. Replace pulley with bolt and two flat washers.

2. Grease cable and place between two flat washers.

3. Adjust cable to proper tension, if possible.

4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-28. MECHANICAL CABLE, BROKEN

Mechanical cables can be severed or damaged in battlefield conditions. Cable should be replaced when damaged. When replacement cable is not available, splice broken cables.

Option 1

Limitations:

None

Personnel/Time Required:

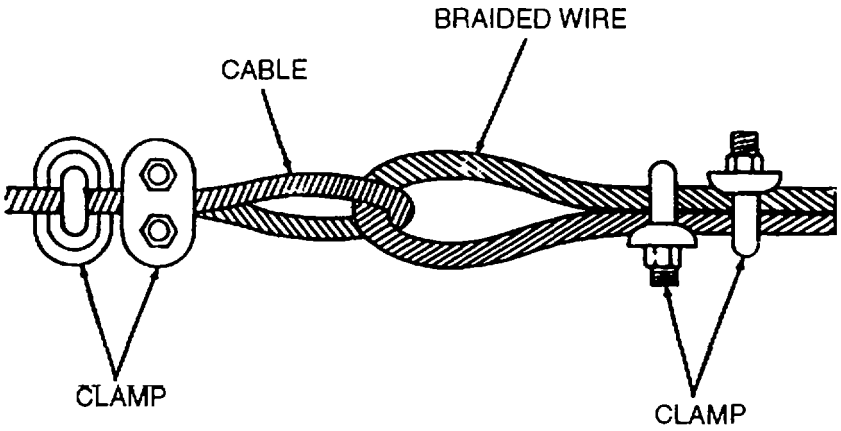
- 1 soldier
- 0.5 hour

Materials/Tools:

- Clamp, cable, eight required (scavenge from available source)
- Wire, braided (scavenge from available source)

3-28. MECHANICAL CABLE, BROKEN - CONTINUED

Procedural Steps:



NOTE

Ensure length of cable and splices will not restrict the operation of cable.

1. Select length of cable where cable splices will not restrict range of cable travel.
2. Loop end of repair braided wire and secure with two cable clamps.
3. Thread broken cable end through loop.
4. Make another loop with broken cable and secure with two cable clamps.
5. Repeat steps 2 through 4 for other end of broken cable.
6. Adjust cable to proper tension, if possible.
7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

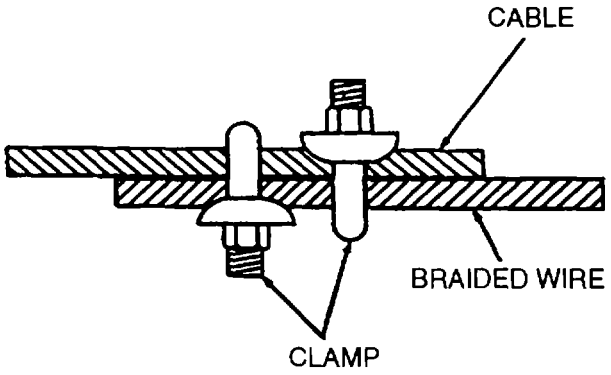
- 1 soldier
- 0.5 hour

Materials/Tools:

- Clamp, cable, four required (scavenge from available source)
- Wire, braided (scavenge from available source)

3-28. MECHANICAL CABLE, BROKEN - CONTINUED

Procedural Steps:



NOTE

Ensure length of cable and splices will not restrict the operation of cable.

1. Select length of cable where cable splices will not restrict range of cable travel.

NOTE

End of cable should extend at least 1 1/2 inches beyond clamp.

2. Splice repair braided wire and broken cable with two clamps.

3. Repeat step 2 for other end of broken cable.

4. Adjust cable to proper tension, if possible.

5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3

Limitations:

None

Personnel/Time Required:

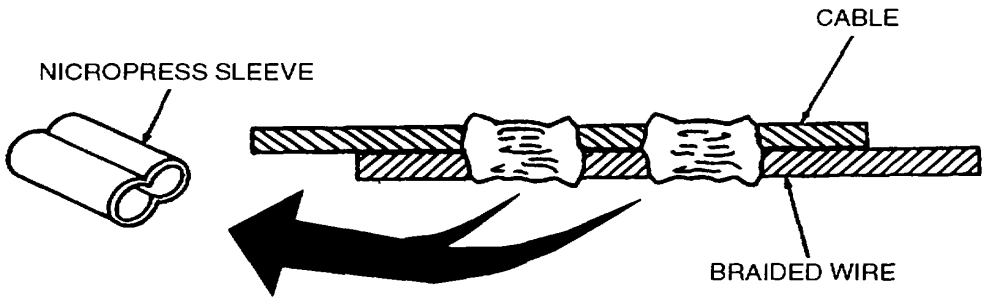
- 1 solder
- 0.5 hour

Materials/Tools:

- Sleeve, nicropress, four required (item 57, Appendix C)
- Wire, braided (scavenge from available source)

3-28. MECHANICAL CABLE, BROKEN - CONTINUED

Procedural Steps:



NOTE

Ensure length of cable and splices will not restrict the operational range of cable travel.

1. Splice repair braided wire and broken cable with two nicropress sleeves.

2. Swage sleeves on cables and wire with installation tool, vise, or hammer.

3 Repeat steps 1 and 2 for other end of broken cable.

4. Adjust cable to proper tension, if possible.

5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.5 hours

Materials/Tools:

- Wire, braided (scavenge from available source)
- Rope or wire (scavenge from available source)

Procedural Steps:

1. Replace damaged cable with 5 to 7 strands of braided wire, common wire, or rope where cable function.

2. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-29. LINKAGE RETAINING DEVICES, MISSING

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 vehicle by securing connecting bolts or pins can be accomplished using wire, welding rod, bolts, or nails. Slotted nuts can also be retained using this method. Alignment pins or dowels can be replaced with cut bolts.

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

Wire, safety (item 80, Appendix C or scavenge from available source)

Procedural Steps:

1. Place wire through hole.
2. Bend ends to keep wire from falling out.
3. Record BDAR action taken When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

Rod, welding (item 51, Appendix C)

Procedural Steps:

1. Place rod through hole.
2. Bend ends to keep rod from falling out.
3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-29. LINKAGE RETAINING DEVICES - CONTINUED

Option 3

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

Bolt or nail (scavenge from available source)

Procedural Steps:

1. Place bolt or nail through hole.

2. Bend (nail) or peen (bolt) end of nail or bolt.

3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

Bolt or nail (scavenge from available source)

Procedural Steps:

NOTE

Following option is for replacing alignment pins or dowels.

1. Select bolt or nail that will fit tight in hole.

2. Tap bolt or nail into the hole.

3. Cut bolt or nail to proper length.

4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION X. BATTERIES

3-30. GENERAL

This procedure provides methods to make temporary repairs to batteries that become cracked. The batteries store energy to start the vehicle engine and to supply energy for accessory systems without requiring engine operation. The batteries also act as a buffer for the electrical charging system. Without a battery in the circuit, the charging system will charge at its maximum rate and rapidly burn out. Battery configuration is a minimum of two 12-volt batteries connected in series to give a 24 V dc (Voltage direct current) output.

3-31. BATTERY, CRACKED

This procedure provides methods to make temporary repairs to batteries that become cracked. Batteries can become cracked from vibration, 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.

Limitations:

- Power may be decreased.
- Battery life may be shortened.

Personnel/Time Required:

- 1 soldier
- Time determined by location and amount of damage.

Materials/Tools:

Sealer, permatex (item 54, Appendix C)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Disconnect negative battery link.

2. Remove battery if necessary

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Spread sealer generously over crack and allow to harden.

4. Refill battery to proper level with water and check for leaks.

3-31. BATTERY, CRACKED - CONTINUED

5. Install battery if necessary.

6 Connect negative battery link.

7 Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-32. BATTERY TERMINAL POST, BROKEN

This procedure provides methods to make temporary repairs to batteries with broken terminal post(s). If melting facilities or tools are not available, a post can be secured with self-tapping screw or bolt. However, the battery should be replaced as soon as possible if the post is screwed or bolted in place. The stub can be built back up with lead.

Option 1

Limitations:

Power may be decreased.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

Materials/Tools:

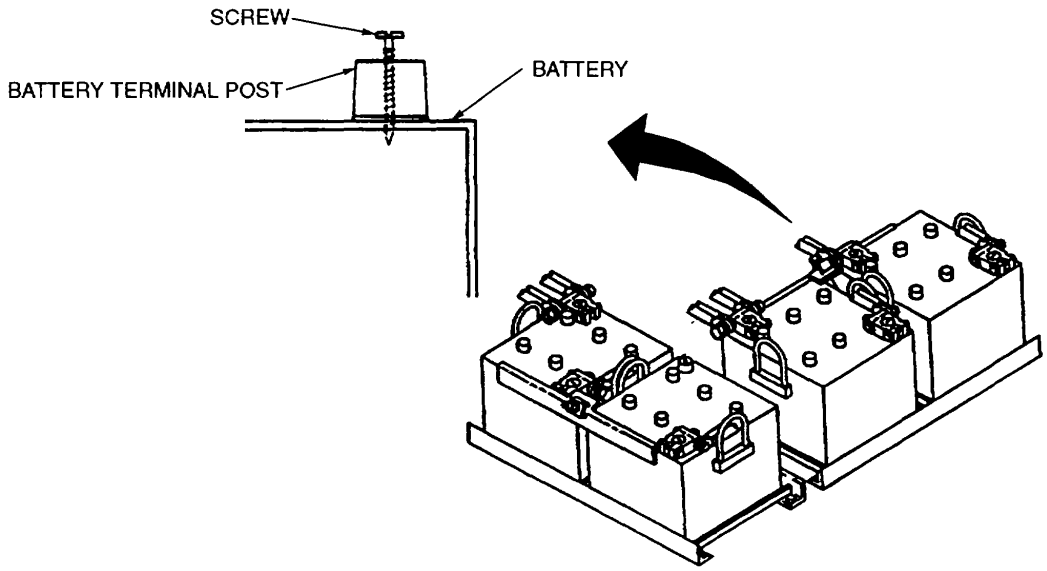
Screw tapping, No 12, 1 1/4-inch (item 53, Appendix C or scavenge from available source)

References:

TM 9-2350-314-20-1-1

Procedural Steps:

1. Disconnect negative battery clamp.



3-32. BATTERY TERMINAL POST, BROKEN - CONTINUED

2. Install tapping screw into battery terminal post stub.

3. Connect negative battery clamp.

4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Clamp, hose, 3/8 to 1 inch (item 7, Appendix C)
- Hose, rubber or tubing, metal, 3/4 to 1 inch ID, 1 inch length (scavenge from available source)
- Pig, lead (item 47, Appendix C)
- Metal container (scavenge from available source)

Procedural Steps:

1. Fabricate mold from 1 inch long, 3/4 to 1 inch ID rubber hose or metal tubing.

2. Install mold around battery terminal post stub.

3. Secure mold with hose clamp.

4. Seal bottom of mold to battery with mud.

WARNING

Hot lead burns easily and can give off harmful vapors. To avoid injury or death, use in well-ventilated area.

5. Melt lead into metal container.

6. Pour molten lead into mold and allow to cool.

7. Remove hose clamp, mold, and mud from battery and battery terminal post.

8. Install battery post clamp.

9. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION XI. HOUSINGS

3-33. GENERAL

Castings of plates may be serviceable 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 failure from crack growth cannot be predicted, and service life will depend on the extent of damage.

3-34. ENGINE/TRANSMISSION HOUSING, DAMAGED

Small cracks or holes may develop in the engine or transmission housing caused by vibration, overheating, or explosive shocks. Cracks that allow oil to escape must be repaired. Large holes or cracks will require replacement of oil. Frequent oil level checks must be performed, after repair. Depending on the extent and location of the damage, the powerpack may have to be removed.

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

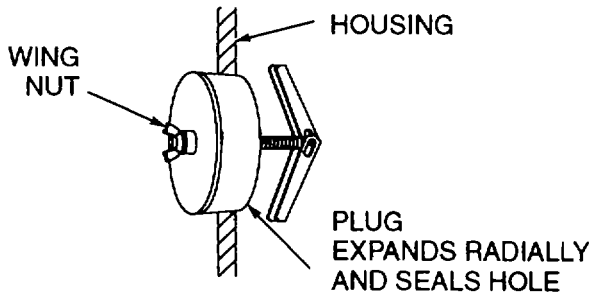
Materials/Tools:

- File (found in M2/3 generic BDR kit, Section III, Appendix C)
- Fuel cell patch kit (plug) (depending on size of hole) (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-20-1-2

Procedural Steps:



1. Drain housing of oil until level is below damaged area. Store oil in container until repair is complete.
2. Obtain plug the approximate size of the hole.
3. Using a round file, file the hole to a size equal to the plug diameter.
4. Install plug assembly and tighten wing nut.
5. Return oil to housing.
6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-34. ENGINE/TRANSMISSION HOUSING, DAMAGED - CONTINUED

Option 2

Limitations:

None

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

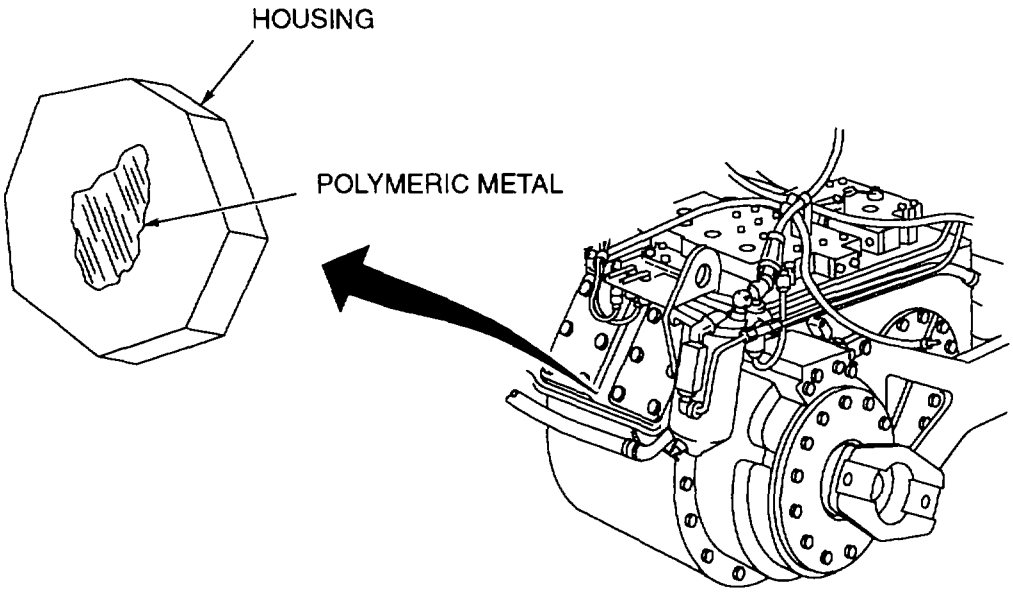
Materials/Tools:

Polymer repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

- LO 9-2350-314-12
- TM 9-2350-314-20-1-1
- TM 9-2350-314-20-1-2
- TM 9-2350-314-34-1
- TM 9-2520-234-35

Procedural Steps:



1. Drain housing of oil until level is below damaged area. Store oil in container until repair is complete.
2. Apply polymer metal to housing using kit instructions.
3. Return oil to housing.
4. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

3-34. ENGINE/TRANSMISSION HOUSING, DAMAGED - CONTINUED

Option 3

Limitations:

Frequent oil level checks must be performed after repair.

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

Materials/Tools:

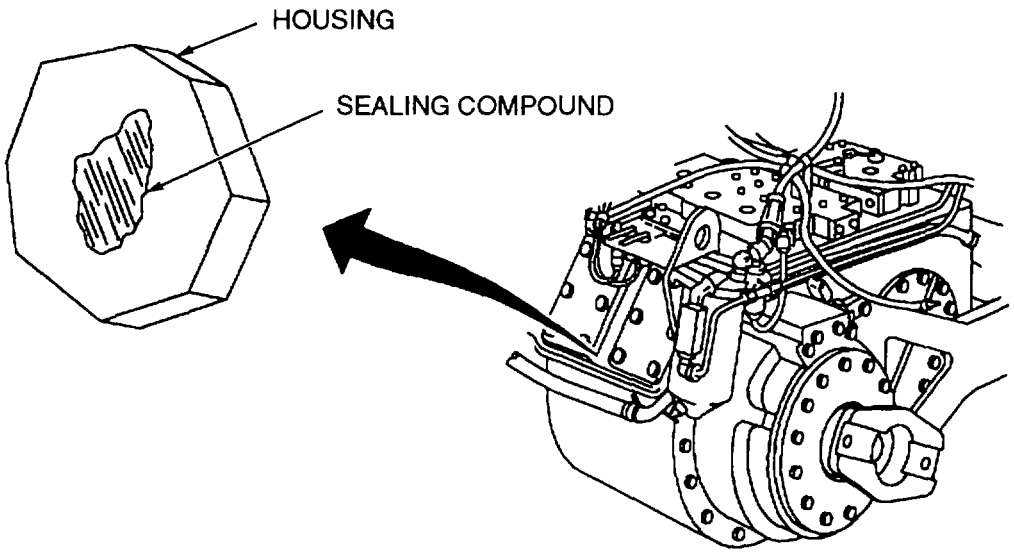
- Sealing compound (item 55, Appendix C)
- Paper, abrasive (item 46, Appendix C)

References:

- LO 9-2350-314-12
- TM 9-2350-314-20-1-1
- TM 9-2350-314-20-1-2
- TM 9-2350-314-34-1
- TM 9-2520-234-35

Procedural Steps:

1. Drain housing of oil until level is below damaged area. Store oil in container until repair is complete.



2. Remove paint from around damaged area with sandpaper.

3-34. ENGINE/TRANSMISSION HOUSING, DAMAGED - CONTINUED

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Cover damaged area and 1/4-inch or more of surrounding area with sealing compound.

NOTE

- **Allow sealing compound to harden.**
- **If available, a heat lamp or other electrical light may be projected onto sealing compound to speed hardening.**

4. Return oil to housing.

5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4

Limitations:

Frequent oil level checks must be performed after repair.

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

Materials/Tools:

- Sealing compound (item 55, Appendix C)
- Plate stock (scavenge from available source)
- Paper, abrasive (item 46, Appendix C)

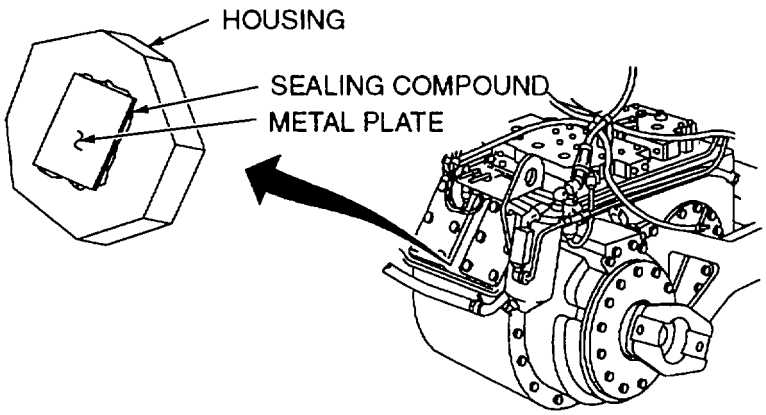
References:

- LO 9-2350-314-12
- TM 9-2350-314-20-1-1
- TM 9-2350-314-20-1-2
- TM 9-2350-314-34-1
- TM 9-2320-234-35

3-34. ENGINE/TRANSMISSION HOUSING, DAMAGED - CONTINUED

Procedural Steps:

1. Drain housing of oil until level is below damaged area. Store oil in container until repair is complete.



2. Remove paint from around damaged area with sandpaper.

3. Cover damaged area with a metal plate large enough to completely cover the area.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

4. Seal edges of metal plate with sealing compound.

NOTE

• Allow sealing compound to harden.

• If available, a heat lamp or other electrical light may be projected onto sealing compound to speed hardening.

5. Return oil to housing.

6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5

Limitation

- Oil saturation will cause tape to soften and leak, requiring frequent replacement.
- Frequent oil level checks must be performed after repair.

3-34. ENGINE/TRANSMISSION HOUSING, DAMAGED - CONTINUED

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

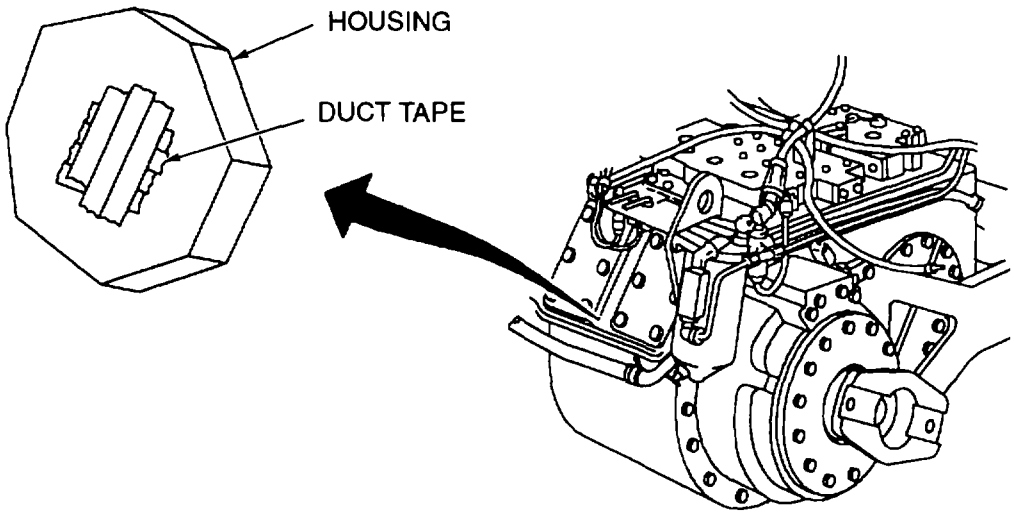
Materials/Tools:

- Rags (scavenge from available source)
- Tape, duct (item 62, Appendix C)

References:

- LO 9-2350-314-12
- TM 9-2350-314-20-1-1
- TM 9-2350-314-20-1-2
- TM 9-2520-234-35

Procedural Steps:



1. Drain housing of oil until level is below damaged area. Store oil in container until repair is complete.
2. Clean area around the damage..
3. Pack crack with rags and completely cover with duct tape.
4. Return oil to housing.
5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 4

ENGINE

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

Fixing the engine system (air Induction, lubrication, fuel management, and electrical) is done by using the repair procedures in this chapter. The proper procedure can be found by using the fault assessment tables or the repair procedure index (para 4-3). Repair of the engine itself is limited to replacing the defective module with a known good module.

4-2. ASSESSMENT PROCEDURE

Table 4-1. Engine Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Engine Failure	para 4-4
Fuel System	Chapter 5
Injector Failure	para 4-6
Throttle Linkage	para 4-7
Air Induction System	para 4-8
Exhaust System	para 4-14
Lubrication System	para 4-16
Cooling System.	Chapter 6

No damage found

Determine if:

Damage can be repaired
- Note repair requirements

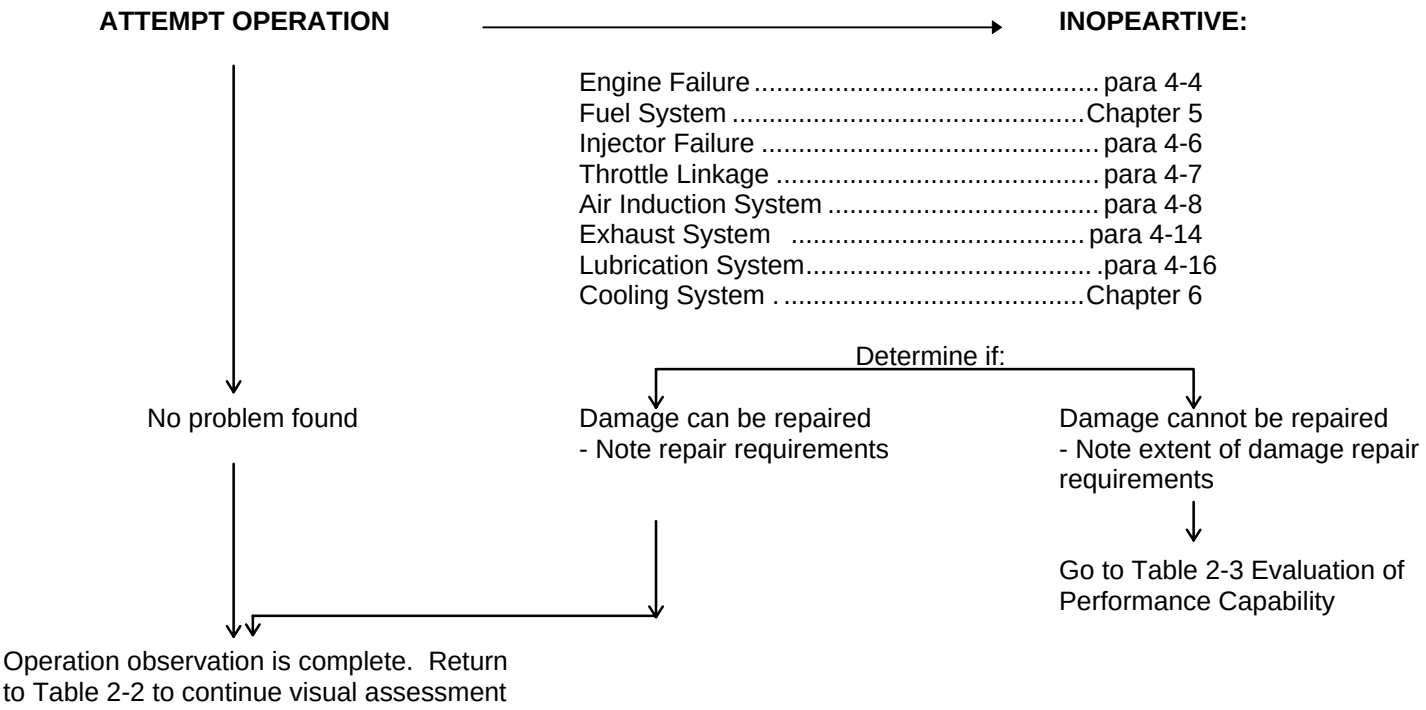
Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Visual Inspection is complete. Return to Table 2-1 to continue visual assessment.

4-2. ASSESSMENT PROCEDURE - CONTINUED

Table 4-2. Engine Visual Assessment



4-3. REPAIR PROCEDURE INDEX

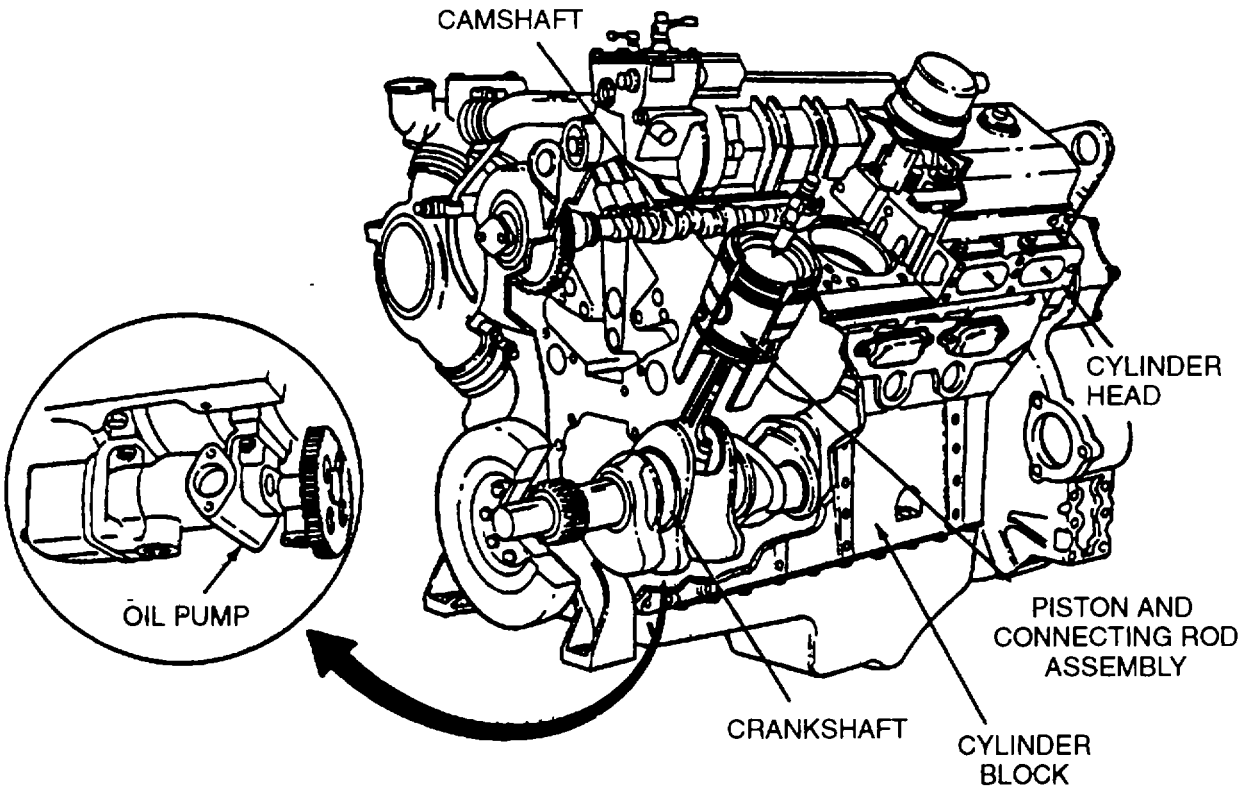
SECTION II. ENGINE FAILURE

4-4. GENERAL

Engine internal components are not easy BDAR fixes because of the tolerances and balances necessary to contain the pressure and forces of the burning fuel, and the need for mechanical integrity of the reciprocating and rotating parts. The best repair for internal engine components is replacement parts from the supply system.

a. It is possible, however, to mix and match parts from two or more damaged engines to reassemble one good engine with used parts. Example, if one engine has a damaged cylinder set or top end, the good cylinder/head set can be matched with a good, used short block to build a serviceable spare.

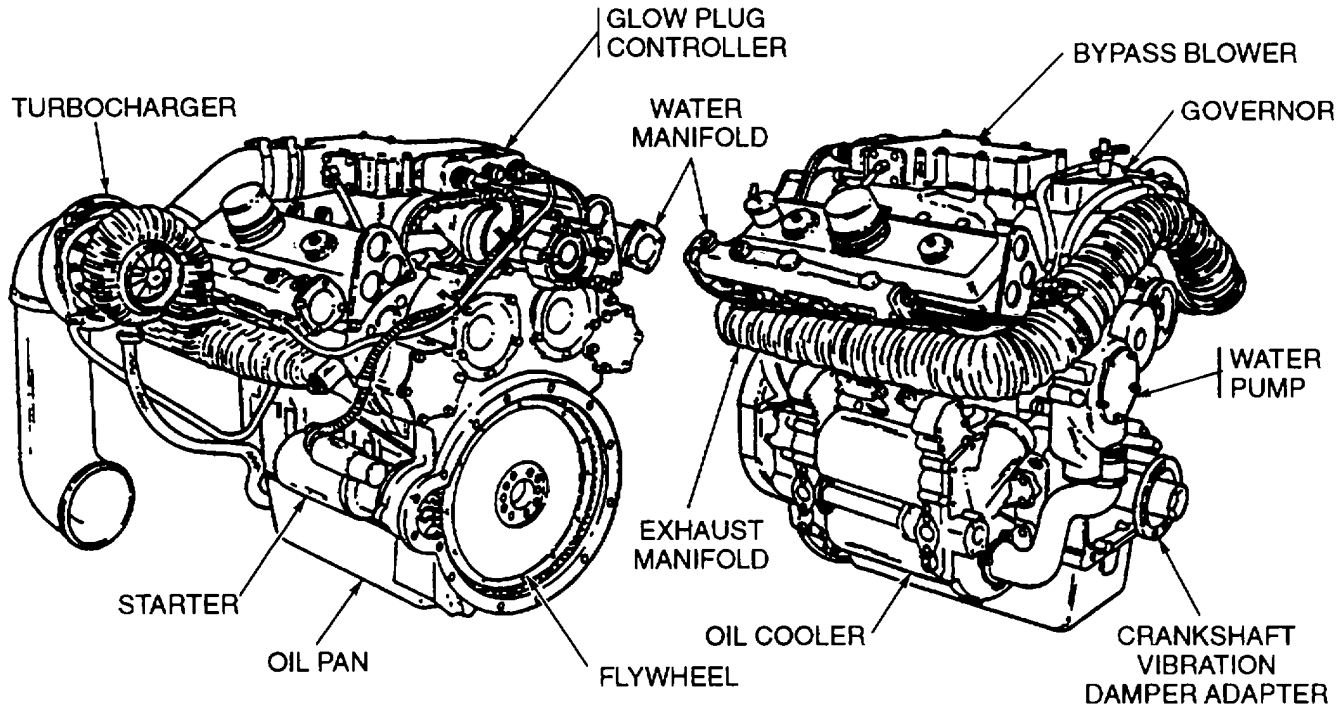
b. Certain internal engine component failures such as cam followers or rocker arm shaft galling may be ignored. Other failures, such as broken rings and galled pistons will result in engine destruction if the vehicle is operated.



4-5. ENGINE SUBSTITUTIONS

General Information:

Availability of engines may become restricted to those found in damaged vehicles. Basic engines from other vehicles can be modified or configurations rearranged to fit the vehicle needing the engine (8V71T model 7083 engine will fit M107, M109, M110, Howitzers, M578 Recovery Vehicle, and the M992 FAASV) The main difference of the 8V71T series is the turbocharger system. When substituting a replacement engine it may be necessary to remove the turbocharger system from the original engine and put on the substitution engine The limiting speed dual-range governor (Recovery Vehicle M578 only) performs the same function as the limiting speed governor with the additional capability of limiting the maximum engine speed at two different values. A non-turbocharged engine can also be used as a substitute but the original turbocharger system must not be installed on the non-turbocharged version. Cooling and exhaust connections may require improvisation to complete the installation.



LEFT REAR VIEW RIGHT FRONT VIEW

MODEL 7083-7391

45. ENGINE SUBSTITUTIONS - CONTINUED

Limitations:

Possible degraded mobility

Personnel/Time Required:

- 3 Soldiers
- 6.0 hours

Materials/Tools:

- Engine- M107, M109, M110, M578, or M992
- Lift capability

References:

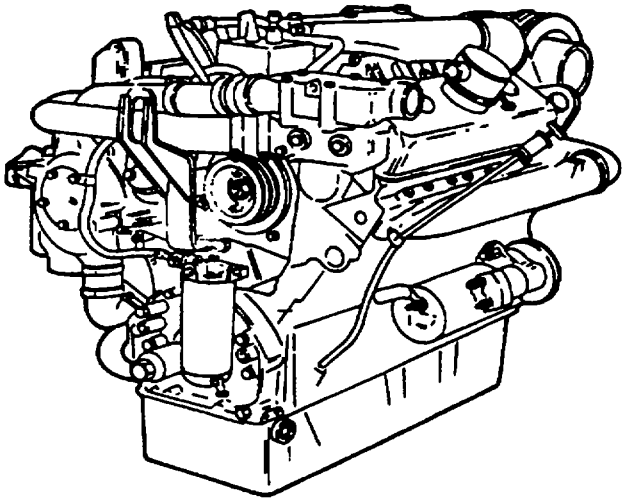
TM 9-2350-314-20-1-1
TM 9-2350-314-34-1
TM 9-2815-202-34

Procedural Steps:

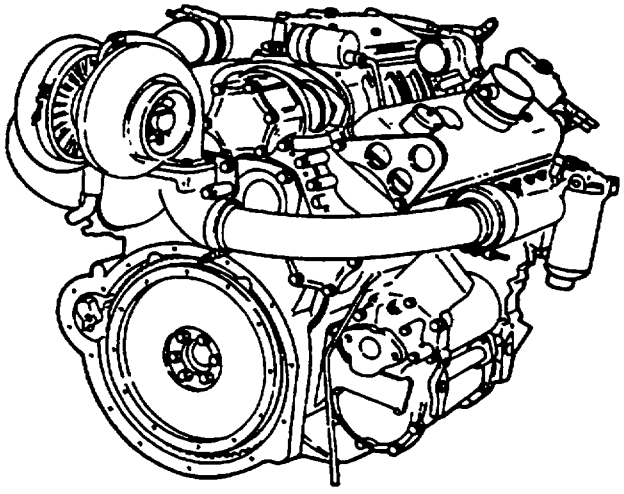
1. Remove powerpack.
2. Separate engine from the transfer case.
3. Place the substitute engine beside the original engine.
4 Note differences between the two engines such as, turbocharger, manifolds, cooling system, mounting brackets, valve covers, and accessories.
5. Remove items noted in step 4 from the substitute engine.
6. Remove items noted in step 4 from the original engine and put onto substitute engine.
7. Reconnect engine to the transfer case.
8. Reinstall powerpack.
9. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 1: MODEL 7083-7395

Option 1: MODEL 7083-7395



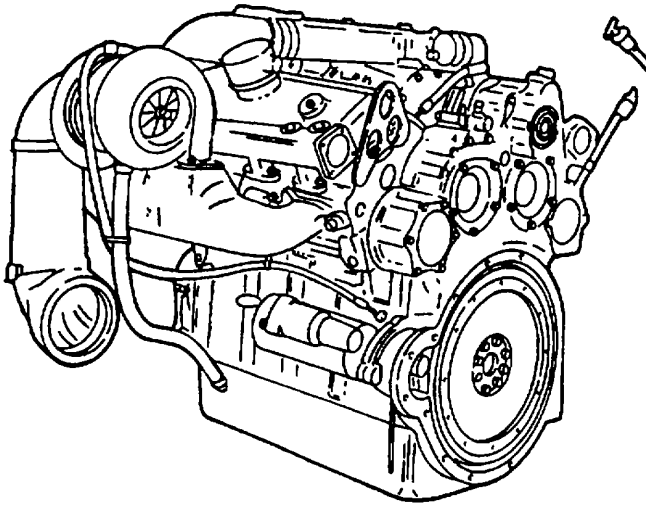
LEFT FRONT VIEW



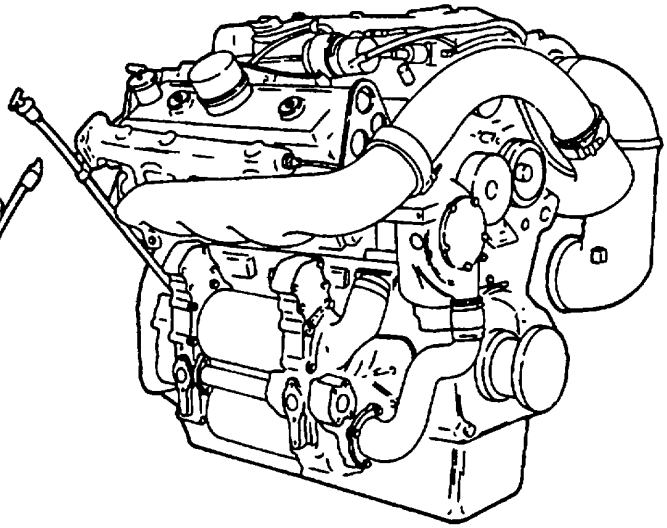
RIGHT REAR VIEW

4-5. ENGINE SUBSTITUTIONS - CONTINUED

Option 2: MODEL 7083-7396

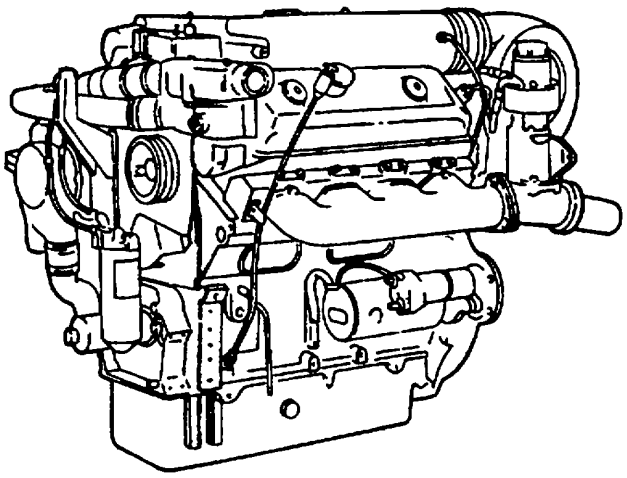


LEFT REAR VIEW

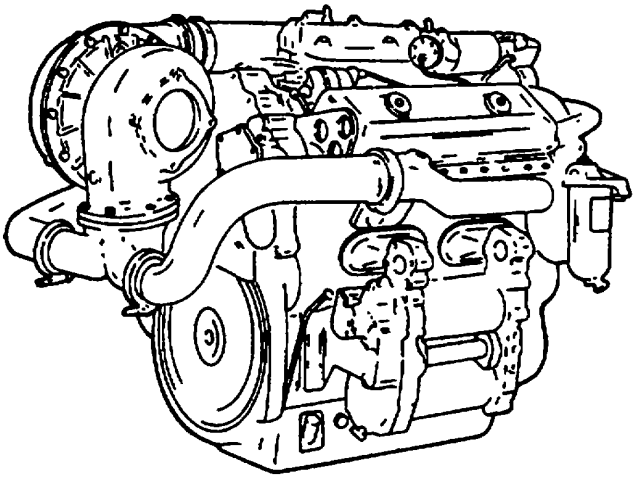


RIGHT FRONT VIEW

Option 3: MODEL 7083-7398



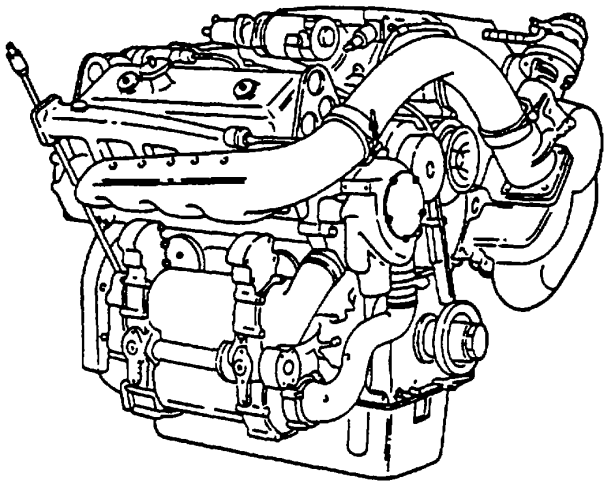
LEFT FRONT VIEW



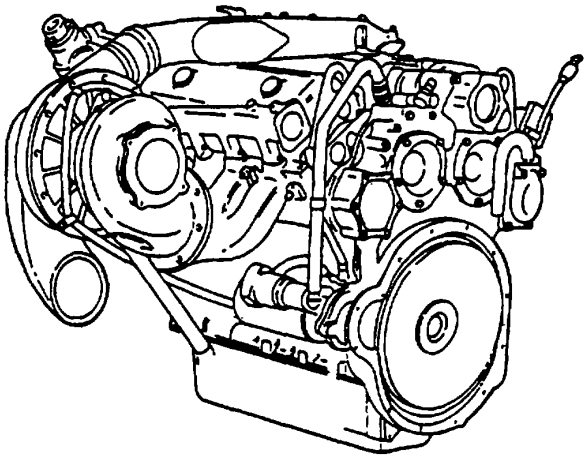
RIGHT REAR VIEW

4-5. ENGINE SUBSTITUTIONS - CONTINUED

Option 4: MODEL
7083-7399



LEFT REAR VIEW



RIGHT FRONT VIEW

4-6. INJECTOR FAILURE

General Information:

Fuel injector failure should be noticeable through a loss of power or excessive smoke. Within the Detroit Diesel family of engines the injectors are physically interchangeable, although their operating characteristics differ for the engine configuration they are designed for injectors should be exchanged in full sets, if possible, to keep engine operation balanced between cylinders, however, single replacement is possible. The defective injector can be located by following this procedure.

Assessment Steps:

1 Remove the valve covers.
2 Start engine.
3 Press firmly on injector guide follower of each injector.
4 Listen for a change in engine operation, if a change is noticed the injector is functioning.
5 If no change in operation is noted, the injector is not functioning.
6 Change injector at defective cylinder with an available injector.

4-6. INJECTOR FAILURE - CONTINUED

Substitutable Injectors

ENGINE	INJECTOR	USED IN
6V-53	M50	M113 F.O.V., Commercial, T.R. Forklifts
6V-53T	N-70	M551 Sheridan
8V-71T	S-80 Crown Type	M109, M110, M107, M108 S.P. Howitzer
	N-80 Needle Type	M578 Recovery Vehicle
	7590	M109A6, M992

7 Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using the standard maintenance procedures.

4-7. THROTTLE LINKAGE BROKEN

WARNING

Some procedures may expose personnel to extreme heat. Care should be taken to protect personnel by whatever means available.

General Information:

Throttle linkage broken. The travel lock is heavy and is not counterbalanced. This expedient is good for a limited period and vehicle should be driven at low speeds. Engine speed should be kept above 1725 RPM. Diesel engines are designated to operate at high RPM.

Limitations:

Reduced speed and maneuverability, possible crew injury.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

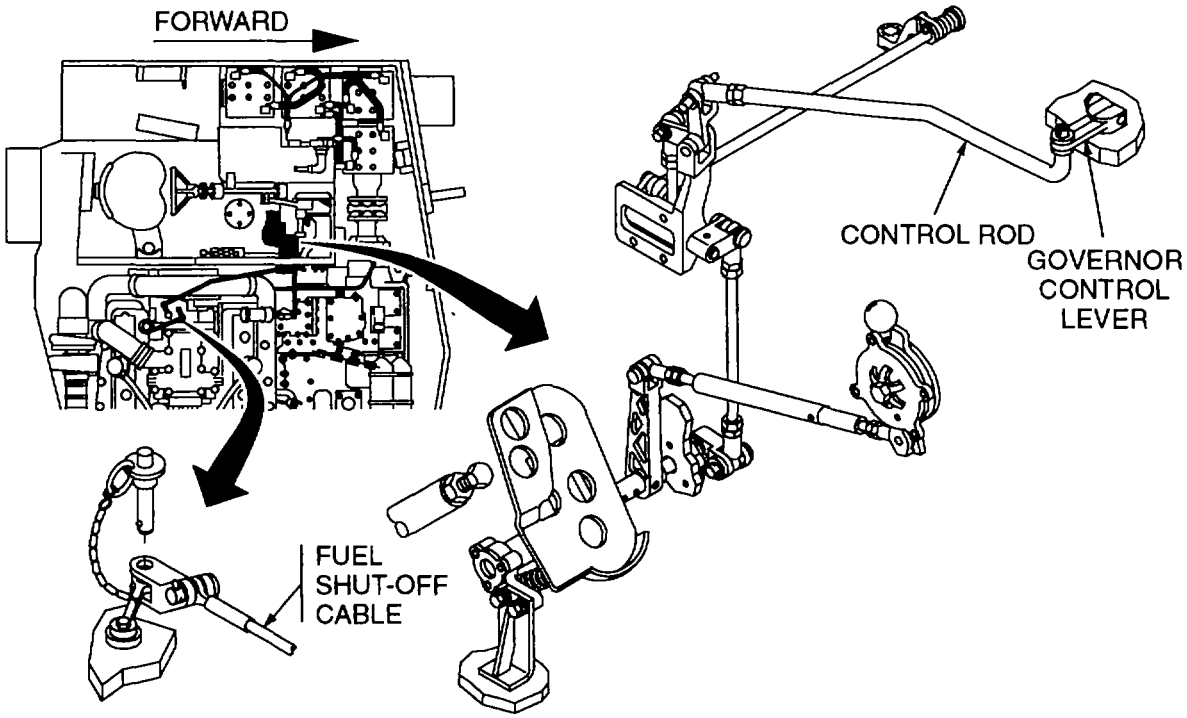
Other Options:

Refer to Chapter 3, para 3-26 for other repair methods.

4-7. THROTTLE LINKAGE BROKEN - CONTINUED

Procedural Steps:

1 Gain access to engine compartment through air-intake grille.



2 Locate and remove damaged section of the engine throttle governor control rod.

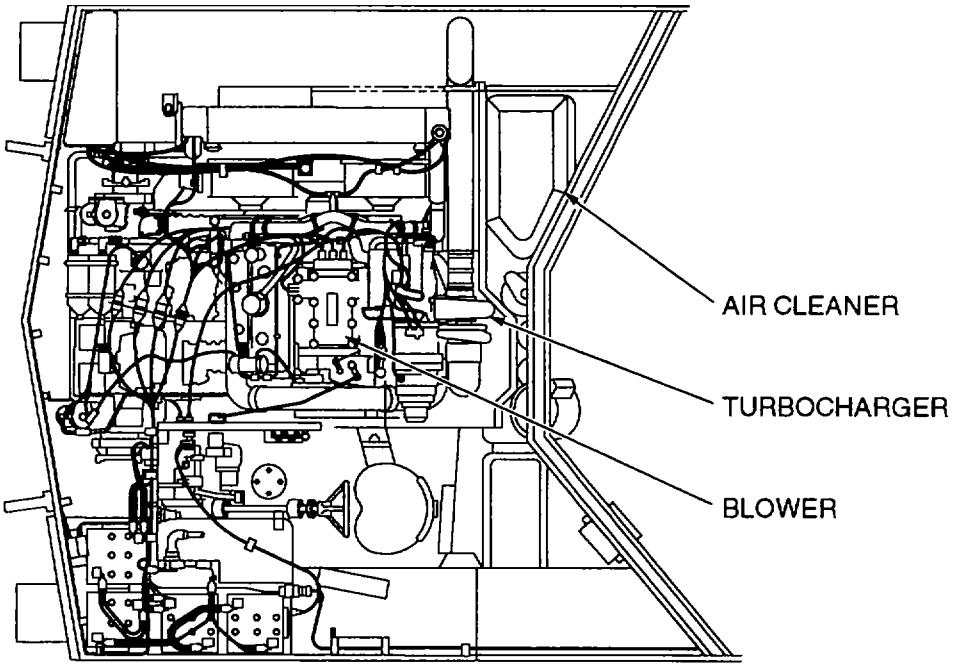
3 Disconnect fuel shut-off cable and reconnect at governor control lever.

4 Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. AIR INDUCTION SYSTEM

4-8. GENERAL

The air induction system is essential for providing clean air to the engine. Dust and dirt, even in small amounts, can cause engine failure. The M109A6 air induction system consists of two air cleaners located in the crew compartment, engine mounted turbocharger and blower, and ducting and hoses. Between the air cleaners and turbocharger, the system is under vacuum. From the turbocharger to the engine, the system is under pressure. Leaking components can be repaired using tape, fiberglass, liquid metal, hose clamps, rags, or other similar materials. Repairs to the turbocharger and blower will usually require repair parts and standards maintenance procedure.



4-9. AIR INDUCTION SYSTEM, LEAKING

General Information:

The air cleaner assembly, ducts, and hoses must not leak for the air cleaners to function effectively. Fiberglass and polymer fillers or gasket sealers can seal cracks and holes. Tape will provide a temporary seal on vacuum portions of the system but, has minimal value for pressurized systems without metal or wire reinforcement.

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.3 hour

4-9. AIR INDUCTION SYSTEM, LEAKING - CONTINUED

CAUTION

Repairs to the air induction system should always be done with materials that do not block the air flow and are securely attached to prevent them from being sucked into and causing failure of the turbocharger, blower, and engine.

Materials/Tools:

Tape, duct (item 62, Appendix C)

Procedural Steps:

1. Gain access to the damaged/leaking area.
2. Clean area around leak.
3. Apply tape to area of leak.
4. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

CAUTION

Repairs to the air induction system should always be done with materials that do not block the air flow and are securely attached to prevent them from being sucked into and causing failure of the turbocharger, blower, and engine.

Materials/Tools:

- Polymer repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Fiberglass repair kit (item 50, Appendix C)
- Wire brush (found in M2/3 generic BDR kit, Section III, Appendix C)
- Paper, abrasive (item 46, Appendix C)

4-9. AIR INDUCTION SYSTEM, LEAKING - CONTINUED

Procedural Steps:

1. Gain access to the damaged/leaking area.
2. Remove dirt and paint from around damaged area with wire brush or abrasive paper.
3. Remove rough edges of damaged area with file or hammer.
4. Repair damaged area with polymer or fiberglass repair kit following kit instructions.
5. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

4-10. AIR CLEANER, CLOGGED

General Information:

The air cleaners are essential for preventing dirt and dust from entering the engine. Under heavy dust conditions the filters can become clogged and restrict the flow of air. Insufficient air to the engine will cause incomplete fuel combustion resulting in reduced power and excessive exhaust smoke. Clogged filters must be cleaned as soon as possible using the following procedures.

Limitations:

None

Personnel/Time Required:

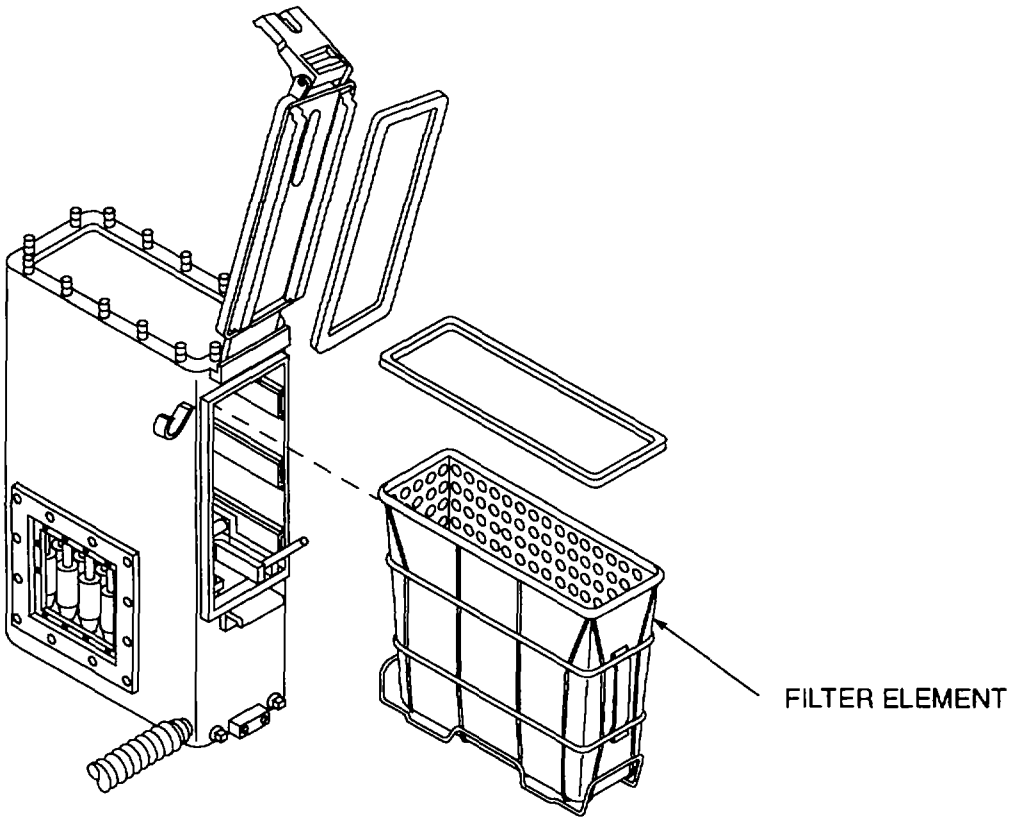
- 1 soldier
- 0.8 hour

Materials/Tools:

- Wheeled vehicle tire inflation hose (scavenge from available source)
- Tape, duct (item 62, Appendix C)
- Wire, electrical (item 75, Appendix C)

4-10. AIR CLEANER, CLOGGED - CONTINUED

Procedural Steps:



WARNING

If NBC exposure is suspected, all filter media will be handled by personnel wearing full NBC protective equipment.

1. Remove air filter elements from air cleaners.

WARNING

Wear eye protection. Particles released from air filter elements during cleaning could injure eyes.

2. Clean dirt from outside of air filter elements by directing pressurized air against the inside of the filter. Pressurized air can be obtained from one of the following sources.

   a. Compressed air source such as wheeled vehicle air brake system by using tire inflation hose or placing filter element directly under air flow from supply valve.
   b. Air from a disabled wheeled vehicle's tires. Remove valve stem and connect tire inflation hose.
   c. Disconnect air hoses from air cleaner blowers. Connect hoses together with duct tape and connect to one blower. With engine running and transmission in any gear (except neutral), blower will operate.

4-10. AIR CLEANER, CLOGGED - CONTINUED

d. Remove an air cleaner blower and connect to power source with long leads.

NOTE

In an emergency, the air filter elements can be cleaned by tapping bottom and sides against a flat surface. Do not strike open or sealing edges which would deform the sealing surfaces.

3. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

4-11. AIR CLEANER, DAMAGED

General Information:

The air cleaners must filter all incoming air to the engine. The air cleaners should be bypassed only as a last resort since damage will occur as the engine injects the dust and dirt in unfiltered air if the air cleaners, ducting, and hoses cannot be repaired, this procedure will provide minimum air filtration.

Limitations:

Damage may occur to turbocharger, blower, and/or engine

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Clean cloth (wiping rag, shirt or blanket) (scavenge from available source)
- Clamp (scavenge from available source)

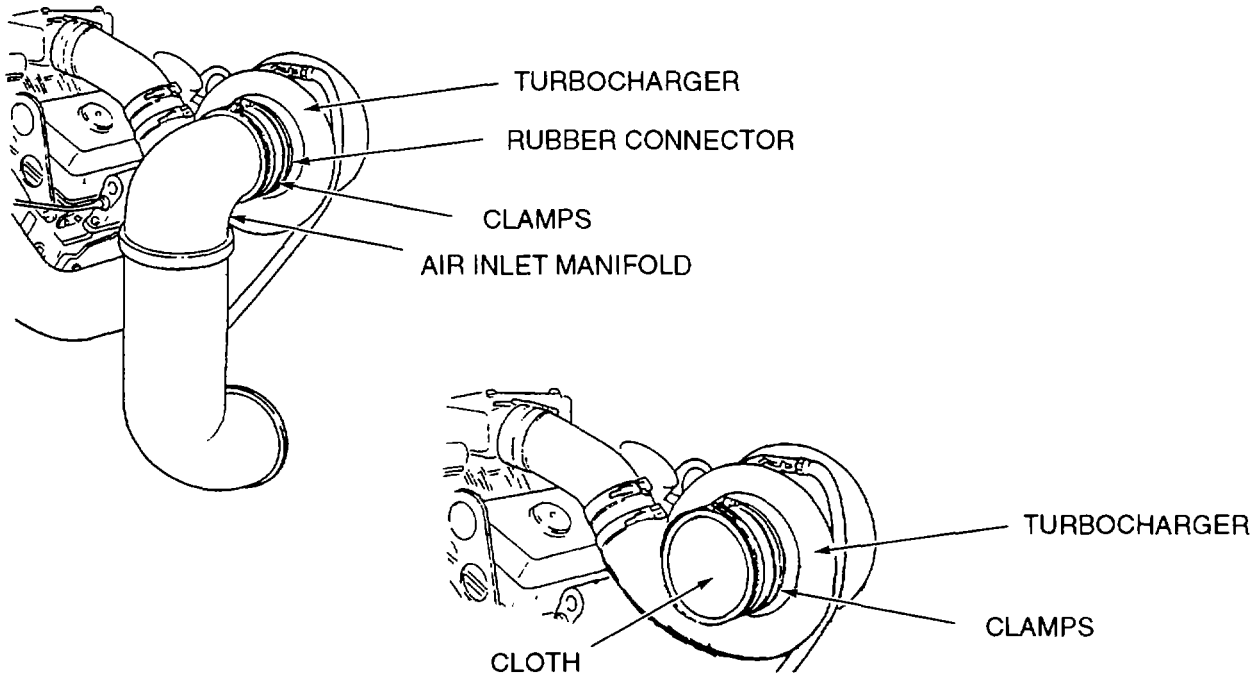
Procedural Steps:

CAUTION

Repairs to the air induction system should always be done with materials that do not block the air flow and are securely attached to prevent them from being sucked into and causing failure of the turbocharger, blower, and engine.

1. Gain access to engine compartment by opening engine air intake grille.

4-11. AIR CLEANER, DAMAGED - CONTINUED



2. Disconnect air inlet manifold and rubber connector from turbocharger air inlet.

3. Cover the turbocharger air inlet with clean cloth.

4. Secure the cloth tightly to the turbocharger air inlet with clamp or wire.

5. Replace or clean the cloth when it gets dirty.

6. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

4-12. BLOWER DRIVE SHAFT, BROKEN

General Information:

The blower provides pressurized air to the engine air box. It is driven by a drive shaft (commonly called a quillshaft) which acts as a safety device for the blower system. The drive shaft shears when overloaded to protect the blower and its drive system from damage. The drive shaft can be repaired with the following procedure which should be used only if a new part is not available.

Limitations:

Blower and/or engine may be damaged.

