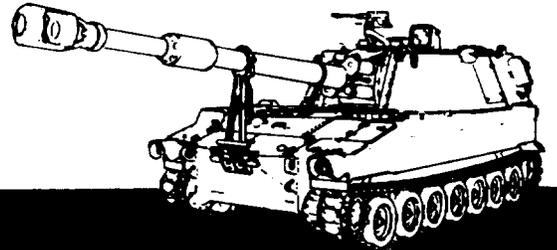


## TECHNICAL MANUAL

OPERATORS, ORGANIZATIONAL  
DIRECT SUPPORT AND  
GENERAL SUPPORT MAINTENANCE



# BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR

M109/M110/M578  
VEHICLES  
HOWITZER, MEDIUM,  
SELF-PROPELLED  
FULL-TRACKED

M109A2 Howitzer  
NSN 2350-01-031-4586 (EIC: 3EZ)  
M109A3 Howitzer  
NSN 2350-01-031-8851 (EIC: 3E2)  
M109A4 Howitzer  
NSN 2350-01-277-5770 (EIC: 3E8)  
M109A5 Howitzer  
NSN 2350-01-281-1719 (EIC: 3E7)  
M110A2 Howitzer  
NSN 2350-01-041-4590 (EIC: 2E3)  
M578 Recovery Vehicle  
NSN 2350-00-439-6242 (EIC: 3LA)

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CHAPTER 2	ASSESSING BATTLEFIELD DAMAGE	▶
CHAPTER 3	ENGINE	▶
CHAPTER 4	FUEL SUPPLY SYSTEM	▶
CHAPTER 5	COOLING SYSTEM	▶
CHAPTER 6	ELECTRICAL SYSTEM	▶
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APPENDIX A	ALTERNATE SOURCES OF SUPPLY	▶
APPENDIX B	SPECIAL AND FABRICATED TOOLS	▶
APPENDIX C	POL SUBSTITUTES	▶

HEADQUARTERS, DEPARTMENT OF THE ARMY

31 JANUARY 1984

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

CHANGE

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
Washington, DC 8 April 1993

NO. 3

OPERATOR'S, UNIT, DIRECT SUPPORT AND  
GENERAL SUPPORT MAINTENANCE

BATTLE DAMAGE ASSESSMENT AND REPAIR  
FOR  
M109 AND M110 SERIES  
SELF-PROPELLED HOWITZERS AND M578 RECOVERY VEHICLE

M109A2 HOWITZER NSN 2350-01-031-0586 (EIC: 3EZ)  
M109A3 HOWITZER NSN 2350-01-031-8851 (EIC: 3E2)  
M109A4 HOWITZER NSN 2350-01-277-5770 (EIC: 3E8)  
M109A5 HOWITZER NSN 2350-01-281-1719 (EIC: 3E7)  
M110A2 HOWITZER NSN 2350-01-0414590 (EIC: 2E3)  
M578 RECOVERY VEHICLE NSN 2350-00-439-6242 (EIC: 31Ji)

TM 9-2350-274-BD, 31 January 1984, is changed as follows:

1. The purpose of this change is to update and include 2028s in BDAR.
2. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the margin of the page.

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C-1 thru C-6  
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Cover

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11-23 thru 11-26  
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A-3 thru A-10  
B-7 and B-8  
C-1 thru C-6  
Index 3 and Index 4  
Cover

3. File this and all other change sheets in front of the publication for reference purposes.

By Order of the Secretary of the Army:

GORDON R. SULLIVAN  
General, United States Army  
Chief of Staff

Official:



MILTON H. HAMILTON  
Administrative Assistant to the  
Secretary of the Army  
03733

DISTRIBUTION:

To be distributed in accordance with DA Form 12-37-E, Block 1433,  
requirements for TM 9-2350-274-BD.

CHANGE  
NO. 2

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
WASHINGTON, D.C. 13 March 1989

OPERATOR'S, UNIT, DIRECT SUPPORT AND  
GENERAL SUPPORT MAINTENANCE

BATTLE DAMAGE ASSESSMENT AND REPAIR  
FOR  
M109 AND M110 SERIES  
SELF-PROPELLED HOWITZERS  
AND M578 RECOVERY VEHICLE

M109A2 HOWITZER NSN 2350-01-031-0586	M109A3 HOWITZER NSN 2350-01-031-8851
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M110A2 HOWITZER NSN 2350-01-041-4590	M578 RECOVERY VEHICLE NSN 2350-00-439-6242
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TM 9-2350-274-BD, 31 January 1984, is changed as follows:

1. The purpose of this change is to add Appendix D, BDAR Fixes Authorized for Training, and add model number M109A2 to M109 series howitzers.
2. Change cover to show same model numbers as title block of this change sheet.
3. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the outside margin of the page.

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Insert pages

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D-1/(D-2 blank)

4. File this change sheet and all other change sheets in back of the publication for reference purposes.

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General, United States Army  
Chief of Staff

Official:

WILLIAM J, MEEHAN II  
Brigadier General, United States Army  
The Adjutant General

DISTRIBUTION:

To be distributed in accordance with DA Form 12-37, Operators, Unit, Direct and General Support Maintenance requirements for Howitzer, Meal, S-P, 155-MM, M109A2/A3, Howitzer, Heavy, S-P, 8 inch, M110A2, Vehicle, Recovery, Light, Full Tracked, M578.

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
WASHINGTON, D.C.  
4 February 1988

CHANGE

No. 1

OPERATORS, ORGANIZATIONAL,  
DIRECT SUPPORT AND  
GENERAL SUPPORT MAINTENANCE

BATTLE DAMAGE  
ASSESSMENT AND REPAIR  
FOR  
M109 AND M110 SERIES  
SELF-PROPELLED HOWITZERS  
AND M578 RECOVERY VEHICLE

M109A1 HOWITZER      M109A3 HOWITZER  
NSN 2350-00-485-9662      NSN 2350-01-031-8851

M110A2 HOWITZER      M578 RECOVERY VEHICLE  
NSN 2350-01-041-4590      NSN 2350-00-439-6242

TM 9-2350-274-BD, 31 January 1984, is changed as follows:

1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the margin of the page.
2. Illustration revisions are indicated by a miniature pointing hand in the area containing the changed material.
3. This change updates TM 9-2350-274-BD to include the M 110 series Self-Propelled Howitzer and the M578 Recovery Vehicle. The proponenty also changes from TACOM to AMCCOM.

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5-1 thru 5-4

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11-19 and 11-20  
11-23 and 11-24  
A-3 and A-4  
Index 3 and Index 4

4. File this change sheet and all other change sheets in back of the publication for reference purposes.

By Order of the Secretary of the Army:

CARL E. VUONO  
General United States Army  
Chief of Staff

Official:

**R. L. DILWORTH**  
*Brigadier General, United States Army*  
*The Adjutant General*

**DISTRIBUTION:**

To be distributed in accordance with DA Form 12-37, Operator's, Unit, Direct Support and General Support Maintenance requirements for Battle Damage for Howitzers, Heavy, Self-Propelled, 8-Inch, M109A1/A2, M110A2 and Recovery Vehicle M578.

WARNING

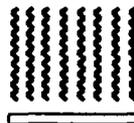
THIS TECHNICAL MANUAL CONTAINS NONSTANDARD MAINTENANCE PROCEDURES. ALL NORMAL SAFETY PROCEDURES SHOULD BE OBSERVED WHEN THE TACTICAL SITUATION PERMITS. EXTRA CARE WILL BE TAKEN WHEN THE TACTICAL SITUATION REQUIRES PERFORMING MAINTENANCE WITH AMMUNITION UP-LOADED AND WHEN FUELS AND LUBRICANTS ARE SPILLED IN HULL AND TURRET.

WARNING  
RADIOACTIVE MATERIAL

WARNING

The antireflective coating on all infrared optics contains thorium fluoride which is slightly radioactive. The only potential hazard involves ingestion (swallowing or inhaling) of this material. Dispose of broken lens, etc. in accordance with AR 385-11.

Heat



**WARNING**

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

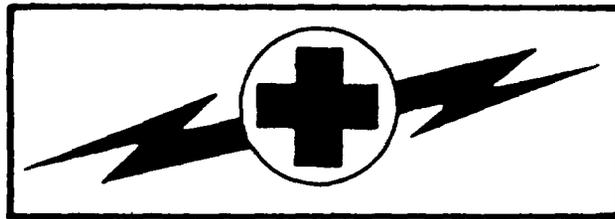


**WARNING**

You can be blinded if you look into a laser beam when you are not wearing laser safety goggles. Never aim the laser rangefinder (LRF) at personnel.

If laser beam reflects from a flat, mirror-like surface, it can blind you unless you are wearing laser safety goggles.

**WARNING**



**HIGH VOLTAGE**

High voltage is used in the operation of this equipment.

**DEATH ON CONTACT**

may result if personnel fail to observe safety precautions. Learn the areas containing high voltage in each piece of equipment. Be careful not to contact high voltage connections when installing or operating this equipment. Before working inside the equipment, turn power off and ground points of high potential before touching them.

For artificial respiration, refer to FM 21-11.

OPERATOR'S, ORGANIZATIONAL  
DIRECT SUPPORT AND GENERAL SUPPORT  
MAINTENANCE

GENERAL BATTLEFIELD DAMAGE  
ASSESSMENT AND REPAIR  
for  
M 109 AND MI 10 SERIES  
SELF-PROPELLED HOWITZER  
AND M578 RECOVERY VEHICLE

REPORTING OF ERRORS

You can help to improve this manual by calling attention to errors and by recommending improvements. Your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms) and/or DA Form 2028-2 (Recommended Changes to Equipment Technical Manuals), may be used. Copies of DA Form 2028-2 are attached in the back of the manual for your use. Please mail your recommended changes directly to Commander, U.S. Army Armament, Munitions and Chemical Command, ATTN; AMSMC-MAS, Rock Island, IL 61299-6000. A reply will be furnished directly to you.

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**CHAPTER 1****INTRODUCTION**

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

**SECTION I. General****1-1. Purpose.**

a. This technical manual (TM) is for use by operators, organizational, and direct support/general maintenance personnel. It provides procedures and guidelines for battlefield repairs on the M 109 Self-Propelled Howitzer/M 110 series Self-Propelled Howitzer/M578 Recovery Vehicle, Full-Tracked, under the forward support maintenance concept during combat.

b. The purpose of Battlefield Damage Assessment and Repair (BDAR) is to rapidly return disabled combat vehicles to the operational commander by expediently fining, by-passing, or jury-rigging components to restore the minimum essential systems required for the support of the specific combat mission or to enable the vehicle to self-recover. These repairs may be temporary and may not restore full performance capability.

**1-2. scope.**

a. This TM describes BDAR procedures applicable specifically to the M 109 vehicles/M110 series vehicles/M578 Recovery Vehicles. Expedient repairs of a general nature applicable to systems or subsystems common to more than one combat vehicle are covered in TM 9-2350-276-BD.

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

c. All possible types of combat damage and failure modes can not be predicted nor are all effective field expedient repairs known. This TM provides guidelines for assessing and repairing battlefield failures of the M 109 vehicles/M110 series vehicles/M578 Recovery Vehicles and is not intended to be a complete catalog of all possible emergency repairs. The repairs described here will serve as guidelines and will stimulate the experienced operator or mechanic to devise expedients as needed to rapidly repair equipment in a combat crisis.

## INTRODUCTION

### 1-3. Application.

a. The procedures in this manual are designed for battlefield environments and should be used in situations where standard maintenance procedures are impractical. These procedures are not meant to replace standard maintenance practices, but rather to supplement them strictly in a battlefield environment. Standard maintenance procedures will provide the most effective means of returning a damaged 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, and only at the direction of the commander.

b. BDAR techniques are not limited to simple restoration of minimum functional combat capability. If full functional 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 M 109 vehicle/M 110 series vehicle/M 578 Recovery Vehicle. The commander must decide whether the risk of having one less vehicle available for combat outweighs the risk of applying the potentially destructive expedient repair technique. Each technique gives appropriate warnings and cautions, and lists systems limitations caused by this action.

### 1-4. Definitions.

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

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

- (1) 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 vehicle.
- (3) Repair using M109/M110/M578 parts that serve a non-critical function elsewhere on the same vehicle for the purpose of restoring a critical function.
- (4) Bypassing of non-critical components in order to restore basic functional capability.
- (5) Expedient cannibalization procedures.

**INTRODUCTION**

- (6) Fabrication of parts from kits or readily available materials.
- (7) Jury-rigging.
- (8) Use of substitute fuels, fluids or lubricants.

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

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

d. A **Maintenance Team** (MT) consists of organizational mechanics, who may be trained in assessing battle damage and field repair procedures. MT 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 MT will assist the crew in restoring the vehicle to mission capability.

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

## INTRODUCTION

f. The **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. The term **fully mission capable** (FMC) means that the vehicle can perform all its combat missions without endangering the life of the crew. To be FMC the vehicle must be complete and fully operable with no faults listed in ■ the "Not Fully Mission Capable If:" column of the operator's Preventive Maintenance Checks and Services (PMCS).

h. The term **combat capable** means that the vehicle meets the minimum functional combat capability requirements. (See paragraph 1-10.)

i. The term **combat emergency capable** means that the vehicle 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 vehicle if it is used. The commander must decide if these limitations are acceptable for that specific emergency situation.

j. The term **self-recovery capable** means that the vehicle meets the needs for recovery under self-power. It could include hazardous equipment conditions such as partial brakes or limited steering

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

### 1-5. BDAR Recommendations and QDR/EIR.

a. Personnel originating new BDAR procedures should forward them directly to Commander, U.S. Army Armament, Munitions and Chemical Command, ATTN: AMSMC-MAS, Rock Island, IL 61299-6000. Personnel are encouraged to develop and report new BDAR ideas, techniques and procedures.

**INTRODUCTION**

b. Equipment Improvement Recommendations (EIR) may be submitted by anyone who knows of an unsatisfactory condition with equipment design or use. You do not have to show a new design or list a better way to do a procedure, just tell why the design is unfavorable or why a procedure is hard. EIR may be submitted on SF 368, Quality Deficiency Report. Mail these directly to Commander, U.S. Army Armament, Munitions and Chemical Command, ATTN: AMSMC-QAD, Rock Island, IL 61299-6000. A reply will be sent directly to you.

## INTRODUCTION

### SECTION II. Battlefield Damage Assessment and Repair - Standards and Practices

#### 1-6. BDAR Characteristics.

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

#### 1-7. Training.

The unit commander should ensure that an adequate number of members of his organization, including supervisors, are trained in BDAR procedures applicable to his equipment. Each vehicle crewman should be trained to perform initial battle damage assessment for his crew position.

#### 1-8. Waiver of Precautions.

Under combat conditions, BDAR may be performed on M 109 vehicles vehicles/M 110 series vehicles/M578 Recovery Vehicles, which are fueled and/or armed. Other similar precautions may be waived at the discretion of the commander. See paragraph 1-13e.

#### 1-9. Environment.

BDAR may be required in a chemically toxic environment or under other adverse conditions with severe limitations in personnel, facilities, equipment, and materials. Performance of repair tasks may be necessary while wearing protective gear. Expedient decontamination procedures are described in FM 3-5.

#### 1-10. Serviceability and Operability (Operating characteristics).

The Minimum Functional Combat Capabiltiy (MFCC) criteria for the M 109 vehicles/M 110 Series Vehicles/M578 Recovery Vehicles are as follows:

#### NOTE

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

##### a. Armament and Fire Control.

- (1) M 109 Vehicle: Turret must traverse 360 degrees and elevate with no oscillations either manually or by power.
- (2) M1 10 Series Vehicle: Turret must traverse either manually or by power 30 degrees right or left of center.
- (3) M109/M110: Main gun must have Recoil Mechanism, Turret, Equilibrators, and Cannon Assembly.
- (4) M109/M110: Must have an operational fire control mount and an indirect sighting device.

b. Mobility.

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

(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) May not be missing two adjacent roadwheel positions.

(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 vehicle to be incapable of traveling 10 miles per hour on a level, unimproved road.

c. Communications. No requirements. ■

**1-11. Permanent Repair.**

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

## INTRODUCTION

### SECTION III. Battlefield Damage Assessment and Repair - Responsibilities and Tasks

#### 1-12. General.

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

b. Battlefield damage repair kits consisting of essential tools, may be carried on-board each vehicle to enable the crew to rapidly fix the simplest and most common types of damage/failure (See Appendix B, Special and Fabricated Tools).

#### 1-13. Commander and Crew.

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

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

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

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

d. Battlefield Damage Assessment/Repair Forms are provided in Chapter 2 to permit a systematic assessment by the crew. Assessment checks include looking at the damaged parts, determining what system they belong to, and deciding how they can be fixed or jury-rigged to permit immediate operation (full or partial).

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

(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 accumulated?

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

(5) Is the fire extinguishing system operational? If not, then one crew member should be stationed in the turret, either with a hand fire extinguisher or prepared to manually operate the turret fire extinguisher. A second crew member should be stationed outside the turret with the other fire extinguisher. He should also be prepared to manually actuate the engine compartment fire extinguisher.

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

g. The vehicle commander shall report to the executive officers post 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 crew is possible, he shall report a total estimated repair time and what functions may be restored.

h. The executive officers post 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, materials, and tools available.

#### **1-14. Organizational Maintenance and Maintenance Teams (MT).**

a. The organizational maintenance team (MT) and assessor operate out of the battery or battalion trains. The MT assessor performs his assessment and the

## **INTRODUCTION**

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 defilade may be necessary. This is still considered "on-site".

b. If the vehicle has been left unattended in the forward battle area, the immediate area of the vehicle should be checked for mines and the vehicle should be checked for booby traps before starting the battle damage assessment. The MT should also make the safety checks listed in paragraph 1-13e.

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

- (1) Reviewing the crew's out-of-action report, if available.
- (2) Interviewing commander and crew if available.
- (3) Visually inspecting damaged parts and systems.
- (4) Performing a self-test,
- (5) Making tests with organizational test equipment, if required.
- (6) Performing additional vehicle operational tests, as necessary.

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

- (1) Determine what must be repaired or replaced.
- (2) Determine sequence and priority of repair actions.
- (3) Estimate repair times for each repair task.
- (4) Total the repair task times and determine if the repairs can be performed in the time available.
- (5) Determine repair location and, if other than on-site, arrange for recovery of the vehicle to the repair site.

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

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

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

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

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

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

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

i. 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 vehicle is damaged catastrophically and evacuation is not possible, remove items in the following order:

(1) Needed spares on-site.

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

(3) Other needed spares or repair parts.

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

#### **1-15. Direct Support/General Support Maintenance Team.**

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

b. Damaged vehicles 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.

#### **1-16. Time Limits for Repairing Damage.**

a. In combat, the time available for BDAR is limited. One of the factors to be considered in the selection of a repair site is the amount of time available at the site based on the tactical situation. Every assessment must include an estimate of total

**INTRODUCTION**

elapsed time for all tasks required to restore the vehicle. The time available at the selected repair site must equal or exceed the estimated time required to accomplish all tasks associated with the BDAR.

b. Determining where BDAR will take place should be based on the guidelines in Table 1-1. These are general rules which must be adjusted by the commander based on his best estimate of how the most responsive maintenance support can be provided. He must consider the tactical situation, maintenance backlog, personnel, tools, TM DE, 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 (MT) 3. Maintenance Support Team (MST) from Forward Support Maintenance Company	2 Hours
Battalion Trains (OMCP)	1. Battalion Maintenance Platoon 2. Maintenance Support Team (MST) from Forward Support Maintenance Company 3. Maintenance Support Team (MST) from Maintenance Battalion.	6 Hours
Brigade Support Area	1. Forward Support Maintenance Co. 2. Maintenance Support Team (MST) from Maintenance Battalion 3. Maintenance Support Team (MST) from COSCOM	24 Hours
Division Support Area	1. Maintenance Battalion 2. Maintenance Support Team (MST) from COSCOM	36 Hours
Corps Support	1. COSCOM Maintenance Companies	96 Hours

**INTRODUCTION****1-17. Recording BDAR Repairs.**

a. All components of an M109 vehicle/M110 series vehicle/M578 Recovery Vehicle, which are repaired using BDAR or other expedient techniques, shall be marked with a tag, DD Form 1577, or similar conspicuous tag. It is not necessary to fill out the form. The purpose of marking an item which has been repaired using BDAR techniques is to quickly enable mechanics to recognize these parts when the vehicle is subsequently returned for authorized permanent repair.

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

c. A tag should also be placed conspicuously in the vehicle commander'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.

e. When the vehicle is recovered/evacuated for permanent standard repair, and DA Forms 2404 and 5504 are used, the notation "BDAR" shall be added in the space provided for description of deficiencies. ■

f. DA PAM 738-750 provides for disposition of DA Form 2404 and copy number 2 of DA Form 5504. When "BDAR" is noted on these forms, they shall be mailed to: Survivability/Vulnerability Information Analysis Center (SURVIAC), AFFDL/FES/CDIC, Wright Patterson AFB, Ohio 45433. The information on these forms will provide data for designing vehicles to be less susceptible to combat damage and easier to repair when damaged. ■

**CHAPTER 2****ASSESSING BATTLEFIELD DAMAGE**

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

**SECTION I. General****2-1. Scope.**

This chapter provides guidelines to use to assess battlefield damage to the M 109 Howitzers/M110A2 Howitzers/M578 Recovery Vehicles. It directs you to an expedient repair procedure, or to the standard system TM if an expedient repair procedure for your problem doesn't exist. ■

**2-2. General.**

Use this TM in conjunction with the vehicle's Technical Manuals (TM) and Lubrication Order (LO). This chapter explains how to use this manual to assess and fix battlefield damage that prevents the M 109 Howitzers/M110 series Howitzers/M578 Recovery Vehicles from moving, shooting, and/or communicating. This chapter contains the general fault assessment tables, general troubleshooting and maintenance instructions including battlefield damage assessment/repair forms. General fault assessment tables, specific fault assessment tables, and detailed assessment procedures are used to locate the damage; and an expedient repair procedure tells how to fix the damage. An index of the expedient repair procedures is located in each chapter. If you don't know or aren't sure of exactly what your problem is, you should use the assessment tables and procedures to find the fault. ■

**2-3. Application.**

Use the following steps to find and fix battlefield damages:

- a. Do the Preventive Maintenance Checks and Services (PMCS) in the TM and LO. At the same time look for obvious damage to the vehicle.
- b. If applicable, do the troubleshooting/repair recommended in the TM.
- c. If you find the problem, determine its effect on the operation (mobility, firepower, or communication) of the vehicle.

## **ASSESSING BATTLEFIELD DAMAGE**

d. If you can't fix the problem using the PMCS'S and procedures in the standard TM and LO, use the assessment table 2-1 to assess and fix the problem.

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

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

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

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

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

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

## **SECTION II. Assessing Battlefield Damage**

### **2-4. General.**

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

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

- (1) procedures in this manual if a "quick-fix" is possible,
- (2) the 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. Each procedure:

- (1) contains general information about the problem,
- (2) lists materials and/or tools required other than those commonly available to the crew, MT, and MST (If the listed items are not available, 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 vehicle,
- (5) provides other expedient options you can use depending on the availability of personnel, materials, tools, and/or time (This does not include standard maintenance procedures or recovery).

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

e. Additional data is contained in the Appendices.

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

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**ASSESSING BATTLEFIELD DAMAGE**

(2) Appendix B lists special or fabricated tools used in performing BDAR repairs,

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

2-5. Assessment Process.

a. The assessment procedures are structured using the logic process shown in figure 2-1 below,

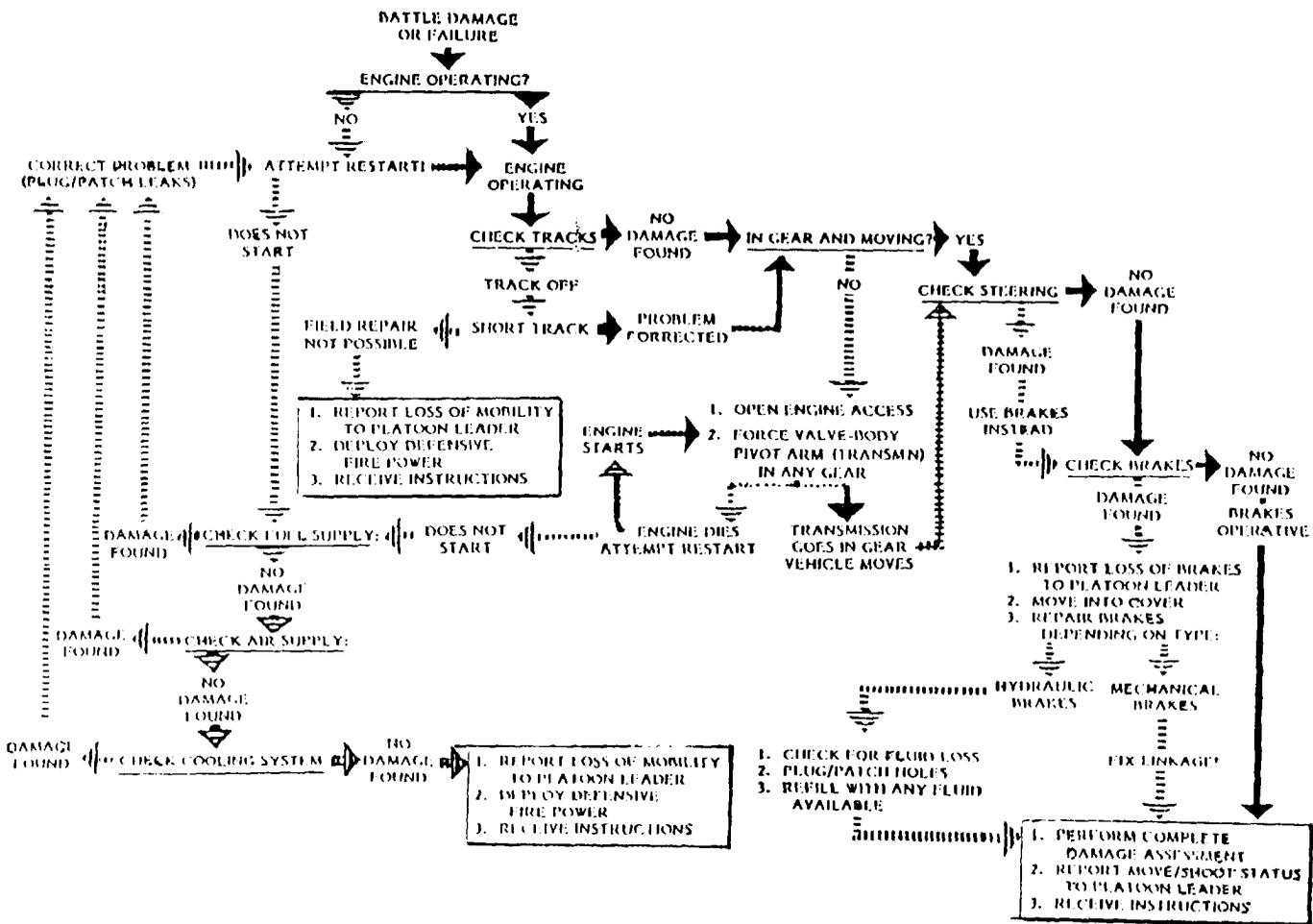


Figure 2-1. Battlefield Damage Assessment Process.

- b. All assessment procedures follow the sequence
  - (1) visually inspect (repair, if necessary),
  - (2) functionally test (repair, if necessary) and,
  - (3) assess the performance.

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

- c. There are three kinds of assessments performed on damaged equipment.
  - (1) The first assessment is extent and kind of damage and how it affects vehicle operation and capabilities.
  - (2) The second is whether the damage needs to be repaired and,
  - (3) The third is assessment of where and how to repair the damage.
- d. Assessments of damage may be made in turn by operator/crew, MT, and MST assessors.
  - (1) Extent and kind of damage is readily assessable.
  - (2) Whether or not to repair the damage may be readily assessable. However, whether to attempt repair and when and how to repair the damage may be judgement calls. No procedure can take all possible situations into account. Assessment of whether the damage needs to be repaired will be made jointly by the MT and vehicle commander as they evaluate the vehicle 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/operator. MST's may redirect or change MT's decisions.

#### **2-6. Overall Vehicle Assessment Procedure.**

- a. This procedure can be used by the crew, but it will be of more use to an MT or MST assessor working to "quick-fix" vehicles for a mission or self-recovery. The procedure provides for assessing the kind of damage and determining
  - (1) the effect of the damage and if it needs to be fixed,
  - (2) if the damage can be fixed using BDAR or if only regular maintenance

operations can fix it, and

(3) how long it will take to fix it.

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

c. As an example, a vehicle develops an engine speed control problem. The overall vehicle assessment table directs the user to perform a number of visual and functional checks, which will narrow down the number of areas possibly at fault. The overall vehicle assessment table provides references to Chapter and/or Sections dealing with a subsystem in which the problem may be found. Additional assessment procedures in that Chapter will either eliminate further assessment in that area or confirm the likelihood of a problem in that area by directing the user to check out specific assemblies or components. Assessment procedures in the beginning of each Chapter provide references to specific paragraphs which may expediently solve the problem.

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

e. Refer to Table 2-1, Vehicle/System Assessment to begin the assessment process.

**ASSESSING BATTLEFIELD DAMAGE**

**Table 2-1. Vehicle/System Assessment.**

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

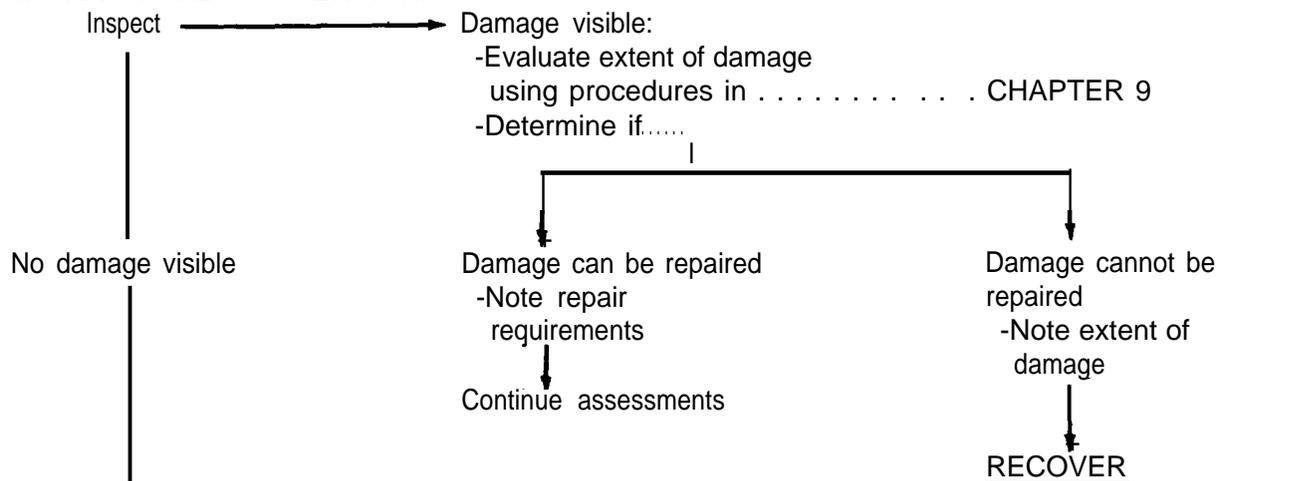
**NOTE**

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

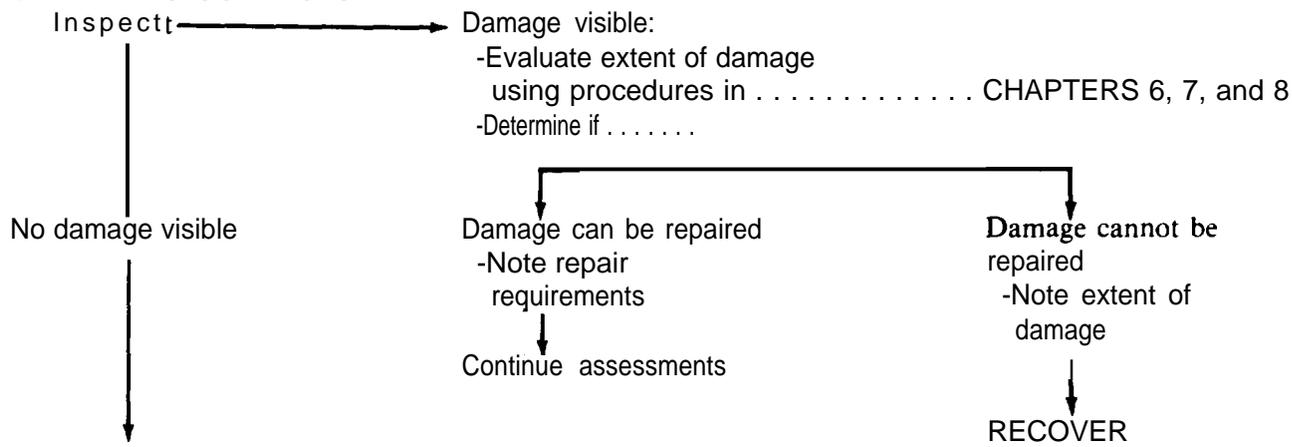
**A. MOBILITY ASSESSMENT.**

**1. VISUALLY INSPECT . . . .**

**a. TRACK AND SUSPENSION:**

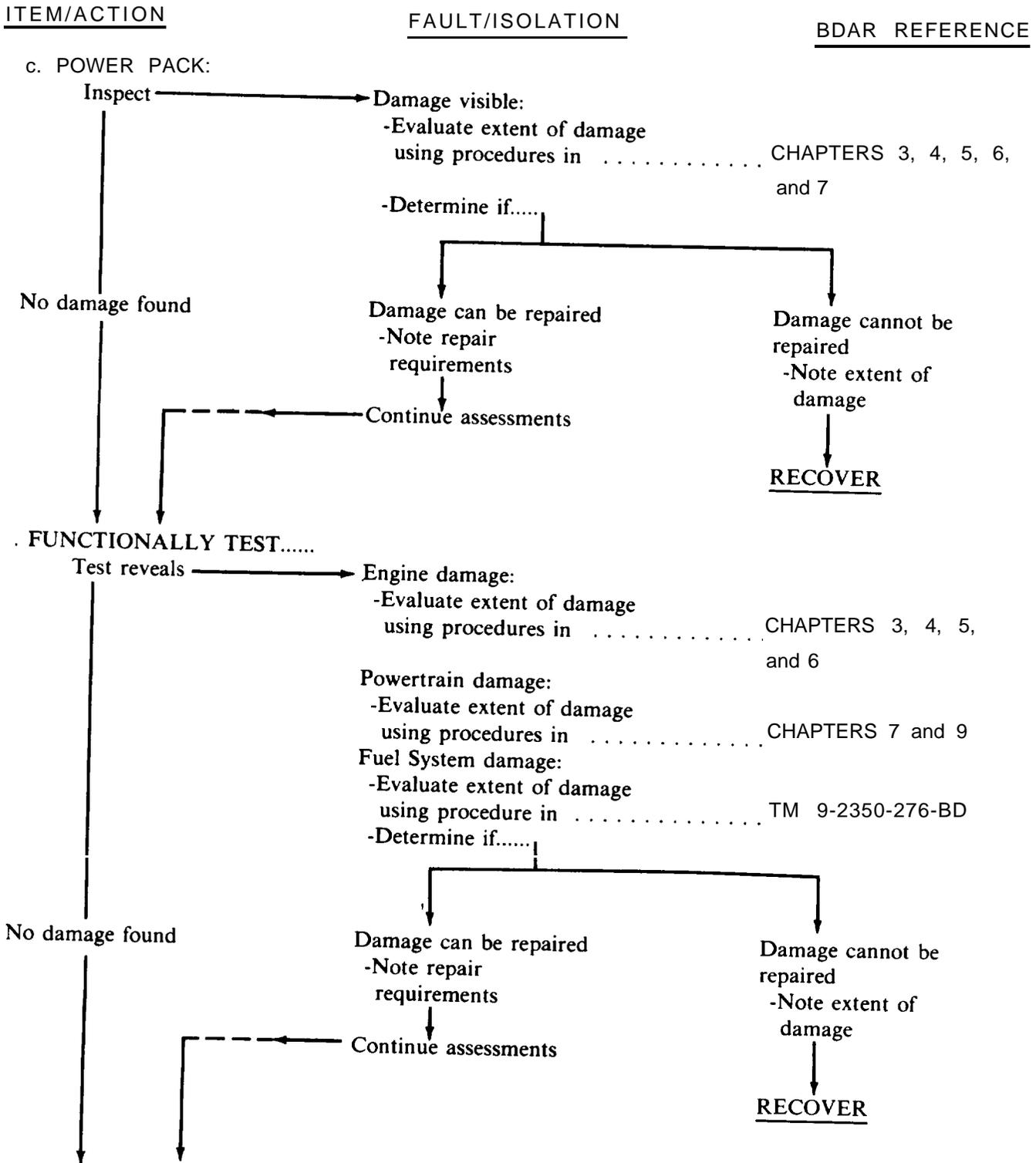


**b. DRIVER'S CONTROLS:**



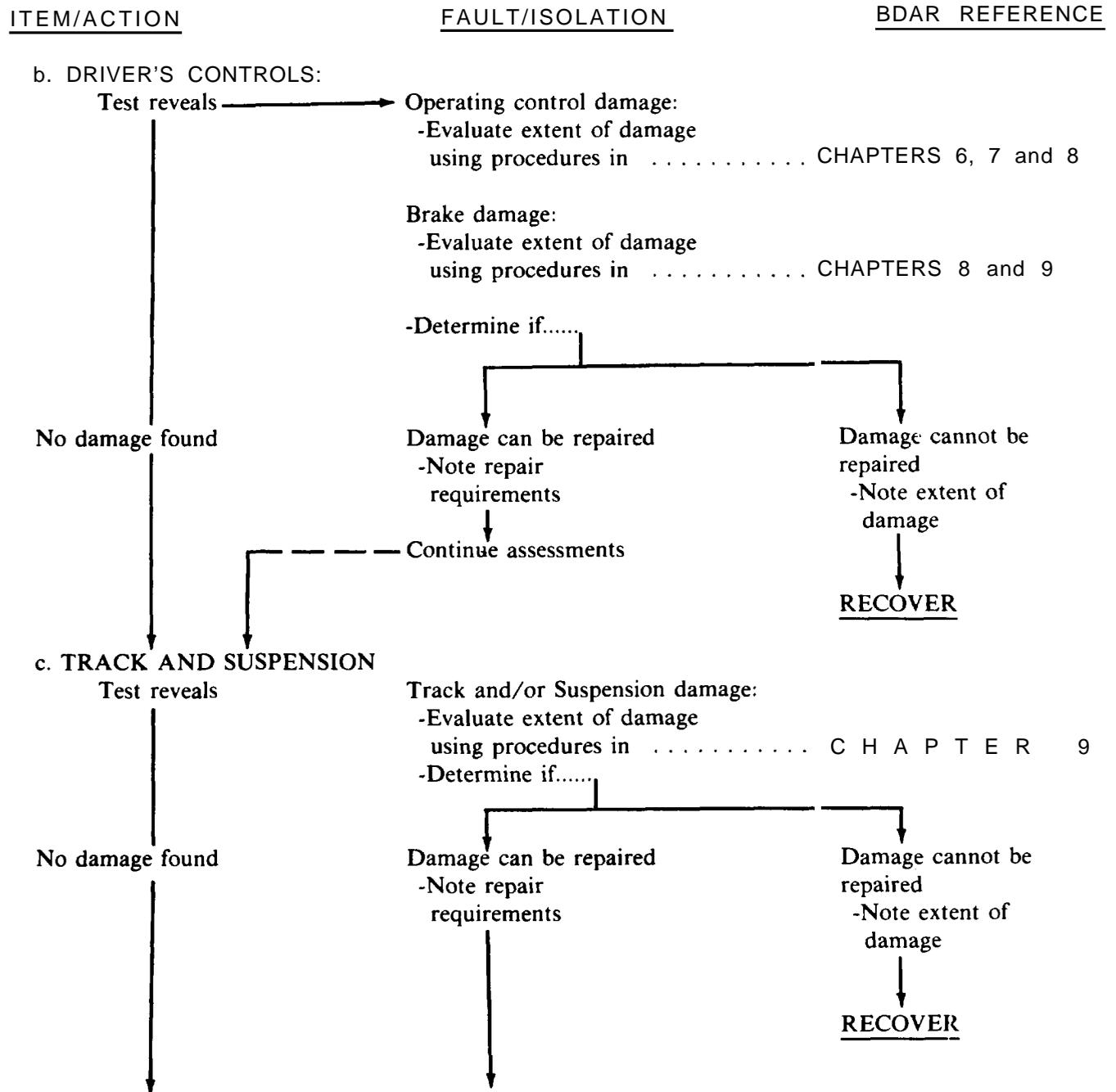
ASSESSING BATTLEFIELD DAMAGE

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



ASSESSING BATTLEFIELD DAMAGE

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



This completes the mobility assessments. Continue with assessments of armament and fire control if required. If after systems are operational, prepare to report.