Personnel/Time Required:

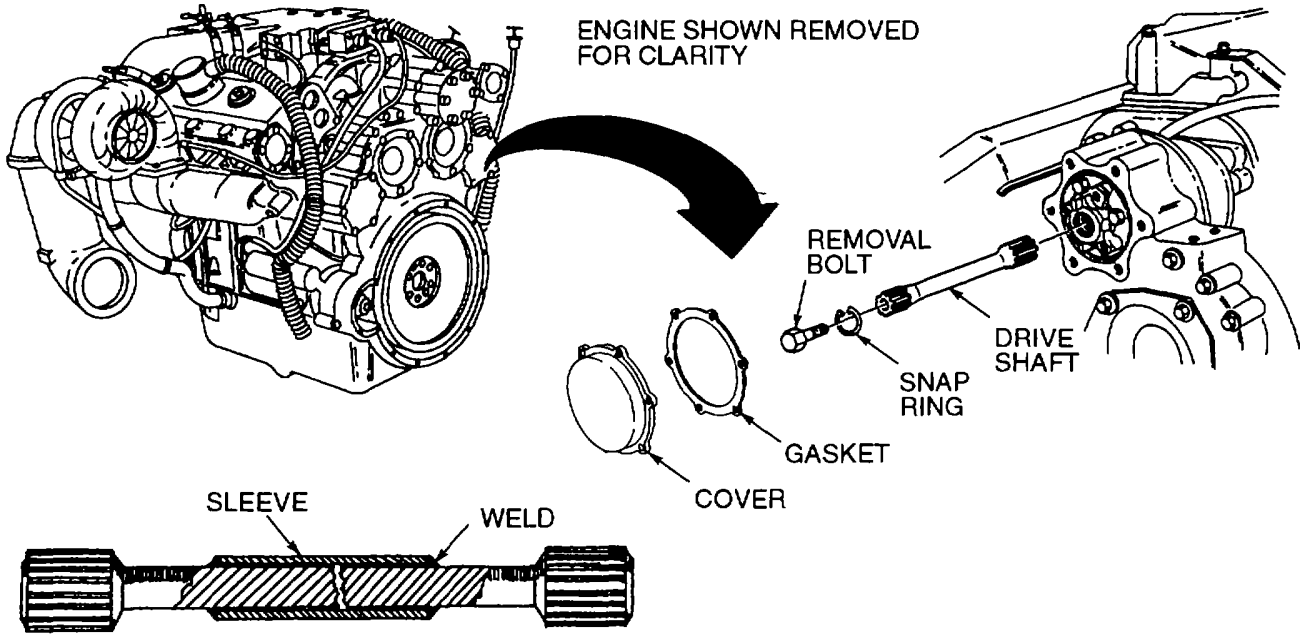
- 1 soldier
- 1.0 hour

4-12. BLOWER DRIVE SHAFT, BROKEN - CONTINUED

Materials/Tools:

- Bolt, 10-32 x 1 inch (scavenge from available source)
- Tubing or sleeve (scavenge from available source)
- Welding equipment

Procedural Steps:



1 Gain access to engine compartment by opening engine air Intake grille.

2 Remove flywheel housing cover and gasket.

3 Remove snap ring securing drive shaft.

4. Remove pieces of broken drive shaft with needle nose pliers and/or bolt threaded into end of shaft.

5 Fabricate or machine a sleeve that will fit broken drive shaft.

6 Install sleeve over broken pieces of drive shaft ensuring that original shaft length Is maintained.

7 Weld ends of drive sleeve to shaft.

8 Install repaired drive shaft and secure with snap ring.

9 Install flywheel housing cover and gasket.

10 Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

4-13. INTAKE MANIFOLD OR OTHER CASTINGS OR CONTAINERS DAMAGED

General Information:

Intake manifolds are difficult to repair. Autobody fillers, epoxys 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 re-enforcement. Epoxy kits will make an almost permanent repair, if time is available for curing. Follow the individual kit directions.

SECTION IV. EXHAUST SYSTEM

4-14. GENERAL

The engine exhaust system consists of the exhaust manifold, ducts 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 ducts or pipes, not including the ducting for the turbocharger drive circuit, are inconvenient but the vehicle can still be operated. Care must be taken, however, to keep carbon monoxide out of the crew compartments. Turbocharger drive circuits must be repaired or engine performance will be degraded.

4-15. EXHAUST MANIFOLDS DAMAGED

General Information:

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

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Suitable fire resistant material (scavenge from available source)
- Clamps (scavenge from available source)

Other Options:

- Weld or braze the manifold..
- Use epoxy, type sealer (for small cracks) or adhesive epoxy (item 2, Appendix C).

Procedural Steps:

1. Gain access to the damaged manifold.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid Injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

4-15. EXHAUST MANIFOLDS DAMAGED - CONTINUED

2. Obtain a (sealing) material, cut material to cover the hole or leak.

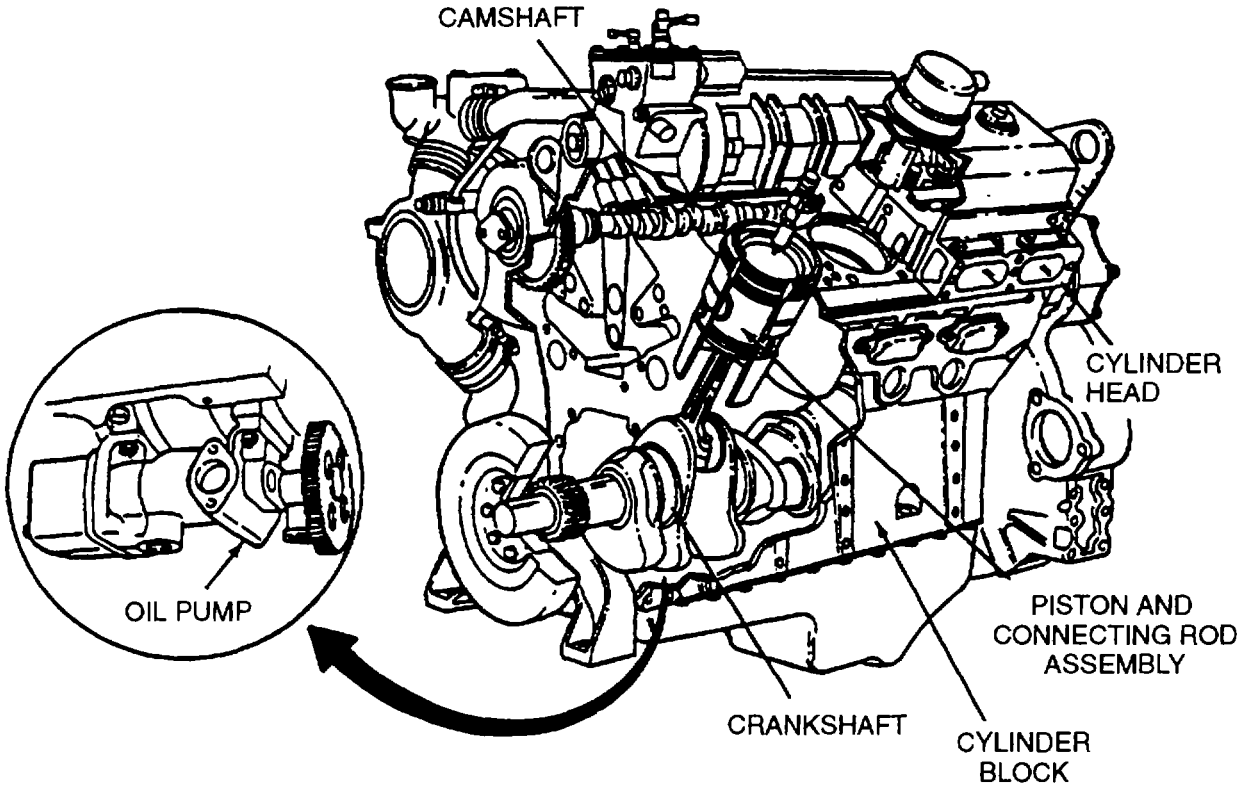
3. Secure the material in place using hose clamps.

4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance equipment procedures.

SECTION V. LUBRICATION SYSTEM

4-16. GENERAL

Engine lubrication is essential for all components. However, crankshaft bearings and diesel engine piston crowns are critical components. The pressure lubrication of the bearings and the cooling spray to the piston crowns are examples of the dual purpose of the engine lubricant. By-passing or rendering any portion of the lubrication system inoperative will shorten the engine life.



4-17. OIL LEVEL LOW

General Information:

Low oil level, engine crankcase. If the engine oil is supplemented with any type of oil other than that recommended by the LO, it will be necessary to drain the oil and replace the oil filter as soon as possible. Oils other than those designed for use in engines will provide limited lubrication. When using diesel fuel, do not dilute the lubrication oil more than approximately 3 parts diesel fuel to 1 part engine oil except in extreme emergencies. Drive slower to prevent damage to the engine. Do not dilute lubricating oil with gasoline.

Limitations;

Possible engine overheating or damage.

Personnel/Time Required:

- 1 soldier
- 1.5 hours

Materials/Tools:

Large clean container

References:

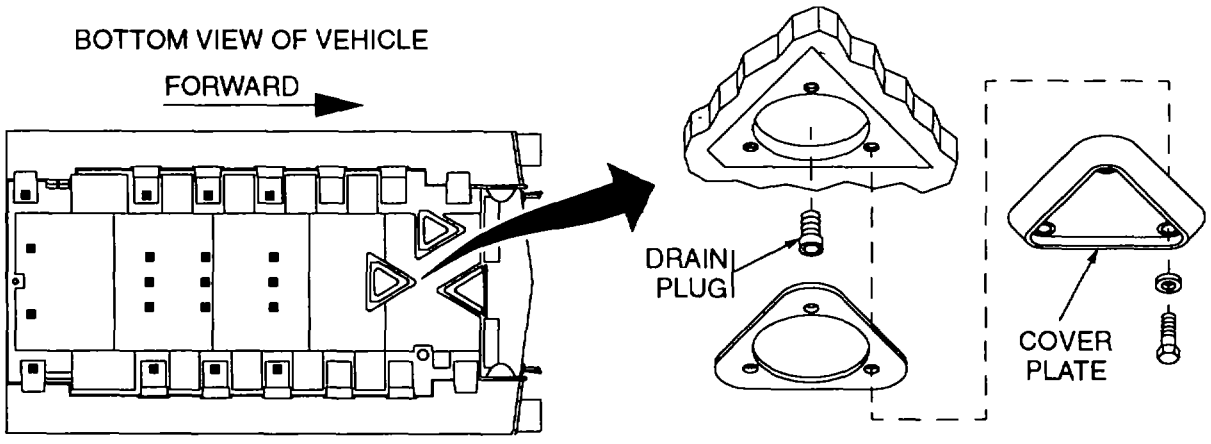
- LO 9-2350-314-12
- TM 9-2350-314-10

Other Options:

- Use oil from damaged vehicle
- Cooking oil
- Diesel fuel
- Hydraulic fluid (item 36, Appendix C)

Procedural Steps:

1. Place vehicle on level ground.



2. Remove cover plate from bottom of hull.
3. Drain oil from a damaged vehicle's transmission or engine by removing drain plug and drain approximately 2 gallons into a container.

4-17. OIL LEVEL LOW - CONTINUED

4. Reinstall drain plug and cover removed above.
5. Add oil to engine crankcase and bring oil level to at least the ADD OIL mark on gage.
6. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

4-18. OIL PAN HOLES

General Information:

Oil pan leaks will be detected by oil in the engine compartment, low oil level and a possible lowering of the oil pressure. The powerpack must be removed to inspect the extent of damage and to make repairs. Repairs are normally made by welding the oil pan, but if welding equipment is not available, and the hole is small, a repair may still be made using this procedure. After this repair has been made, frequent inspections will be required. Small cracks or holes may develop in the engine or transmission housing caused by vibration, overheating, or explosive shocks. Cracks that allow oil to escape must be repaired. Large holes or cracks will require replacement of oil. Frequent oil level checks must be performed, after repair. Depending on the extent and location of the damage, the powerpack may have to be removed.

Option 1

Limitations:

None

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

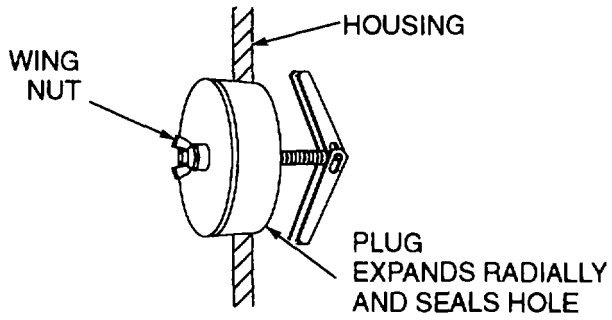
Materials/Tools:

- File (found in M2/3 generic BDR kit, Section III, Appendix C)
- Fuel cell patch kit (plug) (depending on size of hole) (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

TM 9-2350-314-20-1-1

Procedural Steps:



1. Drain housing of oil until level is below damaged area. Store oil in container until repair is complete.
2. Obtain plug the approximate size of the hole.

4-18. OIL PAN HOLES - CONTINUED

3. Using a round file, file the hole to a size equal to the plug diameter.
4. Install plug assembly and tighten wing nut.
5. Return oil to housing.
6. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2

Limitations:

Repair may loosen and leak due to heat and/or vibration.

Personnel/Time Required:

- 1 soldier
- Time to be determined by location and amount of damage.

Materials/Tools:

- Paper, abrasive (item 46, Appendix C)
- Epoxy, adhesive (item 2, Appendix C)
- Wood (scavenge from available source)
- Sheet metal screws (scavenge from available source)
- Leather boot (scavenge from available source)
- Rubber from tire or tube (scavenge from available source)
- Large diameter washer (scavenge from available source)

References:

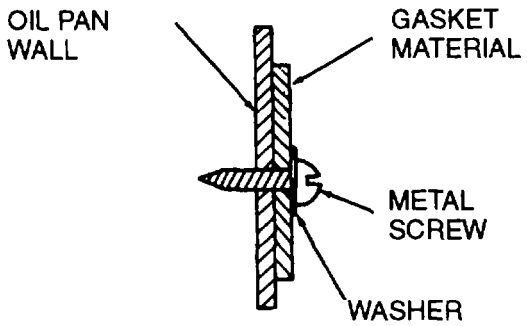
LO 9-2350-314-12

Other Options:

Weld oil pan if welding equipment is available.

Procedural Steps:

1. Locate leak.
2. Clean area around holes with sandpaper.



4-18. OIL PAN HOLES - CONTINUED

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Fill holes with available material, such as self-tapping sheet metal screw and cover with a quick drying epoxy adhesive or force a sheet metal screw through a makeshift washer (leather or rubber). Use a washer to back up the rubber or leather, if available. Install into hole. Tighten securely.

4. Replenish oil supply and check for leaks.

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3

Limitations:

Repair may loosen and leak due to heat and/or vibration.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

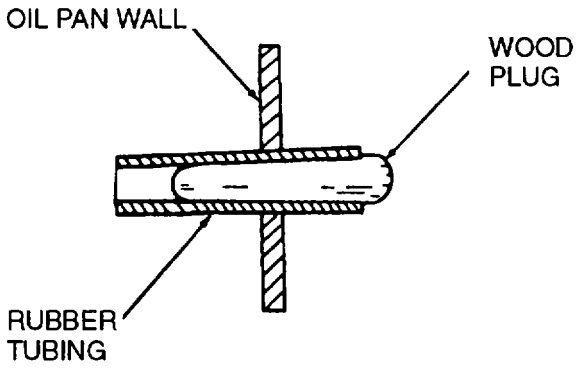
Materials/Tools:

- Plug, wooden (scavenge from available source)
- Tubing or hose, rubber (scavenge from available source)

References:

LO 9-2350-314-12

Procedural Steps:



1. Insert a piece of rubber tubing or hose into puncture.

4-18. OIL PAN HOLES - CONTINUED

2. Insert a tapered wooden plug inside rubber tubing or hose.
3. Replenish oil supply and check for leaks.
4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4

Limitations:

Repair may loosen and leak due to heat and/or improper cleaning of damaged area.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

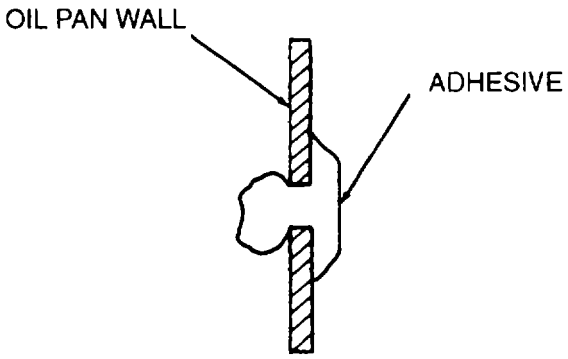
Materials/Tools:

- Adhesive (item 1, Appendix C)
- Solvent, Drycleaning, Type 1 (item 59, Appendix C)

References:

LO 9-2350-314-12

Procedural Steps:



WARNING

Adhesives, solvents, and sealing components can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent or sealing compound gets on skin or clothing, wash immediately with soap and water.

1. Clean area around puncture.

4-18. OIL PAN HOLES - CONTINUED

NOTE

Allow adhesive to harden.

2. Fill puncture and surrounding area with adhesive.
3. Replenish oil supply and check for leaks.
4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5

Limitations:

Repair may loosen and leak due to heat and/or improper cleaning of damaged area.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

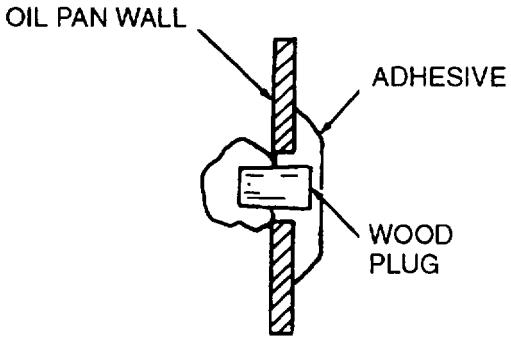
Materials/Tools:

- Adhesive (item 1, Appendix C)
- Plug, wooden (scavenge from available source)
- Solvent, Drycleaning, Type 1 (item 59, Appendix C)

References:

LO 9-2350-314-12

Procedural Steps:



4-18. OIL PAN HOLES - CONTINUED

WARNING

Adhesives, solvents, and sealing components can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent or sealing compound gets on skin or clothing, wash immediately with soap and water.

1. Clean area around puncture.
2. Fill puncture with adhesive and a wooden plug.

NOTE

Allow adhesive to harden.

3. Fill surrounding area of puncture with adhesive.
4. Replenish oil supply and check for leaks.
5. Record the BDAR action taken When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 5

FUEL 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

5-1. SCOPE

This chapter contains fault assessment and expedient repair procedures available to find and fix battlefield damage to the fuel system.

5-2. ASSESSMENT PROCEDURE

Table 5-1. Fuel System Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

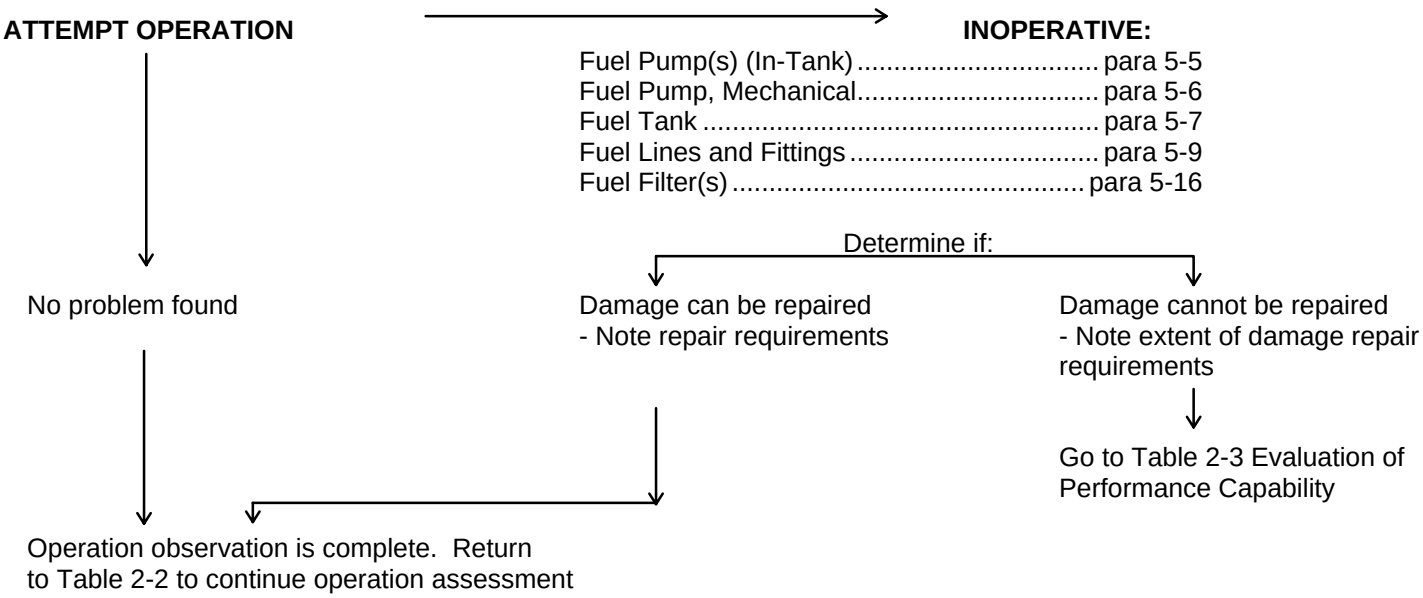
Fuel Pump(s) (In-Tank) ..... para 5-5
Fuel Pump, Mechanical..... para 5-6
Fuel Tank ..... para 5-7
Fuel Lines and Fittings ..... para 5-9
Fuel Filter(s) ..... para 5-16

Determine if:

- No damage found → Visual inspection is complete. Return to Table 2-1 to continue visual assessment
- Damage can be repaired - Note repair requirements → Visual inspection is complete. Return to Table 2-1 to continue visual assessment
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

5-2. ASSESSMENT PROCEDURE - CONTINUED

Table 5-2. Fuel System Operation Assessment



5-3. REPAIR PROCEDURE INDEX

SECTION II. FUEL PUMPS

5-4. GENERAL

In-tank (electrical) and mechanical (engine driven) fuel pumps provide fuel at an adequate volume and pressure to the fuel injectors. Battle damage to the fuel pumps can degrade or eliminate the howitzer's capability of movement. However, the mechanical fuel pump will draw fuel without the operation of the electrical fuel pumps. Replacement of a fuel pump is usually the most expedient method to correct the problem. Fuel pumps on many combat vehicles are interchangeable with those on the M109A6 howitzer.

5-5. FUEL PUMP(S) (IN-TANK), INOPERATIVE

General Information

The in-tank fuel pumps are generally interchangeable between combat vehicles. The difference is the bracketry used to mount the pump in the fuel tank. In-tank electrical fuel pumps from other combat and tactical vehicles can be adapted to function in the M109A6 howitzer. If required, the replacement pump can be removed from its bracket and installed in the bracket from the defective pump. Replacement of the right in-tank pump requires the removal of the powerpack. The following repair will restore the in-tank pump to an operating condition.

5-5. FUEL PUMP(S) (IN-TANK), INOPERATIVE-CONTINUED

Limitations:

None

Personnel/Time Required:

Right in-tank pump

- 3 soldiers
- 6.0 hours (includes 4.0 hours for removal/installation of powerpack)

Left in-tank pump

- 1 soldier
- 2.0 hours

Materials/Tools:

- Fuel pump (scavenged from available source)
- Rubber hose or strips (scavenged from available source)

References:

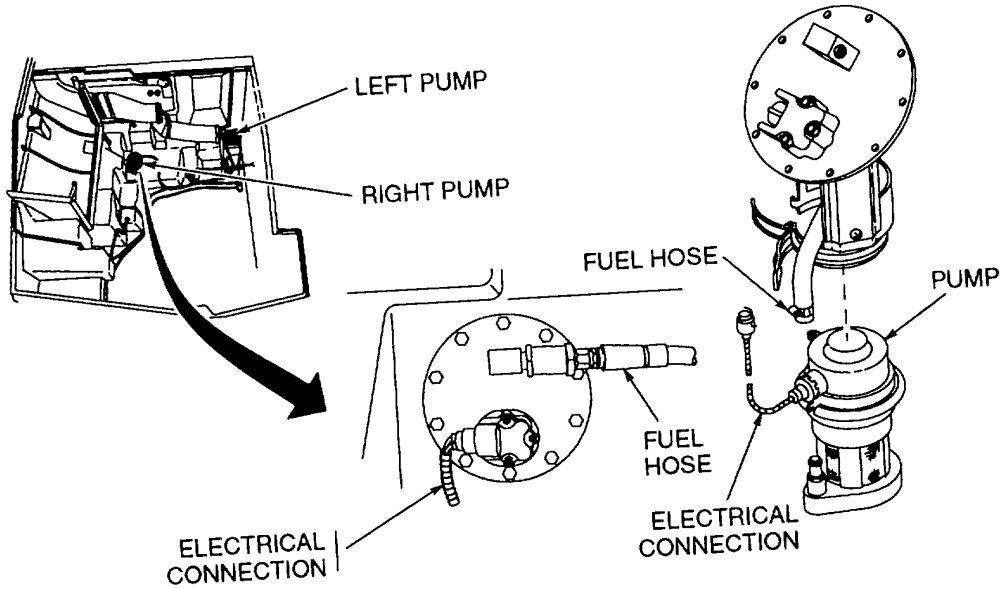
- TM 9-2350-314-10
- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1

Procedural Steps:

1. Drain fuel tanks.

2. Gain access to the lower tank by removing powerpack (right in-tank pump) or engine compartment access cover (left in-tank pump).

3. Ensure that howitzer MASTER power switch is in the OFF position.



5-5. FUEL PUMP(S) (IN-TANK), INOPERATIVE - CONTINUED

4. Disconnect electrical and fuel hose connections to fuel pump.

5. Remove fuel pump and hanger assembly from fuel tank.

6. Remove defective fuel pump from hanger assembly.

7. Wrap rubber hose or strips around replacement fuel pump body, if required, so that it will be tightly secured when installed in hanger assembly.

8. Install replacement fuel pump in hanger assembly

9. Splice electrical connections, if required, using procedures in Chapter 3.

10. Install replacement pump and hanger assembly in fuel tank.

11. Connect electrical and fuel hose connections to fuel pump.

12. Install engine compartment access cover (left in-tank pump) or powerpack (right in-tank pump).

13. Record the BOAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

5-6. FUEL PUMP (MECHANICAL), INOPERATIVE

General Information:

The mechanical (engine driven) fuel pump is critical to the operation of the howitzer. The electrical (in-tank) fuel pumps will not provide the volume and pressure of fuel required by the injector system if the mechanical fuel pump is inoperative. The following repairs will restore the engine to an operating condition.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

Fuel pump (scavenge from available source)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

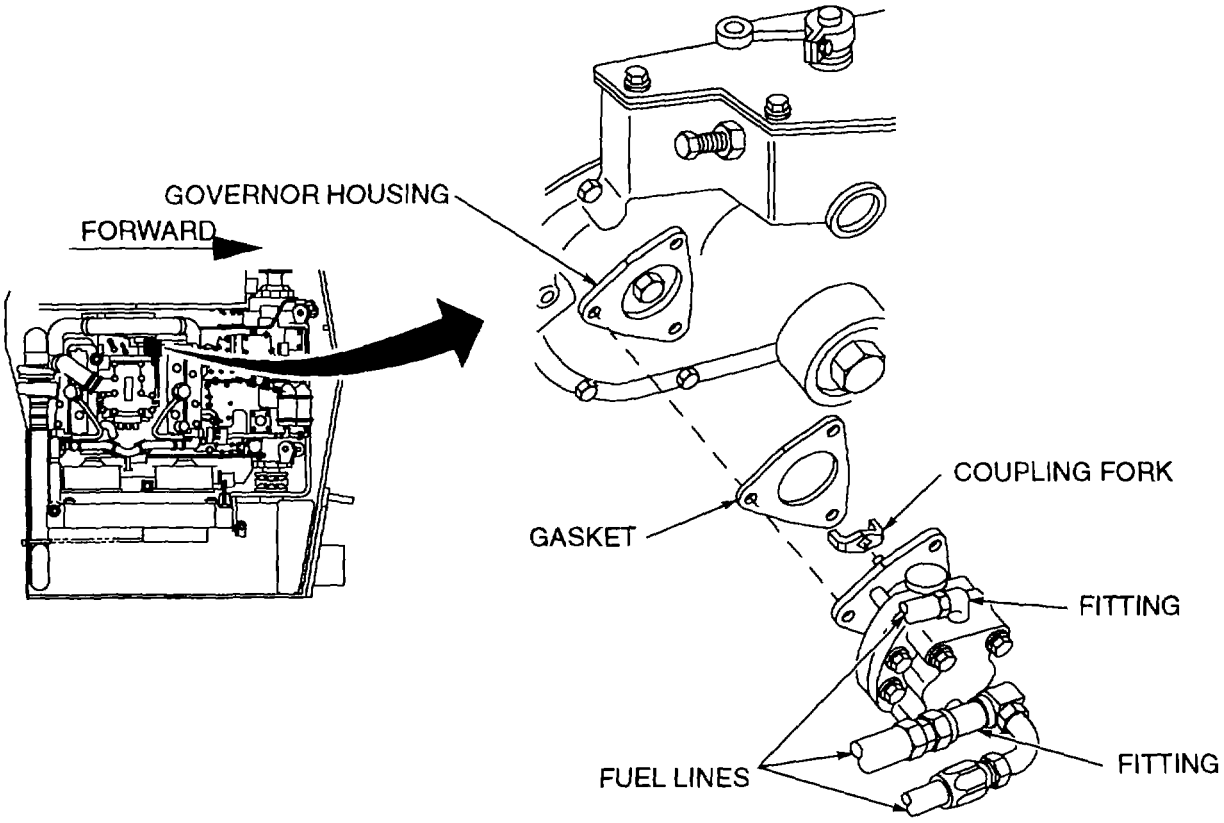
Procedural Steps:

1. Gain access to engine compartment by opening engine air intake grille.

5-6. FUEL PUMP (MECHANICAL), INOPERATIVE - CONTINUED

WARNING

Do not smoke or use open flame when working on fuel systems. An explosion may occur, causing serious injury or death.



2. Disconnect fuel line to fuel pump.

3. Remove fuel pump from governor housing.

4. Remove fittings from fuel pump and install on replacement fuel pump.

5. Install replacement fuel pump.

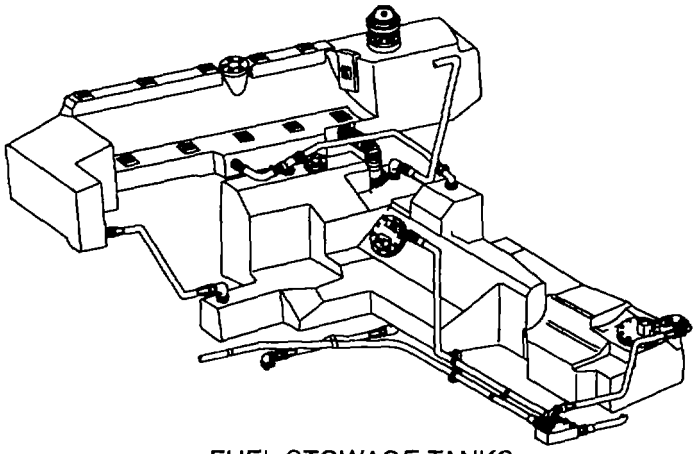
6. Connect fuel lines to fuel pump.

7. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. FUEL TANKS

5-7. GENERAL

The howitzer's fuel supply is stored in two fiberglass fuel tanks. Damage to the fuel tanks can significantly reduce or eliminate the howitzer's mobility.



FUEL STOWAGE TANKS

5-8. FUEL TANK, LEAKING

General Information:

Tactical operations may not allow sufficient time to make normal or expedient repairs to the howitzer's fuel tanks. The howitzer can however be removed by providing a substitute fuel tank . The tank should be placed in a location to provide a gravity feed fuel flow. Any available container may be used as a substitute fuel tank such as a 55-gallon drum, a large gas, oil, or water can, a large wooden barrel, or a cannibalized fuel tank from a disabled jeep or truck.

Option 1: Substitute Fuel Tank.

Limitations:

- Limited mobility (range)
- Limited capability traversing

Personnel/Time Required:

- 2 soldiers
- 1.0 hour

Materials/Tools:

- Plug, hose, plastic, (item 49, Appendix C)

- Fuel container (5-gallon gas or oil can, 55-gallon drum, etc.) (scavenge from available source)
- Hose nonmetallic (item 35, Appendix C)
- Hose clamp (item 7, Appendix C)
- Rope or straps (item 52, Appendix C)

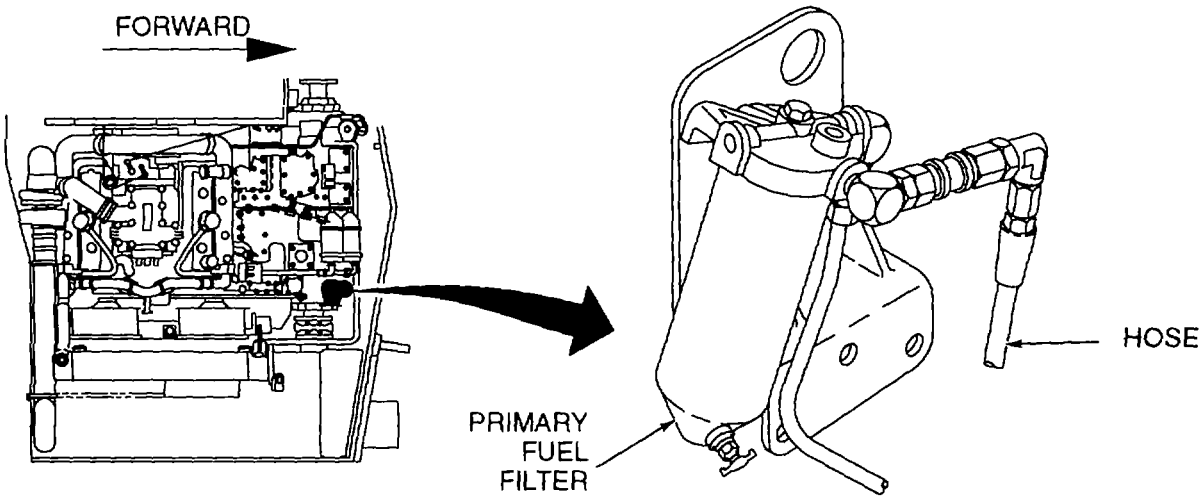
References:

TM 9-2350-314-20-1-1

5-8. FUEL TANK, LEAKING - CONTINUED

Procedural Steps:

Secure a substitute fuel container to the outside of the howitzer.



2. Disconnect hose from primary fuel filter.

3. Connect a hose between fuel container and primary fuel filter in step 3.

4. Install plug in hose disconnected, or disconnect electrical in-tank fuel pumps.

5. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Fiberglass fuel tanks.

Limitations:

None, if fiberglass repair kit is used

Personnel/Time Required:

- 2 soldiers
- Time determined by location and amount of damage.

Materials/Tools:

- Plastic repair kit (item 48, Appendix C)
- Epoxy, adhesive (item 2, Appendix C)
- Paper, abrasive or file (Item 46, Appendix C or found in M2/3 generic BDR kit, Section III, Appendix C)
- Fiberglass repair kit (item 50, Appendix C)
- Polymer repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1

5-8. FUEL TANK, LEAKING - CONTINUED

Procedural Steps:

1. Gain access to fuel tank hole.
2. Drain fuel tank.
3. Clean oil and fuel residue from damaged area.
4. Rough up area around damage with sandpaper or file.
5. Repair using fiberglass kit and kit instructions.
6. Reinstall fuel tank, if removed.
7. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Plugging holes (using BDR kit).

Limitations:

None

Personnel/Time Required:

- 2 soldiers
- Time determined by location and amount of damage.

Materials/Tools:

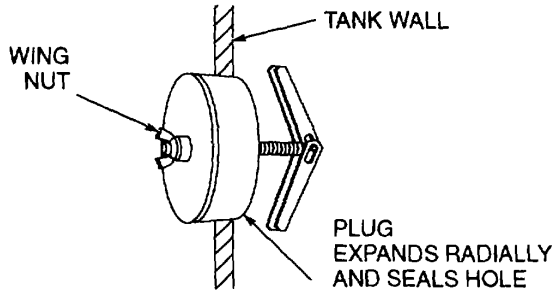
- File (found in M2/3 generic BDR kit, Section III, Appendix C)
- Fuel, cell patch kit (plug depending on size of hole) (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1

Procedural Steps:

1. Gain access to fuel tank hole.
2. Drain fuel until level is below the hole.



3. Obtain plug the approximate size of the hole.

5-8. FUEL TANK, LEAKING - CONTINUED

4. Using a round file, file the hole to a size equal to the plug diameter.

5. Install plug assembly and tighten wing nut.

6. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4: Plugging holes.

Limitations:

None

Personnel/Time Required:

- 2 soldiers
- Time determined by location and amount of damage.

Materials/Tools:

- Plastic repair kit (item 48, Appendix C)
- Epoxy, adhesive (item 2, Appendix C)
- Paper, abrasive or file (item 46, Appendix C or found in m2/3 generic BDR kit, Section III, Appendix C)
- Rubber hose (scavenge from available source)
- Bolt and nut (scavenge from available source)
- Two (2) large flat washers (scavenge from available source)
- Lockwasher (scavenge from available source)

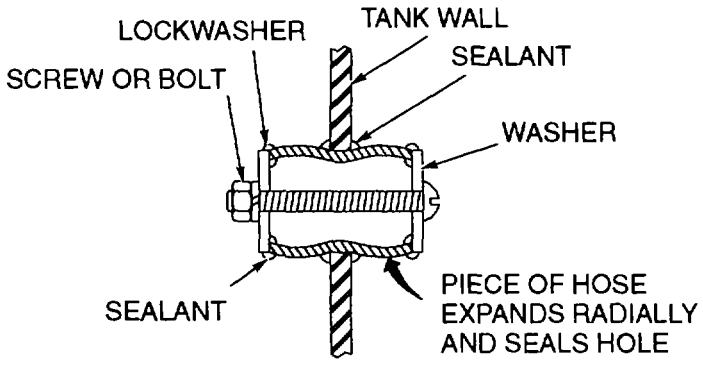
References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1

Procedural Steps:

1. Gain access to fuel tank hole.

2. Drain fuel until level is below the hole



3. Obtain hose the approximate size of the hole.

5-8. FUEL TANK, LEAKING - CONTINUED

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

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

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

6. Coat the assembly with sealer to aid in the repair.

7. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. FUEL LINES AND FITTINGS

5-9. GENERAL

The fuel lines route the fuel from the fuel tanks to the fuel filters and then to the engine. Lines are a combination of rubber hoses, fittings, 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 and fittings must be repaired or bypassed. Various methods of repairs are given in this section, other line repairs are also provided in Chapters 3 and 11.

5-10. QUICK DISCONNECT LEAK

General Information:

There are three quick-disconnects in the fuel system of the M109A6 howitzer.

1. In the main fuel line near the primary fuel filter inlet.

2. In the fuel return line.

3. In the personnel heater fuel line.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

- Hose nonmetallic (item 35, Appendix C)
- Hose clamps (found in M2/3 generic BDR kit, Section III, Appendix C)

5-10. QUICK DISCONNECT LEAK - CONTINUED

- Knife (found in M2/3 generic BDR kit, Section III, Appendix C)
- Wrench, adjustable (found in M2/3 generic BDR kit, Section III, Appendix C)

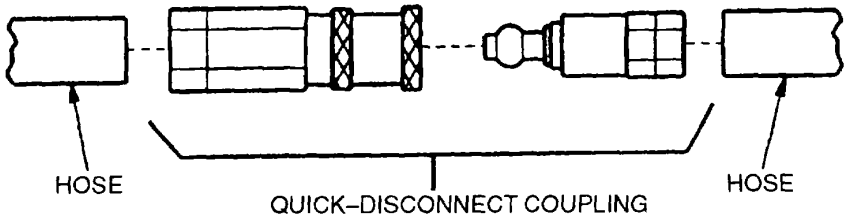
References:

TM 9-2350-314-20-1-1

Other Options:

Replace quick-disconnect with an adapter.

Procedural Steps:



1. Remove quick-disconnect coupling.

2. Insert rubber hose and hose clamps in its place.

3. Check for leaks and bleed fuel line thoroughly.

4. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

5-11. SEALS, FUEL SYSTEM, LEAK

General Information:

O-rings are used 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 -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 a moving surface. See Chapters 3 and 11 also.

5-12. FITTINGS LEAKING

General Information:

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.

5-12. FITTINGS LEAKING - CONTINUED

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

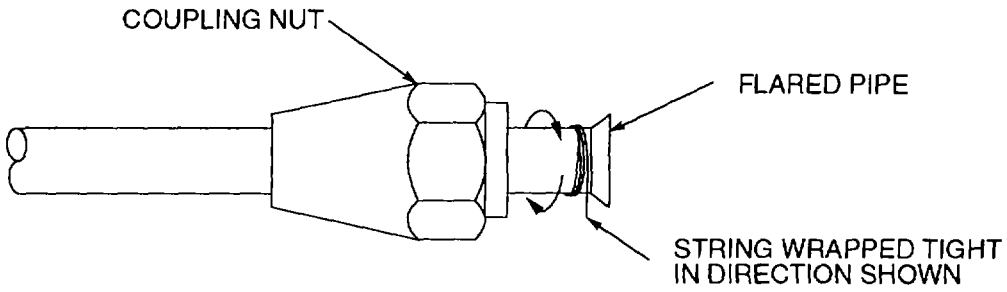
- Fuel resistant sealant (silicone, rubber or similar material) (scavenge from available source)
- String or light tie cord (scavenge from available source)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1
- TM 9-2815-202-34

Other Options:

Wrap teflon tape around lines and tighten fitting.



1. Remove coupling flange nut.
2. Slide coupling flange nut up, away from flared end.
3. Clean grease, oil and fuel from flared end.
4. Wrap string around flared end of line.
5. Coat string liberally with fuel resistant sealant.
6. Reinstall line and tighten nut securely.
7. Check for leaks. If still leaking, repeat procedure using more string.
8. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

5-13. FUEL LINE (LOW PRESSURE) RUPTURE

General Information:

Low pressure fuel lines can rupture or crack because of various reasons. Frozen water in 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.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

- Rubber sheet (tire inner tube, or similar material) (scavenge from available source)
- Tape, duct (item 62 or 63, Appendix C)
- Wire, safety (item 80, Appendix C)
- Rubber hose (scavenge from available source)
- Clamp, hose (item 7, Appendix C)
- Sealant (item 55 or 2, Appendix C)
- Metal tubing (mirror arms, old hydraulic line, or similar material) (scavenge from available source)
- Thin sheet metal (coffee can, or similar material) (scavenge from available source)
- Shell casing, 5.56 mm or 7.62 mm (scavenge from available source)

References:

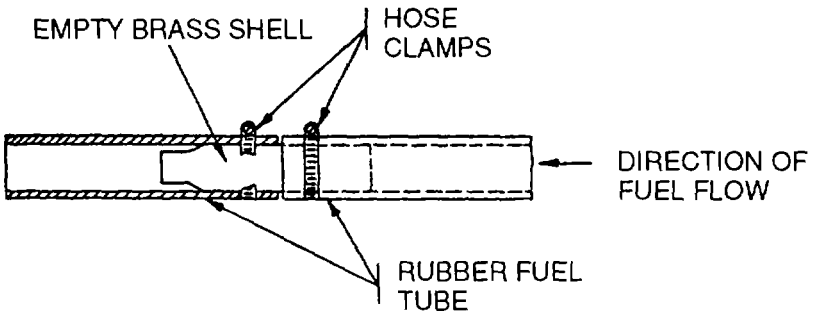
- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1
- TM 9-2815-202-34

Other Options:

Seal the crack with epoxy.

Option 1: For damaged rubber hose:

Procedural Steps:



5-13. FUEL LINE (LOW PRESSURE) RUPTURE - CONTINUED

1. Cut out damaged portion of hose.

WARNING

Ensure shell casing has been expended or serious injury or death may result.

2. 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 5.56 or 7.62 mm shell casing.

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

4. Insert the metal tubing into the hose ends.

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

6. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: For metal tubing cracks:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

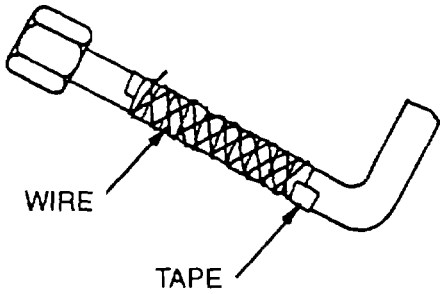
- Rubber sheet (tire inner tube, or similar material) (scavenge from available source)
- Tape, duct (item 62 or 63, Appendix C)
- Wire, safety (item 80, Appendix C)
- Clamp, hose (item 7, Appendix C)
- Sealant (item 55 or 2, Appendix C)
- Thin sheet metal (coffee can, or similar material) (scavenge from available source)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1
- TM 9-2815-202-34

5-13. FUEL LINE (LOW PRESSURE) RUPTURE - CONTINUED

Procedural Steps:



1. Clean all dirt and grease from around the crack.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

2. Coat the crack with sealant.
3. Wrap tubing with a sheet of fuel resistant material.
4. Clamp the sheet, directly over the crack.
5. If clamps are not available, wrap the tubing with tape.
6. Wrap wire around the tape as re-enforcement.
7. Wrap an additional coating of tape over the wire.
8. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: For holes in metal tubing:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 -1.0 hour

5-13. FUEL LINE (LOW PRESSURE) RUPTURE - CONTINUED

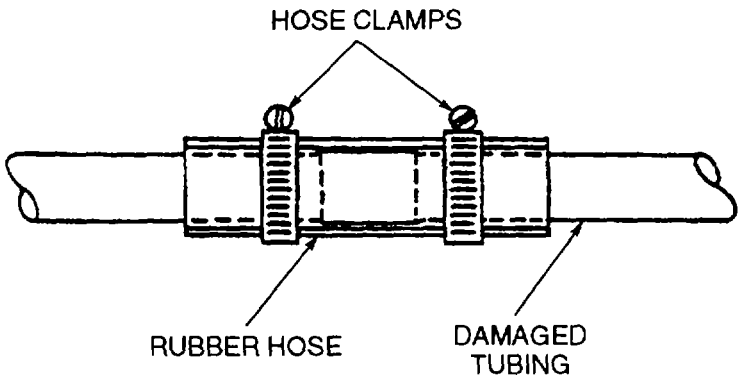
Materials/Tools:

- Tape, duct (item 62 or 63, Appendix C)
- Wire, safety (item 80, Appendix C)
- Clamp, hose (item 7, Appendix C)
- Sealant (item 55 or 2, Appendix C)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1
- TM 9-2815-202-34

Procedural Steps:



1. Cut out damaged portion of metal tubing.
2. Clean both ends of tubing.
3. Cut a piece of rubber hose two inches longer than the length of removed tubing.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

4. Apply sealant to both ends of tubing.
5. Insert the tubing ends one inch into the hose.
6. Secure with hose clamps or tightly twisted wire.
7. If the hose is too large, the tubing can be flared or sleeved to fit.
8. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

5-13. FUEL LINE (LOW PRESSURE) RUPTURE - CONTINUED

Option 4: Patching large metal lines:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 - 1.0 hour

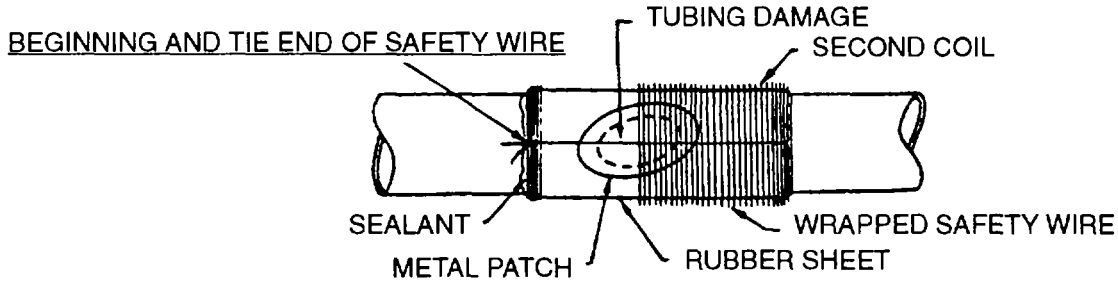
Materials/Tools:

- Rubber sheet (tire inner tube, or similar material) (scavenge from available source)
- Wire, safety (item 80, Appendix C)
- Sealant (item 55 or 2, Appendix C)
- Thin sheet metal (coffee can, or similar material) (scavenge from available source)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1
- TM 9-2815-202-34

Procedural Steps:



1. Smooth damaged areas to remove rough edges.

2. Clean dirt and oil from damaged area.

3. Cut a metal patch from sheet metal.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use In well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water. Coat the metal patch and tubing with sealant and place over damaged area.

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

5-13. FUEL LINE (LOW PRESSURE) RUPTURE - CONTINUED

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

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

7. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5: Repairing damaged bends:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 - 1.0 hour

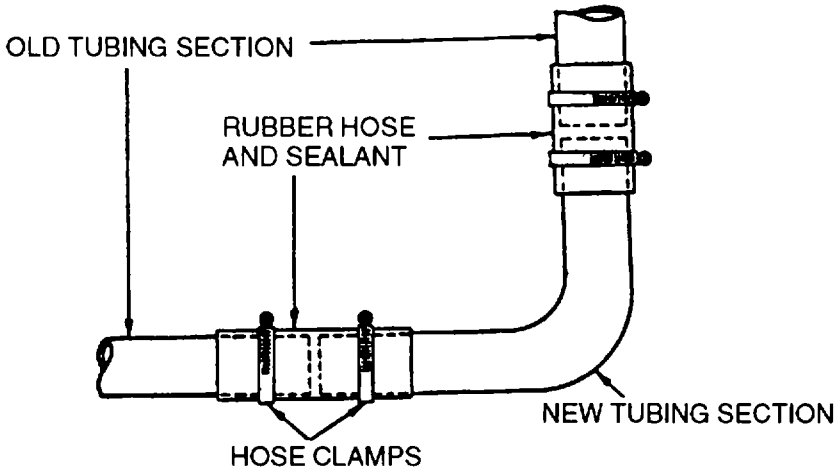
Materials/Tools:

- Wire, safety (item 80, Appendix C)
- Rubber hose (scavenge from available source)
- Clamp, hose (item 7, Appendix C)
- Sealant (item 55 or 2, Appendix C)
- Metal tubing (mirror arms, old hydraulic line, or similar material) (scavenge from available source)

References:

- TM 9-2350-314-20-1-1
- TM 9-2350-314-34-1
- TM 9-2815-202-34

Procedural Steps:



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

2. Remove the damaged bend from the line.

5-13. FUEL LINE (LOW PRESSURE) RUPTURE - CONTINUED

3. Clean the tubing ends.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

4. Apply sealant to tubing ends.

5. Using two, 2 inch sections or rubber hose, install the replacement bend.

6. Clamp with hose clamps or tightly twisted wire.

7. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

5-14. FUEL INJECTOR LINE, RUPTURE

General Information:

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

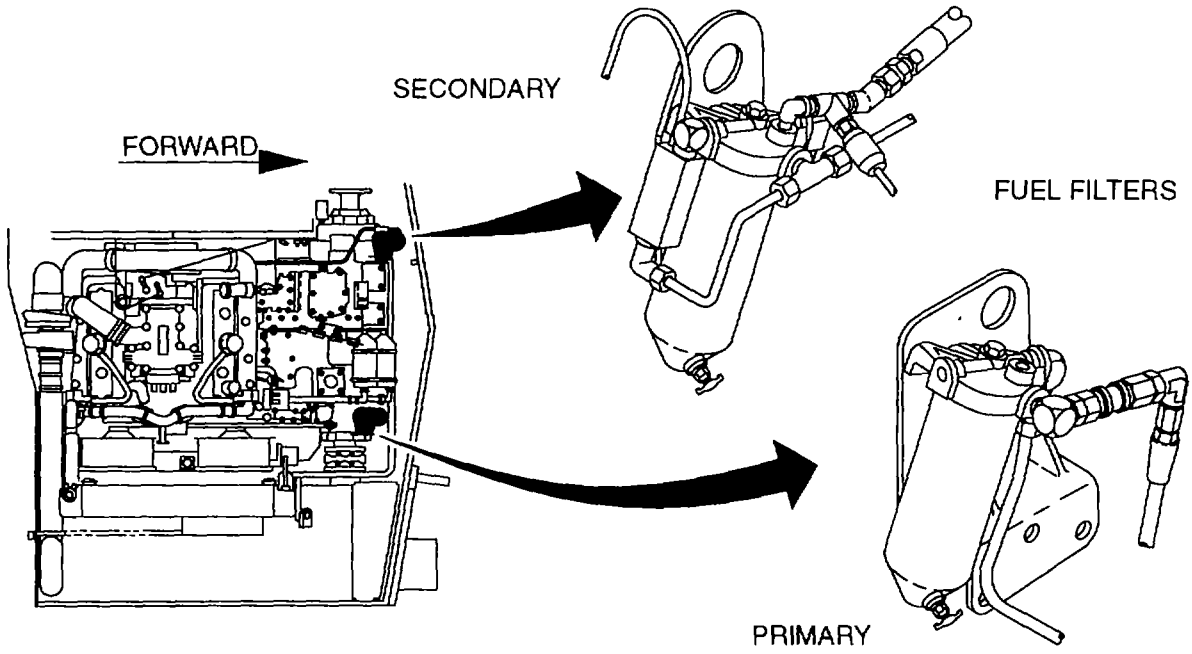
b. If a replacement line is not available, repair the defective line. Remove it from the vehicle and clean it. Braze pin holes closed. If the hole is too large for this procedure, cut out that section of line. Use a piece of slightly larger metal tubing as a sleeve, overlapping both cut ends of the injector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

SECTION V. FUEL FILTERS

5-15. GENERAL

The howitzer has two fuel filters, the primary and secondary fuel filters are accessible through the transmission doors. The filters must be checked for dirt or water to keep the fuel uncontaminated and flowing freely. Filters do, however, become clogged with dirt and the container collects water in cold weather the water can freeze and stop the flow of fuel. Only as a last resort should the filters be by-passed and allow unfiltered fuel to reach the engine.

5-15 GENERAL - CONTINUED



5-16. FUEL FILTER CLOGGED OR FROZEN

General Information:

The first indication of clogged or frozen fuel filters will be a failure of the engine to start or degraded performance because of insufficient fuel. Fuel filters if drained periodically should not freeze. Dirty fuel will harm the injectors and must not be unfiltered for long periods. Clogged filters must be cleaned or changed to correct the problem.

Option 1: Cleaning Filters.

Limitations:

Possible engine internal damage if filters are bypassed

Personnel/Time Required:

- 1 soldier
- 0.5 hour

References:

- TM 9-2350-314-20-1-1

Other Options:

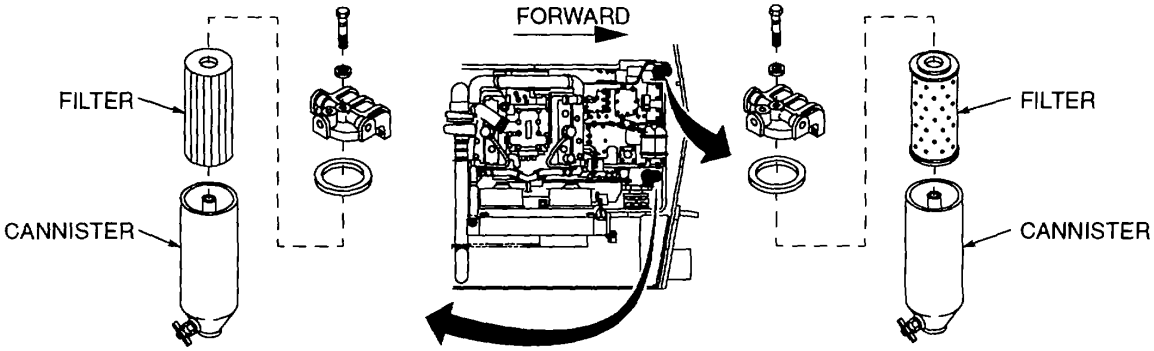
Remove filter elements.

5-16. FUEL FILTER CLOGGED OR FROZEN - CONTINUED

Procedural Steps:

1. Gain access to fuel filters.

2. Remove the fuel filter from the cannister.



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

4. Reinstall the fuel filter.

5. Start the engine.

6. Check for leaks.

7. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Bypassing the Filters.

Limitations:

Possible engine internal damage if filters are bypassed

Personnel/Time Required:

- 1 soldier
- 0.5 hour

References:

- TM 9-2350-314-20-1-1

Procedural Steps:

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

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

3. Record the BDAR action taken. When the mission is complete, as soon as practical, repair the equipment/system 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

This chapter contains fault assessment and expedient repair procedures available to find and fix the battlefield damage to the Cooling System.

6-2. ASSESSMENT PROCEDURE

Table 6-1. Cooling System Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Shrouds, Air Cooling Damaged..... para 6-5
Coolant Substitute ..... para 6-6
Thermostat Stuck..... para 6-7
Engine Coolant Frozen ..... para 6-8
Radiator Leaking ..... para 6-9
Hose Clamp Broken..... para 6-10
Hose Leakage ..... para 6-11
Hose Collapse..... para 6-12
Hose Improvisation ..... para 6-13
Radiator Surge Tank Leaking ..... para 6-14

No damage found

Determine if

Damage can be repaired
- Note repair requirements

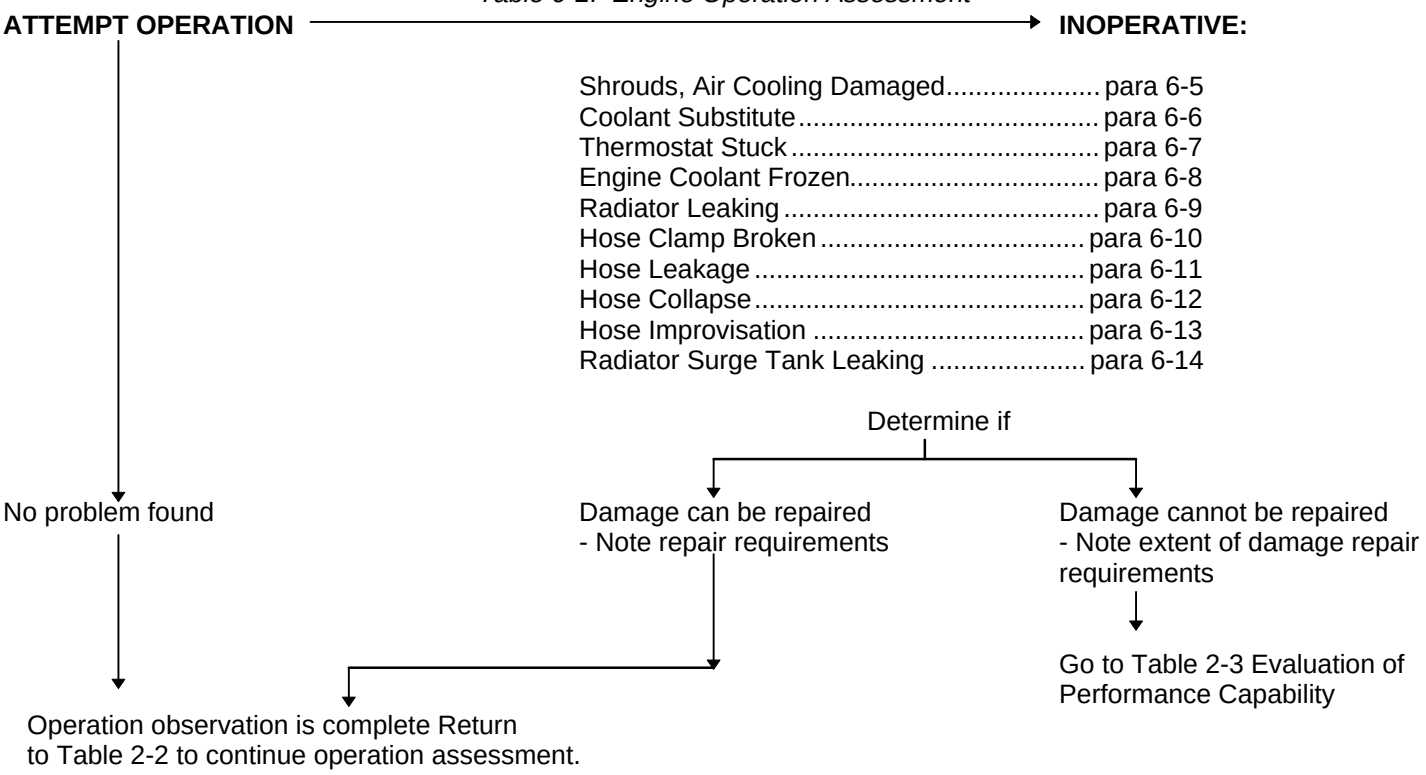
Damage cannot be repaired
-Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Visual inspection is complete. Return to Table 2-2 to continue visual assessment.

6-2. ASSESSMENT PROCEDURE - CONTINUED

Table 6-2. Engine Operation Assessment

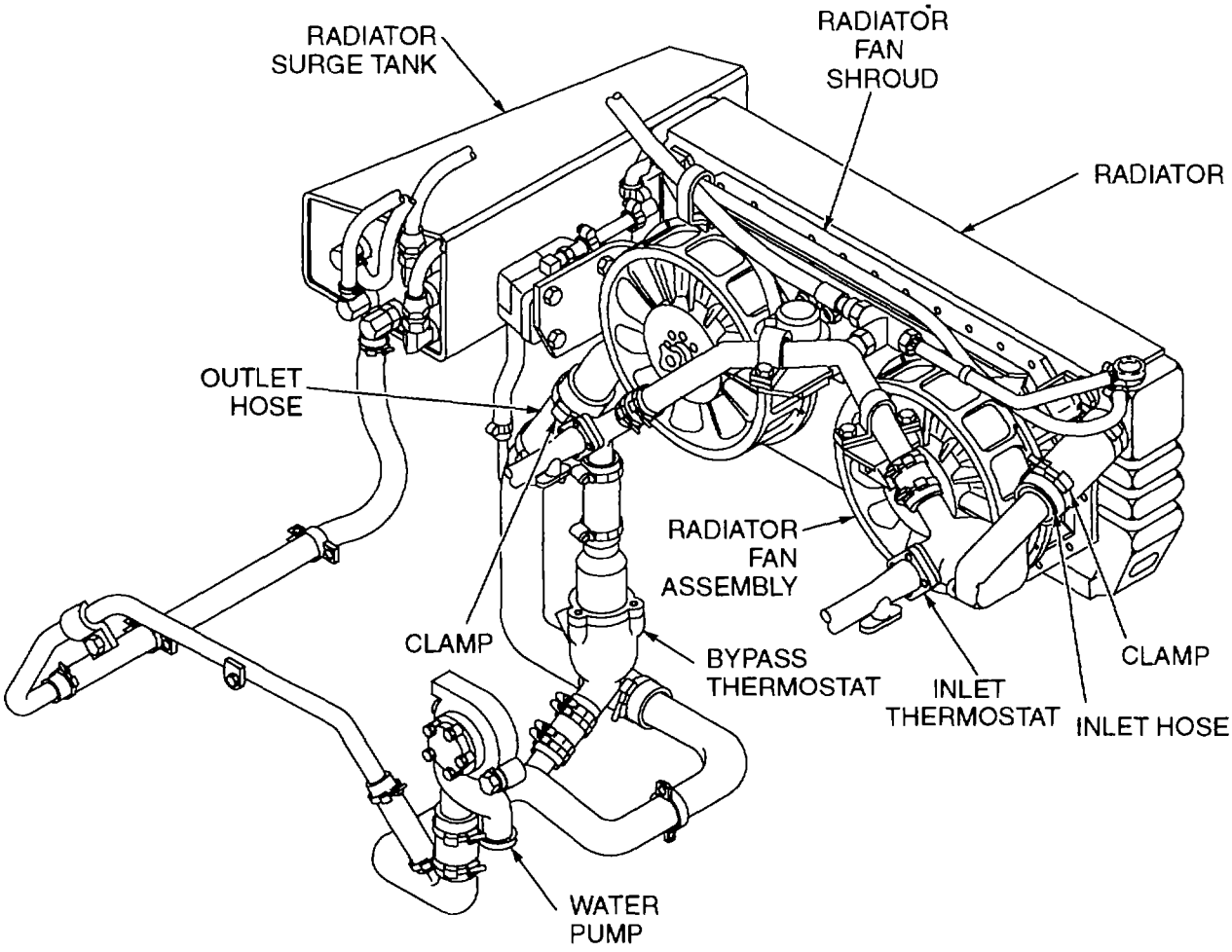


6-3. REPAIR PROCEDURE INDEX

SECTION II. COOLING SYSTEM

6-4. GENERAL

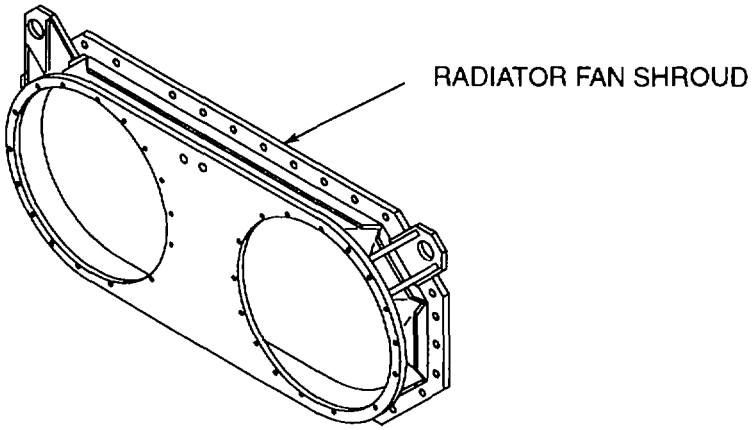
The howitzer has a liquid cooling system consisting of a radiator, two fans, tubes, hoses, fittings, clamps, a surge tank and an engine-driven water pump. To maintain normal operating temperature of the engine, the liquid flow through the cooling system is controlled by an inlet and a bypass thermostat. Battle damage to the cooling system would degrade, and if not repaired, eliminate the mission capability of the howitzer. The most expedient method to correct cooling system problems is by replacing components, many of which are interchangeable with components of other combat vehicles.



6-5. SHROUDS, AIR COOLING DAMAGED

General Information:

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 a minimum, they must be bent to prevent contact with moving components. If the existing shrouds cannot be repaired, new shrouds must be fabricated from sheet metal.



Option 1:

Bend shrouds back into their original position or replace missing portions of shrouds with sheet metal.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 3.0 hours

Materials/Tools:

- Epoxy, adhesive (item 2, Appendix C)
- Sheet metal (scavenge from available source)

References:

TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to shrouds by removing engine access cover.

2. Bend shrouds back to their original positions.

6-5. SHROUDS, AIR COOLING DAMAGED - CONTINUED

3. Cut a piece of sheet metal to cover the area of the missing piece of shroud.

4. Clean the area of the shroud to be patched and the piece of sheet metal.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

5. Patch the shroud with the piece of sheet metal using the epoxy.

6. Reinstall the engine access cover.

7. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

Tape, duct (item 62, Appendix C)

References:

TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to the damaged shrouds by removing the engine access cover.

2. Clean area around damaged shroud.

3. Apply tape to damaged area.

4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-6. COOLANT SUBSTITUTE

General Information:

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, hydraulic systems, may be a possible source of fluids. The cooling system must be drained as soon as possible if petroleum-based fluids are used.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

14.5 gallons of liquid

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Repair cause of liquid loss.

2. Fill cooling system with liquid.

3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-7. THERMOSTAT STUCK

General Information:

The thermostat regulates the engine operating temperature, from 180 to 195 degrees F, by controlling coolant flow through the engine. When the thermostat is stuck in the closed position it prevents coolant from circulating and causes engine overheating. BDAR repair is to remove the thermostat and operate the vehicle. If the thermostat is stuck in the open position or removed, it may degrade engine performance and increase fuel consumption.

Limitations:

None

6-7. THERMOSTAT STUCK - CONTINUED

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

14.5 gallons of liquid

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Remove and dispose of thermostat.
2. Reconnect thermostat housing.
3. Refill cooling system with liquid.
4. Check for leaks.
5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-8. ENGINE COOLANT FROZEN

General Information:

During cold weather, inadequate antifreeze protection will cause the coolant to freeze. Care must be taken when thawing the cooling system that further damage is avoided. The water pump may be unable to turn which will damage engine 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
- 0.5-1.0 hour

References:

TM 9-2350-314-10

6-8. ENGINE COOLANT FROZEN - CONTINUED

Other Options:

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

Procedural Steps:

1. Gain access to radiator and powerpack.

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

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

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

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

6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-9. RADIATOR LEAKING

General Information:

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.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.3-0.5 hour

Materials/Tools:

- Stop leak chemical (found in M2/3 generic BDR kit, Section III, Appendix C)
- Cigarette or tobacco (scavenge from available source)
- Pepper (scavenge from available source)
- Eggs (scavenge from available source)
- Oatmeal (scavenge from available source)
- Farina (cream of wheat) (scavenge from available source)
- Corn meal (scavenge from available source)

References:

TM 9-2350-314-10

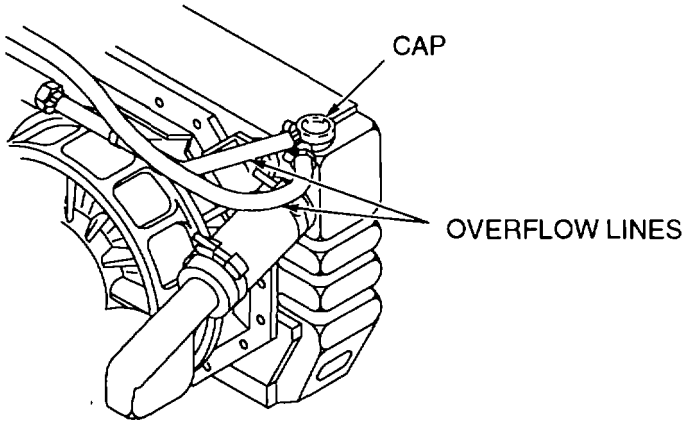
6-9. RADIATOR LEAKING - CONTINUED

Procedural Steps:

WARNING

- **Corrosion Inhibitor contains alkali. Do not get in eyes Wear goggles/safety glasses when using. Avoid contact with skin in case of contact, immediately wash area with soap and water. If eyes are contacted, flush eyes with large amounts of water for at least 15 minutes and get medical attention.**

- **NEVER remove radiator cap on an engine until it has cooled, however steam may be present. Use a rag and remove radiator cap slowly to prevent serious injury to personnel.**



1. Remove radiator cap and start engine.

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

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

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

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

6. Leave radiator cap loose.

7 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-9. RADIATOR LEAKING - CONTINUED

Option 2: Tubing to Hose Joint, Leak.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0-4.0 hours

Materials/Tools:

- Wire brush (found in M2/3 generic BDR kit, Section III, Appendix C)
- Solvent, drycleaning (item 59, Appendix C)
- Epoxy, adhesive (item 2, Appendix C)
- Suitable container (scavenge from available source)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to radiator.

2. Inspect the radiator and pinpoint the leak location.

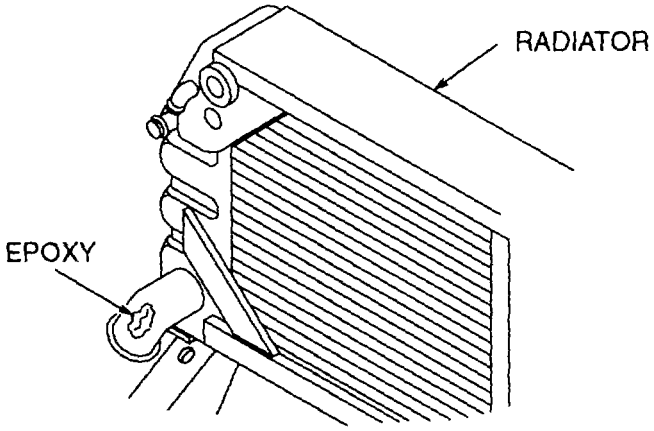
3. Drain the coolant.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

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

6-9. RADIATOR LEAKING - CONTINUED



5. Scrape or rough up the damaged surface.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid Injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

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

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

8. Reinstall coolant and check for leaks.

9. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Core Punctured

Limitations:

Possible reduced cooling

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

- Side cutters (found in M2/3 generic BDR kit, Section III, Appendix C)
- Epoxy, adhesive or solder (item 2 or 58, Appendix C)

6-9. RADIATOR LEAKING - CONTINUED

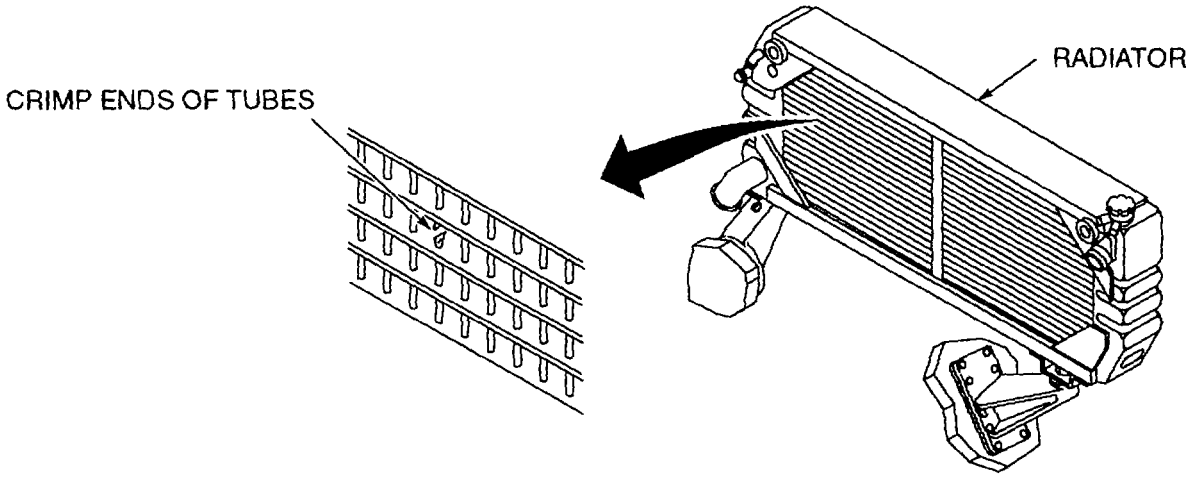
References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to the radiator.

2. Inspect the radiator to pinpoint the leak location.



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

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

5. Squeeze the tube ends together and fold over on itself approximately 1/2-inch.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent or sealing compound gets on skin or clothing, wash immediately with soap and water.

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

7. If no epoxy or solder is available, fold the tube once more 1/2-inch to restrict the coolant leaks.

8. Add coolant as required inspect radiator for leaks.

9. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-10. HOSE CLAMP BROKEN

General Information:

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

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.1-0.3 hour

Materials/Tools:

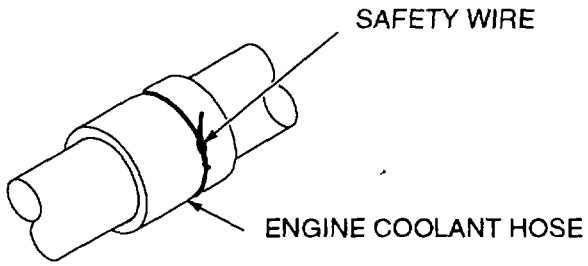
Wire, safety (lacing) or commo (item 80, Appendix C)

Other Options:

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

Procedural Steps:

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



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

3. 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.

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

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-11. HOSE LEAKAGE

General Information:

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

Option 1

Limitations:

Reduced mobility

Personnel/Time Required:

- 1 soldier
- 0.5 hour

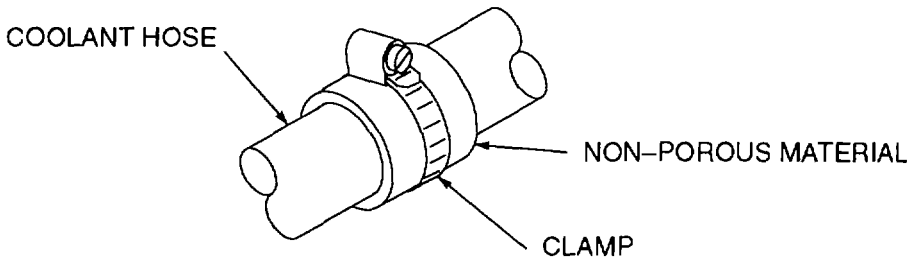
Materials/Tools:

- Non-porous material (rubber, poncho, raincoat) (scavenge from available source)
- Sealer, permatex (item 54, Appendix C)
- Clamps, size determined by size of hose (item 7 or 8, Appendix C)

References:

TM 9-2350-314-20-1-1

Procedural Steps:



1. Gain access to leaking hose.
2. Clean dirt and oil from damaged hose.
3. Coat the damaged area with gasket sealer.
4. Wrap a non-porous material (poncho, rubber mat) over the leak.
5. Secure the material with a clamp.
6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-11. HOSE LEAKAGE - CONTINUED

Option 2

Limitations:

Reduced mobility

Personnel/Time Required:

- 1 soldier
- 0.5 hour

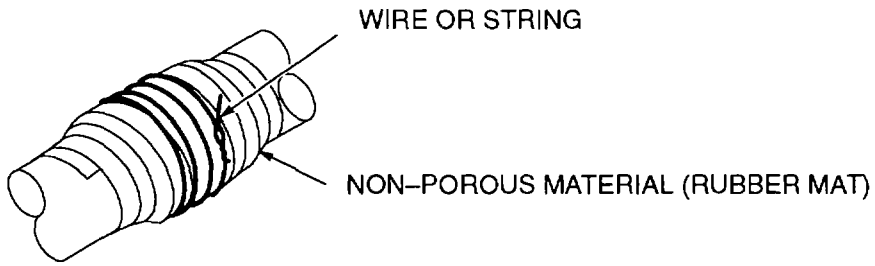
Materials/Tools:

- String or wire, safety (lacing) (item 80, Appendix C)
- Non-porous material (rubber mat) (scavenge from available source)
- Sealer, permatex (item 54, Appendix C)
- Tape, duct (item 62, Appendix C)

References:

TM 9-2350-314-20-1-1

Procedural Steps.



1. Gain access to leaking hose.
2. Clean dirt and oil from damaged area.
3. Coat damaged area with gasket sealer.
4. Cover the damage with a rubber mat section.
5. Wrap the patch with electrical or duct tape.
6. Reinforce the patch with wire or string to distribute the patch sealing pressure evenly over the damaged area.
7. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-11. HOSE LEAKAGE - CONTINUED

Option 3: Joint, Leak.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Patch, tire repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tape, duct (item 62, Appendix C)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to leak.

2. Clean area around leak.

3. Wrap the area with tape.

4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4

Limitations:

Reduced mobility

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Tape, duct (item 62, Appendix C)
- Thin sheet metal (scavenge from available source)
- Sealer, permatex (item 54, Appendix C)
- Clamp, hose (item 7, Appendix C)

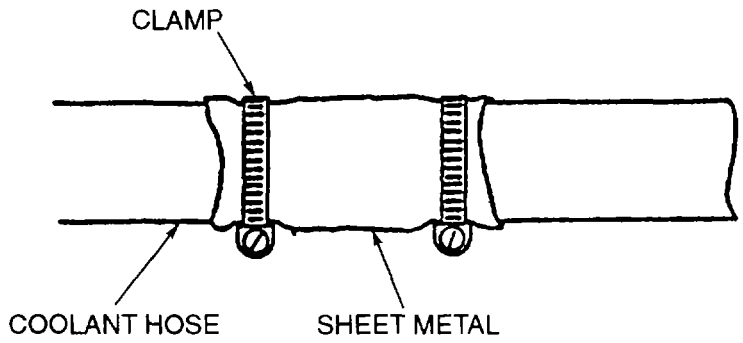
6-11. HOSE LEAKAGE - CONTINUED

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

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



7. Secure the patch with adjustable clamps or tape.
8. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system 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. Operate at reduced engine speed.

Limitations:

None

6-12. HOSE COLLAPSE - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.3-1.0 hour

Materials/Tools:

- Tin can (scavenge from available source)
- Stiff wire (coat hanger, welding rod) (item 51, Appendix C)
- Suitable container (scavenge from available source)

References:

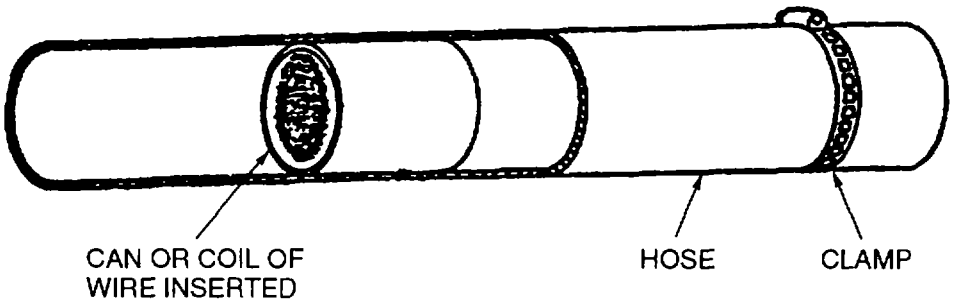
- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to hose.

2. Drain coolant.

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



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

5. Reconnect and tighten the hose.

6. Refill coolant to proper level.

7. Check for leaks.

8. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-13. HOSE IMPROVISATION (LOW PRESSURE)

General Information:

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

6-13. HOSE IMPROVISATION (LOW PRESSURE) - CONTINUED

Option 1:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.3-1.0 hour

Materials/Tools:

- Sealer, permatex (item 54, Appendix C)
- Pipe (scavenge from available source)
- Clamps or wire safety (lacing) (item 7 or 80, Appendix C)
- Hacksaw (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

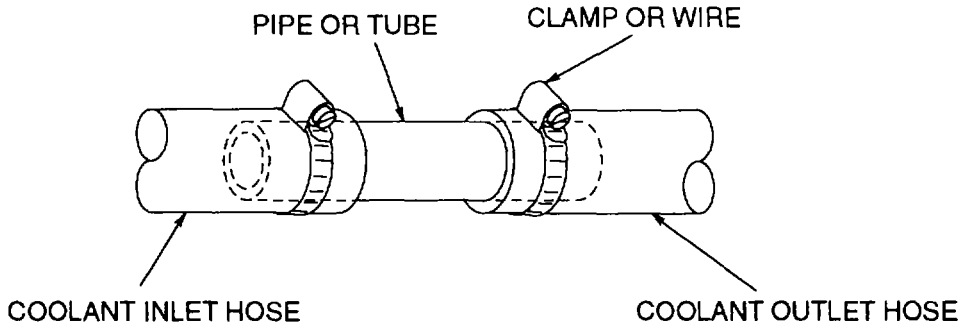
- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Cut out damaged hose section.

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

3. Coat the pipe ends with gasket sealer.



4. Insert the pipe into the damaged hose ends.

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

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

7. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-13. HOSE IMPROVISATION (LOW PRESSURE) - CONTINUED

Option 2:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.3-1.0 hour

Materials/Tools:

- Sealer, permatex (item 54, Appendix C)
- Garden hose, heater hose (scavenge from available source)
- Clamps, hose or wire safety (lacing) (item 7 or 80, Appendix C)
- Hacksaw (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

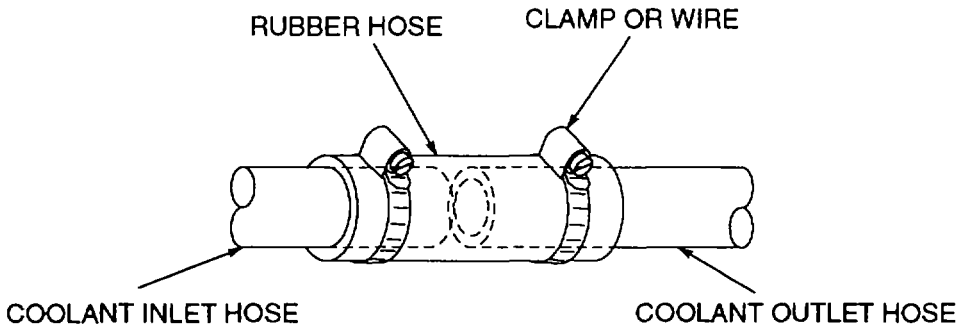
- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Remove the damaged section of hose or tube.

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

3. Coat ends of damaged hose or tube with casket sealer.



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

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

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

7. Refill coolant and check for leaks.

8. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-13. HOSE IMPROVISATION (LOW PRESSURE) - CONTINUED

Option 3:

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.3-1.0 hour

Materials/Tools:

- Sealer, permatex (item 54, Appendix C)
- Inner tube (scavenge from available source)
- Rubber sheet (scavenge from available source)
- Clamps, hose or wire, safety (lacing) (item 7 or 80, Appendix C)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

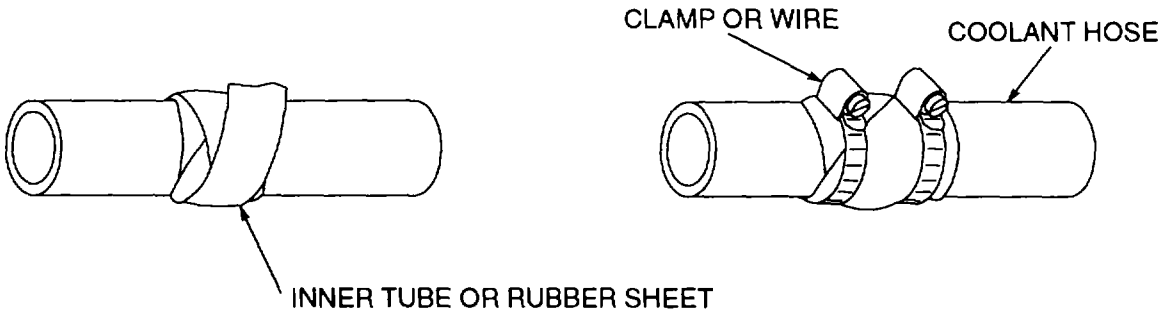
Procedural Steps:

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

2. Coat the tubing ends with sealant.

3. Slip the material over the tubing ends.

4. Wrap the inner tube as tightly as possible on the tubing.



5. Secure the inner tube using hose clamps or tightly wound wire.

6. Refill coolant to proper level

7. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

6-14. RADIATOR SURGE TANK LEAKING

General Information:

Radiator surge tank allows overflow of the radiator during normal operation of the engine. Battle damage to surge tank would cause overheating due to loss of coolant. Damage to the surge tank can be repaired using fiberglass.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 2.0 hours

Materials/Tools:

Plastic repair kit (item 48, Appendix C)

Other Options:

Use fiberglass repair kit (item 50, Appendix C)

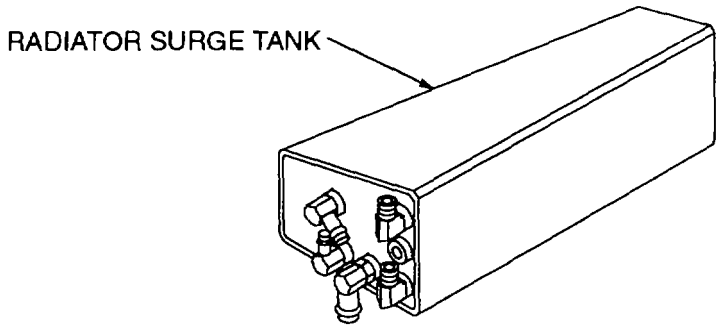
References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-1

Procedural Steps:

1. Gain access to the radiator surge tank.

2. Drain radiator surge tank (if necessary) until level is below damaged area.



3. Repair radiator surge tank using plastic repair kit.

4. Refill the cooling system and check for leaks.

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system 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

The electrical system can be made functional by performing the repair procedures in this manual after standard troubleshooting procedures have isolated a failed electrical component. If proper test equipment is not available for troubleshooting, fabricated test equipment listed in Appendix B may be used. Proper BDAR procedures can be found by using the fault assessment tables in the repair procedure index (para 7-3).

7-2. ASSESSMENT PROCEDURE

Table 7-1. Electrical System Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Motor, starter	para 7-5
Batteries	Chapter 3
Brush, electrical, motor/generator, worn.	para 7-7
Cables	Chapter 3
Wiring	Chapter 3
Circuit breakers	Chapter 3
Switch, relay, oil pressure activated, air cleaner and generator system	para 7-9
Switch, master	para 7-10
Switch, neutral, safety	para 7-11
Relay, master	para 7-12
Relay, starter protection	para 7-13
Relay, generator/fuel pumps	para 7-14
Relay, hydraulic pump motor	para 7-15
Overload-sensor, hydraulic pump motor	para 7-16

7-2. ASSESSMENT PROCEDURE - CONTINUED

Table 7-1. Electrical System Visual Assessment - Continued

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Determine if:

No damage found

Damage can be repaired
- Note repair requirements

Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Visual inspection is complete. Return to Table 2-1 to continue visual assessment

Table 7-2. Electrical System Operation Assessment

ATTEMPT OPERATION → **INOPERATIVE:**

Motor, starter	para 7-5
Batteries	Chapter 3
Starter switch	para 7-6
Brush, electrical, motor/generator worm	para 7-7
Cables	Chapter 3
Wiring.	Chapter 3
Circuit breakers	Chapter 3
Switch, relay, oil pressure activated, air cleaner and generator system	para 7-9
Switch, master	para 7-10
Switch, neutral, safety	para 7-11
Relay, master	para 7-12
Relay, starter protection	para 7-13
Relay, generator/fuel pumps	para 7-14
Relay, hydraulic pump motor	para 7-15
Overload sensor, hydraulic pump motor	para 7-16

Determine If

No problem found

Damage can be repaired
- Note repair requirements

Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Operation observation Is complete. Return to Table 2-2 to continue visual assessment

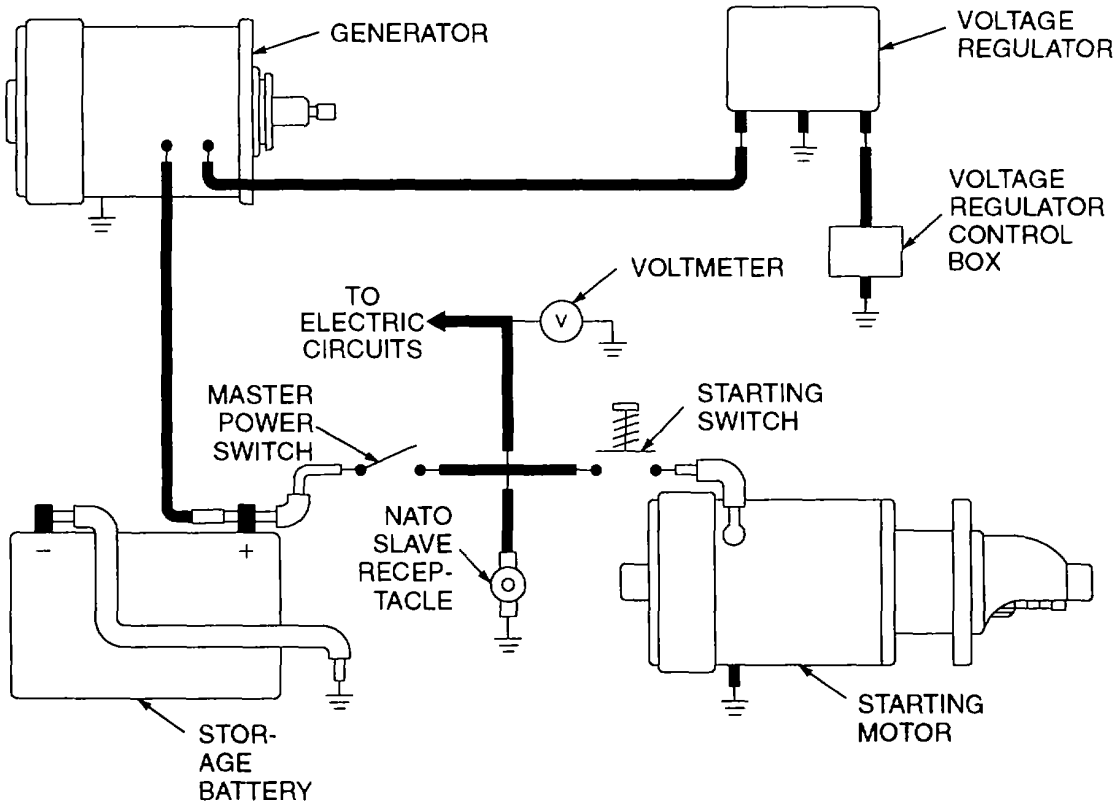
7-3. REPAIR PROCEDURE INDEX

8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION II. ELECTRICAL GENERATION AND STORAGE SYSTEM

7-4. GENERAL

The electrical system on the M109A6 is a 24-volt negative ground, direct current system. Electrical current storage for starting and standby circuits is provided by batteries. The batteries are connected in a series-parallel configuration to provide 24 V dc current. All electrical power to circuits can be turned off by the MASTER power switch. The MASTER power switch prevents accidental discharge of the batteries if a subsystem is not turned off.



7-5. MOTOR, STARTER

General Information:

The starter motor can become inoperative due to a bad field winding causing a "dead spot", freezing a worn solenoid plunger shaft, or a defective starter switch.

Option 1: Sticking starter solenoid

Limitations:

Procedure may have to be repeated each time engine is started.

Personnel/Time Required:

- 2 soldiers
- 0.1-0.3 hour

Materials/Tools:

Crowbar or hammer

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to starter motor.
2. Jolt starter motor by striking several times with rod.
3. Engage starter switch in an attempt to start engine.
4. Repeat steps 2 and 3 several times. If starter still will not work, try option 2.
5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Starter solenoid plunger shaft worn

Limitations:

This repair is only temporary.

Personnel/Time Required:

- 2 soldiers
- 1.5 hours

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

7-5. MOTOR, STARTER - CONTINUED

Procedural Steps:

WARNING

- **Fuel leaks or vapors may be present in engine compartment which can be ignited by electrical spark. Fix leaks and ventilate area before disconnecting starter motor cables. Failure to do so could result in an explosion and injury or death to personnel.**

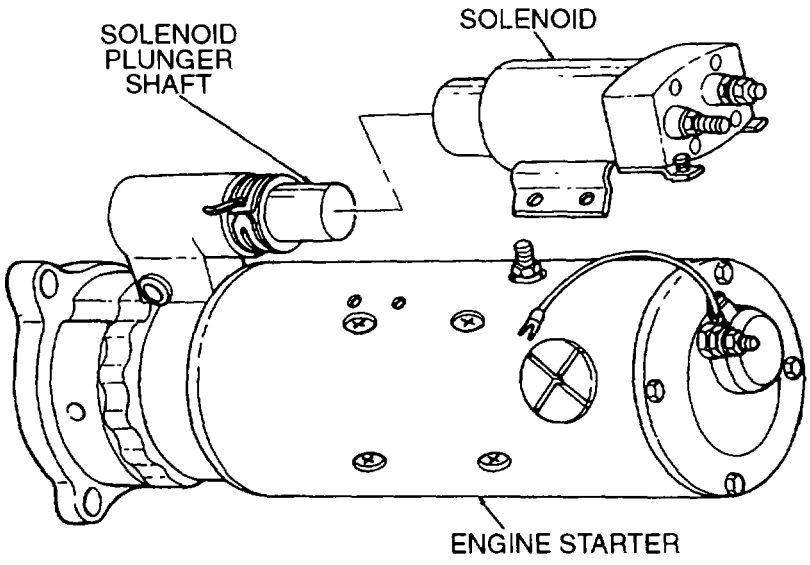
- **Starter motor electrical harness carries up to 200 amps. Before working on starter motor disconnect negative link on batteries. Failure to do so could result in personnel injury or death by electrocution.**

1. Gain access to starter motor.
2. Disconnect negative battery link.
3. Remove starter motor from engine.
4. Remove solenoid from starter motor.

NOTE

With uneven wear of solenoid plunger shaft, a lip is formed on one side of the shaft and the engine starter will not engage.

5. Rotate solenoid plunger shaft 180 degrees.
6. Install solenoid on starter motor.
7. Install starter motor on engine.



7-5. MOTOR, STARTER - CONTINUED

8. Connect negative battery link.

9. Set MASTER power switch to ON.

10. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Starter frozen

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

Piece of flexible hose (borrow from personnel heater ducting or scavenge from available source)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to starter motor.

2. Connect flexible hose from personnel heater to motor compartment, directing warm air onto starter motor as much as possible.
3. Periodically engage starter switch to determine If starter motor has thawed yet.

4. When starter motor is thawed and engine is running, return hoses to normal location.

5. Record BDAR action taken. No follow up is required unless starter motor was damaged. If starter motor was damaged, when mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-6. STARTER SWITCH

General Information:

The starter switch is a spring-loaded switch which is closed only when physically held in place.

Limitations:

Procedure must be repeated each time engine is stopped.

Personnel/Time Required:

- 2 soldiers
- 0.5 hour

7-6. STARTER SWITCH - CONTINUED

Materials/Tools:

- Wire, electrical (item 76, Appendix C)
- Tape, insulation, electrical (item 63, Appendix C)

References:

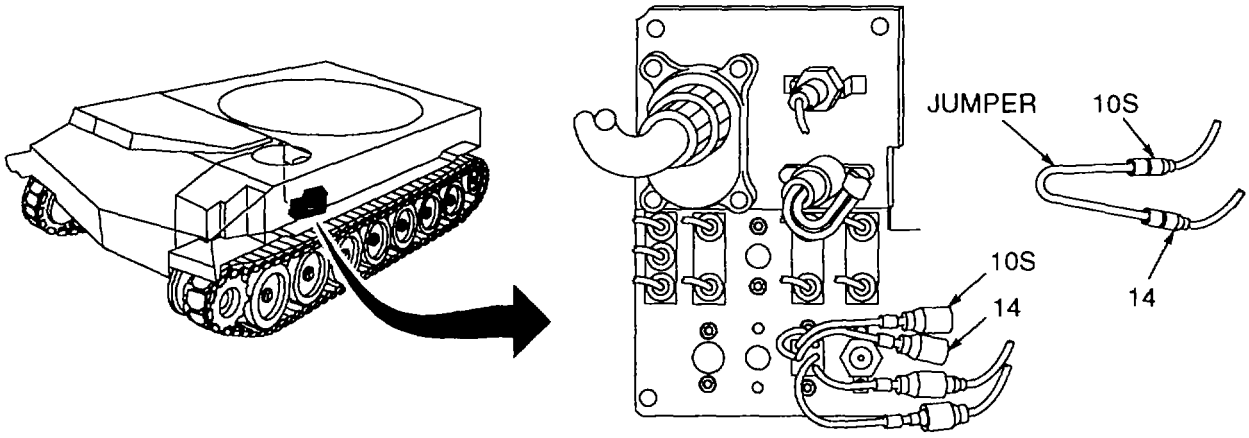
- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

Other Options:

Use toggle switch (item 68, Appendix C)

Procedural Steps:

1. Gain access to starter switch.



2. Set MASTER power switch to OFF.

3. Remove wire 10S and wire 14 from starter switch.

CAUTION

The starter switch is a spring-loaded momentary switch that closes when pushed, but immediately opens when released. Insulated wire or jumper in following steps must be removed as soon as engine starts to avoid damage to starter motor.

4. Set MASTER power switch to ON.

5. Using insulated wire or jumper lead, connect wire 10S and wire 14 until engine starts, then remove insulated wire or jumper lead.

6. Using insulated electrical tape to cover and secure connectors on wires 10S and 14 until needed to start engine again.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-7. BRUSH, ELECTRIC, MOTOR/GENERATOR, WORN

General Information:

Electrical motors and generators use a carbon composition brush to transfer electrical energy to or from the armature commutators. The transfer of energy creates an electrical arc which gradually burns 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 generator/motor life

Personnel/Time Required:

- 1 or 2 soldiers
- 1-8 hours

Materials/Tools:

- BA30 or BA31 battery (scavenge from available source)
- Hacksaw (found in M2/3 generic BDR kit, Section III, Appendix C)
- Paper, abrasive (item 46, Appendix C)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

Other Options:

Modify and use other electrical brush sets.

Procedural Steps:

1. Gain access to generator.
2. Set MASTER power switch to OFF.
3. Remove electrical brush holder.
4. Obtain BA30 or BA31 battery (flashlight, "D" cell or "C" cell battery)

WARNING

Battery acid is very caustic and corrosive and when in contact with skin or eyes can cause severe bums and blindness. Always wear protective clothing and safety goggles when working around batteries. If battery acid does come in contact with eyes or skin, rinse thoroughly with clear water and seek medical aid.

NOTE

In the following steps exercise extreme care to avoid damaging the carbon core.

7-7. BRUSH, ELECTRIC, MOTOR/GENERATOR, WORN - CONTINUED

5. Using a hacksaw or other suitable tool, open battery to expose carbon core.

6. Clean and cut a piece of carbon core and shape to fit the brush holder.

7. Insert the piece of carbon into the brush plate and position the loose end of the old brush wire between the carbon and the retaining spring to ensure electrical continuity.

8. Seat the brushes as follows:

   a. Cut a strip of abrasive paper slightly wider than the commutator surface.

   b. Tape the strip of abrasive paper over the commutator.

   c. Install the brush holder with piece of carbon core enclosed.

   d. Rotate the armature in the normal direction until the piece of carbon core face conforms to the armature surface curvature.

   e. Remove the abrasive paper and blow the armature commutator area free of dust and grit.

9. Reassemble generator and test for proper operation.

10. Reinstall and align generator.

11. Set MASTER power switch to ON.

12. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. SWITCHES, RELAYS, AND SENSORS

7-8. GENERAL

Special switches, relays and a sensor which are used to apply power to activate a circuit or subsystem are covered in this section.

7-9. SWITCH, RELAY, OIL PRESSURE-ACTIVATED, AIR CLEANER AND GENERATOR SYSTEM

General Information:

The air cleaner and generator system, oil pressure-activated relay switch is a safety interlock switch, which opens when oil pressure drops below a SAFE level. Under extreme conditions when system operation must be maintained regardless of excessive wear and/or damage to the engine, the switch can be bypassed.

CAUTION

The oil pressure-activated interlock switch opens when oil pressure drops below a predetermined SAFE level. Bypassing the Interlock switch allowing the engine to continue to run, will cause excessive wear and eventual engine failure.

7-9. SWITCH, RELAY, OIL PRESSURE-ACTIVATED, AIR CLEANER AND GENERATOR SYSTEM - CONTINUED

Limitations:

Oil level must be frequently monitored.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Wire, electrical (item 74, Appendix C)
- Tape, Insulation electrical (item 63, Appendix C)

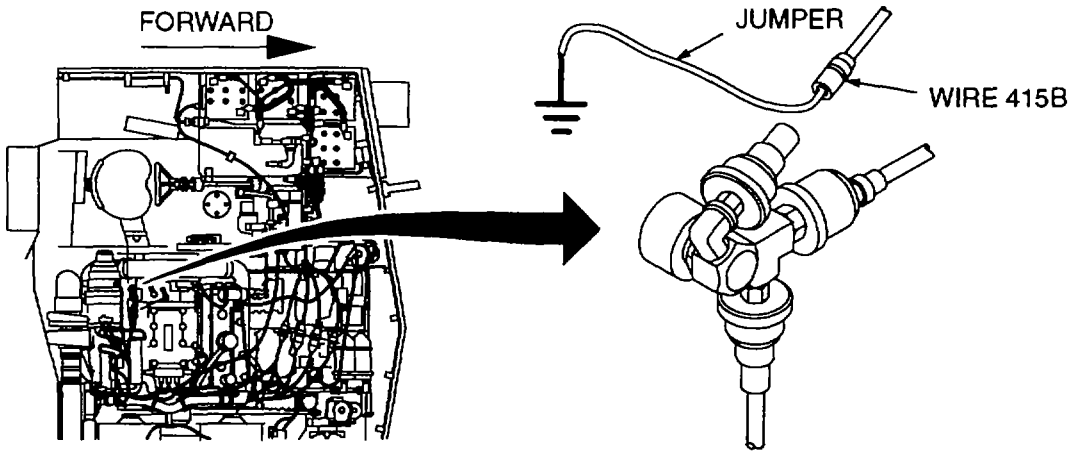
References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

Procedural Steps:

1. Set MASTER power switch to OFF.

2. Gain access to failed switch.



3. Disconnect wire 415B from switch.

4. Use electrical wire or jumper to connect conductor of wire 415B to system ground.

5. Insulate and secure electrical wire or jumper with electrical tape.

6. Set MASTER power switch to ON.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-10. SWITCH, MASTER

General Information:

MASTER power switch removes electrical power from all circuits when open.

Limitations:

- Slave position of switch will not be spring-loaded, therefore not momentary.
- Fuel gage will be inoperative.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

Tape, insulation electrical (item 63, Appendix C)

References:

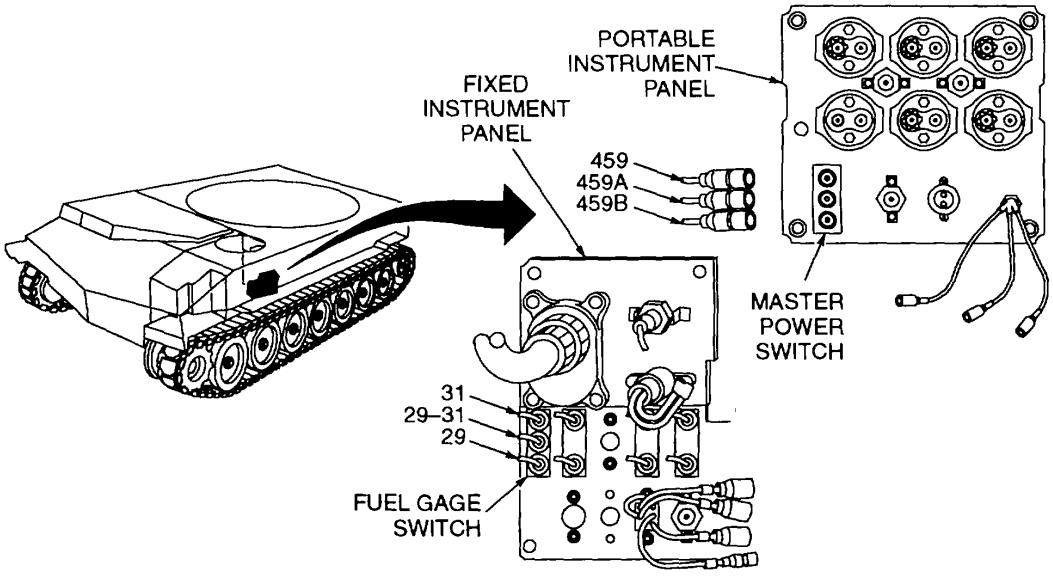
TM 9-2350-314-20-1-2

Procedural Steps:

NOTE

In the following procedure, tag wires as necessary to aid in reconnection.

1. Gain access to MASTER power switch.



2. Remove wires 459, 459A and 459B from MASTER power switch.

3. Remove inoperative MASTER power switch from drivers portable instrument panel.

7-10. SWITCH, MASTER - CONTINUED

4. Remove wires 29, 31 and 29-31 from fuel level switch.

5. Remove fuel gage switch from driver's fixed instrument panel.

6. Cover bare ends of wires 29, 31 and 29-31 and secure using electrical insulation tape.

7. Install good switch taken from fuel gage switch position, into MASTER power switch position.

8. Connect wires 459, 459A and 459B to switch in MASTER power switch position.

9. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-11. SWITCH, NEUTRAL, SAFETY

General Information:

The neutral safety switch is a mechanical/electrical switch that prevents the M109A6 starter motor relay from closing with the transmission in any position other than neutral.

Limitations:

If the neutral safety switch section in the air cleaner blower relay circuit is also inoperative, the air cleaner blowers will not operate, reducing engine power.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Wire, electrical (item 74, Appendix C)
- Tape, insulation electrical (item 63, Appendix C)

References:

TM 9-2350-314-20-1-2

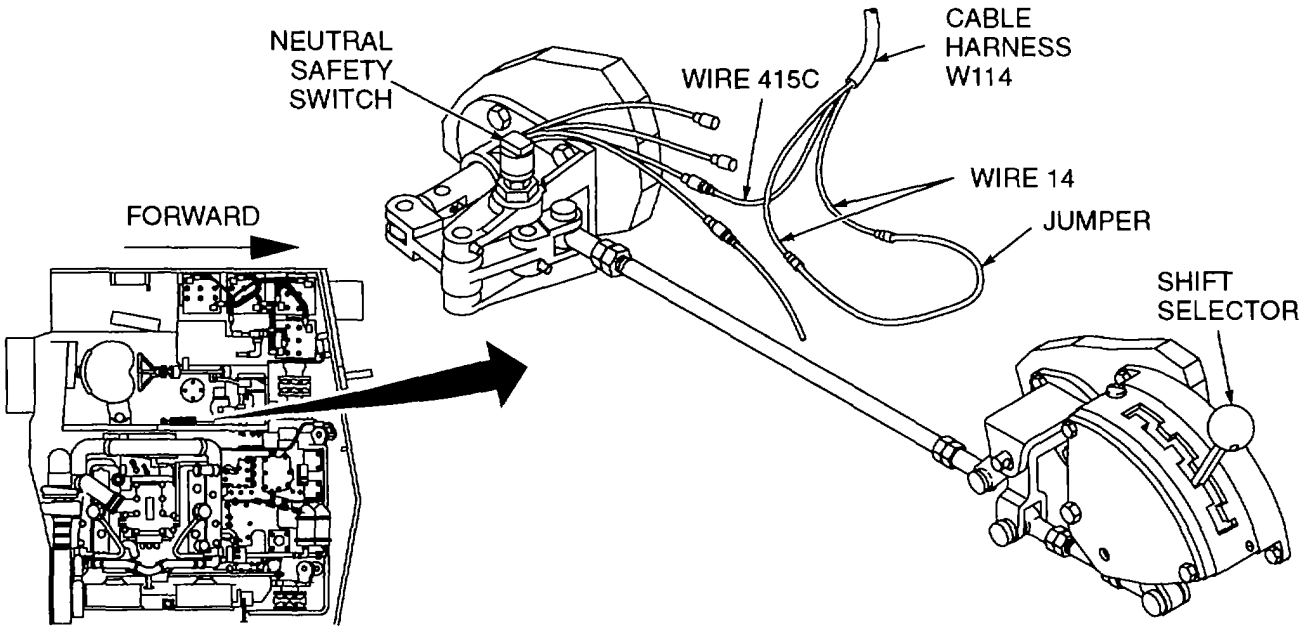
Procedural Steps:

WARNING

With the neutral safety switch bypassed, the engine can be started with the transmission in any gear position. With the neutral safety switch bypassed, always ensure that the transmission is in the neutral (out of gear) position before attempting to start the engine. Failure to heed this warning could cause the M109A6 to lurch forward when the engine is started, if the transmission is in a gear position, causing damage to equipment or injury or death to personnel.

1. Gain access to the neutral safety switch.

7-11. SWITCH, NEUTRAL, SAFETY - CONTINUED



2. Set MASTER power switch to OFF.

3. In wiring harness W114, locate two wires number 14.

4. Remove two wires number 14 from neutral safety switch and connect, using electrical wire or jumper.

5. Insulate and secure electrical wire or jumper using insulation electrical tape.

6. Set MASTER power switch to ON.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-12. RELAY, MASTER

General Information:

The master relay supplies electrical energy to all major electrical systems in the M109A6. With full electrical load applied, the master relay is capable of carrying upwards to 1000 amps of electrical current.

Limitations:

With master relay bypassed, it is impossible to disconnect the electric power without breaking the bypass.

Personnel/Time Required:

- 2 soldiers
- 0.5 hour

Materials/Tools:

Tape, insulation electrical (item 63, Appendix C)

7-12. RELAY, MASTER - CONTINUED

References:

TM 9-2350-314-20-1-2

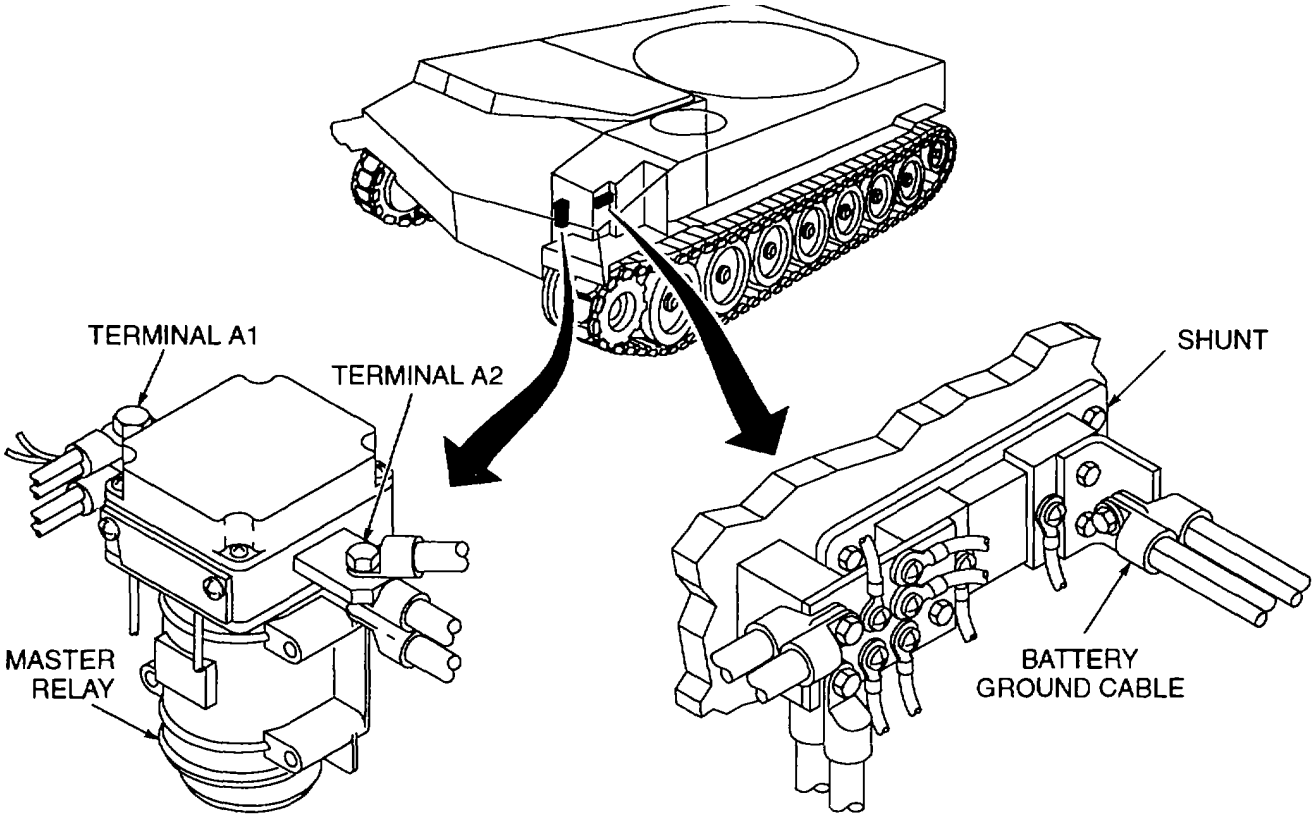
Procedural Steps:

1. Gain access to master relay and batteries

WARNING

- **Fuel leaks or vapors may be present in engine compartment which can be ignited by electrical spark. Fix leaks and ventilate area before disconnecting master relay cables or battery. Failure to do so could result in an explosion and injury or death to personnel.**
- **Master relay cables carry high current. Before working on master relay, disconnect negative link on batteries. Failure to do so could result in personnel injury or death by electrocution.**

2. Disconnect battery ground cable from shunt.



3. Disconnect cables from master relay terminals A1 and A2.

7-12. RELAY, MASTER - CONTINUED

NOTE

While the cables from terminals A1 and A2 of the master relay are connected, the electrical circuits of the M109A6 are hot. When the M109A6 is inoperative and the MASTER power switch would normally be set to OFF, the cables should be disconnected (steps 2 and 3) to avoid possible battery discharge.

4. Using bolt, washers, lockwasher and nut, connect cables taken from terminals A1 and A2.

5. Insulate and secure cables from A1 and A2 while connected, using electrical insulating tape.

6. Connect battery ground cable to shunt.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-13. RELAY, STARTER PROTECTION

General Information:

The starter protection relay prevents damage to starter from cranking beyond a predetermined time limit and therefore overheating.

Limitations:

Logic circuit is disabled and cannot utilize sensing signals from the generator or voltage regulator.

Personnel/Time Required:

- 2 soldiers
- 0.5 hour

Materials/Tools:

Wire, electrical (item 74, Appendix C)

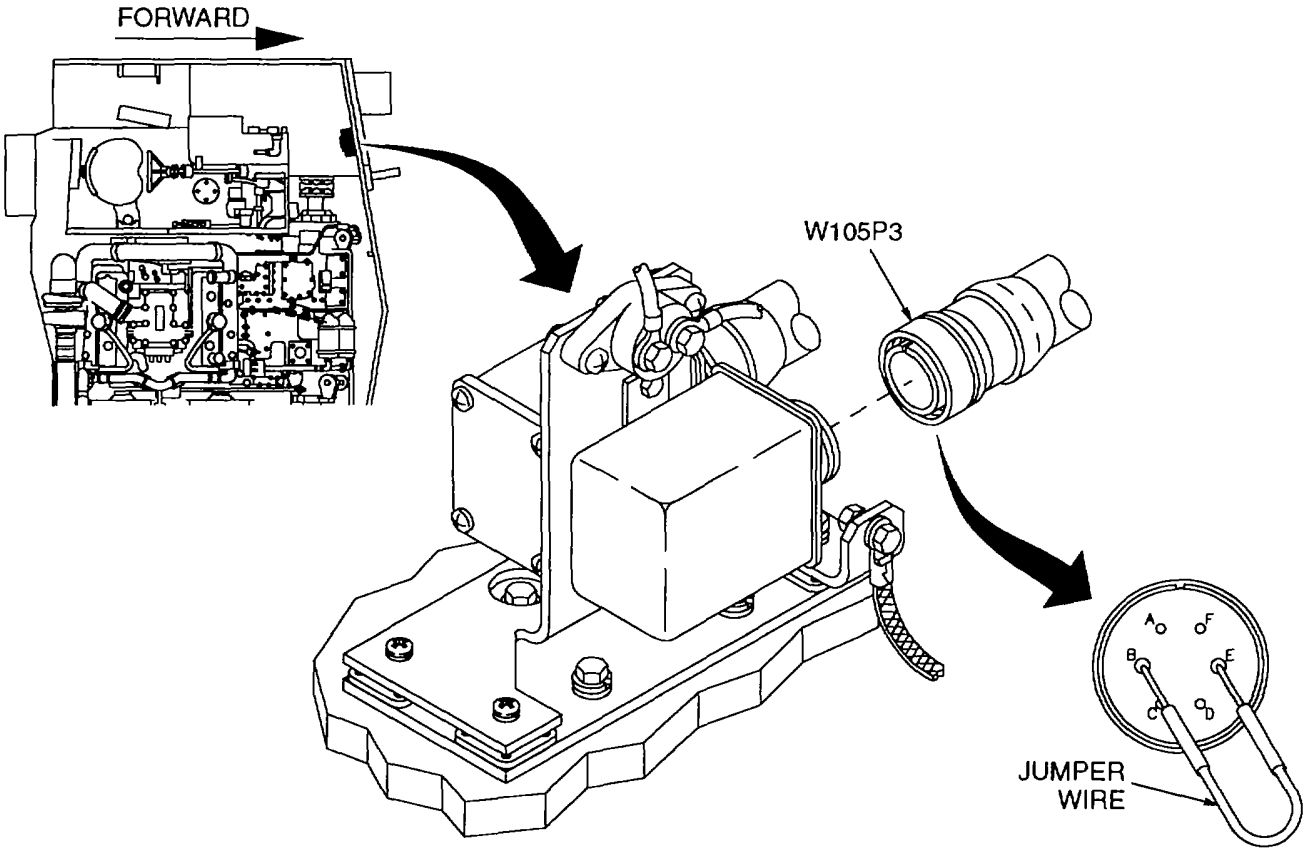
References:

TM 9-2350-314-20-1-2

7-13. RELAY, STARTER PROTECTION - CONTINUED

Procedural Steps:

1. Gain access to the starter protection relay.



2. Set MASTER power switch to OFF.
3. Remove connector P3 of wiring harness W105 from starter protection relay socket.
4. Place insulated electrical wire or jumper from pin B to pin E of connector P3.
5. Set MASTER power switch to ON.
6. As soon as engine starts to run, disconnect insulated electrical wire or jumper from pin B to pin E of connector P3.
7. Return connector P3 to starter protection relay socket.
8. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-14. RELAY, GENERATOR/FUEL PUMPS

General Information:

The generator system and fuel pumps relay provides protection when the oil pressure drops below a predetermined safe pressure.

7-14. RELAY, GENERATOR/FUEL PUMPS - CONTINUED

Limitations:

Air cleaner blowers will be inoperative causing reduced power output from the engine.

Personnel/Time Required:

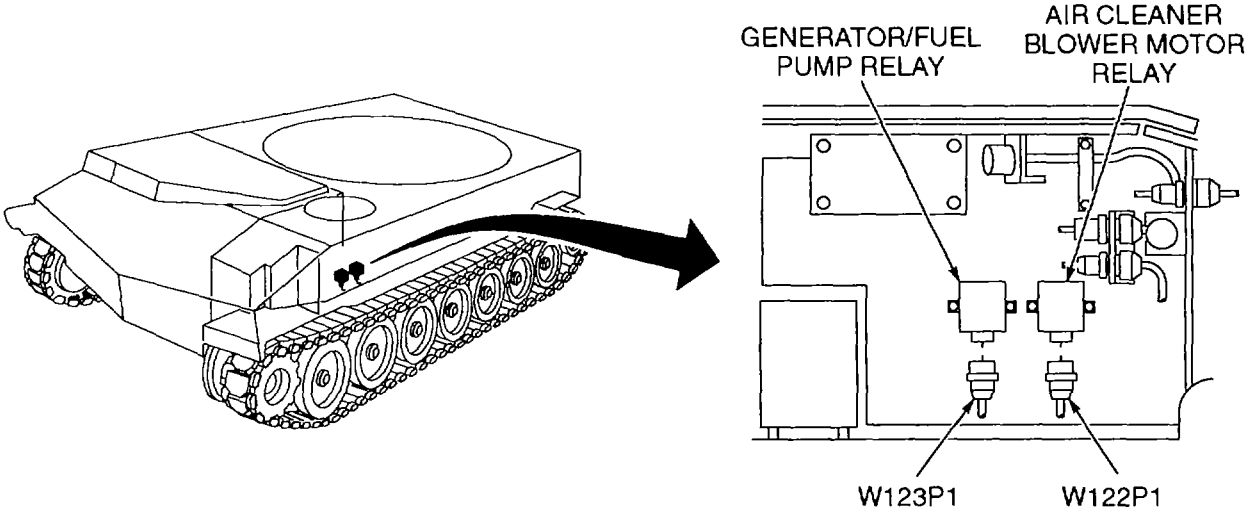
- 1 soldier
- 0.5 hour

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to the generator system and fuel pump relay and the air cleaner blower motor relay.



2. Set MASTER power switch to OFF.

NOTE

The air cleaner blower relay and the generator/fuel pump relay are identical. To maintain an adequate fuel supply to the engine, the air cleaner blower relay is substituted for a failed generator/fuel pump relay.