**ASSESSING BATTLEFIELD DAMAGE**

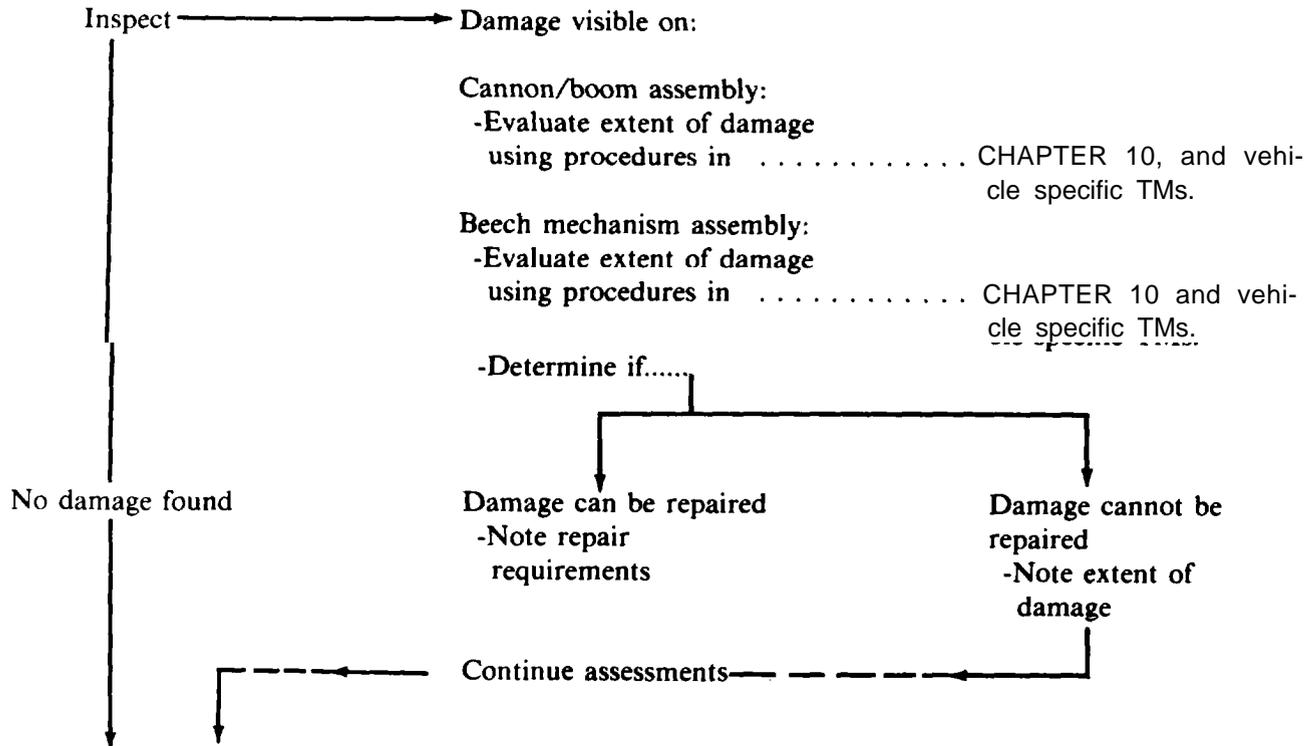
**Table 2-1. Vehicle/System Assessment (Cent),**

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

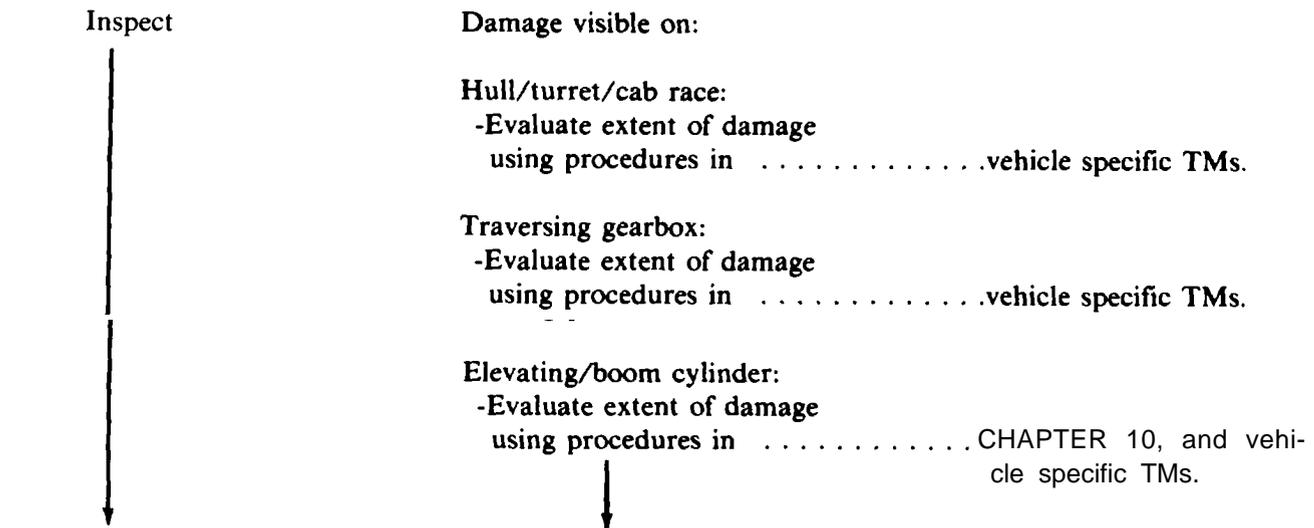
**B. ARMAMENT AND FIRE CONTROL ASSESSMENT.**

**1. VISUALLY INSPECT....**

**a. MAIN GUN/BOOM SYSTEM:**

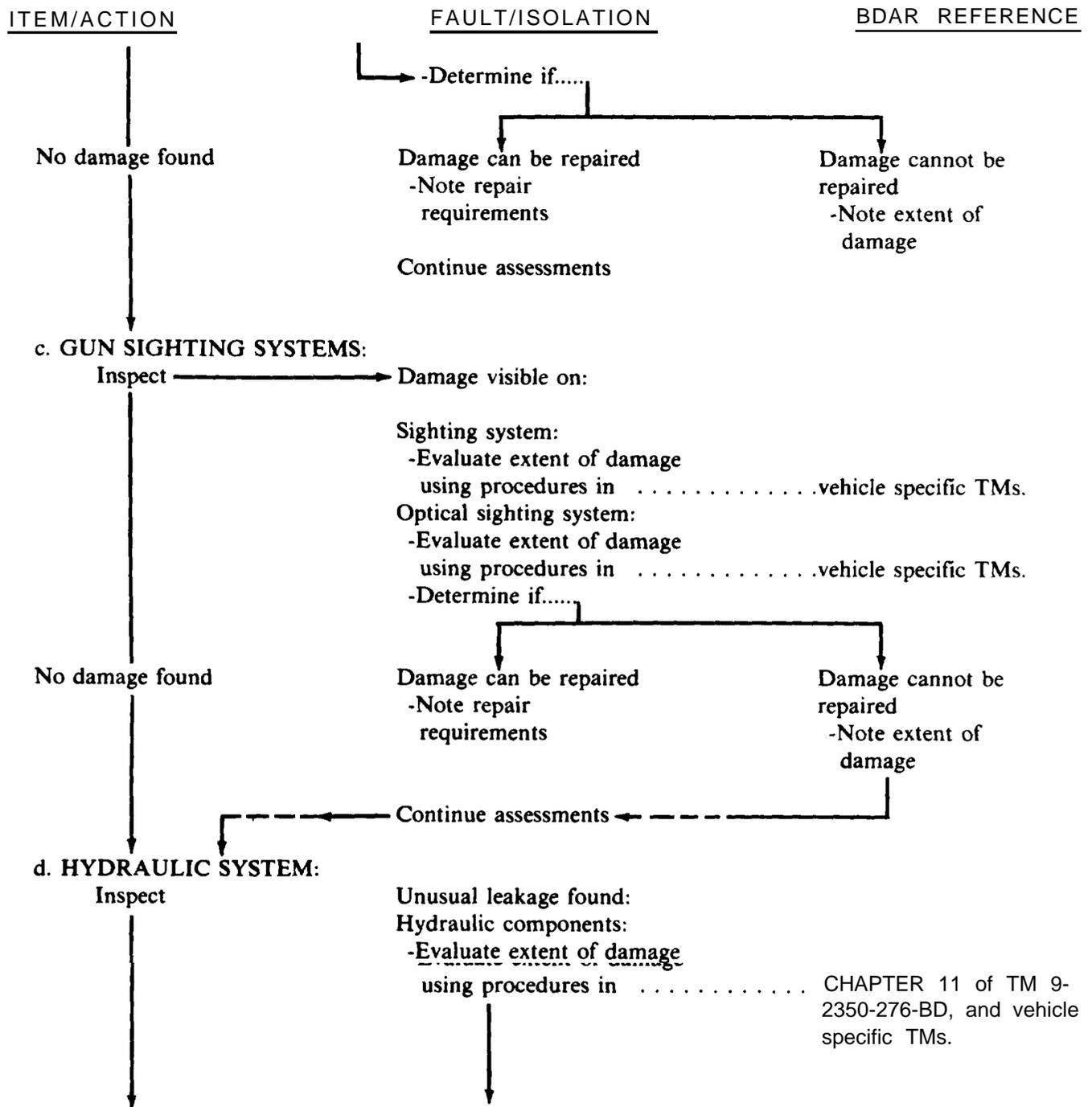


**b. TURRET ASSEMBLY:**



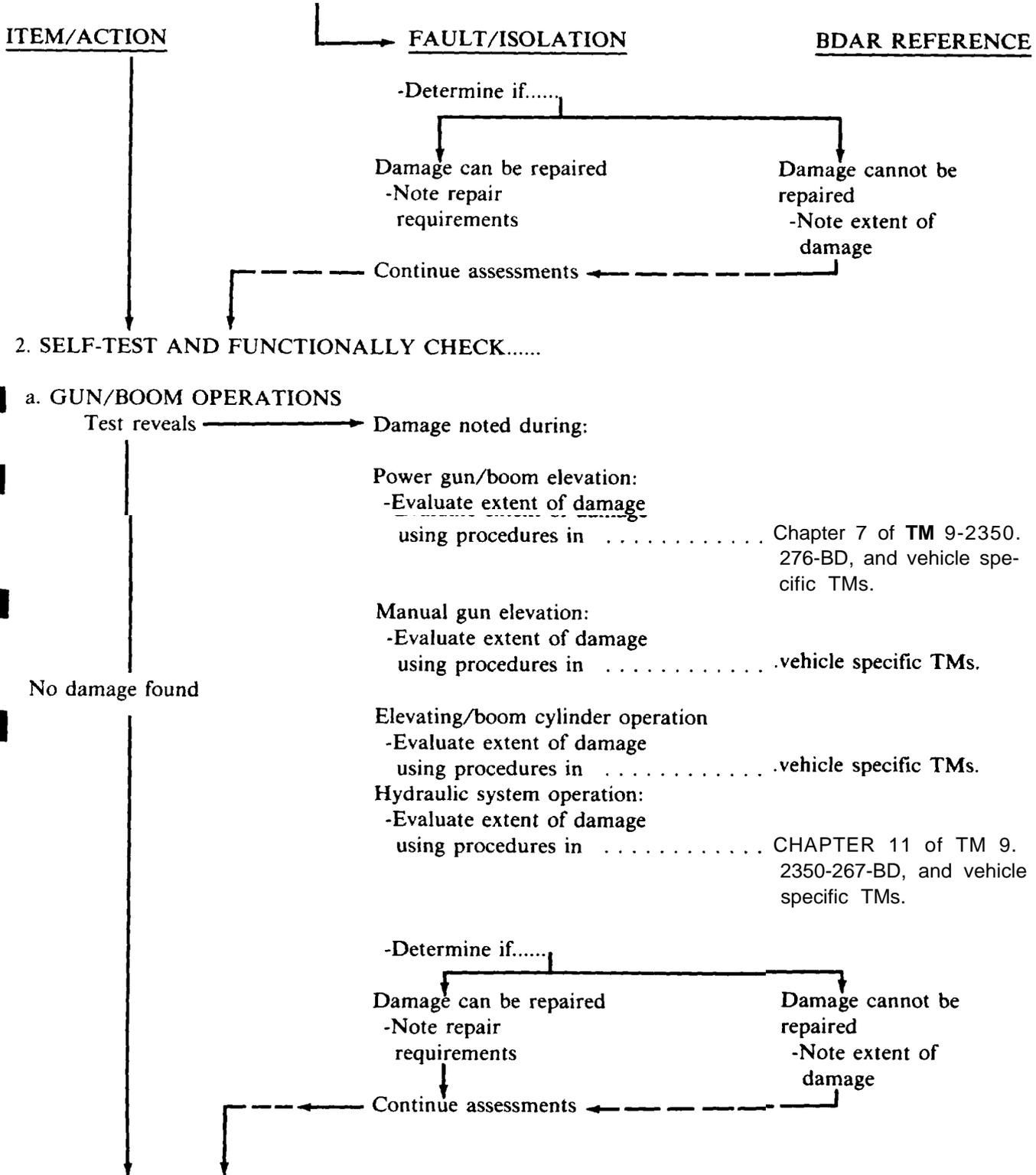
ASSESSING BATTLEFIELD DAMAGE

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



**ASSESSING BATTLEFIELD DAMAGE**

**Table 2-1. Vehicle/System Assessment (Cont).**



**ASSESSING BATTLEFIELD DAMAGE**

**Table 2-1. Vehicle/System Assessment (Cent).**

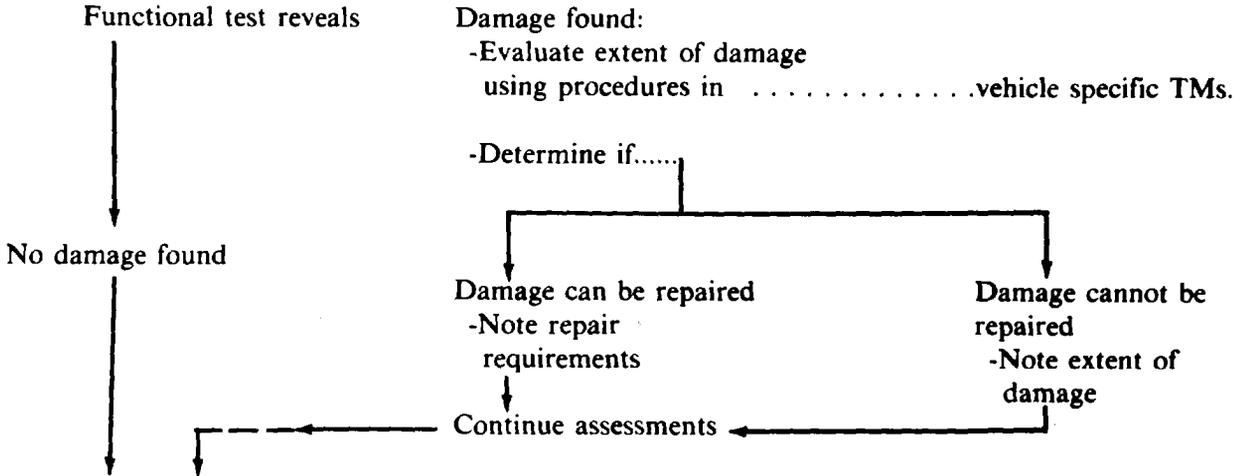
<u>ITEM/ACTION</u>	<u>FAULT/ISOLATION</u>	<u>BDAR REFERENCE</u>
b. TURRET/CAB OPERATIONS:		
Test reveals	Damage noted during:	
	Power traversing of turrets: -Evaluate extent of damage using procedures in . . . . .	CHAPTER 7 of TM 9- 2350-276-BD, and vehicle specific TMs.
	Manual traversing of turret: -Evaluate extent of damage using procedures in . . . . .	vehicle TMs.
No damage found	-Determine if.....	
	Damage can be repaired -Note repair requirements	Damage cannot be repaired -Note extent of damage
	Continue assessments	
c. SIGHTING SYSTEM:		
Operational test reveals	Damage found (to any of the system(s)): -Evaluate extent of damage using procedures in . . . . .	vehicle specific TMs.
	-Determine if.....	
No damage found	Damage can be repaired -Note repair requirements	Damage cannot be repaired -Note extent of damage
	Continue assessments	

**ASSESSING BATTLEFIELD DAMAGE**

**Table 2-1. Vehicle/System Assessment (Cent).**

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

**d. TURRET BLOWER SYSTEM:**



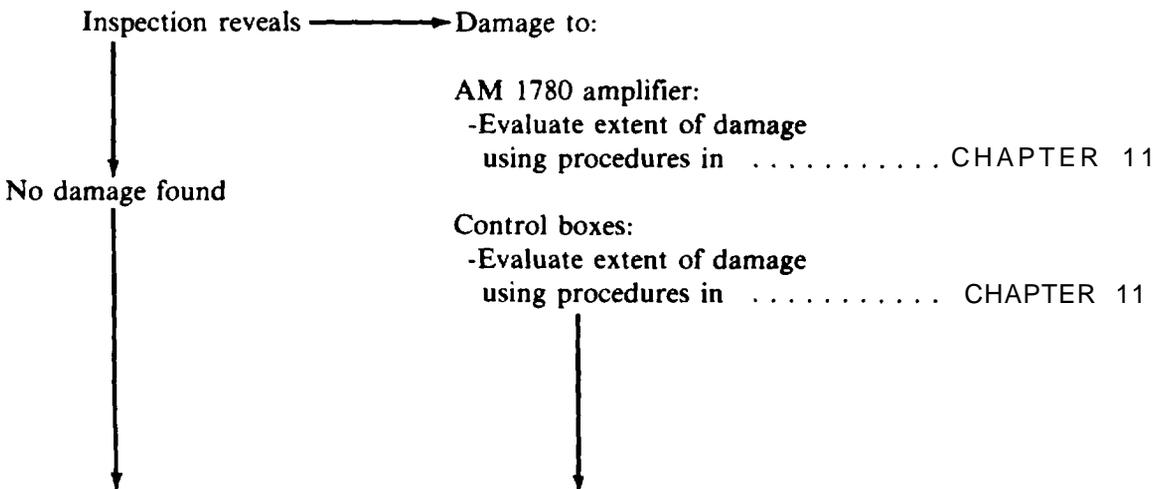
This completes assessments of armament and fire control systems. Continue with assessments of the communication system if required. If communication systems are operational, prepare to report.

**C. COMMUNICATIONS ASSESSMENTS.**

**1. VISUALLY INSPECT.....**

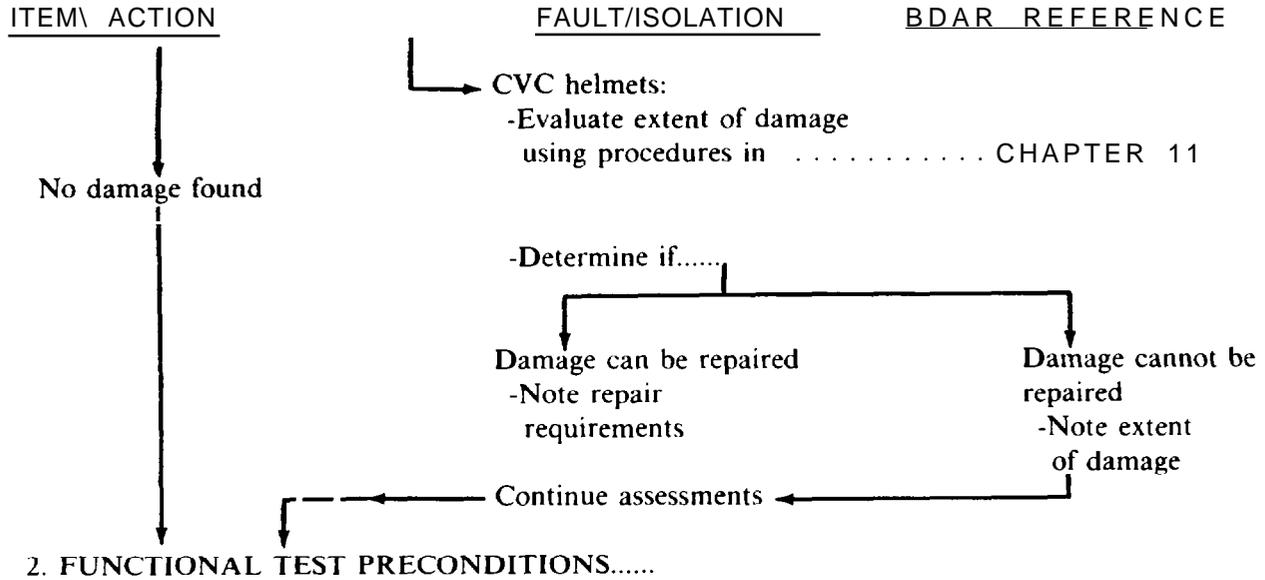
**WARNING**

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



ASSESSING BATTLEFIELD DAMAGE

Table 2-1. Vehicle/System Assessment (Cont).

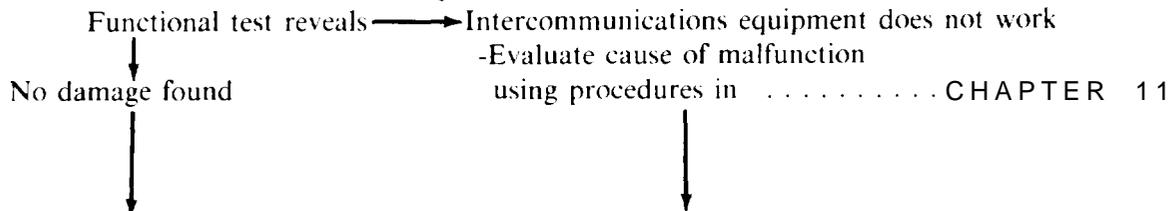


NOTE

- Insure that no current-conducting wires will short out to each other or to ground, when power to equipment is turned on.
- Power must be turned on in the complete communication system to functionally test any component.

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

INTERCOMMUNICATIONS EQUIPMENT:



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

**ASSESSING BATTLEFIELD DAMAGE**

2-8. Index of Failures and Field Fixes.

Table 2-2 below lists the BDAR procedures in this TM in alphabetical order.

Table 2-2. BDAR Procedural Index

<b>FAILURE</b>	<b>PARA</b>
Blower Motor, Air Cleaner Failure . . . . .	6-8
Brake Malfunctions . . . . .	8-6
Brakes, Parking, Locked . . . . .	8-4
Brakes, Service, Locked . . . . .	8-5
Brushes Gummed . . . . .	6-6
Bore Evacuator Damage... . . . .	10-4
Cannibalized Cables Are Too Short; BDAR Installation . . . . .	11-13
Circuit Breaker Failure . . . . .	6-5
Cooling Fan Failure . . . . .	5-4
Drive Sprocket Bolts Sheared Off . . . . .	9-6
Engine Substitutions . . . . .	3-4
Exhaust System Damage... . . . .	3-7
Final Drive Hub Bolts Sheared . . . . .	7-7
Fuel Filter Clogged or Frozen . . . . .	4-13
Fuel Injector Line Rupture. . . . .	3-13
■ Fuel Pump Inoperative . . . . .	4-9
Fuel Pump Interchangeability . . . . .	4-8
Fuel Pump Failure . . . . .	4-7
Fuel Tank Substitute . . . . .	4-5
Gun Interchangeability . . . . .	1-5
Inadequate Traction . . . . .	9-4
Injector Failure . . . . .	3-12
Intercommunications Cable Repair . . . . .	11-12
Isolation of Non-Essential Systems (General) . . . . .	11-14
Isolation of Voltage Suppressors . . . . .	11-15
Intercommunications System Field Expedient . . . . .	11-10
Manual Pump Fluid Loss... . . . .	10-9
Oil Level Low . . . . .	3-9
Oil Pin holes . . . . .	3-10

**ASSESSING BATTLEFIELD DAMAGE**

Table 2-2. BDAR Procedure Index (Continued)

<b>FAILURE</b>	<b>PARA</b>
Quick Disconnect Leak . . . . .	4-11
Repair AN/VIC-1 Intercom with Soviet R-124 Intercom . . . . .	11-11
Roadwheel Arm Damaged . . . . .	9-6
Starter Failure, Substitution . . . . .	6-10
Starter Motor, Relay Failure . . . . .	6-9
Steering Linkage Failure . . . . .	7-6
Throttle Linkage Broken . . . . .	3-14
Track, Roadwheel or Idler Arm Damage . . . . .	9-5
Transmission/Transfer Interchangeability . . . . .	7-4
Turret Interchangeability.....,.. . . . .	10-8
Turret Power Pack Damage . . . . .	10-6
Turret Power Pack Interchangeability . . . . .	10-7

## ASSESSING BATTLEFIELD DAMAGE

### SECTION III. Battlefield Damage Assessment/Repair Forms

#### 2-9. General.

a. This section illustrates and describes the forms 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 triage." Vehicle triage 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.

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

c. All assessment procedures follow the sequence, (1) visually inspect (repair if necessary), (2) functionally test, (repair if necessary), and (3) assess the performance. 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.

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

e. There are four forms to be used when assessing battlefield damage, BDARF-5 (System Summary), BDARF-6 (Hull Damage Report), BDARF-7 (Turret and Cab Damage Report), BDARD-8 (Communications Damage Report). These forms can be used by the crew, a MT, or MST.

(1) BDARF-5 is used to determine:

Can the vehicle move, shoot and communicate?

What subsystems are affected?

Is the damage repairable?

If repairable, are there limitations?

Estimated time to repair?

Estimated number of personnel to effect repair.

What materials are required?

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

Once these questions are answered, a determination can be made as to whether the vehicle should be repaired on-site, recovered to a collection point and repaired, or recovered to the rear.

(2) BDARF-6, -7, and -8 address specific systems and subsystems. These forms are designed to assist the assessor to rapidly assess the damage and rapidly determine the appropriate BDAR fix. The portion of this form 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 damages occurred and what repairs were effected and where.

SYSTEM SUMMARY

Serial No. \_\_\_\_\_

<u>Vehicle Status</u>	<u>Can Vehicle Be Repaired?</u>				<u>Recovery Status</u>	
	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>
Move _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Self Recover	<input type="checkbox"/> <input type="checkbox"/>
Shoot _____	<input type="checkbox"/>	<input type="checkbox"/>			Can be Towed	<input type="checkbox"/> <input type="checkbox"/>
Communicate _____	<input type="checkbox"/>	<input type="checkbox"/>			Transportable	<input type="checkbox"/> <input type="checkbox"/>

<u>Sub-System</u>	<u>Repair</u>	<u>Recover</u>	<u>Limitations</u>	<u>Estimated -</u>	
				<u>Time</u>	<u>Personnel</u>
Engine	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Transmission/Final Drive	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Fuel System	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Electrical System	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Track & Suspension	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Hydraulic System	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Armor & Ammunition Stowage	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Armament & Fire Control	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Communications	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
Other _____	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____	_____
			<b>Total</b>	_____	_____

Material Requirements

	<u>Expendables</u>	<u>Parts</u>	<u>NSN</u>	<u>Tools</u>	<u>NSN</u>
1.	_____	_____	_____	_____	_____
2.	_____	_____	_____	_____	_____
3.	_____	_____	_____	_____	_____
4.	_____	_____	_____	_____	_____
5.	_____	_____	_____	_____	_____

Remarks

HULL DAMAGE ASSESSMENT AND REPAIR

Serial No. \_\_\_\_\_

Estimated Total Time \_\_\_\_\_

No. of Mechanics \_\_\_\_\_

<u>Exchanged Parts</u>	<u>NSN</u>	<u>Cannibalized Parts</u>	<u>NSN</u>
1. _____	_____	1. _____	_____
2. _____	_____	2. _____	_____
3. _____	_____	3. _____	_____
4. _____	_____	4. _____	_____
5. _____	_____	5. _____	_____

<u>Engine System</u>	<u>Time</u>	<u>Personnel</u>	<u>Transmission &amp; Final Drives</u>	<u>Time</u>	<u>Personnel</u>	<u>Fuel System</u>	<u>Time</u>	<u>Personnel</u>
1. Starter	_____	_____	1. Transmission will not shift	_____	_____	1. Fuel Tanks	_____	_____
2. Oil Tank	_____	_____	2. Broken Linkage	_____	_____	2. Fuel Lines	_____	_____
3. Air Induction System	_____	_____	3. Tank will not Steer	_____	_____	3. Fuel Filters	_____	_____
4. Air Cleaner	_____	_____	4. Final Drive Locked	_____	_____	4. Fuel Pumps	_____	_____
5. Oil Filter	_____	_____	5. Transmission Leaks	_____	_____	5. _____	_____	_____
6. Low Oil Pressure	_____	_____	6. Parking Brakes	_____	_____	6. _____	_____	_____
7. Drain Valve	_____	_____	7. Service Brakes	_____	_____	7. _____	_____	_____
8. Accessory Driveshaft	_____	_____	8. Oil Coolers	_____	_____			
9. _____	_____	_____	9. _____	_____	_____			
10. _____	_____	_____	10. _____	_____	_____			
11. _____	_____	_____						

BDARF-6

HULL DAMAGE ASSESSMENT AND REPAIR (Continued)

Serial No. \_\_\_\_\_

TM 9-2350-274-BD  
ASSESSING BATTLEFIELD DAMAGE

<u>Electrical System</u>	<u>Time</u>	<u>Personnel</u>
1. Wiring Harness	_____	_____
2. Slipring	_____	_____
3. Batteries	_____	_____
4. Circuit Breakers	_____	_____
5. Power Distribution Box	_____	_____
6. _____	_____	_____
7. _____	_____	_____
8. _____	_____	_____
Total	_____	_____

<u>Track &amp; Suspension</u>	<u>Time</u>	<u>Personnel</u>
1. Compensating Idlers	_____	_____
2. Track Adjusting Link	_____	_____
3. Road Wheel Arms	_____	_____
4. Roadwheels	_____	_____
5. Support Rollers	_____	_____
6. Sprockets	_____	_____
7. Shock Absorbers	_____	_____
8. Torsion Bars	_____	_____
9. Track Assembly	_____	_____
10. _____	_____	_____
11. _____	_____	_____
12. _____	_____	_____
Total	_____	_____

<u>Hydraulic System</u>	<u>Time</u>	<u>Personnel</u>
1. Hydraulic Lines	_____	_____
2. Hydraulic Fluid	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
Total	_____	_____

<u>Other</u>	<u>Time</u>	<u>Personnel</u>
1. Driver's Controls	_____	_____
2. Driver's Instruments	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
Total	_____	_____

TURRET DAMAGE ASSESSMENT AND REPAIR

Serial No. \_\_\_\_\_

Estimated Total Time \_\_\_\_\_  
 No. of Mechanics \_\_\_\_\_

<u>Exchanged Parts</u>	<u>NSN</u>	<u>Cannibalized Parts</u>	<u>NSN</u>
1. _____	_____	1. _____	_____
2. _____	_____	2. _____	_____
3. _____	_____	3. _____	_____
4. _____	_____	4. _____	_____

<u>Electrical System</u>	<u>Time</u>	<u>Personnel</u>
1. Turret Power	_____	_____
2. Slipring	_____	_____
3. Circuit Breakers	_____	_____
4. Wiring Harnesses	_____	_____
5. _____	_____	_____
6. _____	_____	_____
Total	_____	_____

<u>Hydraulic System</u>	<u>Time</u>	<u>Personnel</u>
1. Aux Hydraulic Pump	_____	_____
2. Hydraulic Fluid	_____	_____
3. Hydraulic Reservoir	_____	_____
4. Tubes & Hoses	_____	_____
5. Accumulator	_____	_____
6. _____	_____	_____
7. _____	_____	_____
Total	_____	_____

<u>Armor &amp; Ammo Stowage</u>	<u>Time</u>	<u>Personnel</u>
1. Ammo Stowage Racks	_____	_____
2. Ammo Ready Rack	_____	_____
3. _____	_____	_____
4. _____	_____	_____
Total	_____	_____

<u>Fire Control</u>	<u>Time</u>	<u>Personnel</u>
1. CMDR Control Handle	_____	_____
2. CMDR Weapon Sight	_____	_____
3. Gunner's Primary Sight	_____	_____
4. Gunner's Aux Sight	_____	_____
5. Range Finder	_____	_____
6. Stabilization System	_____	_____
7. Cross Wind Sensor	_____	_____
8. Wiring Harness	_____	_____
9. Gunner's Control Handle	_____	_____
10. Manual Traverse & Elevation	_____	_____
11. Loader's Panel	_____	_____
12. Blasting Machine	_____	_____
13. _____	_____	_____
14. _____	_____	_____
Total	_____	_____

<u>Armament</u>	<u>Time</u>	<u>Personnel</u>
1. Bore Evacuator	_____	_____
2. Gun Tube	_____	_____
3. Breech Group	_____	_____
4. Main Gun Mount	_____	_____
5. _____	_____	_____
6. _____	_____	_____
Total	_____	_____

TM 9-2350-274-BD  
 ASSESSING BATTLEFIELD DAMAGE

COMMUNICATIONS DAMAGE ASSESSMENT AND REPAIR

Serial No. \_\_\_\_\_

TM 9-2350-274-BD  
ASSESSING BATTLEFIELD DAMAGE

Exchanged Parts	<u>NSN</u>	Cannibalized Parts	<u>NSN</u>
1. _____	_____	1. _____	_____
2. _____	_____	2. _____	_____
3. _____	_____	3. _____	_____
4. _____	_____	4. _____	_____

	<u>Time</u>	<u>Personnel</u>
1. Intercommunications	_____	_____
2. Receiver/Transmitter	_____	_____
3. Antennas	_____	_____
4. AM 1780	_____	_____
5. Security	_____	_____
6. Cables	_____	_____
7. _____	_____	_____
8. _____	_____	_____
Total	_____	_____

# CHAPTER 3

## ENGINE

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

### SECTION I. General

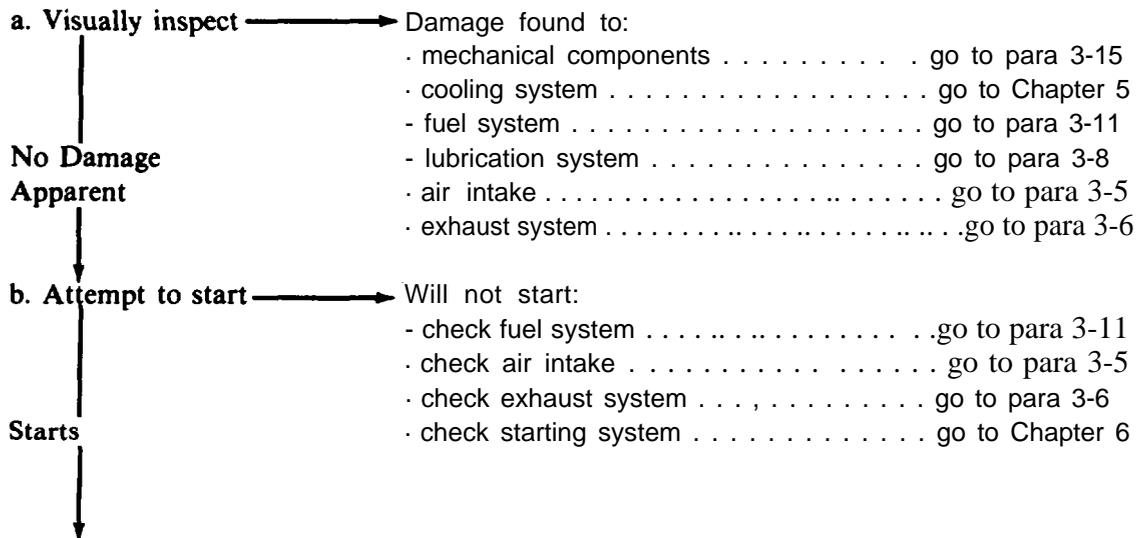
#### 3-1. Purpose.

a. The M 109 Self-Propelled Howitzer/M 110 series Self-Propelled Howitzer/M578 Recovery Vehicle is powered by a V-8, liquid cooled, two cycle, turbosupercharged, diesel engine, 8V71T. Engine damage can be detected by several different method.

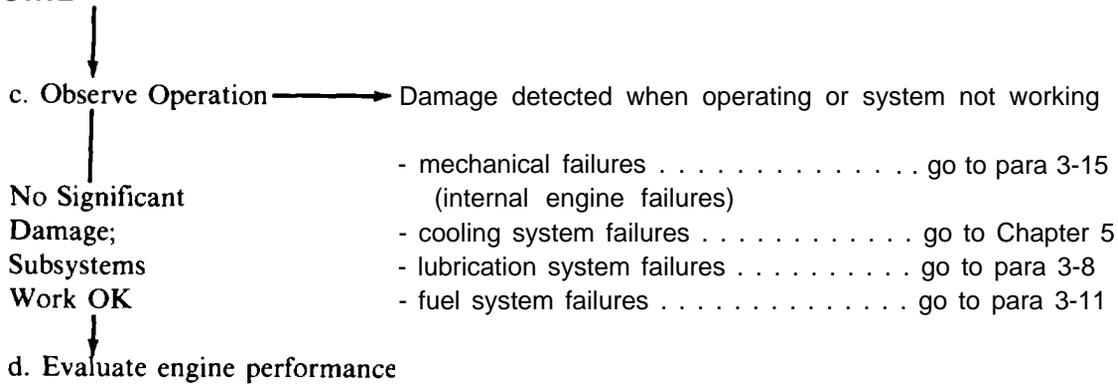
- (1) Abnormal oil pressure, temperature readings or warning lights,
- (2) Abnormal noises,
- (3) Abnormal amounts or coloration of exhaust smoke,
- (4) Sudden loss of power or excessive fuel consumption.

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

#### 3-2. Assessment Procedure.



**ENGINE**



**ENGINE ASSESSMENT**

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self Recovery Capable	Recover
- Power/Output Response Normal/Near Normal	x	x	x		
- Power Output Degraded		x	x	x	
- Power Output Severely Degraded			x	x	
- No Power					x

**3-3. BDAR Procedure Index.**

	Para
Engine Substitutions . . . . .	3-4
Exhaust System Damage . . . . .	3-7
Oil Level Low . . . . .	3-9
Oil Pan Holes . . . . .	3-10
Injector Failure . . . . .	3-12
Fuel Injector Line Rupture . . . . .	3-13
Throttle Linkage Broken . . . . .	3-14

## SECTION II. Engine Failure

### 3-4. 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, Howitzer, M578 Recovery Vehicle, and some NATO vehicles). 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.

#### Limitations:

- Possible degraded mobility

#### Personnel/Time Required:

- 3 Soldiers
- 6 hours

#### Materials/Tools:

- Engine - M107, M109, M110, M578, or M975
- Lift capability

#### Procedural Steps:

1. Remove powerpack.
2. Separate engine from the transfer case.
3. Place the substitute engine beside the original engine.

## ENGINE

### Procedural Steps (Continued)

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.

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

### Option 1:

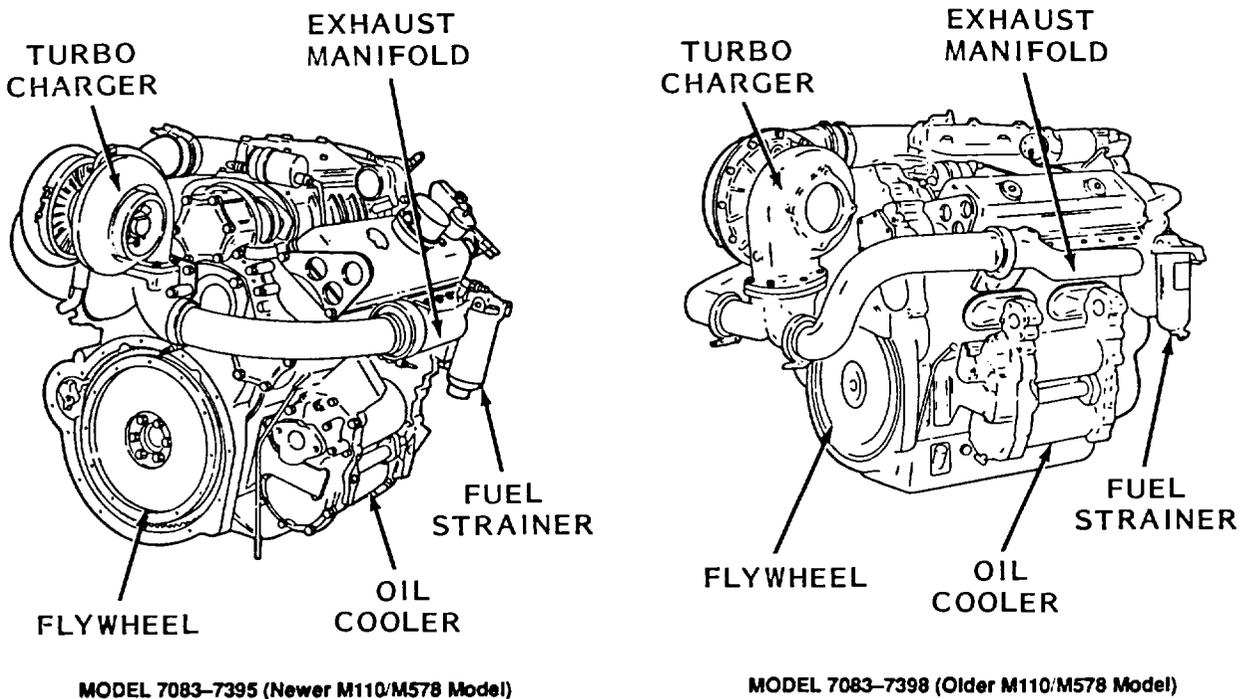


Figure 3-1. Engine Assemblies Right Rear View

Procedural Steps (Cont):

Option 2:

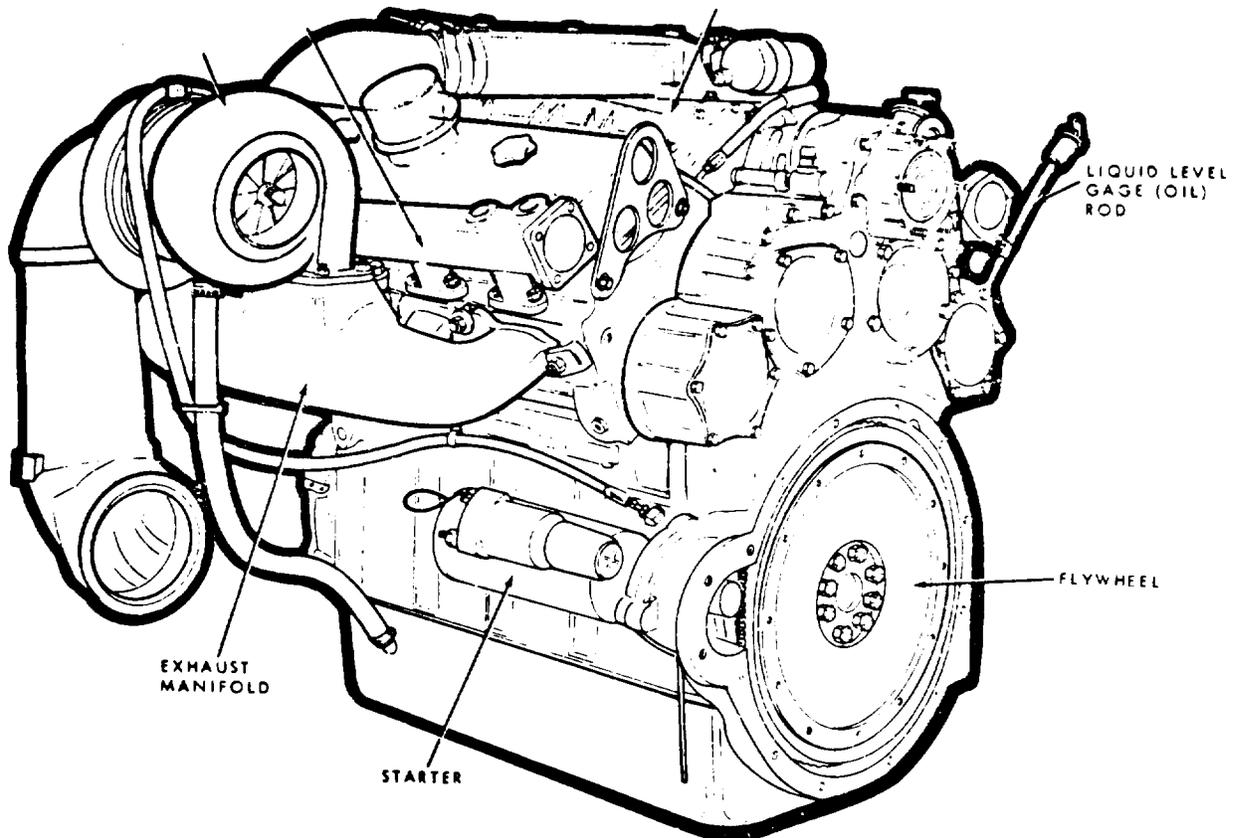


Figure 3-2. Engine Assembly (Model 17083-7396)  
Left Rear View

**Procedural Steps (Cont):**

**Option 3:**

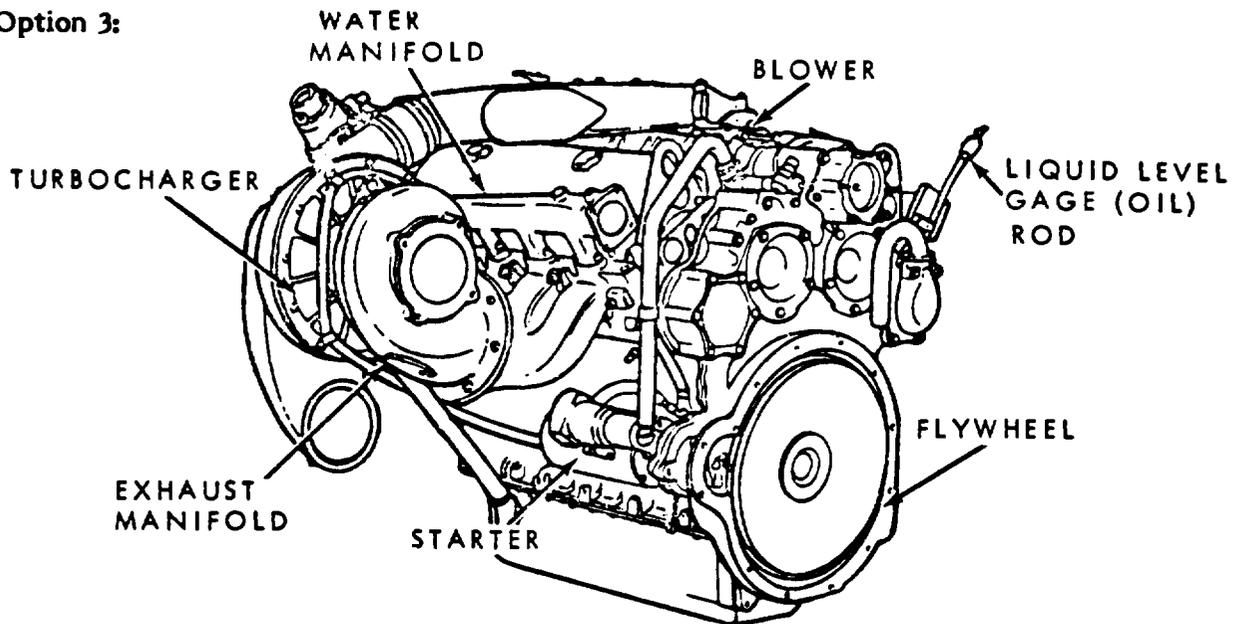


Figure 3-3. Engine Assembly (Model 7083-7396) Left Rear View

**Option 4:**

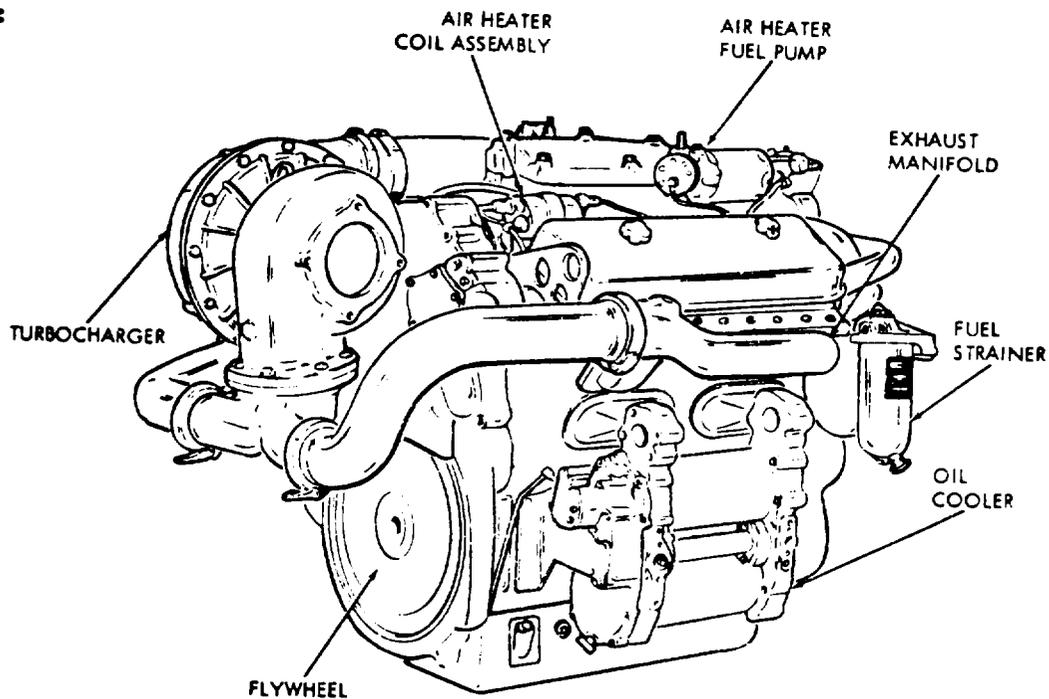
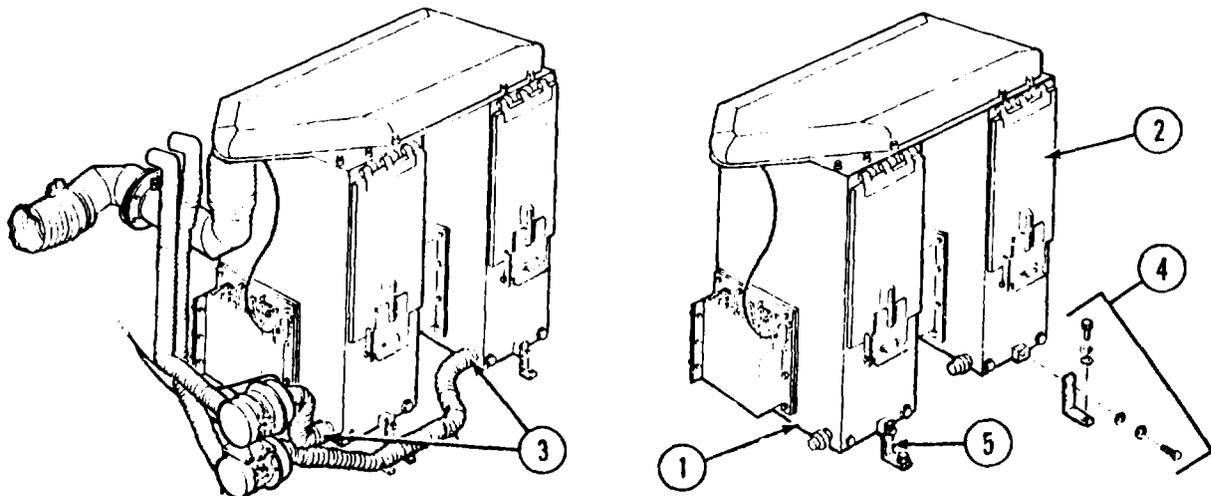


Figure 3-4. Engine Assembly (Model 7083-7398) Right Rear View (Early Version)

### SECTION III. Engine Air Intake Systems

#### 3-5. General.

Turbocharged engines use exhaust gases to drive the turbocharger to compress air and force it into the cylinder under pressure. The engine air intake system therefore has vacuum and pressure. Repairs to turbocharged air intake systems must be done with materials that do not block the air flow. The materials must be securely attached to prevent them from being sucked into the system up to the turbocharger inlet. The repairs must seal so that the air pressure is maintained from the turbocharger outlet to the intake manifold. Care must be taken to keep the air induction system feeding the turbocharger in good condition. Air cleaners may become clogged with dirt and restrict the air flow causing loss of power and incomplete combustion indicated by excessive exhaust smoke. Clogged filters must be cleaned as soon as possible using compressed air, nitrogen, a dismantled blower motor or other air supply. Leaking or damaged air filters, housing or ducting will also cause damage by letting unfiltered air enter the engine causing dust ingestion damage. The dust will cause rapid wear of internal engine components and result in early engine failure. Leaking components can be repaired using tape, auto body filler, hose clamps and rags or any other similar materials available.



1. Air Cleaner Box - Left
2. Air Cleaner Box - Right
3. Air Inlet Ducts and Hoses
4. Screw, Lockwasher and Flatwasher
5. Support Bracket

Figure 3-5. Engine Air Intake System.

#### SECTION IV. Engine Exhaust Systems

##### 3-6. General.

The engine exhaust system consists of the exhaust manifold, header pipes, muffler and other exhaust ducts. Since these engines are turbocharged, the exhaust gases are also routed through the turbocharger. Non-turbocharged engines will operate with exhaust leaks but in a turbocharger system it must be sealed for the gases to properly drive the turbocharger vanes. Exhaust manifolds route the exhaust to the turbochargers. Without the exhaust, the turbochargers will not function properly causing excessive loss of engine power.

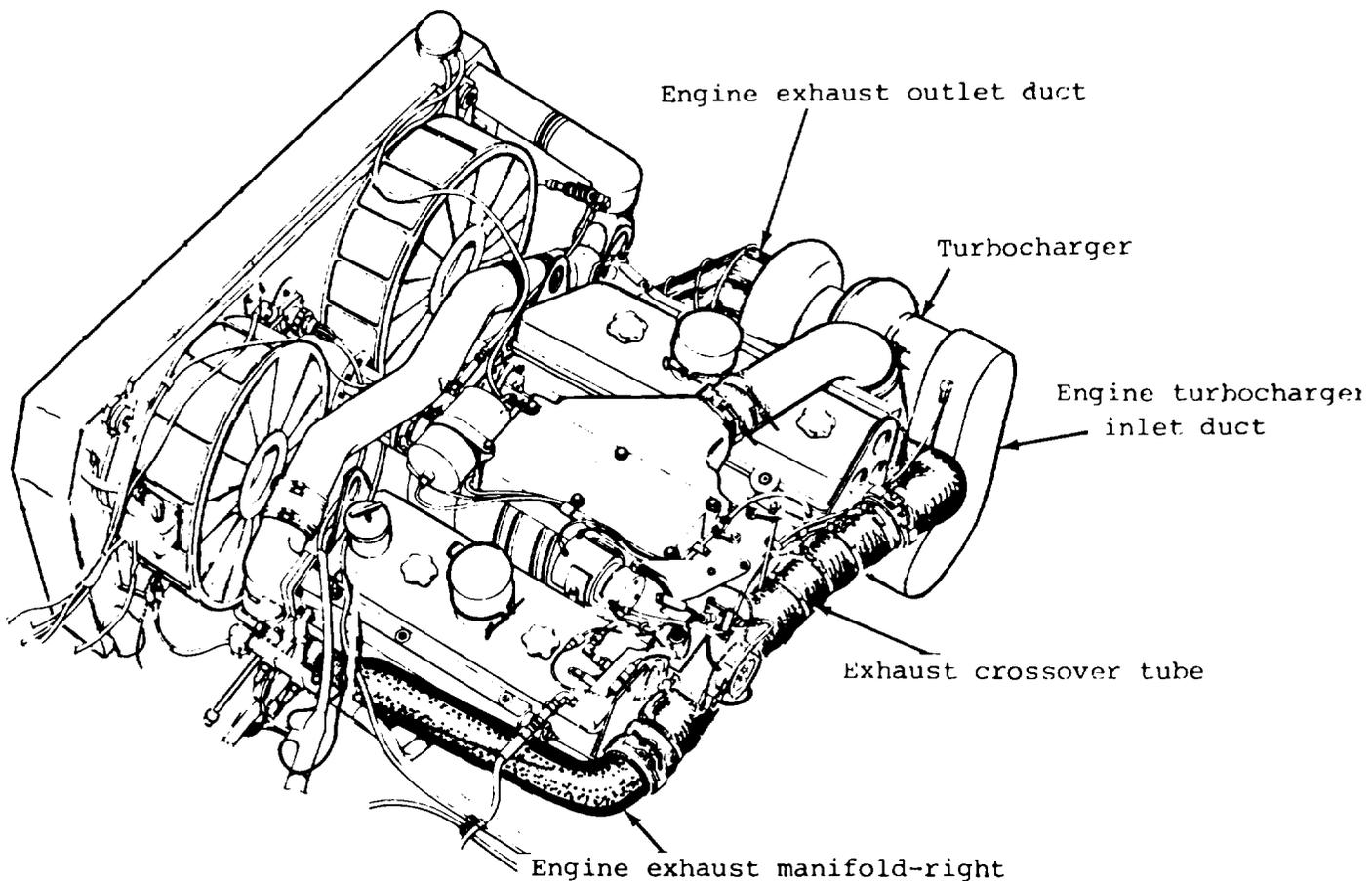
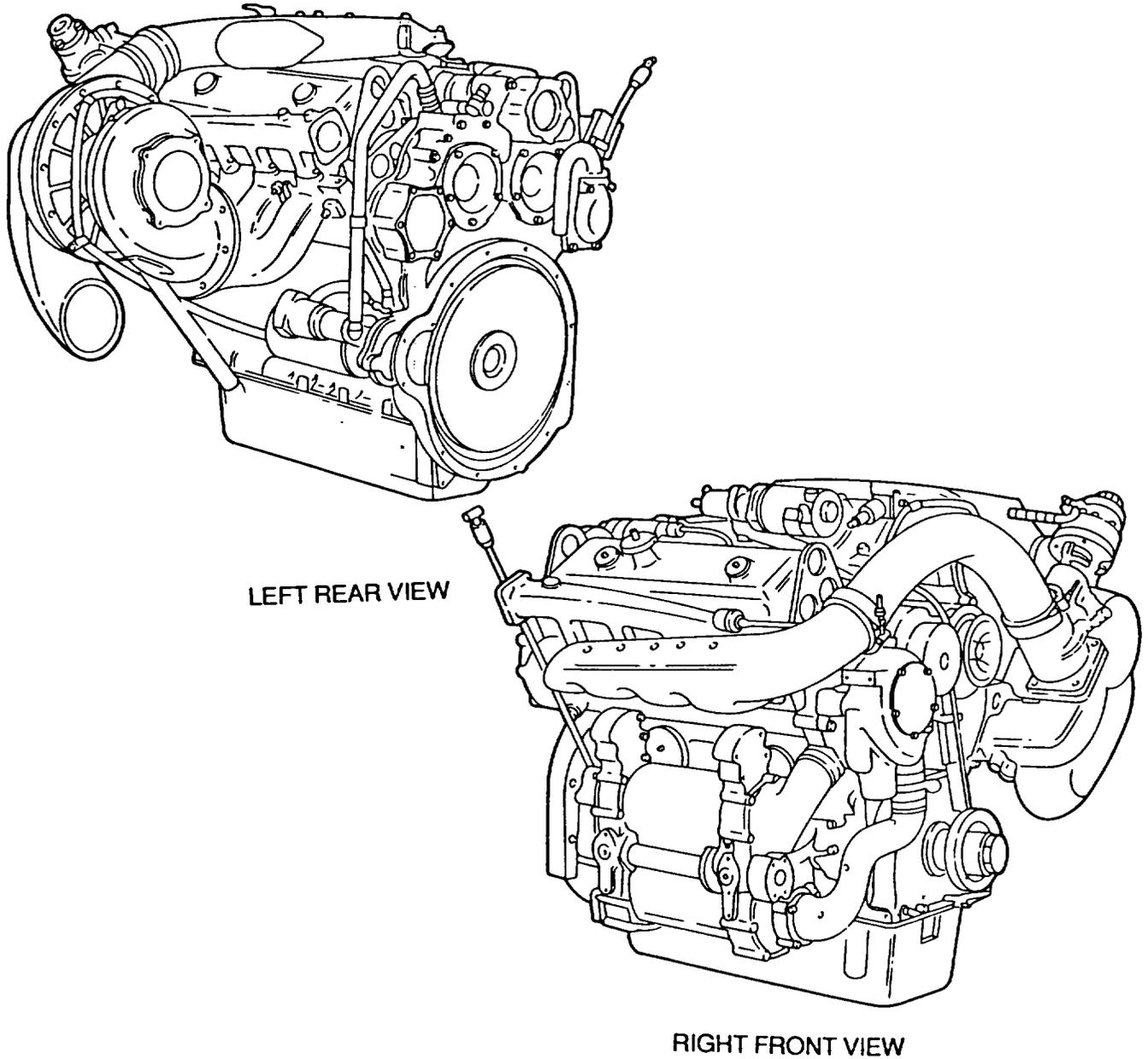


Fig 3-6. Exhaust Systems.

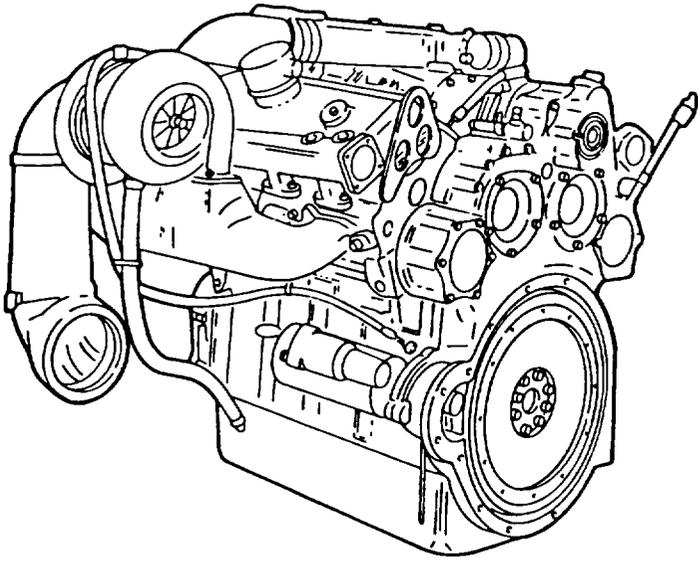
### 3-7. EXHAUST SYSTEM DAMAGE

#### General Information.

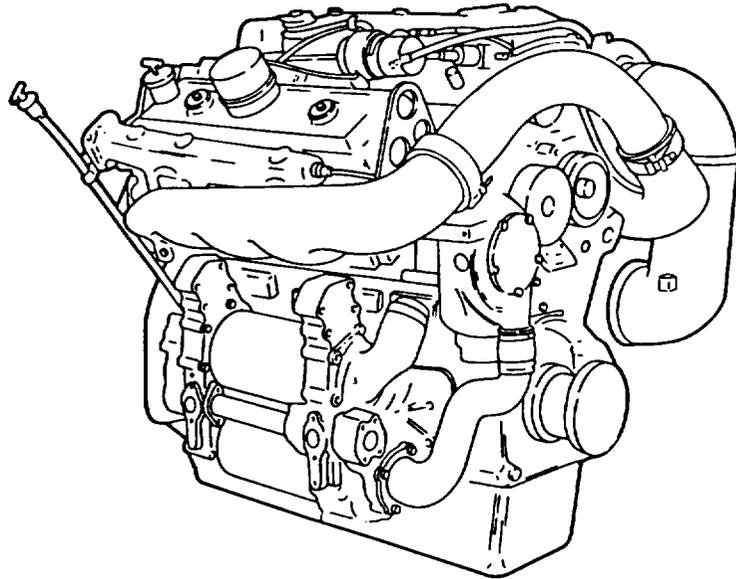
To repair holes or cracks in the exhaust system, holes can be brazed. If a torch is not available, cans or similar metal items can be cut and bent to cover holes. A source for the large clamps needed is the generator air ducting system of a nonrepairable vehicle. Cut metal patch two to three inches wider than damaged area and secure in place with wire or clamps. If available, an epoxy type sealer can be used to seal small cracks in manifold.



MODEL 7083-7399 (Older M109 Model)

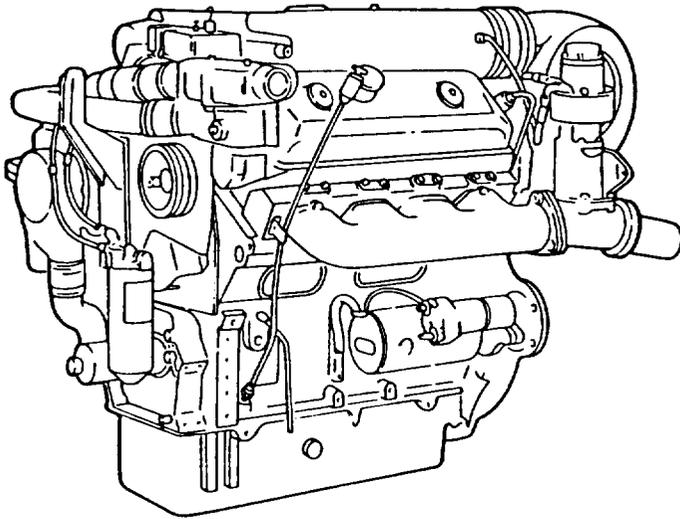


LEFT REAR VIEW

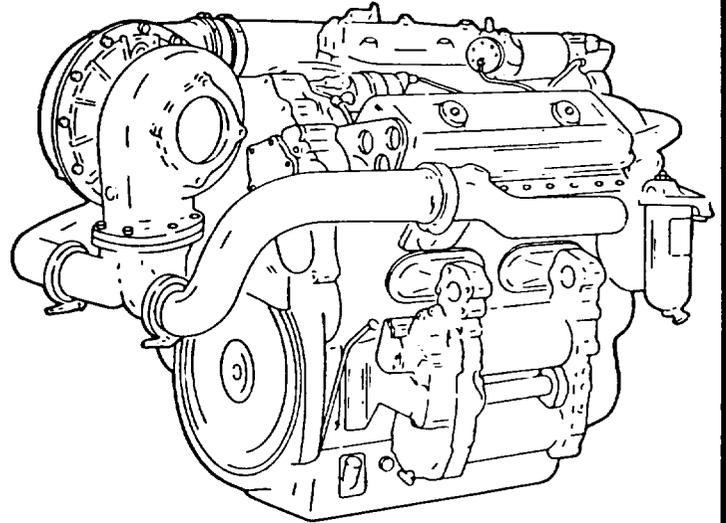


RIGHT FRONT VIEW

**MODEL 7083-7396 (Newer M109 Model)**

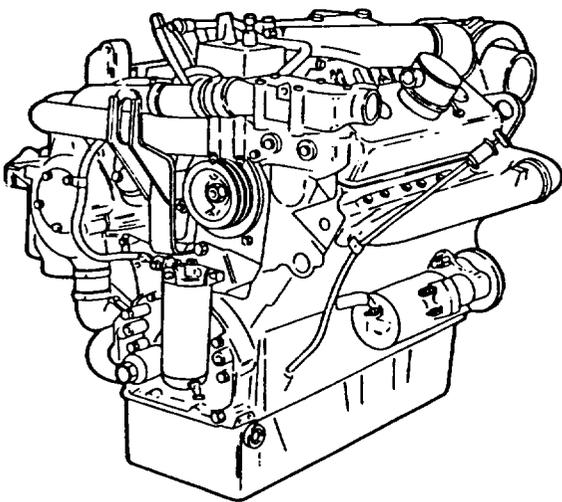


LEFT FRONT VIEW

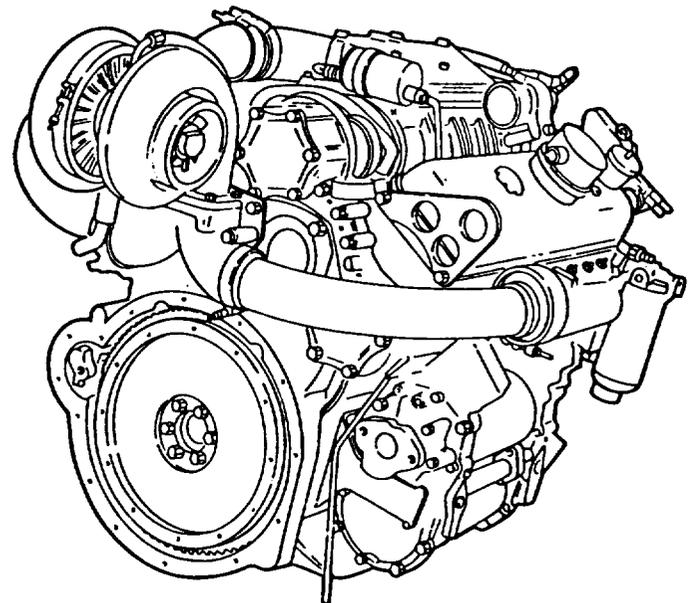


RIGHT REAR VIEW

MODEL 7083-7398 (Older M110/M578 Model)



LEFT FRONT VIEW



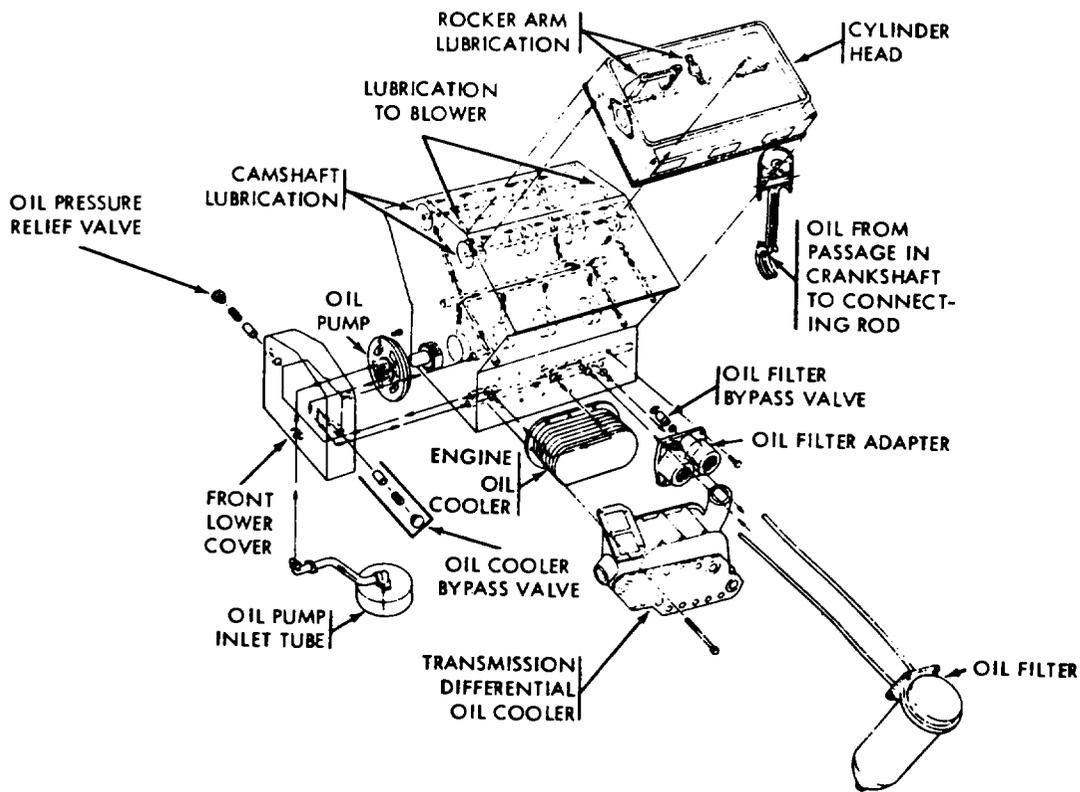
RIGHT REAR VIEW

MODEL 7083-7395 (Newer M110/M578 Model)

### SECTION V. Engine Lubrication Systems

#### 3-8. 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.



### 3-9. 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. See Appendix C for possible substitutes.

#### Limitations

- Possible transmission overheating or damage.

#### Personnel/Time Required:

- 1 soldier
- 15 minutes

#### Material/Tools

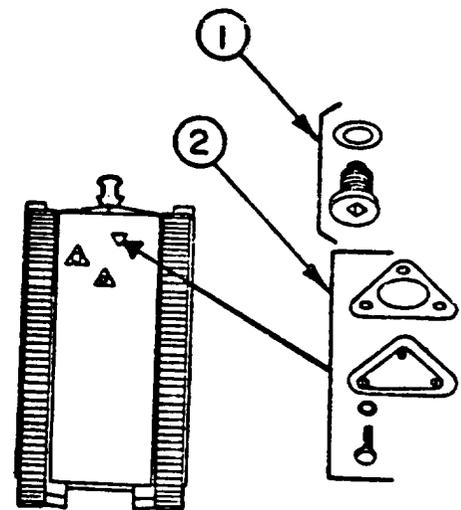
- Large clean container

#### Other Options

- Use oil from damaged vehicle
- Cooking oil
- Diesel fuel
- Hydraulic fluid

#### Procedural Steps:

1. Place vehicle on level ground.
2. Remove cover plate (item 2) from bottom of hull.
3. Drain oil from a damaged vehicles transmission or engine by removing drain plug (item 1) and drain approximately 2 gallons into a container.
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 completed, as soon as practicable, repair the vehicle using standard maintenance procedures.



**BOTTOM OF HULL**

**ENGINE**

**3-10. 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 the 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.

**Limitations:**

- None

**Personnel/Time Required:**

- 3 soldiers
- 2 hours

**Material/Tools**

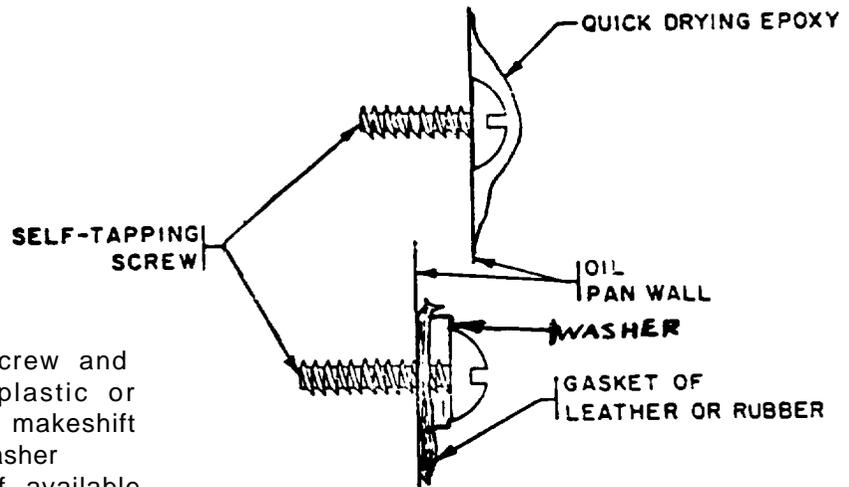
- Sandpaper
- Epoxy
- Wood
- Sheet metal screws
- Leather boot
- Rubber from tire or tube
- Lift capability
- Large diameter washer

**Other Options**

- Weld oil pan if welding equipment is available.

**Procedural Steps**

1. Remove powerpack.
2. Locate leak.
3. Clean area around holes with sandpaper.
4. Fill holes with available material, such as self-tapping sheet metal screw and cover with a quick drying epoxy plastic or force a sheet metal screw through a makeshift washer (leather or rubber). Use a washer to back up the rubber or leather, if available. Install into hole. Tighten securely.



**Procedural Step (Cont):**

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

### SECTION VI. Engine Fuel Systems

#### 3-11. General.

The engine fuel system provides the pressurized fuel needed for proper operation of a compression ignition engine. An engine-mounted mechanical fuel pump provides fuel to the fuel injectors, which inject fuel into the cylinder in the proper quantities. The fuel injectors are cam-operated by pushrods and a rocker arm arrangement to provide fuel injection at the proper time.

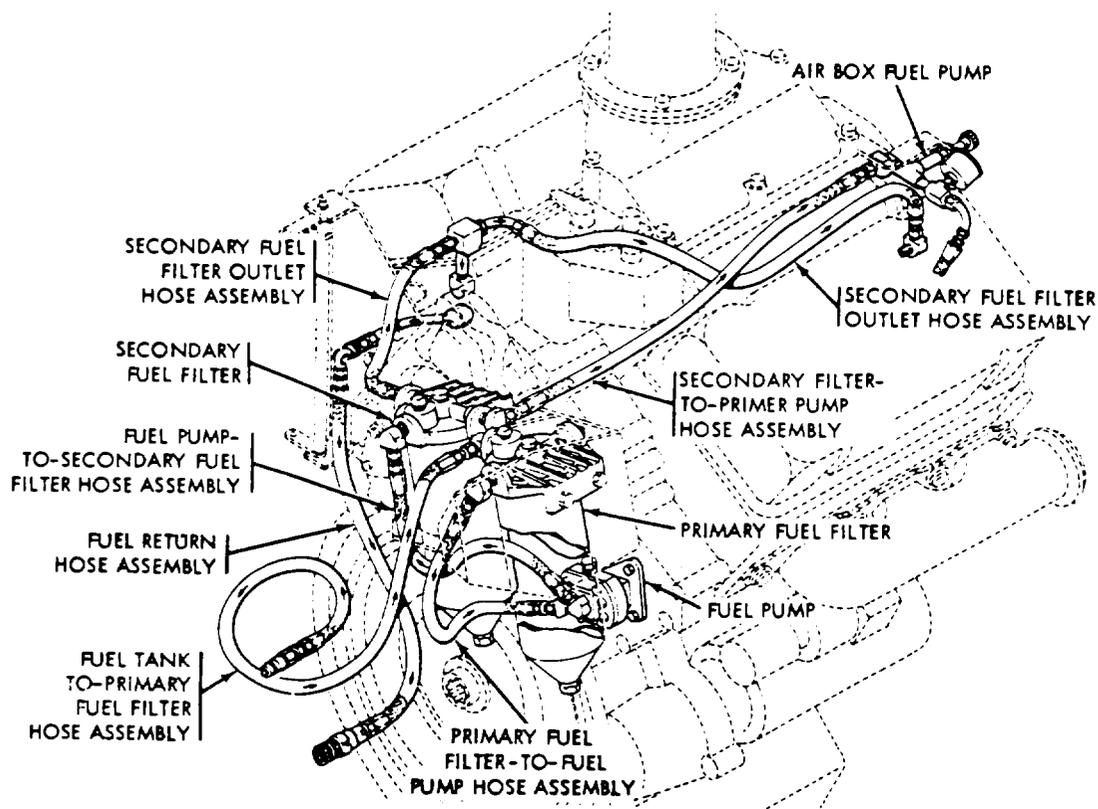


Fig 3-7. Engine fuel system.

### 3-12. 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 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.

**TABLE 3-1.**

#### Substitutable Injectors

<u>ENGINE</u>	<u>INJECTOR</u>	<u>USED IN</u>
3-53		Gama Goat
4-53		Commercial
6V-53	M50	M113F.O.V., Commercial, T.R.Forklifts
6V-53T	N-70	M551Sheridan
8V-71		Power Generation
8V-71T	7E50, 7E55, 7E60, 71C5, 7E65, 71B5, B55, B60, B65, M65, 7C70, 7C75, N70, N85, N75, 9092,9090	M109, M110, M107, M108S.P.Howitzer, M578 Recovery Vehicle

### 3-13. FUEL INJECTOR LINE RUPTURE

#### General Information

Failure of an injector can be noticed by a loss of power or increased fuel consumption. If either occurs the injectors and fuel lines should be inspected to determine the cause. If the crankcase oil is overfull or has a diesel odor, remove the valve covers and inspect the fuel lines for cracks. Operate the engine with the valve covers removed to check for fuel leaks. Unrepaired injector lines will cause the fuel to enter the crankcase, diluting the engine oil and resulting in early engine failure.

#### Limitation

- Reduction of power

#### Personnel/Time Required:

- 1 soldier
- 1 hour

#### Materials/Tool=

- Vice grips

#### Other options:

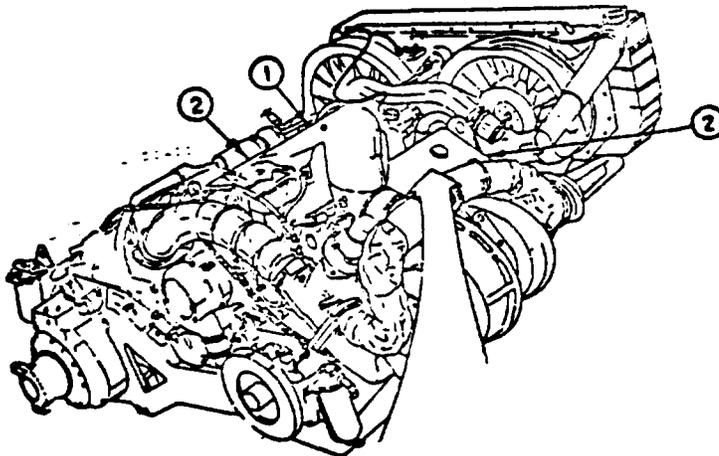
- Crimp the damaged fuel injector line shut.

#### Procedural Steps:

1. Gain access to engine compartment.
2. Remove the valve cover of the affected cylinder (item 2).

#### NOTE

To remove rear valve cover, the engine blower inlet housing must be removed (item 1).



**Procedural Steps (Cont):**

3. Operate engine to determine failed line.
4. Disconnect the leaking line.
5. Bypass the injector by bending the remaining good line and connecting the inlet and outlet together.
6. Back off the injector rocker adjustment to prevent damage to the injector.
7. Adjust the fuel injector rack to a no fuel position at the injector.
8. Reinstall the valve covers.
9. Record the BDAR taken. When the mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

**3-14. 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. If a crew member is stationed outside to operate the throttle, caution should be exercised not to get feet or clothing tangled in universal joints.

**Limitations:**

- Reduced speed and maneuverability, possible crew injury.

**Personnel/Time Required:**

- Two soldiers
- 15 minutes

**Materials/Tools:**

- Crowbar

**Other Option:**

- Station a crew member top side, using a stick or a crowbar, push the throttle control back to increase speed.

**ENGINE**

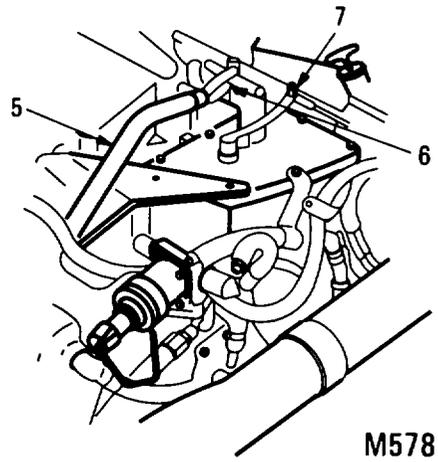
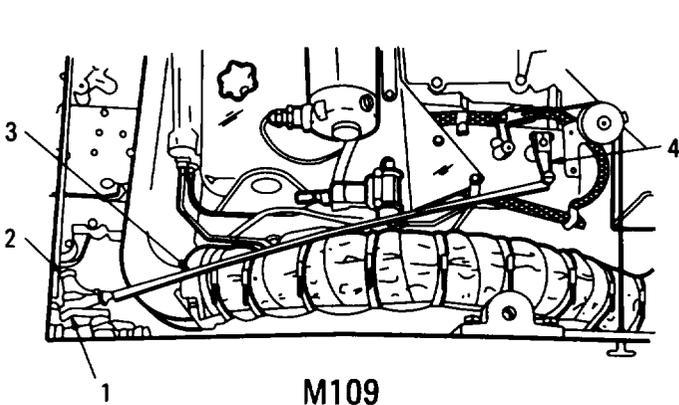
**Procedural Steps:**

1. Gain access to engine compartment through transmission access covers. On the M109 it will be necessary to unlock the howitzer travel lock until access doors are opened. Relock the travel lock before moving the vehicle. Access to engine compartment on M110/M578 is done by removing deck covers.

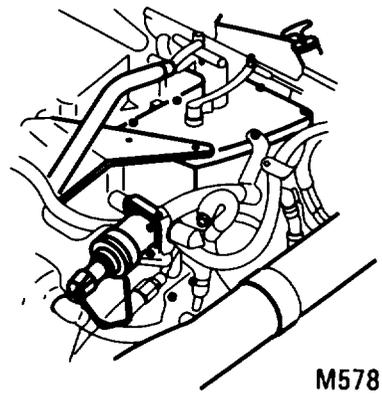
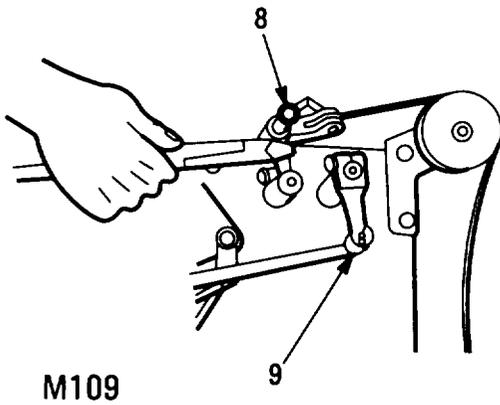
**WARNING**

Engine and components can be very hot.

2. (M 109) Locate the damaged section of the engine throttle governor control rod (3), disconnect the quick release point (2) from level (1). (M578) Disconnect governor throttle control rod (5) by removing cotter pin (6) and straight pin (7). Remove damaged section.



3. Disconnect fuel shut-off cable (8) and reconnect at throttle control (9).



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

## **SECTION VII. Engine Structure And Internal Components**

### **3-15. 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.

CHAPTER 4

FUEL SUPPLY SYSTEM

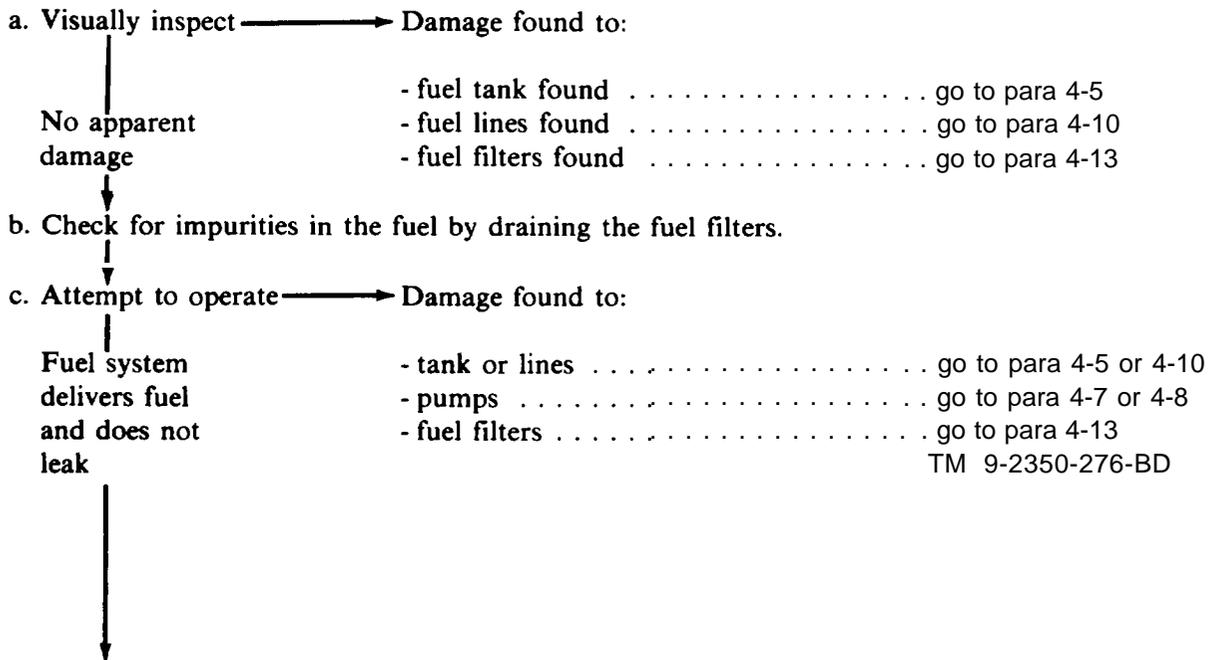
**BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.**

SECTION I. General

4-1. General.

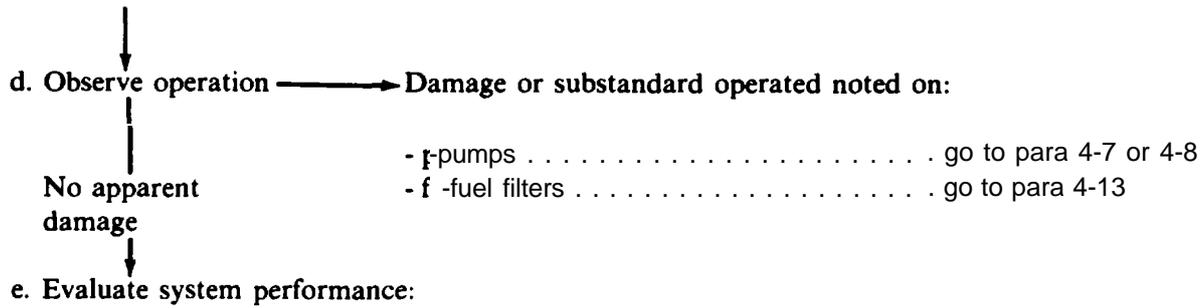
The fuel system consists of 2 fiberglass tanks w/intank fuel pumps, metal and rubber wire reinforced fuel lines, fuel filters and an engine impeller type fuel pump. Loss of fuel or no fuel getting to the engine must be corrected for operation of the vehicle to continue. The engine mechanical fuel pump will draw fuel without the in-tank fuel pump operating but there are options for re-establishing the back-up systems.

4-2. Assessment Procedure.



TM 9-2350-276-BD

**FUEL SUPPLY SYSTEM**



**ENGINE ASSESSMENT**

	Mission Capable	Combat Capable	Combat Emergency Capable	Self Recovery Capable	Recover
- Output adequate	X	X			
- Output degraded		X	X		
- Output severely degraded with BDAR		X	X	X	
- No Output			X'	X'	X

X' Use as towed firing platform only.

**4-3. BDAR Procedure Index.**

	<b>Para</b>
Fuel Tank Substitute . . . . .	...4-5
Fuel Pump Failure . . . . .	...4-7
Fuel Pump Interchangeability . . . . .	...4-8
Fuel Pump (In-Tank) Inoperative. . . . .	...4-9
Quick Disconnect Leak . . . . .	...4-11
Fuel Filter Clogged or Frozen... . . . .	...4-13

## SECTION II. Fuel Storage Systems

### 4-4. General.

Fuel is stored in enclosed fiberglass container. Fuel tanks are susceptible to contamination of the fuel from dirt, water or other impurities. Purging a contaminated fuel system and repairing leaks are the prime BDAR solutions. The tank is particularly susceptible to cracks.

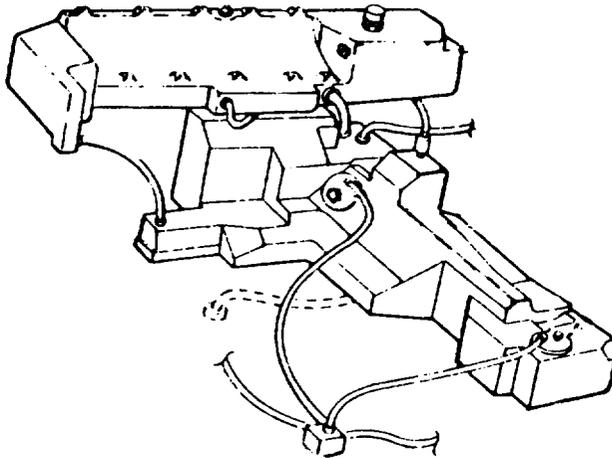


Figure 4-1. Fuel Storage Tank for M109

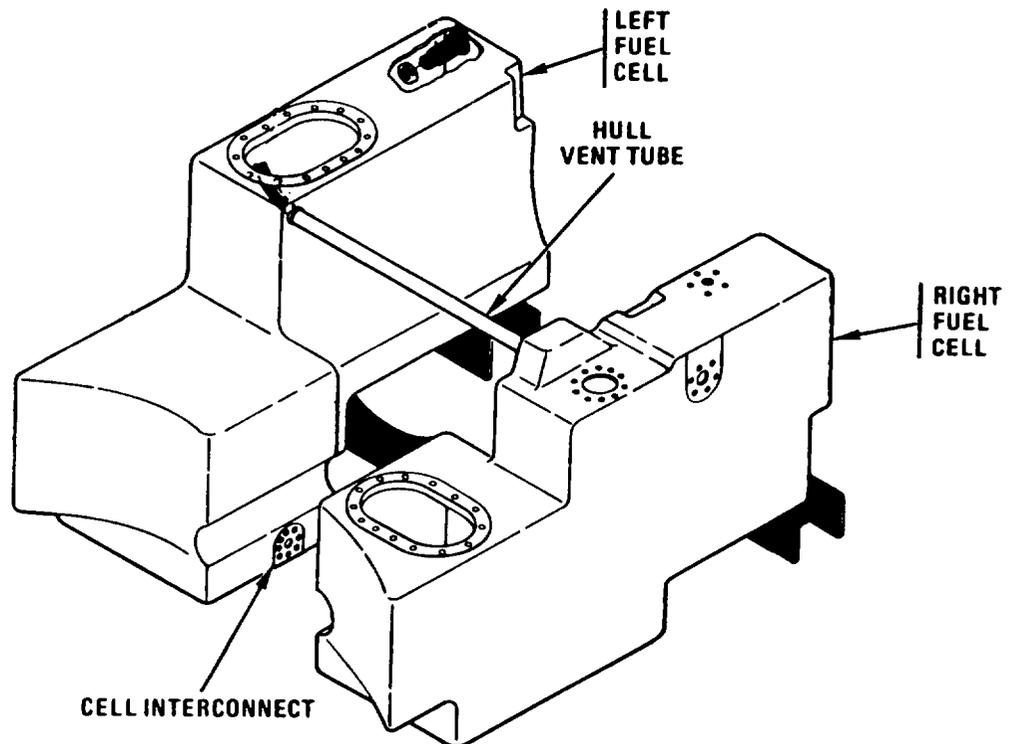


Figure 4-2. Fuel Cells for M110/M578

#### **4-5. FUEL TANK SUBSTITUTE**

##### **General Information**

A fuel tank may become damaged and there is insufficient time to make repairs. The vehicle 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.