3. Remove connector P1 of wiring harness W122 from air cleaner blower relay.

4. Remove connector P1 of wiring harness W123 from generator/fuel pump relay and connect it to air cleaner blower relay.

5. Connect P1 of wiring harness W122 to generator/fuel pump relay for safe storage.

6. Set MASTER power switch to ON.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-15. RELAY, HYDRAULIC PUMP MOTOR

General Information:

Hydraulic pump maintains a predetermined hydraulic pressure. If the hydraulic pump falls, the hydraulic pressure will fall, rendering all hydraulic equipment unusable.

Limitations:

When the hydraulic relay is bypassed, the hydraulic fluid level detector and hydraulic motor thermal switch are no longer effective.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

Tape, insulation electrical (item 63, Appendix C)

References:

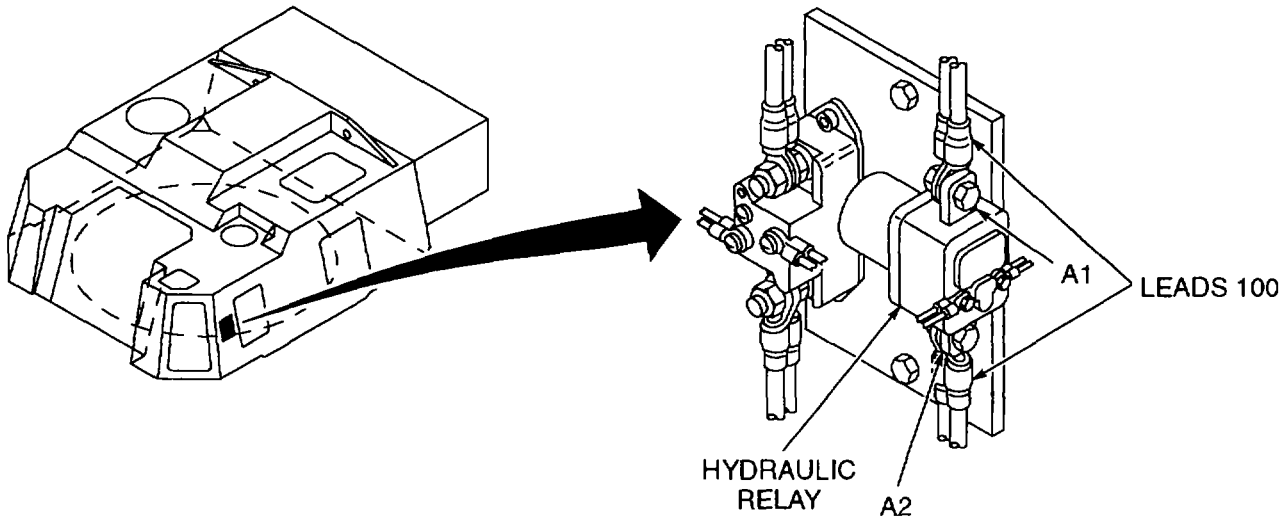
TM 9-2350-314-20-2-1

CAUTION

With hydraulic relay bypassed low hydraulic fluid levels and overheating of hydraulic pump will not turn hydraulic motor off. Hydraulic fluid level must be frequently monitored to insure adequate hydraulic fluid level in the hydraulic reservoir, and temperature of hydraulic pump must be periodically monitored for overheating. Failure to heed this caution may cause damage to, or destruction of the hydraulic pump motor.

Procedural Steps:

1. Gain access to the hydraulic relay.



7-15. RELAY, HYDRAULIC PUMP MOTOR - CONTINUED

2. Set MASTER power switch to OFF.

3. Remove two leads 100 from hydraulic relay terminal A1 and two leads 100 from hydraulic relay terminal A2.

4. Connect the two leads 100 from terminal A1 and the two leads 100 from terminal A2, using screw, washer, lockwasher, and nut from hydraulic relay.

5. Insulate and secure leads 100 using electrical tape.

6. Set MASTER power switch to ON.

7. Record BDAR action taken. When mission Is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

7-16. OVERLOAD SENSOR, HYDRAULIC PUMP MOTOR

General Information:

The overload sensor monitors current drawn by the hydraulic pump motor When the current exceeds a predetermined amount, the sensor opens the circuit to protect the motor.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Wire, electrical (item 74, Appendix C)
- Tape, insulation electrical (item 63, Appendix C)

References:

TM 9-2350-314-20-2-1

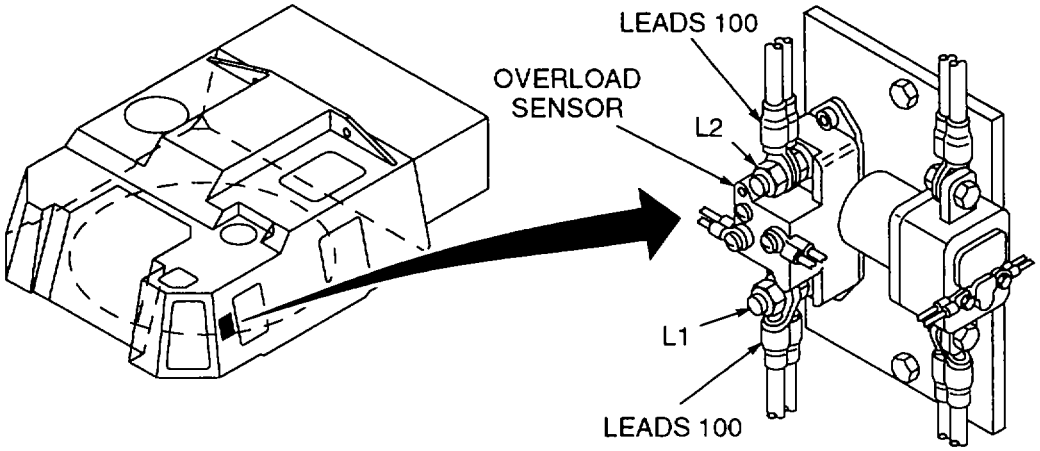
CAUTION

With overload sensor bypassed, an overload condition caused by the hydraulic pump motor will not be detected. The hydraulic pump motor must be periodically monitored for overheating, which would Indicate an overload condition. Failure to heed this caution may cause damage to, or destruction of the hydraulic pump motor.

7-16. OVERLOAD SENSOR, HYDRAULIC PUMP MOTOR - CONTINUED

Procedural Steps:

1. Gain access to the hydraulic overload sensor.



2. Set MASTER power switch to OFF.

3. Remove two leads 100 from hydraulic pump motor overload sensor terminal L1 and two leads 100 from hydraulic pump motor overload sensor terminal L2.

4. Connect the two leads 100 from terminal L1 and the two leads 100 from terminal L2 using 1/2-inch bolt, flat washer, lockwasher, and nut.

5. Insulate and secure leads using electrical tape.

6. Set MASTER power switch to ON.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 8
POWERTRAIN / STEERING

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

This chapter contains fault assessment and expedient repair procedures to find and fix battlefield damage to the powertrain.

8-2. ASSESSMENT PROCEDURE

Table 8-1. Powertrain / Steering Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Transmission linkage, broken	para 3-26
Transmission housing, cracked	para 3-33
Transfer housing, cracked	para 3-33
Final drive housing cracked	para 3-33
Sprocket and hub assembly bolts sheared	para 8-11
Steering linkage, failure	para 8-13

Determine if:

- Damage can be repaired - Note repair requirements
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

No damage found

Visual inspection is complete Return to Table 2-2 to continue visual assessment.

8-2. ASSESSMENT PROCEDURE - CONTINUED

Table 8-2. Powertrain / Steering Operation Assessment

Pre-conditions: Vehicle brakes should be in working condition. The vehicle engine must run to assess the powertrain using this procedure.

ATTEMPT OPERATION → **INOPERATIVE:**

DAMAGE FOUND TO:

Transmission failure	para 8-5
Transfer	para 8-7
Steering linkage failure	para 8-13

Determine if:

No problem found

Damage can be repaired
- Note repair requirements

Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Operation observation is complete. Return to Table 2-2 to continue operation assessment.

8-3. REPAIR PROCEDURE INDEX

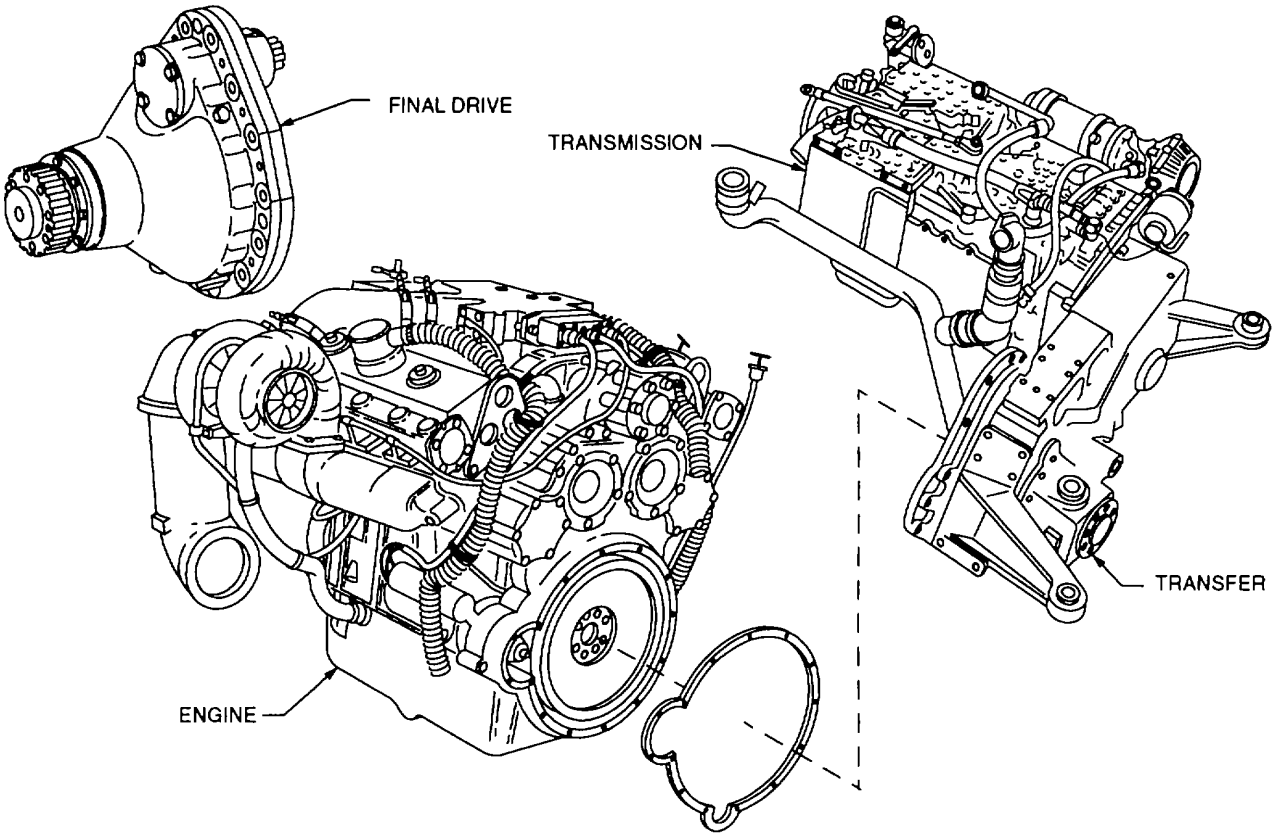
PARA

SECTION II. POWERTRAIN / STEERING

8-4. GENERAL

The M109A6 powertrain, separate from the engine, consists of a transfer case, transmission and two final drives. The transmission and transfer assemblies transmits power from the engine through the transfer assembly to the transmission input spur gear which is splined to the transmission input shaft. The input spur gear operates the driven spur gear to which the torque converter drive gear is splined. The torque converter delivers two branches of power, vehicle drive and steering.

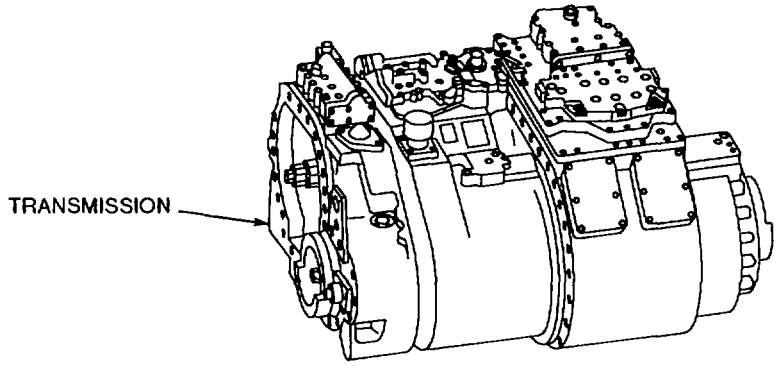
The transmission is hydro-mechanically operated and delivers power to the left and right final drive sprockets. The transmission provides four forward and two reverse speeds, and steering through a differential action.



SECTION III. TRANSMISSION

8-5. GENERAL

Within the self-propelled howitzer family the variations use three basic transmissions; the XTG-411-2, -2A, and -4, which are interchangeable with limited differences within the family. BDAR procedures may consist of cannibalizing complete assemblies from vehicles within the same family.



8-6. TRANSMISSION FAILURE

General Information:

The M109/M110 and M578 are designed for the XTG-411-2, -2A, and -4 transmissions. These transmissions are interchangeable between the following vehicles M107, M108, Ml10, M110A1, M110A2, M109 Series and M992.

Although transmissions are interchangeable and compatible, reduced braking action may result.

Limitations:

Some transmission to engine combinations may reduce vehicle mobility and braking action.

Personnel/Time Required:

- 3 soldiers
- 3.0 hours

Materials/Tools:

- Transmission (scavenged from available source)
- Oil to refill transmission

References:

- LO 9-2350-314-12
- TM 9-2350-314-34-1

Other Options:

Change transmission with substitute.

8-6. TRANSMISSION FAILURE - CONTINUED

Procedural Steps:

1. Replace transmission.

2. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. TRANSFER ASSEMBLY

8-7. GENERAL

Transfer assemblies are interchangeable within the same families of vehicles. Some transfers also drive other accessories such as hydraulic pumps, cooling fans, or power take-offs. Care must be taken to use a transfer case which will provide the minimum essential operations required for the vehicle's mission. BDAR procedures may consist of cannibalizing complete assemblies from vehicles within the family, or parts exchange to repair one from other defective units.

8-8. TRANSFER ASSEMBLY INTERCHANGEABILITY

General Information:

Transfer Assemblies are interchangeable between the following vehicles: M107, M108, M109 Series, M110, M110A1, M110A2, M578, and M992.

Limitations:

Some transfer assemblies may reduce vehicle mobility.

Personnel/Time Required:

- 3 soldiers
- 1.5 hours

Materials/Tools:

- Transfer (scavenged from available source)
- Oil to refill transfer

References:

- LO 9-2350-314-12
- TM 9-2350-314-34-1

Other Options:

Replace transfer assembly with substitute.

8-8. TRANSFER ASSEMBLY INTERCHANGEABILITY - CONTINUED

Procedural Steps:

1. Replace/repair transfer assembly.

2. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION V. FINAL DRIVE ASSEMBLY

8-9. GENERAL

The final drive assemblies transmit power from the transmission to the tracks, allowing howitzer to move.

8-10. FINAL DRIVE, LOCKED

General Information:

Battlefield operations may result in damage that locks up final drive and prevents howitzer movement. The damaged final drive can be disconnected at the final drive hub to allow howitzer to be driven with one track.

Limitations:

- Pivot capability is eliminated.
- Speed Is reduced.
- Steering is difficult.

Personnel/Time Required:

- 1 soldier
- 0.1 hour

Materials/Tools:

Like vehicle for recovery

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Break track on damaged side of howitzer.

2. Use like vehicle to position howitzer.

3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

8-11. SPROCKET AND HUB ASSEMBLY BOLTS, SHEARED

General Information:

The sprocket and hub assembly is secured to the final drive hub with 8 bolts. At least 4 of the 8 mounting bolts are required to remount the sprocket and hub assembly. If the sprocket and hub assembly is remounted with a reduced number of bolts, the bolts should be spaced evenly. If these bolts come loose, they will wear and eventually shear off causing the sprocket, hub assembly, and track to drop off.

Option 1: Substitute bolts.

Limitations:

Reduced mobility.

Personnel/Time Required:

- 3 soldiers
- 3.0 hours

Materials/Tools:

- Vice-grips
- Hammer
- Chisel
- 4 each hub bolts (scavenged from available source)

References:

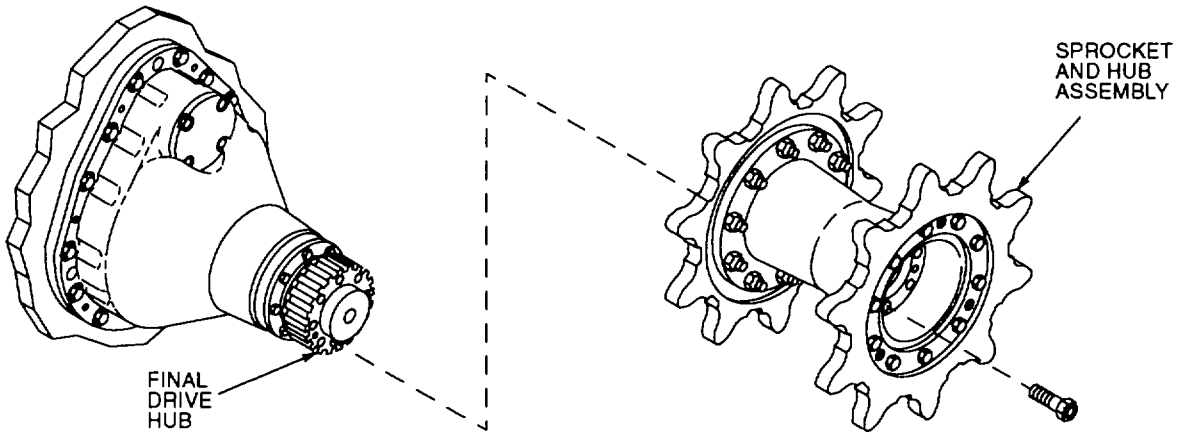
TM 9-2350-314-20-1-2

Procedural Steps:

1. Break track.

2. Remove broken final drive hub bolts.

3. Remount the sprocket and hub assembly with replacement or remaining bolts (minimum of four).



8-11. SPROCKET AND HUB ASSEMBLY BOLTS, SHEARED - CONTINUED

4. Reconnect track and adjust tension.

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Weld hub assembly.

Limitations:

Reduced mobility.

Personnel/Time Required:

- 2 soldiers
- 1.0-2.0 hours

Materials/Tools:

- Vice-grips
- Hammer
- Chisel
- Welding equipment

References:

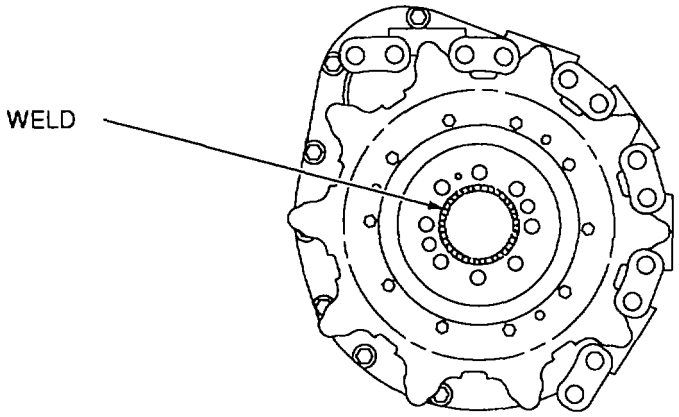
TM 9-2350-314-20-1-2

Procedural Steps:

1. Break track.

2. Remove broken final drive housing bolts.

3. Weld the hub assembly to the output of the final drive.



4. Reconnect track and adjust tension.

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION VI. STEERING

8-12. GENERAL

Steering is accomplished by braking action against the driving force restriction motion. Failures of linkage can be repaired using the following procedures.

8-13. STEERING LINKAGE FAILURE

General Information:

Steering is accomplished in the transmission through differential actions. No reaction to movement of the steering wheel may be because of broken steering linkage.

Option 1: Repair steering linkage.

Limitations:

Reduced mobility.

Personnel/Time Required:

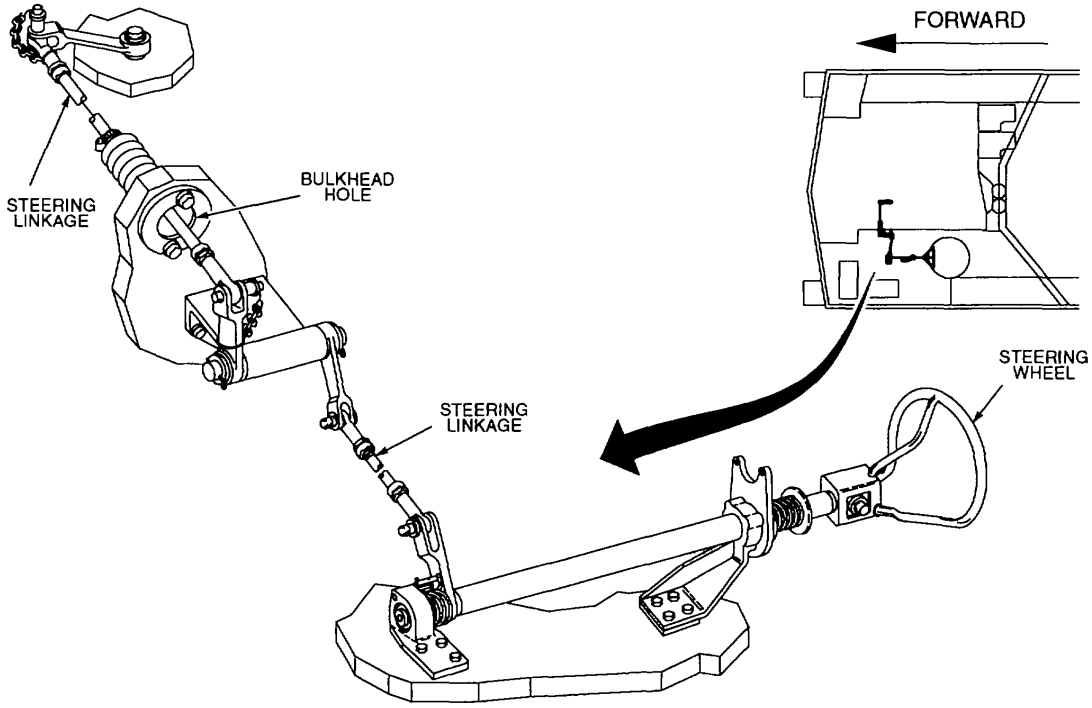
- 2 soldiers
- 0.3 hour

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to steering linkage.



8-13. STEERING LINKAGE FAILURE - CONTINUED

2. Repair steering linkage (Ref Chapter 3).

3. Adjust steering if necessary.

4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Weld steering linkage.

Limitations:

Reduced mobility.

Personnel/Time Required:

- 2 soldiers
- 0.3 hour

Materials/Tools:

Welding equipment

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to steering linkage.

2. Weld steering linkage (Ref Chapter 3).

3. Adjust steering if necessary.

4.. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Replace steering linkage metal rod.

Limitations:

Reduced mobility.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

Materials/Tools:

- Metal rod (scavenged from available source)
- Wire, safety (item 80, Appendix C or scavenge from available source)
- Cutting capability

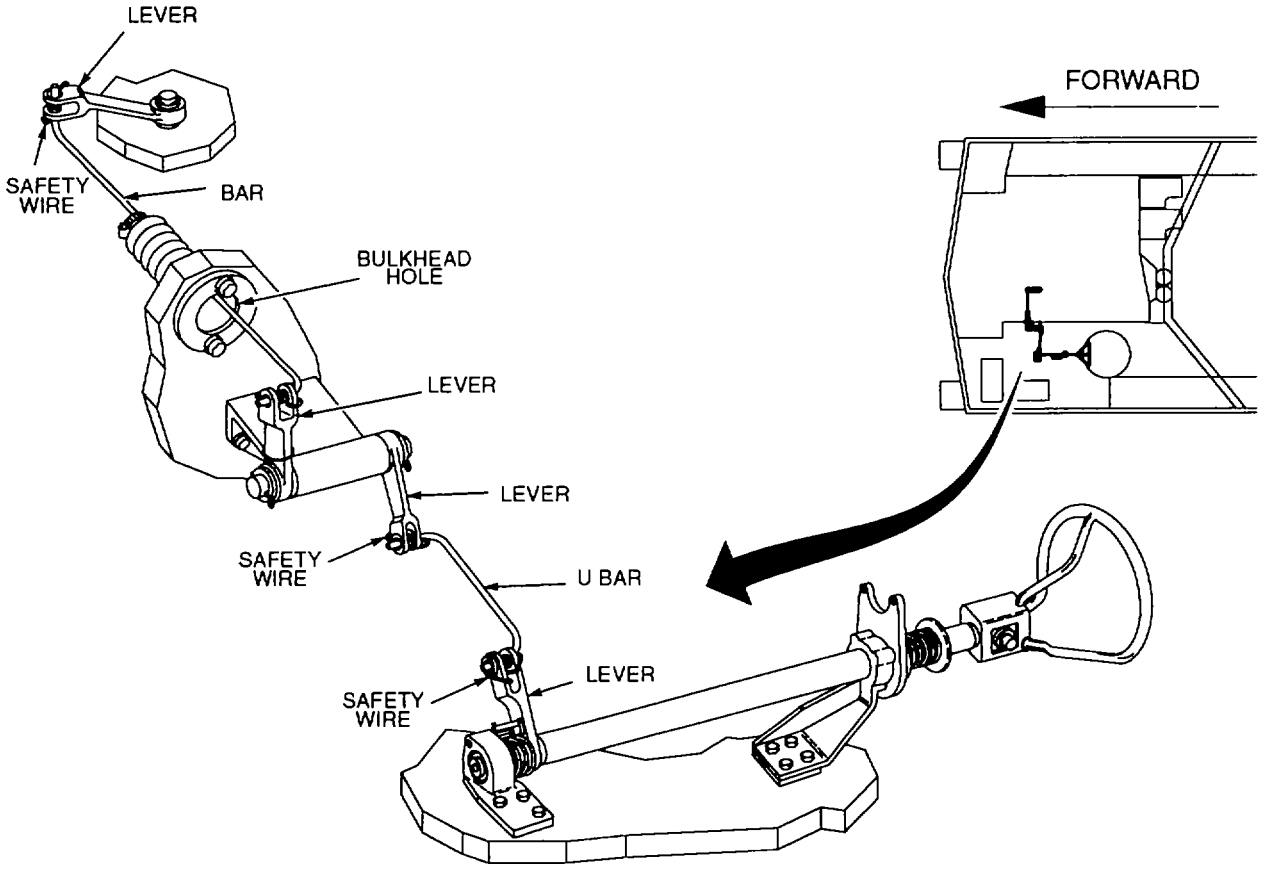
8-13. STEERING LINKAGE FAILURE - CONTINUED

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to steering linkage.
2. Remove broken linkage.
3. Cut a metal rod using the steering linkage as template.



4. Bend the metal rod so that it fits through levers.
5. Secure metal rod to levers with safety wire.
6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4: Replace steering linkage with wire.

Limitations:

Reduced mobility.

8-13. STEERING LINKAGE FAILURE - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.3 hour

Materials/Tools:

- Wire, safety (item 80, Appendix C or scavenge from available source)
- Cutting pliers

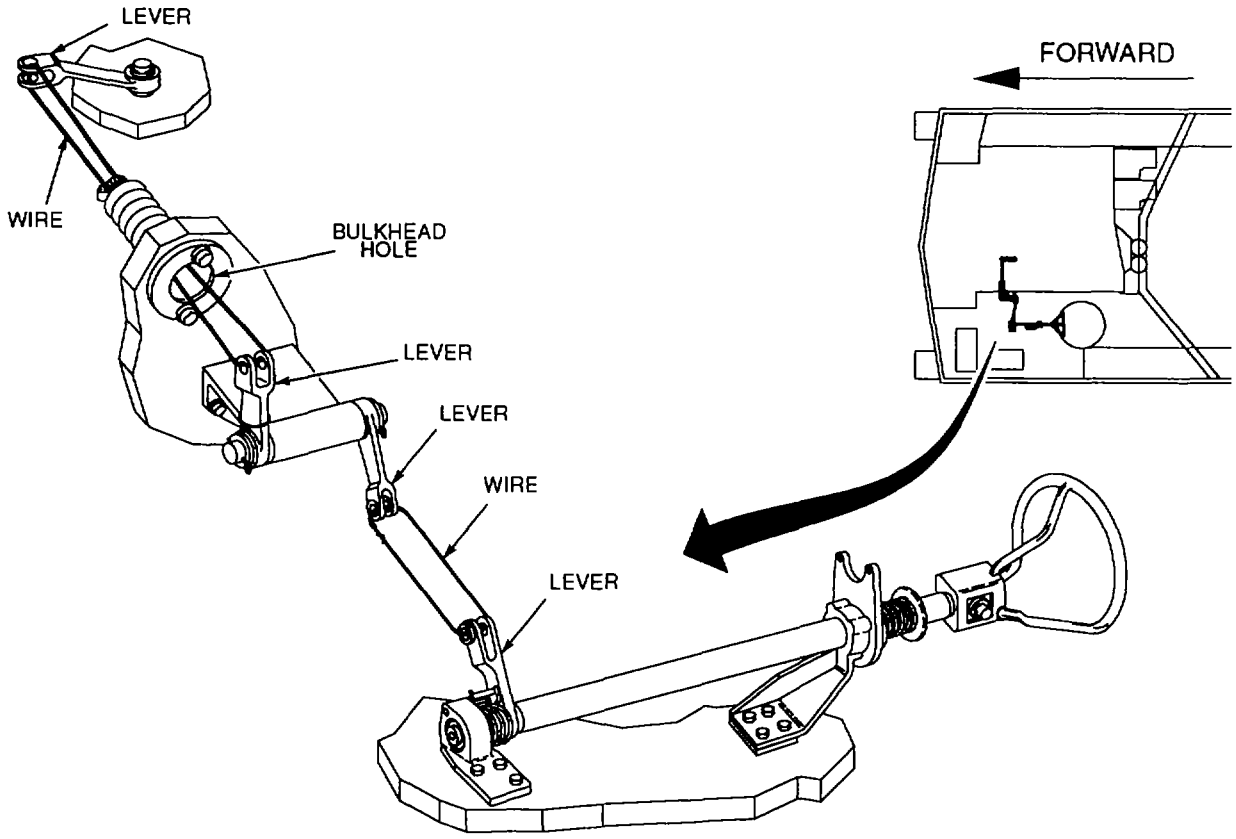
References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to steering linkage.

2. Remove broken linkage.



3. Wrap several strands of wire between levers replacing steering linkage.

4. Record the BDAR action taken. When mission Is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 9
BRAKES

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

9-1. SCOPE

This chapter contains fault assessment and expedient repair procedures available to find and fix battlefield damage to the brakes.

9-2. ASSESSMENT PROCEDURE

Table 9-1. Brakes Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Parking brakes, locked	para 9-5
Service brakes, locked	para 9-6
Chain broken	para 9-7
Linkage broken	Chapter 3

Determine if:

- No damage found → Visual inspection is complete Return to Table 2-1 to continue visual assessment.
- Damage can be repaired - Note repair requirements → Visual inspection is complete Return to Table 2-1 to continue visual assessment.
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

9-2. ASSESSMENT PROCEDURE - CONTINUED

Table 9-2. Brakes Operation Assessment

Assessment Preconditions: Before testing the vehicle brakes, clear the immediate area or, if in a restricted area, restrain the vehicle to be tested with chains or cables. The brakes can be tested using either the test vehicle power or it can be towed by the restraining vehicle up a slight grade for the test.

ATTEMPT OPERATION → **INOPERATIVE:**

Parking brakes, locked ..... para 9-5
Service braked, locked ..... para 9-6
Brake malfunctions ..... para 9-7

Determine if:

No problem found

Damage can be repaired
- Note repair requirements

Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Operation observation is complete. Return to Table 2-2 to continue operation assessment.

9-3. REPAIR PROCEDURE INDEX

PARA

SECTION II. BRAKES

9-4. GENERAL

The brakes are internal to the crossdrive transmission. Brakes are applied through mechanical linkage from the driver's compartment. The linkage allows a balanced application at the transmission levers by using a chain and sprocket assembly. Parking brakes are operated by locking the service brake linkage in the applied position.

9-5. BRAKES, PARKING, LOCKED

General Information:

Parking brake handle will not release causing the brakes to remain applied. Disconnecting the linkage will release the brakes.

Limitations:

No parking brakes.

9-5. BRAKES, PARKING, LOCKED - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.2 hour

References:

TM 9-2350-314-20-1-2

Other Options:

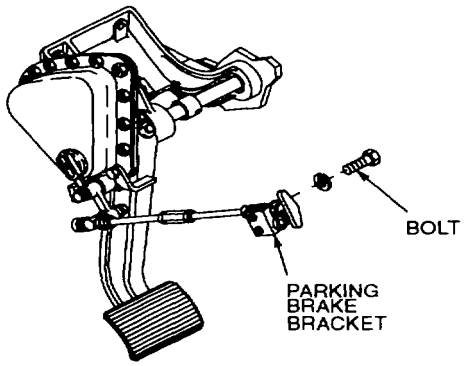
Disconnect linkage at transmission

Procedural Steps:

WARNING

Tracks must be blocked so that the vehicle will not roll out of control when the brake linkage is disconnected. Failure to block tracks may result in severe injury to personnel or equipment damage.

1. Locate parking brake handle directly beneath steering wheel in driver's compartment.



2. Remove parking brake bracket from frame by removing the two bolts.
3. Lay parking brake assembly on floor.
4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

9-6. BRAKES, SERVICE, LOCKED

General Information:

Brakes will not release.

Limitations:

Possible that brakes will lock again.

9-6. BRAKES, SERVICE, LOCKED - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.3 hour

Materials/Tools:

- Pipe (scavenge from available source)
- Breaker bar (scavenge from available source)
- Shovel handle (scavenge from available source)

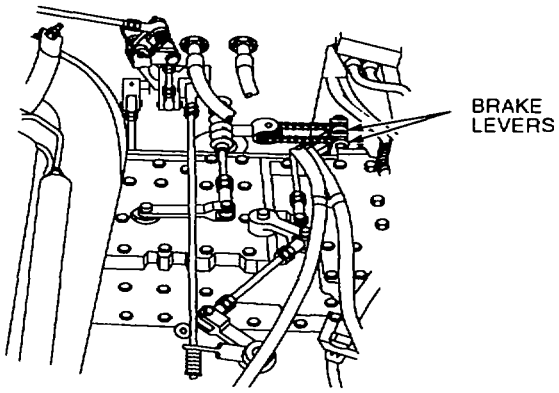
References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Gain access to transmission compartment and locate brake control levers.

2. Using pry bar, pry brake levers into released position.



3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

9-7. BRAKE MALFUNCTIONS

General Information:

Brake control chain is broken. A substitute brake chain can be installed, however, it should be checked frequently and adjusted as necessary to ensure it has not frayed or broken.

Limitations:

- Reduced braking ability
- Reduced speed

Personnel/Time Required:

- 1 soldier
- 0.5 hour

9-7. BRAKE MALFUNCTIONS - CONTINUED

Materials/Tools:

- Wire coat hanger (scavenge from available source)
- Rope (Item 52, Appendix C)
- 1/8-inch cable and cable clamp (scavenge from available source)
- Commo wire WD-1/TT (scavenge from available source)

References:

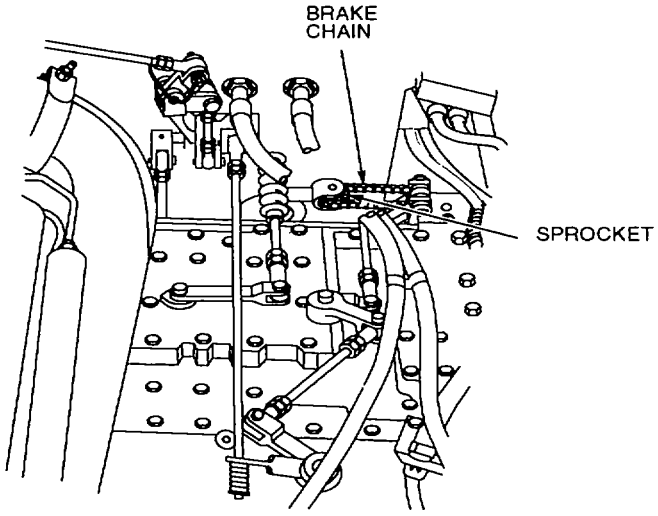
TM 9-2350-314-20-1-2

Other Options:

Slow vehicle down as much as possible by down shifting, stop by running into a tree or similar object or by shifting into reverse.

Procedural Steps:

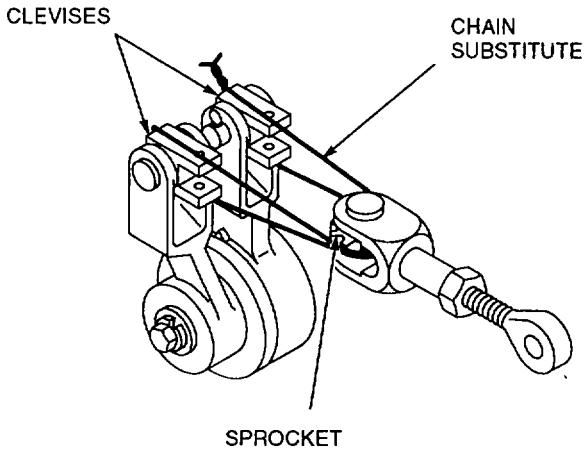
1. Gain access to transmission compartment and locate brake control chain.



2. Remove broken pieces of chain from around sprocket, if any.

3. Feed chain substitute around sprocket and underneath clevises of both brake levers.

9-7. BRAKE MALFUNCTIONS - CONTINUED



4. Pull chain replacement as tight as possible and fasten ends together.

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 10
WHEELS AND TRACKS

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

10-1. SCOPE

This chapter contains fault assessment and repair procedures available to find and fix battlefield damage to wheels and tracks (suspension assembly).

10-2. ASSESSMENT PROCEDURE

Table 10-1. Wheels and Tracks Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Roadwheel arm	para 10-5
Roadwheel arm hub	para 10-6
Roadwheel	para 10-8
Torsion bar	para 10-9
Track adjuster	para 10-11
Idler wheels	para 10-12
Drive sprocket	para 10-14
Track	para 10-15

Determine if:

No damage found

Damage can be repaired
- Note repair requirements

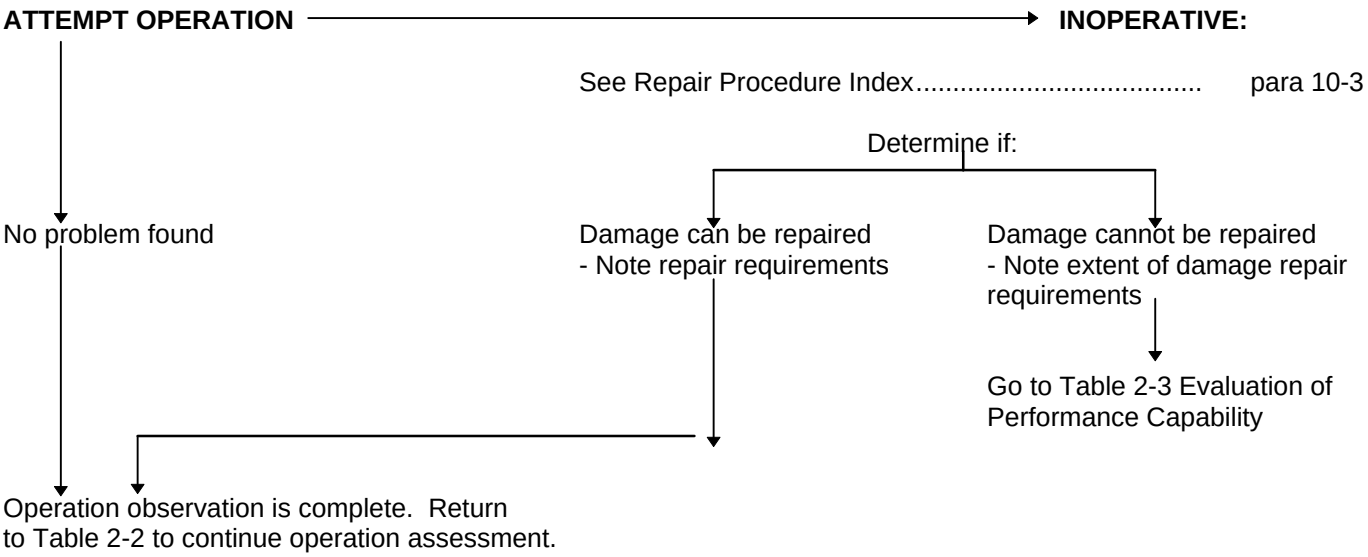
Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

Visual inspection is complete. Return to Table 2-1 to continue visual assessment.

10-2. ASSESSMENT PROCEDURE - CONTINUED

Table 10-2. Wheels and Tracks Operation Assessment



10-3. REPAIR PROCEDURE INDEX

PARA.

SECTION II. ROADWHEEL ARM ASSEMBLY

10-4. GENERAL

The M109A6 howitzer can have two roadwheel positions disabled on each side of the vehicle and still be combat capable. The two positions, however, cannot be adjacent to one another. The first and last roadwheel positions, will accept intermediate position component. Exchange parts from intermediate positions, if required, to keep the first and last positions operative. Roadwheel arms can be obtained from other positions to provide support and separate the two adjacent positions. This will give the vehicle additional balance when operating on rough terrain. Disabled roadwheel arms should be secured or removed to prevent interference with the track.

10-5. ROADWHEEL ARM, DAMAGED

General Information:

Severe damage or loss of any roadwheel arms will increase the vehicle weight distribution on the remaining roadwheel arms. This procedure allows continued operation of vehicle at reduced speeds with roadwheel arm damage.

Options:

Limitations:

- Reduced mobility.
- Reduced speed.

Personnel/Time Required:

- 3 soldiers
- 3.0 hours

Materials/Tools:

- Stanchion from water barrier tripod or metal rod (scavenge from available source)
- Straps and/or wire (scavenge from available source)

References:

- TM 9-2350-314-10
- TM 9-2350-314-20-1-2

Procedural Steps:

1. If necessary, break track.

NOTE

When necessary, use oxygen/acetylene torch to cut off roadwheel arm(s), and any other metal that may interfere with track and go to step 5.

2. Position damaged roadwheel arm(s) over a hole to release tension on torsion bar(s). If no holes exist, dig a hole.

3. Remove the roadwheels from damaged roadwheel arm(s).

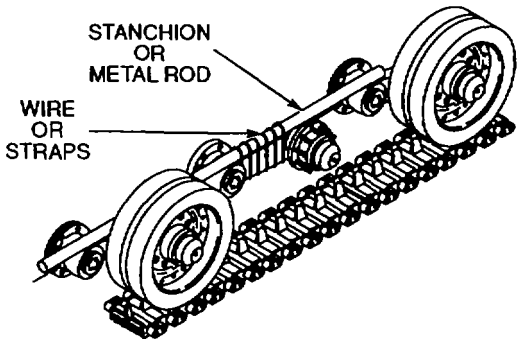
4. Remove torsion bar(s).

CAUTION

Roadwheel arm(s) must be securely bound to the stanchion. If they come loose, they can be caught in track center guides. This will immobilize the vehicle.

5. Raise and secure the damaged roadwheel arm(s) to stanchion.

10-5. ROADWHEEL ARM, DAMAGED - CONTINUED



6. Reconnect track if disconnected.

7 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

10-6. ROADWHEEL ARM HUB, DAMAGED

General Information:

The roadwheel hub must be serviceable to use single or double roadwheels (reference para 1-8). If the hub or spindle is damaged and interferes with track operation it must be removed or tied up (reference para 10-5). This procedure lists three options to fix a damaged roadwheel hub depending on materials available.

Option 1:
Limitations:

Repair may loosen and leak due to improper cleaning of damaged area.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

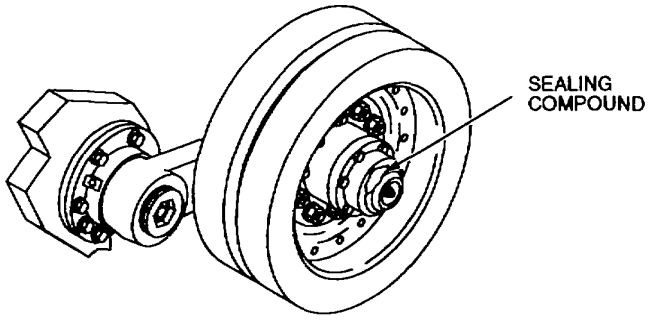
Materials/Tools:

- Polymer kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Grease (item 34, Appendix C)

References:

- LO 9-2350-314-12

Procedural Steps:



10-6. ROADWHEEL ARM HUB, DAMAGED - CONTINUED

1. Use polymer kit to repair damaged roadwheel cap.

2. Pack cap with grease.

3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2:

Limitations:

Repair may loosen and leak due to heat and/or vibration.

Personnel/Time Required:

- 1 soldier
- 0.2 hour

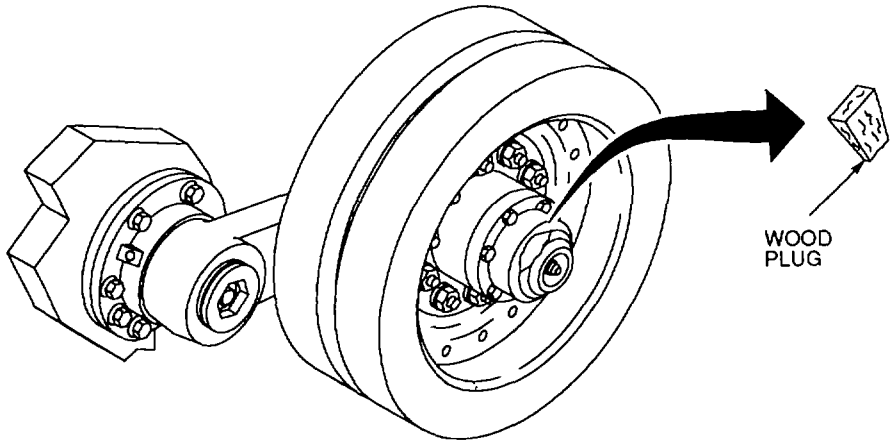
Materials/Tools:

- Hammer
- Grease (Item 34, Appendix C)
- Wood plug (scavenge from available source)

References:

LO 9-2350-314-12

Procedural Steps:



1. Wedge wood plug into the crack or hole in cap.

2. Fill cap with grease.

3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

10-6. ROADWHEEL ARM HUB, DAMAGED - CONTINUED

Option 3:

Limitations:

Repair may loosen and leak due to heat and/or vibration.

Personnel/Time Required:

- 1 soldier
- 0.2 hour

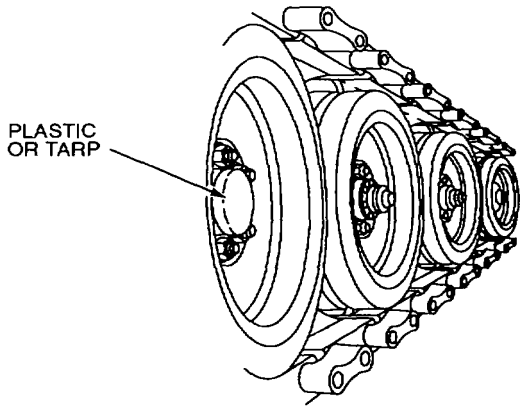
Materials/Tools:

- Piece of plastic or tarp (scavenge from available source)
- Grease (item 34, Appendix C)
- Tape, duct (item 62, Appendix C)

References:

LO 9-2350-314-12

Procedural Steps:



1. Pack bearings and hub assembly with grease.
2. Cut piece of plastic or tarp to fit over end of hub.
3. Place plastic or tarp over end of hub and secure with tape.
4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. ROADWHEEL ASSEMBLY

10-7. GENERAL

Wheel assemblies bear entire weight of vehicle at all times. Damage or loss of any wheel increases the load on remaining wheels, which will reduce their life and can cause sudden over stress failure.

10-8. ROADWHEEL, DAMAGED OR MISSING

General Information:

Operating with less than the standard number of roadwheels is possible. Do not put two single wheel positions next to one another if necessary, make them alternating single inner and single outer. When positioning a wheel as an outer guide, a shim plate must be installed.

Limitations:

Sharp turns should not be attempted.

Personnel/Time Required:

- 3 soldiers
- 2.0 hours

Materials/Tools:

Spacers (washers), 1/2-inch thick, ten required, or an old roadwheel (scavenge from available source)

References:

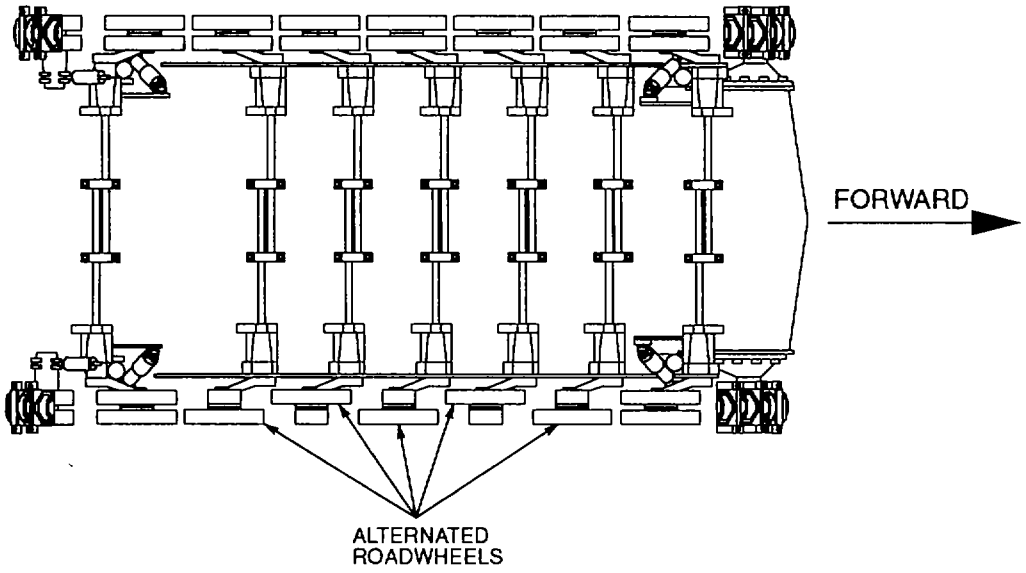
TM 9-2350-314-20-1-2

Procedural Steps:

NOTE

- **If roadwheel is damaged and interferes with the track, it should be removed.**
- **If spacers or washers are not available to use when putting on a single roadwheel, use the Inner hub parts of a broken roadwheel. Break off any part that might interfere with the track.**
- **Positions 1, 7, and compensating idler must have both roadwheels.**
- **Positions 3 through 6 can operate with a single roadwheel.**
- **Consecutive single roadwheels should be alternated.**

10-8. ROADWHEEL, DAMAGED OR MISSING -CONTINUED



1. Rearrange roadwheels as necessary.

2. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

10-9. TORSION BAR, BROKEN

Torsion bars are integral parts of the suspension system. They help counter roadwheel upward thrust on rough terrain. Torsion bars have a pre-twist which the bar spring in one direction. To prevent improper installation the bars use a blind spline for alignment purposes. If a first or last support position torsion bar is broken, replace it with one from the intermediate positions. A broken torsion bar must be removed to prevent other damage.

Limitations:

Degraded suspension.

Personnel/Time Required:

- 3 soldiers
- 1.0 hour

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Break roadwheel nuts before positioning wheels over hole.

2. Position roadwheel arm over a hole, so that tension on torsion bar can be released, if no hole exists, dig a hole.

3. Break track at forward edge of hole and let track drop in hole.

10-9. TORSION BAR, BROKEN - CONTINUED

4. Remove roadwheels.

5. Remove broken torsion bar.

6. Tie up disabled roadwheel arm (para 10-5).

7. Reconnect track.

8. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. TRACK ADJUSTER / IDLER WHEEL ASSEMBLY

10-10. GENERAL

The track adjuster and idler wheels are used to provide the tension to the track. The idler bearing unit housing provide the hub for the inner and outer idler wheels to rotate on. If damaged, tension on the track will be lost. Mobility can be restored by short tracking to the number 7 roadwheel position, which will require the removal of track shoes to provide limited track tension.

10-11. TRACK ADJUSTER, DAMAGED

General Information:

Damage to the track adjuster will probably include damage to the idler wheels. Whether damaged or not, this procedure will allow mobility to be restored to the vehicle.

Option 1: Fix damaged track adjuster.

Limitations:

- Steering capability nay be degraded.
- Reduced speed.

Personnel/Time Required:

- 2 soldiers
- 1.5 hours

Materials/Tools:

- Chain hoist
- Welding equipment

References:

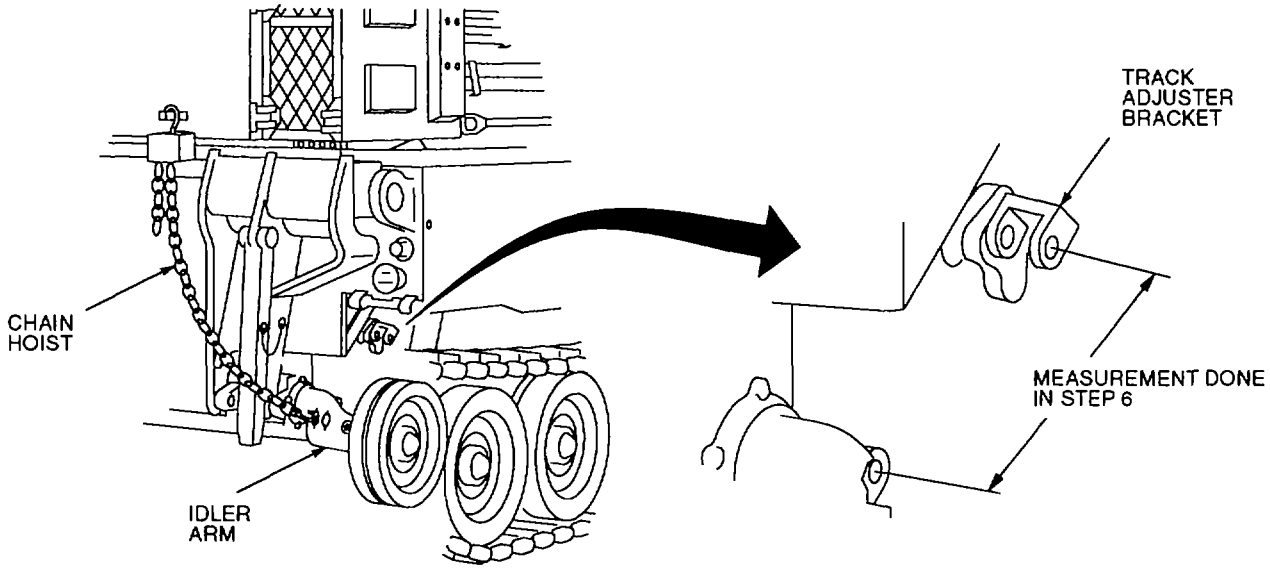
TM 9-2350-314-20-1-2

Procedural Steps:

1. Remove fender on damaged side.

2. Connect chain hoist between stowage basket hinge and bracket on idler arm.

10-11. TRACK ADJUSTER, DAMAGED - CONTINUED



3. Operate chain hoist to take up slack in track.

4. Remove broken track adjuster.

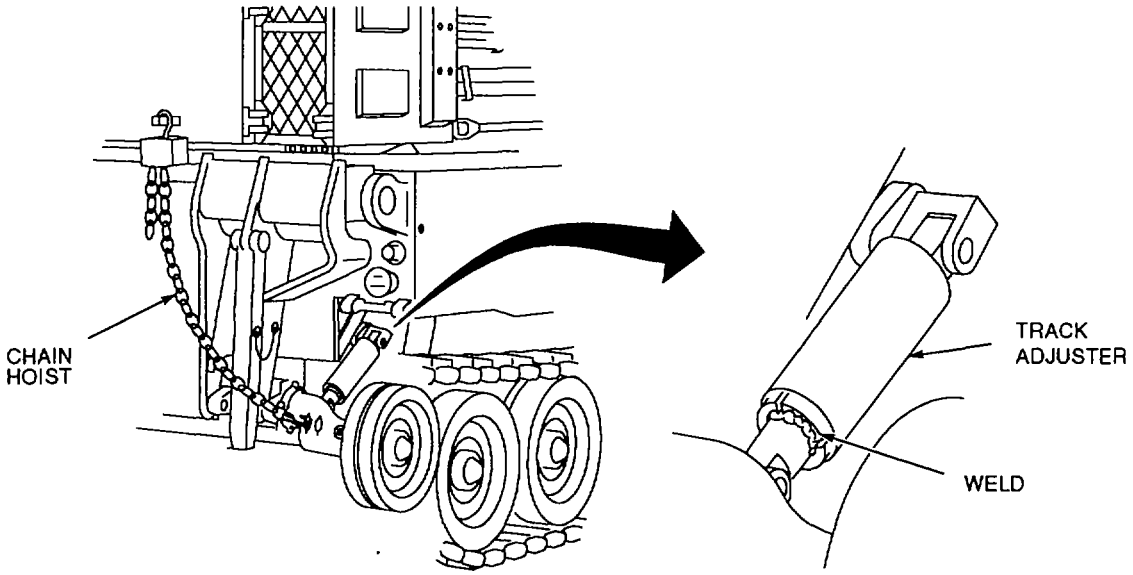
5. Operate chain hoist to put tension on track.

NOTE

Allow enough space to compensate for installation of substitute track adjuster.

6. Measure distance between track adjuster mounting bracket and idler arm mounting lugs.

7. Extend broken track adjuster to length of measurement In step 6, and weld the cylinder and piston at that point.



10-11. TRACK ADJUSTER, DAMAGED - CONTINUED

8. Reinstall track adjuster.

9. Reinstall chain hoist.

10. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Substitute track adjuster.

Limitations:
- Steering capability may be degraded.
- Reduce speed.

Personnel/Time Required:
- 2 soldiers
- 2.5 hours

Materials/Tools:
- Chain hoist
- Bar, steel, 1 1/2 to 2 inches, round stock, 36 inches long (scavenge from available source)
- Welding equipment

References:
TM 9-2350-314-201-2

Procedural Steps:
1. Remove fender on damaged side.

2. Connect chain hoist between stowage basket hinge and bracket on idler arm.

3. Operate chain hoist to take up slack in track.

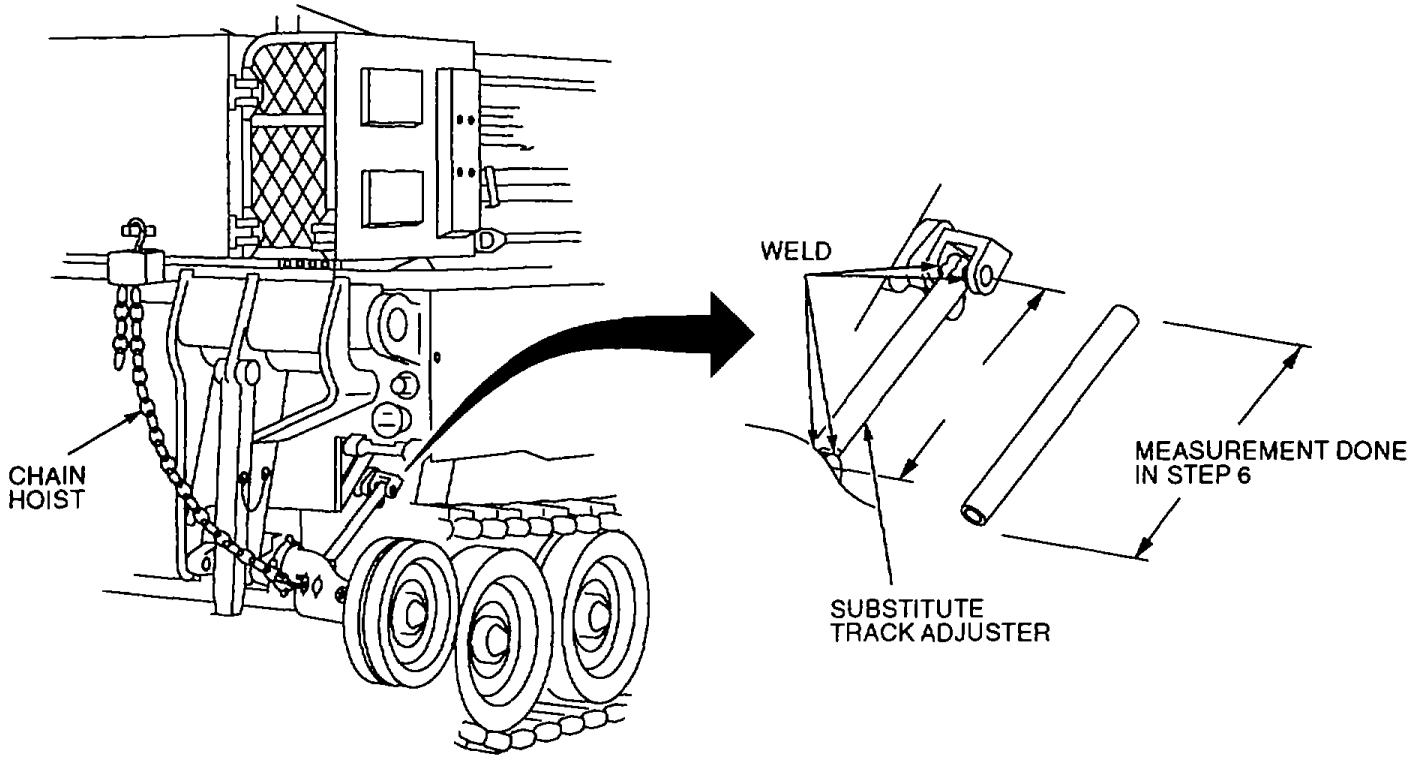
4. Remove broken track adjuster.

5. Operate chain hoist to put tension on track.

NOTE

Allow enough space to compensate for installation of substitute track adjuster.

10-11. TRACK ADJUSTER, DAMAGED - CONTINUED



6. Measure distance between track adjuster mounting bracket and idler arm mounting lugs.
7. Cut steel bar to length of measurement in step 6.
8. Weld substitute track adjuster to track adjuster mounting bracket and idler arm mounting lugs.
9. Release chain hoist.
10. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Short tracking track.

Limitations:
- Steering capability may be degraded.
- Reduce speed.
- Track will be more likely to be thrown.

Personnel/Time Required:
- 2 soldiers
- 2.5 hours

References:
TM 9-2350-314-201-2

Procedural Steps:
1. Disconnect track between idler wheels and number 7 roadwheel.

2. Remove track shoes, if necessary, to obtain limited track tension.

10-11. TRACK ADJUSTER, DAMAGED- CONTINUED

3. Remove broken track adjuster.

4. Pivot steer to pull slack out of track with sprocket and lock brakes.

5. Remove more track shoes, if necessary, and reconnect track.

NOTE

Occasionally check track for signs of slack and loss of tension. Drive slowly over rough terrain and during turns.

6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

10-12. IDLER WHEELS, DAMAGED

This procedure allows continued operation of vehicle at reduced speeds with suspension damage to the idler wheels or arm housing.

Limitations:
- Sharp turns.
- Reduce speed.

Personnel/Time Required:
- 3 soldiers
- 3.0 hours

References:
TM 9-2350-314-20-1-2

Procedural Steps:
1. Disconnect track between idler wheels and number 7 roadwheel.

2. Remove track shoes, if necessary, to obtain limited track tension.

3. Remove damaged idler wheels.

4. Pivot steer to pull slack out of track with sprocket and lock brakes.

5. Remove more track shoes, if necessary, and reconnect track.

NOTE

Occasionally check track for signs of slack and loss of tension. Drive slowly over rough terrain and during turns.

6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION V. SPROCKET WHEEL

10-13. GENERAL

Sprocket wheels transmit both driving and braking forces from transmission to tracks. Damage to sprocket wheels can greatly reduce or eliminate howitzer's mobility.

10-14. DRIVE SPROCKET BOLTS SHEARED OFF

General Information:

The final drive sprocket bolts can work loose allowing the sprocket to shift and shear part or all of the mounting bolts, resulting in the track being thrown. If new mounting bolts are not available the sprocket can be remounted by obtaining bolts from the other side of the vehicle. At least five of the ten mounting bolts must be installed. If a sufficient number of bolts are not available, the sprocket can be welded to the hub. If the full amount of mounting bolts are not used, or the sprocket is welded, pivot steer should not be used. The side stress could cause the bolts or weld to shear. The vehicle cannot operate when a drive sprocket has sustained substantial damage. Sprockets with one or several non-consecutive teeth missing can operate at reduced speeds.

Option 1:

Limitations:
If welded, reduced mobility.

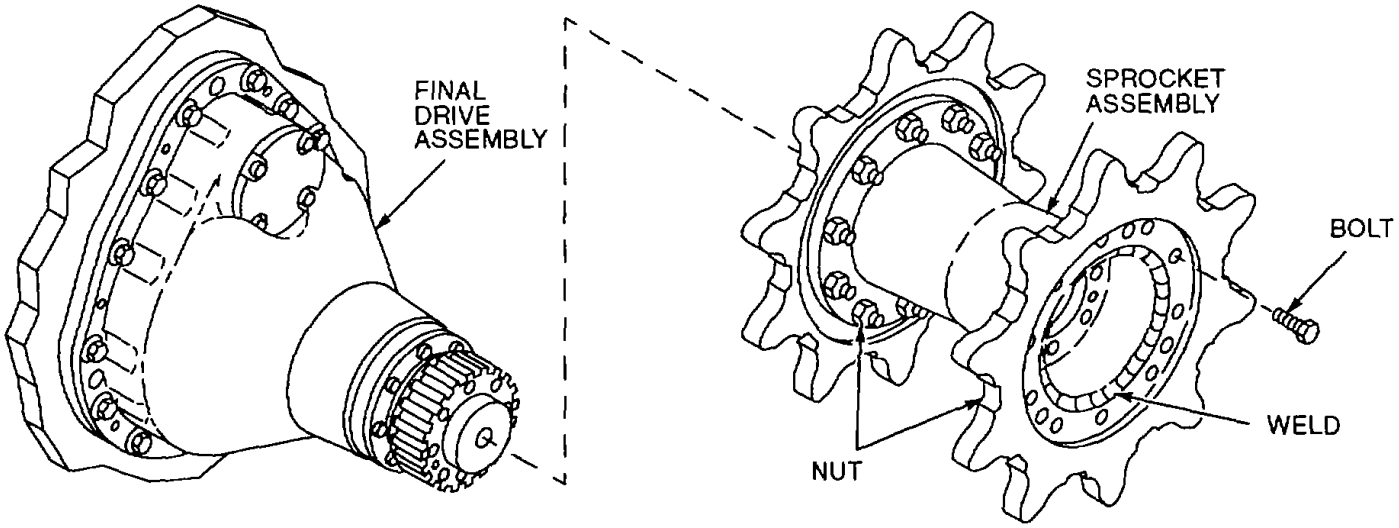
Personnel/Time Required:
- 2 soldiers
- 1.0-2.0 hours

Materials/Tools:
- Replacement sprocket bolts, nuts (scavenged from available source)
- Welding equipment
- Lift capability

References:
TM 9-2350-314-20-1-2

Procedural Steps:
1. Separate track to allow access to drive sprocket assembly.

10-14. DRIVE SPROCKET BOLTS SHEARED OFF - CONTINUED



2. Remove drive sprocket and hub assembly from final drive assembly.

3. Remove loose damaged bolts and nuts. Clear holes of inside and outside sprockets and hub of remains of sheared bolts.

NOTE

Bolts and nuts are available from transmission / battery doors or front slope plate.

4. Properly align and use replacement bolts or weld sprockets to hubs.

5. Mount repaired hub and sprocket back onto final drive assembly.

6. Reconnect track and adjust tension.

7. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2:

Limitations:
- Mobility will be reduced.
- Steering and braking capabilities on damaged side will be lost.

Personnel/Time Required:
- 3 soldiers
- 4.0 hours

References:
TM 9-2350-314-20-1-2

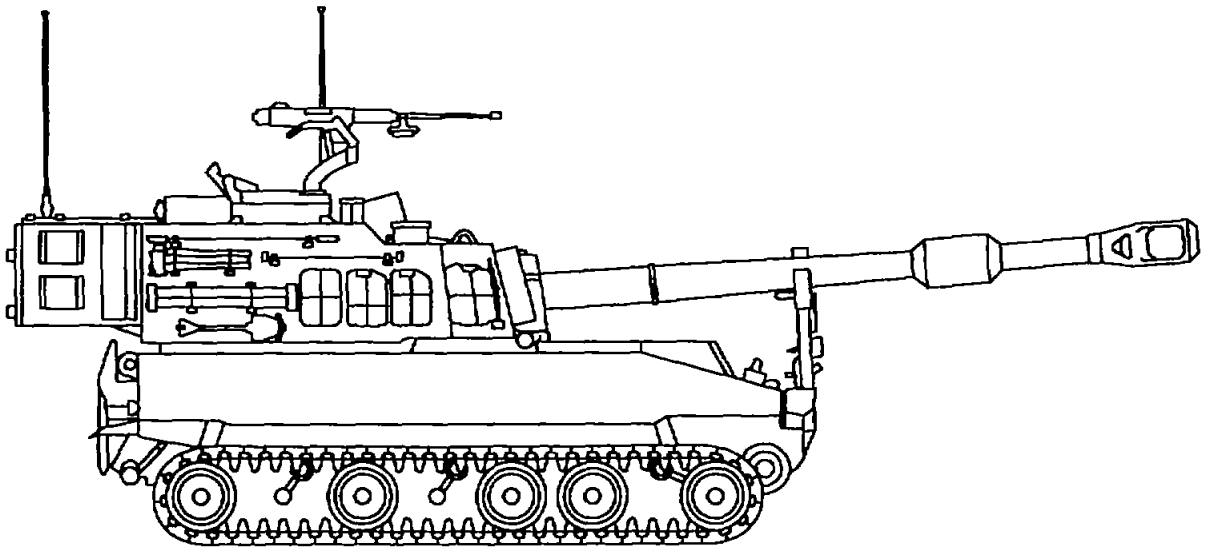
10-14. DRIVE SPROCKET BOLTS SHEARED OFF - CONTINUED

Procedural Steps:

NOTE

Track must be disconnected before damaged roadwheels and roadarms are removed.

1. Remove damaged roadwheels and roadarms that might interfere with track movement.
2. Disengage torsion bar at most forward roadarm that is to be used.
3. Move roadarm to a 45 degree forward position and lock in place by engaging torsion bar.
4. Place track around roadwheels and remove as many track shoes as necessary.
5. Connect track.



NOTE

Use ground conditions and terrain to as much advantage as possible to help steer vehicle. Keep damaged side on hardest surface, if a choice is possible, to get a longer run. Go up hills at an angle with damaged side on uphill side. When going downhill, use brakes or apply power to keep vehicle going in desired direction.

6. Drive forward until vehicle swings too far to damaged side.
7. Place an obstacle (such as a log or damaged roadwheel) behind track on damaged side.
8. Back up slowly against obstacle until vehicle is headed in desired direction.
9. Continue forward and repeat steps 8 and 9.
10. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION VI. TRACK ASSEMBLY

10-15. GENERAL

a. A track is a temporary roadbed laid for vehicle wheels to roll on, without sinking in. Center guides ensure that the wheels remain on the road. Track pins are hinge-pins which permit pick-up and transport of the road (track). Because the ground contact area of the track is much greater than the combined contact areas of all wheels, tracks distribute the vehicles weight better than wheels. The more rigid the ground contact area is, the better the weight distribution will be. Track rigidity is achieved through tension applied to the track by roadwheels, arms and torsion bars.

b. When track and suspension components are damaged the vehicle can still operate by eliminating some wheel positions. With reduced ground contact area, however, weight distribution is decreased, and each of the remaining wheel and suspension positions must support a heavier load. This will result in reduced ground clearance, loss of agility, imbalance in steering, and loss of engine power, thereby directly affecting top speed of the vehicle. To compensate, the crew must reduce vehicle speed, select smoothest terrain available and avoid sharp turns.

c. Track assembly provides howitzer with mobility over a variety of different terrain. Without an operable track assembly, the howitzer has near zero mobility.

10-16. TRACK WEDGE OR BOLT, MISSING

General Information:
This procedure allows continued operation of vehicle at reduced speeds with suspension damage.

Limitations:
Repair will be of an extremely short duration.

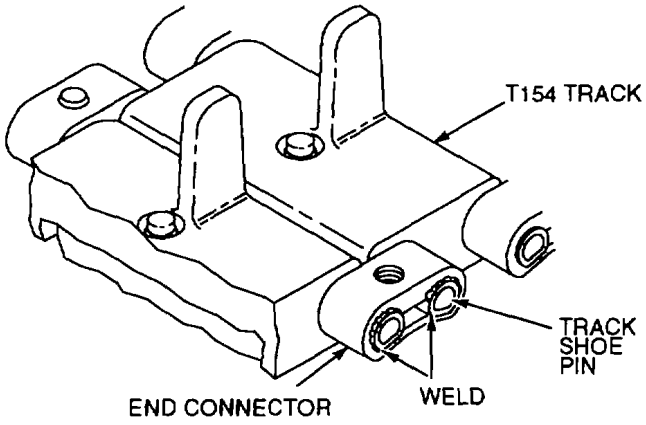
Personnel/Time Required:
- 1 soldiers
- 0.3 hour

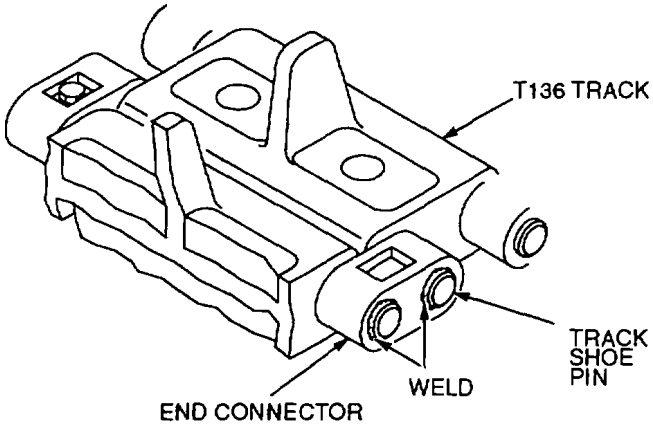
Materials/Tools:
- Rod, welding (item 51, Appendix C)
- Welding equipment

References:
TM 9-2350-314-20-1-2

10-16. TRACK WEDGE, MISSING - CONTINUED

Procedural Steps:





1. Drive end connector in place with hammer.

2. Weld end connector to track shoe pin.

3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

10-17. CENTER GUIDE(S), BROKEN

General Information:

Track center guides, as structural design elements of track blocks, are designed to keep the track on vehicle's wheels. An occasional broken-off center guide tooth will have little or no effect on the vehicle's operation as long as the base of the center guide is still present. A vehicle may still be functional if every other center guide is missing. If two consecutive center guides are missing, the likelihood of throwing a track is increased greatly. When two center guides are missing in a row, great stress is placed on the track pins, which may shear at high speeds and during sharp turns in soft, sandy soil.

This procedure allows continued operation of vehicle at reduced speeds with suspension damage.

Limitations:
Sharp turns and fast starts should be avoided.

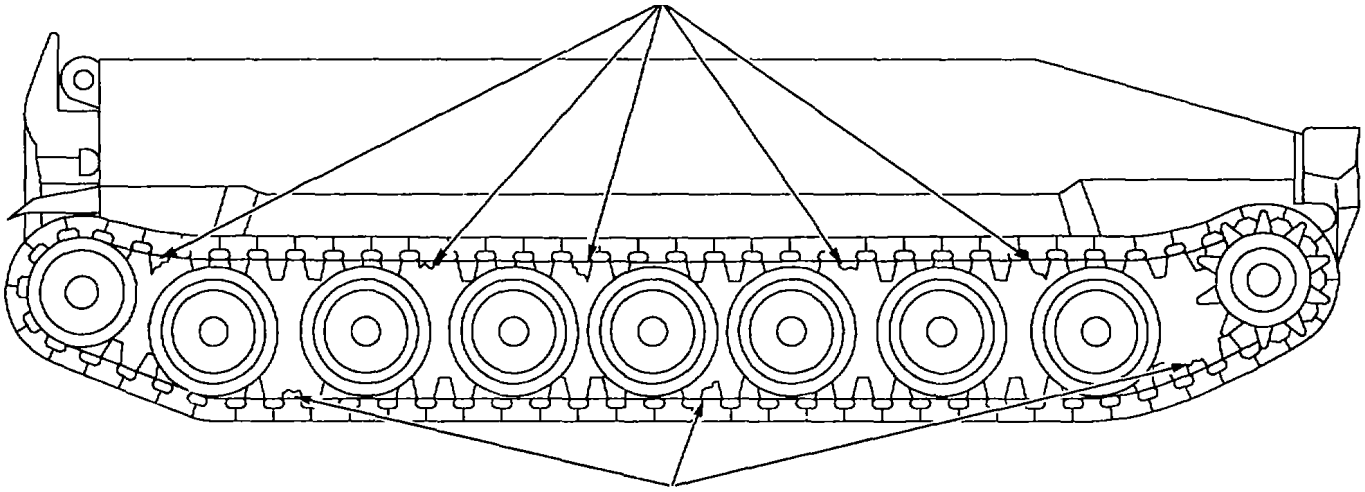
Personnel/Time Required;
- 3 soldiers
- 3.0 hours

References:
TM 9-2350-314-20-1-2

Procedural Steps:
1. Remove track shoes with broken center guides.

10-17. CENTER GUIDE(S), BROKEN - CONTINUED

2. Stagger track shoes with broken center guides so that there is at least one good center guide in every other position.



TRACK SHOES WITH BROKEN CENTER GUIDES

3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

10-18. TRACK SHOE(S), DAMAGED

General Information:

A track shoe that is distorted (dead shoe) will have little or no effect on the vehicle's operation as long as three distorted (dead shoes) track shoes are not on the same side. A vehicle may still be functional if distorted shoes (dead shoes) are relocated to the other side of the vehicle. The likelihood of throwing a track is greatly decreased. Also, the crew must reduce vehicle speed and avoid sharp turns.

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

Other Options:

Track Damage, Short Tracking para 10-19.

10-19. TRACK DAMAGE, SHORT TRACKING

General Information:

The howitzer can be short-tracked. This is accomplished by removing track blocks to shorten the track and reroute it over fewer suspension positions. When the track tensioning components are bypassed, the track cannot be adjusted. Relocate suspension components from other positions to keep as much track as possible in contact with the ground.

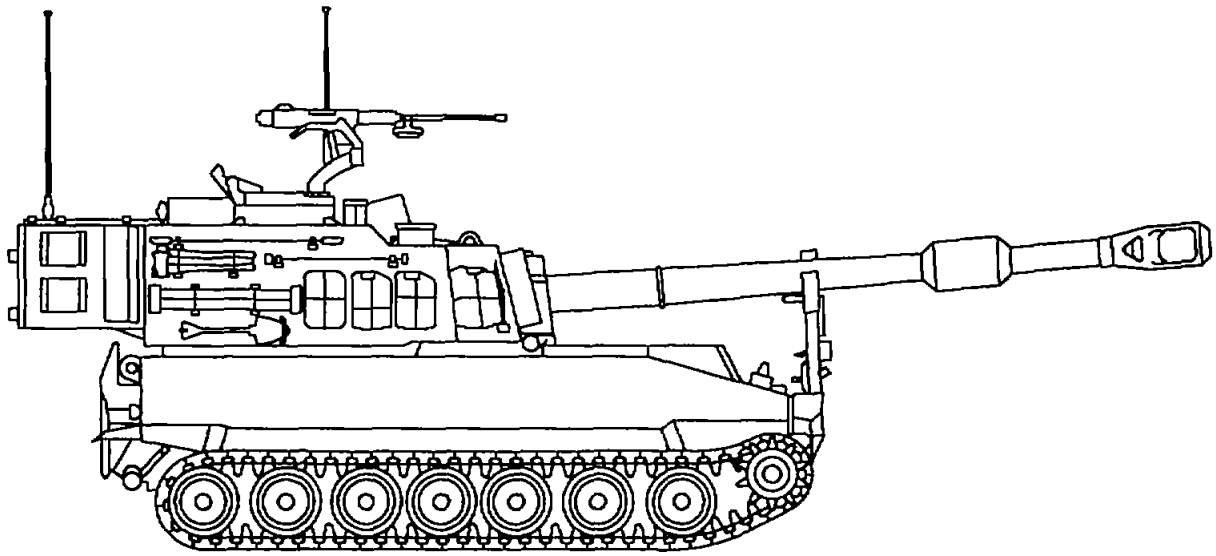
Limitations:
- Reduced speed.
- Reduced steering capabilities.

10-19. TRACK DAMAGE, SHORT TRACKING - CONTINUED

Personnel/Time Required:
- 2 soldiers
- 2.0-3.0 hours

References:
TM 9-2350-314-20-1-2

Procedural Steps:
1. Remove damaged suspension components.
2. Remove a sufficient number of track blocks so that the track may be reconnected over the remaining roadwheels and drive sprocket.



3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 11
HYDRAULIC 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

11-1. SCOPE

This chapter contains fault assessment and expedient repair procedures available to find and fix battlefield damage to the hydraulic system.

11-2. ASSESSMENT PROCEDURE

Table 11-1. Hydraulic System Visual Assessment

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

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Preformed packing	para 11-7
Hydraulic tube and hose repair (low pressure)	para 11-10
Hydraulic tube and hose repair (high pressure)	para 11-11
Hydraulic fuze manifold	para 11-15

Determine if:

- No damage found → Visual inspection is complete. Return to Table 2-1 to continue visual assessment.
- Damage can be repaired - Note repair requirements → Visual inspection is complete. Return to Table 2-1 to continue visual assessment.
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

11-2. ASSESSMENT PROCEDURE - CONTINUED

Table 11-2. Hydraulic System Operation Assessment

ATTEMPT OPERATION → **INOPERATIVE:**

Mode selector valve	para 11-15
Hydraulic fuze manifold	para 11-15
Manual elevation hand pump	para 11-15
Equilibration hand pump	para 11-15

Determine if:

- No problem found → Operation observation is complete. Return to Table 2-2 to continue operation assessment.
- Damage can be repaired - Note repair requirements → Operation observation is complete. Return to Table 2-2 to continue operation assessment.
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

11-3. REPAIR PROCEDURE INDEX

SECTION II. PROCEDURAL INFORMATION

11-4. GENERAL

BDAR for a hydraulic system is generally confined to component replacement, expedient line repairs, or bypassing damaged lines. If a hydraulic circuit cannot be repaired, it may be necessary to isolate it (cutting 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.

11-4. GENERAL - CONTINUED

WARNING

- **Hydraulic system pressure is 1925 ± 50 psi. Do not torque hydraulic fittings or perform removal procedures when hydraulic system is pressurized. Discharging system pressure before performing any maintenance procedures will avoid serious injury to personnel.**
- **Eye protection will be worn when performing maintenance procedures on all hydraulic components to avoid injury to personnel.**

CAUTION

- **All hydraulic lines and ports must be capped to prevent contaminants from entering the hydraulic system and causing internal damage to hydraulic components.**
- **All serviceable components must be placed in plastic bags to prevent contamination of hydraulic system during installation.**

NOTE

- **All hydraulic lines and components must be tagged before removal for identification during installation.**
- **System specific TMs must be checked before any isolation is performed.**

SECTION III. FLUIDS AND SEALS

11-5. GENERAL

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

11-6. HYDRAULIC FLUID SUBSTITUTIONS

General Information:

If the original intended fluid is lost and standard replacement is not available, a substitute fluid must be used. Refer to Appendix D for a compatible fluid. If a compatible fluid is not available, any liquid can be utilized.

11-7. PREFORMED PACKING LEAKAGE

General Information:

Damaged preformed packings may be repaired or replaced using sealing compound or other substitute material such as rubber.

Limitations:
May hold for short duration only.

Personnel/Time Required:
- 1 soldier
- 1.5-2.0 hours

Materials/Tools:
- Rubber (scavenge from available source)
- Sealing compound (item 52, Appendix C)

References:
TM 9-2350-314-20-2-2

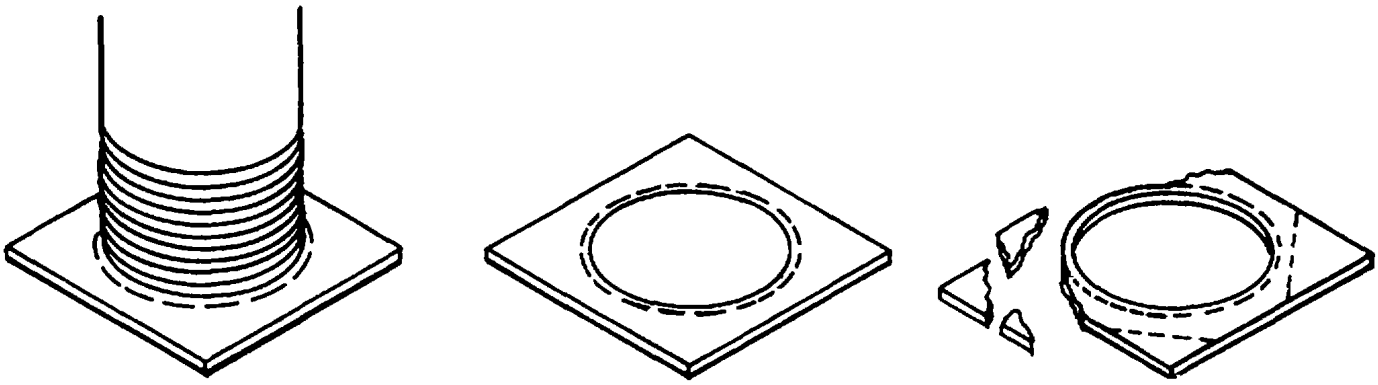
Other Options:
Reference Chapter 3.

Procedural Steps:
1. Cut a section of rubber using the removed packing as a template.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash Immediately with soap and water.

2. Apply sealing compound to the piece of rubber and allow to dry for 30 minutes. Reconnect lines, allow an additional 30 minutes drying before starting system.



3. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. HYDRAULIC LINE REPAIRS

11-8. GENERAL

To operate some of the vehicle mechanisms a considerable amount of energy must be exerted. Hydraulic power is used to perform these high energy tasks. High energy requirements (or high speed tasks) are usually met with high-pressure hydraulic hose or metal tubing. There are also metal low-pressure lines used when heat is a consideration or shape is critical. This section provides expedient repair procedures for the repair of high and low pressure tubes and hoses.

11-9. METAL TUBE BENDING

General Information:

Bending may be required to make tubing repairs. Dry sand can be poured into the tube to be bent If, tube bender is not available. The ends must be plugged to keep the sand from falling out. Soft metal tubes can be sealed with finger pressure but harder lines should have a plug inserted. After bending the tube, flush the sand from the tubing with a liquid to ensure removal of all the particles.

11-10. HYDRAULIC TUBE AND HOSE REPAIR (LOW PRESSURE)

General Information:

The M109A6 hydraulic system uses o-ring seal (ORS) hose and tube fittings, all fabricated or replacement hydraulic lines must use ORS fittings as end connectors. The repair procedures in this paragraph are for the repair or damage to the center section of low pressure hydraulic hoses or tubes. For the fabrication of lines or the replacement of end connectors reference paragraph 11-11 high pressure hose and tube repair.

Option 1: Low-pressure line repair (same size tube ends).

Limitations:
Not recommended for pressure over 70 psi.

Personnel/Time Required:
- 1 soldier
- 0.5-1.2 hours

Materials/Tools:
- AN/MS fittings (found in M2/3 generic BDR kit, Section III, Appendix C)
- Hacksaw (found in M2/3 generic BDR kit, Section III, Appendix C)
- Hand file (found In M2/3 generic BDR kit, Section III, Appendix C)
- Deburring tool (found in M2/3 generic BDR kit, Section III, Appendix C)
- Bending tool
- Wire (scavenge from available source)
- String (scavenge from available source)
- Sealing compound (item 55, Appendix C)
- Hose clamps (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tube cutter
- Hose medium/high pressure (scavenge from available source)

11-10. HYDRAULIC TUBE AND HOSE REPAIR (LOW-PRESSURE) - CONTINUED

References:
TM 9-2350-314-20-2-2

Other Options:
- Reference Chapter 3 Hose and tube repairs.
- Reference tube repair instruction in M2/3 generic BDR kit.

Procedural Steps:
1. Cut out the damaged portion of the tubing.
2. Square, deburr and clean the ends.
3. Bead the tubing 1/2-inch from the ends.

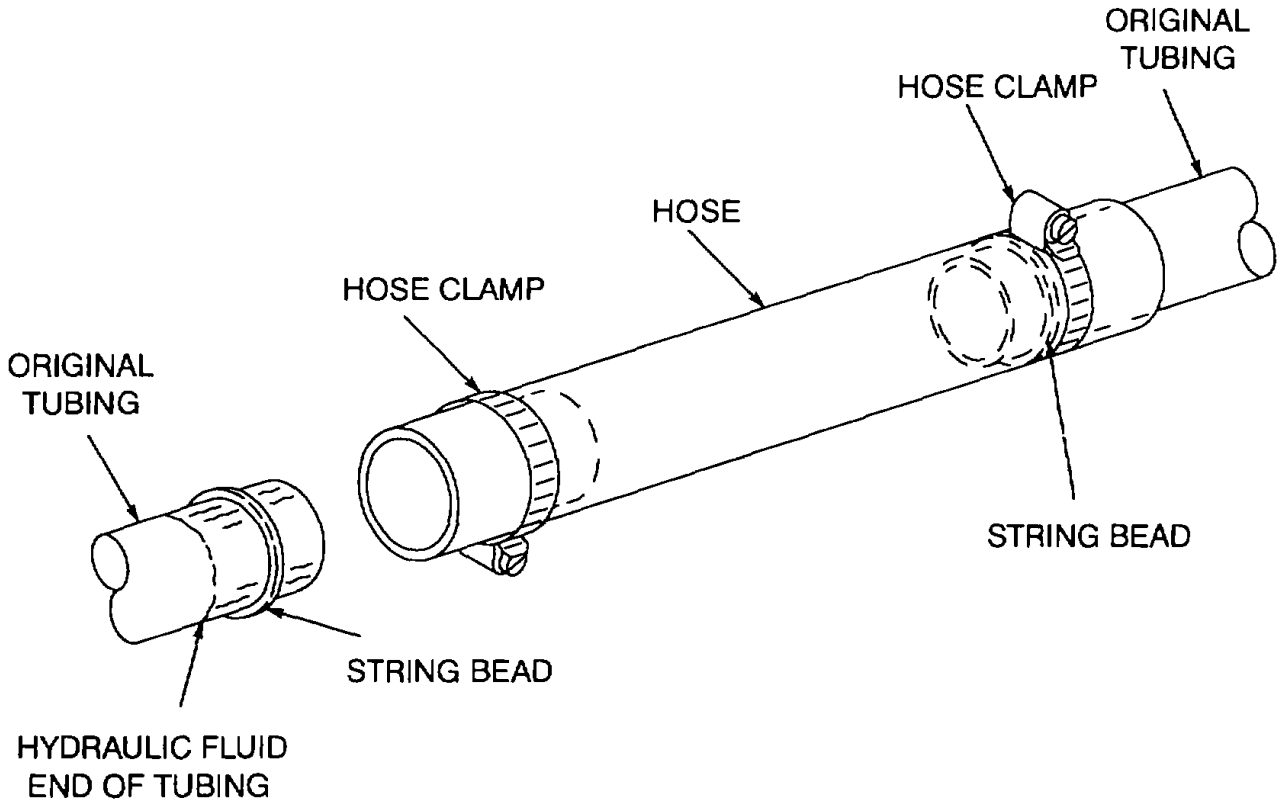
NOTE

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

4. Select a length of medium or high-pressure hose with an inside diameter equal to the outside diameter of the tube. Cut the length 6 inches longer than the removed piece of tubing.

5. Slide the hose ends over the ends of the tubing. Use system fluid to aid In sliding the hose over the tubing, particularly the bead.

6. Secure the hose on each end with a hose clamp on each end.



7. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

11-10. HYDRAULIC TUBE AND HOSE REPAIR (LOW-PRESSURE) - CONTINUED

Option 2: Low pressure hose repair (center section).

Limitations:
Not recommended for pressure over 70 psi

Personnel/Time Required:
- 1 soldier
- 0.5-1.0 hour

Materials/Tools:
- Tubing (scavenge from available source)
- Sealing compound (item 55, Appendix C)
- Hose clamp (found In M2/3 generic BDR kit, Section III, Appendix C)
- Hacksaw (found In M2/3 generic BDR kit, Section III, Appendix C)

References:
TM 9-2350-314-20-2-2

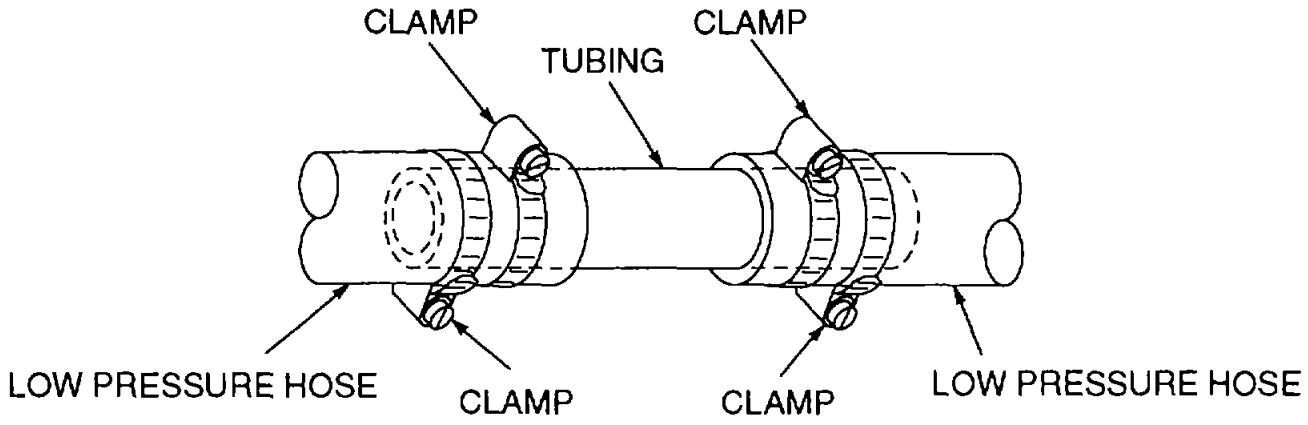
Procedural Steps:

1. Cut out damaged section of hose.
2. Select a piece of tubing with the outside diamater equal to the inside diameter of the damage hose, and cut a piece two inches longer than the piece of damaged hose.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Apply sealing compound to both ends of the tube.
4. Slide the tubing into both ends of the tube.
5. Secure the hose to the tube with two hose clamps on each end positioned 180 degrees to each other.



6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

11-10. HYDRAULIC TUBE AND HOSE REPAIR (LOW-PRESSURE) - CONTINUED

Option 3: Repair of long damaged tube section (center section).

Limitations:
None

Personnel/Time Required:
- 1 soldier
- 0.5-1.5 hour

Materials/Tools:
- Tube cutter
- Oil or hydraulic fluid (scavenge from available source)
- Hand file (found in M2/3 generic BDR kit, Section III, Appendix C)
- Metal tubing (scavenge from available source)
- Tube fittings (found in M2/3 generic BDR kit, Section III, Appendix C)

Other Options:

Use a piece of metal tubing the length of the damaged section, 2 pieces of hose and 8 hose clamps. Two on each end of hoses placed 180 degrees to each other.

Procedural Steps:
1. Refer to instructions for tube repair In the M2/3 generic BDR kit.

2. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4: Low pressure line repair (same size hose ends) (center section).

Limitations:
None

Personnel/Time Required:
- 1 soldier
- 0.5- 1.0 hour

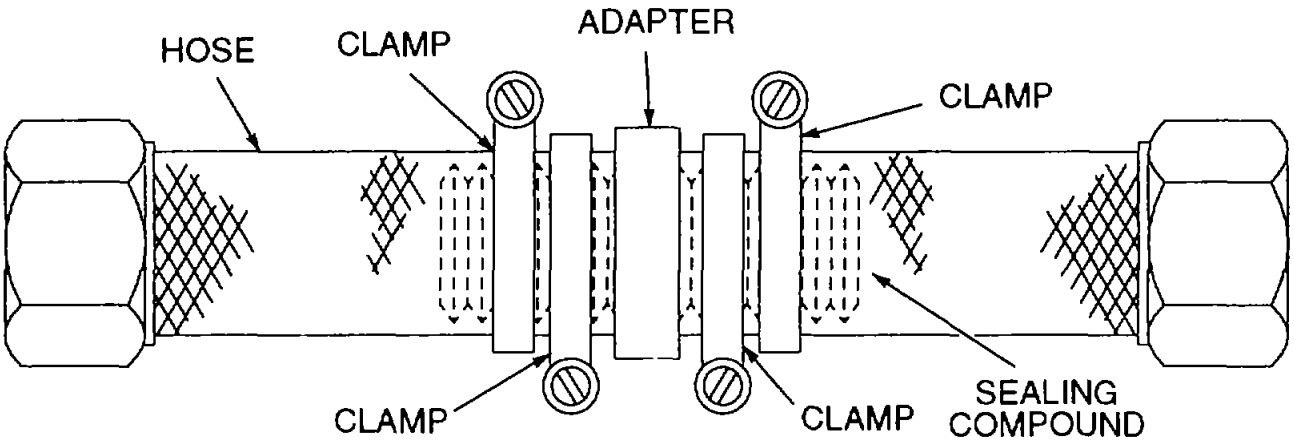
Materials/Tools:
- Tube pipe fitting kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Clamps (found in M2/3 generic BDR kit, Section III, Appendix C)
- Sealing compound (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tape (found In M2/3 generic BDR kit, Section III, Appendix C)

References:
TM 9-2350-314-20-2-2

11-10. HYDRAULIC TUBE AND HOSE REPAIR (LOW-PRESSURE) - CONTINUED

Other Options:
- Reference Instructions in M2/3 generic BDR kit.
- Reference Chapter 3.

Procedural Steps:



1. Wrap each end of hose to be cut with tape. Squarely cut each end of damaged hose. Clean loose particles from ends of hose.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash Immediately with soap and water.

2. Spread a light coat of sealing compound on threads of adapter or tube.

3. Install adapter or tube into each end of hose.

4. Secure the hose on each end of adapter with two hose clamps. Position clamp screws 180 degrees to each other.

5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5: Low pressure line repair (different size line ends) (center section).

Limitations:
None

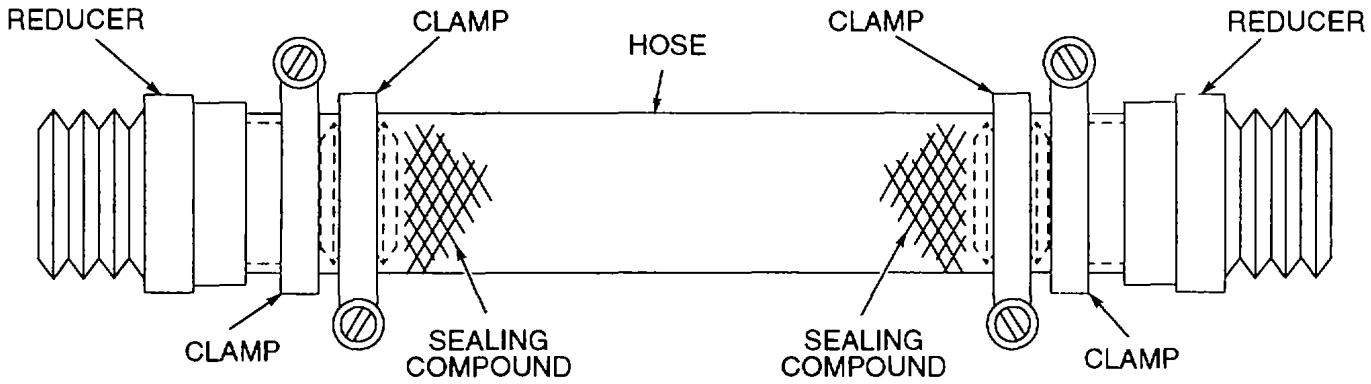
Personnel/Time Required:
- 1 soldier
- 0.5-1.0 hour

11-10. HYDRAULIC TUBE AND HOSE REPAIR (LOW-PRESSURE) - CONTINUED

Materials/Tools:
- Clamps (found in M2/3 generic BDR kit, Section III, Appendix C)
- Sealing compound (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tape (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tube pipe fitting kit (found in M2/3 generic BDR kit, Section III, Appendix C)

References:
TM 9-2350-314-20-2-2

Procedural Steps:



1. Wrap each end of hose to be cut with tape. Cut section of hose to length required. Be sure each end is cut squarely.
2. Spread a light coat of sealing compound on threads of one end of reducer.
3. Install end of reducer with sealing compound into hose. Secure with two clamps. Position clamp screws 180 degrees to each other.
4. Repeat steps 2 and 3 for other end of hose.
5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE)

General Information:

The following options are offered for the repair/fabrication of high pressure hydraulic hoses and tubes using reuseable ORS fittings.

Option 1: High pressure hose fabrication.

Limitations:
None

Personnel/Time Required:
- 1 soldier
- 0.5 - 2.0 hours

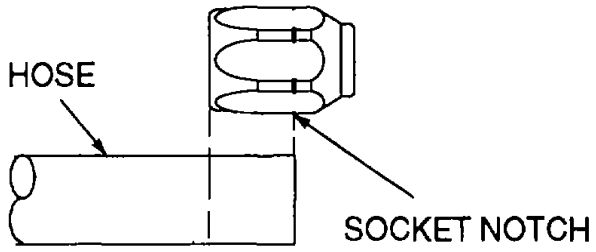
11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE) - CONTINUED

Materials/Tools:

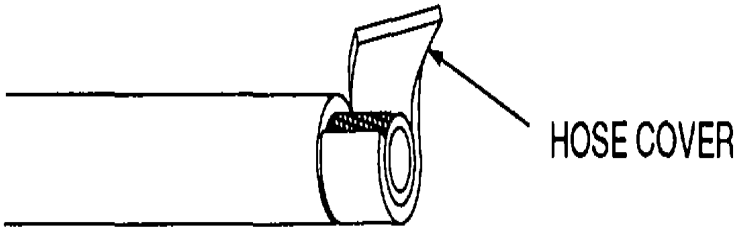
- Fitting, hose, elbow, 45 degree, 1/4, 3/8, 1/2, 3/4-inch determined by size (item 13, 14, 15, 16, Appendix C)
- Fitting, hose, elbow, 90 degree, 1/4, 3/8, 5/8, 3/4-inch determined by size (item 17, 18, 19, 20, Appendix C)
- Fitting, hose, straight, 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 21, 22, 23, 24, 25, Appendix C)
- Fitting, hose, socket, 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 26, 27, 28, 29, 30, Appendix C)
- Packing, preformed, kit (item 45, Appendix C)
- Heavy lubrication oil (scavenge from available source)
- High pressure hose (scavenge from available source)
- Hydraulic fluid (item 36, Appendix C)
- Hacksaw or knife (found in M2/3 generic BDR kit, Section III, Appendix C)

References:
TM 9-2350-314-20-2-2

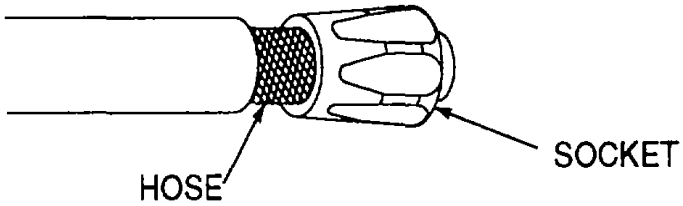
Procedural Steps:
1. Determine ORS fitting required.
2. Using unserviceable hose as template for size and length and cut new hose as required.
3. Clean out inside bore of hose.
4. Place hose end of fitting socket next to end of hose and measure from end of hose to notch on socket and mark hose.



5. Cut hose cover down to the wire reinforcement from measurement done in step 4 to end of hose.

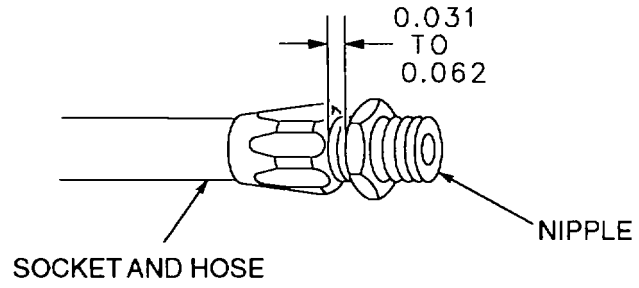


6. Insert hose into socket using a back and forth rocking and clock-wise motion until hose bottoms out in socket, or alternate method is to screw socket onto the hose in a counterclockwise motion until it bottoms out.



11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE)- CONTINUED

7. Lubricate nipple threads and inside of hose liberally using a heavy lubricating oil.
8. Screw nipple clockwise into socket and hose. Leave 1/32 to 1/16-inch clearance between nipple and socket.



9. Clean and inspect assemblies before installation.
10 Install fabricated hose.
11. Fill and bleed hydraulic system.
12. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Fabricate high pressure metal tubing using ORS fittings (wedge type).

Limitations:
None

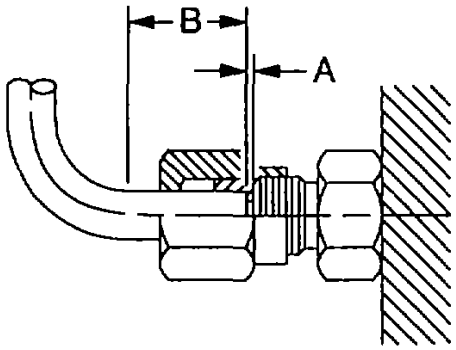
Personnel/Time Required:
- 1 soldier
- 0.5-2.0 hours

Materials/Tools:
- Nipple, tube, straight, 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 40, 41, 42, 43, 44, Appendix C)
- Packing, preformed, kit (item 45, Appendix C)
- Tube, fitting kit 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 69, 70, 71, 72, 73, Appendix C)
- Hydraulic fluid (item 36, Appendix C)
- High pressure metal tubing (scavenge from available source)
- Tube cutter

References:
- LO 9-2350-314-12
- TM 9-2350-314-20-2-2

Procedural Steps:
1. Measure the length of the tube assembly from the flat face of the ORS adapter in one port to the face of the ORS adapter in the opposite port. The length of the tube should then be adjusted to account for the shoulder thickness of the sleeve. It is imperative that the routing leave a length of unbent tubing to fully enter the ORS fitting. This straight length must be free from surface defects, thin-out distortion, and ovality. Refer to para 11-9 metal tube bending.

11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE) - CONTINUED



Size	Tube OD (inches)	Sleeve Shoulder Thickness "A" (inches)	Straight Tubing Required "B" (inches)
-04	.25 (1/4)	.07	.78
-06	.38 (3/8)	.08	.88
-08	.50 (1/2)	.09	1.00
-10	.63 (5/8)	.09	1.06
-12	.75 (3/4)	.09	1.19
-16	1.00 (1)	.09	1.25
-20	1.25 (1 1/4)	.09	1.31
-24	1.50 (1 1/2)	.09	1.38

2. Inspect the tubing to ensure that the surface is free of defects (i e, scatches, burrs, dents).

3. Cut the measured tube squarely.

4. Deburr the tube ends and remove contaminants from interior and exterior of tube.

5. Inspect ORS adapter and components for damage. Assure sealing surfaces are free from gouges, scratches, dirt and contaminants.

6. Inspect preformed packing to ensure it is properly seated in the groove and free of damage. Apply a thin coat of hydraulic fluid to preformed packing before installation.

NOTE

The ORS tube fitting sleeve cannot be reused once it has been tightened in any way it must be replaced.

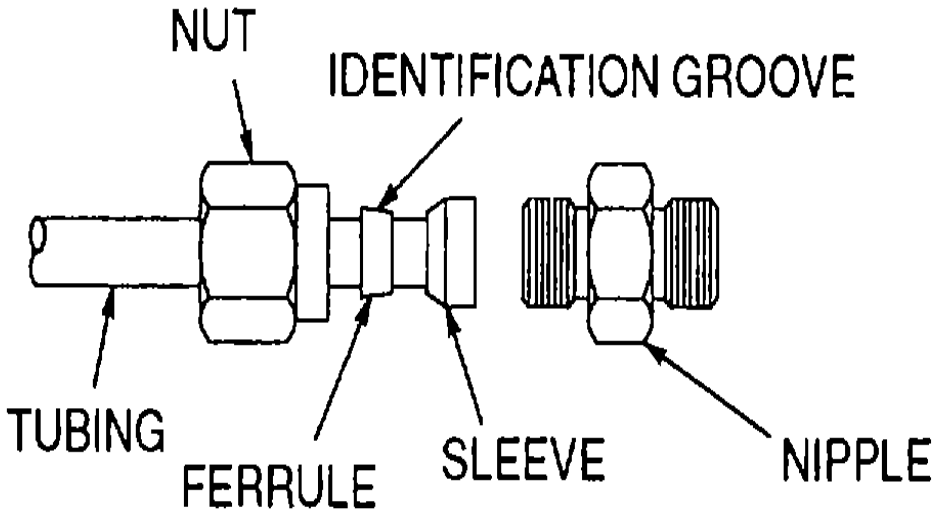
7. Place a nut, ferrule and sleeve onto tubing. Assure that the identification groove of the ferrule is facing toward the nut.

11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE) - CONTINUED

WARNING

Tubing must be fully inserted into fitting and the nut tightened as specified in this procedure to prevent leakage and injury to personnel from high pressure hydraulic fluid In the event of fitting blow-off. Excessive tightening on the nut beyond the recommended level may affect performance.

8. Install the nut onto the nipple hand tight. Ensure tube is fully inserted into the fitting (bottom out) Mark the nut in relation to the adapter. Tighten nut 1-1/2 turns.



NOTE

- **The ORS tube fitting assemblies are designed for reuse and can be reinstalled by tightening nut until a sharp increase in resistance is felt (approximately 1/4 turn beyond hand tight)**
- **If connections must be temporarily disassembled, use a threaded plug to contain the ORS tube fitting components and keep contaminants from entering the system**

9. Fill and bleed hydraulic system.

10. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: High pressure tubing repair small damage (1/4-inch or less).

Limitations:
None

Personnel/Time Required:
- 1 soldier
- 0.5 - 2.0 hours

11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE) - CONTINUED

Materials/Tools:
- Nipple, tube, straight, 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (Item 40, 41, 42, 43, 44, Appendix C)
- Packing, preformed, kit (Item 45, Appendix C)
- Tube, fitting kit 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (Item 69, 70, 71, 72, 73, Appendix C)
- Hydraulic fluid (Item 36, Appendix C)
- Tube cutter

References:
- LO 9-2350-314-12
- TM 9-2350-314-20-2-2

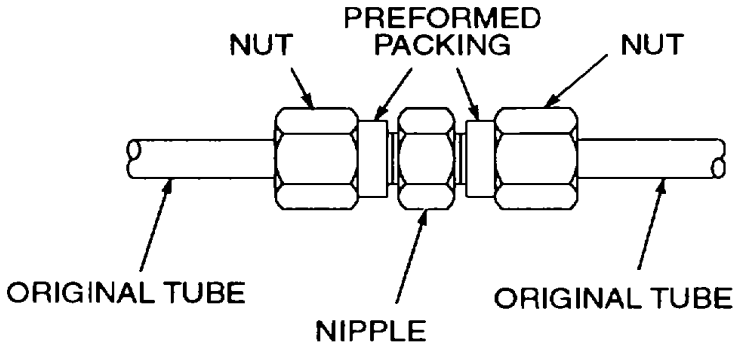
Procedural Steps:

1. Cut out damaged section of tube. Do not exceed 1/2-inch.

2. Determine size of tube Select nipple and tube fitting kit required for repair.

3. Pre-set fitting kits to nipple using instruction in Option 2.

4. Disconnect fitting kits from nipple.



5. Install two preformed packings, one in the face grove on each end of the nipple.

6. Reconnect fitting kits to nipple until a sharp increase in resistance is felt (approximately 1/4 turn beyond hand tight).

7. Fill and bleed hydraulic system.

8. Record the BDAR action taken When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4: High pressure tubing repair large damage (above 1/4-inch).

Limitations:
None

11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE) - CONTINUED

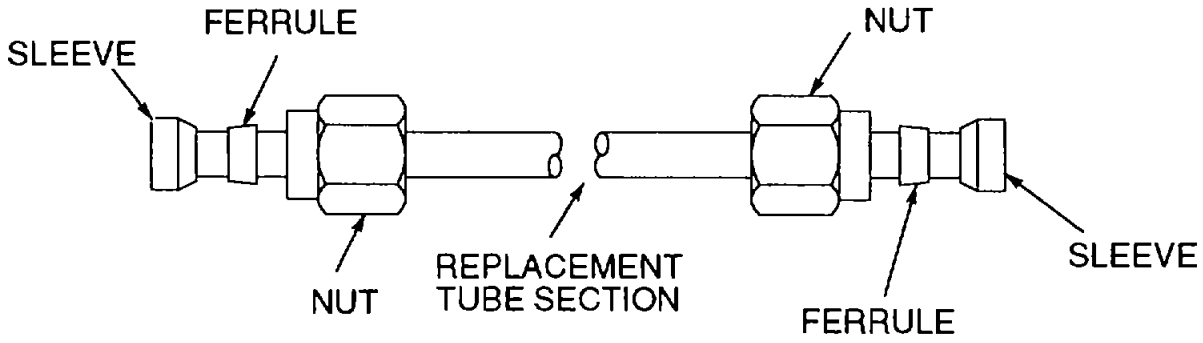
Personnel/Time Required:
- 1 soldier
- 0.5-2.0hours

Materials/Tools:
- Nipple, tube, straight, 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 40, 41, 42, 43, 44, Appendix C)
- Packing, preformed, kit (item 42, Appendix C)
- Tube, fitting kit 1/4, 3/8, 1/2, 5/8, 3/4-inch determined by size (item 69, 70, 71, 72, 73, Appendix C)
- Hydraulic fluid (item 36, Appendix C)
- High pressure tubing (scavenge from available source)
- Tube cutter

References:
- LO 9-2350-314-12
- TM 9-2350-314-20-2-2

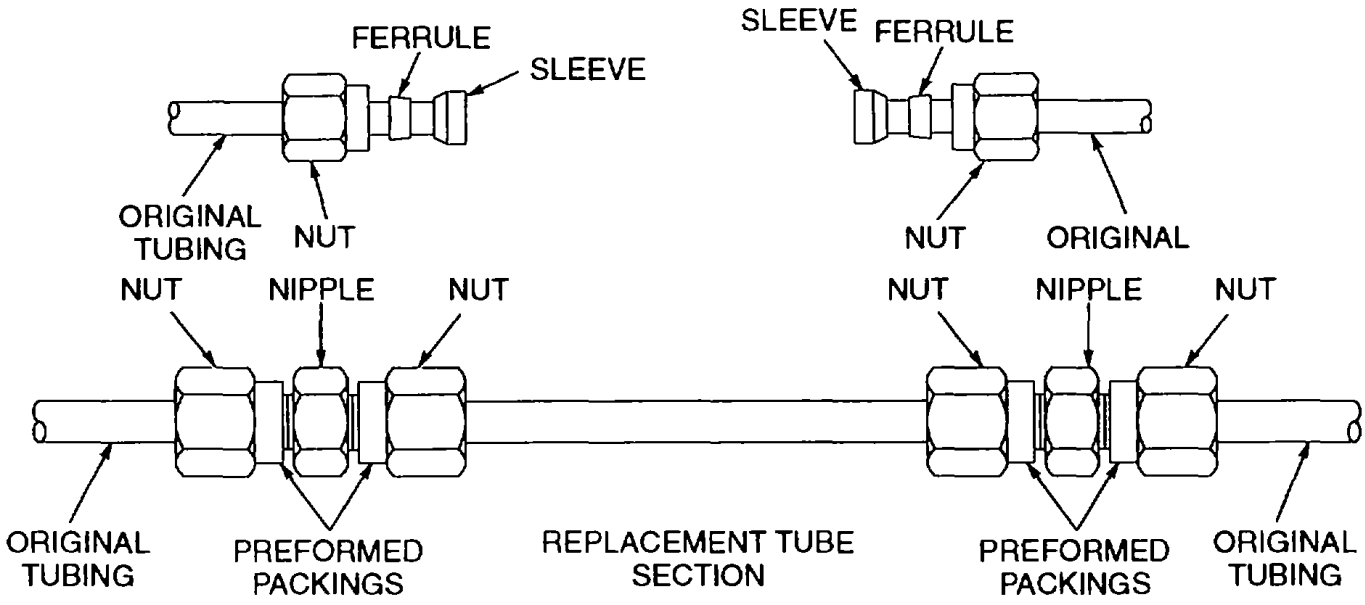
Procedural Steps:

1. Cut out damaged section of tube.
2. Determine size of tube Select two nipples and four tube fitting kits required.
3. Measure length of replacement section of tube, see Option 2 (high pressure tube fabrication) for measuring and cutting instructions.
4. Install nut ferrule and sleeve from fitting kit one each end or measured piece tube.



5. Install one nut, ferrule and sleeve on each end of original high pressure tube.
6. Install two preformed packings, one In the face groove on each end of the nipple.
7. Install one nipple straight tube in each nut on original high pressure tube.
8. Install replacement tube section onto original high pressure tube.

11-11. HYDRAULIC TUBE AND HOSE REPAIR (HIGH PRESSURE) - CONTINUED



9. Refill hydraulic fluid to proper level and check for leaks.

10. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

11-12. HYDRAULIC HIGH-PRESSURE TUBING REPAIR (PERMASWAGING)

General Information:

Permaswaging fittings may be used to repair damaged tubing. These repairs require cutting and replacing the damaged tube section. Permaswaging fitting and replacement tubing are rated up to 3000 psi operating pressure.

Limitations:
None

Personnel/Time Required:
- 1 soldier
- 0.5-1.5 hour

Materials/Tools:
- Tube cutter
- Hydraulic fluid (item 36, Appendix C)
- Hand file (found in M2/3 generic BDR kit, Section III, Appendix C)
- Metal tubing (scavenge from available source)
- AN fittings (found in M2/3 generic BDR kit, Section III, Appendix C)
- MS fittings (found in M2/3 generic BDR kit, Section III, Appendix C)

11-12. HYDRAULIC HIGH-PRESSURE TUBING REPAIR (PERMASWAGING) - CONTINUED

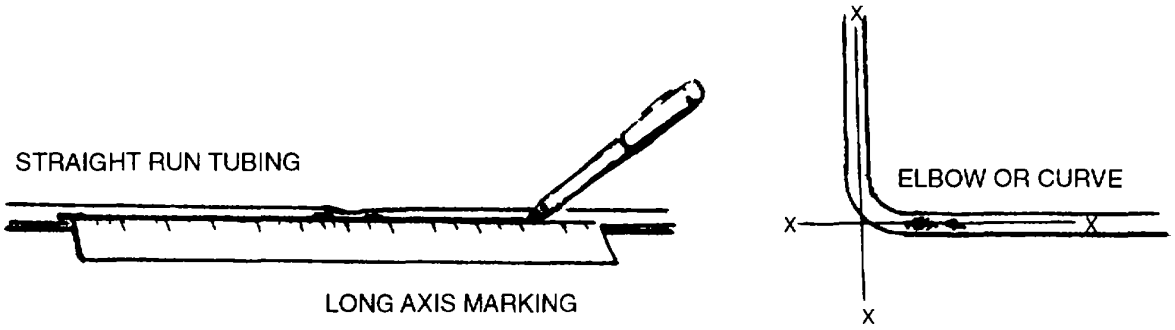
References:
TM 9-2350-314-20-2-2

Procedural Steps:

NOTE

Effective, leak-proof permaswaging depends on tube ends being square, deburred and very clean, and precise marking of tubing to avoid twisting of line (stress) and centering inside fitting(s).

1. Long Axis marking. Using a marking 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, as shown.



2. Determine the repair method required.

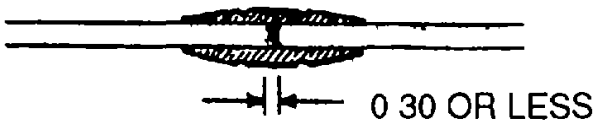
   A. Pinhole or circumferential crack not exceeding 0.30 inch, perform step 3 and steps 7 thru 13.

   B. Pinhole, circumferential or longitudinal crack exceeding 0 30 inch, perform step 4 and steps 7 thru 13.

   C. Repair of leaking tee or elbow (permanent tube connection type), perform step 5 and steps 7 thru 13.

   D. Repair leaking end fitting, perform step 6 and steps 7 thru 13.

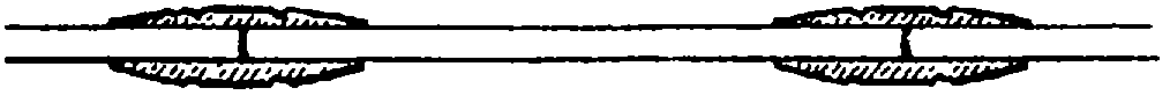
3. Make one or two cuts as necessary to enable removal of damaged section. If two cuts are required, the distance between them shall not exceed 0.30 inch.



PIN HOLE AND CIRCUMFERENTIAL CRACKS NOT EXCEEDING 0.30 INCH

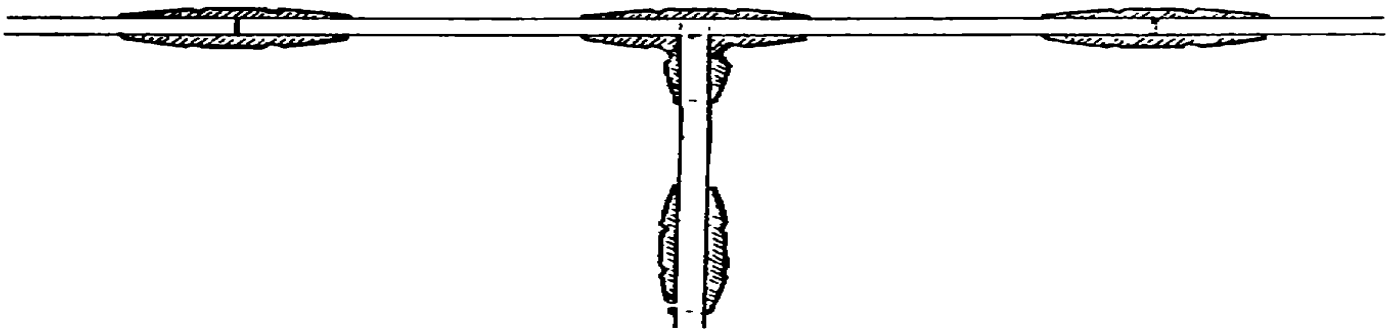
11-12. HYDRAULIC HIGH-PRESSURE TUBING REPAIR (PERMASWAGING) - CONTINUED

4. Make two cuts and remove the damaged section. Prepare a replacement tubing section. Use two tube-to-tube unions when this step is used.