##### **Limitations**

- Less fuel available, therefore requiring periodic checks and frequent refueling.

##### **Personnel/Time Required**

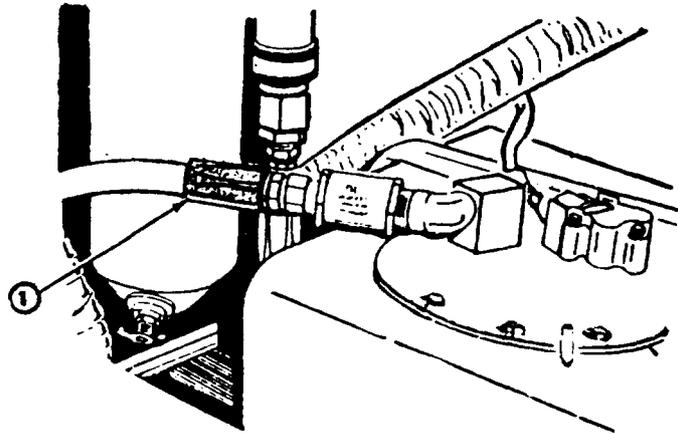
- 2 soldiers
- 1 hour

##### **Materials/Tool=**

- Drum (55 gallon)
- Large can
- Cannibalized fuel tank
- Long hose
- Rope
- Hose clamps

##### **Procedural Steps:**

1. Secure a substitute tank to the outside of the vehicle.
2. Remove engine access panel in driver's compartment.
3. Disconnect hose (item 1) from fuel pump check valve.
4. Connect a hose between (item 1) hose and substitute fuel tank.
5. Record BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.



**FUEL SUPPLY SYSTEM****SECTION 111. Fuel Pumps****4-6. General (M110/M578 only).**

Engine will not start, no fuel to injector pump. The in-tank fuel pumps are generally interchangeable between combat vehicles. The difference is in the bracketry used to mount the pump in the fuel tanks. The electrical pump unit can be removed and used on the brackets to fit M109/M110/M578 vehicle,

**4-7. FUEL PUMP FAILURE****General Information:**

As long as the engine driven fuel pump is operational and fuel tanks are at least half full, none of the electric fuel pumps are crucial to the operation of the vehicle. The following battle damage solution substitutes the air box heater fuel pump for a damaged engine-driven fuel pump. Some vehicles of the M109/M110 M578 family do not have a primary fuel filter drain hose. In this case, a length of rubber hose approximately 5 feet long will be required to act as the fuel line between the air box heater fuel pump and the secondary fuel filter.

**Limitations:**

- None

**Personnel/Time Required:**

- 1-2 soldiers
- 30-45 minutes

**Materials/Tools:**

- Hose
- Screwdriver

**NOTE**

Must purge fuel system thoroughly.

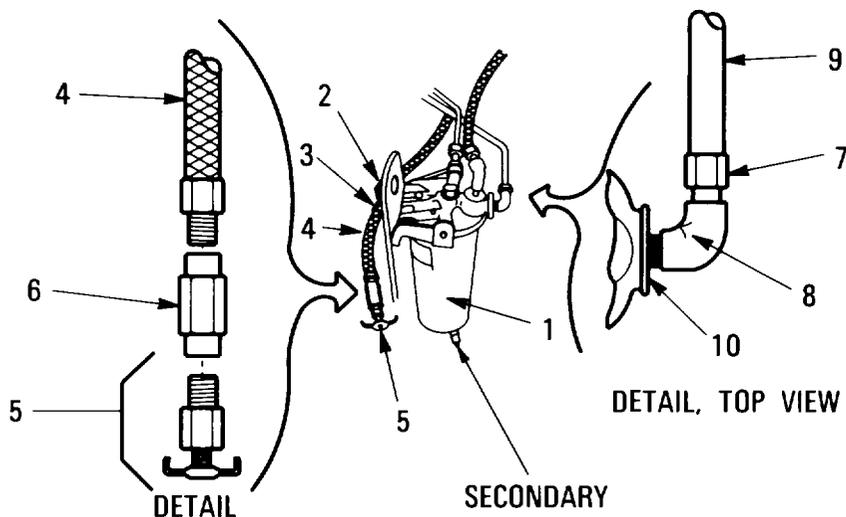
**Procedural Steps:****a. Secondary:**

1. Gain access to engine compartment and locate secondary fuel filter (item 1) (110/578).
2. Remove screw (item 2) and hose restraining clamp (item 3).
3. Loosen nut (item 7) and disconnect engine driven fuel pump-to-secondary fuel filter tube (item 9).
4. Remove elbow (item 8) from secondary fuel filter inlet (item 10).

**FUEL SUPPLY SYSTEM**

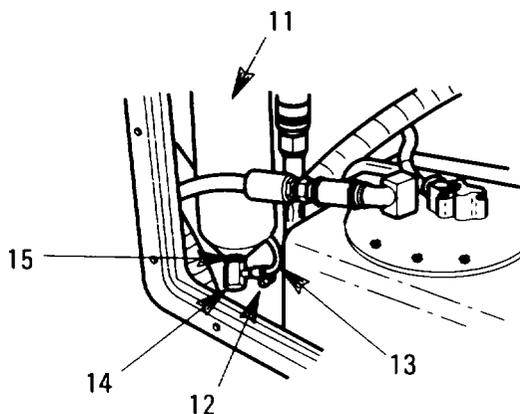
**Procedural Steps (Cent):**

5. Remove pet cock fitting (item 5) from primary fuel filter drain hose (item 4) and retain for later use,
6. Remove adapter (item 6).
7. Connect primary fuel filter drain hose (item 4) to secondary fuel filter at inlet item( 10) from which elbow was removed in step 4.



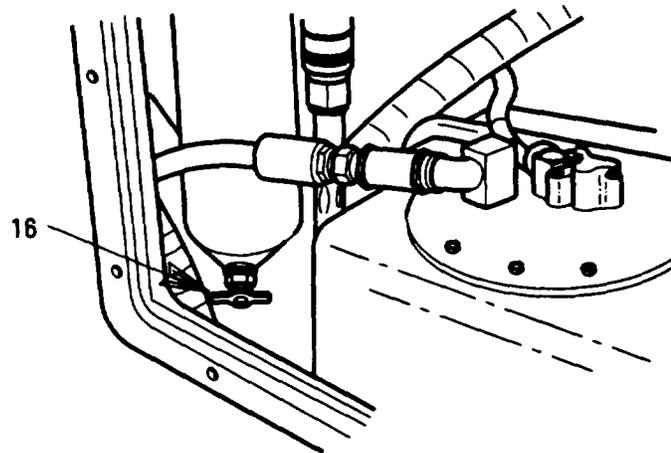
**b. Primary:**

8. Remove engine compartment access door in driver's compartment and locate primary fuel filter (item 1 1).
9. Loosen hose clamp (item 12) and disconnect primary fuel filter drain hose (item 13). Retain hose clamp for later use.
10. Remove elbow (item 14) from filter drain hole (item 15) and retain for later use.

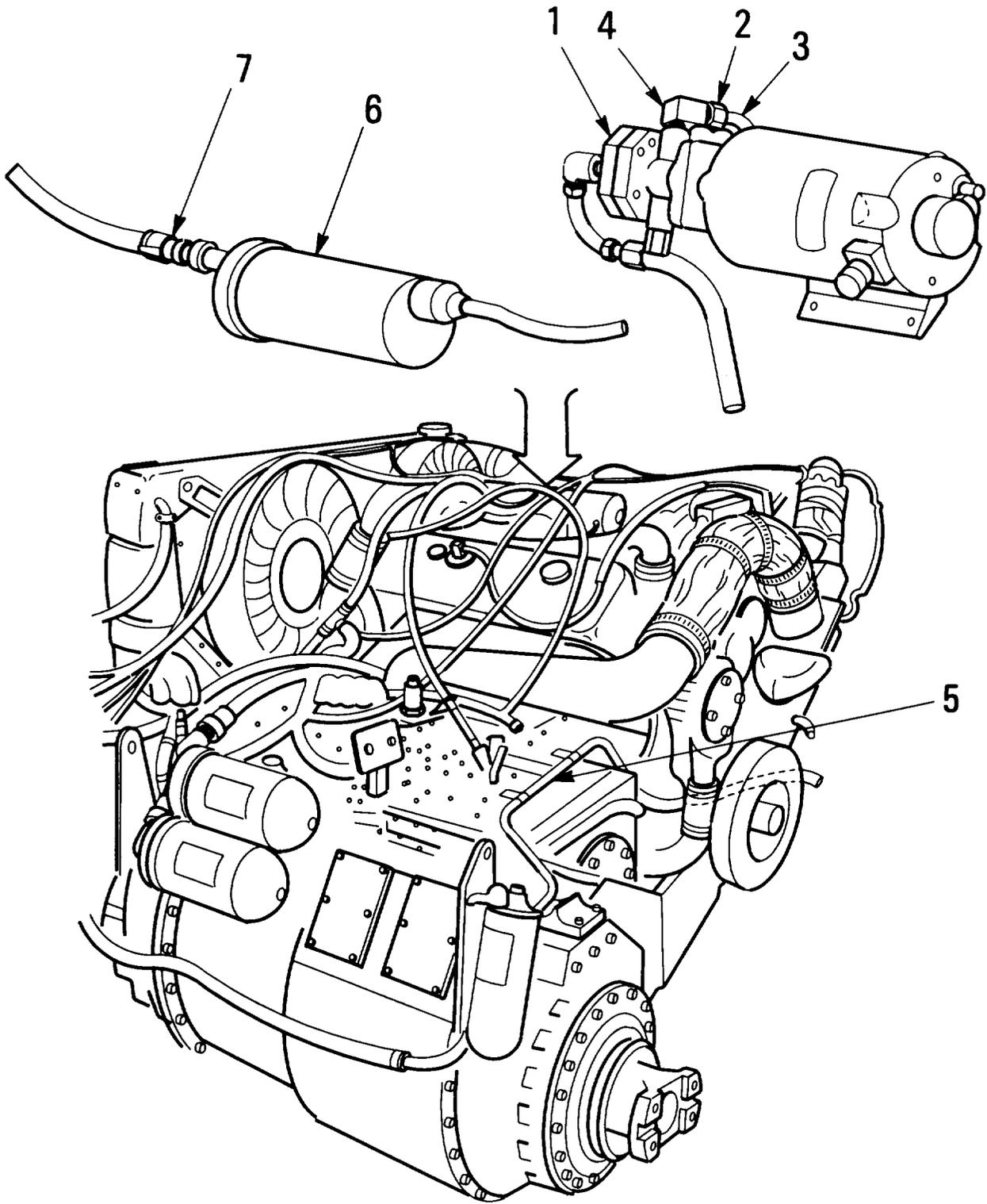


**FUEL SUPPLY SYSTEM****Procedural Steps (Cont):**

11. Screw pet cock fitting (item 16) into drain hole as shown.



12. Locate air box heater fuel pump (item 17).
13. Loosen nut (item 18) and disconnect fuel line (item 19).
14. Remove elbow (item 4) from air box heater fuel pump outlet.
15. Screw elbow (item 4) removed from primary fuel pump in step 10 into air box heater fuel pump outlet.
16. Pull loose end of primary fuel filter drain hose (item 5) free from beneath engine.
17. Connect loose end of primary fuel filter drain hose to elbow at air box heater fuel pump outlet and secure with hose clamp from step (9).
18. Locate air box heater coil (item 6) and disconnect electrical connector (item 7).
19. Operate the fuel pump by placing FLAME HEATER MASTER SWITCH located on operator's control panel in "ON" position before starting engine and leave on until engine is shut off.
20. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.



#### 4-8. FUEL PUMP INTERCHANGEABILITY

##### General Information:

- The fuel pumps used on the M109/M110/M578 are used on other similar vehicles and can be cannibalized from U.S. and foreign owned equipment.

Stock numbers and part numbers may differ but these items will interchange within the following vehicles: M107, M108, M110, M578, M975 and Pershing.

1. Engine Driven Rotary Fuel Pump
2. Fuel Tank Discharge Electric Fuel Pumps
3. Air Purge Electric Fuel Pump (M109A3)
4. Personnel Heater Electric Fuel Pump
5. Air Box Heater Rotary Fuel Pump
6. Engine Coolant Heater Electric Fuel Pump (Winterization Kit)

#### 4-9. FUEL PUMP (IN-TANK) INOPERATIVE

##### General Information:

- Engine will not start, caused by no fuel to injector pump. Installing a substitute fuel pump will correct the problem. The in-tank fuel pumps are generally interchangeable between combat vehicles. The difference is in the bracketry used to mount the pump in the fuel tanks. The electrical pump unit can be
- removed and used on the brackets to fit the M109/M110/M578 vehicle.

##### Limitations:

- None

##### Personnel/Time Required:

- 2 soldiers
- 3 hours



**Materials/Tools**

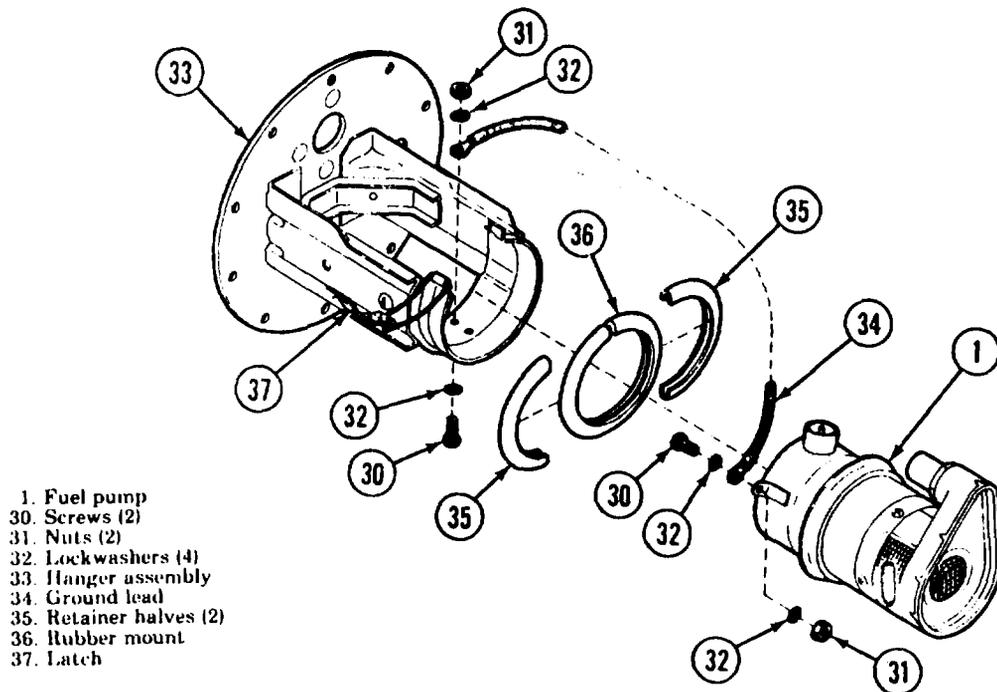
- In-tank fuel pump from any of the following
  - 2-1/2 ton truck
  - 5 ton truck
  - M48/M60 tank
  - M1 tank

**Other Options:**

- Use the heater's fuel pump to provide fuel to the engine.

**Procedural Steps:**

1. Gain access to the left or right engine compartment (in-tank) fuel pump mounting cover assembly that has defective fuel pump.
2. Remove fuel pump cover assembly with attached defective fuel pump. Remove defective pump from cover assembly.
3. Wrap rubber strips or hose around substitute fuel pump body, if required, so that it will be tightly secured when installed.
4. Install substitute fuel pump in cover assembly.
5. Obtain a fuel pump connector and cable. Connect fuel pump to connector.



**FUEL SUPPLY SYSTEM**

**Procedural Steps (Continued)**

6. Attach ground wire from cover assembly cable to ground terminal on fuel pump.
7. Install cover and pump assembly to fuel tank.
8. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

## SECTION IV. Fuel Lines and Valves

### 4-10. General.

The fuel lines route the fuel from the fuel tanks to the fuel filters and then to the engine. Fuel lines are susceptible to leaks and being clogged by dirt or ice in cold weather. Leaking or plugged lines can be bypassed temporarily but must be repaired to keep the fuel supply adequate. Some other tubing and hose repairs are also provided in TM 9-2350-276-BD.

### 4-11. QUICK DISCONNECT LEAK

#### General Information:

There are three quick-disconnects in the fuel system of the M109/M110/M578 series. They are:

1. In the main fuel line near the primary fuel filter inlet.
2. In the fuel return line.
3. In the personnel heater fuel lines.

#### Limitations:

- None

#### Personnel/Time Required:

- 1 soldier
- 15-30 minutes

#### Materials/Tools:

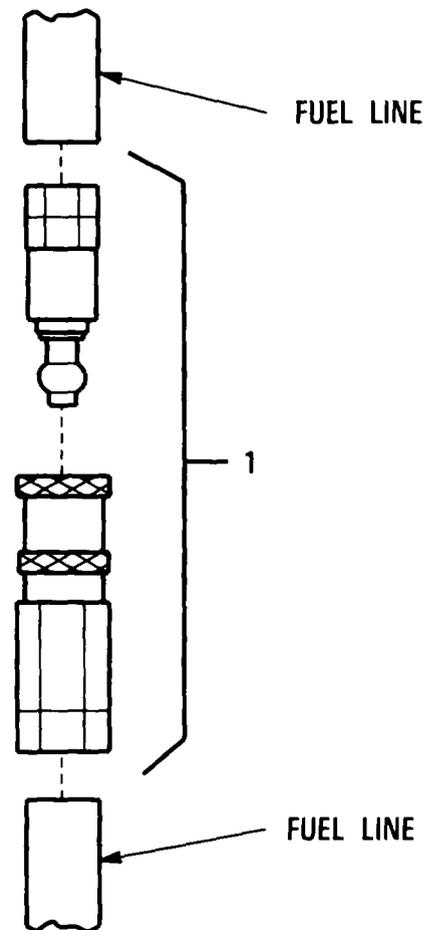
- Rubber hose
- Hose clamps
- Knife
- Adjustable wrench

#### Other Options:

- Replace quick-disconnect with an adapter.

#### Procedural Steps:

1. Remove quick-disconnect coupling (1).
2. Insert rubber hose and hose clamps in its place.
3. Check for leaks and bleed the fuel line thoroughly.
4. Record the BDAR action taken. When mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

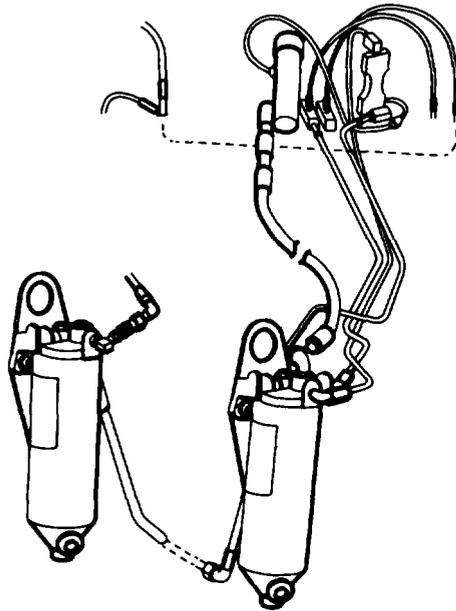


**FUEL SUPPLY SYSTEM**

**SECTION V. Fuel Filters**

**4-12. General.**

The M109/M110/M578 series has two fuel filters; the primary fuel filter is accessible from the driver's compartment and the secondary is accessible through the transmission access doors/deck covers. The M109A2 primary fuel filters are accessible thru the transmission access 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.



**4-13. FUEL FILTER CLOGGED OR FROZEN**

**General Information:**

Engine will not start because the fuel filters frozen or clogged. Dirty fuel will harm the injectors and must not be unfiltered for long periods.

**Limitations:**

- Unfiltered fuel and no manifold preheater operation.

**Personnel/Time Required:**

- 1 soldier
- 30 minutes

**Materials/Tools:**

- 
-

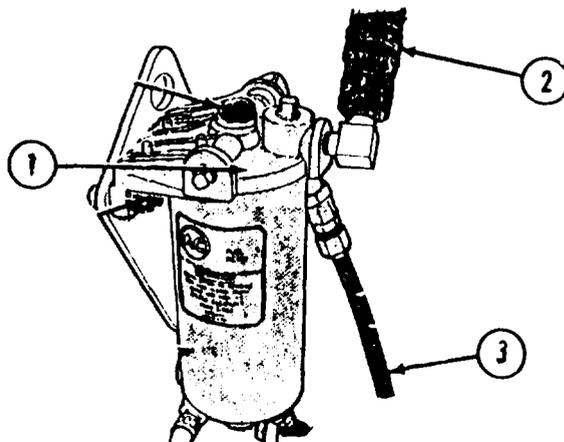
**Other Options**

- Remove element.

**Procedural Steps:**

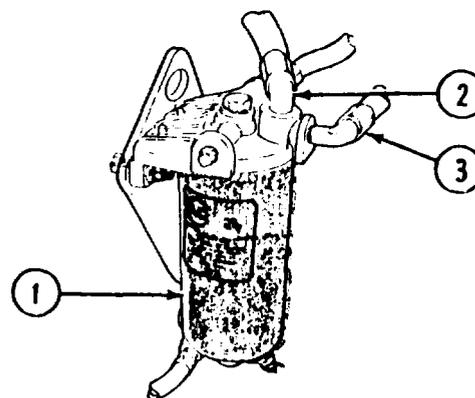
1. Primary filter:

- Drain fuel filter assembly (item 1).
- Disconnect the main fuel hose from the filter assembly (item 2).
- Disconnect the primary filter-to-fuel pump hose from the filter assembly (item 3) and connect to the main fuel hose using the existing fittings.



2. Secondary filter:

- Drain fuel filter assembly (item 1).
- Disconnect fuel inlet line from electric fuel pump (item 2) from the filter assembly.
- Disconnect fuel outlet line to engine driven fuel pump (item 3) and connect to fuel inlet line (item 2) using existing fittings.



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

# CHAPTER 5

## COOLING SYSTEM

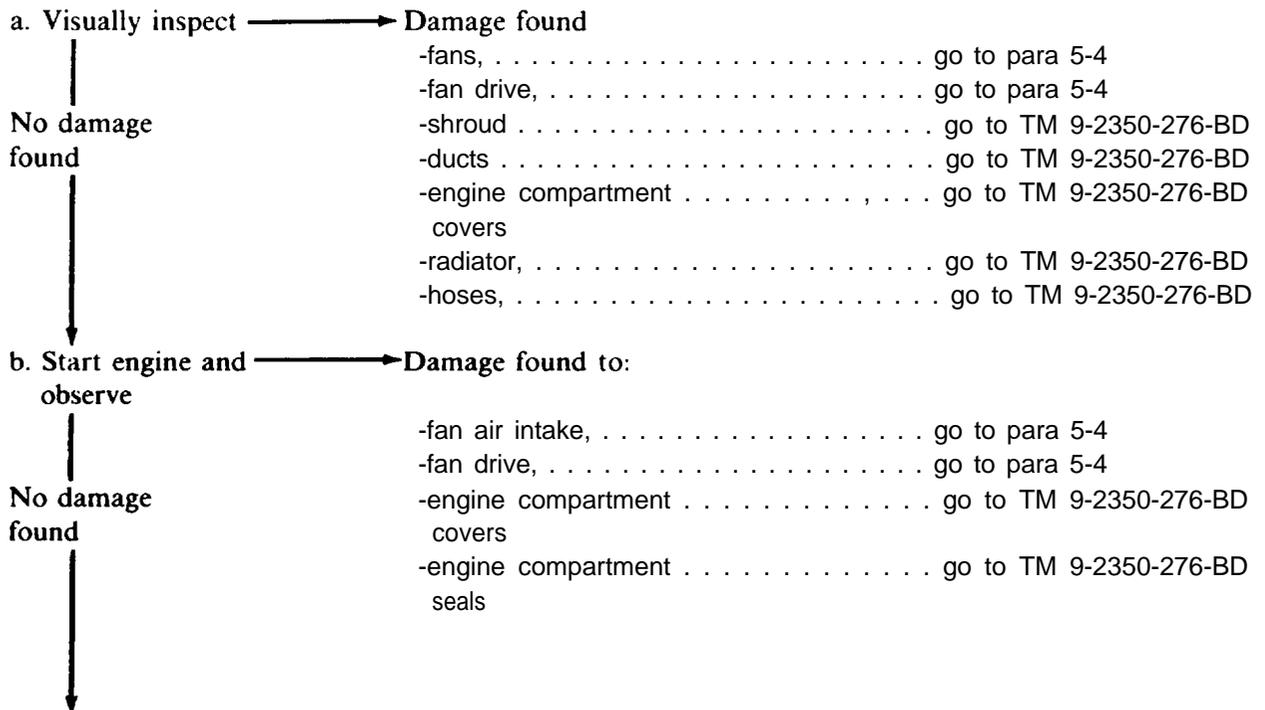
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AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.**

### SECTION L General

**5-1. General.**

The M 109 has a liquid cooling system consisting of a radiator and two fans located to the rear of the engine. Air is drawn in through an air inlet grille, located immediately in front of the cab. The air passes over the top of the engine, through the fans and radiator, curves 90 degrees and is discharged through the exhaust grille. Coolant flow is regulated by two thermostats, an inlet and a by-pass thermostat. The M 110 series/M578 has two radiators and a fan that forces air through the power plant compartment and the radiators to cool the engine. Cooling system problems may be indicated by a variety of faults. Typically, the driver's indicator panel will show overheating. However, sporadic overheating or constant high temperature indications may indicate an impending major cooling system problem.

**5-2. Assessment Procedure.**



COOLING SYSTEM

c. Evaluate system performance:

Cooling System Assessment					
	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self-Recovery Capable	Recover
- Cooling normal\ near normal	X	X	X		
- Cooling degraded		X	X		X
- Cooling severely degraded		X <sup>1</sup>	X <sup>1</sup>	X <sup>1</sup>	X
- No cooling			X <sup>1</sup>	X <sup>1</sup>	X

Note 1

Careful operation under these conditions will not damage the engine if it is operated only to reposition or move the vehicle under light acceleration for short periods of time. The engine oil temperature must be allowed to cool between operations.

**5-3. BDAR Procedure Index.**

	Para
Cooling Fan Failure . . . . .	.5-4

## SECTION II. BDAR Procedures

### 5-4. COOLING FAN FAILURE

#### General Information:

Cooling fan failure can be detected through excessive vibrations and a noticeable increase in engine temperature. The fans and drive assemblies must be checked to determine the cause. The M109 has two impeller-type engine cooling fans. If necessary, the engine may be run with only one fan operational. This procedure gives a way to eliminate the drive to one fan.

#### Limitations:

- Reduced engine cooling capability

#### Personnel/Time Required:

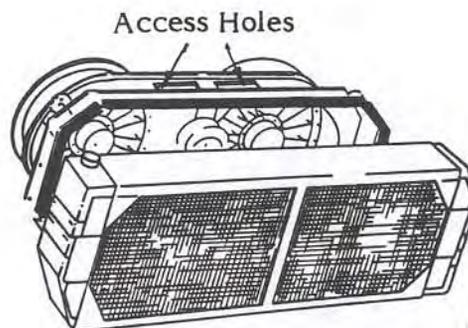
- 1 soldier
- 15 minutes

#### Materials/Tools:

- Long screwdriver, pry bar, or stick

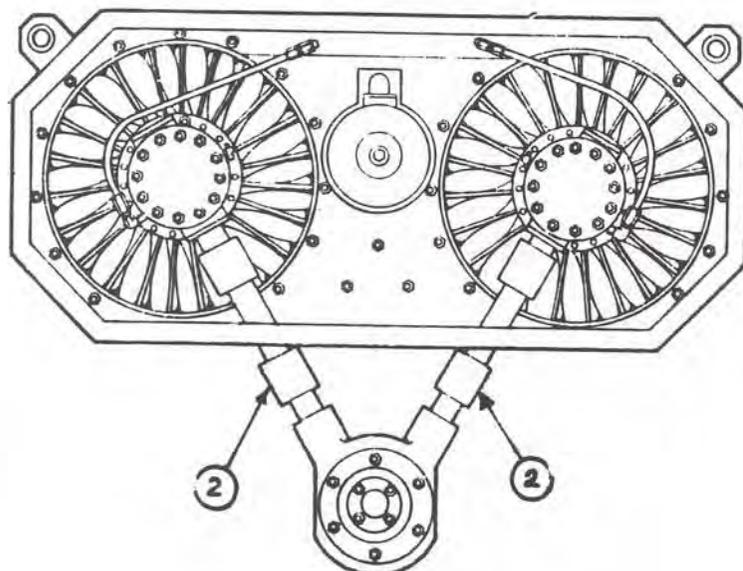
#### Procedural Steps:

1. Gain access to engine compartment.
2. Remove cover plate from access holes on top of engine cooling fan shroud.



**Procedural Steps (Cont):**

3. Using a long screwdriver or similar implement, reach down through the access hole, compress the spring-loaded universal joint (item 2) of the damaged fan and disengage it from splined shafts at the fan and drive assembly.



4. Remove universal joint.

5. Reinstall cover plate.

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

CHAPTER 6

ELECTRICAL SYSTEM

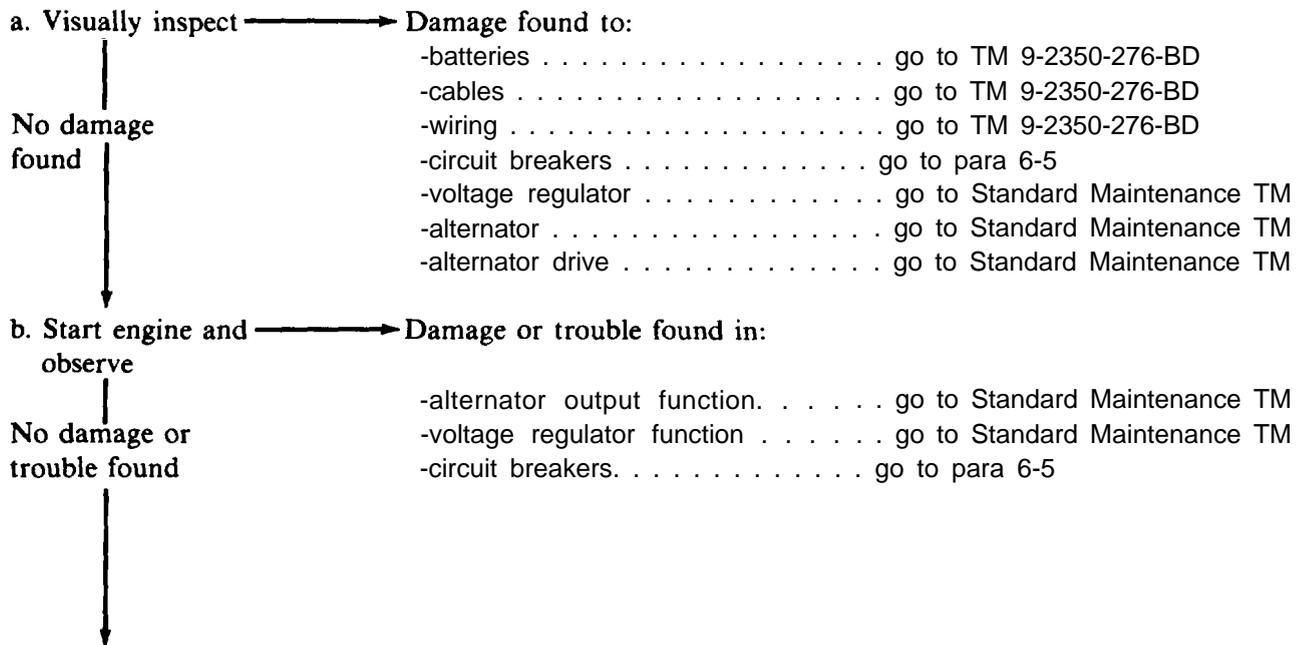
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AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.**

SECTION I. General

6-1. General.

The M 109 electrical system is 24VDC using four storage batteries to provide power without the engine operating. The engine mounts a 28 volt alternator used to recharge the batteries through a rectifier which changes the AC current to DC and a voltage regulator which controls the amount of current flow. The M110/M578 electrical system is provided power by a 24 volt 300 amp generator and four series - parallel - connected 12 volt storage batteries. Output of the generator is controlled by a solid state voltage regulator. A slave receptacle is located in the battery compartment to allow an outside source to provide electrical current if the batteries fail. The electrical circuit protection is provided by circuit breakers located in back of the driver's instrument panel. This chapter provides methods which can correct some faults, see also TM 9-2350-276-BD for other electrical repairs.

6-2. Assessment Procedure.



**ELECTRICAL SYSTEM**

c. Evaluate system performance:

<b>Charging System Assessment</b>					
	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
- Charging system works ok	X	X	X		
- Charging system works marginally		X	X	X	
- Charging system does not work			X	X	X

**6-3. BDAR Procedure Index.**

	Para
Circuit Breaker Failure . . . . .	6-5
Brushes Gummed . . . . .	6-6
Blower Motor, Air Cleaner Failure . . . . .	6-8
Starter Motor, Relay Failure . . . . .	6-9
Starter Failure, Substitution . . . . .	6-10

## SECTION II. General Electrical Repairs

## 6-4. General.

Most electrical repairs are general in nature. If a repair procedure is not given, also see TM 9-2350-276-BD for a repair. This section gives some procedures which are specific to the M109/M110/M578 electrical systems.

## 6-5. CIRCUIT BREAKER FAILURE

**General Information:**

The M109/M110/M578 series vehicles have circuit breakers to protect different electrical circuits. The circuit breakers are located behind the driver's instrument panel. Circuit breakers can also be removed from other damaged vehicles. The affected circuit must be checked for short circuits before bypassing the circuit breakers.

**Limitation**

- No overload protection if bypassed

**Personnel/Time Required:**

- 1 soldier
- 5-10 minutes

**Materials/Tools:**

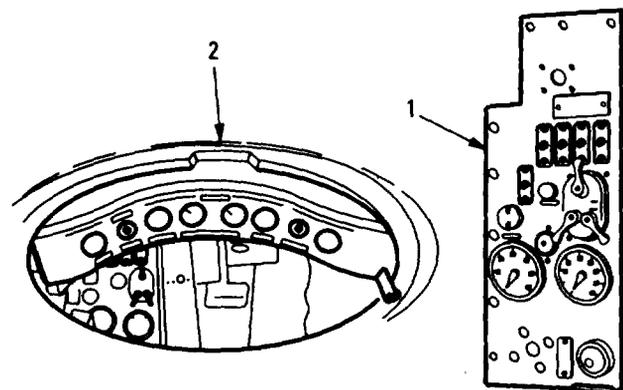
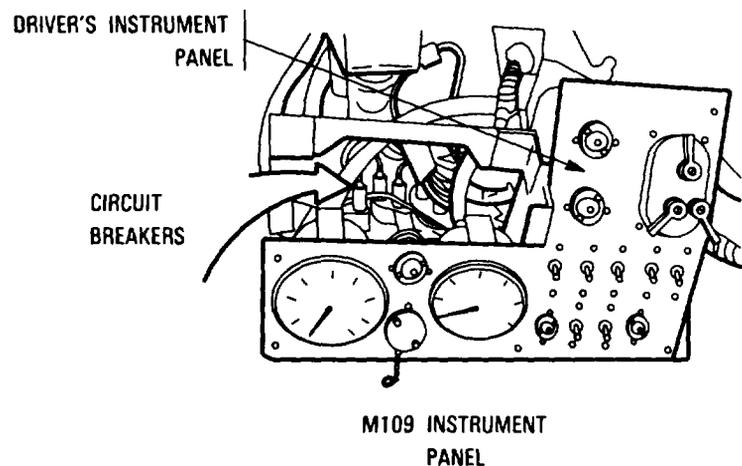
- Solder
- Insulated wire
- Tape

**Other Options:**

- Use noncritical circuit (bilge pump, auzillary outlet) circuit breaker
- Splice wires together

**Procedural Steps:**

1. Loosen driver's instrument panel to gain access to the circuit breakers.



M110/M578 Master Switch Panel (1) and Instrument Panel (2)

## ELECTRICAL SYSTEM

### Procedural Steps (Cont):

2. Locate circuit breaker for the faulty circuit.

Auxiliary outlet, dome light

Bilge pump

Master warning lights:

Engine oil pressure

Transmission oil temperature

Transmission oil pressure

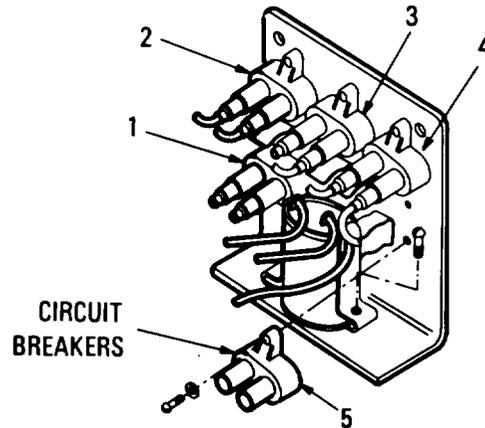
Engine water temperature

Starter switch, flame heater master switch

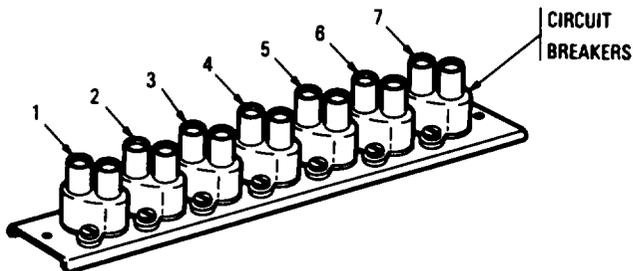
Air cleaner blower motors

Electric fuel prime pump (M109A3)

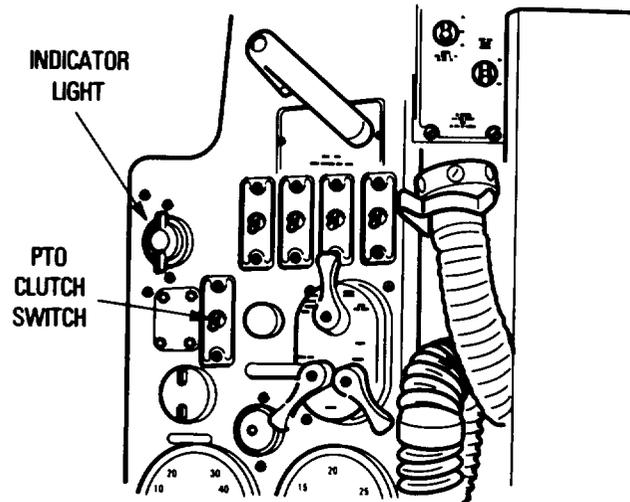
Fuel tank electric fuel pumps



M110 CIRCUIT BREAKER DESIGNATIONS



M109 CIRCUIT BREAKER DESIGNATIONS



M578 CIRCUIT BREAKER DESIGNATIONS

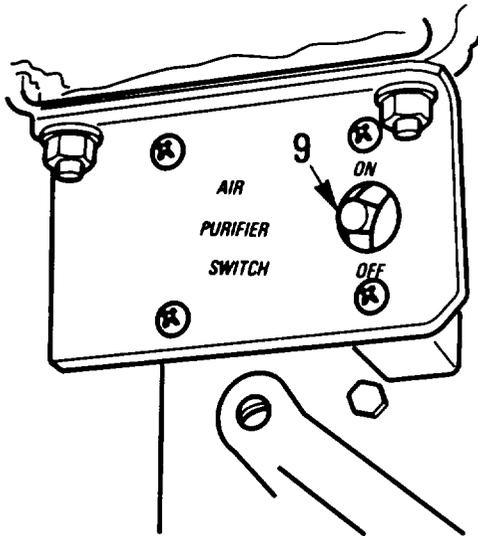
**ELECTRICAL SYSTEM**

**Procedural Steps (Cont):**

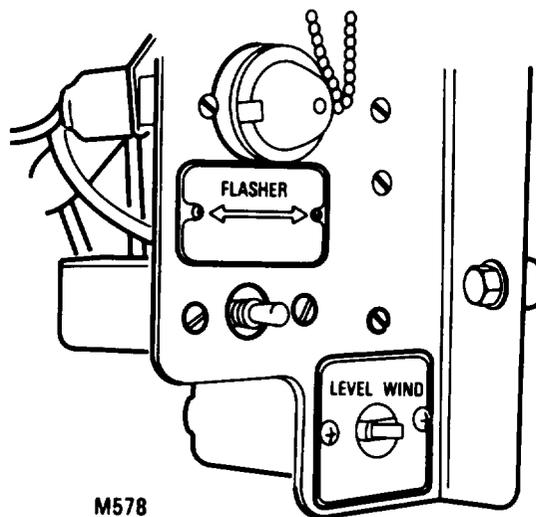
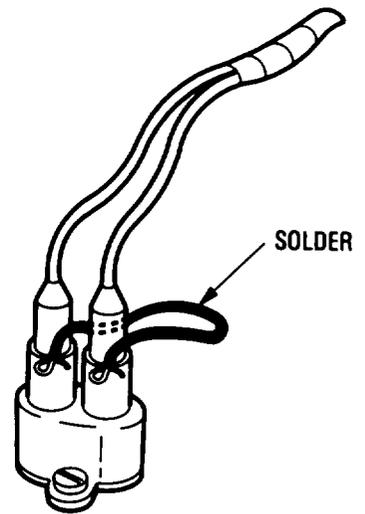
3. Remove electrical wires from the defective circuit breaker.

**NOTE**

Solder will provide a limited fuse capability.



**M578**



**M578**

4. Connect the electrical wires together by inserting a piece of solder or insulated wire in the connector plugs or cut wires and twist together.



**Procedural Step (Cont):**

5. Insulate and secure wires with tape.
6. Re-tighten instrument panel mounting.
7. Record the BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

## 6-6. BRUSHES GUMMED

### General Information

Slip ring brushes gummed. Most alcohol based solvents are good cleaning agents and will restore electrical or mechanical continuity on all types of contacts. On the M 109 with serial numbers below 1122, there are three contact arm assemblies. Serial numbers above 1122 have five contact arm assemblies.

### Limitations:

- None

### Personnel/Time Required:

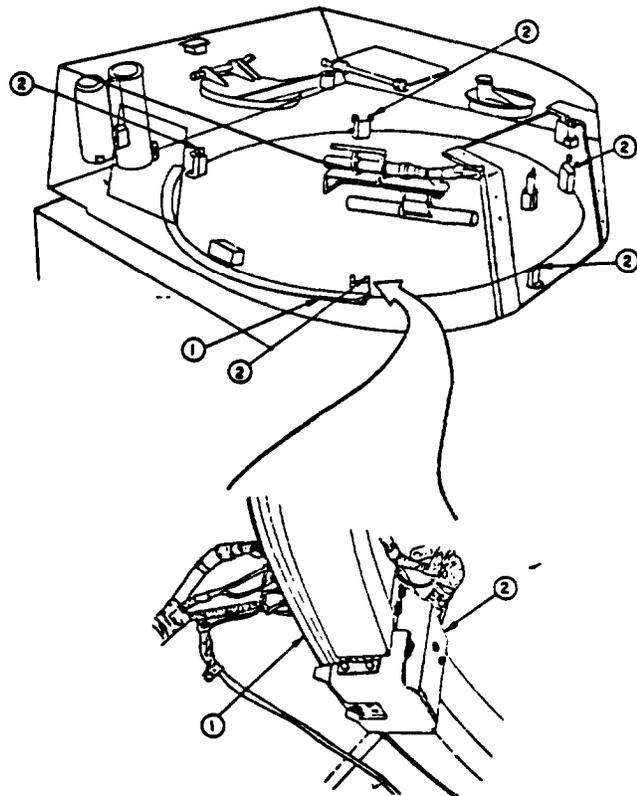
- 1 soldier
- 30-60 minutes

### Materials/Tools:

- Cleaning solvent
- Diesel fuel

### Procedural Steps:

1. Traverse the cab until the slip ring contact arm assembly (item 2) to be cleaned is at the rear of the vehicle.
2. Turn vehicle MASTER switch off or disconnect battery cables.
3. Spray a small amount of diesel fuel or other solvent, such as contact RE-NU, onto the surface of the brushes. Work the spray from top to bottom allowing the force of the spray to flush away the gum or dirt.
4. Repeat step 3 to clean slip ring segment board (item 1).
5. Record the BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.



### SECTION III. Motors, Starters, Alternators

#### 6-7. General.

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

#### 6-8. BLOWER MOTOR, AIR CLEANER FAILURE

##### General Information

The air cleaner blower motors get electrical power through a relay. When the relay is defective it may be by-passed to regain the use of the blower motors. The charging system is also controlled through the same relay. When the engine is not running the jumper wire must be removed to prevent the electrical system from being discharged.