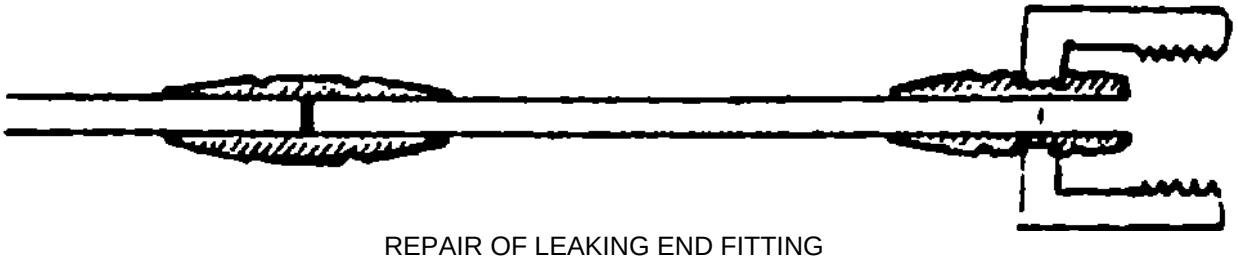
REPAIR OF LONGITUDINAL CRACK IN TUBING
(CRACK LENGTH EXCEEDING .030 INCH)

5. Cut out defective tee or elbow and duplicate tubing sections for each branch. Use three tube-to-tube unions and one tee when this step is used.



REPAIR OF LEAKING TEE OR ELBOW
(PERMANENT TUBE CONNECTION TYPE)

6. Cut tubing to remove damaged tube end and end fitting. Connect a new end fitting to the mating equipment connection. Cut replacement section to fit between cut tube end and end fitting Install splice section in new end fitting first and tighten nut as required.

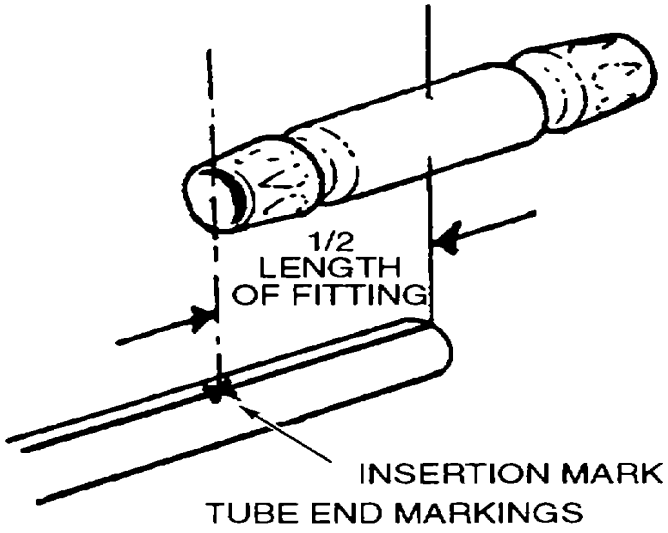


REPAIR OF LEAKING END FITTING

7. Ends of tubing to permaswaged must be centered inside the permaswage fitting Use steps a. and b.

   a. Mark half of the overall length of the permaswage fitting on the tubing end as shown.
   b. Repeat marking procedure on the other tubing end to be swaged.

11-12. HYDRAULIC HIGH-PRESSURE TUBING REPAIR (PERMASWAGING) - CONTINUED

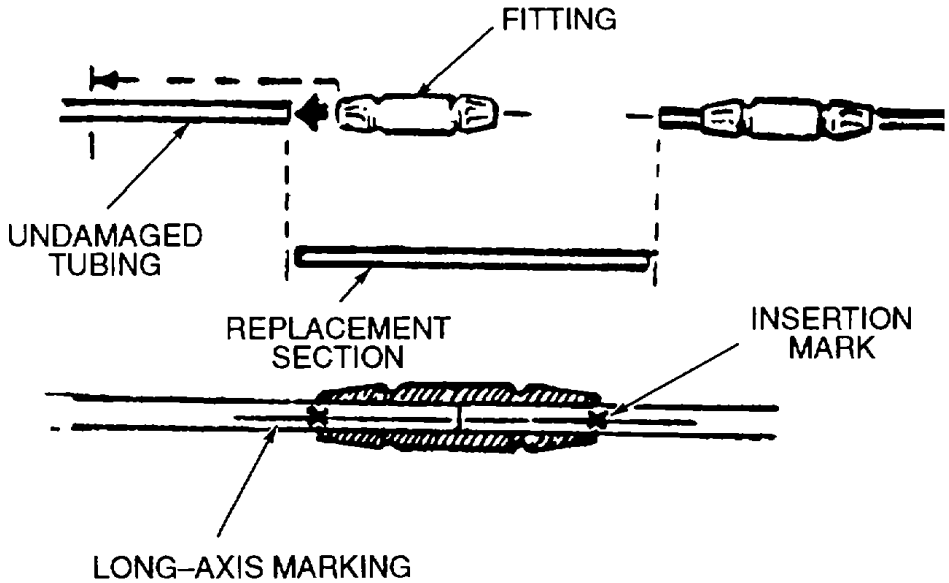


8. Slide permaswage fitting(s) all the way on the undamaged tube ends.
9. Position replacement section between cut ends of undamaged tubing and slide permaswage fittings over gaps between tube ends.
10. Make sure insertion marks are visible on either side of the fitting. Also, rotate fitting and replacement section until long-axis marking align with marking on the undamaged tube end.

NOTE

For replacements requiring an end fitting, swage end fitting to replacement section first, as described in step 11. Then secure nut of the end fitting finger tight to the adapter.

11. Position the permaswage tool one side the fitting and swage. Then swage the other side of the fitting.
12. Repeat steps 8 and 9 on the other end of the replacement section.



13. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

11-13. HYDRAULIC TUBE AND HOSE ISOLATION

General Information:

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

Option 1: Low-pressure hose isolation

Limitations:

Not recommended for pressures above 70 psi.

Personnel/Time Required:

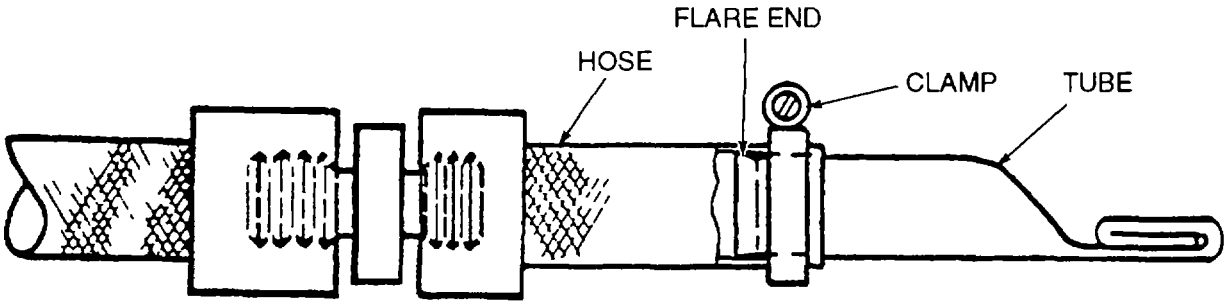
- 1 soldier
- 0.2-0.5 hour

Materials/Tools:

- Correct size tubing (scavenge from available source)
- Clamps (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tape (found in M2/3 generic BDR kit, Section III, Appendix C)
- Sealing compound (found in M2/3 generic BDR kit, Section III, Appendix C)
- Hacksaw or tube cutter (found in M2/3 generic BDR kit, Section III, Appendix C)

References:
TM-9-2350-314-20-2-2

Procedural Steps:



1. Wrap tape around area to be cut. Squarely cut end of hose and remove loose particles.

2. Flatten about 4 inches of one end of tubing. Fold flat end over twice.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

11-13. HYDRAULIC TUBE AND HOSE ISOLATION - CONTINUED

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

Option 2: High-pressure line repair (tube isolation) using plugs.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2-1.0 hour

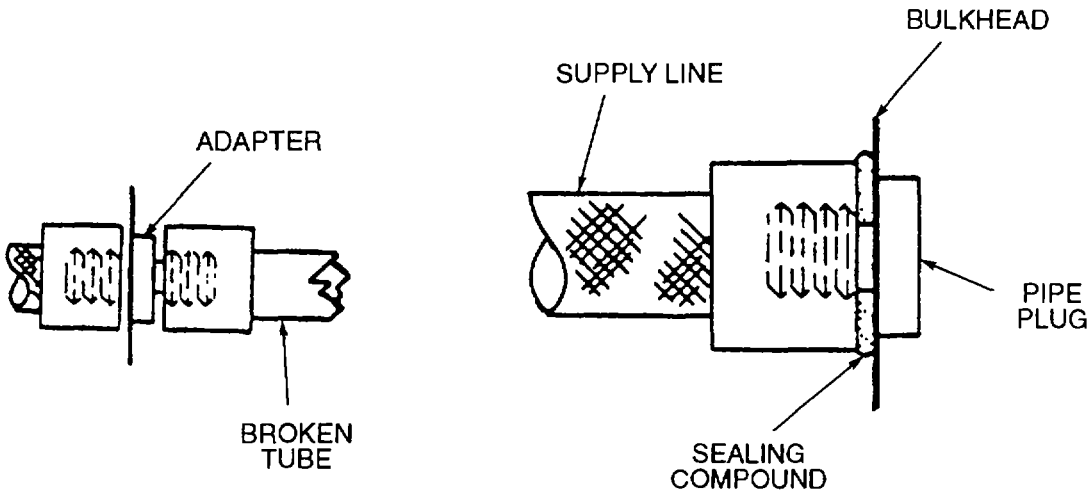
Materials/Tools:

- Tube pipe fitting kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Sealing compound (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

TM 9-2350-314-20-2-2

Procedural Steps:



1. Remove broken tube from bulkhead adapter.

11-13. HYDRAULIC TUBE AND HOSE ISOLATION - CONTINUED

2. Remove adapter from bulkhead and supply hose.

WARNING

Adhesives, solvents, and sealing compounds can bum easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid Injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

3. Coat threads of pipe with sealing compound.
4 Install pipe plug in supply hose from other side of bulkhead.
5 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: High-pressure line repair (tube isolation) using cap.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

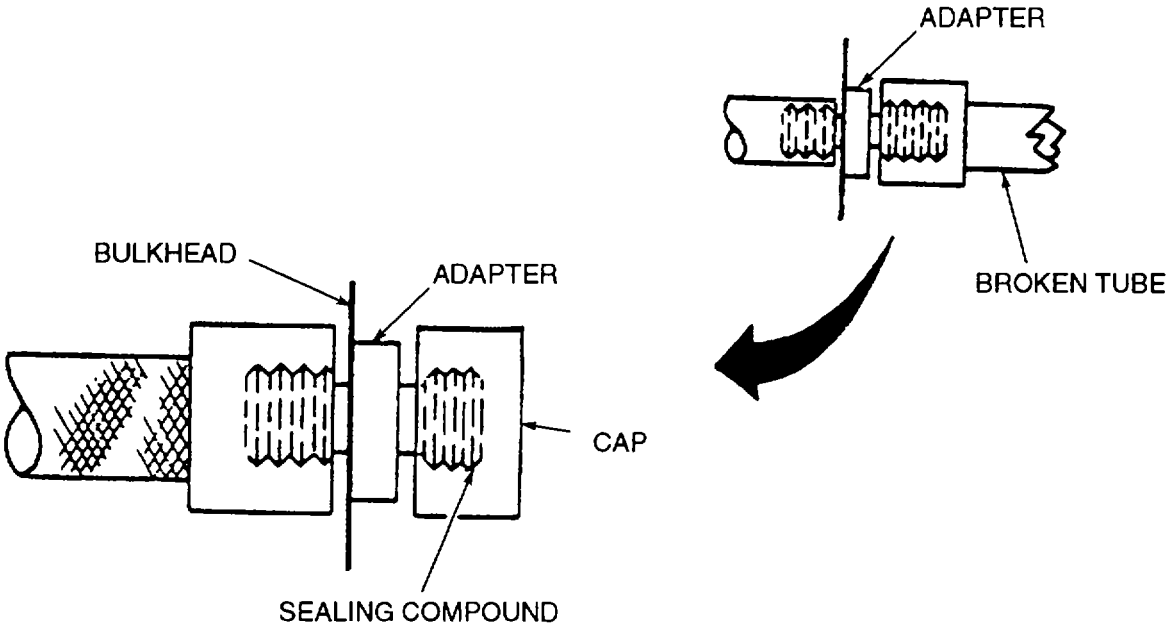
- Tube pipe fitting kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Sealing compound (found in M2/3 generic BDR kit, Section III, Appendix C)

References:

TM 9-2350-314-20-2-2

11-13. HYDRAULIC TUBE AND HOSE ISOLATION - CONTINUED

Procedural Steps:



1. Remove broken tube from adapter.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

2. Coat threads of pipe plug with sealing compound.
3. Install cap on adapter.
4. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4: High-pressure line repair (tube isolation) using flattened tube end.

Limitations:

None

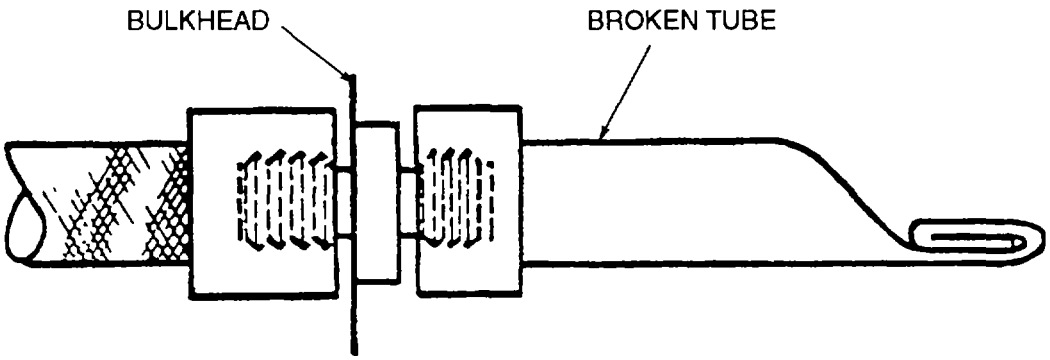
11-13. HYDRAULIC TUBE AND HOSE ISOLATION - CONTINUED

Personnel/Time Required:

- 1 soldier
- 0.2-0.5 hour

References:

TM 9-2350-314-20-2-2



1. Remove broken tube, if necessary.

2. Flatten about 6 inches of tubing near break.

3 Fold flattened portion of tube over twice.

4 Install repaired tube if removed.

5 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5: Low pressure line repair (tube isolation) using bolt.

Limitations:

Not recommended for pressure over 70 psi.

Personnel/Time Required:

- 1 soldier
- 0.2-0.5 hour

Materials/Tools:

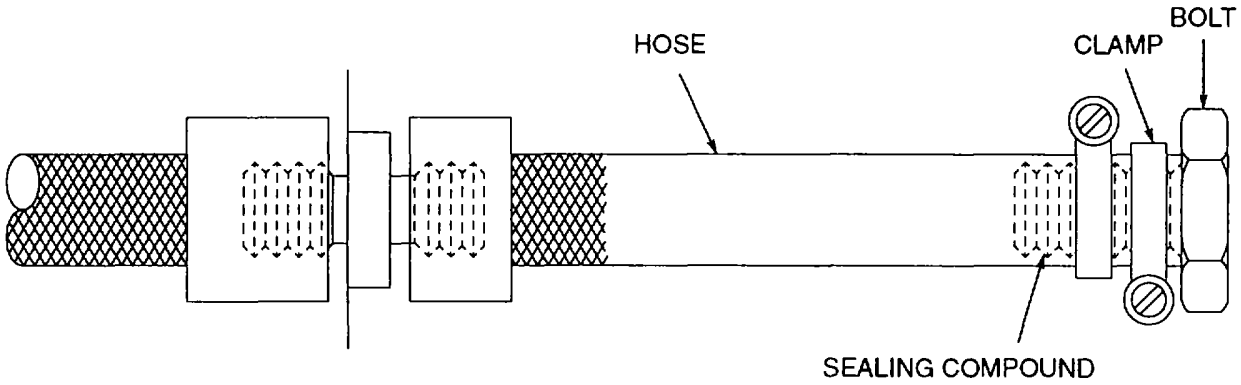
- Sealing compound (found in M2/3 generic BDR kit, Section III, Appendix C)
- Hexagon head bolt (scavenge from available source)
- Pressure sensitive adhesive tape (found in M2/3 generic BDR kit, Section III, Appendix C)
- Clamp (found in M2/3 generic BDR kit, Section III, Appendix C)

11-13. HYDRAULIC TUBE AND HOSE ISOLATION - CONTINUED

References:

TM 9-2350-314-20-2-2

Procedural Steps:



1. Wrap tape around area to be cut. Squarely cut end of hose and remove loose particles.

WARNING

Adhesives, solvents, and sealing compounds can burn easily, can give off harmful vapors, and are harmful to skin and clothing. To avoid Injury or death, keep away from open fire and use it in well-ventilated area. If adhesive, solvent, or sealing compound gets on skin or clothing, wash immediately with soap and water.

2 Coat threads of long hexagon head bolt with sealing compound.
3 Install long hexagon head bolt inside hose.
4 Secure with two hose clamps. Position clamp screws 180 degrees to each other.
5 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION V. COMPONENT ISOLATION

11-14. GENERAL

The hydraulic system directs the flow of energy through lines, manifolds, and valves to perform a required task. Two manual hand pumps are used to manually elevate and equilibrate the system. This section covers expedient repairs to isolate the system. This section covers expedient repairs to isolate the fuze manifold, selector valve, manual elevation hand pump, and the equilibration hand pump. The preferred method of repairs for these components would be to replace them with like serviceable items since isolation of these components degrade the system in various degrees.

11-15. BYPASSING FAILED COMPONENTS

General Information:

This paragraph contains procedures for bypassing failed components.

Option 1: Mode selector valve inoperative (isolate).

Limitations:

Degraded AFCS

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

Materials/Tools:

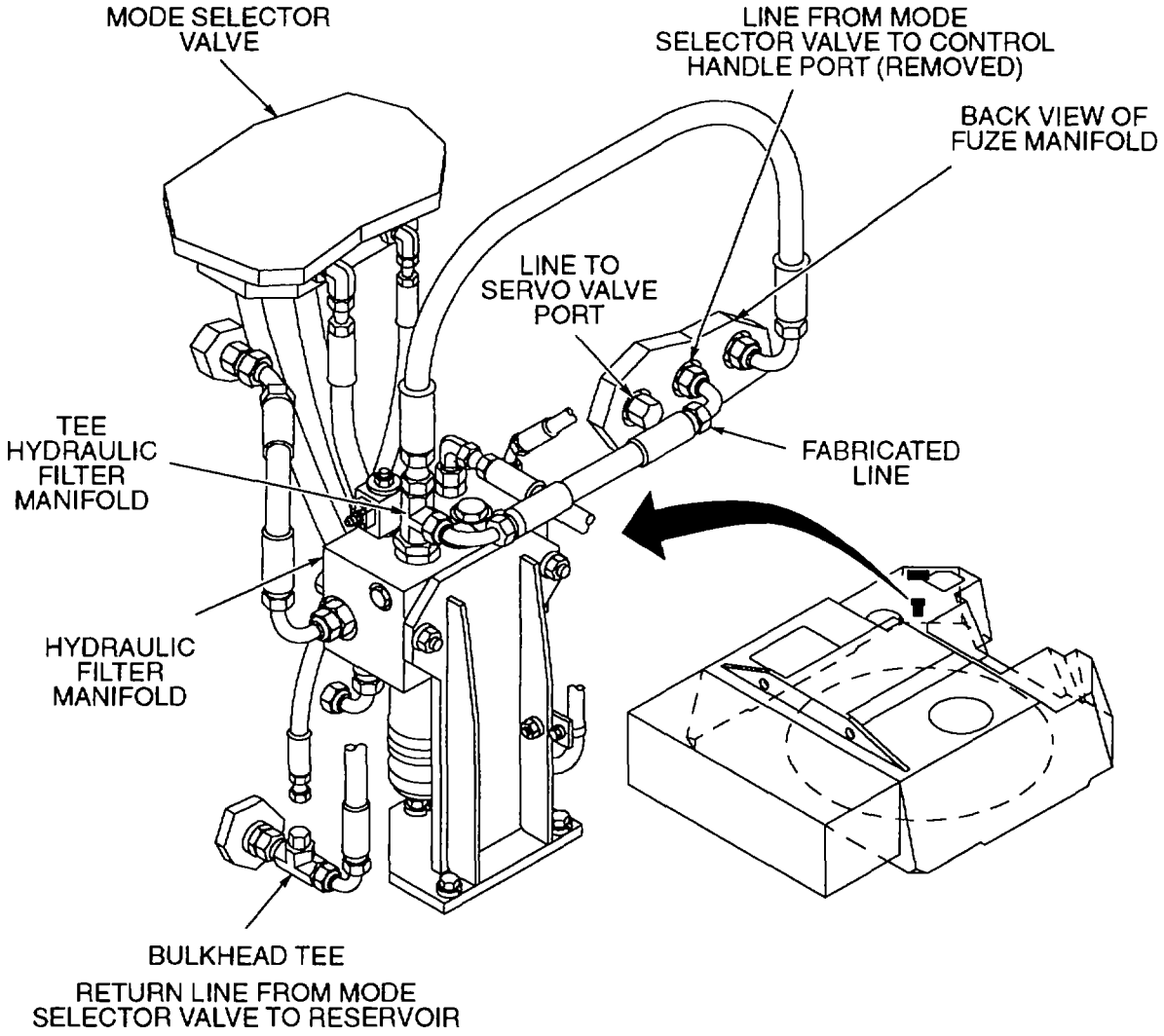
- Cap tube (item 5, Appendix C)
- Cap tube (item 6, Appendix C)
- Elbow, 2 each (item 19, Appendix C)
- High pressure hose 5/8-inch ID 4 feet long (scavenge from available source)
- Socket, 2 each (item 29, Appendix C)
- Hydraulic fluid (item 36, Appendix C)

References:

TM 9-2350-314-20-2-2

11-15. BYPASSING FAILED COMPONENTS - CONTINUED

Procedural Steps:



1. Remove equilibration accumulator.

2. Disconnect mode selector valve hydraulic line from tee at hydraulic filter manifold.

3 Disconnect mode selector valve hydraulic line at fuze manifold servo valve port. Cap port.

4. Disconnect mode selector valve hydraulic line at fuze manifold power control handle port.

5. Using a piece of 5/8-inch hose two sockets and two elbows, manufacture and install a line from tee at hydraulic filter manifold to control handle port at fuze manifold. (Reference para 11-11 for hose fabrication.)

6. Remove hydraulic compartment interior access panel.

7. Disconnect mode selector valve hydraulic return line at bulkhead tee. Cap tee.

11-15. BYPASSING FAILED COMPONENTS - CONTINUED

8. Install equilibration accumulator.
9. Fill and bleed hydraulic system.
10. Install hydraulic compartment Interior access panel.
11. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Fuze manifold inoperative (isolate).

Limitations:

Degraded safety if hydraulic line breaks reservoir will completely drain.

Personnel/Time Required:

- 1 soldier
- 1.0-2.0 hours

Materials/Tools:

- Hose fitting sockets, 6 each (item 29, Appendix C)
- High pressure hose 5/8-inch ID 3 feet long (scavenge from available source)
- High pressure hose 1/2-inch ID 3 feet long (scavenge from available source)
- High pressure hose 1/4-inch ID 3 feet long (scavenge from available source)
- Hydraulic fluid (item 36, Appendix C)
- Nipple, tube, reducer, 1/2 to 1/4-inch (item 38, Appendix C)
- Nipple, tube, reducer, 5/8 to 1/2-inch (2 each) (item 39, Appendix C)
- Elbow, tube 90 degree, 1/4-inch (item 11, Appendix C)
- Elbow, tube 90 degree, 1/2-inch (item 12, Appendix C)
- Tee, tube 1/4-inch (item 66, Appendix C)
- Tee, tube 1/2-inch (2 each) (item 65, Appendix C)
- Nipple tube 1/2-inch (2 each) (item 42, Appendix C)

References:

TM 9-2350-314-20-2-2

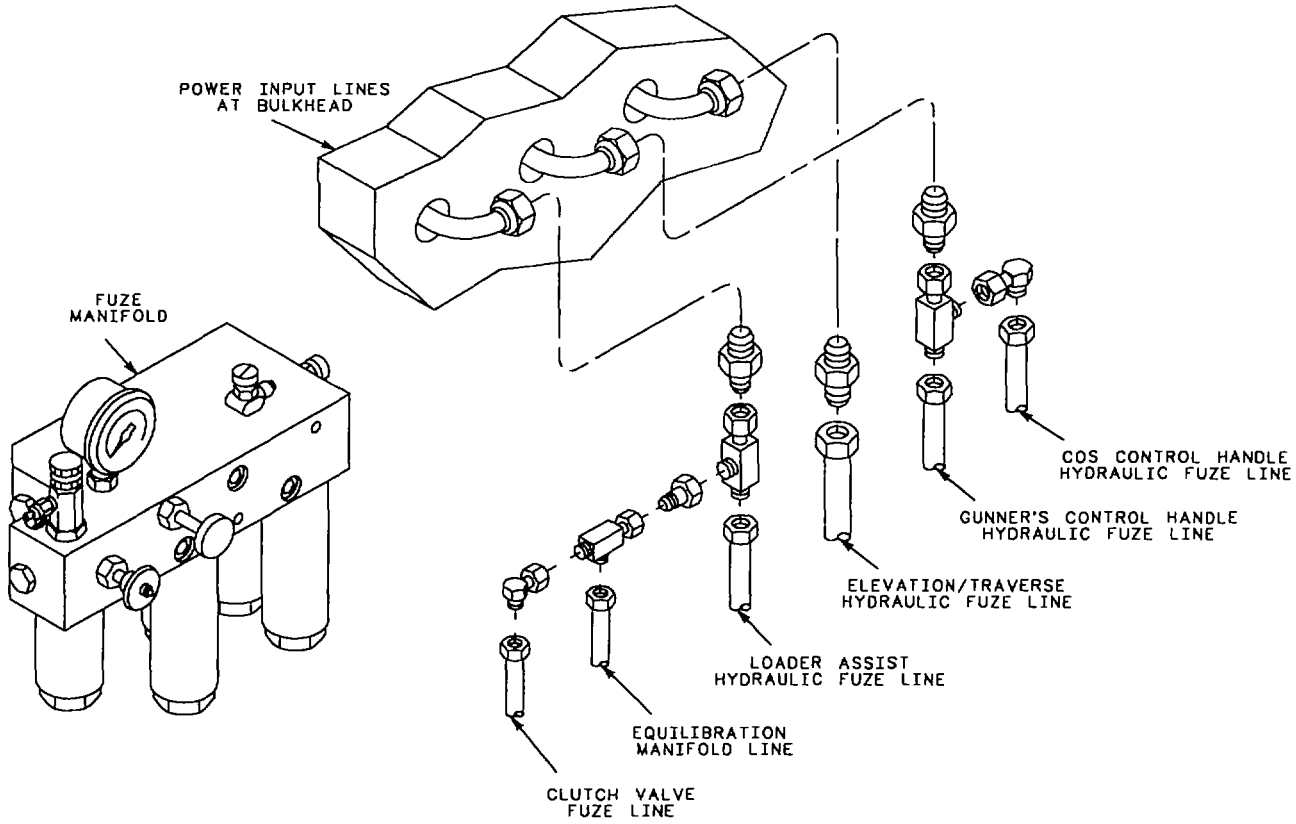
11-15. BYPASSING FAILED COMPONENTS - CONTINUED

Procedural Steps:

1. Remove fuze manifold.

NOTE

The three power input lines to the fuze manifold from the filter manifold and mode selector valve are not long enough to reach through the bulkhead. Extension lines will have to be fabricated. (Reference para 11-11 for hose fabrication.)



2. Using a 5/8-inch straight adapter, connect mode selector servo valve hydraulic line to the elevation/traverse hydraulic fuze line.
3. Using a 5/8 to 1/2-inch adapter reducer and a 1/2-inch tee, connect the hydraulic line from the mode selector valve to the control handles port to the hydraulic line from the gunner's control handle hydraulic fuze.
4. Install a 1/2-inch elbow into the tee in step 3 and connect the hydraulic line from the chief of section control handle hydraulic fuze.
5. Using a 5/8 to 1/2-inch adapter reducer and 1/2-inch tee, connect the hydraulic output line from the tee at the hydraulic filter manifold to the hydraulic line from the loader assist hydraulic fuze.
6. Using a 1/2 to 1/4-inch adapter reducer and a 1/4-inch tee connected to the tee in step 5, connect the hydraulic line from the equilibration manifold.

11-15. BYPASSING FAILED COMPONENTS - CONTINUED

7 Using a 1/4-inch elbow connected to the tee in step 6, connect the hydraulic line from the clutch valve fuze.

8 Fill and bleed the hydraulic system.

9 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Equilibration hand pump inoperative (hydraulic reservoir damaged, no hydraulic fluid).

Limitations:

- No hydraulic system pressure.
- All functions must be done manually.

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

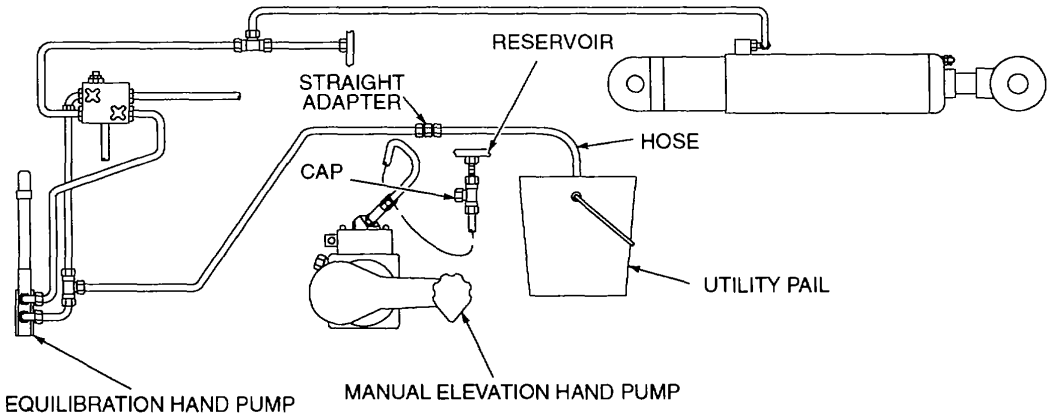
Materials/Tools:

- Cap tube 1/4-inch (item 5, Appendix C)
- Nipple tube, straight 1/4-inch (item 40, Appendix C)
- Hose 7/16-inch ID 4 feet long (scavenge from available source)
- Pail utility
- Hydraulic fluid (item 36, Appendix C)

References:

- TM 9-2350-314-20-2-2
- TM 9-2350-314-34-2

Procedural Steps:



11-15. BYPASSING FAILED COMPONENTS - CONTINUED

1. Disconnect the hydraulic supply line from reservoir to the equilibration hand pump at the bulkhead tee.
2. Using a 1/4-inch cap, cap the tee in step 1.
3. Install a 1/4-inch straight adapter into the line disconnected in step 1.
4. Connect a 7/16-inch hose onto the straight adapter in step 3.
5. Submerge the hose from step 4 into a utility pail. Fill with clean hydraulic fluid.
6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system, using standard maintenance procedures.

Option 4: Manual elevation pump inoperative (hydraulic reservoir damaged no hydraulic fluid).

Limitations:

- No hydraulic system pressure.
- All functions must be done manually.

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

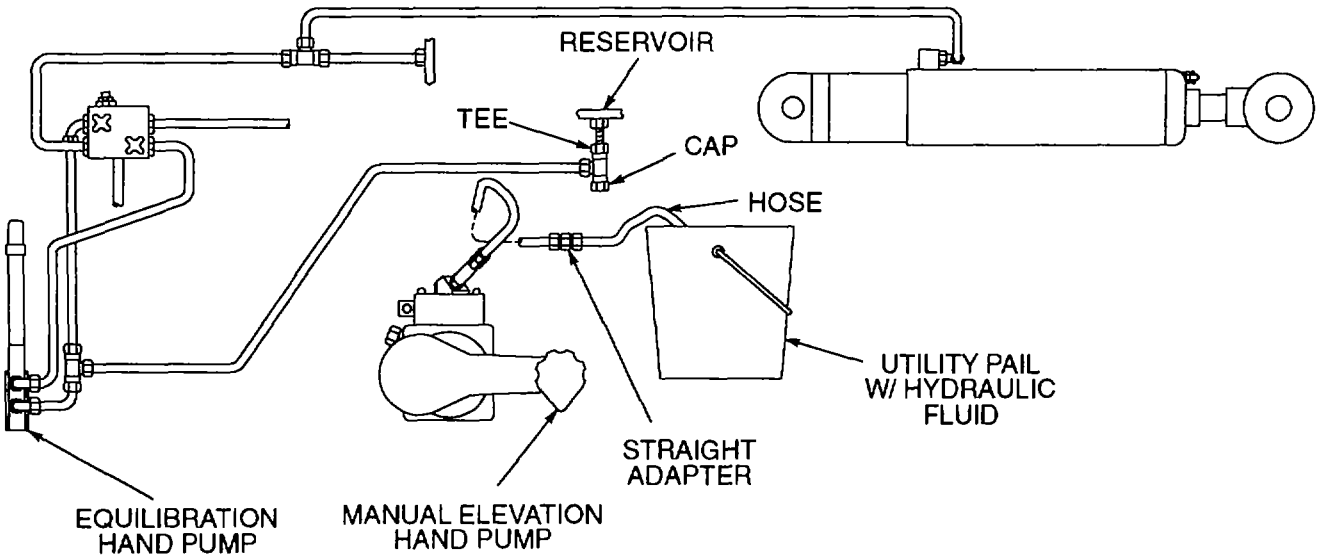
Materials/Tools:

- Cap tube 1/4-inch (item 5, Appendix C)
- Nipple tube, straight 1/4-inch (item 40, Appendix C)
- Hose 7/16-inch ID 4 feet long (scavenge from available source)
- Pail utility
- Hydraulic fluid (item 36, Appendix C)

References:

TM 9-2350-314-20-2-2

Procedural Steps:



11-15. BYPASSING FAILED COMPONENTS - CONTINUED

1. Disconnect the hydraulic supply line from the reservoir to the manual elevation hand pump at the reservoir bulkhead tee.
2. Using a 1/4-inch cap, cap the tee in step 1.
3. Install a 1/4-inch straight adapter into the line disconnected in step 1.
4. Connect a 7/16-inch hose onto the straight adapter in step 3.
5. Submerge the hose from step 4 into a utility pail fill with clean hydraulic fluid.
6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5: Manual elevation and equilibration hand pumps inoperative (hydraulic reservoir damaged no hydraulic fluid).

Limitations:

- No hydraulic system pressure.
- All functions must be done manually.

Personnel/Time Required:

- 1 soldier
- 0.5-1.0 hour

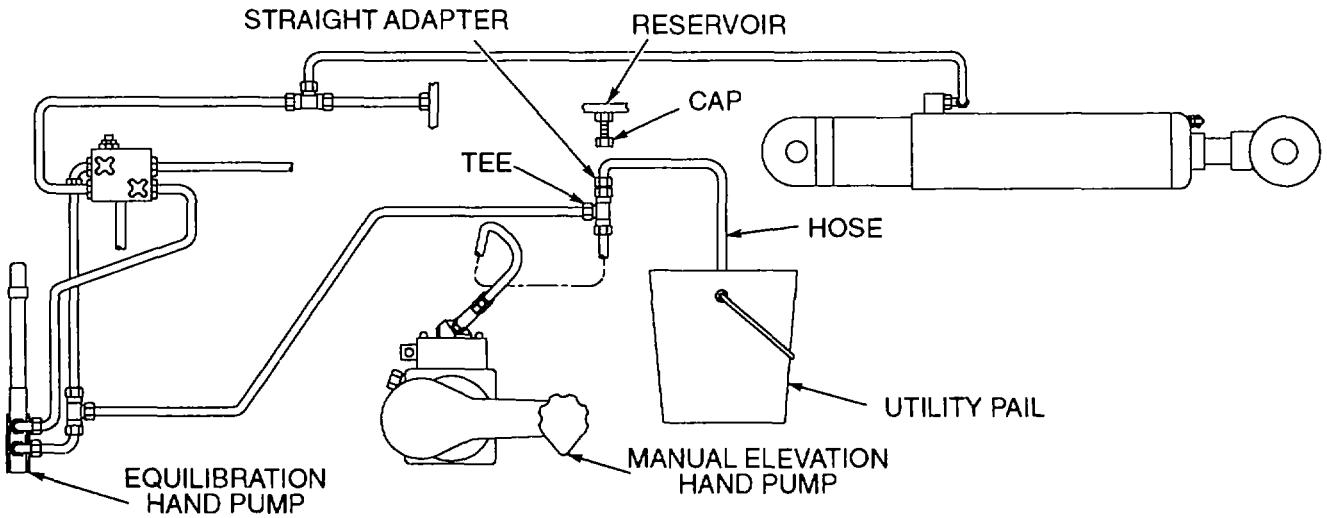
Materials/Tools:

- Cap tube 1/4-inch (item 5, Appendix C)
- Nipple tube, straight 1/4-inch (item 40, Appendix C)
- Hose 7/16-inch ID 4 feet long (scavenge from available source)
- Pail, utility
- Hydraulic fluid (Item 36, Appendix C)

References:

TM 9-2350-314-20-2-2

Procedural Steps:



11-15. BYPASSING FAILED COMPONENTS - CONTINUED

1. Disconnect the tee in the hydraulic supply line from the reservoir to the manual elevation and equilibration hand pumps from the bulkhead fitting at the reservoir.

2. Using a 1/4-inch cap, cap the bulkhead in step 1.

3. Install a 1/4-inch straight adapter into the tee disconnected in step 1.

4. Connect a 7/16-inch hose onto the straight adapter in step 3.

5. Submerge the hose from step 4 into a utility pail. Fill with clean hydraulic fluid.

6. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

CHAPTER 12
CANNON AND MOUNT

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

12-1. SCOPE

The BDAR of the cannon and mount, and sighting equipment is done by the procedures in this chapter. The procedure can be found using the fault assessment table or the repair procedure index (para 12-3). Repair of the sighting equipment is done by replacement.

12-2. ASSESSMENT PROCEDURE

Table 12-1. Cannon and Mount Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Replenisher accumulator	para 12-5
Gun tube	para 12-6
Bore evacuator	para 12-7
Sighting equipment	para 12-9
Composite armor	para 12-11
Traverse mechanism	para 12-12

Determine if:

- No damage found → Visual inspection is complete. Return to Table 2-1 to continue visual assessment.
- Damage can be repaired - Note repair requirements → Visual inspection is complete. Return to Table 2-1 to continue visual assessment.
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

12-2. ASSESSMENT PROCEDURE - CONTINUED

Table 12-2. Cannon and Mount Visual Assessment

ATTEMPT OPERATION → **INOPERATIVE:**

Replenisher accumulator	para 12-5
Gun tube	para 12-6
Bore evacuator	para 12-7
Sighting equipment	para 12-9
Traverse mechanism	para 12-12

Determine if:

No problem found

Damage can be repaired
- Note repair requirements

Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

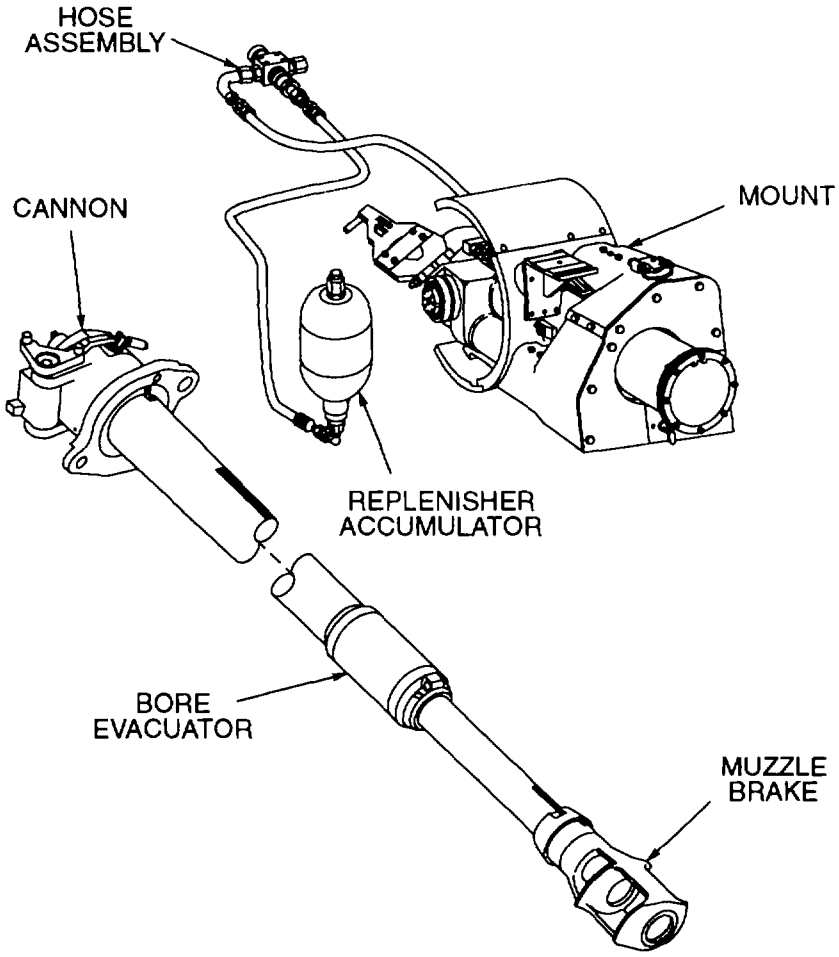
Operation observation is complete. Return to Table 2-2 to continue operation assessment.

12-3. REPAIR PROCEDURE INDEX

SECTION II. MOUNT COMPONENTS

12-4. GENERAL

Armament and sighting equipment are two classes of equipment. Sighting equipment are essentially aids to improve the accuracy and speed of armament firing operations. All armament systems provide manual back up devices should the power controlled systems fail. This chapter provides information primarily intended to overcome armament system failures. Sighting equipment, because of their complexity, do not lend themselves to BDR procedures. Refer to the standard TMs for sighting equipment repairs.



12-5. REPLENISHER ACCUMULATOR DAMAGE

General Information:

The replenisher accumulator allows for change in the quantity of oil required by the recoil cylinders during recoil, and also for expansion and contraction due to temperature changes. Damage to the replenisher accumulator will degrade the system to non-mission capable. The preferred repair procedure would be to replace the replenisher accumulator with a new or used part from available source. This is not always possible. This BDR procedure is only for the repair of the bladder. The repair of the housing, hoses, lines and fittings are covered in Chapter 3 and Chapter 11.

Limitations:

Due to the oil and nitrogen mixture the patch may not last long.

Personnel/Time Required:

- 2 soldiers
- 2.3 hours

Materials/Tools:

- Elastomer repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Nitrogen charging kit
- Hydraulic fluid (item 36, Appendix C)
- Rubber patch (scavenge from available source)
- M3 oil pump

References:

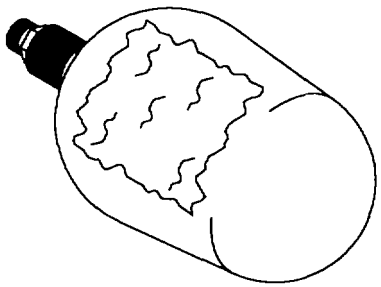
- TM 9-2350-314-20-2-1
- TM 9-2350-314-34-2

Other Options:

Patch replenisher bladder with tire repair kit.

Procedural Steps;

1. Remove and disassemble replenisher.
2. Clean damaged area of bladder.
3. Apply elastomer and rubber patch to bladder using elastomer kit instructions.



4. Reassemble and install replenisher.
5 Fill and charge replenisher.
6 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. CANNON ASSEMBLY

12-6. GUN TUBE INTERCHANGEABILITY

General Information:

Gun tubes and mounts sustain damage easily in a combat environment which may prevent fire missions. A wrecker, block and tackle or improvised lifting device may be used to assist Interchanging them. The 155MM gun of the M109A6 vehicle is interchangeable only with the M109A5

Interchangeability Information

Vehicle	Tube	Mount
M109A5	M284	M182

12-7. BORE EVACUATOR DAMAGE

General Information:

As a round is propelled through the gun tube, gas pressure is forced inside the bore evacuator. As the round leaves the tube, bore evacuator pressure rushes out behind the round, exhausting excessive smoke and fumes. If the evacuator is damaged or leaks, this pressure is lost, causing excessive smoke and fumes to enter the cab as the breech block opens. This procedure repairs puncture damage to the bore evacuator.

Option 1: Fabricated clamp.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Other Options:

- Open cab hatches and turn on crew blower.
- Ensure lead filter is ON.

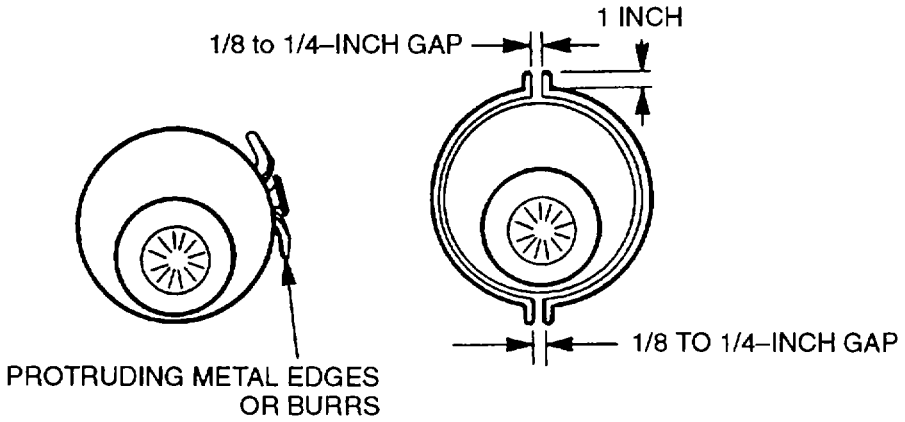
Materials/Tools:

- Acetylene torch
- Suitable fire resistant material (scavenge from available source)
- Grinder
- Hexagon head nut, 3/8-inch (as required) (scavenge from available source)
- Lockwashers (as required) (scavenge from available source)
- Machine screws, 3/8-inch (as required) (scavenge from available source)
- Sheet metal, 1/4-inch thick, about 21 inches long and wide enough to overlap damage (scavenge from available source)
- Drill

12-7. BORE EVACUATOR DAMAGE - CONTINUED

1. Use acetylene torch and grinder to cut and remove any burrs or protruding metal edges that may effect air-tight seal.

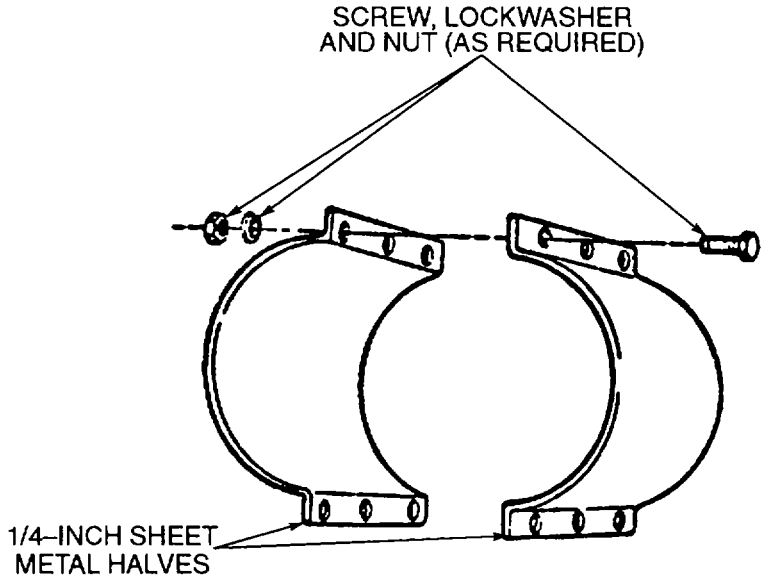
Procedural Steps:



2. Clean any blocked gas ports, if accessible.
3. Measure and record dimensions of damaged area.

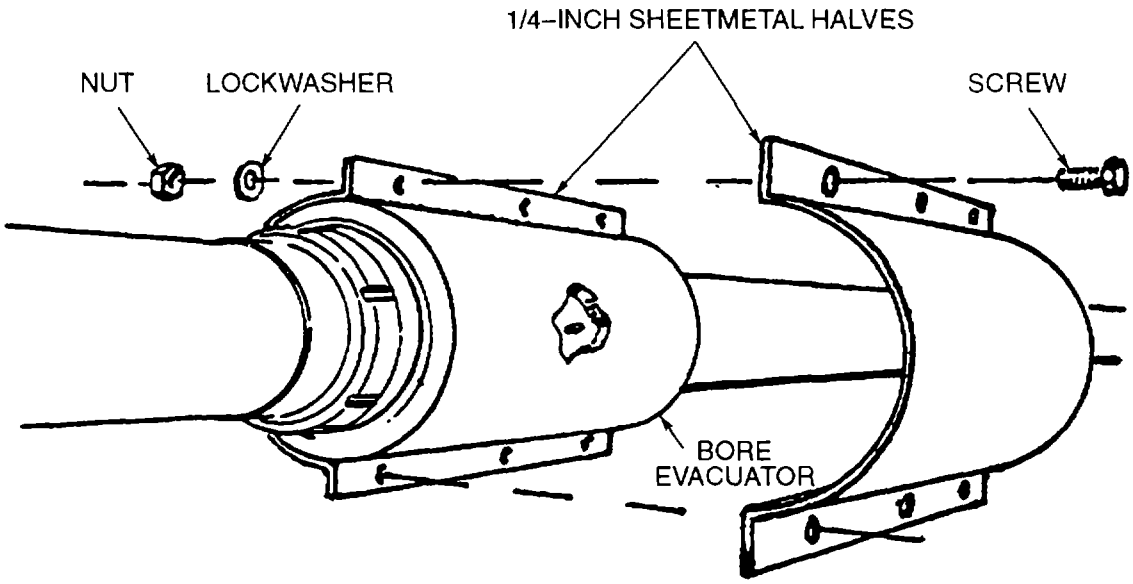
NOTE

If damage is extensive, clamp should be made same width as bore evacuator to ensure a proper seal.



12-7. BORE EVACUATOR DAMAGE - CONTINUED

4. Use acetylene torch to cut two 10 1/2-inch long metal strips at least 1 inch wider than damaged area.
5. Shape each metal band to fit curve of bore evacuator. When metal bands are placed around bore evacuator, a gap between 1/8 to 1/4-inch should exist between halves (see Illustration).
6. Remove bands from bore evacuator and line inside surface of each band with suitable fire resistant material.
7. Drill 3/8-inch evenly spaced holes in each end of both bands, set bands in place over damaged area.



8. Secure bands against bore evacuator with screws, nuts, and lockwashers.
9. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Welded patch repair.

Limitations:

None

Personnel/Time Required:

- 2 soldiers
- 1.0 hour

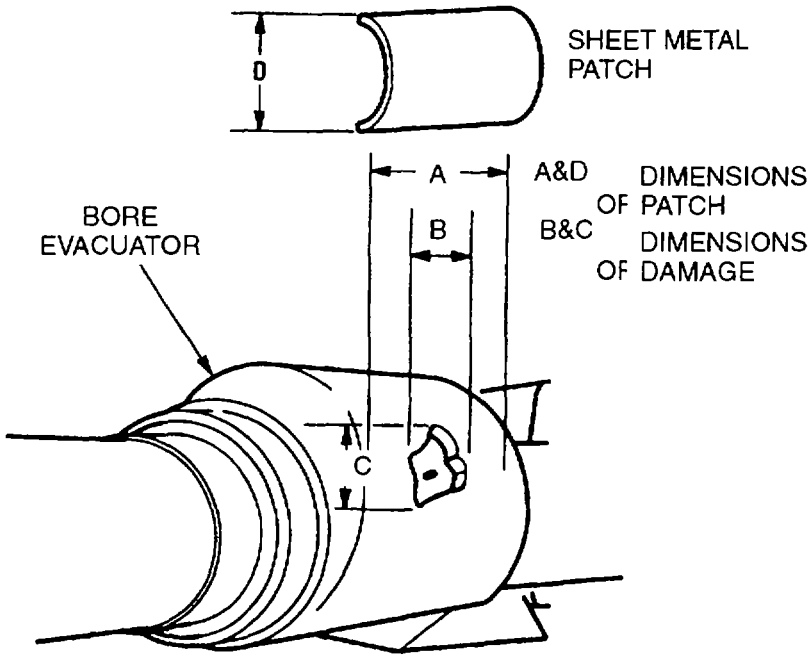
12-7. BORE EVACUATOR DAMAGE - CONTINUED

Materials/Tools:

- Welding equipment
- Grinder
- Sheet metal, 1/4-inch thick (size dependent on damage) (scavenge from available source)
- Wire brush

Procedural Steps:

1. Use acetylene torch and grinder to cut and remove any burrs or protruding metal edges from damaged bore evacuator.
2. Clean any blocked gas ports, if accessible.
3. Measure and record dimensions of damaged area (items B and C).



4. Use acetylene torch to cut a patch from sheet metal 1/4 to 1/2-inch larger than damaged area (Items A and D).
5. Shape patch to fit curve of bore evacuator.
6. Wire brush both mating surfaces.

CAUTION

If arc welding cab, ground welding equipment to cab only. Parts of slipring and race bearings can be damaged from high currents conducted between hull and cab. If welding equipment is not grounded correctly.

12-7. BORE EVACUATOR DAMAGE - CONTINUED

7. Set and secure patch in place over damaged area.
8. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Repair with fiberglass or polymer kit.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Polymer repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Fiberglass repair kit (item 50, Appendix C)
- Wire brush (found in M2/3 generic BDR kit, Section III, Appendix C)
- Paper, abrasive (item 46, Appendix C)
- File or hammer (found in M2/3 generic BDR kit, Section III, Appendix C)

Other Options:

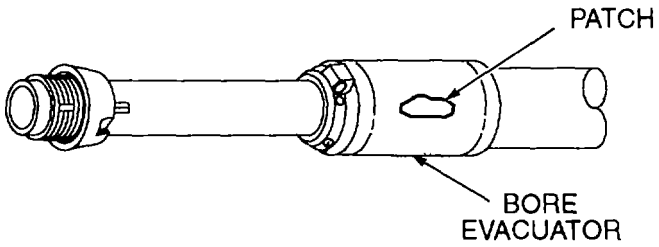
- Use elastomer repair kit (found in M2/3 generic BDR kit, Section III, Appendix C)

Reference:

TM 9-2350-314-20-2-1

Procedural Steps:

1. Gain access to the damaged/leaking area.
2. Remove dirt and paint from around damaged area with wire brush or abrasive paper.
3. Remove rough edges of damaged area with file or hammer.



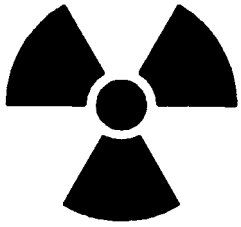
4 Repair damaged area with polymer or fiberglass repair kit following kit instructions.
5 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. SIGHTING EQUIPMENT

12-8. GENERAL

WARNING

RADIOACTIVE MATERIAL(S)



TRITIUM (HYDROGEN-3) GAS

Handle with care in the event the radioluminous source is broken, cracked or there is no illumination, immediately refer to warning page inside front cover of manual.

The sighting equipment are essentially aids to improve the accuracy speed of armament firing operations.

12-9. SIGHTING EQUIPMENT DAMAGE

General Information:

The quickest method of repair for damaged sighting equipment may be to cannibalize replacement from disabled vehicles. There are some minor differences in certain sighting equipment of the vehicles listed below, but they will function. Cannibalize the required sighting equipment from another vehicle as available. Sighting equipment of the M109A6 are interchangeable with those of the following vehicles.

A. M1A1/A2 Gunner's Quadrant: M109 thru M109A5 and M110
B. M1A1 Collimator: M109 thru M109A5 and M110
C. M140 Alignment Device: M109 thru M109A5 and M110
D M117A1/A2 Panoramic Telescope: M109thru M109A5
E. M145A1 Mount: M109thru M109A5

SECTION V. COMPOSITE ARMOR

12-10. GENERAL

To improve the survivability of the M109A6 composite armor is used.

12-11. ARMOR, PENETRATED

General Information:

The M109A6 has three types of armor composite, permanent, and removeable BDR to the permanent armor of the hull and cab is limited to improvised patching, using bolt-on type repairs, welding, or the polymer kit found In the BDR kit. The removable armor, such as fenders and covers, can be removed and replaced with fabricated substitutes.

12-11. ARMOR, PENETRATED - CONTINUED

NOTE

- **The procedures in this section for armor repair are general field repairs Major armor repair must be performed by depot maintenance.**
- **Assessment of armor will consist of a visual inspection to determine the extent of damage and repairs required.**

Option 1: Large hole in armor.

Limitations:

Degraded armor protection.

Personnel/Time Required:

- 2 soldiers
- 2.0 hours

Materials/Tools:

- Plate stock (scavenge from available source)
- Welding equipment
- Grinder

Other Option:

- Drill holes in metal plate and armor and secure plate to armor with bolts, washers and nuts.
- Secure metal plate to armor using polymer kit (found in M2/3 generic BDR kit, Section III, Appendix C).

Procedural Steps:

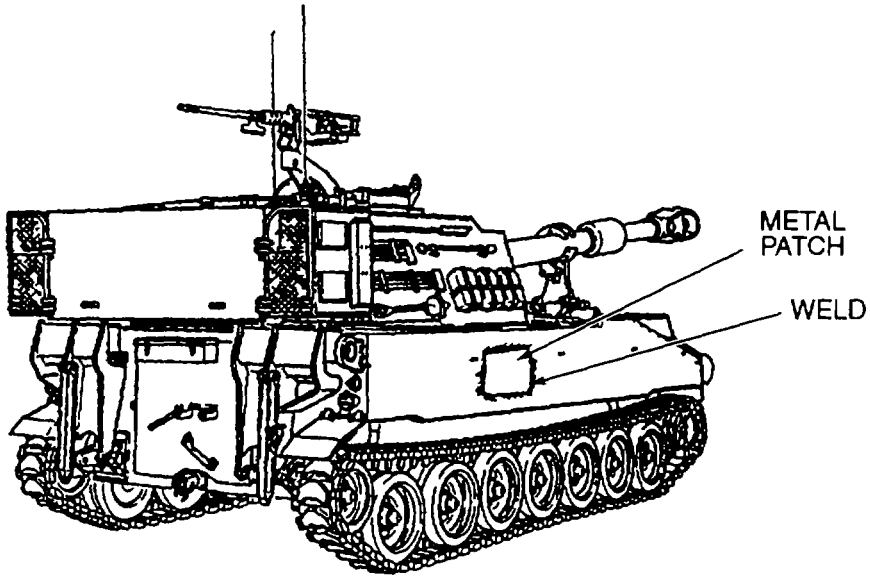
1. Cut aluminum patch so that it will extend at least 6 inches, where possible, beyond edges of hole in armor.
2. Remove all dirt, paint, and rust from area on armor to be covered by patch.
3. Grind edges of patch smooth.

CAUTION

Ground arc welding equipment to the portion of vehicle being welded (i e, cab or hull). Failure to comply could result in damage to slipring and race bearing.

4. Tack weld patch 4 inch long on 8 inch centers.
5. Remove slag with chipping hammer and wire brush (after each pass).

12-12. ARMOR, PENETRATED - CONTINUED



6. Weld additional stringer passes until weld is secure.
7. Check for maximum allowable opening of 1/8-inch between patch and armor.
8. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 2: Large holes in armor.

Limitations:

Degraded armor protection.

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Paper abrasive (item 46, Appendix C) or wire brush
- Polymer kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Screw (scavenged from available source)
- Nuts (scavenged from available source)
- Flat washers (scavenged from available source)

Other Options:

Use fiberglass repair kit (item 50, Appendix C)

References:

TM 9-2350-314-20-2-2

12-11. ARMOR, PENETRATED - CONTINUED

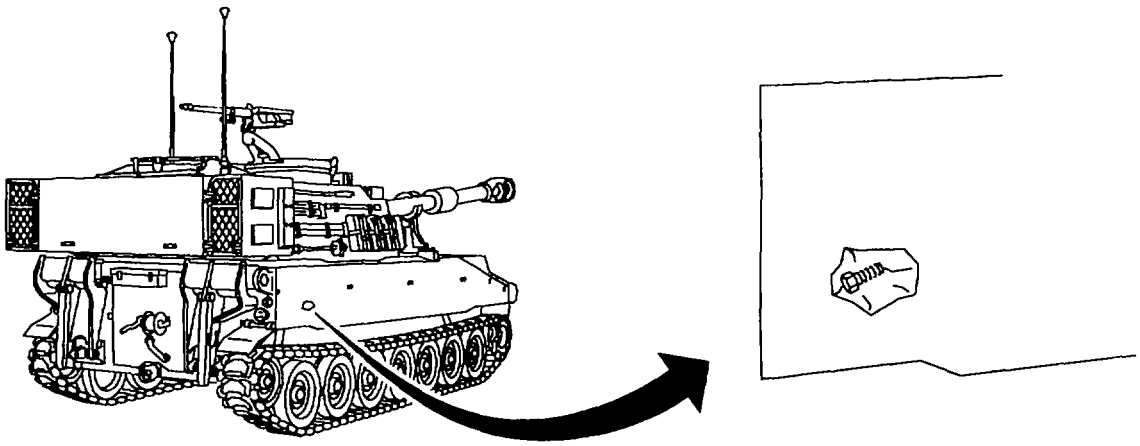
Procedural Steps:

1. Gain access to the damaged area.
2. Clean damaged area allow a 2 inch lip.

NOTE

Rocks, mud, or other substances or materials may be used as fillers.