##### Limitations:

- None

##### Personnel/Time Required:

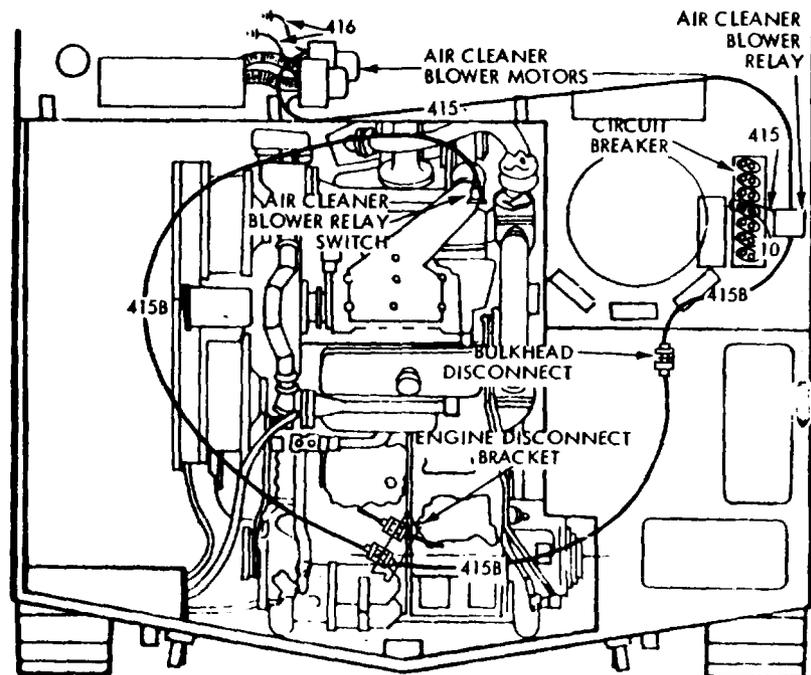
- 1 soldier
- 15 to 30 minutes

##### Materials/Tools:

- Insulated wire
- Multimeter lead
- Needle-nose pliers
- Tape

##### Procedural Steps:

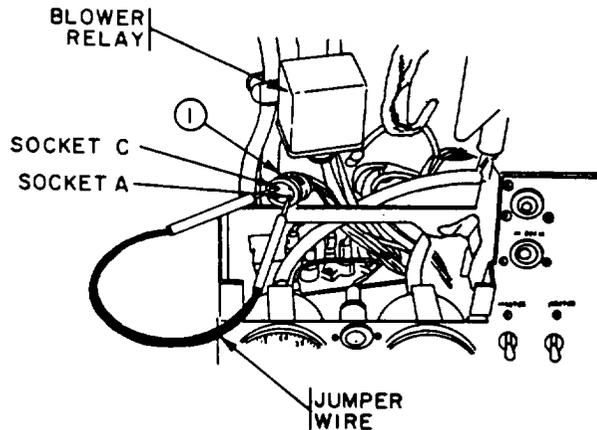
1. Turn off MASTER switch.



2. Locate air cleaner blower relay behind portable operators panel in driver's compartment.

**Procedural Steps (Cont):**

3. Disconnect electrical connector (item 1) from relay.



4. Using jumper lead connect sockets A and C together. The jumper lead must be wedged into the female sockets of connector to prevent them from vibrating out of the sockets.

**NOTE**

If uninsulated material is used for jumper, wrap with electrical tape to prevent electrical short.

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

**6-9. STARTER MOTOR, RELAY FAILURE**

**General Information**

Starter motor will not engage due to starter motor relay failure. Insertion of jumper lead will energize starter motor. If non-insulated material is used for jumper, use an insulating material to hold jumper lead. If engine is shut down this procedure must be repeated. Two options below can be utilized to get the engine started.

**Option 1:**

**Limitations:**

- Slow starting

**Personnel/Time Required:**

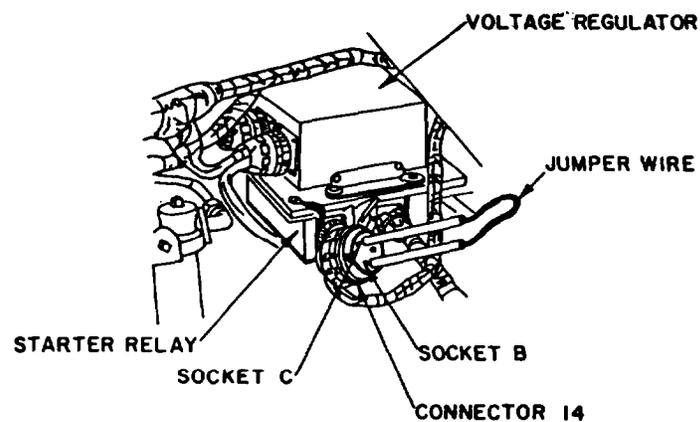
- 1 soldier
- 15 minutes

**Materials/Tools=**

- Jumper wire

**Procedural Steps:**

1. Gain access to left side of transmission compartment and locate starter relay.



2. Remove connector #14 from starter relay.
3. Using jumper lead, connect socket B and socket C together.
4. After engine has started, remove jumper and re-install connector #14 to starter relay.

**Option 2:**

**Limitations:**

- Bilge pump will not operate.

**Personnel/Time Required:**

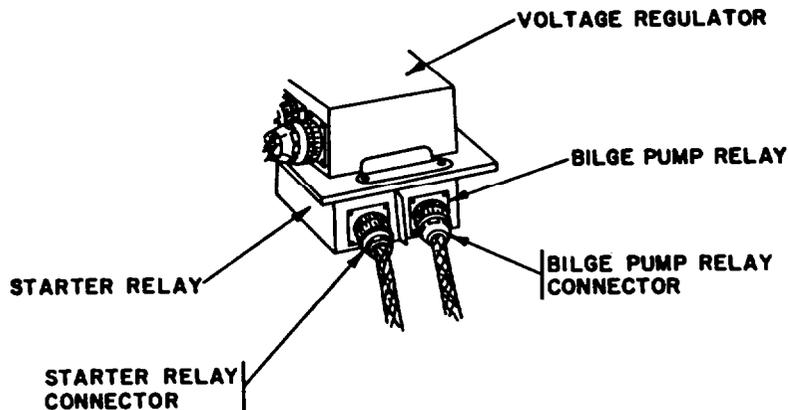
- 1 soldier
- 15 minutes

**Materials/Tools:**

- None

**Procedural Steps:**

1. Gain access to left side of transmission compartment; locate starter relay and bilge pump relay.
2. Remove connectors from starter and bilge pump relays.



3. Connect the starter relay connector to the bilge pump relay. Start engine.
4. If bilge pump is not needed at present time, starter cable may be left on bilge pump relay.

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

**6-10. STARTER FAILURE, SUBSTITUTION**

**General Information**

Starter motor seized or defective. Solenoid will not engage. Starter motors from the M107, M108 Howitzers, and M809 Series 5-ton truck with a Cummings engine may be substituted, ensure the starter motor has an 11-tooth drive gear.

**Limitations:**

- Reduced starter life if 5 ton starter is used.

**Personnel/Time Required:**

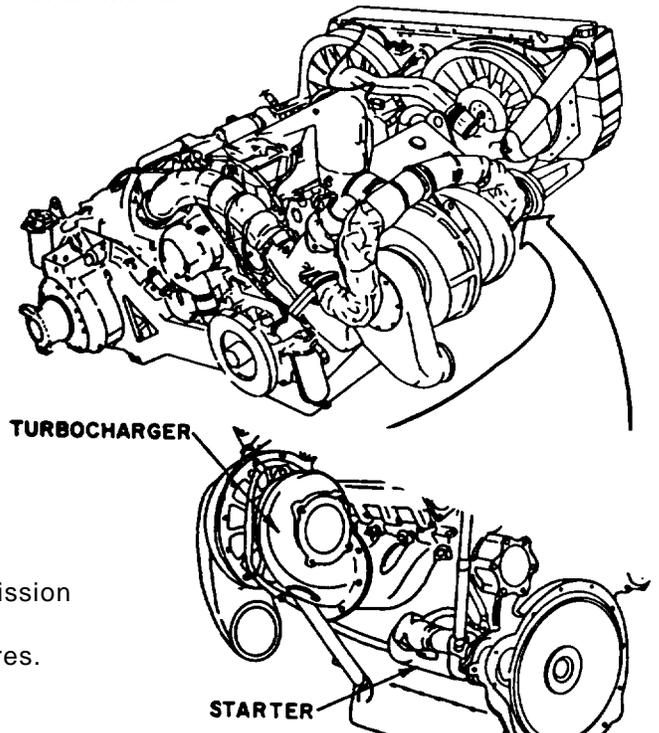
- 1 soldier
- 5 minutes to 2 hours

**Materials/Tools**

- Fist size stone
- Hammer
- Breaker bar

**Procedural Steps**

1. Gain access to engine compartment and locate starter motor on engine. The starter is located beneath turbocharger, directly behind radiator.
2. Using hammer, breaker bar, or stone, tap starter motor.
3. Attempt to start engine.
4. If starter is still inoperative, replace with a starter from:
  - a. M 107 S. P. Howitzer
  - b. M 108 S. P. Howitzer
  - c. M110 S. P. Howitzer
  - d. M578 Recovery Vehicle
  - e. M809 Series 5-Ton Truck
  - f. M975 Roland
5. Record the BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.



CHAPTER 7

POWERTRAIN/STEERING

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

SECTION L General

7-1. General.

The M109/M110/M578 series powertrain (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.

7-2. Assessment Procedure.

a. Pre-conditions: Vehicle brakes should be in working condition. The vehicle engine must run to assess the powertrain using this procedure.

b. Visually inspect Damage found to:
-housings . . . . . go to TM 9-2350-276-BD
No damage -drives . . . . . go to para 7-7
found -linkages . . . . . go to para 7-6

c. Start engine Damage found to:
to operate;
observe operation
No damage -forward gears . . . . . go to para 7-4
found -reverse gears . . . . . go to para 7-4
-steering capability . . . . . go to para 7-6

d. Check powertrain/steering performance

**POWERTRAIN/STEERING**

**Assessment Procedure (Cont.)**

c. Evaluate system performance:

**Powertrain/Steering Assessment**

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
all gears and steering	X	X	X		
reverse, one forward gear and steering		X	X	X	
one gear only and steering			X	X	X
one gear only, no steering			X	X	X
- no gears, no steering			X		X

**7-3. BDAR Procedure Index:**

	Para
Transmission/Transfer Interchangeability . . . . .	7-4
Steering Linkage Failure . . . . .	7-6
Final Drive Hub Bolts Sheared . . . . .	7-7

**POWERTRAIN/STEERING****SECTION II. Transmission/Transfer****7-4. TRANSMISSION/TRANSFER INTERCHANGEABILITY.****General Information:**

Transmission failure can be caused by a multitude of causes. Availability of replacement transmissions/transfers may become a problem that can only be solved by removal from other damaged equipment.

The M109/M110/M578 is designed for the XTG 411-2 transmission only. This transmission and the transfer assemblies are interchangeable between the following vehicles:

1. M107.
2. M108.
3. M110.
4. M110A1.
5. M110A2.
6. M578 Recovery Vehicle.

An alternate source of supply for transmissions/transfers is foreign owned equipment (see Appendix A).

**POWERTRAIN/STEERING**

**SECTION III. Linkages**

■ 7-5. Deleted.

## 7-6. STEERING LINKAGE FAILURE

### General Information:

No reaction to movement of steering wheel, because of broken linkage. The travel lock must be moved to gain access to the transmission. Travel lock is heavy (110 lbs.). The M109A2 travel lock is not counter balanced. Caution should be exercised by crew member stationed outside vehicle not to get feet or clothing tangled in universal joints.

### Limitation:

- Hazardous to crew member stationed outside vehicle

### Personnel/Time Required:

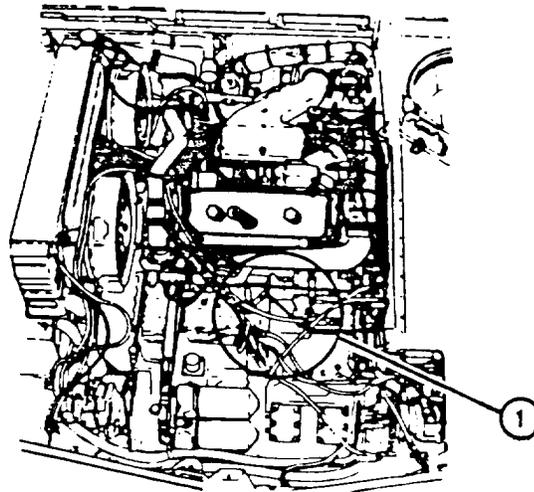
- 2 soldiers
- 20 minutes

### Other Options

- Repair damaged linkage by welding or riveting.

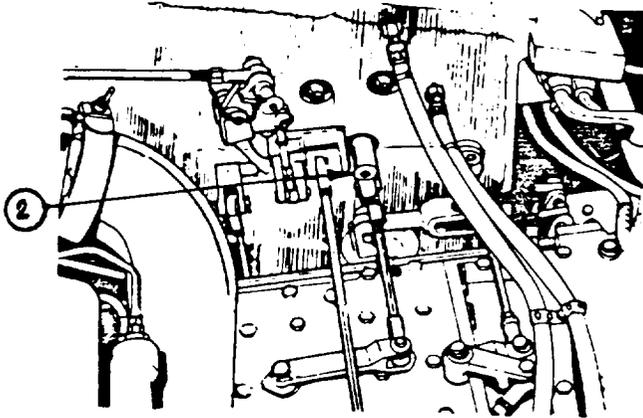
### Procedural Steps:

1. Gain access to engine compartment thru transmission access covers. On the M109A2/A3, it will be necessary to unlock the howitzer travel lock and lay it forward until access doors are opened. Relock before moving vehicle.
2. Locate damaged steering control linkages (item 1).



**Procedural Steps (Cont):**

3. Disconnect sliding steer shaft by removing quick-disconnect pin (item 2).



4. Manual steering can now be performed outside of driver's compartment by pushing the control (item 1) back for right hand movement or forward for left hand movement.
5. Record the BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

## SECTION IV. Final Drive

### 7-7. FINAL DRIVE HUB BOLTS SHEARED

#### General Information

Final drive mounting bolts will work loose during normal operation. If they are not noticed and retightened, the shifting of the sprocket hub will shear the bolts. Bolts can be cannibalized from the good side to enable the mounting of the sprocket hub. If the hub is remounted with a reduced number of bolts, the bolts should be spaced evenly. At least 4 of the 8 mounting bolts are required to remount the hub.

#### Limitations:

- Reduced mobility

#### Personnel/Time Required:

- 2 soldiers
- 1-2 hours

#### Materials/Tools:

- Vice-grips
- Hammer
- Chisel

#### Other Options:

- Weld the hub assembly to the output of the final drive.

#### Procedural Steps:

1. Break track.
2. Remove broken final drive housing bolts.
3. Remount the hub with replacement or remaining bolts (minimum of four).
4. Reconnect track and adjust tension.
5. Record the BDAR action taken. When mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedure.

**CHAPTER 8  
BRAKES**

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

**SECTION I. General**

**8-1. General.**

The brakes are internal to the crossdrive transmission. Brakes are applied through mechanical linkage from the drivers 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.

**8-2. Assessment Procedure**

a. Assessment Preconditions Before testing the vehicle brakes, clear the immediate area or, if in a restricted area, restrain the vehicle to be tested with chains or cables. 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.

b. Check fluid level.

c. Visually inspect → Damage found to:

No damage found -pedal and linkage . . . . . go to para 8-5 and 8-6

d. Start or tow the vehicle up a slight grade and check brake operation/effectiveness → Damage found to:

No damage found  
- no stopping power . . . . . go to para 8-6  
- pulling or other erratic . . . . . go to para 8-5 and 8-6 action  
- to parking brakes . . . . . go to para 8-4



**d. Evaluate system performance:**

**BRAKE ASSESSMENT**

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
- brakes normal	X	X	X		
- brakes degraded		X	X	X	
- brakes severely degraded			X	X	
no brakes			X	X	X

**8-3. BDAR Procedure Index.**

	Para
Brakes, Parking, Locked . . . . .	8-4
Brakes, Service, Locked . . . . .	8-5
Brake Malfunctions. . . . .	8-6

## SECTION II. Brake BDAR

### 8-4. 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

#### Personnel/Time Required

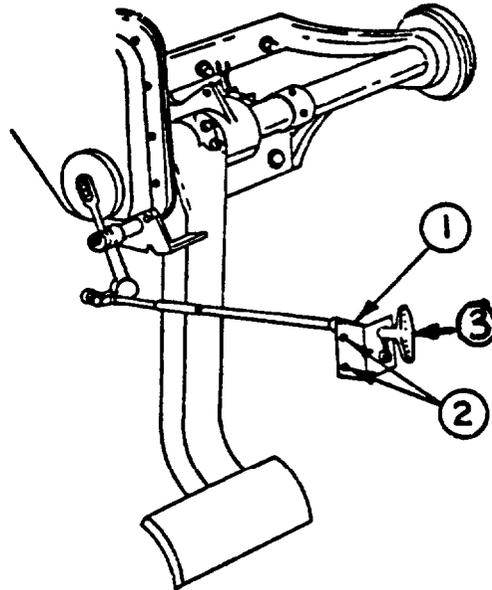
- 1 soldier
- 5 minutes

#### Other Options

- Disconnect linkage at the transmission

#### Procedural Steps

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 (item 2).
3. Lay parking brake assembly on floor.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

**BRAKE**

**8-5. BRAKES, SERVICE, LOCKED**

**General Information**

Brakes will not release.

**Limitations**

- Possible that brakes will lock again.

**Personnel/Time Required:**

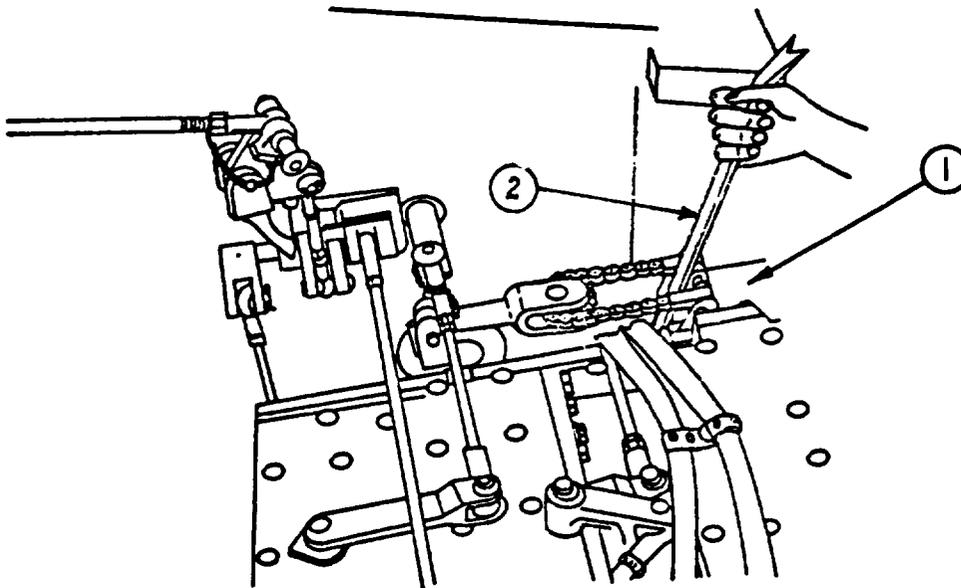
- 1 soldier
- 15 minutes

**Materials/Tools:**

- Pipe
- Breaker bar
- Shovel handle

**Procedural Steps:**

1. Gain access to transmission compartment and locate brake control apply levers (item 1).
2. Using pry bar (item 2), pry brakes into released position.



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

## 8-6. 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
- 30 minutes

**Materials/Tools:** Any of following to use as chain substitute (approx. 2 ft. length required)

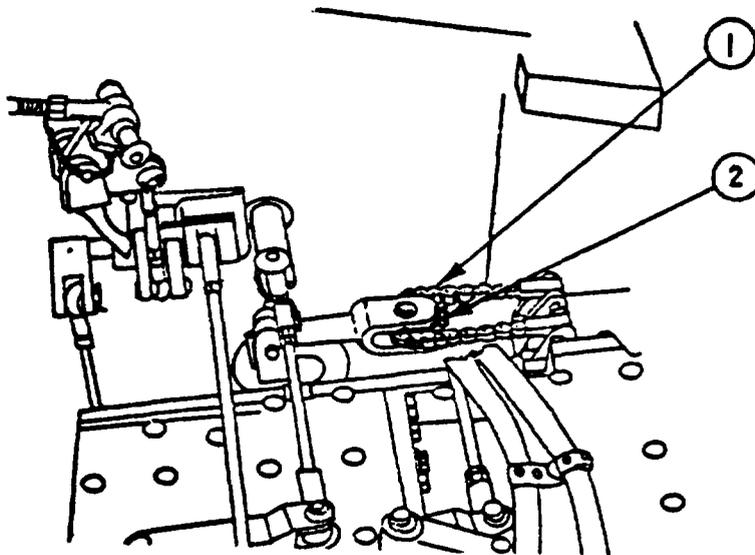
- Wire coat hanger
- Rope
- 1/8-inch cable and cable clamp
- Commo wire WD-1/TT

### 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.

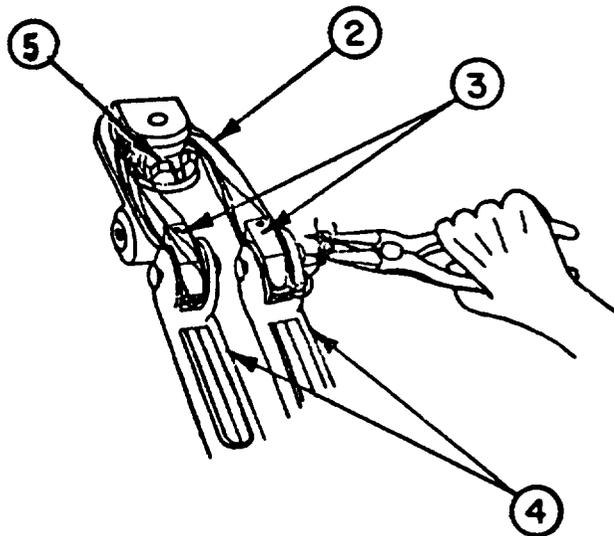


2. Remove broken pieces of chain (item 1) from around sprocket (item 5), if any.

**BRAKE**

**Procedural Step (Cont):**

3. Feed chain substitute (item 2) around sprocket (item 5) and underneath devises (item 3) of both brake levers (item 4).



4. Pull chain replacement as tight as possible and fasten ends together.
5. Record the BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

CHAPTER 9  
TRACK AND SUSPENSION

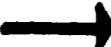
**BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.**

SECTION I General

9-1. General.

The M 109 suspension works with torsion bar springs with seven individual y sprung dual roadwheels on each side of the hull with four shock dampened roadwheel arms, one at each corner. The track is a two double pin steel track adjusted by a rear mounted idler assembly. Center guides are intergral to the track shoe and keep the track in position by threading between the upper surfaces of the dual road wheels. The hull allows clearance for the use of short tracking to recover or provide limited mobility.

9-2. Assessment Proceudue.

a. Visually inspect  Damage found to:



- track, . . . . . go to para 9-5
- roadwheels, . . . . . go to para 9-5
- drive sprockets, . . . . . go to para 9-6
- roadwheel arms, . . . . . go to para 9-7
- idler assembly, . . . . . go to para 9-5
- shock absorbers, . . . . . go to TM 9-2350-276-BD

↓  
**b. Functionally check** → **Damage found to:**

↓  
**No damage**  
 ↓

- track, .....go to para 9-5
- roadwheels, .....go to para 9-5
- drive sprockets, .....go to para 9-6
- roadwheel arms, .....go to para 9-7
- idler assembly .....go to para 9-5
- shock absorbers, ..... go to TM 9-2350-276-BD
- torsion bars, .....go to TM 9-2350-276-BD

**c. Evaluate Suspension System:**

	Fully Mission Capable	Combat Capable	Combat Emergency Capable	Self- Recovery Capable	Recover
-All components serviceable	X	X	X	X	
-Both tracks, drive sprockets, idlers, and positions 1 and 7 with 3 other positions serviceable		X	X	X	
-Both tracks, drive sprockets, idlers and positions 1 and 7 serviceable			X	X	
-Either track, drive sprocket, idler or position 1 and 7 unserviceable		X <sup>1</sup>	X <sup>1</sup>	X	X

X<sup>1</sup>Use as Towed firing platform.

**9-3 BDAR Procedure Index**

	Para
Inadequate Traction .....	9-4
Track, Roadwheel or Idler Arm Damage .....	9-5
Drive Sprocket Bolts Sheared Off .....	9-6
Roadwheel Arm Damaged .....	9-7

## **SECTION II. Track**

### **9-4. INADEQUATE TRACTION**

#### **General Information**

Conventional track configuration is not sufficient for adequate traction and mobility on ice. Reversing several track blocks will give added traction by digging into the ice. The vehicle will have to be moved several times to gain access to each track shoe to be reversed.

#### **Limitations:**

- Reduced speed in turns.

#### **Personnel/Time Required:**

- 3 soldiers
- 2-3 hours

#### **Materials/Tools:**

- Wrench
- Crowbar

#### **Other Options:**

- Remove track rubber pads.

#### **Procedural Steps:**

1. Break track.
2. Remove every 5th track block and re-install upside down.
3. Reinstall track and adjust tension.
4. Record the BDAR action taken. When mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

### **9-5. TRACK, ROADWHEEL OR IDLER ARM DAMAGE**

#### **General Information:**

Damage to the track, roadwheel or idler arm may be repaired by short tracking.

#### **Limitations**

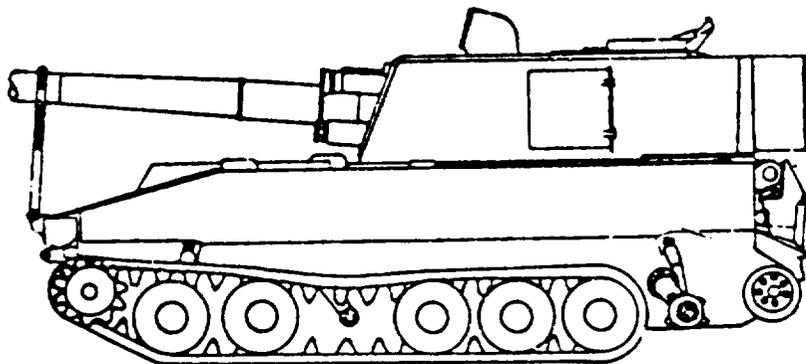
- Reduced speed
- Reduced steering capabilities

#### **Personnel/Time Required**

- 2 soldiers
- 2-3 hours

#### **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 completed, as soon as practicable, repair vehicle using standard maintenance procedures.

## TRACK AND SUSPENSION

## SECTION III. Drive and Roadwheels

## 9-6. 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.

**Limitations:**

- If welded, reduced mobility

**Personnel/Time Required:**

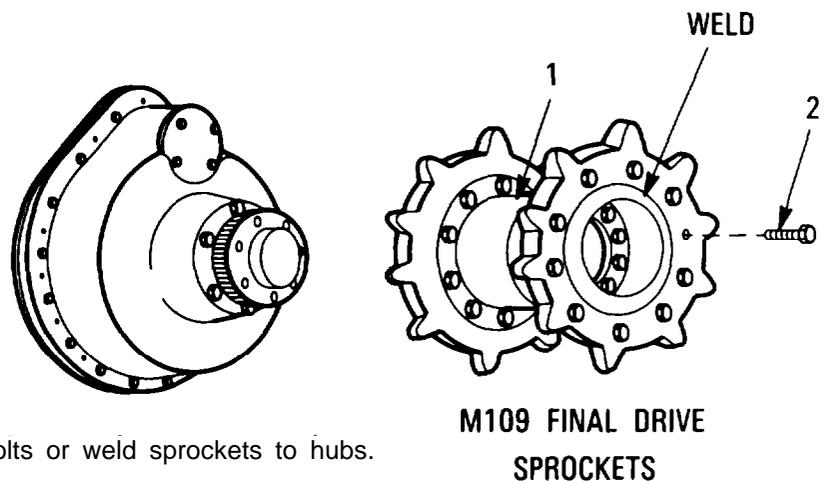
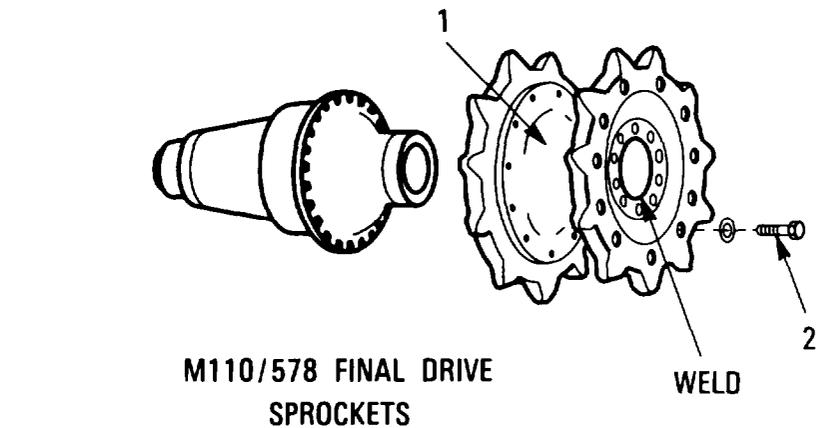
- 2 soldiers
- 1-2 hours

**Materials/Tools**

- Replacement sprocket bolts, nuts
- Welding equipment
- Lift capability

**Procedural Steps:**

1. Separate track to allow access to drive sprocket assembly (item 1).
2. Remove drive sprocket and hub assembly from final drive assembly.
3. Remove loose damaged bolts (item 2) and nuts. Clear holes of inside and outside sprockets and hub of remains of sheared bolts.



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 completed, as soon as practicable, repair vehicle using standard maintenance procedures.

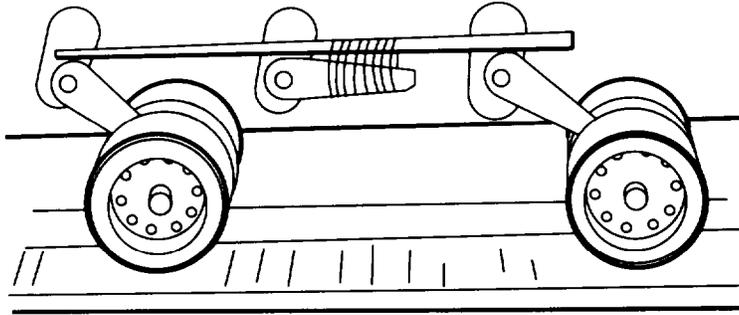
**TRACK AND SUSPENSION**

**SECTION IV. Suspension Components**

**9-7. ROADWHEEL ARM DAMAGED**

**General Information: (M109 Road Wheel only.)**

The M 109 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. Roadwheel arms can be obtained from other positions to provide support and separate the two adjacent positions. The roadwheel arms designed for the shock struts are shorter and if used in other positions will limit the mobility to reduced speeds. Disabled roadwheel arms should be secured or removed to prevent interference with the track. Tie up using a tanker's bar as shown, or use the tie down chains, snow chains, etc.



M 109 Roadwheel

CHAPTER 10

ARMAMENT AND FIRE CONTROL SYSTEM

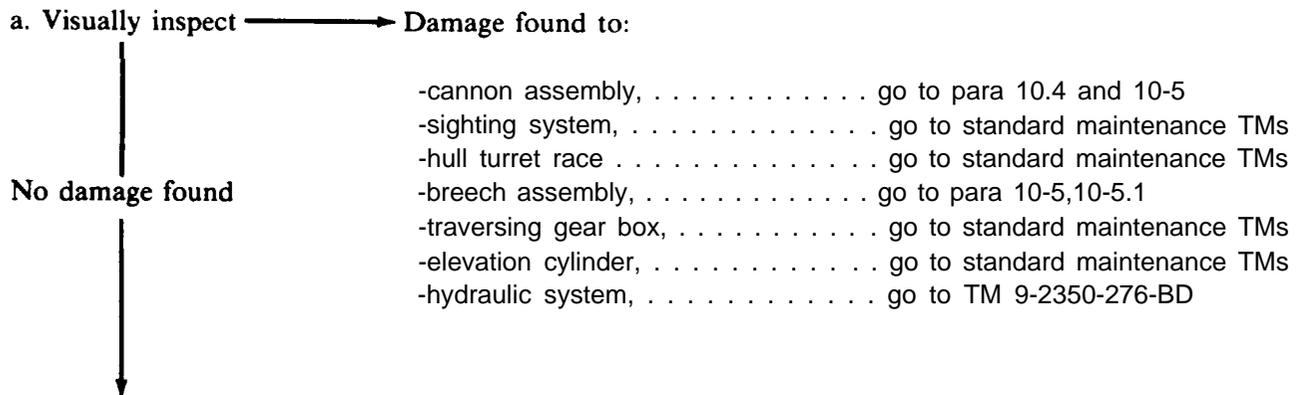
**BDAR FIXES SHALL BE USED ONLY IN COMBAT  
AT THE DISCRETION OF THE COMMANDER  
AND SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES  
AS SOON AS PRACTICABLE AFTER THE MISSION IS COMPLETED.**

SECTION I. General

10-1. General.

Armament and fire control systems are two classes of equipment. Fire control systems 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, Fire control systems, because of their complexity, do not lend themselves to BDAR procedures. Refer to the standard TMs for fire control repairs.

7-2. Assessment Procedure.



**ARMAMENT AND FIRE CONTROL SYSTEM**

**b. Self-test and functionally check: → Damage found to:**

**No damage found**

- gun elevation/traversing system, . . . go to para 10-6 and 10-7
- sighting system, . . . . . go to standard maintenance TMs
- turret blower system, . . . . . go to TM 9-2350-276-BD

**c. Evaluate system performance:**

Armament and Fire Control Assessment

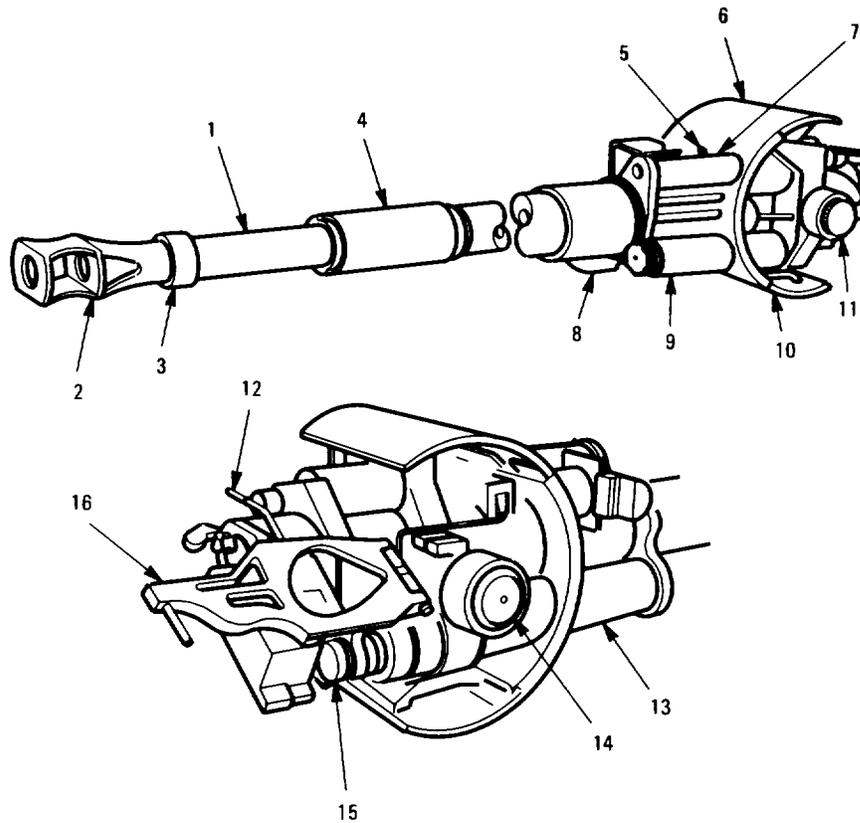
	Fully Mission Capable	Combat Capable	Combat Emergency Capable
- system operates normally	X	X	X
- system is degraded; however, redundant system available		X	X
- system is degraded; no redundant system			X
- gun tube will not elevate or depress			X
- gun tube will not traverse			X

**10-3. BDAR Procedure Index:**

	Para
Bore Evacuator Damage . . . . .	.10-4
Gun Interchangeability (M109 Family) . . . . .	.10-5
Gun Interchangeability (M110 Family) . . . . .	.10-5.1
Turret Power Pack Damage . . . . .	.10-6
Turret Power Pack Interchangeability . . . . .	.10-7
Turret Interchangeability (M109 Family) . . . . .	10-8
Turret Interchangeability (M110 Family) . . . . .	.10-8.1
Winch/Boom Interchangeability (M578 RV) . . . . .	.10-8.2
Manual Pump Fluid Loss (M109 only) . . . . .	.10-9
Fire Control Interchangeability (M109/M110 Families) . . . . .	.10-10
Loss of Accumulator Pressure Switch (M109 vehicles) . . . . .	10-11
Power Loss to 645 Pressure Switch Line . . . . .	.10-12
Pivot Interlock Switch . . . . .	.10-13
Rammer Tray Interlock Switch . . . . .	10-14
Traversing Mechanism Damage . . . . .	.10-15

**ARMAMENT AND FIRE CONTROL SYSTEM**

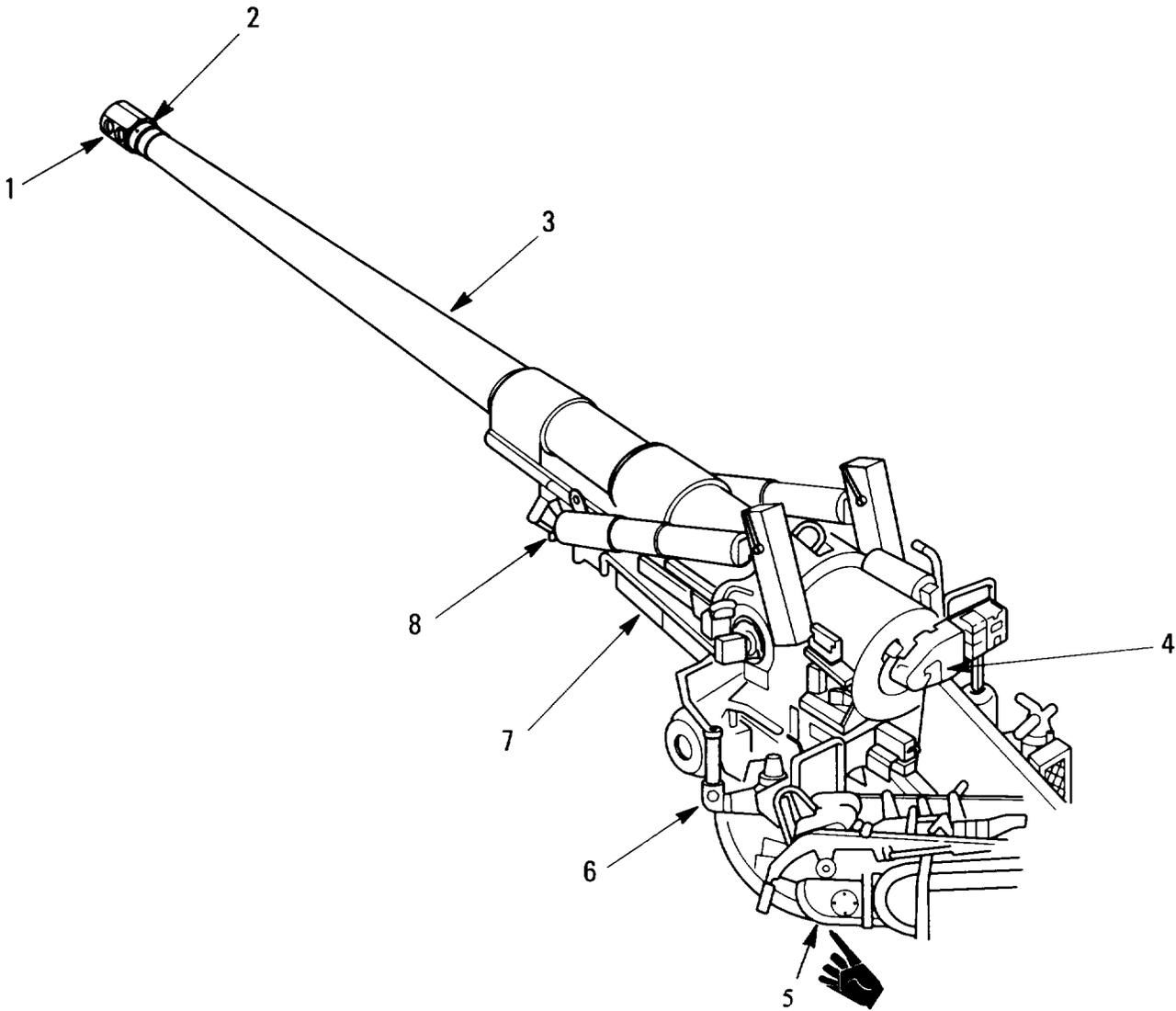
Location and Description of Howitzer Cannon and Mount Components



1. Howitzer cannon M185 or M284
2. Muzzle brake
3. Muzzle brake locking ring
4. Evacuator
5. Torque key (hidden)
6. Upper rotor shield
7. Upper recoil cylinder
8. Dust shield
9. Recuperator
10. Lower rotor shield
11. Howitzer mount M178 or M182
12. Breech operating handle
13. Lower recoil cylinder
14. Trunnion
15. **Buffer (hidden)**
16. Breech operating cradle cam

M109 Cannon and Mount

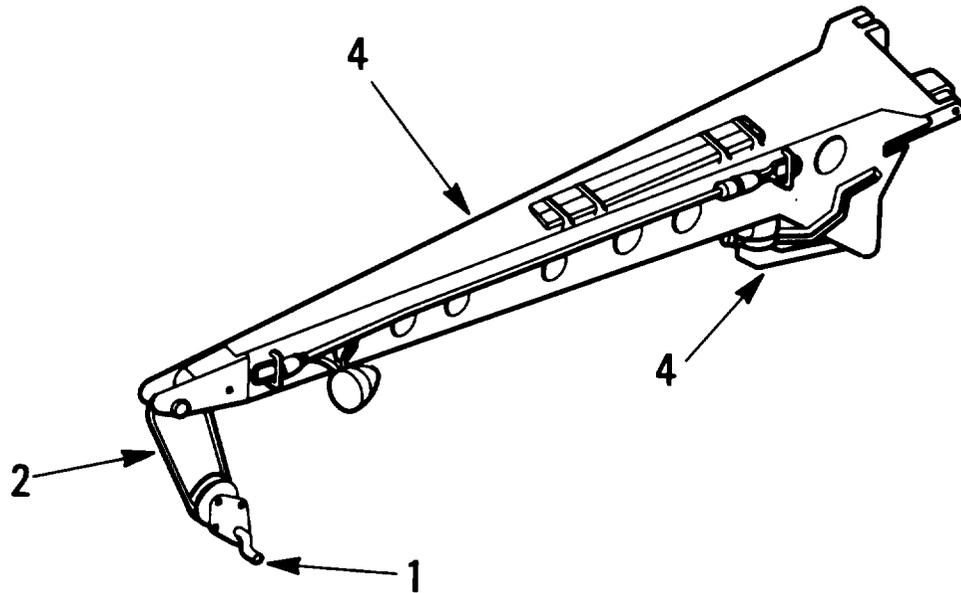
ARMAMENT AND FIRE CONTROL SYSTEM



- 1. Muzzle Brake
- 2. Thrust collar
- 3. Cannon
- 4. Breech
- 5. Loader/Rammer
- 6. Manual Traversing Mechanism
- 7. M174 Mount
- 8. Equilibrator

M110A2 Cannon and Mount

ARMAMENT AND FIRE CONTROL SYSTEM



M578 Boom and Mount

- 1. Single Boom Block
- 2. Wire Rope
- 3. Boom
- 4. Level Wind

**ARMAMENT AND FIRE CONTROL SYSTEM**

**SECTION II. Armament BDAR**

**10-4. 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 turret as the breech block opens. This procedure repairs puncture damage to the bore evacuator.

**Limitations:**

- None

**Personnel/Time Required:**

- 1 soldier
- 1 hour

**Other Option(s):**

- Open turret hatches and turn on turret blower.

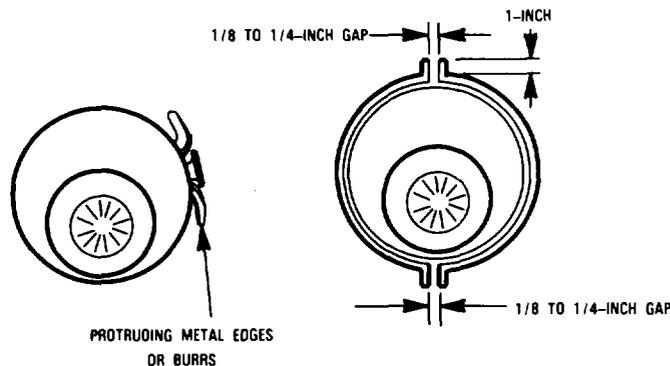
Option 1: Fabricated clamp repair.

**Material/Tools:**

- Acetylene torch.
- Abestos paper or other suitable fire resistant material.
- Grinder.
- Hexagon head nut, 3/8-inch (as required).
- Lockwashers (as required).
- Machine screws, 3/8-inch (as required).
- Sheet metal, 1/4-inch thick, about 21-inches long and wide enough to overlap damage.

**Procedural Steps:**

1. Use acetylene torch and grinder to cut and remove any burrs or protruding metal edges that may effect air-tight seal.

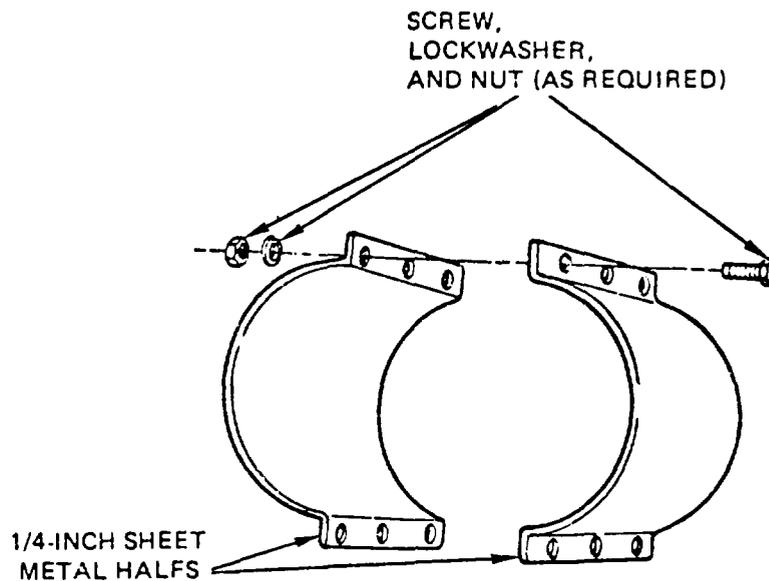


**Procedural Steps (Cont):**

2. Clean any blocked gas ports, if accessible.
3. Measure and record dimensions of damaged area.

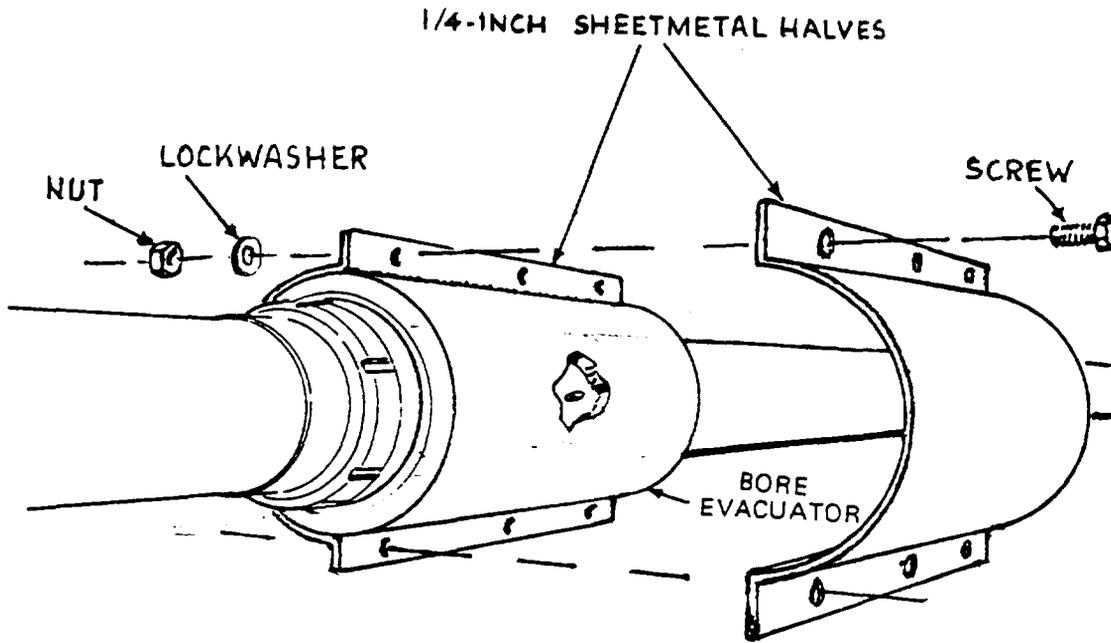
**NOTE**

If damage is extensive, clamp should be made same width as bore evacuator to ensure a proper seal.



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 asbestos paper or some other 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.

**Procedural Steps (Cont):**



8. Secure bands against bore evacuator with screws, nuts, and lockwashers.

**Option 2:** Welded patch repair.

**Materials/Tools:**

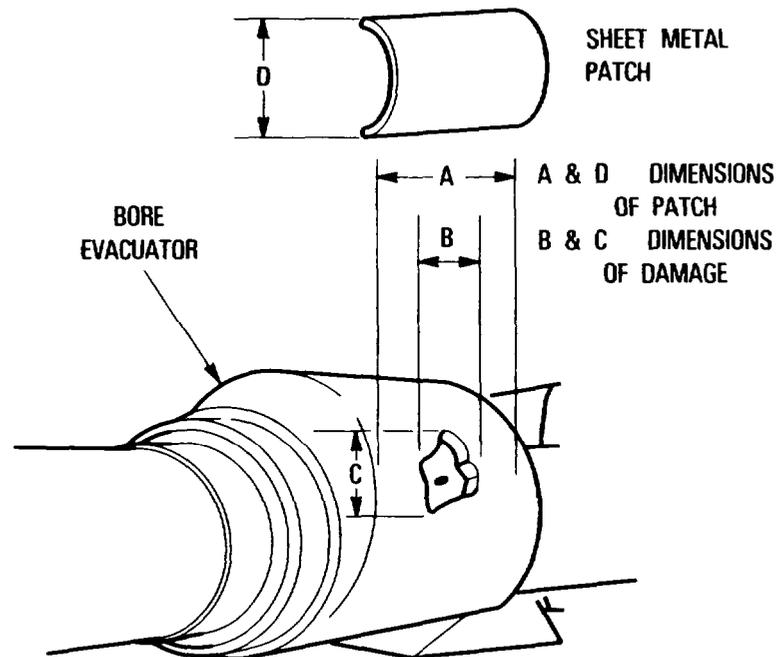
- o Welding equipment
- o Grinder
- o Sheet metal, 1/4-inch thick (size dependent on damage)

**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).

## ARMAMENT AND FIRE CONTROL SYSTEM

## Procedural Steps (Cont):



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.
7. Set and secure patch in place over damaged area.

**CAUTION**

If arc welding on turret, ground welding equipment to turret only. Parts of slipping and race bearings can be damaged from high currents conducted between hull and turret if welding equipment is not grounded correctly.

**ARMAMENT AND FIRE CONTROL SYSTEM**

**Procedural Steps (Cont):**

8. Use gas or arc to weld a continuous bead around the patch. Check weld for cracks or openings, and repair if necessary.

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

**10-5. GUN INTERCHANGEABILITY (M109 FAMILY).**

**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 maybe used to assist interchanging them. The 155MM gun of the M 109 vehicle is interchangeable only within the M109 family. Use of the longer gun tube on the M109 or a short tube on the M109A2, M109A3, M109A4 or M109A5 will eliminate the use of the travel lock.

**Interchangeability Information**

<u>Vehicle</u>	<u>Tube</u>	<u>Mount</u>
M109	M126A1	M127
M109A1	M185	M127
M109A2	M185	M178
M109A3	M185	M178
M109A4	M185	M178
M109A5	M284	M182

Any tube or mount combination may be used but using the longer gun tube will change the vehicle's balance which may require the vehicle to move at slower speeds. Firing tables for the appropriate tube length must also be used.

**10-5.1. GUN INTERCHANGEABILITY (M110 FAMILY)**

**General Information:**

Gun tubes and mounts sustain damage easily in a combat environment, which may prevent tire missions. A wrecker, block and tackle or improved lifting device may be used to assist interchanging them. The 8" gun of the M1 10 series vehicle is interchangeable only within the M1 10 family.

**Interchangeability Information**

<u>Vehicle</u>	<u>Tube</u>	<u>Mount</u>
M107		M158
M110		M158
M110A2	M201A2	M174

Any tube or mount combination may be used but using the longer gun tube will change the vehicle's balance which may require the vehicle to move at slower speeds. Firing tables for the appropriate tube length must also be used.

**ARMAMENT AND FIRE CONTROL SYSTEM****10-7. TURRET POWER PACK INTERCHANGEABILITY.****General Information:**

The quickest method of repair for a damaged power pack may be to cannibalize replacement parts from disabled vehicles. There are some minor differences in certain power pack components of the vehicles listed below, but they will function. Cannibalize the required power pack component from another vehicle

## ARMAMENT AND FIRE CONTROL SYSTEM

### General Information (Cent):

- as available. Turret power pack components of the M109/M110 series/M578 are interchangeable with those of the following vehicles:
- a. Electric Motor: M48, M60, M107, M110 series, M728.
  - b. Filter: M48, M60, M109, M728.
  - c. Power Valve: M48, M60, M109, M728.
  - d. Pressure Regulator: M48, M60, M109, M728.
  - e. Pump: M48, M60, M109, M728.
  - f. Reservoir: M48, M60, M109, M728,
  - g. Manual Accumulator: M48, M60, M109, M728.
  - h. Traversing Hydraulic Motor: M48, M60, M109, M728.
  - i. Main Accumulator: M48, M60, M109, M728.
  - j. Manual Elevation Hand Pump: M48, M60, M109, M198, M578, M110, M728.
  - k. Pressure Switch: M48, M60, M109, M728.
  - l. Cab Power Relay Box: M48, M60, M109, M728.
  - m. Solenoids: M48, M60, M109, M728.
  - n. Pressure Gage: M48, M60, M109, M728.

**ARMAMENT AND FIRE CONTROL SYSTEM****10-8. TURRET INTERCHANGEABILITY (M109 FAMILY).****General Information:**

Removal of the complete cab of an M109 requires a lifting capacity of at least 15,000 pounds. Turrets on the M109 are interchangeable only within the M109 family itself. Turrets with five slip ring contact arm assemblies can replace models with three, but not the other way around. M109, M109A1, M109A3 and M109A4 vehicles through serial no. 1122 have three slip ring contact arm assemblies, two slip ring segments, and a slip ring cover. M109, M109A1, M109A3 and M109A4 vehicles after serial no. 1122 and all M109A2 and M109A5 vehicles have five slip ring contact arm assemblies, one slip ring segment and no slip ring cover.

**10-8.1. TURRET INTERCHANGEABILITY (M110 FAMILY).****General Information:**

Removal of the complete turret of an M 110 series requires a lifting capacity of at least 15,000 pounds. Turrets on the M 110 series are interchangeable only within the M 110 family itself.

**10-8.2. WINCH\BOOM INTERCHANGEABILITY (M578 Recovery Vehicle).****General Information:**

The quickest method of repair for a damaged boom may be to cannibalize replacement parts from disabled vehicles. There are some minor differences in certain components of the vehicles listed below, but they will function. Cannibalize the required component from another vehicle as available. Boom components of the M578 Recovery Vehicle are interchangeable with those of the following vehicles:

- a. Traversing Drive Unit: M107, M110, M110A1, M110 series.
- b. Turret Bearing Ring: M107, M110, M110A1, M110 series, M578.

The following items may be cannibalized from other areas of the M578 Recovery Vehicle in order to make the more critical area operable. Note that the items will work; however, the mission capabilities will be degraded.

- a. Boom Winch Hydraulic Motor is directly interchangeable with the Tow Winch Hydraulic Motor.
- b. Boom Winch Hydraulic Relief Valve, 1525 psi, PN 12253778-1: interchangeable with Boom Cylinder and Two Winch Hydraulic Relief Valve, 2275 psi, PN 12253778-1.
- c. Check Valve, 2 psi, PN 12253779-1: interchangeable with Check Valve, 5 psi, PN 12253779-2.

## ARMAMENT AND FIRE CONTROL SYSTEM

### 10-9. MANUAL PUMP FLUID LOSS (M109 Only).

#### General Information:

A damaged reservoir will cause the hydraulic oil to escape. However, because of the check valves in the system, once pressure is made, the system is independent of the reservoir. Oil contamination probability is high. There are two manual pumps in the M 109 system, manual elevation hand pump, and the equilibrator system hand pump.

#### Limitations:

None

#### Personnel/Time Required:

- 1-2 soldiers
- 15 minutes

#### Materials/Tools:

- Hydraulic hose (optional).
- Hydraulic line (optional).
- Adjustable wrench.
- Vicegrips.
- Water pump pliers.

#### Procedural Steps:

1. Find and repair/correct the cause of the fluid loss.
2. Disconnect or cut the input line to the manual (hand) pump.
3. Put the input line into a can/container of hydraulic fluid as a substitute reservoir.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

ARMAMENT AND FIRE CONTROL SYSTEM

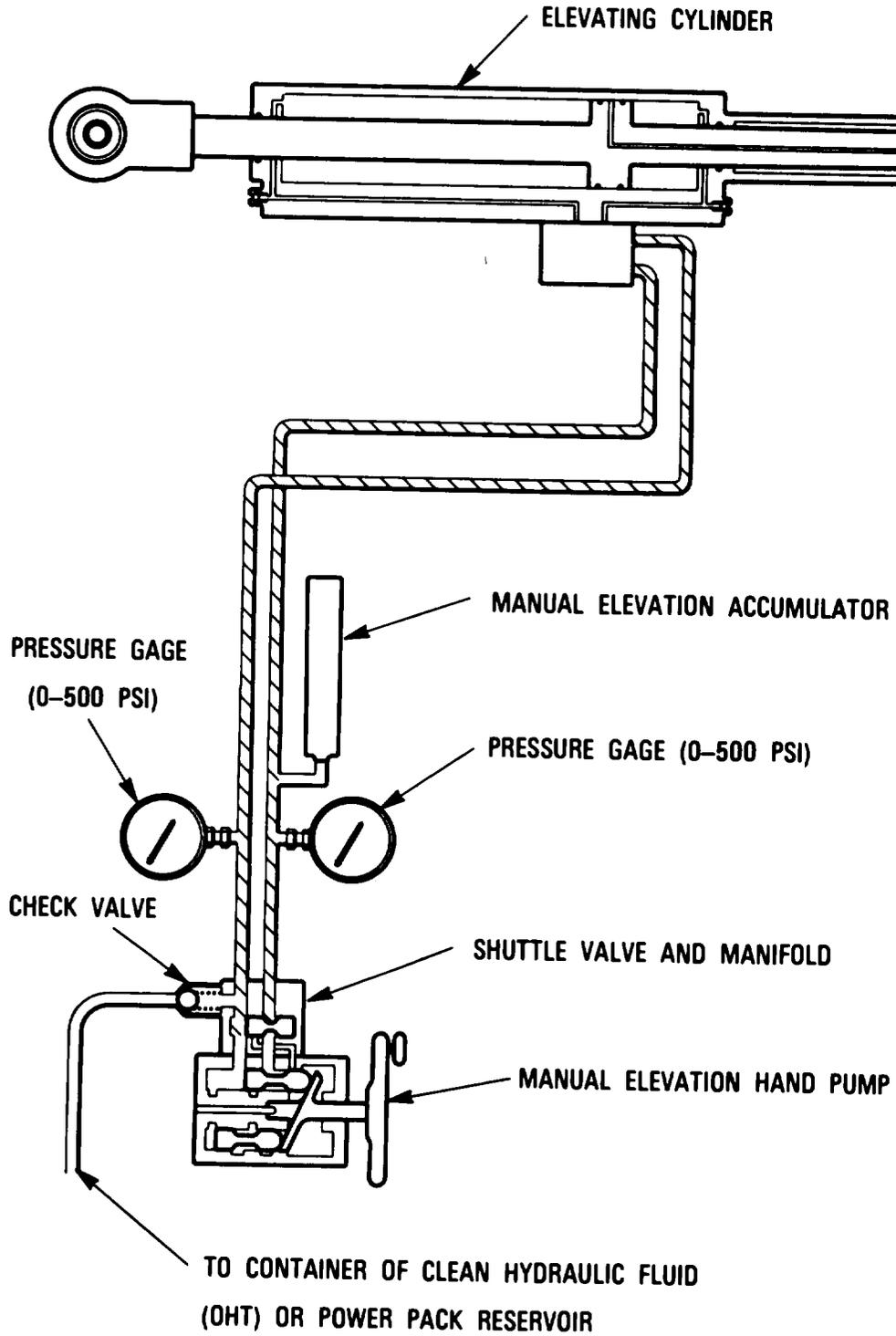


Figure 10-1. Manual Elevating Hand Pump (M109 Only)

ARMAMENT AND FIRE CONTROL SYSTEM

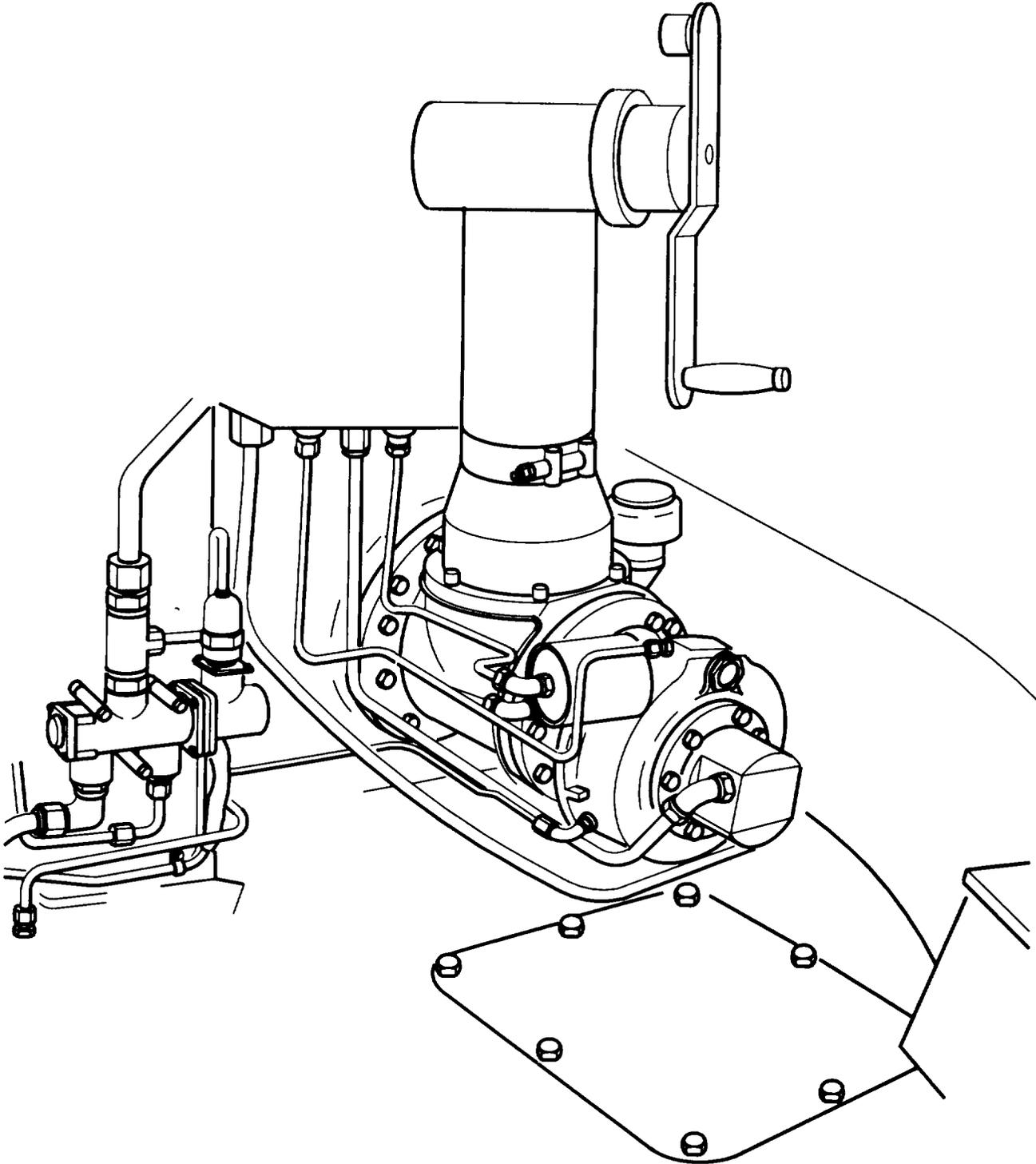


Figure 10-1.1. Manual Elevating Hand Pump (M 110 series only)

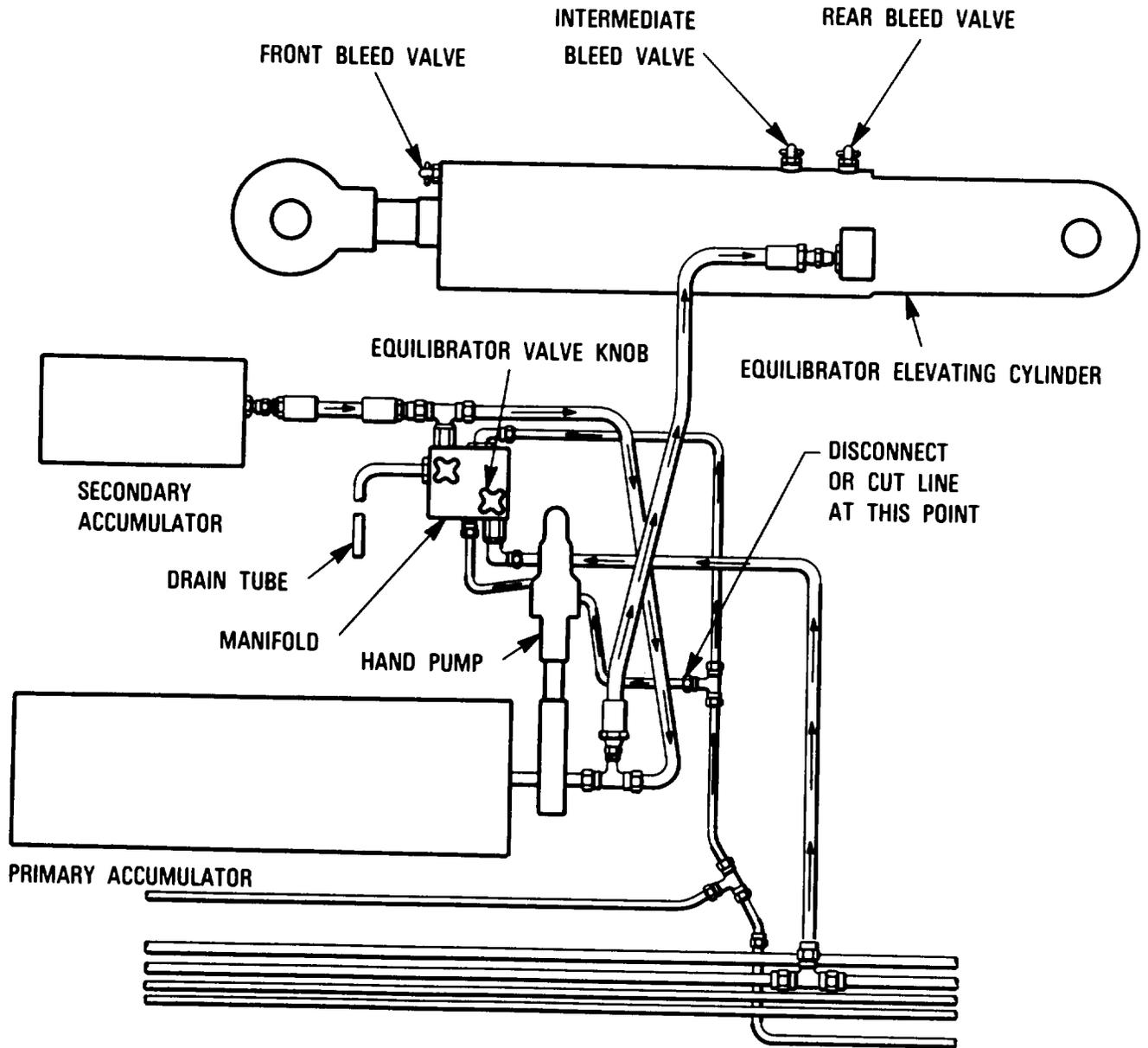


Figure 10-2. Equilibrator Hand Pump (M109 Only)

## ARMAMENT AND FIRE CONTROL SYSTEM

### 10-10. FIRE CONTROL INTERCHANGEABILITY (M109/M110 Families).

#### General Information:

The quickest method of repair for damaged fire control equipment may be to cannibalize replacement from disabled vehicles. There are some minor differences in certain fire control components of the vehicles listed below, but they will function. Cannibalize the required fire control component from another vehicle as available. Fire control components of the M109/M110 family of vehicles are interchangeable with those of the following vehicles:

- a. M15 Quadrant: M109, M110.
- b. M1A1/A2 Gunner's Quadrant: M109, M110.
- c. M1A1 Collimator: M109, M110.
- d. M140 Alignment Device: M109, M110.
- e. M113/M115 Pantel: M102, M110.

1. The following fire control components can be cannibalized from disabled vehicles and utilized with minor modified with some decrease in mission capability:

- a. M137 Telescope Mount and M115 Panoramic Telescope can be replaced with an M113 unit. Align and scribe per the Operator's Manual using DAP. (Do complete alignment when time permits.)
- b. M139 Elbow Telescope and M138 Mount. Place M137 and M115 on scribes, check against M140 Alignment Device. Use indirect telescope after above procedures are completed for direct tire.
- c. M113 Panoramic Telescope from the M102 Howitzer can be mounted on the M110 Howitzer by expanding the opening on the telescope mount subassembly, upper.
- d. M15 Quadrant: Use quadrant seat on the M137 Telescope Mount and a gunner's quadrant.

#### Materials/Tools:

- Aiming Stakes
- Aiming Post Light
- Light Bulbs

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

**ARMAMENT AND FIRE CONTROL SYSTEM****10-11. LOSS OF ACCUMULATOR PRESSURE SWITCH (M109 VEHICLES).****General Information:**

The purpose of the pressure switch is to turn on the accumulator pump motor when the pressure falls below 925 PSI or to turn off the pump motor when the pressure reaches 1225 PSI.

**Limitations:**

When the pressure switch is by-passed, the accumulator pump motor will run continuously causing wear on the motor and excessive battery drain. To avoid this, the by-pass should be disconnected when the pressure is within the proper range.

**Personnel/Time Required:**

- 1 soldier
- 1 minute

**Materials/Tools**

- Knife or wire cutters with stripper
- Electrical Tape

**Procedural Steps:**

1. Cut lines 645 and 100 that lead into the pressure switch.
2. Strip 1/4 in. to 1/2 in. from the end of each wire.
3. Twist the wires together.
4. When the pressure is between 925 PSI and 1225 PSI, the wires may be disconnected, mission permitting.
5. Insulate all connections with electrical tape.

**NOTE**

Insure that the stripped end of wire does not touch the hull.  
This will prevent a short circuit.

**10-12. POWER LOSS TO 645 PRESSURE SWITCH LINE.****General Information:**

A loss of power in the 645 line will render the pressure switch/power solenoid inoperative. Power can be returned to these components by jumping from a dome light.

**Limitations:**

**None**

**Personnel/Time required:****Material/Tools:**

- Knife or wire cutters with stripper
- Commo wire
- Electrical tape

## ARMAMENT AND FIRE CONTROL SYSTEM

### 10-12. POWER LOSS TO 645 PRESSURE SWITCH LINE (Cent).

#### Procedural Steps:

1. Strip 1/2 in. to 1/4 in. from both ends of 10 feet of commo wire.
2. Remove domelight body from domelight assembly.
3. Clip "hotwire" to lightbulb and strip 1/4 in. to 1/2 in. from it.
4. Twist ends of hotwire and commo wire together.

#### NOTE

Insure that the stripped end of wire does not touch ground.  
This will prevent a short circuit.

5. Determine if the power solenoid is functioning by engaging the cab power switch and listening for a "click."
6. If the solenoid is functional, cut the 645 line on the "hot" side of the pressure switch and strip 1/4 in. to 1/2 in. of insulation from it.

#### CAUTION

Do not cut 645 line between the pressure switch and power relay box.

7. Twist commo wire and pressure switch wire together.
8. If solenoid is not functional, strip a bare spot in the 625 A line at the power solenoid.
9. Twist the stripped commo wire around the bare spot.
10. Insulate all connections with electrical tape.

### 10-13. PIVOT INTERLOCK SWITCH (M110 series only).

#### General Information:

The purpose of the pivot interlock switch is to prevent the rammer from moving until the arm is in position.

#### Limitations:

Trigger lock must be in position and locked.

#### CAUTION

Do not use the rammer unless the swing-arm is in position.

#### Personnel/Time Required

- 1 soldier
- 2 minutes

#### CAUTION

Do not cut wire 37B (hot wire).

#### NOTE

Utilize existing male and female plug, if possible.

**ARMAMENT AND FIRE CONTROL SYSTEM****10-13. PIVOT INTERLOCK SWITCH (Cont).****Materials/Tools:**

- Knife or wire cutter with stripper
- Electrical tape

**Procedural Steps:**

1. Cut wires 37B and 174 and strip 1/4 in. to 1/2 in. on each piece.
2. Twist stripped ends together.
3. Insulate with electrical tape.

**10-14. RAMMER TRAY INTERLOCK SWITCH.****General Information:**

The purpose of the rammer tray interlock is to prevent the tube from being elevated or depressed while the rammer tray is in use.

**Limitations:**

This procedure may not be used if the pivot interlock switch has been by-passed. The rammer loader may be severely damaged if the gun is elevated or depressed while the rammer tray is in use without an interlock switch.

**Personnel/Time Required:**

- 1 soldier
- 2 minutes

**Materials/Tools:**

- Knife or wire cutter with stripper
- Electrical tape

**Procedural Steps:**

1. Cut wires 1740 and 174A and strip 1/4 in. to 1/2 in. on each piece.
2. Twist stripped ends together.
3. Insulate with electrical tape.

**10-15. TRAVERSING MECHANISM DAMAGE.****General Information:**

In the event the traversing mechanism becomes so damaged that it is impossible to traverse either under power or manually, the gun may be traversed using a vehicle to push the tube if the traverse lock is still.

**Limitations:**

Pushing the tube into position causes reduced accuracy and a reduced rate of fire.

**Personnel/Time Required:**

- 3 soldiers
- 2 minutes

**Materials/Tools:**

- Vehicle

## ARMAMENT AND FIRE CONTROL SYSTEM

### 10-15. TRAVERSING MECHANISM DAMAGE (Cont).

#### Procedural Steps:

##### Option One:

1. Completely remove damaged traversing mechanism from howitzer.
2. Position soldier so that he can see both the gunner and the driver of the second vehicle.
3. Attach the second vehicle to the howitzer muzzle using a rope or a chain.
4. Gunner communicates direction of traverse, either verbally or by hand and arm signals, to the soldier located outside the vehicle.
5. Soldier outside the vehicle communicates direction of traverse, either verbally or by hand and arm signals, to the driver of the second vehicle.
6. Driver carefully traverses tube in the required direction.
7. Gunner signals to the soldier standing outside of the vehicle when the tube is at proper deflection.
8. The soldier then signals the driver to stop.
9. Driver stops and engages travel lock.
10. Soldier removes rope or chain from the tube.
11. Move second vehicle to a safe location.
12. Fire mission.

##### Option Two:

##### Personnel/Time Required:

- 2 soldiers
- 2 minutes

##### Material/Tools:

- Vehicle
- Radio

##### Procedural Steps:

Procedural steps are the same for Option 1 except that the gunner communicates directly with the driver of the second vehicle via the radio.

##### Option Three:

##### Personnel/Time Required:

- 7 soldiers
- 2 minutes

##### Material/Tools:

None

##### Procedural Steps:

Same as Option 1, except 5 soldiers pull the tube into position instead of using a second vehicle.

**ARMAMENT AND FIRE CONTROL SYSTEM****10-15. TRAVERSING MECHANISM DAMAGE (Cent).****Option Four:****Personnel/Time Required:**

- soldiers
- minutes

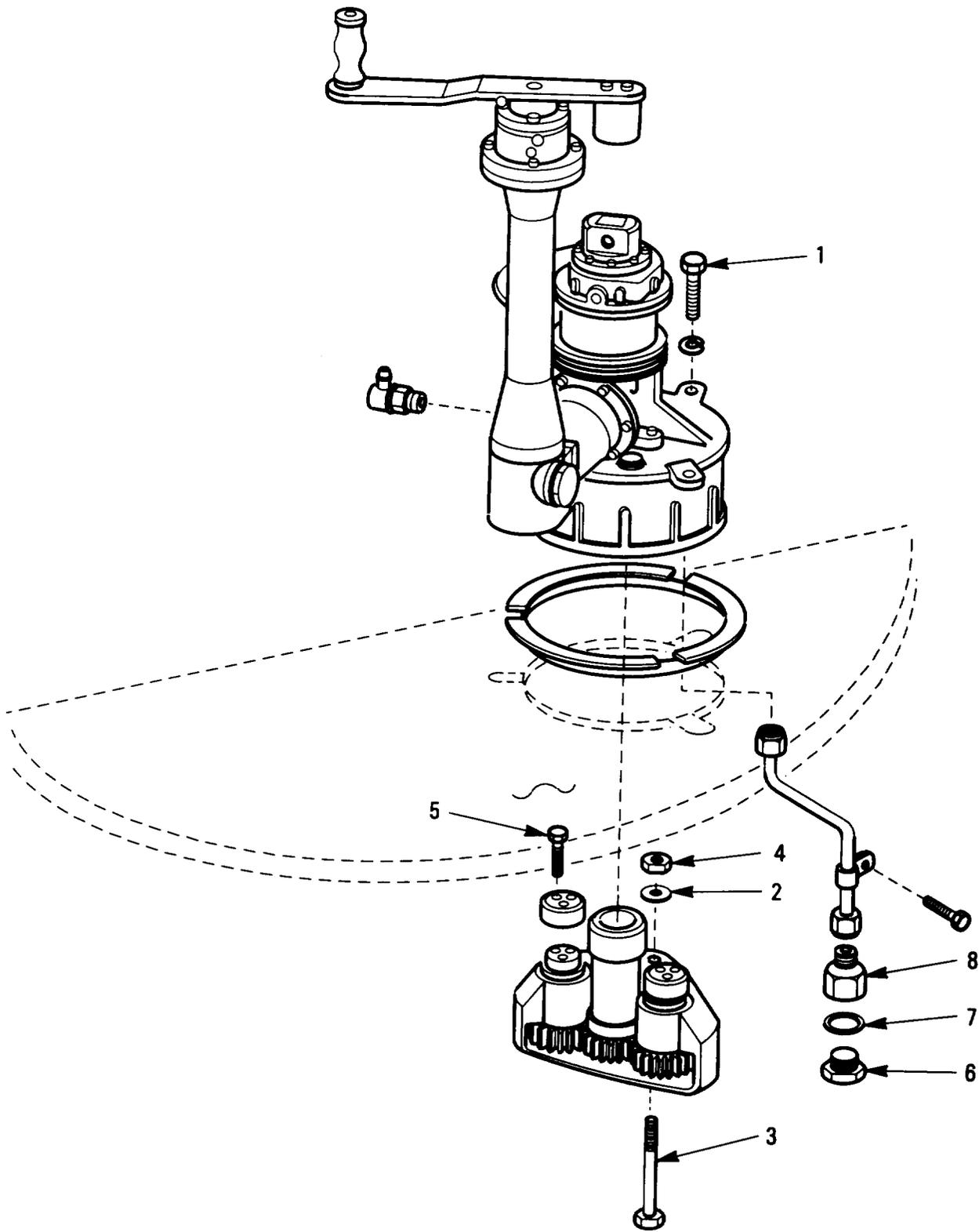
**Material/Tools:**

- Rope, common wire or other suitable material
- 

**Procedural Steps:**

1. Remove three screws (1) at the base of traversing differential assembly.
2. Two men are required to lift-up traversing assembly from deck of vehicle.
3. Remove one screw (2), washer (3) and nut (4) from traversing final drive housing.
4. Remove six screws (5) from final drive retainer plates and drop down traversing final drive in cannon weld.

ARMAMENT AND FIRE CONTROL SYSTEM



**CHAPTER 11**  
**COMMUNICATION SYSTEMS**

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

**SECTION I. General**

**11-1. scope.**

This chapter contains the fault assessment and expedient repair procedures needed to locate and fix battlefield damage to the vehicle's communications system.

**11-2. General.**

The procedures in this chapter are used to repair battlefield damage to the AN/VIC-1 intercommunications set, and all associated wiring and cables.

**11-3 Functional Details.**

The AN/VIC-1 intercom set consists of the AM-1780 amplifier, four C-10456 or C-2298 control boxes, four CVC helmets and all associated wiring and cables. The AN/VIC-1 allows voice intercom to take place between the vehicle commander and all crew members.

## SECTION II. General Operating Procedures

### 11-4. General.

This section contains general operating procedures for the AN/VIC-1 intercommunications set. TM 11-5830-340-12 lists operating procedures for the system, but for convenience, the main points have been reproduced here.

a. Normal Intercom Operation with the AN/VIC-1 Intercommunications Set without radios.

1. Turn turret power on. Turn MAIN PWR switch on the AM-1780 to INT ONLY. Power is now available for intercom equipment. See figure 11-1.
2. Turn POWER CKT BKR switch on the AM-1780 to ON. This supplies power to AM-1780 and all control boxes connected to the AM-1780.
3. Turn INSTALLATION SWITCH on the AM-1780 to OTHER.
4. Intercom only operation is now possible using the control boxes and the audio accessories connected to them.
5. To turn off the AM-1780, place the MAIN PWR and POWER CKT BKR switches to OFF.

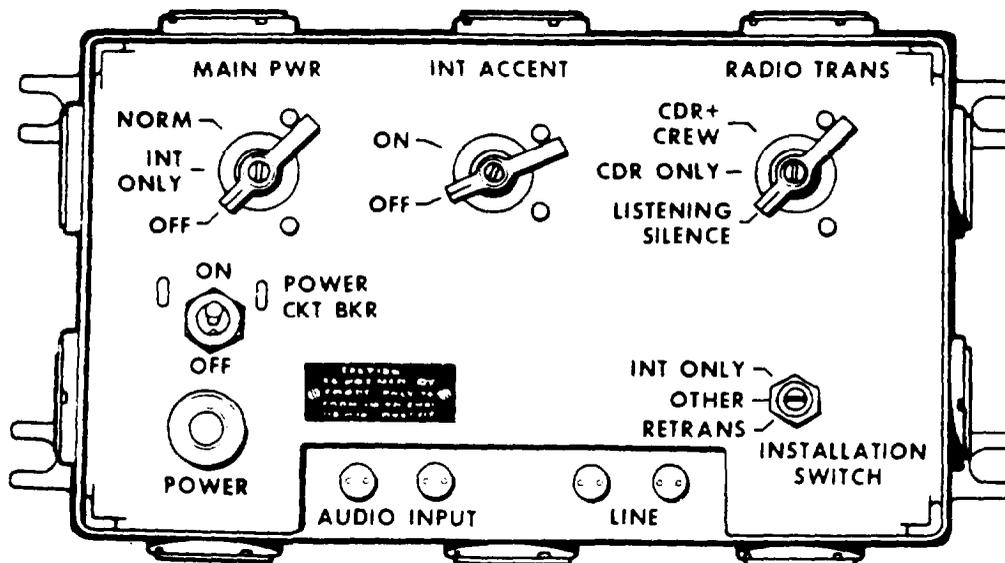
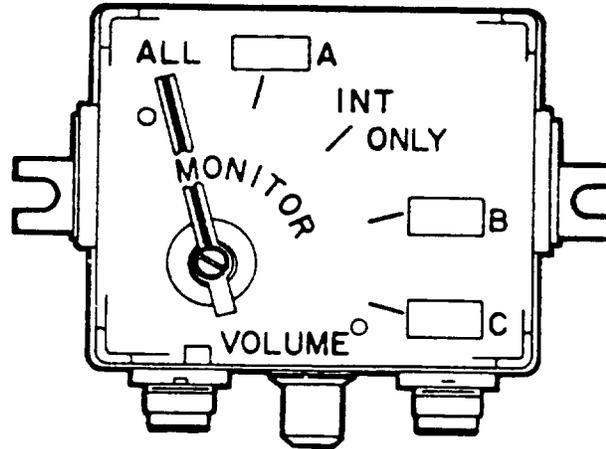


Figure 11-1. AM-1780 Amplifier

b. Normal Intercom Operation with Crew Members Control Box. See figure 11-2.



**Figure 11-2. Crew Members Control Box**

1. Place the MONITOR switch in the desired position.
  - (a) ALL - Receives all radio and intercom transmission. Transmit on primary radio and intercom.
  - (b) A - Receives primary radio and intercom transmission. Transmit on primary radio and intercom.
  - (c) INT ONLY - Receives and transmits on intercom only. There are no radio capabilities.
  - (d) B - Receives secondary radio (if equipped) and intercom transmission. Transmits on primary radio and on intercom.
  - (e) C - Receives third radio (if equipped). Transmits on third radio (if equipped). With this switch position, the only crew member with intercom capability is the crew commander.
2. Adjust the VOLUME control to a comfortable listening level.

**SECTION III. Fault Assessment and Procedures**

**11-5. Fault Assessment Table and Procedures.**

a. Be sure to read chapter 2 before starting troubleshooting. The appearance of an assembly or component may indicate its general condition and reflect the type of damage it has suffered. Examine for dented surfaces or holes, torn insulation, severed cables, or other evidence of damage. This might indicate the source of trouble and the need for repairs. Also check component boxes for unusual odors. After obvious damage has been repaired, attempt to operate the communications system to check for damage that might not be so obvious. The detailed assessment procedure leads to an expedient repair procedure, if one exists, for the particular battlefield damage or to another chapter in this manual.

b. Check the intercommunications set for damage.

**Inspection reveals** → **Damage found to:**

↓  
**No damage found**

- AM 1780 Inoperative.....go to para 11-10
- C-2298 or C-10456 Inoperative, . . . . . go to para 11-13
- Cables Damaged . . . . . go to para 11-12

**Table 11-1. DELETED.**



**11-6. OBSERVABLE SYMPTOM: THE INTERCOM DOES NOT WORK ON ANY CONTROL BOX**

**Detailed Assessment Steps:**

- 1. Check that the DC power is available to the turret by checking the dome light or other electrical equipment in the turret.
- 2. Check that the MX-7777 or MX-7778 Transient Voltage Suppressors operational by depressing the Battle-Override switch. If the suppressor is bad, replace or repair as necessary.
3. Check that communication equipment is turned on and the switches are in the proper positions. (Refer to para. 11-4.)
4. Check that cables are connected to the proper connectors, correctly aligned, and tightly connected to the receptacles.
5. Jiggle the cables to check for intermittent opens or shorts.
  - a. If a defective cable is found, follow the procedures listed below:
    - (1) Replace the defective cable in accordance with standard repair procedures.
    - (2) Replace the defective cable with an acceptable replacement cable (refer to para. 11-16).
    - (3) Repair the defective cable in accordance with the repair procedures in para. 11-12, or the electrical chapter of TM 9-2350-276-BD.
  - b. If a defective cable is not found, then follow the troubleshooting procedures in TM 11-5820-401-12.

**11-7. OBSERVABLE SYMPTOM: THE INTERCOM WORKS ON SOME CONTROL BOXES BUT NOT ALL**

**Detailed Assessment Steps**

1. Repeat steps 3 thru 5 in para. 11-6.
2. Replace CVC helmet and connecting cable with a known operational CVC helmet and connecting cable.
  - a. If the problem no longer exists, no further action is necessary.
  - b. If the problem has not been corrected, go to step 3.

**Detailed Assessment Steps (Cont):**

3. Disconnect CX-4723 cable leading to the non-operational control box at the AM-1780, and switch it with another CX-4723 cable at the AM-1780 receptacles.
  - a. If the same problem occurs in the control box now connected to that receptacle, repair or replace the AM-1780.
  - b. If the problem stays with the same control box, go to step 4.
4. Switch the CX-4723 cables back to their original positions on the AM-1780, and replace the non-operational control box with a-known operational control box.
  - a. If the problem no longer exists, replace or repair the control box.
  - b. If the problem still exists, replace or repair the CX-4723 cable between the control box and the AM-1780. (Refer to para. 11-12 or 11-13.)
5. If the cable and/or the control box cannot be repaired or replaced, install the field expedient intercom described in para. 11-10 or 11-11.

**SECTION IV. Expedient Repair Procedures**

**11-8. GENERAL:**

This section contains expedient repair procedures to restore inter-communications needed to complete the mission.

**11-9. PROCEDURAL INDEX.**

The index below is provided as a quick reference to locate specific problems or repair procedures. In the event that the specific repair does not appear to be contained in this section, refer to the electrical chapter in TM 9-2350-276-BD.

Intercommunication System Field Expedient.....	go to para 11-10
Replace AN/VIC-1 Intercom with Soviet R-124 Intercom . . . . .	go to para 11-11
Intercommunication Cable Repair . . . . .	go to para 11-12
Cables Are Too Short; BDAR Installation.....	go to para 11-13
Isolation of Non-Essential Systems (General).. . . . .	go to para 11-14
Isolation of Voltage Suppressors . . . . .	go to para 11-15

## **11-10. INTERCOMMUNICATIONS SYSTEM FIELD EXPEDIENT**

### **General Information:**

This procedure gives instructions for constructing field expedient intercoms.