3. Fill hole with a mixture of the polymer kit (follow kit instructions). Use bolts, nuts, and washers as filler.



5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 3: Small holes in armor.

Limitations:

Degraded armor protection.

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Paper abrasive (item 46, Appendix C) or wire brush
- Bolts, nuts and flat washers (scavenged from available source)
- Polymer kit (found in M2/3 generic BDR kit, Section III, Appendix C)

Other Options:

Use fiberglass repair kit (item 50, Appendix C)

12-11. ARMOR, PENETRATED - CONTINUED

References:

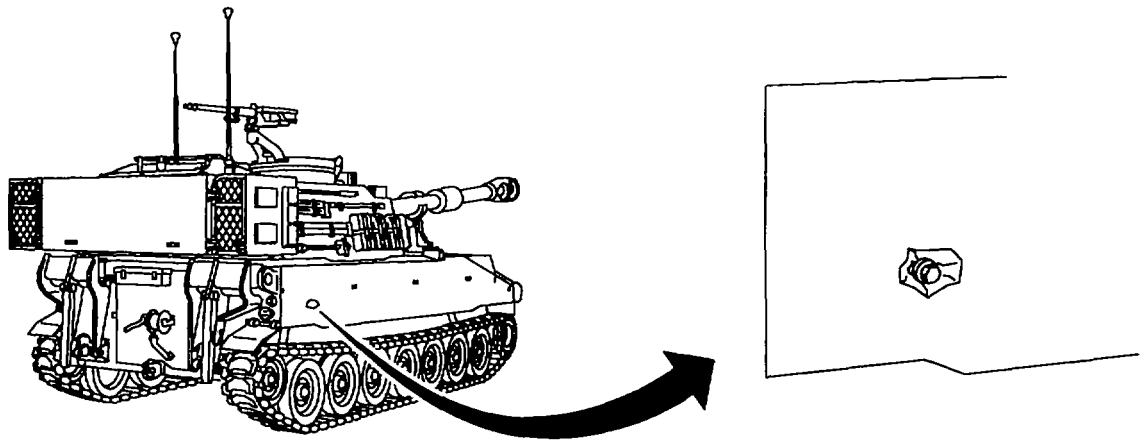
TM 9-2350-314-20-2-2

NOTE

If bolts, nuts or washers are not available, holes in armor may be closed using any of the above listed other options.

Procedural Steps:

1. Gain access to the damaged area.
2. Clean area around damage.



3. Insert bolt with flat washer through hole in armor.
4 Place another flat washer and a nut on the end of the bolt and tighten nut from inside the vehicle.
5 Spread polymer over the bolt, nut, and flat washers.
6 Allow polymer to dry.
7 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 4: Small holes in armor.

Limitations:

Degraded armor protection

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Paper, abrasive (item 46, Appendix C) or wire brush
- Polymer kit (found in M2/3 generic BDR kit, Section III, Appendix C)

12-11. ARMOR, PENETRATED - CONTINUED

References:

TM 9-2350-314-20-2-2

Other Options:

Use fiberglass repair kit (item 50, Appendix C)

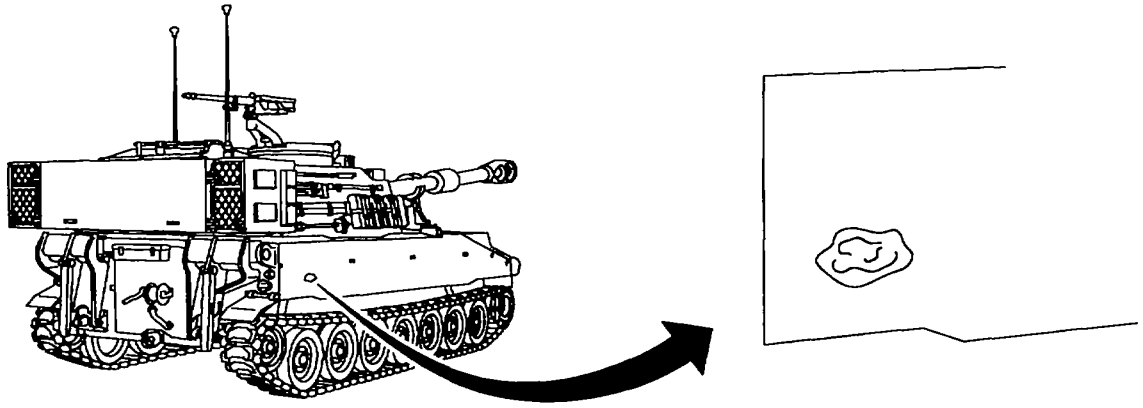
Procedural Steps:

1. Gain access to the damaged area.
2. Clean area around damage.

NOTE

Bolts, nuts, washers, or rocks may be used as fillers depending on the size of the hole.

3. Fill hole in armor with polymer.



4. Wait for polymer to dry.
5. Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5: Holes in armor.

Limitations:

Degraded armor protection

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

- Paper, abrasive (item 46, Appendix C) or wire brush
- Polymer kit (found in M2/3 generic BDR kit, Section III, Appendix C)
- Screw (scavenged from available source)

12-11. ARMOR, PENETRATED - CONTINUED

- Nuts (scavenged from available source)
- Flat washers (scavenged from available source)

References:

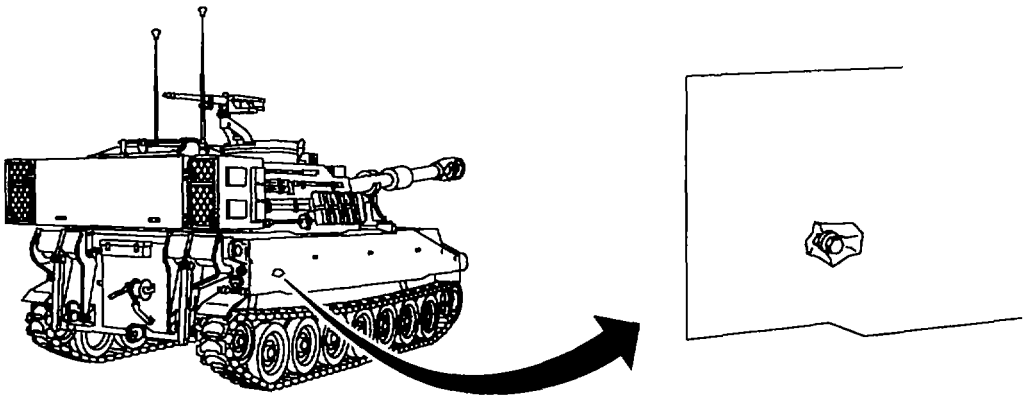
TM 9-2350-314-20-2-2

Other Options:

Use fiberglass repair kit (Item 50, Appendix C)

Procedural Steps:

1. Gain access to the damaged area.
2. Clean area around damage.
3. Insert screw with flat washer Into hole in armor.



4 Install a flat washer and nut onto the screw from inside the vehicle.
5 Spread polymer over the head of the screw and flat washer on the outside and over the nut and flat washer on the inside.
6 Allow polymer to dry.
7 Record the BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION VI. TRAVERSE MECHANISM

12-12. GENERAL

In the event the traversing mechanism becomes so damaged that it is impossible to traverse either under power or manually, the gun may be layed by repositioning vehicle.

CHAPTER 13
COMMUNICATIONS

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

13-1. SCOPE

This chapter contains the BDAR procedures for the radio communications system components necessary to maintain the combat effectiveness of the M109A6. The proper repair procedure can be found using the fault assessment table or the repair procedure index (para 13-3) for cable or wiring repair reference Chapter 3. If proper test equipment is not available for troubleshooting, fabricated test equipment listed in Appendix B may be used.

13-2. ASSESSMENT PROCEDURE

Table 13-1. Communication System Visual Assessment

VISUALLY INSPECT → **DAMAGE FOUND TO:**

Antenna	para 13-8
Coaxial cables	para 13-9
Intercommunication cable	para 13-10
IF-141/VRC filter	para 13-12

Determine if:

- No damage found → Visual inspection is complete. Return to Table 2-1 to continue visual assessment.
- Damage can be repaired - Note repair requirements → Visual inspection is complete. Return to Table 2-1 to continue visual assessment.
- Damage cannot be repaired - Note extent of damage repair requirements → Go to Table 2-3 Evaluation of Performance Capability

13-2. ASSESSMENT PROCEDURE - CONTINUED

Table 13-2. Communication System Operation Assessment

ATTEMPT OPERATION → **INOPERATIVE:**

Radio, does not work with intercom ..... para 13-6
Radio, mount field expedient repair ..... para 13-7
Intercommunications cables ..... para 13-11
IF-1461/VRC filter, damaged ..... para 13-12
Intercom system, inoperative ..... para 13-14

Determine if:

No problem found

Damage can be repaired
- Note repair requirements

Damage cannot be repaired
- Note extent of damage repair requirements

Go to Table 2-3 Evaluation of Performance Capability

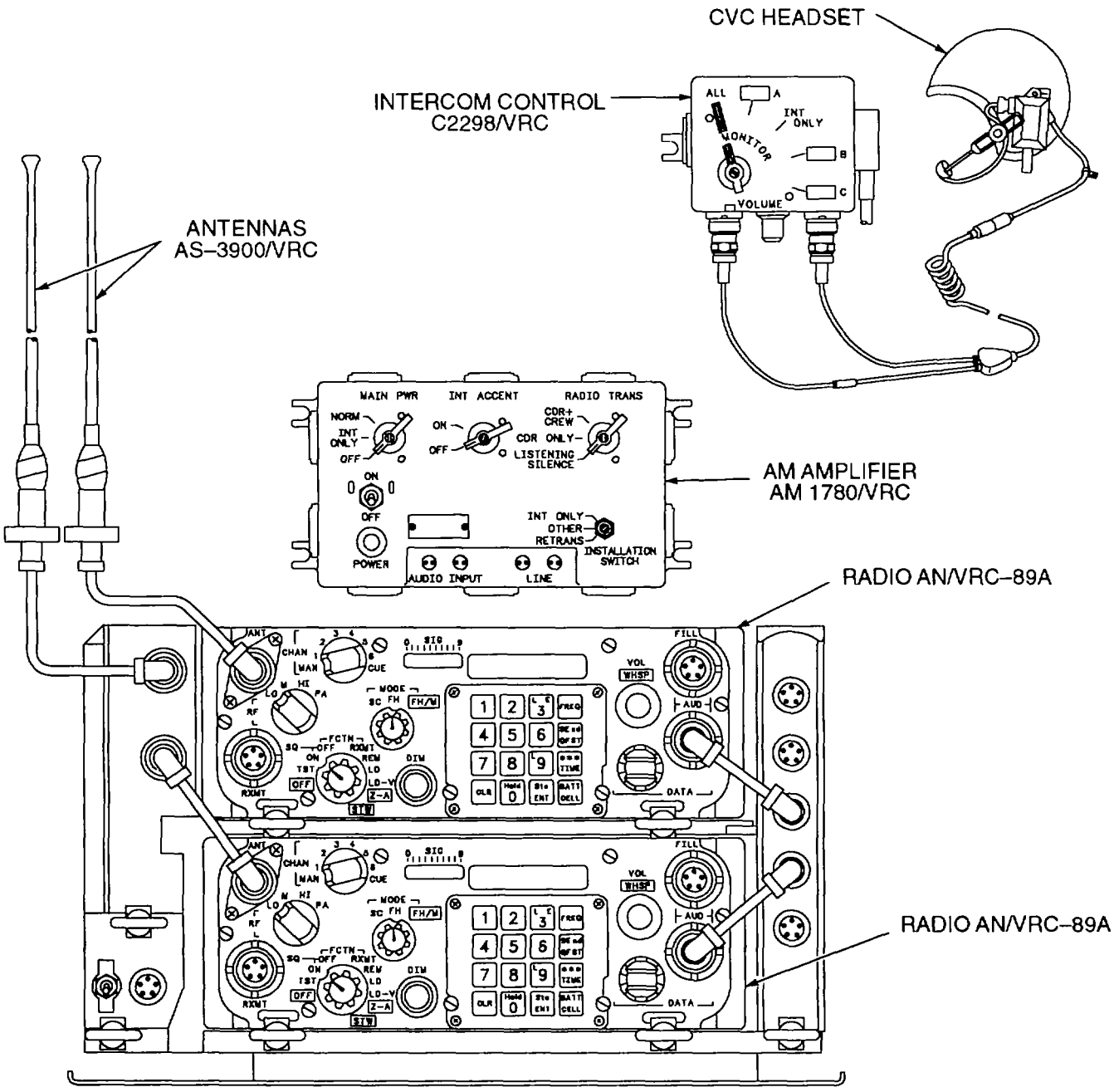
Operation observation is complete. Return to Table 2-2 to continue operation assessment.

13-3. REPAIR PROCEDURE INDEX PARA

SECTION II. COMMUNICATION SYSTEM COMPONENTS

13-4. GENERAL

The communication system of the M109A6 consists of two AN/VRC 89A radios, one is used for voice communications, the other for digital, two antennas, two mounts and an AN/VIC-1 intercom set consisting of the AM-1780 amplifier, five C-2298 control boxes, one C-2742 remote switching control box, four Communications Vehicular Crewman (CVC) helmets and all associated wiring and cables. The AN/VIC-1 allows voice intercom between the chief of section and all crew members. Due to the complexity of the communication system in most cases BDAR is limited to replacement of the damaged component with a like working item. See general interchangeability information para 13-14.



SECTION III. RADIO SYSTEM

13-5. GENERAL

This section contains repair procedures to restore radio communications needed to complete the mission.

13-6. RADIO DOES NOT WORK WITH INTERCOM

General Information:

There are no known methods of constructing a field expedient radio. It should be noted, however, that hand signals, signal flags, flashlights, telephones, and messengers can be used in place of a radio.

Limitations:

No voice communications to crew or driver

Personnel/Time Required:

- 1 soldier
- 0.1 hour

Materials/Tools:

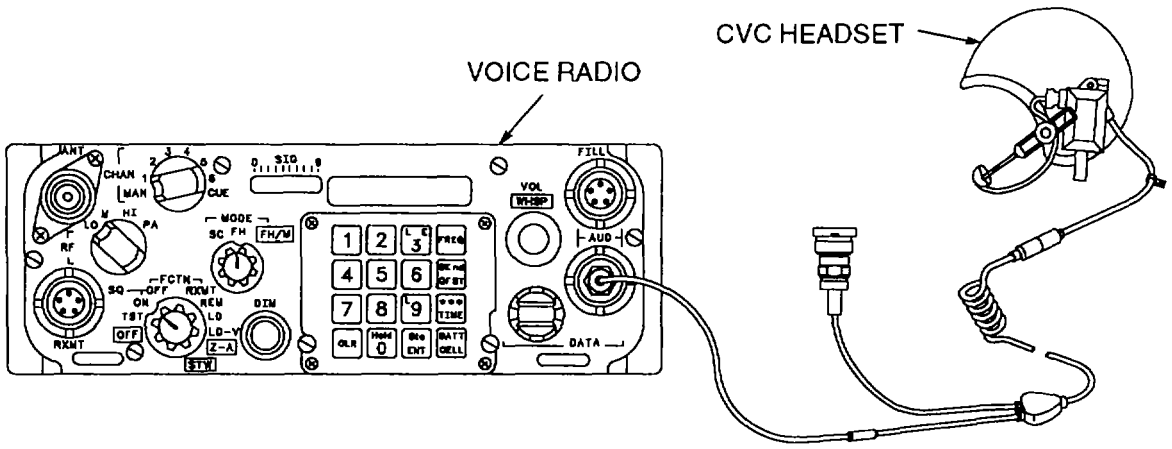
None

Other Options:

- Cable, telephone, WD-1/TT (scavenge from available source)
- Field telephone TA-312/PT, or TA-1/PT (scavenge from available source)

Procedural Steps:

1. Connect CVC helmet to audio output on voice radio.



2. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-7. RADIO MOUNT FIELD EXPEDIENT REPAIR

Because of the configuration of plugs and jacks located on the mount and the way that the radio sets and mounts are mated, the fixes are very limited. Power and signal cables are routed in and out of the mount through cables and plugs and in turn with a plug and jack method to the radio. If any of those plugs and jacks are damaged, the only feasible alternative is to replace the mount.

Limitations:

None

Personnel/Time Required:

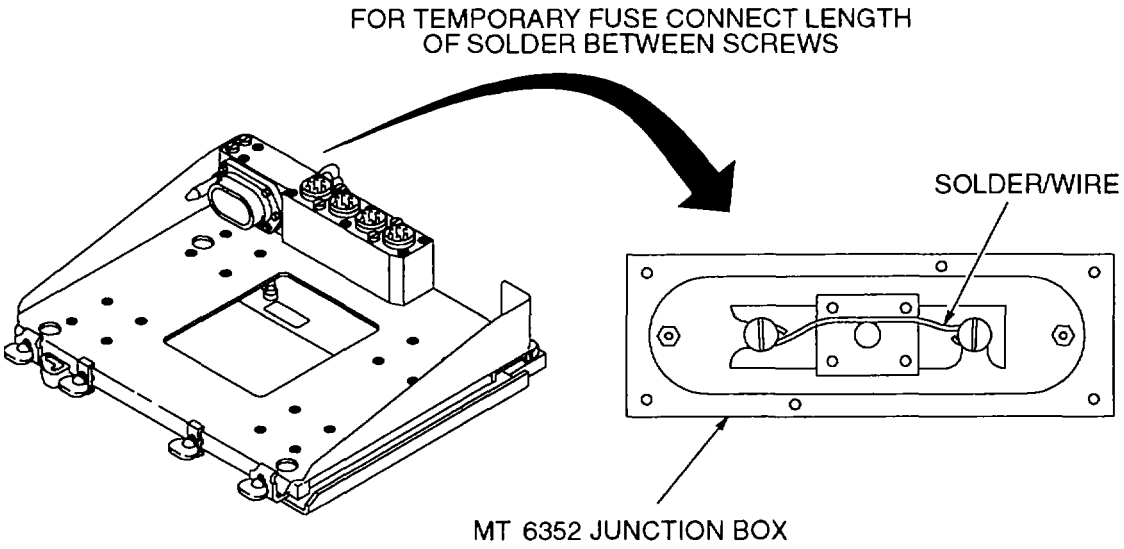
- 1 soldier
- 0.8 hour

Materials/Tools:

Solder, lead-tin alloy (item 58, Appendix C)

Procedural Steps:

1. Turn off MASTER power switch to the radios.
2. Remove radio from damaged mount.
3. Carefully remove damaged mount from vehicle.
4. Remove all cables from damaged mount and note their positions.
5. Remove undamaged plugs from mount and reconnect them to the proper cables.
6. Check for blown fuse in mount. The fuse junction box is located on top of radio receptacle plug. Replace a blown fuse with a piece of solder or wire.



13-7. RADIO MOUNT FIELD EXPEDIENT REPAIR - CONTINUED

7. Turn MASTER power switch ON.

8. Measure voltage on W26 (P2) (power cable) at terminals A (negative) and B (positive). Voltage should be between 22 and 30 V dc.

9. Turn MASTER power switch OFF.

10. Attach radio receptacle plug to radio.

11. Strap or tie down radio to prevent falling.

12. Make sure radio is grounded by connecting a wire from a screw on the radio to any convenient screw or bolt on the vehicle.

13. Turn MASTER power switch and radio ON Check radio for power operation.

14. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-8. ANTENNA, DAMAGED OR MISSING

General Information:

This procedure provides instructions for repairing or constructing antennas for receiving and transmitting over the radio.

CAUTION

Field repaired antennas are fragile and will not take much abuse. The continued use of field repaired antennas may result in damage to receiver/transmitters.

Option 1: Using WD-1/TT.

Limitations:

Slight reduction in reception and transmission range.

Personnel/Time Required:

- 2 soldiers
- 0.3 hour

Materials/Tools:

- Cable, telephone, WD-1/TT, 10 feet length (scavenge from available source)
- Plug, wooden (scavenge from available source)
- Pole, wooden or stick, 10 feet length (scavenge from available source)
- String or rope (scavenge from available source)
- Tape, insulation, electrical (item 63, Appendix C)

13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

Other Options:

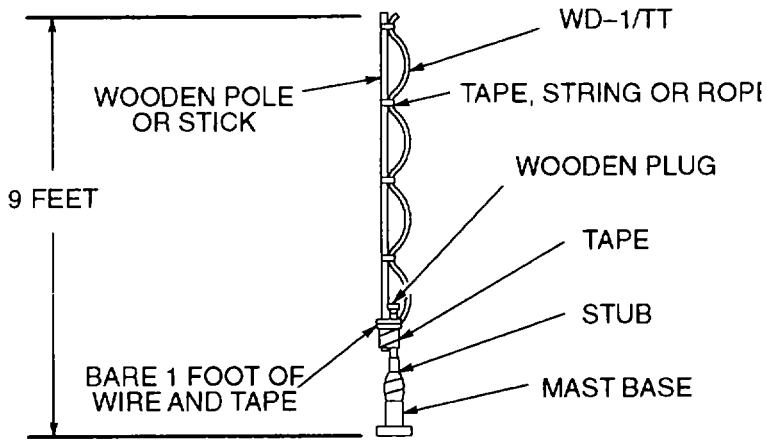
- Field expedient replacement antenna
- Field expedient ground plane antenna

Procedural Steps:

WARNING

Do not touch bare wires on repaired antennas with the radio keyed. You could get burned and/or shocked.

1. Scrape paint from top 2 or 3 Inches of the antenna stub.



2. Scrape insulation from 1 foot of telephone cable.

3. Attach remaining 9 feet of cable along length of pole with tape.

NOTE
Total length of cable and stub should not exceed 9 feet.

4. Hold pole along side of antenna stub and wrap bare cable tightly around scraped portion of antenna stub and wooden pole.

5. Push cable into stub hole and jam in place with a wooden plug.

6. Tape pole and peg to antenna stub.

7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

Option 2: Using coaxial cable.

Limitations:

May result in degraded performance.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Other Options:

Connect antenna cable to exterior antenna connector, if not damaged.

Materials/Tools:

- Cable, coaxial, RG-8 or RG-58, 20 feet length (scavenge from available source)
- Pencil, nail, or sharp stick (scavenge from available source)
- Pole, wooden or stick, 10 feet length (scavenge from available source)
- Rope (scavenge from available source)
- Tape, insulation, electrical (item 63, Appendix C)

Procedural Steps:

WARNING

Do not touch bare wires on repaired antennas with the radio keyed. You could get burned and/or shocked.

1. Measure off and mark, but do not cut, 5 feet of coaxial cable.

NOTE
Use care so that the shielded wire is not cut.

2. Strip outer insulation from cable in 1 foot lengths to expose braided shielded wire.

3. Bend cable into a loop, holding it with one hand.

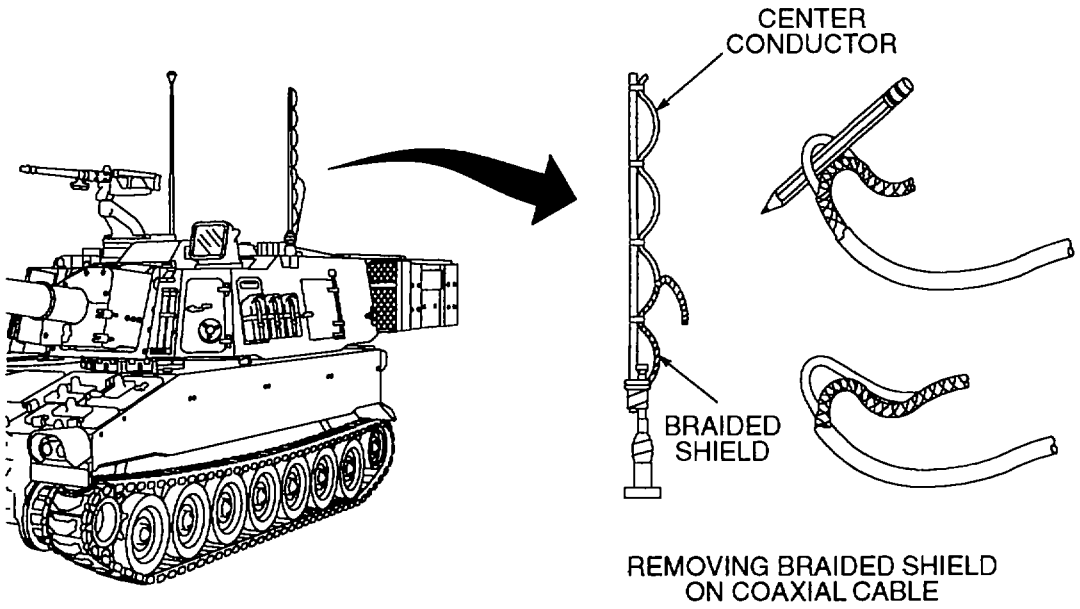
4. Separate braided shield from insulated center conductor using a pencil or nail, staying as close to remaining insulation as possible.

13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

5. Form a hole by working pencil/nail between insulation and center conductor.

6. Place a finger in hole and slowly pull the center conductor out of the insulation while keeping loop formed.

7. Tape center conductor to top portion and braided shield to bottom portion of a 10 feet pole Tape as necessary to hold cable securely in place.



REMOVING BRAIDED SHIELD
ON COAXIAL CABLE

8. Fasten pole to antenna base with rope or tape.

9. Feed remaining coaxial cable through antenna cable inlet in rear of vehicle.

NOTE

If there is a connector (twist type lock) on cable, attach it to radio antenna connector. If not, do steps 10, 11, 12, and 13.

10. Carefully strip outer insulation of coaxial cable to expose enough braided shield to reach a screw near antenna connector on radio case.

11. Use a pencil or nail and carefully separate braided shield from around insulated center conductor. Twist shield into a pigtail.

12. Strip inner insulation to expose enough center conductor to push into antenna connector.

13. Wedge center conductor into antenna connector and attach pigtail to a screw on radio case.

14. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

Option 3: Suitable mast.

Limitations:

Can only be used on a stationary vehicle and when a tree is available for suspension of the antenna.

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Cable, telephone, WD-1/TT, 1 roll (scavenge from available source)
- Insulators (e.g. , glass, plastic, leather, nylon, etc.), five required (scavenge from available source)
- Rope (item 52, Appendix C)
- Sticks or branches, 4 feet length, three required (scavenge from available source)

Procedural Steps:

WARNING

Do not touch bare wires on expedient antennas with the radio keyed. You could get burned and/or shocked.

1. Determine length of wire needed for radiating element of a one-quarter wave antenna using the following formula:

Length (feet)	=	234 divided by frequency (MHz)
		or
Length (meters)	=	71.37 divided by frequency (MHz)

EXAMPLE: radiating element for a frequency of 50 MHz:

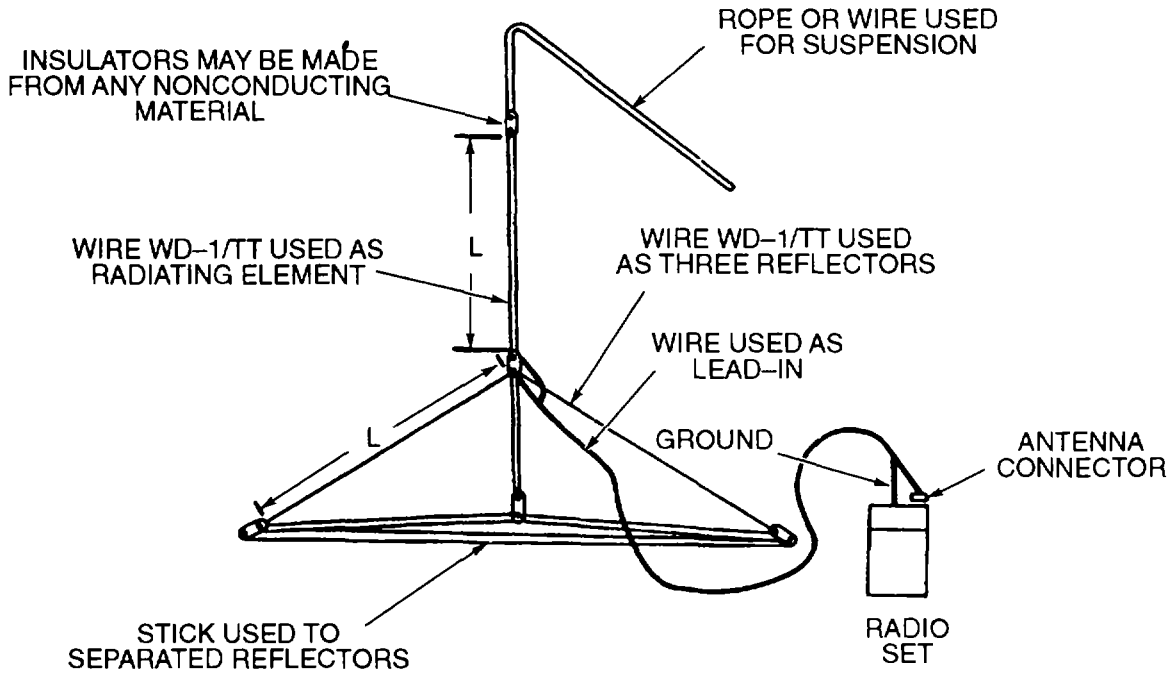
L (feet)	=	234 divided by 50 MHz = 4.68 feet
		or
L (meters)	=	71.37 divided by 50 MHz = 1.43 meters

2. Cut required length from telephone cable.

3. Cut three reflector elements approximately the same length as radiating element.

13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

4. Strip insulation from one end of three reflectors. Twist together and connect to an insulator.



5. Tie three sticks together, each approximately 4 feet long, to form a triangular support for lower ends of reflector elements.

6. Connect lower ends of reflector elements to corners of triangular support using three insulators.

CAUTION

Make sure radiating element does not touch the three reflectors. Damage to radio may result.

7. Connect one end of radiating element to insulator at upper end of reflector elements.

NOTE

If wire is used for suspension, make sure suspension wire does not touch the radiating element.

8. Connect an insulator and a suspension rope or wire to the upper end of the radiating element.

9. Cut a piece of telephone cable long enough to reach from auxiliary antenna connection at the rear of the vehicle to the height of the antenna.

13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

10. Strip insulation from one end of two cable wires.

11. Untwist wires enough to splice one wire to a bare section of the radiating element and the other wire to a bare section of the reflectors.

12. Toss suspension rope or wire over limb of a tree, and pull antenna up to desired height.

13. Strip insulation from other end of two-wire cable.

NOTE
Reverse connections at radio if communications are not satisfactory.

14. Connect one wire to the auxiliary antenna connector at the rear of the vehicle and the other wire to ground.

15. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

Option 5: Using 16 AWG electrical wire.

Limitations:

Reduced transmission and reception

Personnel/Time Required:

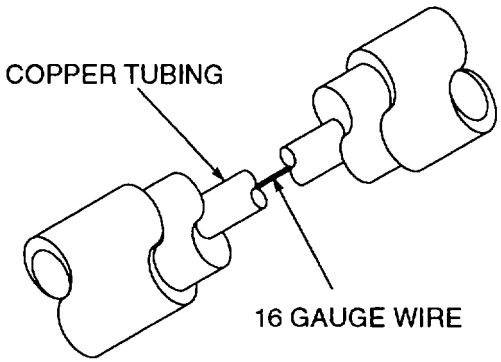
- 1 soldier
- 0.5 hour

Materials/Tools:

- Tape, insulation, electrical (item 63, Appendix C)
- Wire, electrical, 16 AWG (item 76, Appendix C)
- Flexible aluminum (scavenge from available source)
- Clamp (scavenge from available source)
- Fiberglass, repair kit (Item 50, Appendix C)

Procedural Steps:

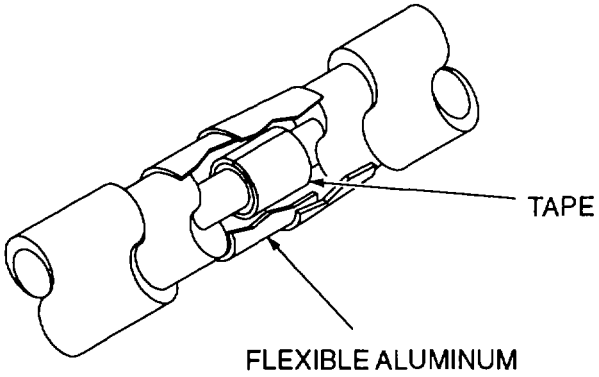
1. Cut the antenna into two pieces at the damaged point.
2. Expose the copper tubing inside both ends of the antenna.
3. Connect the two exposed ends of the copper tubing using 16 gauge electrical wire.



13-8. ANTENNA, DAMAGED OR MISSING - CONTINUED

4. Cover the connection with electrical tape.

5. Cut 2 strips of flexible aluminum 1 inch wide x 4 inch and wrap them around the aluminum tubing of the antenna.

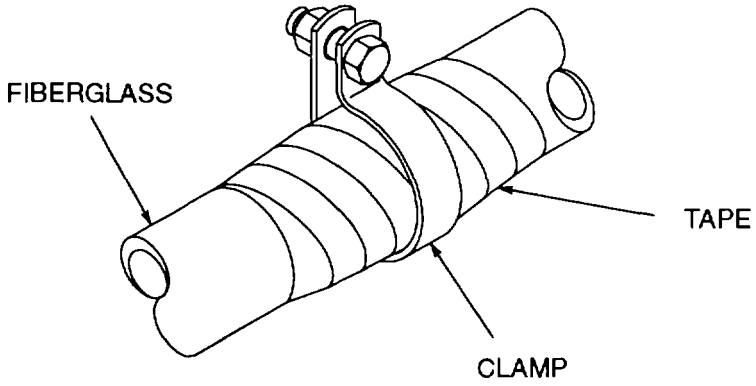


6. Cover the aluminum strips with electrical tape.

7. Use fiberglass repair kit to cover damaged area and follow kit instructions.

8. Wrap the damaged area with electrical tape.

9. Install clamp to secure the damaged area.



10. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-9. COAXIAL CABLE REPAIR

General Information:

This procedure gives instructions and identifies materials recommended for repair of coaxial or other shielded cables when standard replacement parts are not available.

Option 1: Using matching plug and jack.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.4 hour

Materials/Tools:

See illustrations in this procedure for materials required.

Other Options:

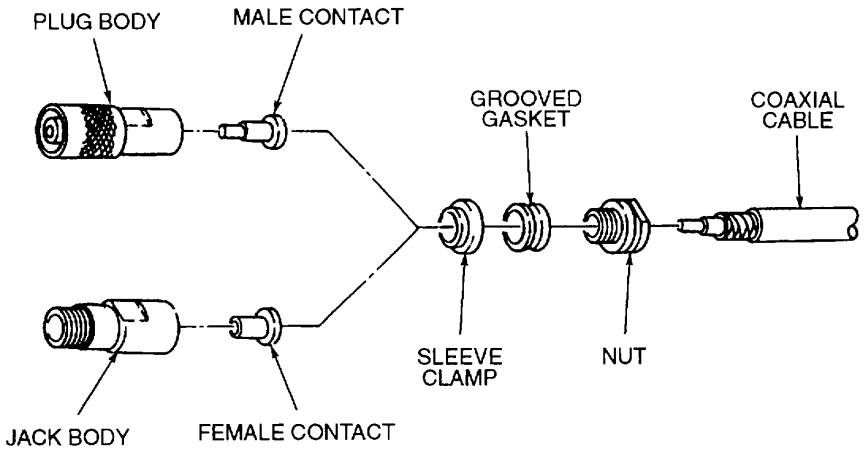
Reference shielded cable repair procedures in Chapter 3.

Procedural Steps:

NOTE

Do not attempt to repair broken or damaged coaxial cables unless absolutely necessary. Replace the entire cable whenever possible.

1. If replacement is not practical, install a matching plug and lack of the proper size and type for splicing the damaged or broken part.



2. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-9. COAXIAL CABLE REPAIR - CONTINUED

Option 2: Using conductive materials.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.5 hour

Materials/Tools:

- Tubular copper braid (scavenge from available source)
- Conductive foil (gum wrappers, cigarette packages) (scavenge from available source)
- Tape, pressure (aluminum) (found in M2/3 generic BDR kit, Section III, Appendix C)
- Kitchen foil (scavenge from available source)
- Tape, insulation, electrical (item 63, Appendix C)

Other Options:

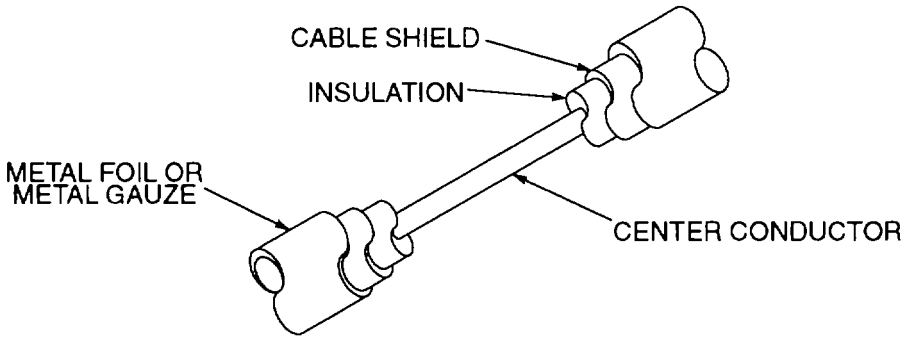
Remove one inch of insulation, unravel exposed shielding, and twist into pigtails. Join the pigtails by splicing in a piece of insulated wire. Insulate the entire repair when using either method of repair.

Procedural Steps:

CAUTION

To prevent damage to the equipment ensure that this repair is sufficiently insulated to prevent the center conductor from shorting to the shield.

1. Remove 1/2-inch of insulation from the shielding and join the severed ends of the shielding together by wrapping a conductive material over the repair. Some suitable materials are tubular copper braid, metal gauze, conductive foil from .gum wrappers. cigarette packages or common kitchen foil.



2. Wrap the entire repaired area with electrical tape.

3. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-10. INTERCOMMUNICATIONS CABLE REPAIR

General Information:

This procedure gives methods for connecting broken wires in multiple wire cables such as the CX-4723 intercommunications cables.

Limitations:

None

Personnel/Time Required:

- 1 soldier
- 0.2 hour per individual wire

Materials/Tools:

- Knife (found in M2/3 generic BDR kit, Section III, Appendix C)
- Tape, Insulation, electrical (item 63, Appendix C)
- Solder, lead-tin alloy (item 58, Appendix C)

Other Options:

Reference other methods for splicing wires and cables in Chapter 3.

Procedural Steps:

1. Turn off power or unplug cable at both ends if possible or at end nearest the damaged area.
2. Peel back outside insulation about 3 inches on each side of damaged area.
3. Identify wires with broken insulation and those with actual separated wires.
4. Tape those with broken insulation but with wire intact.
5. Cut clean ends on broken wires.
6. Strip insulation back 1/2-inch.
7. Matching color coding on wires, twist together, solder if possible, or tighten with pliers if available.
8. Bend twisted wires back along length of wire.
9. Tape repaired wire with length of tape.
10. When all wires are repaired, tape around entire bundle and try to seal insulation ends peeled back in step 2.
11. Plug cable back into equipment, turn on power, and test.
12. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-11. INTERCOMMUNICATIONS CONNECTING CABLES TOO SHORT

General Information:

This procedure gives methods for connecting two or more cables to make the desired cable length. This procedure is for CX-4723 cable. Other types of cables can be extended using similar methods.

Limitations:

- Preferred method - none
- Alternate methods - possible lowered volume

Personnel/Time Required:

- 1 soldier
- 0.4 hour

Materials/Tools:

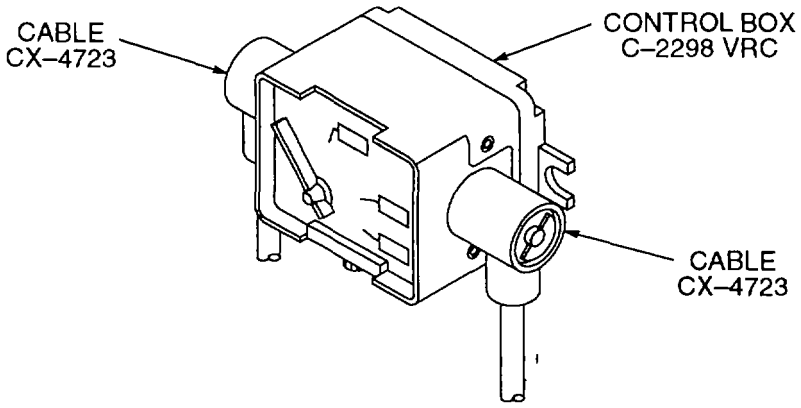
- Preferred method:
  Box, control, C-10456 or C-2298 VRC (scavenge from available source)
- Alternate method:
  Solder, lead-tin alloy (item 58, Appendix C)

Other Options:

- See other methods for spicing cables in electrical Chapter 3.
- Another method is fabricating a junction by removing the J-801 and J-804 connectors from a C-2298 control box. Solder jumper wires between the corresponding connector pins. Insulate the jumper wires and the rear of the connectors.
- A less desirable method is to remove one connector from each cable and splice the corresponding wires from the two cables together insulate the spice.

Procedural Steps:

1. Connect a C-2298 control box between the two CX-4723 cables.



2. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-12. ISOLATION OF NONESSENTIAL SYSTEMS (IF-146/VRC FILTER)

General Information:

This procedure gives Instructions for isolating and bypassing the IF/1461/NRC filter.

Limitations:

Possible loss of all communications.

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Procedural Steps:

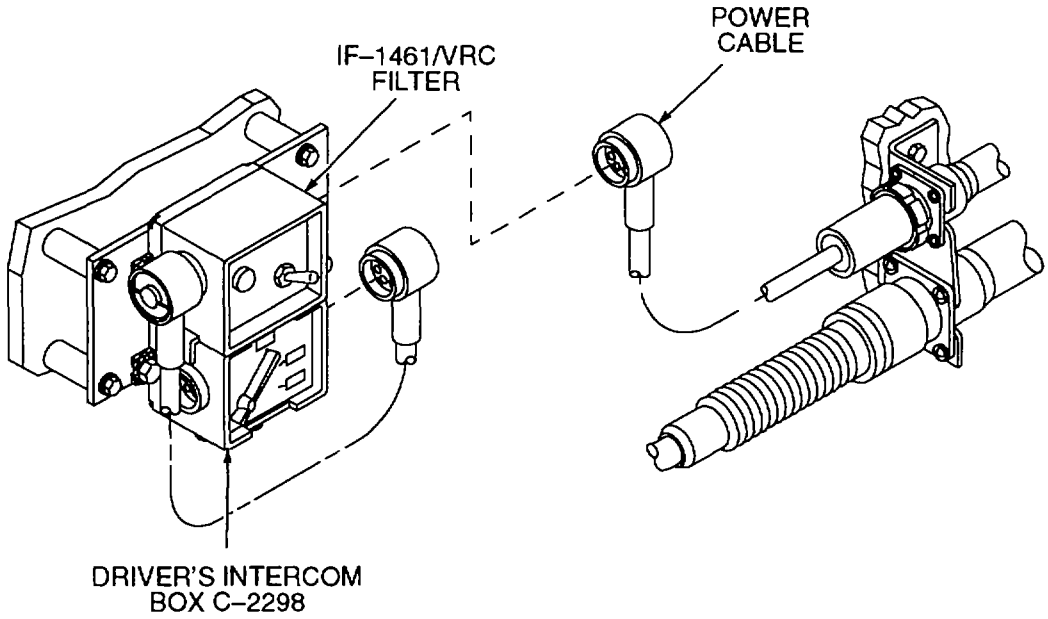
CAUTION

Without the IF-1461/VRC filter in the circuit, voltage spikes will be routed through the communications equipment and damage could occur. Bypass the suppressor only as a last resort.

1. Locate the IF-1461/VRC filter in the vicinity of the driver's compartment.

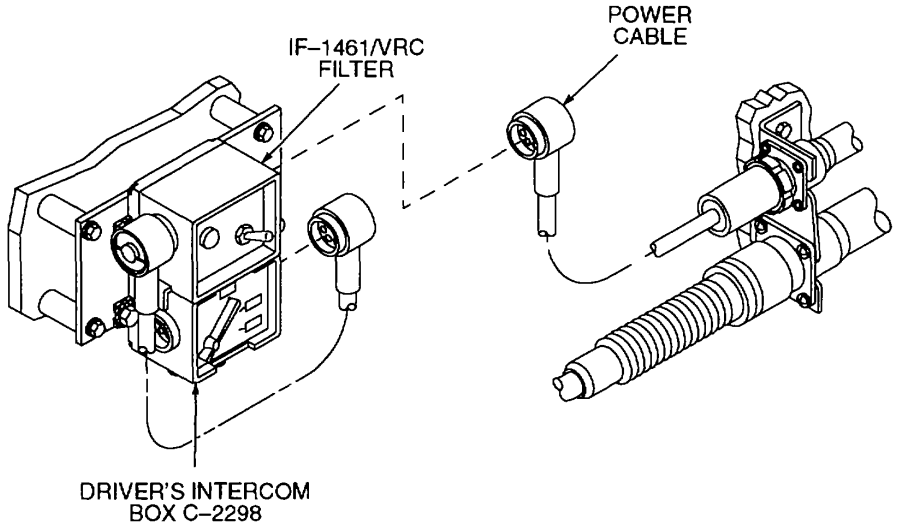
2. Disconnect the power cable from IF-146/VRC filter connector.

3. Disconnect the CX-4723 cable from the driver's intercom box C-2298.



13-12. ISOLATION OF NONESSENTIAL SYSTEMS (IF-146/VRC FILTER) - CONTINUED

4. Connect the power cable directly to the driver's intercom box C-2298.



5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. INTERCOM SYSTEM

13-13. GENERAL

The intercom system allows voice communications between the chief of section and all members of the crew to render this vehicle fully mission capable. The chief of section must have communication with the driver.

13-14. INTERCOM SYSTEM, INOPERATIVE

General Information:

This procedure restores communications between the chief of section and all members of the crew and driver.

Limitations:

- If the AM-1780 is nonoperational, the radio systems will not be usable through the intercom.
- If telephone cable WD-1/TT is routed to the driver's station, the cab cannot be traversed without cutting the cable.

Personnel/Time Required:

- 1 soldier
- 0.2 hour

Materials/Tools:

- If AM-1780 is nonoperational, one TA-312/PT or TA-1/PT field telephone for each station where requirement for intercom exists (scavenge from available source)
- If AM-1780 is operational, one TA-312/PT or TA-1/PT field telephone for each nonoperational C-2298 control box (scavenge from available source)
- Cable, telephone, WD-1/TT, 10 to 15 feet long (scavenge from available source)

13-14. INTERCOM SYSTEM, INOPERATIVE - CONTINUED

Procedural Steps:

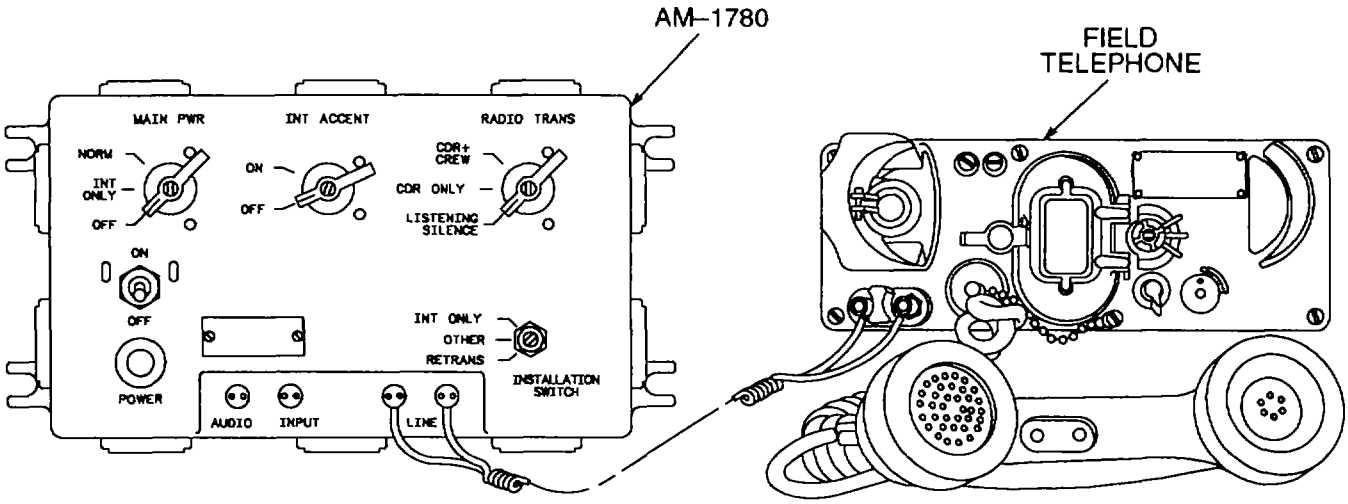
CAUTION

Do not crank or ring the field telephone because damage could occur to the AM-1780 and/or the entire AN/VIC-1 system.

NOTE

- **If the AM-1780 is not operational, do steps 1, 2, and 5.**
- **If one or more of the C-2298 control boxes becomes inoperable, but AM-1780 is still operational, do steps 2 through 5.**

1. Run wire in a circle throughout vehicle so that all telephones are connected to the same wire.
2. Place TA-312 or TA-1 field telephones at station(s) where bad control boxes are located.
3. Run field telephone wire back to AM-1780.
4. Hook up WD-1/TT wire to "LINE" jacks of the AM-1780.



5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

13-15. GENERAL INTERCHANGEABILITY INFORMATION

General Information:

Repairs made to combat damaged equipment should be the same as repairs made during the normal maintenance posture. However, due to the extreme nature of damage that might be found in combat-damaged equipment, normal maintenance procedures might not be sufficient. In the interest of rapidly repairing damage to communications system in this situation, it will often be faster to exchange some components rather than repair them. The following is a partial listing of interchangeable parts for the AM-1780 and the AN/VRC-894 as installed in the M109A6 on the battlefield. It is provided as a guide only and is not necessarily a complete listing of all components from other vehicles that could be substituted. This table considers only U S equipment. Any component that has been replaced should be turned in for repair through the normal channels and thereby returned to the inventory. When time permits, route all replaced cables to conform to the original configuration. If haste is essential, route replaced cables as necessary and secure them where possible to prevent damage to the cables.

13-16. EQUIPMENT INTERCHANGEABILITY LISTING

Nomenclature	Description	Compatible Component	Compatible Vehicle	Notes
1. ANTENNAS				
AS-1729	N/A	AS-1729	All radio	5, 6
AS-1729	N/A	AS-1729	All auxiliary receiver	5, 6
2. INTERCOM				
AM-1780	Amplifier	A-1780	All w/AN/VIC-1	1
C-2298	Member control box	C-10456	M1, M2, M3	1
C-2298	Member control box	C-2298	All w/AN/VIC/1	1
3. CABLES				
CX-4723	2ft 0 in.	CX-4723	M551, MAB	1, 2, 4
CX-4723	3 ft 0 in.	CX-4723	M60, M551, M2, M3, MAB	1, 2, 4
CX-4723	4 ft 0 in.	CX-4723	M901, M109	1, 2, 4
CX-4723	4 ft 6 in.	CX-4723	M561, M1, M2, M3, M88 M113, M901	1, 2, 4
CX-4723	5 ft 0 in.	CX-4723	M551, M577, AVLB 2, 5	1, 2, 4
CX-4723	6 ft 0 in.	CX-4723	AVLB	1, 2, 4
CX-4723	7 ft 0 in.	CX-4723	M1, M2, M3, M110	1, 2, 4
CX-4723	8 ft 0 in.	CX-4723	M2, M88, M110, M151 MAB	1, 2, 4
CX-4723	9 ft 0 in.	CX-4723	M60, M88, M 113, M577 M578, M901	1, 2, 4
CX-4723	10 ft 0 in.	CX-4723	M60, MAB, M88, M578	1, 2, 4
CX-4723	12 ft 0 in.	CX-4723	M3	1, 2, 4

13-16. EQUIPMENT INTERCHANGEABILITY LISTING - CONTINUED

Nomenclature	Description	Compatible Component	Compatible Vehicle	Notes
3. CABLES - CONTINUED				
CX4723	13 ft 0 in	CX4723	M88	1, 2, 4
CX-4723	14 ft 0 in	CX4723	M551	1, 2, 4
CX-4723	15 ft 0 in	CX-4723	M2, M109	1, 2, 4
CX-4723	16 ft 0 in	CX-4723	M60, M901	1, 2, 4
CX-4723	18 ft 0 in	CX4723	M110	1, 2, 4
CX-4723	20 ft 0 in	CX-4723	M1, M60	1, 2, 4
CX-4723	21 ft 0 in	CX-723	M1	1, 2, 4
CX-9640	1 t 6 in	CX-9640	M109	1, 2, 4
CX-9640	2 ft 6 in	CX-9640	M109	1, 2, 4
CX-13089	2 ft 1 in	CX-13089	M109	1, 2, 4
CX-13089	3 ft 0 in	CX-13089	M88	1, 2, 4
CX-13089	7 ft 0 in	CX-13089	M2, M3	1, 2, 4
CX-13089	10 ft 0 in	CX-13089	M578	1, 2, 4
4. CV HELMETS				
CVC	MK-1039	DH-132	Most with AN/VIC-1	1, 2, 4
DH-132	MK-1697	CVC	Older vehicles w/AN/VIC-1	1, 2, 3 6
5. TRANSIENT VOLTAGE SUPPRESSORS				
MX-7777, MX-7778	Suppressor	MK-2096 MX-7778 MX-7777	All w/AN/VIC-1	1

NOTES

NOTE #1 - No degradation. Continue normal mission.

NOTE #2 - Any cable with the same number can be substituted if it is of an equal length to or longer than the cable being replaced. Most of the time a shorter cable can also be used by routing it in the most direct path between components. Additionally, two shorter cables can be spliced together to attain the desired length.

NOTE #3 - Ensure the connector compatability. If the older type CVC helmet is substituted for the DH-132 series helmet then the cord assembly CX-8650 B/GR must also be exchanged with the CVC-helmet.

NOTE #4 - Any cable with the same number can be substituted if it is of equal length to or longer than the cable being replaced. Most of the time a shorter cable can also be used by routing it in the most direct path between components. Additionally, two shorter cables can be spliced together to attain the desired length.

13-16. EQUIPMENT INTERCHANGEABILITY LISTING - CONTINUED

NOTE #5 - The AS-1729 antennas can be used to replace the AS-3900 antennas, however the complete system, including the base matching unit, must be used.

NOTE #6 - All frequency adjustments must be made manually.

CHAPTER 14
AUXILIARY EQUIPMENT

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

14-1. SCOPE

This chapter contains fault assessment and repair procedures available to find and fix battlefield damage to equipment other than that needed for howitzer mobility

14-2. ASSESSMENT PROCEDURE

There is no specific assessment procedure for auxiliary equipment. Refer to the Repair Procedure Index (para 14-3) for available BDAR fixes

14-3. REPAIR PROCEDURE INDEX

SECTION II. MICROCLIMATE CONDITIONING SYSTEM (MCS)

14-4. GENERAL

The MCS system provides decontaminated, conditioned air supply for crewmen operating under Nuclear, Biological, and Chemical conditions. Failure of the MCS will result in contaminated air.

14-5. MCS CONTROL BOX DEFECTIVE

General Information:

The control box contains a four position multi-ganged switch which permits choosing HIGH or LOW volume air flow from the blower motor and turns the compressor motor and the vaneaxial fan ON or OFF. The only BDAR fix for the switch is replacement.

For replacement of defective switch, see Chapter 3, "Switches Damaged".

14-6. MCS CIRCUIT BREAKERS DEFECTIVE

General Information:
nMCS circuit breakers provide protection for a malfunctioning electric circuit within the MCS system. When a circuit breaker becomes damaged it will open removing electrical power from the circuit. The only BDAR fix is to bypass the damaged circuit breaker.

For BDAR fix of a circuit breaker see Chapter 3, para 3-16 "Circuit Breakers Damaged".

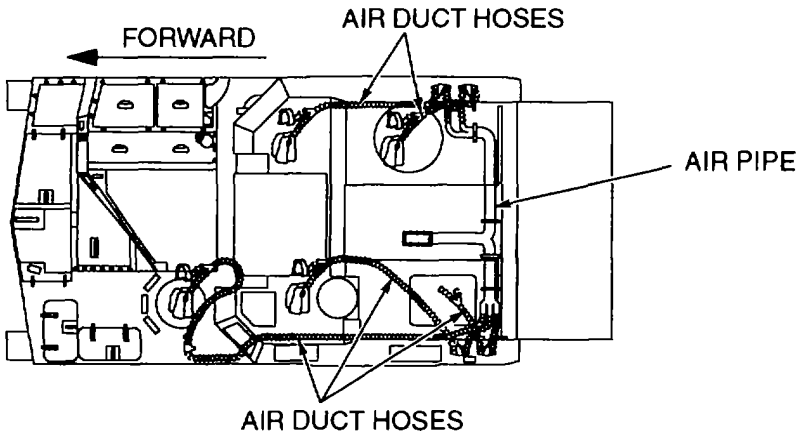
14-7. MCS M3 HEATER DEFECTIVE

General Information:
The M3 heater warms the air for each individual member of the crew keeping them comfortable and thereby maintaining a high level of effectiveness and efficiency of the crew.

There is no BDAR action to return a defective heater to normal operation, however, since all heaters are identical they can be relocated by moving from one station to another depending on critical needs and priorities.

14-8. MCS AIR DUCT HOSES AND AIR PIPE PERFORATED

General Information:
Warmed, filtered, and conditioned air is ducted through the microclimate air pipe and air duct hoses to the crew members at 5 separate locations in the vehicle. Damaged air ducts allow air to escape preventing adequate air supply to all stations.



Limitations:
None

Personnel/Time Required:
- 1 soldier
- 0.1 to 0.5 hour

Materials/Tools:
- Tape, duct (item 62, Appendix C)
- Knife

References:
TM 9-2350-314-20-1-2

14-8. MCS AIR DUCT HOSES AND AIR PIPE PERFORATED - CONTINUED

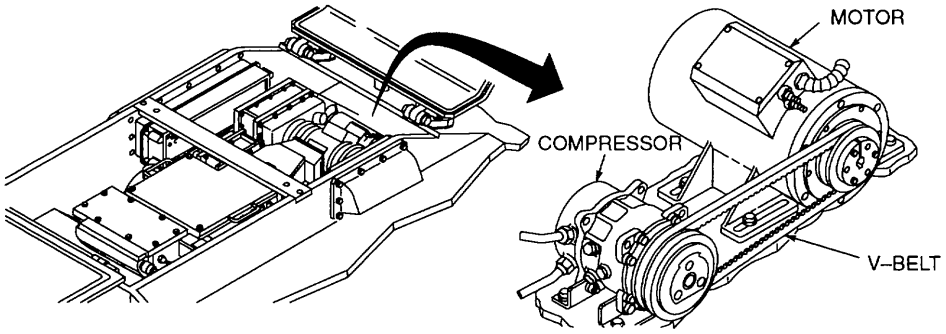
Procedural Steps:

1. Locate tear or perforation from which air is leaking.
2. Remove any rough edges or lagged points which might puncture tape, especially on air pipe.
3. Clean area around tear or puncture so tape will properly adhere to surface and prevent air leakage.
4. Apply duct tape to torn or perforated air duct, covering an area large enough to allow tape to remain attached when air flow in duct is maximum.
5. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

14-9. MCS COMPRESSOR/MOTOR V-BELT DAMAGED

General Information:

The compressor is driven by a small electric motor. The power is transferred from the motor to the compressor via a 29 x 0.531 V-belt. Because the compressor presents a constant load to the motor, it is very difficult to repair a damaged belt well enough to function adequately. Therefore, the BDAR fix is limited to replacing the belt.



Limitations:
None

Personnel/Time Required:
- 1 soldier
- 1.0 hour

Materials/Tools:
- V-Belt, (found in M2/3 generic BDR kit, Section III, Appendix C)
- V-Belt tool (found in M2/3 generic BDR kit, Section III, Appendix C)

References:
TM 9-2350-314-20-2-2

Procedural Steps:
1. Loosen 6 mounting screws on compressor motor so that motor can be moved as required to remove damaged belt.

14-9. MCS COMPRESSOR/MOTOR V-BELT DAMAGED - CONTINUED

2. Remove damaged belt.
3. Get 1/2-inch V-belt from M2/3 generic BDR kit and remove or add links as necessary to achieve the required length using kit instructions.
4. Mount belt on compressor and motor.
5. Adjust belt to proper tension.
6. Tighten all 6 screws on motor base making sure tension on belt remains correct.
7. Record BDAR action taken. When mission is complete, as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION III. PERSONNEL HEATER

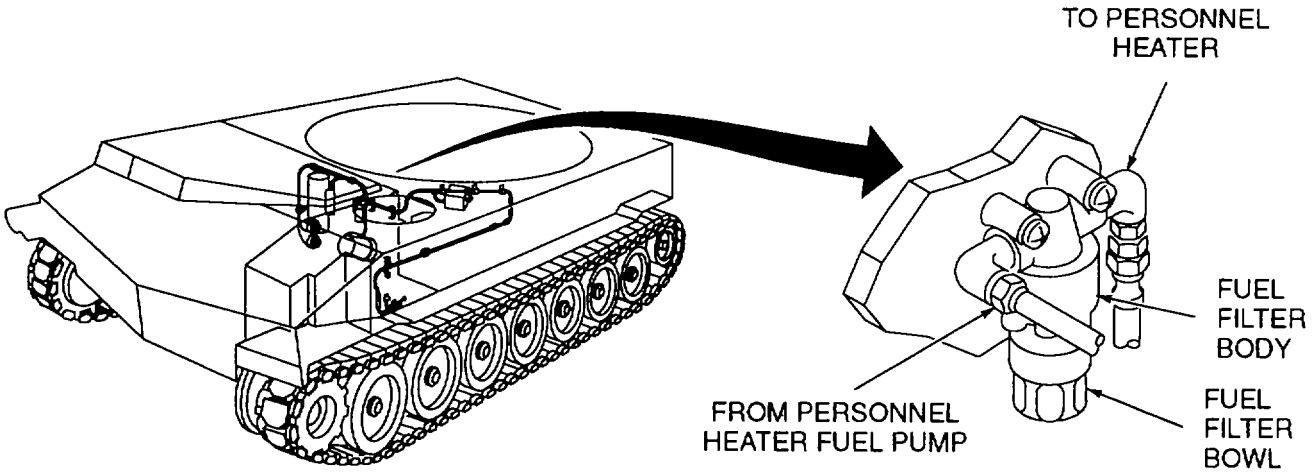
14-10. GENERAL

The personnel heater supplies warm air for the cab enclosure allowing more efficient performance of the crew, and ensuring proper operating temperatures for the equipment. Failure of the heater in a cold climate will reduce crew efficiency and performance and may reduce the effectiveness of the equipment.