### **Limitations:**

- None

### **Personal/Time Required:**

- 1 soldier
- 10 minutes

### **Materials Tools:**

- One TA-312/PT or TA-1/PT field telephone for each station where requirement for intercom exists.
- Cable, telephone, WD-1/TT, 10 to 15-foot length.

### **Other Option(s):**

- Replace with Soviet R-124 intercom. (Refer to paragraph 11-11.)

### **CAUTION**

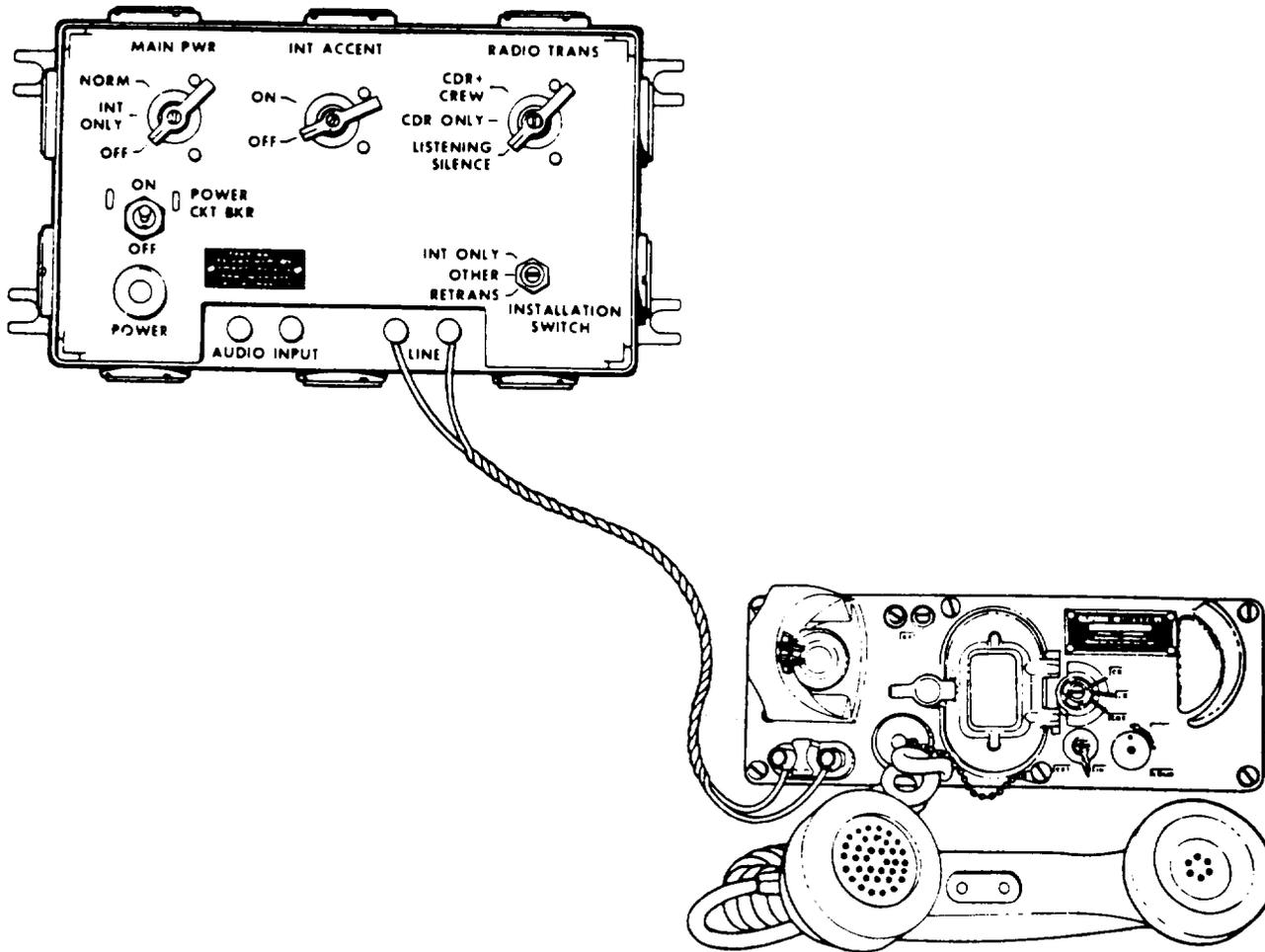
Do not crank or ring the field telephone because damage could occur to the AM-1780 and/or the entire AN/VIC-1 system.

### **Procedural Steps:**

1. If one or more of the control boxes becomes inoperable but the AM-1780 is still operational, install TA-312 or TA-1 field telephones at the station(s) where the bad control boxes are located and run field telephone wire back to the AM-1780. The WD-1/TT should be hooked up on the "line" jacks of the AM-1780.
2. If the AM-1780 is not operational, replace the entire intercom system with TA-312 or TA-1 telephones and field telephone wire. Run the wire in a circle throughout the vehicle so that all telephones are connected to the same wire.

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COMMUNICATIONS SYSTEM

Procedural Steps (Cont):



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

## 11-11. REPLACE AN/VIC-1 INTERCOM WITH SOVIET R-124 INTERCOM

### General Information

This procedure gives installation and operating instructions for the Soviet R-124 intercom.

### Limitations:

- Turret cannot be rotated with drivers box secured.

### Personnel/Time Required:

- 1 soldier
- 1 hour

### Materials/Tools:

- Handset, H-189/GR, or standard CVC helmet (each chest plate)
- Plate, chest, Soviet (one for each control box)
- Tape, electrical
- Wire, 4-conductor, ill-gauge, 5-foot length or cable, telephone, WD-1/TT, 5-foot length (two required)
- 12 Gauge wire, 3-foot (two required)
- Gun, soldering
- Solder, rosin-core

### Other Option(s):

- Field expedient intercom (refer to para. 11-10.)

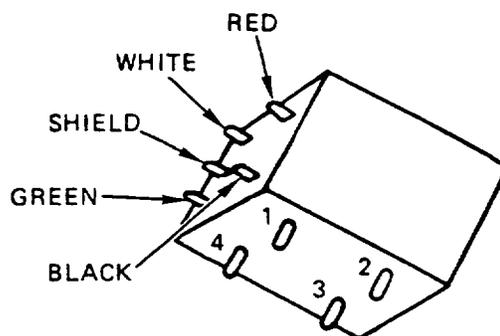
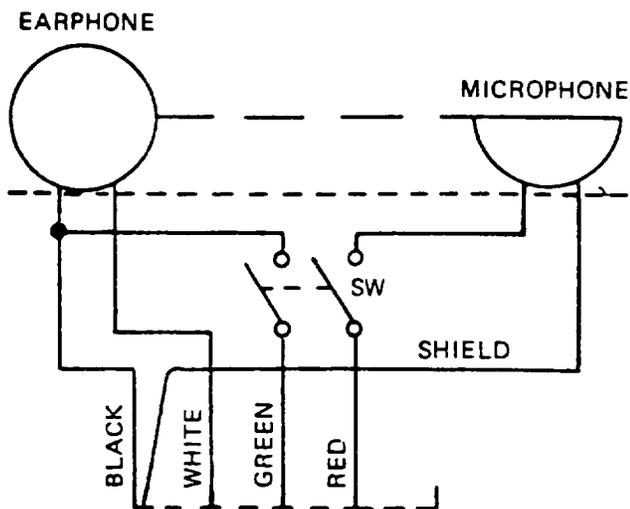
### Procedural Steps:

#### NOTE

All wires in the R-124 interconnecting cables are soldered directly to the internal connecting points in the individual boxes. Use care in removal/installation. Do not disconnect individual boxes unless absolutely necessary.

1. Remove the R-124 from Soviet vehicle and install in U.S. vehicle.
2. Locate the power cable that runs from the turret wall. Remove the cable from the connection. Without removing the connector from the cable, strip back and remove approximately four inches of the outer insulation. Stagger the splices, and scrape approximately 1/4 to 1/2-inch of the inner insulation off each of the four wires in the cable.
3. Using two 12 gauge wires attach the red and white wires from the power cable to the black terminal on the bottom of the A-1 box of the R-124. Attach the blue and green wires from the power cable to the ground strap on the A-1 box. See position 6 in the intercom figure.

Procedural Steps (Cont):



NOTE:  
BOTTOM AND END VIEW OF SWITCH

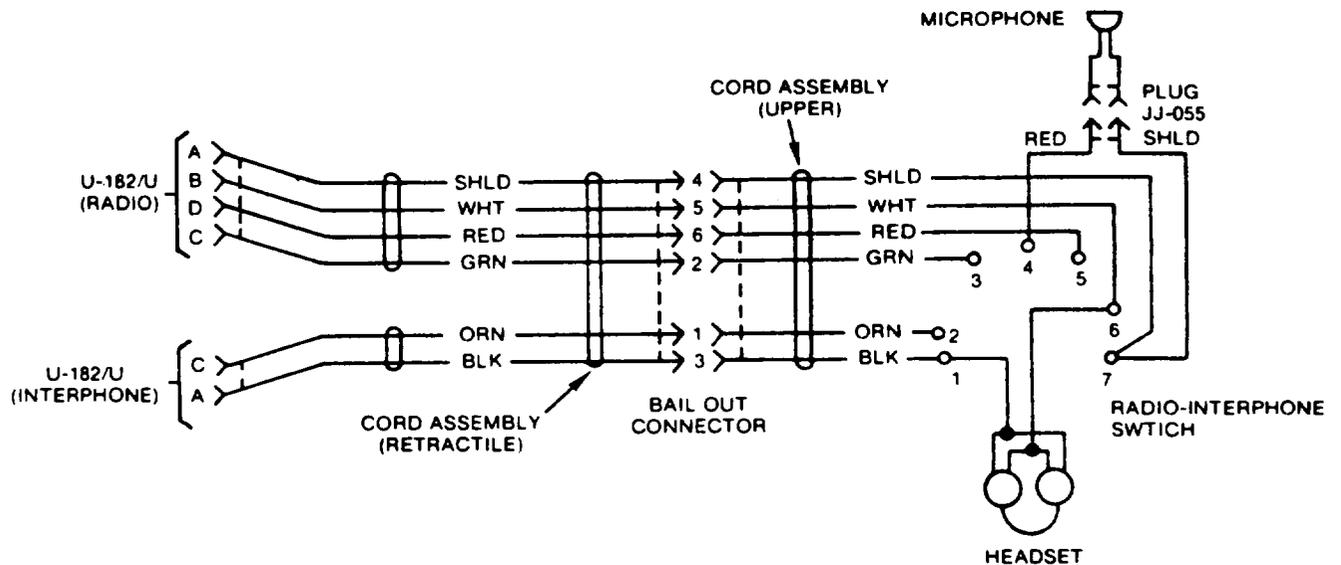
4. H-189 Handset:

- a. Insert and connect the four wires through the handset to the black, white, green, and red wire connections on the switch.
- b. Hook the black wire to one of the inside jacks on the Soviet chest plate and the white wire to the other inside jack. (Points A and B.)
- c. Hook the green wire connection to one of the outside jacks and the red wire to the other outside jack (points C and D).

5. CVC Helmet:

- a. Remove plastic earphone cushion and receiver retainer to gain access to the switch assembly.

**Procedural Steps (Cont):**



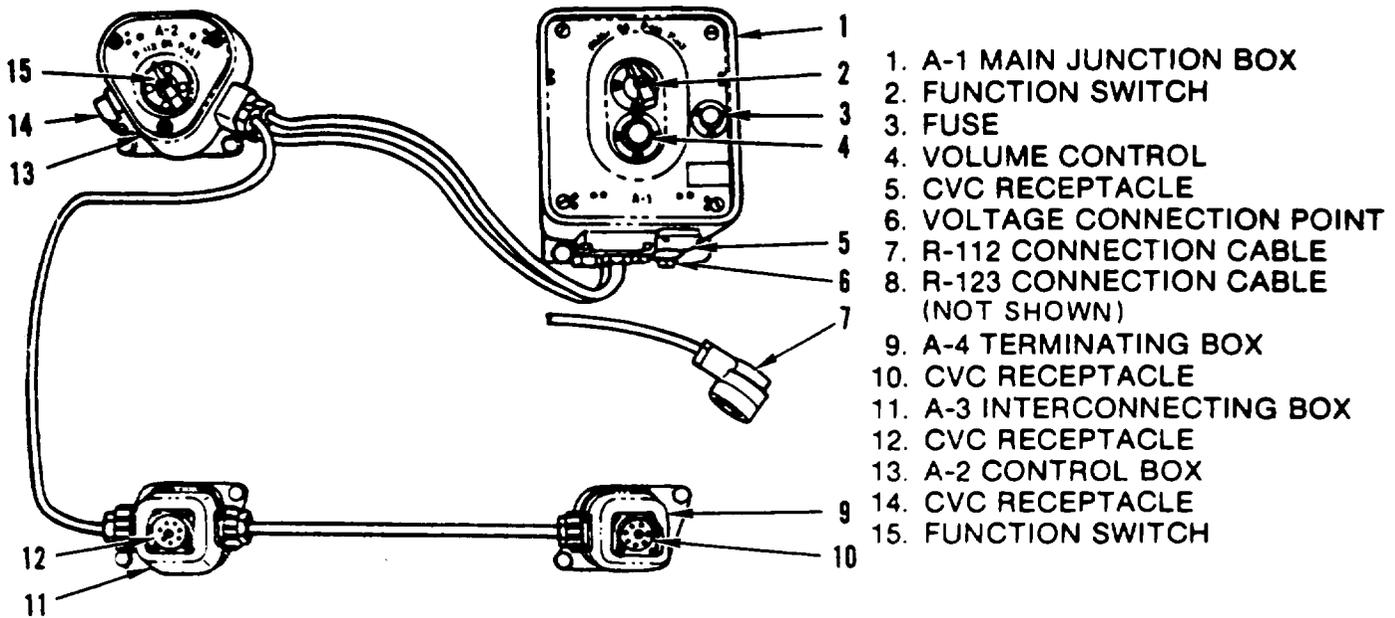
**CVC HELMET**  
*(Headset-Microphone Kit MK-1697-G. wiring diagram.)*

- b. Connect four wires to white (switch position 6), black (1), shield (7), and red (4) wires.
  - c. Hook the white wire to one of the inside jacks on the Soviet chest plate and the black wire to the other inside jack (Points A and B on chestplate figure).
  - d. Hook the shield wire to one of the outside jacks and the red wire to the other outside jack. (points C and D on chest plate figure).
  - e. Reassemble helmet. If you can receive but not transmit, reverse the red wire lead and shield wire lead on the two outside jacks.
6. Operating procedures for the R-124.

**NOTE**

Operating procedures are keyed to the intercom.

**Procedural Steps (Cont):**



- a. Connect the CVC helmet to the chest plate switch. Connect the chest plate switch to any of the R-124 receptacles (5, 10, 12, or 14 in the intercom figure).
  - b. Set FUNCTION SWITCH (2) and FUNCTION SWITCH (15) to the intercom BC position. (Both function switches must be in the BC position to allow all four boxes access to intercom.)
  - c. Adjust VOLUME CONTROL (4) for desired audio level in the headsets.
7. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

## **11-12. 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
- 5-10 minutes per individual wire

### **Materials/Tools:**

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

### **Other Options:**

- See other methods in the electrical chapter of TM 9-2350-276-BD.

### **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 only 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 the mission is complete, as soon as practicable, repair vehicle using standard maintenance procedures.

### **11-13. CABLES ARE TOO SHORT; BDAR INSTALLATION**

#### **General Information:**

This procedure gives methods for connecting two or more cables together 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
- 20 minutes

#### **Materials/Tools:**

- Preferred method:  
Box, control, C-10456 or C-2298 VRC
- Alternate method:  
Gun, soldering  
Solder, rosin-core

#### **Other Option(s):**

- o See other methods in electrical chapter of TM 9-2350-276-BD

#### **Procedural Steps:**

1. The preferred method uses a junction box such as a C-2298 control box between two CX-4723 cables.
2. Another method is fabricating a junction by removing the 3-801 and 3-804 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.
3. A less desirable method is to remove one connector from each cable and splice the corresponding wires from the two cables together. Insulate the splice.
4. Record the BDAR action taken. When the mission is complete, as soon as practicable, repair vehicle using standard maintenance procedures.

## **11-14. ISOLATION OF NON-ESSENTIAL SYSTEMS (GENERAL)**

### **General Information:**

**This** procedure lists general guidelines for the isolation of non-essential systems.

### **Limitations:**

- Varies depending on which system is isolated.

### **Personnel/Time Required:**

- 1 soldier
- 5-30 minutes

### **Materials/Tools:**

- Crimp-on end caps, electrical tape or other insulating material.

### **Procedural Steps:**

1. Insulate/isolate non-essential wiring or cabling with crimp-on end caps, tape, or any other insulating material. Secure wires to some structure and tag them for rapid identification.
2. Any intercom control box can be considered non-essential if one is willing to operate without it. Disconnect the cable leading to that particular control box at AM-1780 and consider using field expedient means for intercom. Also, consider switching control boxes and/or cables within the vehicle to provide intercom at the desired points. For repairs of this type, existing cabling can be rerouted if the original cables have been damaged. ■
3. Record the BDAR action taken. When the mission is complete, **as** soon as practicable, repair vehicle using standard maintenance procedures.

## 11-15. ISOLATION OF VOLTAGE SUPPRESSORS

### General Information

This procedure gives instructions for the isolation and by-passing the MX-7777/MX-7778 Transient Voltage Suppressor.

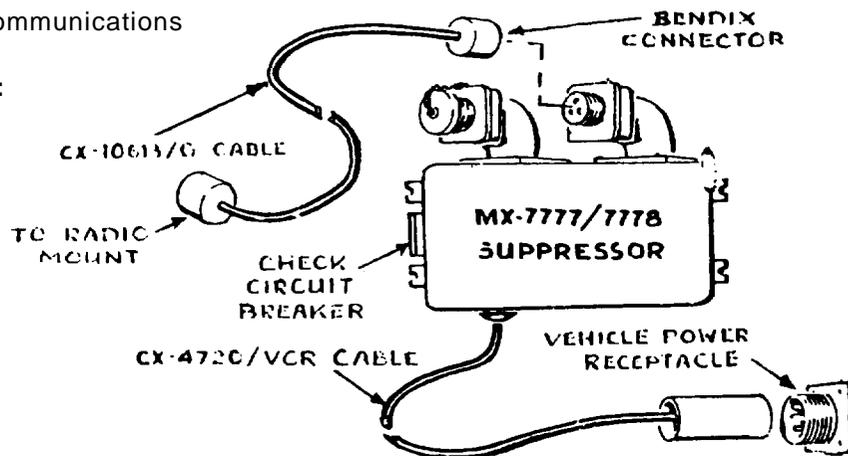
### Limitations:

- Possible loss of all communications

### Personnel/Time Required:

- 1 soldier
- 5-10 minutes

### Procedural Steps:



### CAUTION

Without the transient voltage suppressor in the circuit, voltage spikes will be routed through the communications equipment and damage could occur. Use only as a last resort.

1. Removal of MX-7777/MX-7778 transient voltage suppressor:
  - a. Locate the MX-7777/MX-7778 in the vicinity of the driver's compartment.
  - b. Remove the CX 10613/G cable which runs between the vehicle power receptacle and the rear of the voltage suppressor.
  - c. Remove the Bendix connector which is attached to one of two possible plugs on the top of the suppressor.
  - d. Plug this Bendix connector directly into vehicle power receptacle.
  - e. The suppressor is now out of the circuit.
2. Record the BDAR action taken. When the mission is complete, as soon as practicable, repair vehicle using standard maintenance procedures.

**COMMUNICATIONS SYSTEM****11-16. 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 AN/VIC-1. It is provided as a guide only and is not necessarily a complete listing of all components from other vehicles that could be substituted. Further assistance can be obtained by studying the cording diagrams. This listing 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 time is essential, route replaced cables as necessary and secure them where possible to prevent damage to the cables.

**Equipment Interchangeability Listing**

	<u>Nomenclature</u>	<u>Description</u>	<u>Compatible Component</u>	<u>Compatible Vehicle</u>	<u>Notes</u>
1.	INTERCOM				
	AM- 1780	Amplifier	AM-1780	All w/AN/VIC-1	2
		Outside Member		M60,M551	
	C-2298	Control Box	C-10456	M1,M2,M3	2
		Member			
	C-2298	Control Box	C-2298	All w/AN/VIC/1	2
	C-10456	Control Box	C-10456	M1,M2,M3	2
	C-10456	Control Box	C-2298	All w/AN/VIC-1	1
2.	CABLES				
	CX-4720	2'0"	CX-4720	MAB,M561	2,3
	CX-4720	3'0"	CX-4720	M151,M561	2,3
	CX-4720	4'0"	CX-4720	M113	2,3
	CX-4720	8'0"	CX-4720	M110	2,3

**COMMUNICATIONS SYSTEM****Equipment Interchangeability Listing (Continued)**

<u>Nomenclature</u>	<u>Description</u>	<u>Compatible Component</u>	<u>Compatible Vehicle</u>	<u>Notes</u>
CX-4720	10'0"	CX-4720	AVLB	2,3
CX-4723	2'0"	CX-4723	M551,M561 MAB	2,3
CX-4723	3'0"	CX-4723	M60,M551 M2,M3,MAB	2,3
CX-4723	4'0"	CX-4723	M901,M109	2,3
CX-4723	4'6"	CX-4723	M561	2,3
CX-4723	5'0"	CX-4723	M1,M2,M3,M88 M113,M901,M561 M551,M577,AVLB	2,3
CX-4723	6'0"	CX-4723	AVLB	2,3
■ CX-4723	7'0"	CX-4723	M1,M2 M3,M110A2	2,3
■ CX-4723	8'0"	CX-4723	M2,M88,M110A2 M151,MAB	2,3
CX-4723	9'0"	CX-4723	M60,M88,M113, M577,M578,M901	2,3
CX-4723	10'0"	CX-4723	M60,MAB M88,M578	2,3
CX-4723	12'0"	CX-4723	M3	2,3
CX-4723	13'0"	CX-4723	M88	2,3
CX-4723	14'0"	CX-4723	M551	2,3
CX-4723	15'0"	CX-4723	M2,M109	2,3
CX-4723	16'0"	CX-4723	M60,M901	2,3
■ CX-4723	18'0"	CX-4723	M110A2	2,3

**Equipment Interchangeability listing (Continued)**

<u>Nomenclature</u>	<u>Description</u>	<u>Compatible Component</u>	<u>Compatible Vehicle</u>	<u>Notes</u>
CX-4723	20'0"	CX-4723	M1, M60	2,3
CX-4723	21'0"	CX-4723	M1	2,3
CX-8650	Y Cord	CX-8650	All w/AN/VIC-1	2,4
CX-9640	1'6"	CX-9640	M109	2,3
CX-9640	2'6"	CX-9640	M109	2,3
CX-13089	2'1"	CX-13089	M109	2,3
CX-13089	3'0"	CX-13089	M88	2,3
CX-13089	7'0"	CX-13089	M2, M3	2,3
CX-13089	10'0"	CX-13089	M578	2,3
3. CVC HELMETS				
CVC	MK-1039	DH-132	Most with AN/VIC-1	2,4
DH-132	MK-1697	CVC	Older Vehicles w/AN/VIC-1	2,4
4. TRANSIENT VOLTAGE SUPPRESSORS				
MX-7777, MX-7778	Suppressor	MX-7778 MX-7777	All w/AN/VIC-1	2

NOTE #1 - System is slightly degraded. Replace with original component as soon as possible.

NOTE #2 - No degradation. Continue normal mission.

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NOTE #3 - 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.

NOTE #4 - Watch the connectors for comparability. 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.

**COMMUNICATIONS SYSTEM**

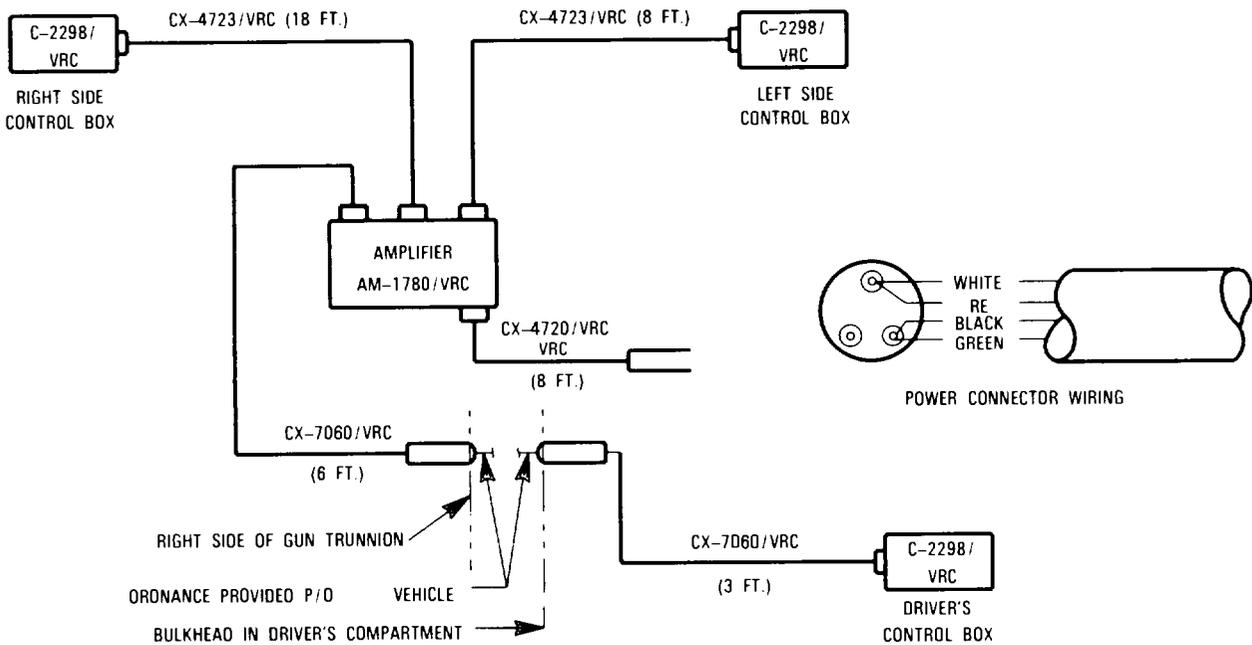
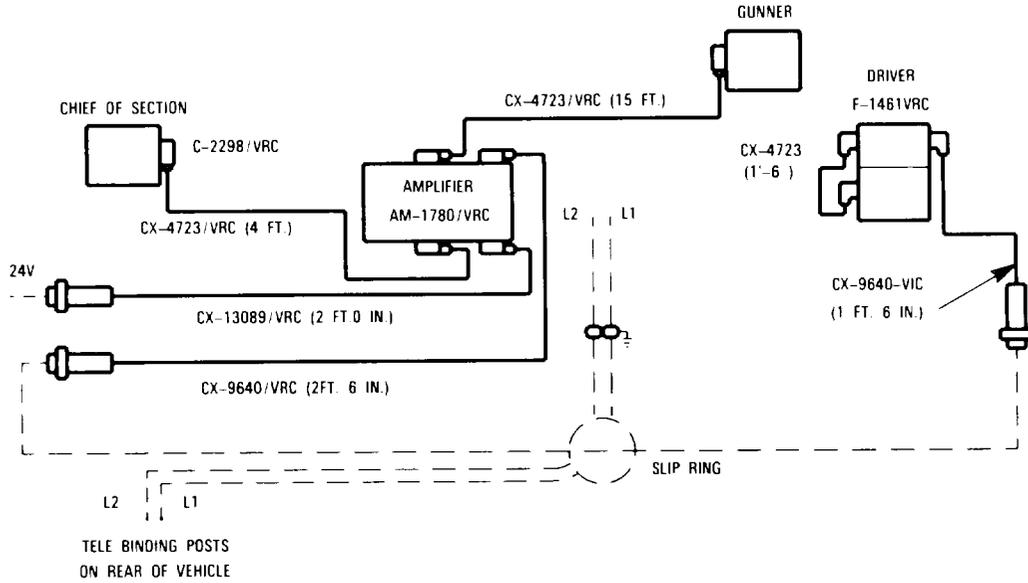
**SECTION V. Common Vehicle Cording Diagrams**

**11-17. General**

Cording diagrams for common U.S. vehicles on the battlefield have been provided in this section to aid in identifying components and cables that are interchangeable. These diagrams also assist in identifying cables without having to trace them throughout the vehicle.

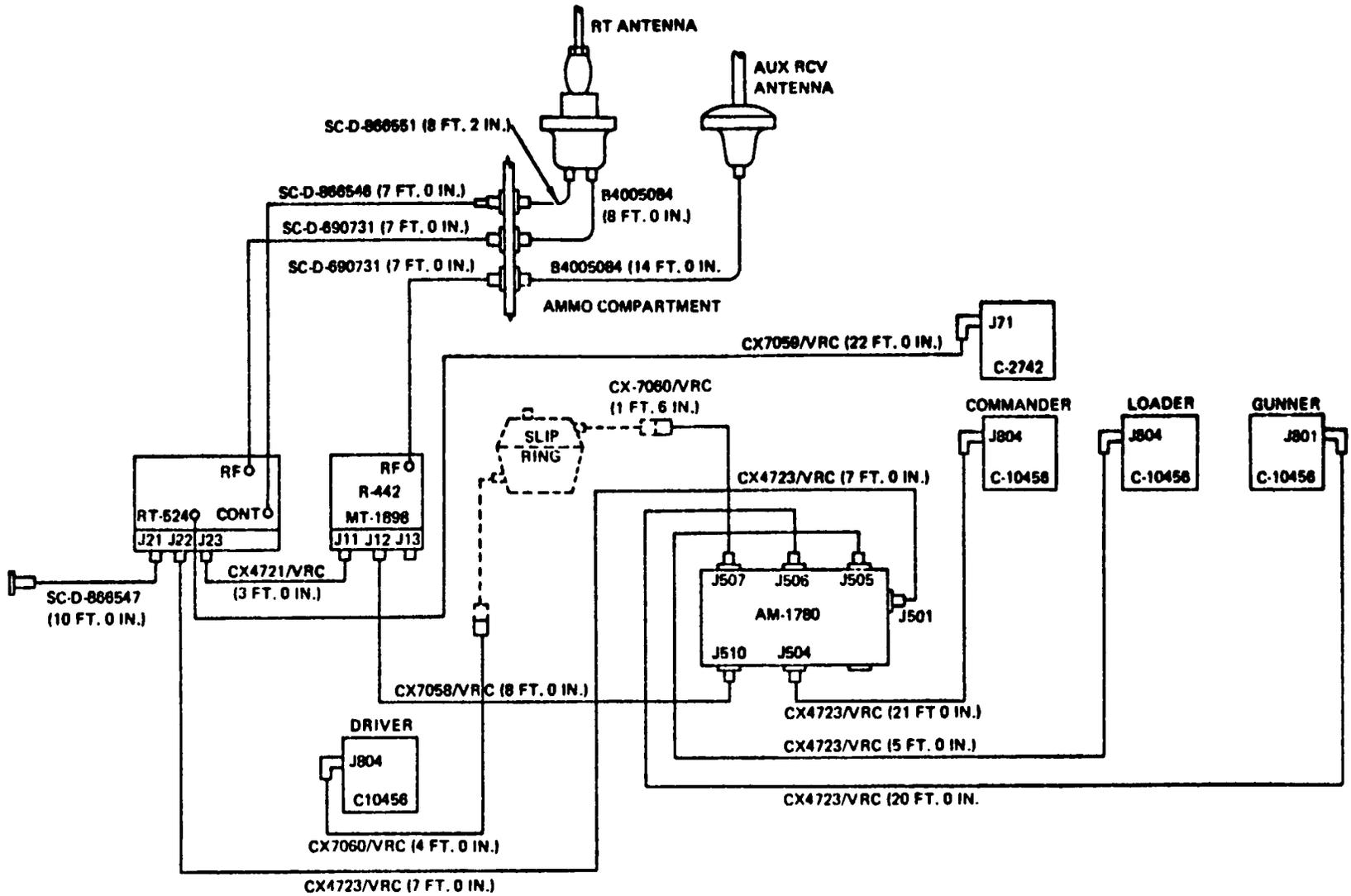
<u>Cording Diagram For:</u>	Page
AN/VIC-1 in M109A2 and M109A3 . . . . .	11-24
AN/VIC-1 in M110A2 . . . . .	11-24
AN/VIC-1 and AN/VRC-12 in M1 Tank . . . . .	11-25
AN/VIC-1 in M2 (chassis) . . . . .	11-26
AN/VIC-1, in M3 (chassis) . . . . .	11-26
AN/VRC-46, AN/VRC-64 or (two) AN/GRC-160's with AN/VIC-1, in M2 and M3 (turret) . . . . .	11-27
AN/VIC-1 and AN/VRC-12 in M60A1 Tank . . . . .	11-28
AN/VRC-46, AN/VRC-64, or AN/GRC-160 with AN/VIC-1 in M88A1 . . . . .	11-29
AN/VRC-46, AN/VRC-53, AN/GRC-125, AN/VRC-64, or AN/GRC-160 and AN/VIC-1 in M578 . . . . .	11-30
AN/VIC-1 in M113 and M577 . . . . .	11-31
AN-GRC-160 and AN/VIC-1 in Improved Two Vehicle M901 . . . . .	11-32
AN/VIC-1 in Mobile Floating Assault Bridge/Ferry . . . . .	11-33
AN/VRC-12 and AN/VIC-1 in AVLB (M60 chassis) . . . . .	11-34
AN/VIC-1 in M561 Commo Vehicle with I/C Equipment in Cab or in Rear . . . . .	11-35

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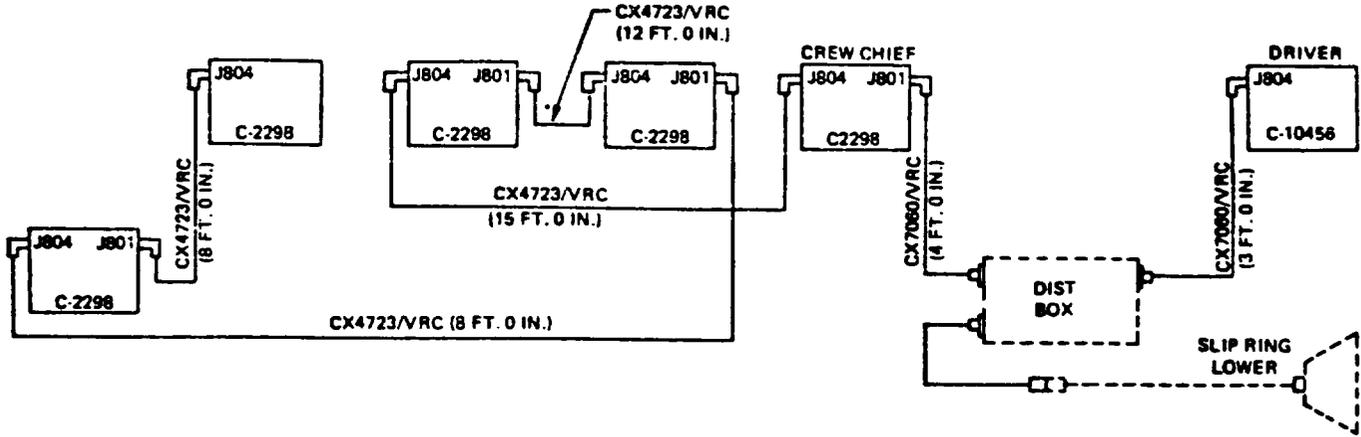
AN/VIC-1 in M110A2

AN/VIC-1 and AN/VRC-12 in M1 Tank

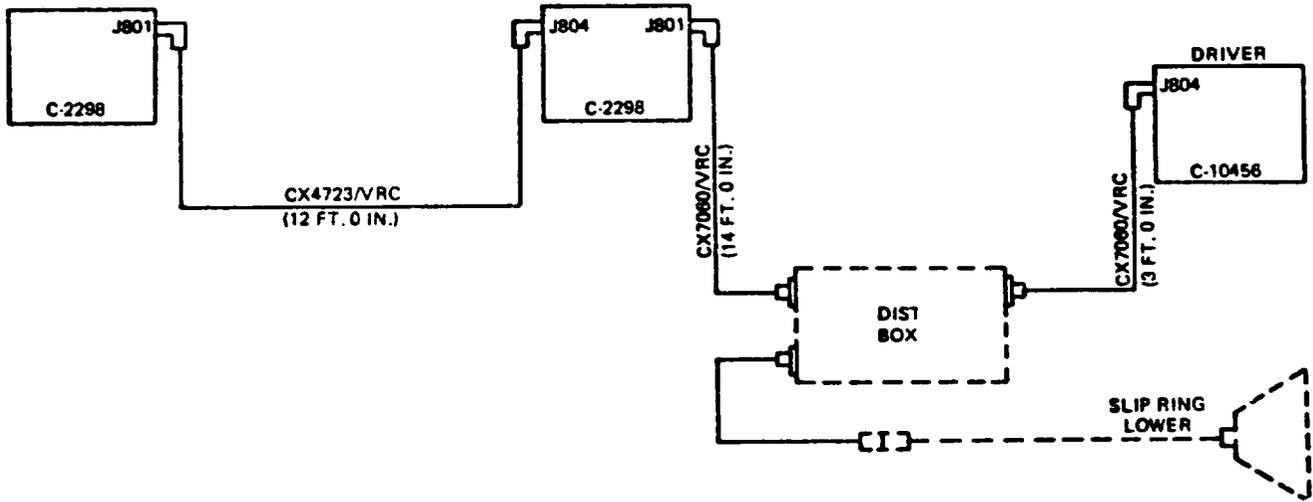


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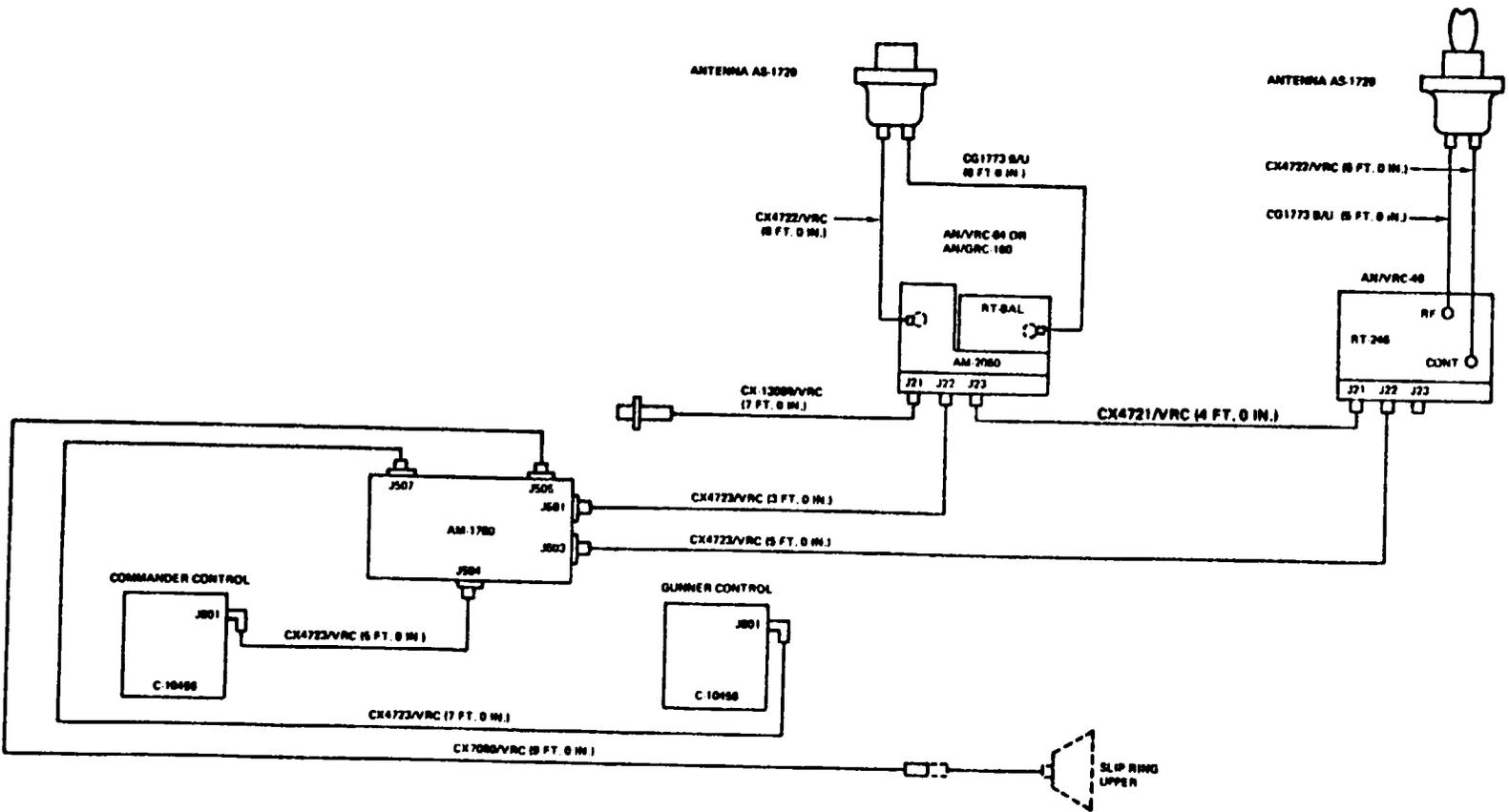
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AN/VIC-1 in M2 (chassis)

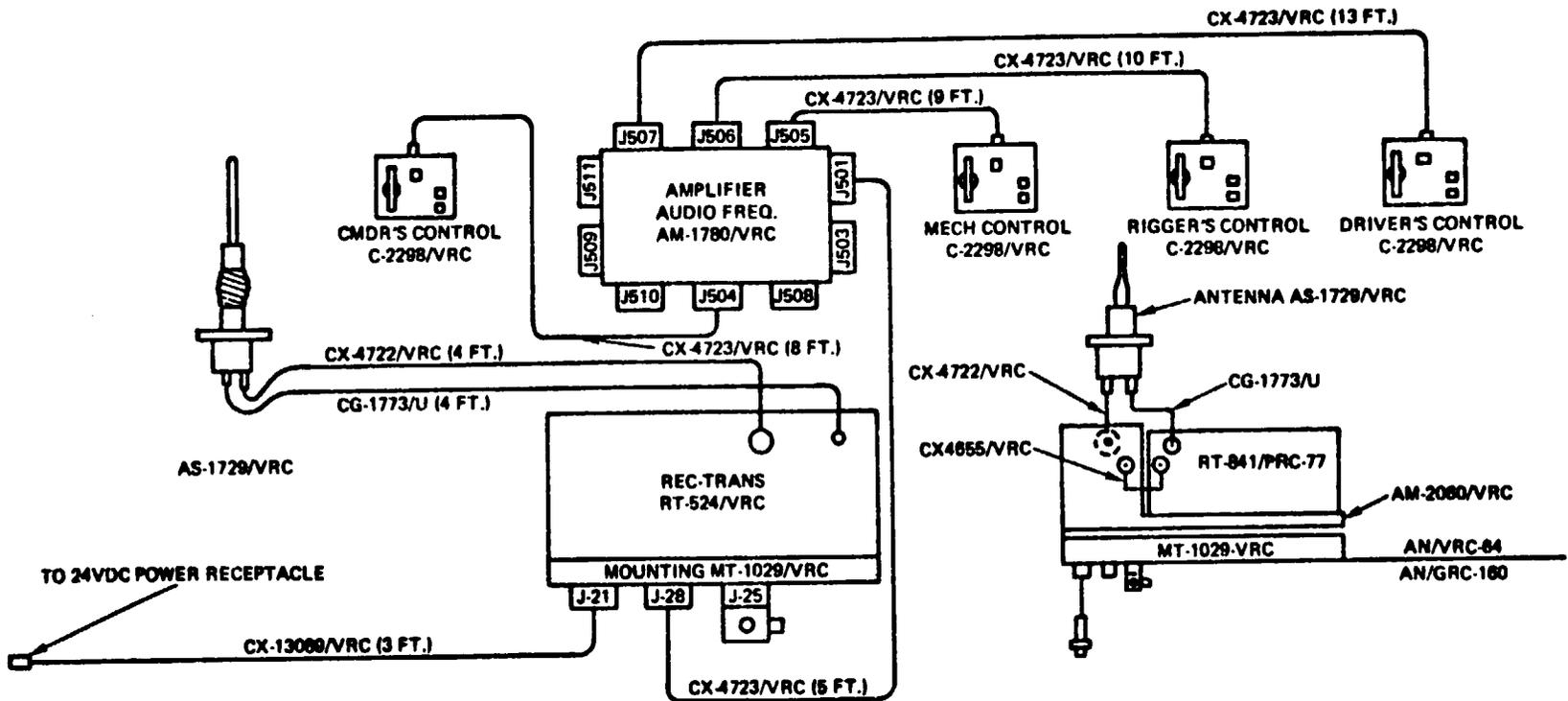


AN/VIC-1 in M3 (chassis)

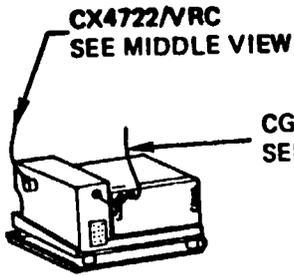


AN/VRC-46, AN/VRC-64, or Two AN/GRC-160's with AN/VIC-1 in M2 and M3  
(Turret)





AN/VRC-46, AN/VRC-53, AN/VRC-64, or AN/VRC-64, or AN/GRC-125, AN/GRC-125, AN/VRC-59, AN/VRC-64 OR AN/GRC-160



CG1773/U  
SEE MIDDLE VIEW

AN/VRC-59  
AN/GRC-125  
AN/VRC-64 OR  
AN/GRC-160

CX4723/VRC (10 FT.)