14-11. IN-LINE FILTER ELEMENT CLOGGED

General Information:

Water and contaminates are removed from the fuel by the personnel heater in-line filter element. Contaminates collected in the in-line fuel filter can cause loss of pressure and reduce fuel flow. Also at low temperatures, water accumulated in the fuel filter bowl may freeze blocking fuel flow to the personnel heater.



Limitations:

Personnel heater fuel filtration will be reduced.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

14-11. IN-LINE FILTER CLOGGED - CONTINUED

Materials/Tools:

Tape, antiseizing (item 61, Appendix C)

References:

TM 9-2350-314-20-1-2

Procedural Steps

1. Remove fuel filter bowl from fuel filter body being careful not to damage fuel filter bowl gasket.
2. Remove filter element and discard.
3. Clean old tape from threads of filter bowl and wrap threads of fuel filter bowl with new antiseizing tape.

NOTE

If antiseizing tape is not available, the BDAR fix can still be completed, but seeping may occur.

4. Mount fuel filter bowl and filter bowl gasket on fuel filter body.
5. Clean up spilled fuel as necessary.
6. Operate personnel heater and check for leaks.

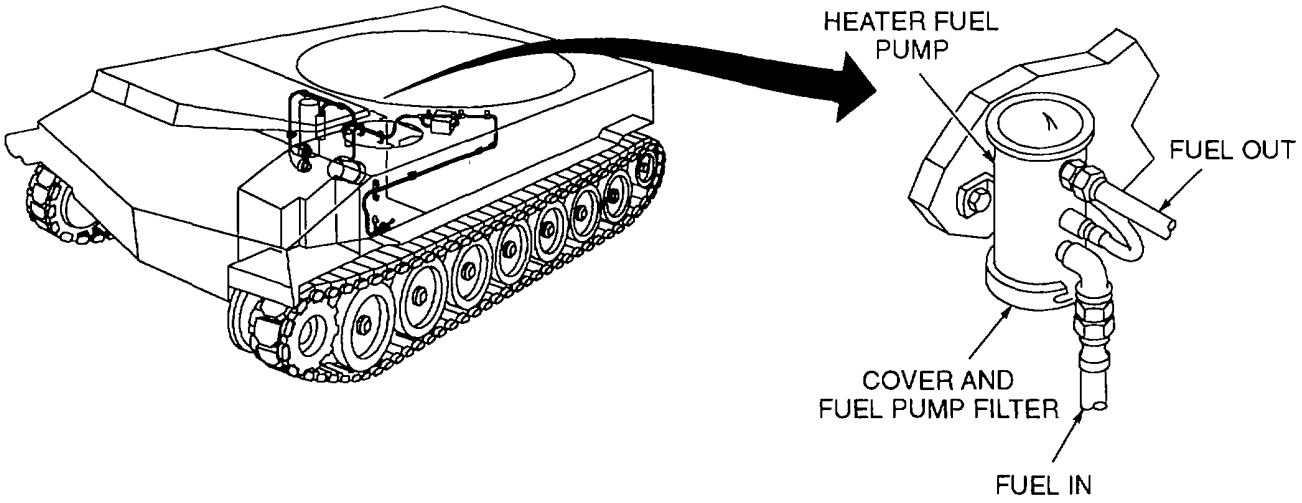
NOTE

Expect some leaks on low pressure side.

7. Check connections for leaks.
8. Record BDAR action taken. When mission is complete, as soon as practical, repair the system/equipment using standard maintenance procedures.

14-12. FUEL PUMP FILTER CLOGGED

General Information:
Water and contaminates are removed from the fuel by the fuel pump filter element. Contaminates collected in the fuel pump filter can cause loss of pressure and reduce fuel flow.



14-12. FUEL PUMP FILTER CLOGGED - CONTINUED

Limitations:

Personnel heater fuel filtration will be reduced.

Personnel/Time Required:

- 1 soldier
- 0.3 hour

References:

TM 9-2350-314-20-1-2

Procedural Steps:

1. Remove cover from bottom of heater fuel pump.
2. Remove fuel pump filter and discard.
3. Insert cover on bottom of fuel pump.
4. Clean up spilled fuel as necessary.
5. Operate fuel pump and check for leaks.

NOTE

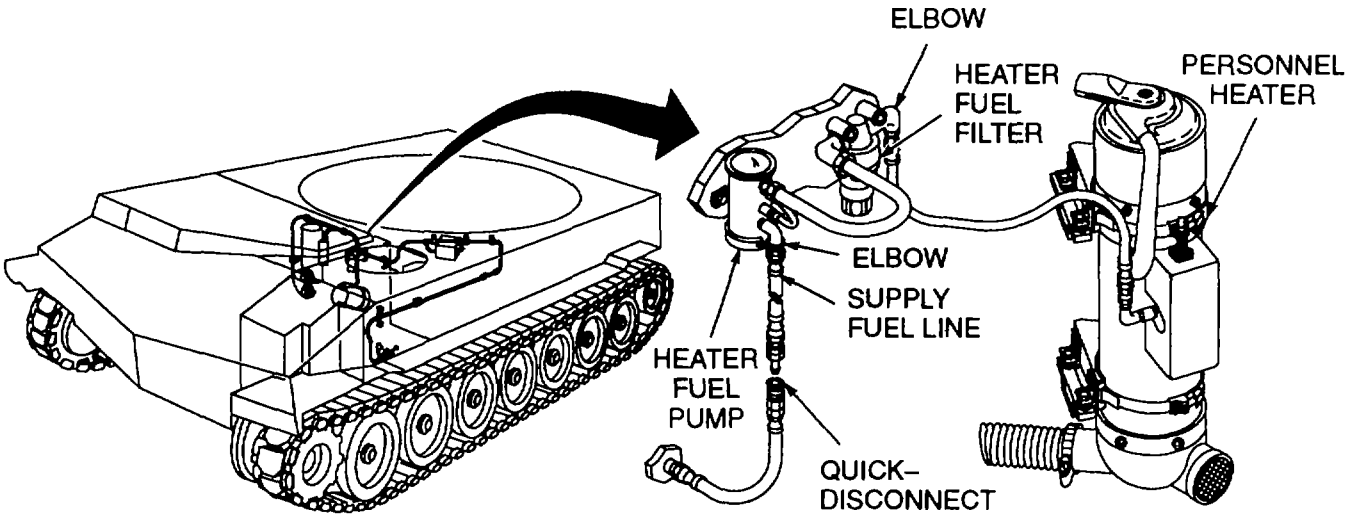
Expect some leaks on low pressure side.

6. Check connections for leaks.
7. Record BDAR action taken. When mission is complete, as soon as practical, repair the system/equipment using standard maintenance procedures.

14-13. PERSONNEL HEATER FUEL LINE DAMAGED

General Information:

Fuel lines damage may consist of crimped lines, broken lines, blocked lines, leaking joints, etc. The following procedures should restore proper pressure and flow rate of personnel heater fuel.



14-13. PERSONNEL HEATER FUEL LINE DAMAGED - CONTINUED

Limitations:

If filter is removed, fuel may contain contaminants and water.

Personnel/Time Required:

- 1 soldier
- 1.0 hour

Materials/Tools:

Tape, antiseizing (Item 61, Appendix C)

References:

TM 9-2350-314-20-1-2

Procedural Steps:

WARNING

Spilled fuel is highly flammable and slippery on steel deck. Using rags, wipe away all traces of spilled fuel and properly dispose of rags. Failure to heed this warning can result in personnel injury or death.

NOTE

- **If fuel line tubes, elbows, and/or hoses are cracked, bent, or leaking, refer to paragraph 3-22.**
- **Place suitable container beneath heater fuel pump, heater fuel filter, and/or fuel lines to collect any fuel that may leak out.**

1. Remove fuel line tube from the elbow at the input to the heater fuel pump.
2. Lower open end of fuel line and look for fuel to flow from line. If fuel does flow from line, reconnect line and go to step 8.
3. If fuel did not flow in step 2, separate fuel line above quick-disconnect, leaving male connector in quick-disconnect so fuel can flow.
4. If fuel flows from quick-disconnect, remove quick-disconnect and then remove blockage from line using compressed air. Reconnect fuel line tube to heater fuel pump.
5. If fuel does not flow from quick-disconnect, remove fuel line from bulkhead.
6. If fuel flows from bulkhead connector, remove blockage from line using compressed air. Reconnect fuel line tube at quick-disconnect and at bulkhead.
7. If fuel does not flow from bulkhead connector, blockage is in engine compartment and powerpack will have to be removed to isolate cause of blockage. Reconnect line at this time.
8. Remove heater fuel pump outlet tube from heater fuel pump.

14-13. PERSONNEL HEATER FUEL LINE DAMAGED - CONTINUED

9. Set MASTER power switch to ON.
10. Set PERSONNEL HEATER switch to ON.
11. Check fuel flow at output of heater fuel pump.
12. Set MASTER power switch and PERSONNEL HEATER switch to OFF.
13. If fuel did not flow from heater fuel pump perform the following steps:

    (a) Carefully remove filter from heater fuel pump and clean filter to remove contaminates Reinsert filter and repeat steps 9 thru 12.
    (b) If fuel still does not flow, remove and discard filter. Repeat steps 9 thru 12.
    (c) If fuel still does not flow, replace heater fuel pump and reconnect heater fuel pump outlet tube to heater fuel pump.

14 If fuel did flow, reconnect fuel pump outlet tube to heater fuel pump.
15. Remove heater fuel filter outlet tube from heater fuel filter at elbow.
16. Repeat steps 9 and 10.
17. Check fuel flow at output of heater fuel filter elbow.
18. Repeat step 12.
19. If fuel did not flow from heater fuel filter output elbow perform the following steps.

    (a) Remove fuel filter bowl from fuel filter body, being careful not to damage fuel filter bowl gasket. Remove fuel filter from fuel filter bowl and clean filter to remove contaminants.
    (b) Clean old tape from threads of filter bowl and wrap threads with new antiseizing tape.
    (c) Reinsert filter into filter bowl. Install filter bowl gasket and filter bowl to filter bowl body taking care not to damage filter bowl gasket.
    (d) Repeat steps 15 through 18.
    (e) If fuel still does not flow, remove filter bowl and discard filter. Reinstall filter bowl gasket and filter bowl to filter bowl body taking care not to damage filter bowl gasket.
    (f) Repeat steps 15 thru 18.
    (g) If fuel still does not flow, remove heater fuel pump outlet tube from heater fuel pump and clear blockage from fuel line tube, elbows, and heater fuel filter body using compressed air.
    (h) Reconnect fuel line tube at heater fuel pump outlet and at heater fuel filter outlet.

20. If fuel did flow from heater fuel filter output elbow, remove fuel line tube from heater fuel filter to personnel heater at personnel heater.
21. Using compressed air, remove any blockage from fuel line tube.

14-13. PERSONNEL HEATER FUEL LINE DAMAGED - CONTINUED

22. Connect fuel line tube at elbow on heater fuel filter.
23. Repeat steps 9 and 10.
24. Check fuel flow at output of fuel line tube.
25. If pressure and flow rate are adequate, replace fuel line tube, at input to personnel heater.
26. If heater still does not operate, replace heater.
27. Check operation of personnel heater.
28. Check all fuel line tubes and fittings for leaks.
29. Clean up any spilled fuel, as necessary, using cleaning rags. Properly dispose of dirty rags.
30. Record BDAR action taken. When mission is complete, or as soon as practical, repair the equipment/system using standard maintenance procedures.

SECTION IV. LEAD FILTER SYSTEM

14-14. GENERAL

The lead filter system is designed for the removal of contaminants, primarily lead contaminants, that are present in the propellent fumes generated when the cannon is fired. Failure of the lead filter system will allow fumes to enter the crew cab, thereby, causing the crewmembers to breathe the toxic fumes. BDAR action of the lead filter system is limited to the accessory control box.

14-15. ACCESSORY CONTROL BOX

General Information:

The accessory control box contains a circuit breaker and the ventilation fan selector switch which applies power to the lead filter fan, when in the UP position. The only BDAR fix for the lead filter system is to replace the circuit breaker and/or the ventilation fan selector switch when they are damaged or when they malfunction.

For BDAR fix of the ventilation fan selector switch, see Chapter 3, para 3-15 "Switches Damaged".

For BDAR fix of the circuit breaker, see Chapter 3, para 3-16 "Circuit Breakers Damaged".

APPENDIX A

REFERENCES

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

This appendix lists publications referenced in this manual which may be required for Battlefield Damage Assessment and Repair of the M109A6 Howitzer. Appropriate indexes should be consulted frequently for latest applicable changes and revisions.

SECTION II. LIST OF REFERENCED PUBLICATIONS

Publication Number	Title
CTA 8-100	Army Medical Department Expendable/Durable Items
CTA 50-970	Expendable/Durable Items (Except Medical, Class V, Repair Parts, and Heraldic Items)
DA Form 2028	Recommended Changes to Publications and Blank Forms
DA Form 2404	Equipment Inspection and Maintenance Worksheet
DA Form 2407	Maintenance Request
DA PAM 738-750	The Army Maintenance Management System (TAMMS)
DD Form 1577	Unserviceable (Condemned) Tag - Material
FM 3-5	NBC Decontamination
FM 20-22	Vehicle Recovery Operations
FM 20-30	Battlefield Damage Assessment and Repair
FM 21-11	First Aid for Soldiers
LO 9-2350-314-12	Lubrication Order, Howitzer, Medium, Self-Propelled: 155MM, M109A6
SF 368	Product Quality Deficiency Report
TB 9-1300-278	Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor which contain Depleted Uranium
TM 9-254	General Maintenance Procedures for Fire Control Material
TM 9-2350-276-BD	Operator's, Organizational, Direct Support, and General Support Maintenance, Battlefield Damage Assessment and Repair for Combat Vehicles
TM 9-2350-314-10	Operator's Manual for Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2350-314-20-1-1	Unit Maintenance Manual for Hull Systems and Components, Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2350-314-20-1-2	Unit Maintenance Manual for Hull Systems and Components, Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2350-314-20-2-1	Unit Maintenance Manual for Cab Systems and Components, Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2350-314-20-2-2	Unit Maintenance Manual for Cab Systems and Components, Howitzer, Medium, Self-Propelled 155MM, M109A6

SECTION II. LIST OF REFERENCED PUBLICATIONS - CONTINUED

Publication Number	Title
TM 9-2350-314-24P-1	Unit, Direct Support and General Support Maintenance Repair Parts and Special Tools List for Hull Associated Components of Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2350-314-24P-2	Unit, Direct Support and General Support Maintenance Repair Parts and Special Tools List for Cab Associated Components of Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2350-314-34-1	Direct Support and General Support Maintenance Manual for Hull Systems and Components of Howitzer, Medium, Self-Propelled: 155MM, M109A6
TM 9-2350-314-34-2	Direct Support and General Support Maintenance Manual for Cab Systems and Components of Howitzer, Medium, Self-Propelled 155MM, M109A6
TM 9-2520-234-35	Field and Depot Maintenance Manual for Power Train Assembly
TM 9-2815-202-34	Direct Support and General Support Maintenance for Diesel Engine Model 7083-7391, 7395, 7396, 7398 and 7399

APPENDIX B
SPECIAL OR FABRICATED TOOLS

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

B1. SCOPE

This appendix lists fabricated tools recommended for the support of the M109A6 howitzer in a combat environment.

B-2. GENERAL

The fabricated tools listed in Section II are tools to be used for testing when test equipment is not available.

SECTION II. FABRICATED TOOLS

Description:

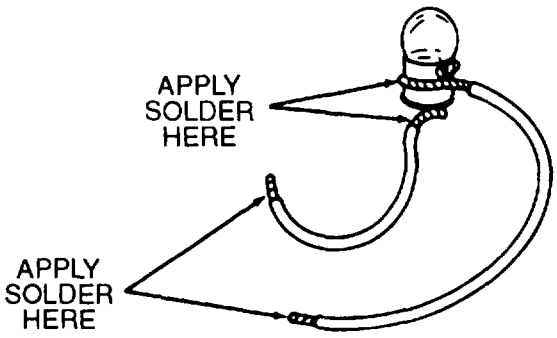
Voltmeter, 18-30 V dc, 5 V dc or less

NOTE

The voltage rating of the bulb should be close to the value of the expected voltage being measured.

Materials/Tools:

- Bulb
- Wire, electrical, length as required, two pieces
- Solder
- Soldering iron



Voltmeter Fabrication/Test Procedure:

1. Solder a wire to center terminal and another wire to case of bulb.

SECTION II. FABRICATED TOOLS - CONTINUED

NOTE

An 18- to 30-volt bulb from the driver's instrument panel can be used A 5-volt bulb from a 2-battery flashlight also can be used.

2. Touch soldered wire ends to voltage source test voltage.

NOTE

Polarity need not be observed - even alternating current voltage can be tested.

Description:

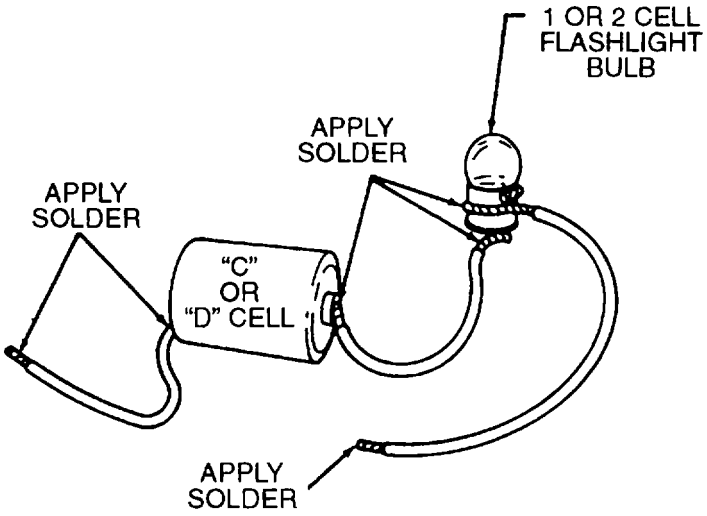
Ohmmeter

NOTE

If a two-cell flashlight bulb is used with only one battery, the bulb glow will be dim.

Materials/Tools:

- Bulb, flashlight
- Battery, flashlight
- Wire, electrical, length as required, three pieces
- Solder
- Soldering iron



Ohmmeter Fabrication/Test Procedure:

1. Solder end of two wires to bulb.
2. Solder one wire from bulb to end of battery.
3. Solder third wire to other end of battery.
4. Tin two loose ends.
5. Test voltage by touching loose wire ends together.

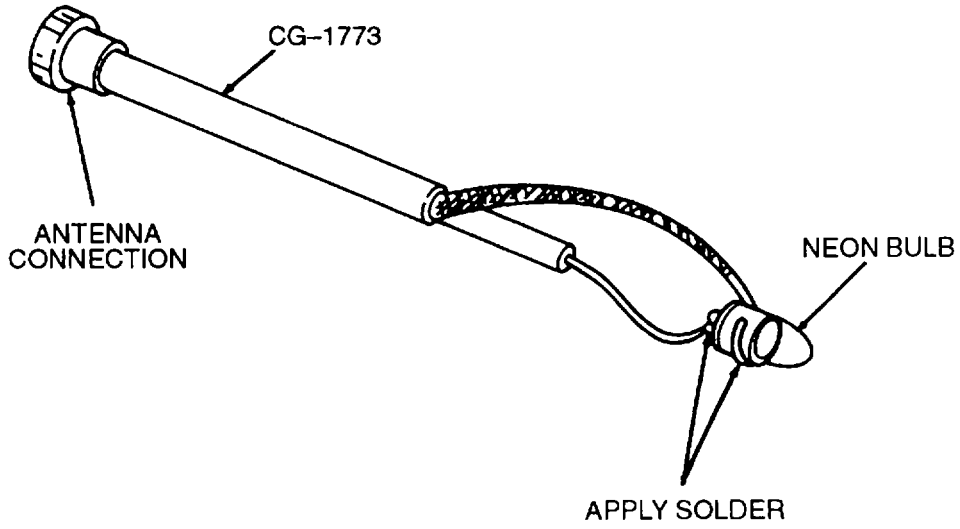
SECTION II. FABRICATED TOOLS - CONTINUED

Description:

RF Transmitter Output Tester

Materials/Tools:

- Bulb, neon light
- Cable, radio frequency, CG-1773, one piece
- Solder
- Soldering iron



RF Transmitter Output Tester Fabrication/Test Procedure:

1. Solder cable to bulb.
2. Connect cable to antenna connection on front of radio.
3. Key radio. The bulb will glow if RF power is present at antenna connection.

SECTION II. FABRICATED TOOLS - CONTINUED

Description:

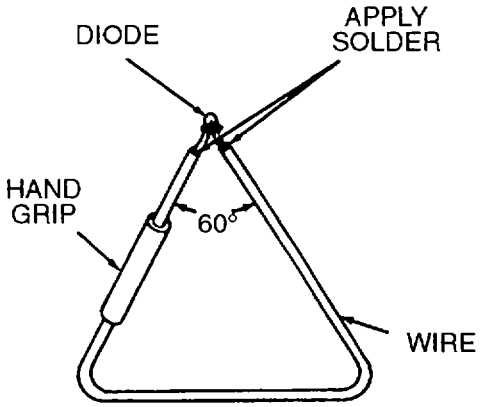
Antenna Output Tester

NOTE

The diode light will give an indication of signal strength. The brighter the light, the stronger the signal.

Materials/Tools:

- Diode, light emitters (LED)
- Wire, electrical, 10 AWG, 18-inch piece (scavenge from available source)
- Insulator or hand grip
- Solder
- Soldering iron



Antenna Output Tester Fabrication/Test Procedure:

1 Bend wire into a triangle, as shown.
2 Add insulator or hand grip for safety.
3 Solder diode across open ends of wire.
4 Hold tester vertically and move it toward antenna.
5 Key radio and watch diode. Do not move diode too close to antenna or it will burn out.

SECTION II. FABRICATED TOOLS - CONTINUED

Description:

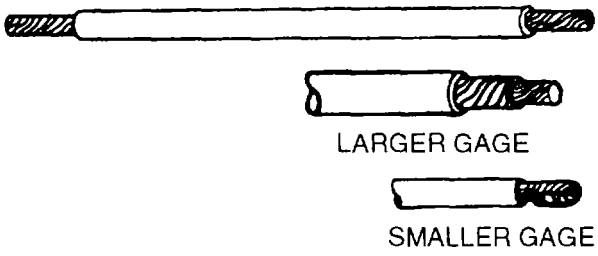
Jumper Wires

NOTE

This jumper wire is not for use with test jack connectors. It can short-circuit equipment. (For test jack jumper wire, see procedure being performed.)

Materials/Tools:

Wire, electrical, 10 AWG (scavenge from available source)



Jumper Wires Fabrication/Test Procedure:

1. Strip 1/2-inch of insulation from both ends of wire.
2. Twist ends for insertion directly into connector sockets and tape in place.

NOTE

- **If wire is a larger AWG than required, do step 3.**
- **If wire is a smaller AWG than required, do step 4.**

3. Pull back strands as required and clip off; tape over exposed wire and tape in place.
4. Strip more insulation from ends, fold ends over until proper size is obtained, and tape in place.

APPENDIX C
EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST

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

C-1. SCOPE

This appendix lists expendable supplies and materials you will need to make BDAR fixes on the M109A6 Howitzer. Items are listed alphabetically by the item name shown in the Description column. These items are authorized by CTA 50-970, Expendable/Durable Items (Except Medical, Class V, Repair Parts, and Heraldic Items, or CTA 8-100, Army Medical Department Expendable/Durable Items)

C-2. EXPLANATION OF COLUMNS IN 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 (e g, "Use hose clamp, item 5, Appendix C").
b. Column (2) - National Stock Number (NSN) This is the NSN 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 (CAGE) code in parentheses, followed by the part number.
d. Column (4) - Unit of Issue (U/I) The abbreviation "U/I" identifies the unit(s) under which material is issued:

SECTION II. EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) NSN	(3) DESCRIPTION	(4) (U/I)
1	8040-00-865-8991	Adhesive (01139) RTV 103	kt
2	8040-00-738-6429	Adhesive epoxy (33564) EA9340	kt
3	8105-00-299-8532	Bag, plastic (10 each, pkg) (81348) PPP-B-26	ea
4	8115-00-190-5020	Box, shipping (10 each,bdl) (81348) PPP-B-36	ea
5	4730-01-269-9570	Cap, tube 1/4-inch (01276) FF9863-04S	ea
6		Cap, tube, 5/8-inch (01276) FF9863-10S	ea

SECTION II. EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) NSN	(3) DESCRIPTION	(4) (U/I)
7	4730-00-289-5909	Clamp, hose, 3 /8-inch to 1 inch (81349) MIL-C-11569	ea
8	4730-00-908-3193	Clamp, hose, 1 1/16-inch to 2 inch (81349) MIL-C-11569	ea
9	6610-00-407-0242	Clamp, screw (70210)537561	ea
10	1220-01-254-5939	Connector splice (10001) 231 6832P1	ea
11	4730-01-281-0965	Elbow, tube, 90 degree, 1/4-inch (01276) FF2098T-0404S	ea
12		Elbow, tube, 90 degree,1/2-inch (01276)FF2098T-0808S	ea
13		Fitting, hose, elbow, 45 degree,1/4-inch (01276)FJ9729-0404S	ea
14		Fitting, hose, elbow, 45 degree, 3/8-inch (01276) FJ9729-0606S	ea
15		Fitting, hose, elbow, 45 degree, 1/2-inch (01276) FJ9729-088S	ea
16		Fitting, hose, elbow, 45 degree, 3/4-inch (01276) FJ9729-1212S	ea
17		Fitting, hose, elbow, 90 degree, short, 1/4-inch (01276) FJ9730-0404S	ea
18		Fitting, hose, elbow, 90 degree, short, 3/-inch (01276) FJ9730-0606S	ea
19		Fitting, hose, elbow, 90 degree, short, 5/8-inch (01276) FJ9730-1010OS	ea
20		Fitting, hose, elbow, 90 degree, short, 3/4-inch (01276) FJ9731-1212S	ea
21		Fitting, hose, straight, 1/4-inch (01276) FJ9728-0404S	ea
22		Fitting, hose, straight, 3/8-inch (01276) FJ9728-0606S	ea
23		Fitting, hose, straight, 1/2-inch (01276) FJ9728-0808S	ea
24		Fitting, hose, straight, 5/8-inch (01276) FJ9728-1010S	ea
25		Fitting, hose, straight, 3/4-inch (01276) FJ9728-1212S	ea
26		Fitting, hose, socket, 1/4-inch (01276) FC2642-04	ea
27		Fitting, hose, socket, 3/8-inch (01276) FC2642-06	ea

SECTION II. EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) NSN	(3) DESCRIPTION	(4) (U/I)
28		Fitting, hose, socket, 1/2-inch (01276) FC2642-08	ea
29		Fitting, hose, socket, 5/8-inch (01276) FC2642-1 0	ea
30		Fitting, hose, socket, 3/4-inch (01276) FC2642-12	ea
31	5330-00-399-7960	Gasket, material (82094) 315	ft
32		Gloves, patient, exam (package of 100) (89875)	pg
	6515-01-150-2976	E-010 Size small	
	6515-01-150-2979	E-012 Size medium	
	6515-01-150-2977	E-011 Size large	
33	9150-00-944-8953	Grease, aircraft (81349) MIL-G-81322	lb
34	9150-01-197-7689	Grease, automotive and artillery (81349) MIL-G-10924	lb
35	4720-00-288-9837	Hose, nonmetalllc, 3/4-inch ID (81349) MIL-H-24135	ft
36	9150-00-111-6256	Hydraulic fluid, fire-resistant (FRH) type 1 (81349) MIL-H-46170	qt
37	5970-00-815-1295	Insulation sleeving, electrical, 1/4-inch (24011) FP301-1	ft
38		Nipple, tube, reducer, 1/2-inch to 1/4-inch (01276) FF2000T-0804S	ea
39		Nipple, tube, reducer, 5/8-inch to 1/2-inch (01276) FF2000T-1008S	ea
40		Nipple, tube, straight, 1/4-inch (01276) FF2000T-0404S	ea
41		Nipple, tube, straight, 3/8-inch	ea
42		Nipple, tube, straight, 1/2-inch (01276) FF2000T-0808S	ea
43		Nipple, tube, straight, 5/8-inch (01276) FF2000T-1010S	ea
44		Nipple, tube, straight, 3/4-inch (01276) FF2000T-1212S	ea
45		Packing, preformed, kit (01276) FF10280-01	kt
46	5350-00-264-5050	Paper, abrasive (81348) P-P-121	ea

SECTION II. EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) NSN	(3) DESCRIPTION	(4) (U/I)
47	9650-00-264-5050	Pig, lead, 5 pound (81348) QQ-C-40	lb
48	8030-00-078-4065	Plastic repair, kit (19207)10941900	ea
49	5340-01-165-1159	Plug, hose, plastic (81349) N5501/7-F21	ea
50	8040-01-108-6660	Repair, kit fiberglass (73168) 900N 195	kt
51	3439-00-246-0566	Rod, welding, 0125-inch. (81349) MIL-R-908	lb
52	4020-00-289-8615	Rope, fibrous, 600-ft roll (81348) TR605	ro
53	5305-00-143-9842	Screw, tapping, no 12, 11/4-inch (14002) 257-001-003	ea
54	8030-01-299-1762	Sealer, permatex (0A083) 77BR	tb
55	8030-00-159-5032	Sealing compound (16059) DEVON F2	kt
56	6685-00-920-0340	Shielding, material (06682) CA041500	ea
57	5895-01-111-0457	Sleeve, nicropress (87341) 18-4-P	ea
58	3439-00-896-8746	Solder, lead-tin alloy, 0 036-inch, 1 lb (81348) SN60WRAP2	lb
59	6850-00-281-1985	Solvent, drycleanlng (81348) P-D-680	gl
60	9510-00-463-7110	Steel rod (98897) A104	ea
61	8030-00-889-3535	Tape, antiseizing, pipe plug, teflon, 1/2-inch (81755) P5025-2R	ea
62	5640-00-103-2254	Tape, duct (39428) 1791K70	ea
63	5970-00-186-6627	Tape, insulation, electrical, 1/2-inch wide (81349) MIL-L-19166	ro
64	7510-01-146-7767	Tape, pressure sensitive 2-inches wide (81348) PPP-T-60	ro
65		Tee, tube, 1/2-inch (01276) FF2114T-0808S	ea
66	4730-01-281-0976	Tee, tube, 1/4-inch (01276) FF2114T-0404S	ea
67	5940-00-283-5280	Terminal, lug, crimp style, 16 AWG (96906) MS25036-106	ea

SECTION II. EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) NSN	(3) DESCRIPTION	(4) (U/I)
68	5930-00-001-7400	Toggle switch, single-pole, single-throw (91929) 1T149-31K	ea
69		Tube, fitting kit 1/4-inch (01276) FF90146-04S	ea
70		Tube, fitting kit 3/8-inch (01276) FF90146-06S	ea
71		Tube, fitting kit 1/2-inch (01276) FF90146-08S	ea
72		Tube, fitting kit 5/8-inch (01276) FF90146-10S	ea
73		Tube, fitting kit 3/4-inch (01276) FF90146-12S	ea
74	6145-01-020-1095	Wire, electrical, 10AWG (81343) SAE J1128	ft
75	6145-00-845-5961	Wire, electrical, 12 AWG (81343) SAE J1128	ft
76	6145-00-889-8551	Wire, electrical, 16 AWG (81343) SAE J1128	ft
77	6145-00-435-8613	Wire, electrical, 18 AWG (81349) M81044/12-18-9	ft
78	6145-00-107-7913	Wire, electrical, 20 AWG (81349) M81044/4-20-9	ft
79	6145-00-071-1148	Wire, fuze, 1 lb spool (71400) FW15AMP	ea
80	4010-01-206-8627	Wire, safety (82878) 8227211	ea

C-3. BATTLEFIELD DAMAGE REPAIR KIT - SECTION III

This section lists the contents of supplies and materials provided in the M2/3 Generic BDR kit for fixes on the M109A6 Howitzer. Items are listed alphabetically by the item name shown in the description column. These items are authorized by CTA 50-970, Expendable/Durable Items (Except Medical, Class V, Repair Parts, and Heraldic Items, or CTA 8-100, Army Medical Department Expendable/Durable Items). Commanders are authorized to modify kit to meet their specific mission.

C-4. EXPLANATION OF COLUMNS IN SECTION III

a. Column (1) - National Stock Number (NSN) This Is the NSN assigned to the item, use it to request or requisition the item.
b Column (2) - Description. Indicates the federal item name, and if required, a description to identify the item.
c. Column (3) - Quantity (Qty). The quantity identifies the number of items issued.

SECTION III. BDR KIT LIST

(1) NSN	(2) Description	(3) (Qty)
4730-01-327-8551	Adapter, straight	1
4730-01-327-8552	Adapter, straight	1
4730-01-327-8553	Adapter, straight	1
4730-01-327-8556	Adapter, straight	1
4730-01-327-8557	Adapter, straight	1
8040-00-776-9605	Adhesive, plastic epoxy	1
3030-00-224-8357	Belting, V .375	1
3030-00-224-8358	Belting, V .500	1
5110-00-227-4588	Blade, hand hacksaw	5
7920-00-514-2417	Brush, acid	2
7920-01-195-5355	Brush, wire	1
4730-00-277-5172	Clamp, hose 1 inch	2
4730-01-327-7133	Clamp, hose 2 inch	2
5120-01-327-5170	Crimping, tool	1
8315-01-115-7617	Fastener, tape hook	1
8315-01-043-9881	Fastener, tape pile	1
5110-00-528-9000	File, hand	1
4730-01-327-6740	Fitting	2
4730-01-327-6742	Fitting, kit	2
4730-01-327-6743	Fitting, kit	2
4730-01-327-6744	Fitting, kit	2
4730-01-327-6745	Fitting, kit	2
4730-01-327-8836	Fitting, kit	2
5110-00-289-9657	Frame, hand hacksaw	1
2910-01-328-0261	Fuel, cell patch kit 2.062	1
2910-01-328-0262	Fuel, cell patch kit 3.500	1
2910-01-328-0263	Fuel, cell patch kit 0.308	1
	Kit, repair elastomer	1
2510-01-327-6145	Kit, repair polymer	1
5110-00-162-2205	Knife, pocket	1
6625-01-342-8935	Multimeter	1
4730-00-077-1009	Nipple, boss	1
4730-00-781-6089	Nipple, tube	1
4730-01-242-2840	Nipple, tube	1

SECTION III. BDR KIT LIST CONT

(1) NSN	(2) Description	(3) (Qty)
2640-00-404-0754	Patch, kit tire	1
5120-01-021-5730	Pliers, linnemans	1
5120-01-131-1864	Pliers, slip joint	1
5110-00-570-6896	Saw, hand finger grip	1
5110-01-327-5171	Saw, hand metal cutting	1
5120-00-997-2858	Screwdriver, bit set	1
8030-01-299-1762	Sealing, compound	1
5940-01-079-1335	Splice, connector AWG 10-12	24
5940-01-079-1975	Splice, connector AWG 14-16	24
5940-01-347-0008	Splice, connector AWG 18-22	24
6850-01-344-7147	Stopleak	1
5975-00-984-6582	Strap, tie-down	10
8030-00-889-3534	Tape, antiseizing	1
5970-00-815-9818	Tape, insulation	1
4020-00-071-0222	Tape, lacing	1
7510-00-684-8803	Tape, pressure sens	1
5940-00-727-5351	Terminal, lug AWG 10-12	24
5940-01-087-0284	Terminal, lug AWG 18-22	24
5120-00-903-2506	Tool, deburring	1
5120-01-347-4947	V-belt, tool	1
6145-00-600-6052	Wire, electrical 16 AWG	1
9505-00-293-4208	Wire, non-electrical	1
5120-00-473-6476	Wrench, adjustable	1
5120-00-277-4243	Wrench, pliers 7 inch	1

APPENDIX D
SUBSTITUTE MATERIALS/PARTS

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

D-1. SCOPE

This appendix lists spares and repair parts which can be taken from other systems and used on the M109A6 Howitzer. These parts are cross-referenced by National Stock Number (NSN), name, and weapon system. There are two basic sections that list interchangeable parts. Section II lists howitzer spare and repair parts that can be replaced directly with parts found in other weapon systems. Table D-1 covers interchangeable hull parts by functional group code. Table D-2 covers interchangeable cab parts by functional group code. Table D-3 lists other countries with U S combat vehicles that can be used as alternate sources of supply. Section III provides detailed information covering the types, uses, and effects of substitute fuels, lubricants, and hydraulic fluids used In the M109A6 Howitzer. Table D-4 lists substitute lubricants and hydraulic fluids. Table D-5 contains substitute fuels for diesel fuel.

D-2. GENERAL

Spares and repair parts are organized by NSN and therefore can be requisitioned throughout the military system The NSN parts classification system Is a reliable and quick method In which to identify parts In a battlefield situation, this system will be invaluable as time, maintenance, and supply demands increase.

SECTION II. INTERCHANGEABLE PARTS

D-3. SCOPE

This section lists and cross-references M109A6 Howitzer spares and repair parts to other weapon systems having these parts.

D-4. GENERAL

Parts carrying the same NSN require no modification prior to installation in the howitzer. Parts carrying different NSNs may require some mounting modifications before installation. Table D-3 identifies nations owning American combat vehicles that may have repair parts or equipment available for scavenging

D-5. EXPLANATION OF COLUMNS - TABLE D-1 & TABLE D-2

a. Column lists interchangeable parts by manufacturer’s part number (P/N).

b. Column 2 lists parts by NSN in National Item Identification Number (NIIN) sequence (i.e., the last nine numbers In the NSN are in numerical order), within each functional group.

c. Column 3 describes the parts by noun nomenclature.

d. Columns 4 identify the applicable weapon system in which the same part can be found. An "X" appears In the column under the weapon system where the part is found.

TABLE D-1. INTERCHANGEABLE HULL PARTS FOR THE M109A6 HOWITZER

(1) P/N	(2) NSN	(3) NOMENCLATURE	(4) FROM WEAPONS SYSTEM								
			M9	M1 Family	M2/ M3 Family	M48/ M60 Family	M109 Family	M110 Family	M578	M728	M992
		GROUP 0106 ENGINE LUBRICATION SYSTEM									
5126546	2940-00-852-9675	Filter, Fuel					X	X			X
		GROUP 0302 FUEL PUMPS									
10922136	2910-00-782-1376	Fuel Pump					X				X
10946915	2910-00-923-4248	Pump, Fuel, Electrical			X	X	X			X	X
10922137	2910-00-937-7435	Fuel Pump and					X				X
5199735	2910-01-024-9238	Pump Assembly, Fuel					X		X		X
		GROUP 0309 FUEL FILTERS									
5574533	2910-00-781-1354	Filter, Fluid					X				X
5575009	2910-00-884-1207	Filter, Fluid					X	X	X		X
		GROUP 0312 ACCELERATOR THROTTLE									
10920717	2590-00-010-3794	Bracket, Throttle					X				X
10920725	5307-00-104-4617	Stud, Plain					X				X
11643782	3040-00-121-6150	Lever, Remote					X				X
10920714	2590-00-135-4478	Support, Accelerator					X				X
10920712	5315-00-135-4479	Pin, Straight					X				X
10903058	5315-00-135-4480	Pin, Straight					X				X
10920715	4730-00-135-4482	Flange, Pipe					X				X
10941827	3040-00-226-1997	Connecting, Link					X				X
10920747	2590-00-345-8027	Lever, Remote					X				X
10920748	2590-00-345-8028	Lever, Remote					X				X
10920749	2590-00-345-8029	Bell Crank					X				X
10920722	3040-00-345-8030	Bell Crank					X				X
10903062	5340-00-420-4999	Bracket, Accelerator					X				X
10895376-8	5306-00-443-4833	Rod, Threaded End					X				X
8741800-1	3120-00-809-6434	Bearing, Plain Rod				X	X			X	X
10925349	5206-00-878-8134	Rod, Threaded End					X				X
11664924	2540-01-023-4990	Pedal, Control					X				X
MS14104-12	3120-01-104-5989	Bearing, Plain	X	X	X		X				X

TABLE D-1. INTERCHANGEABLE HULL PARTS FOR THE M109A6 HOWITZER-CONT

(1) P/N	(2) NSN	(3) NOMENCLATURE	(4) FROM WEAPONS SYSTEM								
			M9	M1 Family	M2/ M3 Family	M48/ M60 Family	M109 Family	M110 Family	M578	M728	M992
		GROUP 0501 RADIATOR									
10882098	2930-01-090-4932	Cap, Filling, Opening					X				X
		GROUP 0503 WATER MANIFOLD HEADERS									
10903081	2930-00-932-7610	Housing, Thermostat					X				X
10919238	2930-00-993-1100	Housing, Thermostat					X				X
10919235	2930-00-993-1102	Housing, Thermostat					X				X
11675559	6680-01-004-1859	Detector, Headers					X	X	X		X
12268159	2930-01-250-8112	Housing, Thermostat					X				X
		GROUP 0504 WATER PUMP									
5130797	2930-00-972-8099	Pump, Cooling System					X	X			
		GROUP 0505 FAN ASSEMBLY									
10921762-1	2520-00-475-1290	Propeller Shaft					X				X
10921762-2	2520-00-475-1296	Propeller Shaft					X				X
10942176	2930-00-921-6475	Drive Assembly, Fan					X				X
12268231	4140-01-284-5722	Fan, Vaneaxial					X				X
12268230	3010-01-287-0742	Gearbox, Assembly					X				X
		GROUP 0603 STARTING MOTOR									
MS53011-1	2920-00-304-3493	Starter, Engine	X				X	X	X		
		GROUP 0608 MISCELLANEOUS ITEMS									
7357485	5945-00-636-8778	Relay, Electromagnet					X	X	X		X
12363092	5945-01-291-0734	Relay, Electromagnet									
		GROUP 0705 GEAR SHIFT AND CONTROLS									
10895376-1	5307-00-102-9944	Stud, Plain					X				X
10920725	5307-00-104-4617	Stud, Plain					X				X
11643781	3040-00-123-0199	Lever, Remote					X				X
10895376-3	5307-00-143-6377	Stud, Plain					X				X
10920668	3040-00-179-7105	Support, Bellcrank					X				X
10920669	3040-00-179-7115	Bell, Crank					X				X
10895376-2	5307-00-457-0478	Stud, Plain					X				X

TABLE D-1. INTERCHANGEABLE HULL PARTS FOR THE M109A6 HOWITZER-CONT

(1) P/N	(2) NSN	(3) NOMENCLATURE	(4) FROM WEAPONS SYSTEM								
			M9	M1 Family	M2/ M3 Family	M48/ M60 Family	M109 Family	M110 Family	M578	M728	M992
		GROUP 0705 GEAR SHIFT AND CONTROLS - CONTINUED									
10920667	2520-00-808-6745	Bell Crank					X				X
8741800	3120-01-131-0153	Bearing, Plain, Rod	X			X	X				X
		GROUP 0801 POWER TRANSFER AND FINAL									
7983274	2520-00-738-3274	Spider, Universal					X				
7983275	2520-00-798-3275	Plate, Retaining					X				X
10936609	2520-00-964-9203	Final Drive					X				X
		GROUP 1201 HAND BRAKE									
10936438	2530-00-135-9035	Park Brake Assembly					X				X
		GROUP 1206 MECHANICAL BRAKE									
10936436	3120-00-089-3322	Bearing, Plain, Rod					X				X
7748994	3020-00-133-8117	Sprocket, Wheel					X				X
10930363	3040-00-179-5477	Lever, Remote					X				X
10936441	2530-00-179-5482	Lever, Remote					X				X
10895548	3040-00-179-5492	Lever, Remote					X				X
MS26534C40	3020-00-196-0803	Chain, Roller					X				X
10936435	5340-00-433-2300	Clevis, Rod End					X				X
10921474	2540-00-808-6813	Pedal, Control					X				X
10895552	5340-00-887-8922	Clevis, Brake					X				X
10922907	2530-00-930-4674	Support Assembly					X				X
		GROUP 1301 SUSPENSION ASSEMBLY									
10919004	2530-00-801-6702	Wheel, Solid Rubber					X				
10903675	2530-00-884-4869	Cab Assembly, Wheel					X				
10920704	2530-01-083-5415	Arm and Hub Assembly					X				
10920657	2530-00-967-3346	Hub Assembly, Wheel					X				
		GROUP 1303 TRACK IDLERS AND BRACKET									
11593743	2530-00-132-0842	Arm Assembly					X				X
10955890	5430-00-179-5483	Bracket Mounting					X				X
10920616	3040-00-179-5562	Housing, Idler Arm					X				

TABLE D-1. INTERCHANGEABLE HULL PARTS FOR THE M109A6 HOWITZER-CONT

(1) P/N	(2) NSN	(3) NOMENCLATURE	(4) FROM WEAPONS SYSTEM								
			M9	M1 Family	M2/ M3 Family	M48/ M60 Family	M109 Family	M110 Family	M578	M728	M992
		GROUP 1303 TRACK IDLERS AND BRACKET - CONTINUED									
10955889	2540-00-925-8042	Cylinder Assembly					X				X
11593540	2530-00-939-7113	Wheel, Idler					X				X
		GROUP 1304 TRACK DRIVE SPROCKET									
10936277	2520-00-066-0239	Hub, Sprocket, Final					X				X
10954052	3020-00-789-2204	Sprocket, Wheel					X				X
		GROUP 1305 TRACK ASSEMBLY									
10954051-1	2530-00-799-0020	Track Shoe					X				X
		GROUP 1401 MECHANICAL STEERING GEAR									
10921204	3040-00-130-4294	Lever Assembly					X				X
11643780	3040-00-130-5253	Lever, Remote									X
10921206	3130-00-130-5352	Bracket Assembly					X				X
10925753	3040-00-130-5354	Bracket, Eye					X				X
10909875	2530-00-133-9767	Wheel, Steering					X				X
10913311	3340-00-179-5502	Shaft, Shouldered					X				X
10919047	3040-00-179-5503	Housing Assembly					X				X
10930952	5340-00-179-5515	Bracket, Mounting					X				X
10895376-5	5307-00-443-0551	Stud, Plain					X				X
10903381	3040-00-454-5086	Shaft, Straight					X				X
10903378	3040-00-575-0394	Lever, Remote									X
10931067	3040-00-934-8294	Shaft, Steering									X
10925752	3110-00-967-6274	Adapter Assembly									X
10917149	3120-00-537-0154	Bearing, Plain, Self					X				X
8741800	3120-01-131-0153	Bearing, Plain, Rod					X				X
10920690-1	3040-01-286-2059	Lever, Remote									X
		GROUP 2202 ACCESSORY ITEMS									
SMD415261	5830-00-892-3339	Control									X

TABLE D-2. INTERCHANGEABLE CAB PARTS FOR THE M109A6 HOWITZER

(1) P/N	(2) NSN	(3) NOMENCLATURE	(4) FROM WEAPONS SYSTEM					
			M109A2/ A3/A4	M109A5	M145 (NEW)	M102 HOW	M728,M485A,M60A1 W/AOS M60A1 W/O AOS, M60 AIR W/P, M6 AIR W/O P, M60A3/M60A3 FTS, M1A1, M1 W/IMPROVED ARMOR	20MM M167A2 GUN, AIR DEF ARTY
		GROUP 020101 REPLENISHER ACCUMULATOR						
11640231	1025-01-127-2921	Accumulator	X	X				
		GROUP 020103 HOWITZER CRADLE						
11636055	5315-00-085-2261	Damper Assembly	X	X				
10913566	1025-00-802-2522	Pin, Shoulder	X	X				
11636056	1025-01-137-0954	Cam Control	X	X				
		GROUP 02010304 CRADLE ASSEMBLY						
10895167	1025-00-937-2024	Equilibrator, Cannon	X	X				
		GROUP 0201030402 VARIABLE RECOIL						
10925678	1025-00-083-5782	Gear, Sector	X	X				
10925680	3020-00-083-5784	Gear, Spur	X	X				
10895595	1025-00-802-2455	Plate, Retaining	X	X				
10895596	5365-00-802-2457	Bushing, Machine	X	X				
10895628	1025-00-802-2465	Housing Assembly	X	X				
10888786	5315-00-871-5447	Key, Machine	X	X				
10953696	3040-00-931-8206	Connecting Link	X	X				
12012324	4730-01-065-0037	Restrictor, Fluid	X	X				
12012329	1025-01-065-0038	Rod, Piston, Linear	X	X				
8449331	1025-01-137-7545	Buffer Assembly	X	X				
12576072	1025-01-293-0813	Follower, Front		X				
125776076		Seal Assembly		X				
125776077		Seal Assembly		X				
125776078		Seal Assembly		X				
		GROUP 020103040205 ACTUATOR ASSEMBLY						
10923027	1025-00-439-6541	Lever Assembly	X	X				
10895674		Housing Assembly	X	X				
10923029	5340-01-328-1339	Cover Assembly	X	X				
10923030	3040-00-439-6545	Gearshift, Bevel	X	X				
10953665	1025-00-868-8060	Gearshift, Assembly	X	X				

TABLE D-2. INTERCHANGEABLE CAB PARTS FOR THE M109A6 HOWITZER-CONT

(1) P/N	(2) NSN	(3) NOMENCLATURE	(4) FROM WEAPONS SYSTEM					
			M109A2/ A3/A4	M109A5	M145 (NEW)	M102 HOW	M728,M485A,M60A1 W/AOS M60A1 W/O AOS, M60 AIR W/P, M6 AIR W/O P, M60A3/M60A3 FTS, M1A1, M1 W/IMPROVED ARMOR	20MM M167A2 GUN, AIR DEF ARTY
		GROUP 0202 CANNON ASSEMBLY						
11580270	1025-01-326-0125	Barrel Assembly		X				
11580201		Breech Mechanism		X				
		GROUP 020202 GUN TUBE ASSEMBLY						
11580138	1025-01-313-8943	Tube, Cannon		X				
		GROUP 05 SIGHTING EQUIPMENT						
11747246	1025-01-071-0633	Mount Alignment Dev	X	X			X	
8267701-1	1240-01-313-6842	Mount M145	X	X	X			
		GROUP 16 EQUILIBRATION HAND						
9398982		Pump Assembly	X	X				
		GROUP 16 EQUILIBRATION MANIFOLD						
11636342	4730-00-183-7678	Manifold, Hydraulic	X	X				
		GROUP 16 GUNNERS CONTROL						
10922902	1025-00-840-9552	Gun Control	X	X				
		GROUP 16 MANUAL ELEVATION						
7974982	3040-00-508-0126	Accumulator	X	X			X	
		GROUP 16 INTERCOM AUDIO						
818214	5820-00-892-3342	Amplifier, Audio						X

TABLE D-3. FOREIGN OWNERSHIP OF U.S. WEAPONS SYSTEMS

	M1A1	M2A2	M48/M60	M109	M110	M578	M992
NORTH AMERICA AND EUROPE							
AUSTRIA			X	X			
BELGIUM				X	X		
BRITAIN					X		
CANADA				X			
DENMARK				X			
GERMANY			X	X	X		
GREECE			X	X	X		
ITALY			X	X			
LUXEMBOURG							
NETHERLANDS				X	X		
NORWAY			X	X			
PORTUGAL			X	X			
SPAIN			X	X	X		
SWEDEN							
SWITZERLAND				X			
TURKEY			X		X		
USA			X	X	X		
SOUTH AND CENTAL AMERICA							
ARGENTINA			X				
BOLIVIA							
BRAZIL							
CHILE							
COLUMBIA							
COSTA RICA							
DOMINICAN REPUBLIC							
ECQUADOR							
EL SALVADOR							

TABLE D-3. FOREIGN OWNERSHIP OF U.S. WEAPONS SYSTEMS - CONT

	M1A1	M2A2	M48/M60	M109	M110	M578	M992
SOUTH AND CENTAL AMERICA - CONTINUED							
GUATEMALA							
HONDURAS							
NICARAGUA							
PERU							
PANAMA							
PARAGUAY							
VENEZUELA							
ASIA							
AUSTRALIA							
BURMA							
CAMBODIA (KAMPUCHEA)							
CHINA							
FIJI							
INDONESIA							
JAPAN					X		
LAOS							
NEPAL							
NEW ZEALAND							
PAKISTAN			X	X			
PHILLIPINES							
SINGAPORE			X				
SOUTH KOREA			X	X	X		
TAIWAN			X	X	X		
THAILAND			X				
VIETNAM			X	X	X		

TABLE D-3. FOREIGN OWNERSHIP OF U.S. WEAPONS SYSTEMS - CONT

	M1A1	M2A2	M48/M60	M109	M110	M578	M992
AFRICA							
CHAD							
CENTRAL AFRICAN EMPIRE							
DJIBOUTI							
EGYPT	X		X				
ETHIOPIA			X	X			
LIBERIA							
LIBYA				X			
MOROCCO			X	X			
SENEGAL							
SIERRA LEONE							
SOMALIA							
SUDAN			X				
TUNISIA			X				
ZAIRE							
MIDDLE EAST							
BAHRAIN			X				
IRAN			X	X	X		
ISRAEL			X	X			
JORDAN			X	X	X		
KUWAIT			X	X			
LEBANON			X			X	
NORTH YEMAN			X				
OMAN			X				
SAUDI ARABIA	X	X	X	X	X		
YEMAN			X				

SECTION III. PETROLEUM, OIL, AND LUBRICANT (POL) SUBSTITUTES

D-6. SCOPE

This section provides information covering the types, uses, and effects of substitute fuels, lubricants, and hydraulic fluids used in the M109A6 Howitzers. It also contains general information covering after-use purging and system flushing methods.

D-7. GENERAL

There are three kinds of POL products fuels, lubricants (oil and grease), and hydraulic fluids. These products vary greatly in characteristics and chemical properties. Never assume that since a product is used in a system of another type vehicle it can be used safely in the same system in the M109A6 Howitzer. Some POL will be destructive if used. POL products fall into three categories as follows:

a. Primary: The correct product for the system.
b. Alternate: A product that closely matches the primary but may result in reduced performance. Using the alternate POL will have no effect on the durability of the system. There are no restrictions on the duration of use.
c. Emergency: A product that can be used for a short period of time only. These products are a last resort only and will result in a significant reduction in performance. The use of an emergency fuel will not materially degrade the design operating life of the howitzer.

D-8. PRODUCT IDENTIFICATION

a. 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).
b. 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.

Table D-4 identifies primary and alternate lubricants and hydraulic fluids. The primary products listed are reflected in the vehicle lubrication order. The "Remarks" column contains specific details about the alternate product, when applicable.

Table D-5 lists primary, alternate, and emergency fuels for use in ground diesel fuel consuming equipment.

D-9. FLUSHING LUBRICANT AND HYDRAULIC SYSTEMS

a. For those systems using oils, flushing involves draining, refilling with proper product, operating to ensure complete circulation and, when possible, stable operating temperature (this usually means at least 1/2 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, as a minimum, must be removed and cleaned. 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.
b. 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.

D-10. FLUSHING THE FUEL SYSTEM OF EMERGENCY FUELS

NOTE

Alternate fuels need not be drained and flushed. These fuels can be further diluted by adding an approved primary fuel and continuing operations

a. Drain or pump out emergency fuel.
b. Refill tank with 10 to 15 gallons (37.8 to 56.8 liters) of approved primary or alternate fuel.

NOTE

It is desirable that the engine be kept under load by driving the vehicle This will bring engine to operating temperature

c. Run engine for at least 1/2-hour, or until fuel has been consumed.
d. Fill fuel tanks with an approved fuel.
e. Resume operation.

TABLE D-4. PRIMARY AND ALTERNATE LUBRICANTS AND HYDRAULIC FLUIDS

	Primary POL	Alternate POL	Remarks
1.	OE/HDO-15/40, MIL-L-2104 NATO - 0-1236	Next Grade OE/HDO OEA	
2.	OE/HDO-10, MIL-L-2104 NATO - 0-237	Next Grade OE/HDO OEA	
3.	OE/HDO-30, MIL-L-2104 NATO - 0-238	Next Grade OE/HDO OEA	
4.	OEA, M IL-L-46167 NATO - 0-183	OE/HDO	
5.	OHT, MIL-H-6083 NATO - 0-635	OHA, MIL-H-5606 NATO - H-515	Use OHA in hydraulic system under emergency conditions only
6.	CLP, MIL-L-63460 NATO - S-758	PLS, VV-L-800 NATO - 0-190 RBC, MIL-C-372 No NATO equiv.	
7.	GO-75, MIL-L-2105 NATO - 0-186	Next Grade GO	
8.	GO-80/90, MIL-L-2105 NATO - 0-226	Next Grade GO	
9.	GO-85/140, MIL-L-2105 NATO - 0-228	Next Grade GO	
10.	GGP, MIL-G-23549 No NATO equiv.	GMD GAA	
11.	GMD, MIL-G-21164 NATO - G-353	GAA GGP	
12.	LOMD, DOD-L-25681 NATO - S-1735	GMD	
13.	GAA, MIL-G-10924 NATO - G-403		
14.	0-156, MIL-L-23699 NATO - 0-156		

TABLE D-5. ALTERNATE AND EMERGENCY FUELS

Primary Fuel	Alternate Fuel	Emergency Fuel
OCONUS Environments Diesel Fuel VV-F-800 (DF-2, DF-1, DF-A) NATO-F-54	Aviation Turbine MIL-T-83133 (JP-8) NATO-F-34 Aviation Turbine MIL-T-5624 (JP-5) NATO-F-44 Naval Distillate MIL-F-1 6884 NATO-F-76 Naval Distillate NATO-F-75 Aviation Turbine ASTM-D-1655 (Jet A-1 Diesel Blend NATO-F-65 (1:1 mix of F-54 with F-34/F-35)	Military Gasoline MIL-G-3056 NATO-F-40 Auto Gasoline STANAG 2845 NATO-F-57 Auto Gasoline NATO-F-67 Aviation Gasoline MIL-D-910 NATO-F-1 8 Aviation Turbine MIL-T-5624 (JP-4) NATO-F-40
CONUS Environments Diesel Fuel VV-F-800 (DF-2, DF-1, DF-A)	Automotive Diesel ASTM-D-975 (See Note) Aviation Turbine ASTM-D-1655 (Jet A) Fuel 0il ASTM-D-396 (F01 and F02)	S-1 Engine Fuel ASTM-D-4814 Aviation Gasoline ASTM-D-910 Aviation Turbine. MIL-T-5624 (JP-4) NATO-F-40

NOTE: Although VV-F-800 is shown as the primary fuel, MIL-T-83133 (JP-8) or MIL-T-5624 (JP-5) will be used as the primary fuel In those theaters where the single fuel on the battlefield is implemented IAW DOD Directive 4140.43.

APPENDIX E
BDAR FIXES AUTHORIZED FOR TRAINING

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.

REPAIR PROCEDURE - CONTINUED **Para**

ELECTRICAL SYSTEM

POWERTRAIN / STEERING

BRAKES

WHEELS AND TRACKS

HYDRAULIC SYSTEM

COMMUNICATIONS

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T

By Order of the Secretary of the Army:

GORDON R. SULLIVAN
General, United Stales Army
Chief of Staff

Official

MILTON H HAMILTON
Administrative Assistant to the
Secretary of the Army
06135

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TEAR ALONG PERFORATED LINE

THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
1 kilometer = 1000 Meters = 0.621 Miles

WEIGHTS

1 Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
1 Kilogram = 1000 Grams = 2.2 Lb.
1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
1 Liter = 1000 Milliliters 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

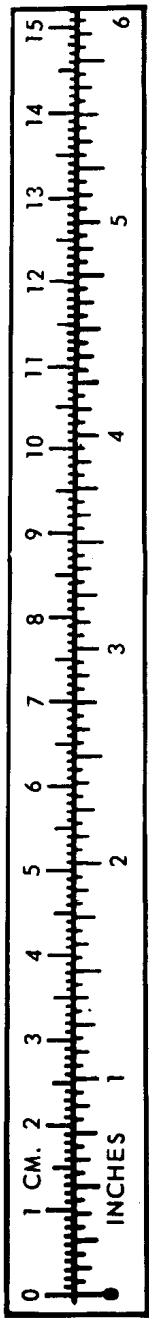
TEMPERATURE

5/9 (°F - 32) = °C
212° Fahrenheit is equivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5 (°C + 32) = °F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
Pints	Liters	0.473
Quarts	Liters	0.946
Gallons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
Liters	Gallons	0.264
Grams	Ounces	0.035
Kilograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pound-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
Kilometers per Liter	Miles per Gallon	2.354
Kilometers per Hour	Miles per Hour	0.621



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