CX13089/VRC (10 Ft.)  
POWER CABLE

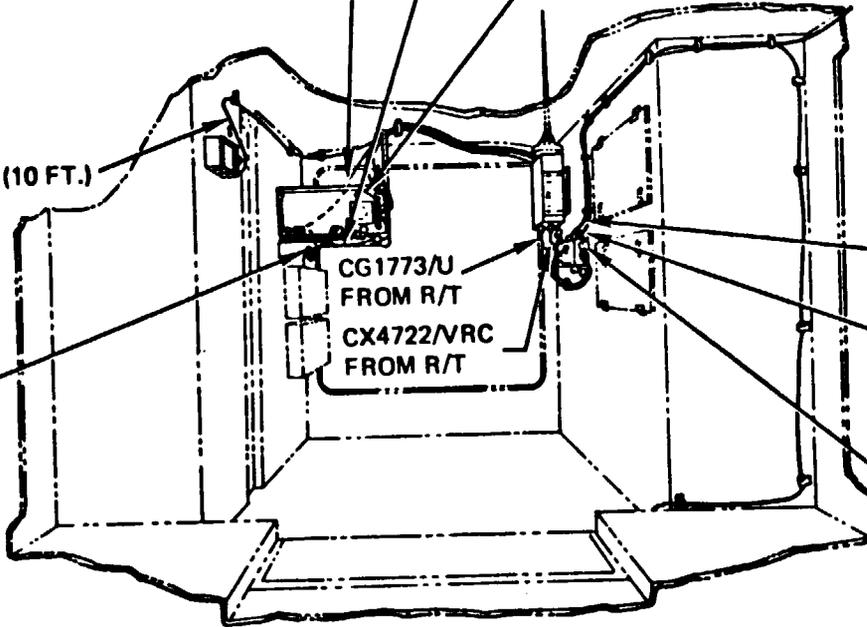
CX4723/VRC  
R/T TO AM-1780/VRC

CX4722/VRC (7 FT.)  
R/T TO RF AMPLIFIER

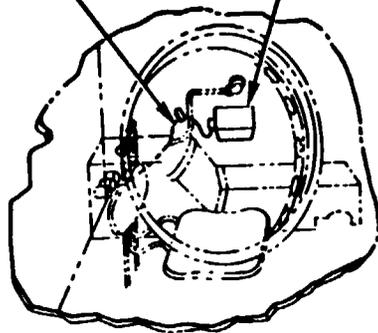
CG1773/U (6 FT.)  
R/T TO RF AMPLIFIER

CX7060/VRC (3 FT.)

C2298/VRC



FRONT  
OF  
VEHICLE

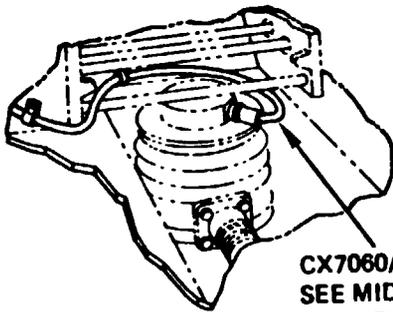


FRONT OF VEHICLE  
DRIVER'S LOCATION IN HULL

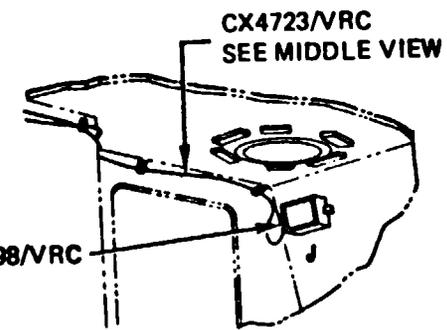
CX7060/VRC (14 FT.)  
FROM SLIP RING

CX4723/VRC (9 FT.)  
FROM CAB RIGGER LOCATION  
C2298/VRC

CX4723/VRC (9 FT.)  
FROM R/T TO AM-1780/VRC



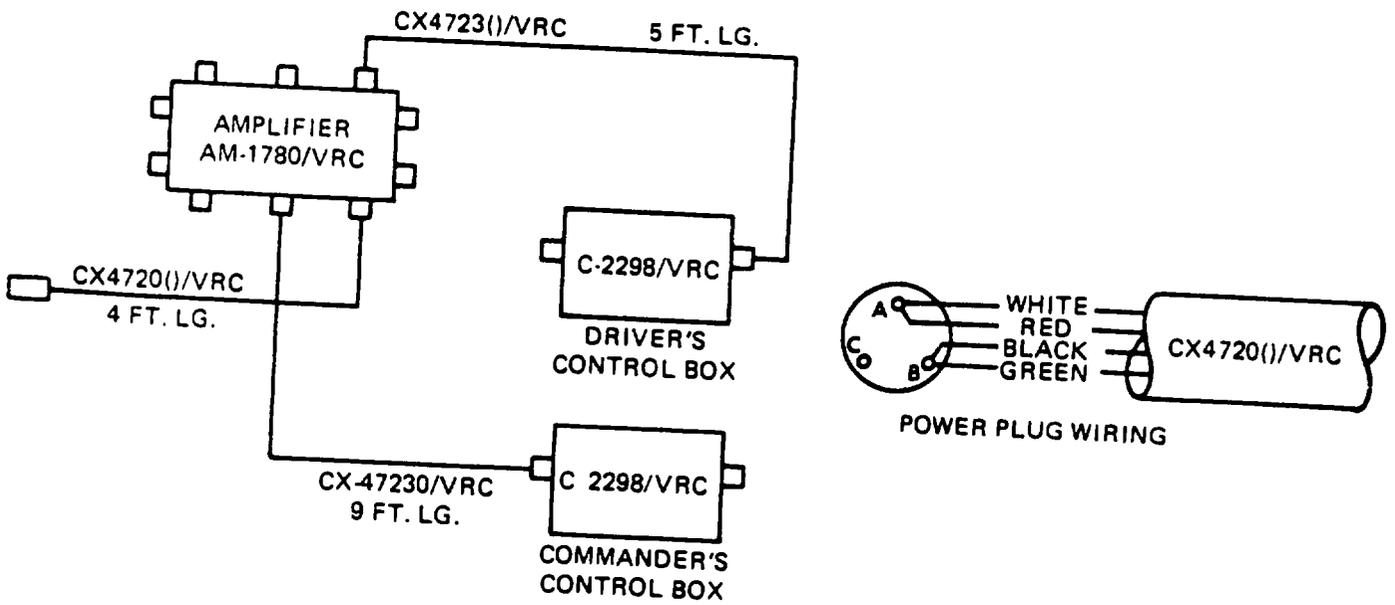
CX7060/VRC  
SEE MIDDLE  
VIEW



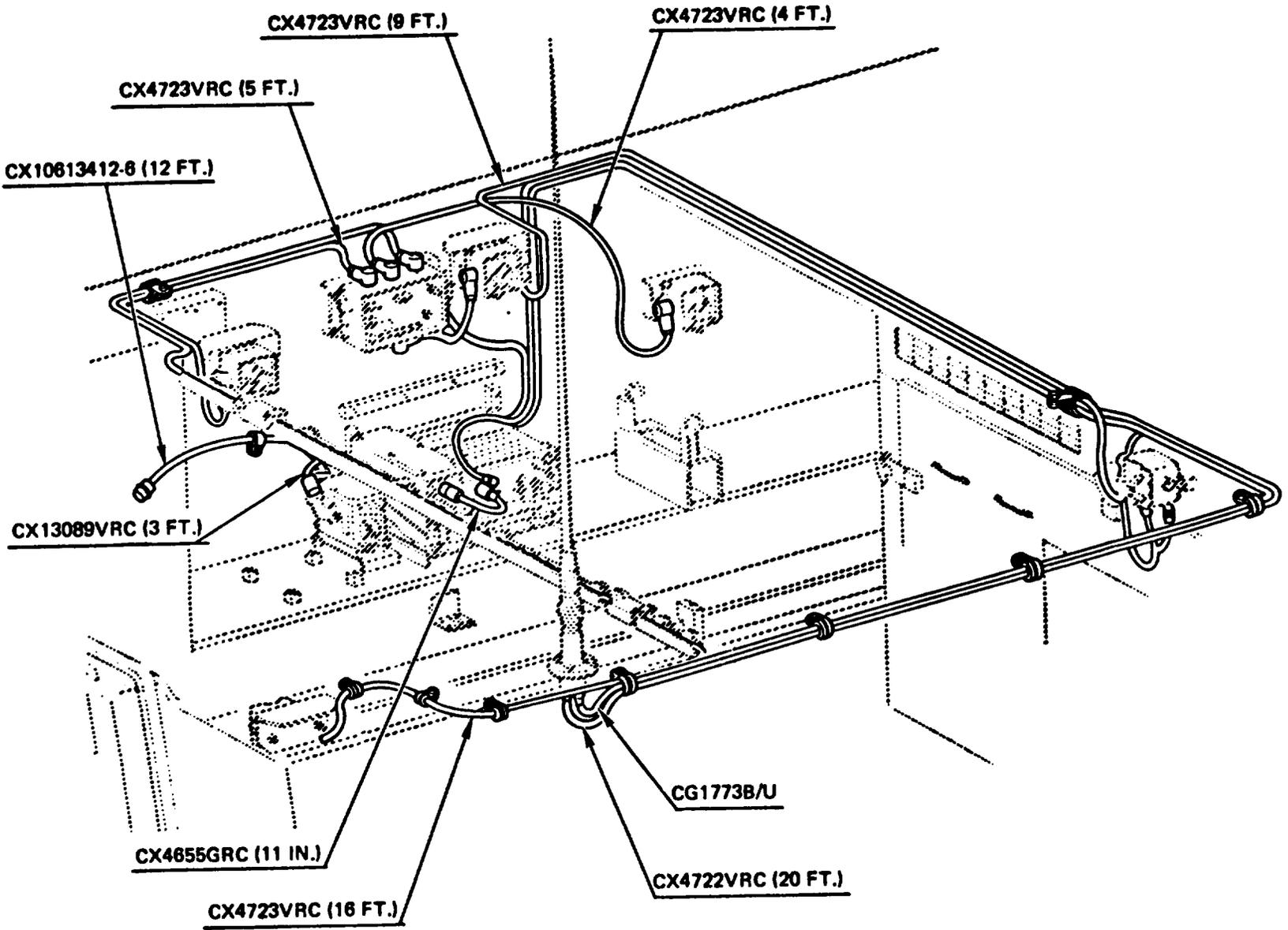
FRONT OF VEHICLE  
RIGGER'S LOCATION IN CAB

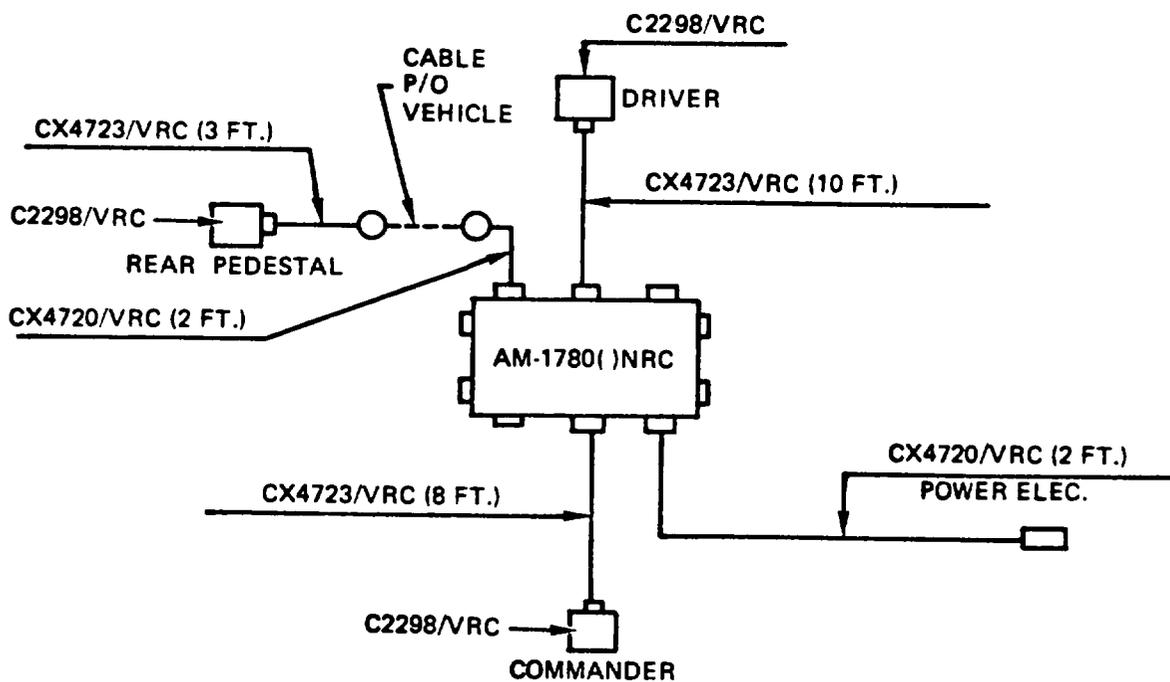
C2298/VRC

CX4723/VRC  
SEE MIDDLE VIEW

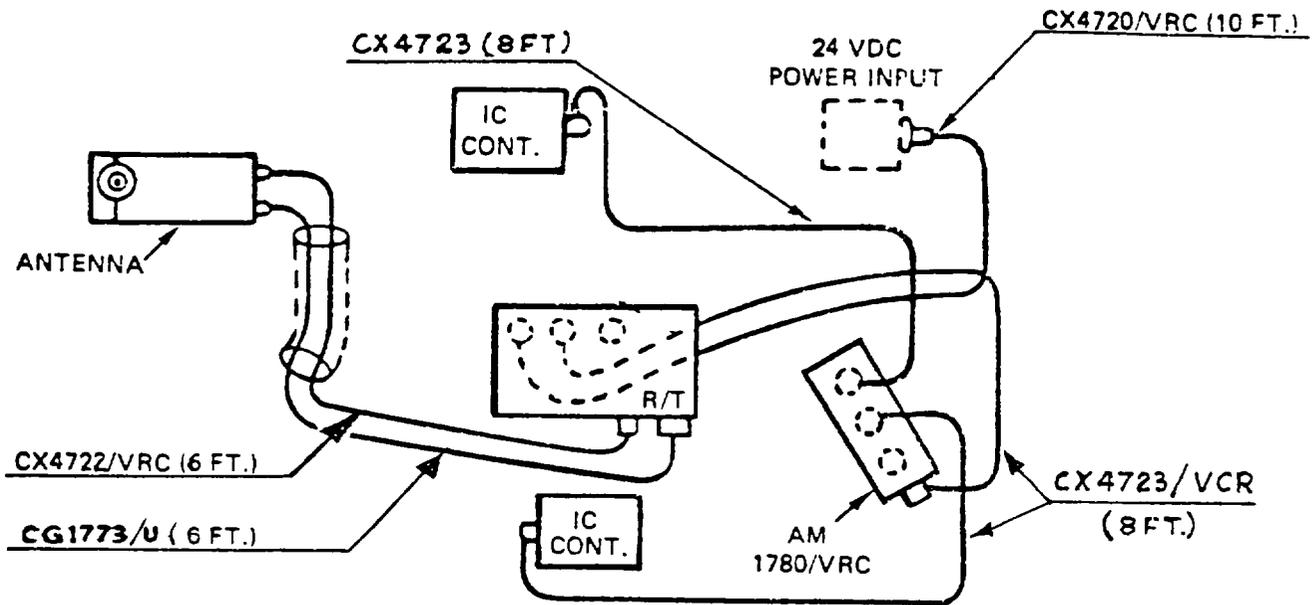


AN/VIC-1 in M113 and M577



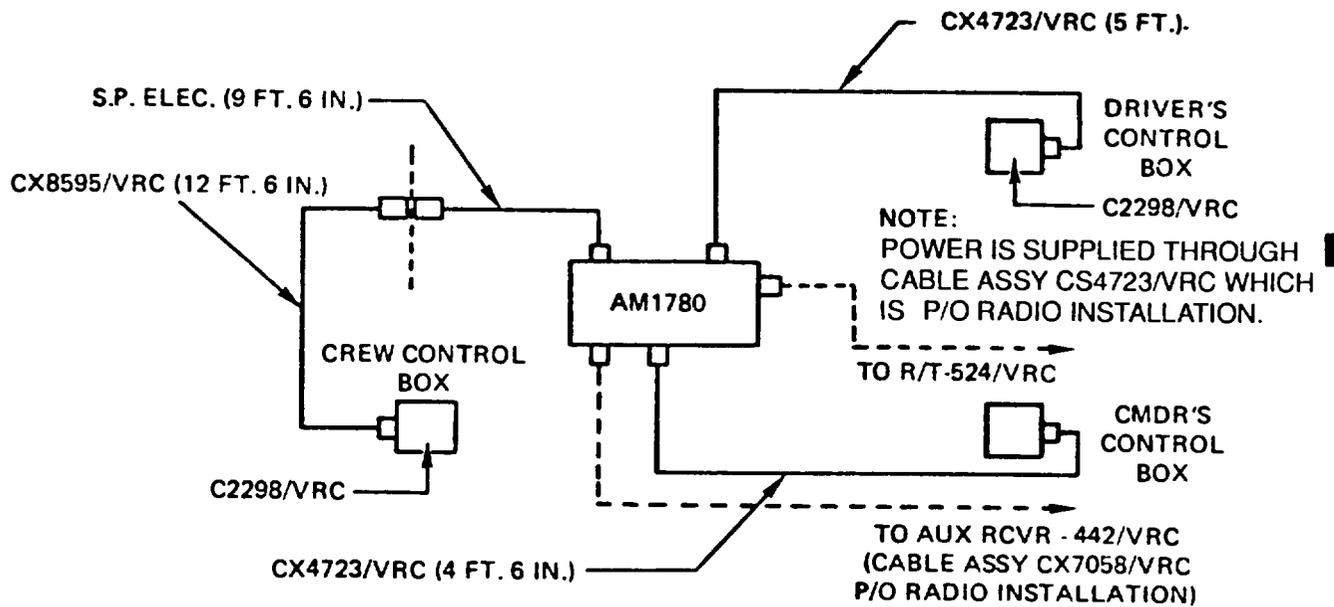


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NOTE: THERE IS A 40 FT. AUDIO EXTENSION CABLE AND RF CABLE BETWEEN THE MX-6707 AND THE R/T.

AN/VRC-12 and AN/VIC-1 in AVLB (M60 Chassis)



AN/VIC-1 in M561 Commo Vehicle, Radio Sets in Cab

**APPENDIX A  
ALTERNATE SOURCES OF SUPPLY**

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

**SECTION I. General.**

**A-1. General.**

This appendix lists alternate sources of supply to include foreign ownership of US combat vehicles and expendable supplies which may be utilized for repairs on this vehicle.

**SECTION II. Foreign Ownership of US Weapons Systems**

**A-2. General.**

Repair parts are expected to be in short supply. Parts may be available from other nations involved in the immediate combat areas. Friendly nations owning US weapons systems may have stocks of repair parts or equipment available for cannibalization. The following tables identify nations owning American combat vehicles.

Table A-1

North American and Europe

	Tank M60/M48 Family	M113 FOV	S.P. How M110 Series	S.P. How M109 Series	S.P. How M108	S.P. Gun M107	Lance	
Austria	X			X				
Belgium		X	X	X	X		X	
United Kingdom			X	X		X	X	■
Canada		X		X				
Denmark		X		X				
Fed Rep Ger	X	X	X	X		X	X	
Greece	X	X	X	X			X	
Italy	X	X		X			X	
Netherlands		X	X	X		X	X	
Norway	X	X		X				
Portugal	X	X		X				
Spain	X	X	X	X	X	X		
Turkey	X	X	X		X			■
Switzerland		X		X				
USA	X	X	M110A2	X			X	

**APPENDIX A**

**Table A-2**

**Asia**

	Tank M60/M48 Family	M113 FOV	S.P. How M110	S.P. How M109	S.P. How M108	S.P. Gun M107	Lance
Japan			X				
New Zealand		X					
Pakistan	X	X		X			
Phillipines		X					
Singapore		X					
South Korea	X	X	X			X	
Taiwan	X	X	X	X	X		
Thailand	X	X					
Viet Nam	X	X	X			X	

**Table A-3**

**Africa and Middle East**

	Tank M60/M48 Family	M113 FOV	S.P. How M110	S.P. How M109	S.P. How M108	S.P. Gun M107	Lance	■
Egypt	X	X						■
Ethopia		X		X				
Iran	X	X	X	X				
Israel	X	X		X		X	X	
Jordan	X	X	X	X				
Kuwait		X		X				■
Lebanon	X	X						
Libya		X		X				
Morocco	X	X		X				
North Yeman	X	X						
Oman	X							
Saudia Arabia	X	X	X	X				■
Sudan	X	X						
Tunisia	X	X						
Zaire		X						

**Table A-4**  
**South America**

	Tank M60/M48 Family	M113 FOV	S.P. How M110	S.P. How M109	S.P. How M108	S.P. Gun M107	Lance
Brazil					X		
Peru				X			

**SECTION III. Expendable Supplies**

**A-3. General.**

This appendix lists items recommended for the support of the M 109 Howitzer in a combat environment. The lists include expendable supplies and materials which may be used to expedite BDAR repairs in a combat situation. The items listed may be required for Battlefield Damage Assessment and Repair at maintenance levels from crew through DS.

The column marked "Level" indicates the maintenance level at which it is recommended these items be stocked or carried. The unit commander may modify the items in the list and the maintenance levels carrying the items, based on current mission requirements and recent operational experience.

The items marked "C" (Crew) are recommended to be carried on the vehicle for use in combat emergencies at the discretion of the unit commander. Those items marked "MT" are recommended to be carried by each Battlefield Damage Assessment and Repair Maintenance Team (MT). Some of these items may already be available at organizational maintenance, however, additional items will be required to stock each MT. Those items marked "O" are recommended to be stocked at organizational level and those marked "MST" are recommended to be carried by the DS Maintenance Support Team (MsT).

**EXPENDABLE SUPPLIES**

<b>ITEM NUMBER</b>	<b>LEVEL</b>	<b>NSN</b>	<b>DESCRIPTION</b>	<b>U/I</b>
1	o	8040-00-831-3403	Adhesive, epoxy 1 pt	kt
2	0	8040-00-865-8991	Adhesive	kt
3	0	8040-00-738-6429	Adhesive, epoxy	kt
4	MT	5999-00-280-3499	Cap, electrical: crimp style	pkg
5	c	8030-00-159-5032	Cement, epoxy, devcon F-2	kt
6	c	4730-00-289-5909	Clamp, hose: 3/8 in. to 1 in.	ea
7	c	4730-00-908-3193	Clamp, hose: 1 1/16 in. to 2 in.	ea
8	c	5350-00-192-5047	Cloth, abrasive al-oxide 1/09 in. w, 11 in. lg (50 sheets)	pkg
9	MT	5315-00-598-5916	Cotter pin assortment	A t
10	MT	5940-00-296-5326	Ferrule, electrical: wristlock type 22-14 wire size (10 in pkg)	pkg
11	o	5330-00-291-1605	Gasket, cork, 1/32 in.	sh
12	0	5330-00-171-9134	Gasket, cork, 3/16 in.	sh
13	c	5330-00-467-3615	Gasket, material, 1/32 in. (w.o.g. resistant)	ft
14	c	5330-00-223-5845	Gasket, material, 1/64 in, (w.o.g. resistant)	sh
15		Use item 13		

**EXPENDABLE SUPPLIES (Cont)**

<b>ITEM NUMBER</b>	<b>LEVEL</b>	<b>NSN</b>	<b>DESCRIPTION</b>	<b>U/I</b>
16	0	4720-01-017-6616	Hose, non-metallic, 1/4 in. ID	f t
17	0	4720-00-169-5112	Hose, non-metallic, 1/2 in. ID	f t
18	0	4720-00-288-9873	Hose, non-metallic, 3/4 in. ID	f t
19	0	8010-00-515-2487	Lacquer, insulating, electrical	pt
20	0	5310-00-297-3751	Nut Assortment	at
21	MT	5330-00-966-8657	Packing Assortment (O-rings)	ea
22	o	9650-00-264-5050	Pig Lead	ck
23	0	5410-00-793-2021	Repair Kit, electronic equipment shelter (fiberglass)	ea
24	c	4020-00-968-1352	Rope, polypropylene (600 ft roll)	roll
25	MT	5320-01-004-0238	Rivet, pop, steel, SB4-2, 1/8 in. dia 1/8 in. lg (quantity 100)	hd
26	MT	5320-01-028-6621	Rivet, pop, steel, SB4-4, 1/4 in. dia 1/4 in. lg (quantity 50)	box
27	MT	5320-00-510-7823	Rivet, pop, aluminum, AB4-2A 1/8 in. dia 1/8 in. lg	hd
28	MT	5320-00-408-6073	Rivet, pop, aluminum, AB6-2A 3/16 in. dia 1/8 in. lg	hd
29	MT	8030-00-656-1426	Sealing Compound, gasket, non-hardening	pt
30	o	5335-00-054-5273	Screen Wire Mesh 60 in. x 150 ft	roll

**EXPENDABLE SUPPLIES (Cont)**

<b>ITEM NUMBER</b>	<b>LEVEL</b>	<b>NSN</b>	<b>DESCRIPTION</b>	<b>U/I</b>
31	0	8030-00-935-1083	Sealant, asphalt base, 8-lb	can
32	0	8030-00-965-2004	Sealant, synthetic rubber 1 pt	kt
33	0	8030-00-881-5238	Sealant and Puttying Compound Kit: kit no. 3 qt	kt
34		Deleted		■
35	MT	5940-00-840-0139	Splice, conductor: crimp style, wire size 10	ea
36	MT	5940-01-079-1936	Splice, conductor: crimp style, wire size 10	hd ■
37	c	5975-00-451-5001	Strap, tiedown (nlyon)	hd
38	MT	5820-00-783-9035	Strap, clamp, perforated	f t
39	c	9905-0&537-8957	Tag, blank, white	bd ■
40	c	8030-00-889-3535	Tape, anti-seizing pipe plug, teflon, 1/2 in. wide	ea
41	MT	5970-00-543-1005	Tape, electrical	roll
42	c	7510-00-802-8311	Tape, filament-reinforced 3/4 in., 50 yd roll	roll
43	MT	5940-00-813-0698	Terminal, lug: crimp style, stud sz 6, wire sz, 22-18	hd ■
44	MT	5940-00-143-4771	Terminal, lug: crimp style stud sz 10, wire sz 22-18	hd
45	MT	5940-00-283-5280	Terminal, lug: crimp style, stud sz 6, wire sz 16- 14	hd ■
46	MT	5940-00-143-4780	Terminal, lug: crimp style stud sz 10, wire sz 16-14	hd ■

**EXPENDABLE SUPPLIES (Cent)**

<b>ITEM NUMBER</b>	<b>LEVEL</b>	<b>NSN</b>	<b>DESCRIPTION</b>	<b>U/I</b>
47	MT	5940-00-143-4794	Terminal, lug: crimp style, stud sz 10, unspec	ea
48	MT	5940-00-804-9185	Terminal, quick disconnect, wire sz 18	pkg
49	Mt	5940-00-804-9184	Terminal, quick disconnect, wire sz 14-16	pr
50	MT	5970-00-815-1295	Tubing, shrink, 1/4 in.	ft
51	MT	5970-00-812-2967	Tubing, shrink, 1 in.	ft
52	MT	5970-00-812-2968	Tubing, shrink, 1/6in.	ft
53	MT	5970-00-812-2969	Tubing, shrink, 1/8in.	ft
54	MT	5310-00-209-2312	Washer, lock, assortment	at
55	MT	5310-01-268-2735	Washer, flat, assortment	at
56	c	6145-00-152-6499	Wire, wire sz 14	ft
57	c	6145-00-435-8613	Wire, wire size 18	ft
58	MT	5315-00-271-4251	Woodruff Key Assortment	at

**APPENDIX B  
SPECIAL AND FABRICATED TOOLS**

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

**SECTION I. General**

**B-1. Scope.**

This appendix lists items recommended for the support of the vehicle in a combat environment. The items listed may be required for Battlefield Damage Assessment and Repair at maintenance levels from crew through D.S. Also listed are expedient tools for performing BDAR repairs using non-standard equipment.



## **SECTION II. Tools**

### **B-2. General.**

Tools listed in this appendix will enhance crew members and mechanics at all levels to accomplish Battlefield Damage and Assessment repairs in a more expedient manner. Some tools listed may already be on hand in the unit.

The column marked "Level" indicates the maintenance level at which it is recommended these items be stocked or carried. The unit commander may modify the items in the list and the maintenance levels carrying the items, based on current mission requirements and recent operational experience.

The items marked "C" (Crew) are recommended to be carried on the vehicle for use in combat emergencies at the discretion of the unit commander. Those items marked "MT" are recommended to be carried by each Battlefield Damage Assessment and Repair Maintenance Team (MT). Some of these items may already be available at organizational maintenance, however, additional items will be required to stock each MT. Those items marked "O" are recommended to be stocked at organizational and those marked "MST" are recommended to be carried by the DS maintenance support teams (MST).

**TOOLS**

<b>ITEM NUMBER</b>	<b>LEVEL</b>	<b>NSN</b>	<b>DESCRIPTION</b>
1	c	5110-00-277-4591	Blade, hand hancsaw: 24 teeth per in., 10 in.
2	c	5110-00-927-1063	Blade, hacksaw, flat (tungsten)
3	MT	5120-00-203-6431	Clamp, C: 6 in. (2 required)
4	MT	5120-00-278-2423	Crimping Tool: terminal, hand w/cutting pin, stripper
5	MT	5120-00-278-6520	Cutter, tubing, close quarters
6	c	5120-00-227-8074	Extension, socket wrench: 1/2 in. sq dr 10 in. lg
7	c	5110-00-241-9153 5110-00-241-9156	File, hand: half rnd 10 in.
8	c	5110-00-234-6559	File, hand rnd style
9	c	5110-00-289-9657	Frame, hand hacksaw, 10 in. and 12 in. blade accommodated
10	0	4940-00-561-1002	Gun, thermal: PN 8031088
11	c	5110-00-263-0349	Handle, file
12	c	5110-00-240-5943	Knife, pocket: w/clevis, screwdriver, wire scraper and cutting blade
13	c	5120-00-221-1536	Knife, putty
14	c		Lifter, roadwheel arm
15	c	5120-00-239-8251	Pliers: linemans w/side cutter, 8 in.
16	c	5120-00-247-5177	Pliers: 1 rnd nose w/cutter, 6 in.

**TOOLS (Cont)**

<b>ITEM NUMBER</b>	<b>LEVEL</b>	<b>NSN</b>	<b>DESCRIPTION</b>
17	c	5120-00-278-0352	Pliers, slip joint: angle nose, multiple tongue and groove, 10 in.
18	c	5120-00-624-8065	Pliers, slip joint: conduit w/o hall, w/removable plastic inserts, 9 in. lg
19	c	5120-00-293-0448	Punch, aligning 3/16 in. pt, 8 in. lg, 3/8 in. dia
20	c	5120-00-595-9531	Punch, aligning 1/4 in. pt, 12 in. lg
21	c	5120-00-242-5966	Punch, drive pin: 1/8 in.
22	o	4931-01-119-7103	Repair Kit, electrical connector: PN 12285360
23	MT	5120-00-017-2849	Riveter: blind, hand
24	c	5120-00-234-8913	Screwdriver, cross tip: No. 2
25	c	5120-00-221-7063	Scriber, machinists double point
26	c	5120-00-237-0982	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 3/8 in.
27	c	5120-00-189-7924	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 7/16 in.
28	c	5120-00-237-0984	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 1/2 in.
29	c	5120-00-189-7932	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 9/16 in.
30	c	5120-00-189-7946	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 5/8 in.
31	c	5120-00-235-5870	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 11/16 in.
32	c	5120-00-189-7985	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 3/4 in.

## TOOLS (Cont)

ITEM NUMBER	LEVEL	NSN	DESCRIPTION
33	c	5120-00-189-7933	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 13/16 in.
34	c	5120-00-189-7934	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 7/8 in.
35	c	5120-00-189-7935	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 15/16 in.
36	c	5120-00-189-7927	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 1 in.
37	c	5120-00-242-3349	Socket, deepwell, 1/2 in. dr, 3/4 in.
38	MT	5110-00-803-6339	Splitting Tool, nut, 7/8 in. cap
39	MT	6625-01-102-6878	TA-1 Continuity and Test Probe Kit: PN 12303622
40	c	5140-00-498-8772	Tool Box, portable: steel w/removable tray 21 in. lg, 8-1/2 in. w, 7-3/8 in. h
41	MT	5120-01-128-5511	Tool Set, supplement, organizational: PN 12310894
42	c		Web Strap Assembly, adjustable: PN 12273481
43	c	5120-01-121-4981	Wrench, plug, sraight bar hex: PN 12284998
44	c	5120-00-240-5328	Wrench, adjustable: 8 in.
45	c	5120-00-277-4244	Wrench, plier: straight jaw, 8-1/2 in.
46	c	5120-00-148-7917	Wrench Set, combination box with open end, 12 components, 5/16 in. - 1 in.
47	c	5120-00-148-7918	Wrench Set, open end, fixed, 6 components 3/16 in. - 1-1/16 in.

### SECTION III. Test Equipment

#### B-3. FIELD EXPEDIENT TEST EQUIPMENT

##### General Information

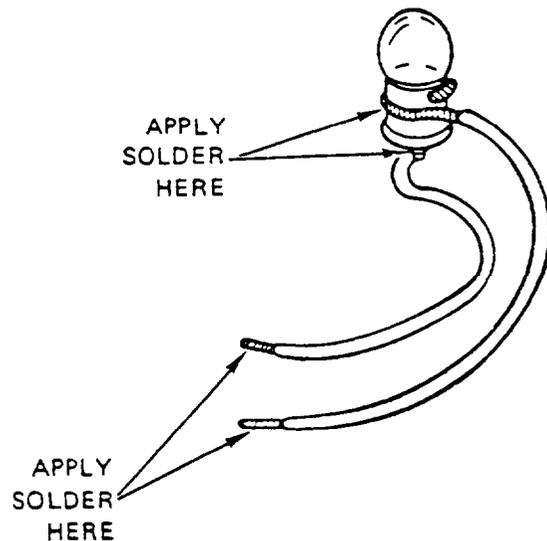
Sometimes, in the process of assessing the battlefield damage, it is necessary to make voltage and resistance measurements to determine where the fault is. Standard test equipment (voltmeter, ohmmeter, SWR meter, etc.) should be used whenever possible. If standard test equipment is not available, field expedient equipment can be fabricated using parts commonly found on the vehicle and in the forward maintenance areas. The following paragraph provides fabrication instructions for making a voltmeter, ohmmeter, and RF transmitter output tester.

##### NOTE

Accurate measurements are not available. These are Go - No-Go meters.

##### 1. Making a Voltmeter.

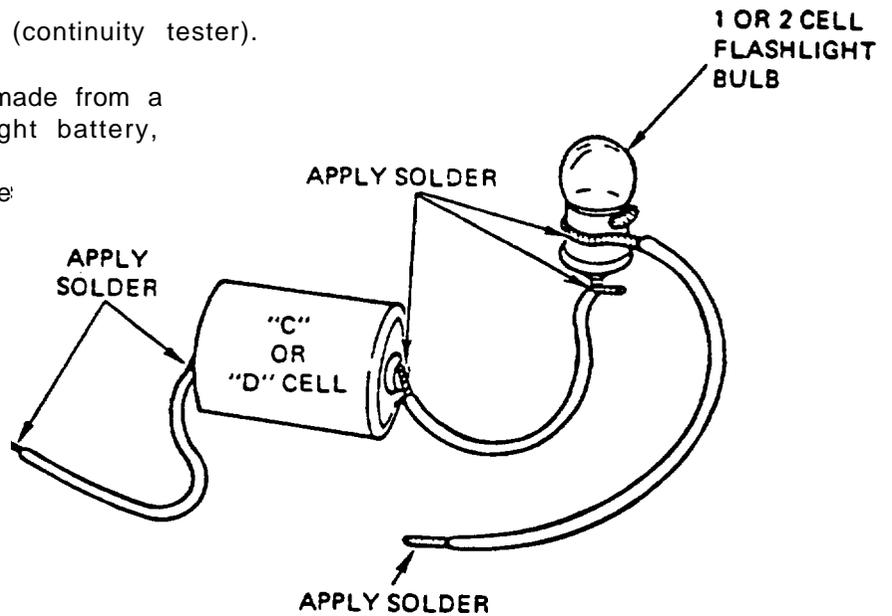
A voltmeter can be made from a light bulb and two pieces of wire. The pieces of wire can be connected to the case and center terminal of the bulb by means of solder, twisting, or simply holding the wire ends against the bulb (see illustration). The voltage rating of the bulb should be close to the value of the expected voltage being measured. For voltages in the 18 to 30 vdc range, any light bulb on the driver's master panel, driver's instrument panel, gunner's panel, commander's panel, or gunner's primary sight can be used. For voltages of 5 vdc or less a two-battery cell flashlight bulb can be used. The presence of voltage will cause the bulb to glow. polarity of dc voltage does not have to be observed; even ac voltage can be measured. Twist exposed wire ends together and apply solder, if available, and solder. Touch to voltage source when ready to make measurement.



### FIELD EXPEDIENT TEST EQUIPMENT (CONT)

#### 2. Making an Ohmmeter (continuity tester).

An ohmmeter can be made from a flashlight bulb, flashlight battery, and three pieces of wire. When the free ends of the wires are touched to a circuit where continuity (or a short) exists, the bulb will glow. If a two-cell flashlight bulb is used with only one battery, the bulb will glow with one-half its normal brilliance.



#### 3. DELETED.

## **Section IV. Welding Expedients**

### **B-4. CONTROLLED AMPERAGE**

#### **General Information:**

Battlefield repairs requiring welding can be done by using the auxiliary generator (Little Joe) from the M88 or generator recovery vehicle if a regular welder is not available.

#### **Limitations:**

- Possible degraded armor protection

#### **Materials/Tools:**

- Auxiliary generator (24 vdc)
- Control unit from a welder or similar control
- Welders helmet and gloves
- Welding rod, coat hangers, or barbed wire
- Heavy gauge cable (2.0 gauge or larger)
- Vise grips or clamps
- Fuel line

#### **Personnel/Time Required:**

- 2 soldier
- 1-2 hours

#### **Other Options:**

- Use uncontrolled amperage
- Weld using vehicle battery power

#### **Procedural Steps:**

1. Remove auxiliary generator from M88 recovery vehicle and place close to area to be welded. Connect heavy gauge cables to (+) and (-) output posts. Also connect control unit to (+) and (-) output posts. Tighten terminal securely.
- 2. Connect negative (-) cable to vehicle hull with clamp close to area to be welded. Connect welding rod to positive (+) cable with vise grips. Insulate vise grips with gloves, rags, or several layers of dry paper.

### **WARNING**

Use welder's helmet to protect eyes and face from arc. Do not touch exposed cable or vise grips with bare hands; metal gets very hot. Do not perform this task in rain or on wet ground because of electrical shock hazard.

### **Procedural Steps (Cont)**

3. Start auxiliary generator, strike arc, and weld. Set control unit for amperage level required by the thickness of the metal.
4. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair vehicle using standard maintenance procedures.

### **B-5. UNCONTROLLED AMPERAGE**

#### **General Information:**

Battlefield repairs requiring welding can be accomplished by using auxiliary generator (Little Joe) from M88 recovery vehicle or a generator if a regular welder is not available. Welding will be difficult without amperage control.

#### **Limitations:**

- Possible degraded armor protection

#### **Personnel/Time Required:**

- 2 soldiers
- 1-3 hours

#### **Materials/Tools:**

- Auxiliary generator (24 vdc)
- Heavy gauge cable (2.0 gauge minimum)
- Vise grips or clamps
- Fuel line
- Welder helmet and gloves
- Welding rod, coat hangers, or barbed wire

#### **Other Options**

- Weld using the vehicle battery power

#### **Procedural Steps:**

1. Remove auxiliary generator from M88 recovery vehicle and place close to area to be welded. Connect heavy gauge cables (+) and (-) output posts and tighten securely.
2. Connect negative (-) cable to vehicle hull with clamp close to area to be welded. Connect welding rod to positive (+) cable with vise grip and insulate area against heat with gloves, rags, or several layers of dry paper.

**APPENDIX B**

**Procedural Steps (Cont):**

**WARNING**

Use welder's helmet to protect eyes and face from arc. Do not touch exposed cable or vise grips with bare hands; metal will get very hot. Do not perform this task in rain or on wet ground because of possible electric shock hazard.

3. Start auxiliary generator, strike arc, and weld. Use small diameter welding rod for thin metal; use large welding **rod** for thick metal. Continue to weld until repair is satisfactory.

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

**Section V. Containers**

**B-6. IMPROVISED CONTAINER**

**General Information:**

Many repairs require the draining of the fluid systems (fuel, coolants, or oils). An improvised container can be used to catch the fluids.

**Limitations:**

- None

**Personnel/Time Required:**

- 2 soldiers
- 20-30 minutes

**Materials/Tools:**

- Large plastic sheet
- Poncho
- Tarpalin

**Procedural Steps:**

1. Dig a basin large enough to hold liquid.
2. Line the hole with a liner to hold the fluids.
3. Drive the vehicle over the hole.
4. Drain the liquid.
5. Dip the liquid from the hole using a steel helmet, can or canteen cup.
6. Record the BDAR action taken. When the mission is completed, as soon as practicable, repair the vehicle using standard maintenance procedures.

**APPENDIX C**  
**POL SUBSTITUTES**

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

**SECTION I. General**

**C-1. General.**

a. POL products available within the US and NATO military supply systems, commercial products and, captured products may be acceptable substitutes for POL shortages. Some POL will be destructive if used. This appendix provides tables on how to blend or mix good fuels with poor or non-fuels to increase the available quantity of fuel. This appendix also presents information on lubricants and hydraulic fluids. The tables divide POL products into three categories as follows:

Primary. The correct product for the system.

Alternate. A product that closely matches the primary but will result in reduced performance. Using the alternate POL will have no effect on the durability of the system. There are no restrictions on the duration of use.

Emergency or Expedient. A product that can be used for a short period of time only. These products are a last resort only and will result in a significant reduction in performance and in serious harm to the system with continued use.

b. POL products are usually identified by NSNS or part numbers which identify the product, however, specification numbers and product names may also be a means of identifying the product. Guidance provided is keyed to specification numbers, product names, application (automotive, aviation, marine), and the type of user (military, commercial and foreign).

c. NATO products can usually be assumed to be direct replacements for US Military products, but there are some products which do not meet the same user applications. The American Society of Testing and Measurements (ASTM) specifications relate to commercial products found in the US.

d. This section will list a few elementary characteristics of importance, although you will have no means of measuring or predicting them. You can use the basic fuels, as provided, in order or priority. It will tell you how to mix one or more fluids to produce a usable fuel and finally tell how to remove or flush a fuel from the system.

**APPENDIX C**

e. Table C-1 identifies fuels or products that can be used as fuels. One of the best means to increase the available fuel is to use potential substitutes as extenders by mixing them with the primary fuels and not using them as the sole fuel source. This allows some products which could not ordinarily be burned (or pumped) to be used by diluting them. Because of the dangers of varying combustibility of fuels, increased by vaporization during filling, the blending process is very important. The most direct and expedient procedure to mix fuels is to add the two fuels at the same time from two separate fuel lines. If added directly to the vehicle fuel tanks as separate fuels there is not sufficient turbulence in filling or shaking by normal driving to provide a properly mixed fuel. In vehicles with more than one tank, you could end up with a distinct fuel type in each tank.

**C-2. FUEL BLENDING.**

a. In following the blending procedure it must be remembered that the basic fuel is the better of the two fuels and the extender is the poorer. The blending fuel is the extender. While you can use up to 50 percent (half and half) of the extender you should not use more than is needed to obtain the supply needed. Also, ensure a fuel tank or container is available to hold the quantity of fuel needed to perform the mixing operation.

b. Blending Procedure. The preferred location to accomplish blending is at a fuel dispensing site or in fuel dispensing vehicles that utilize their own pumps. The least desirable is using vehicle's fuel tanks. Blending in vehicle fuel tanks should only be done as a last resort because it is imprecise and time consuming.

(1) Blending in Fuel Dispensing Vehicles. Add the blending fuel to the fuel tank and mix by reconnecting the pump inlet hose to the vehicle and recirculating the fuel for a minimum of 15 minutes.

(2) Blending in 55 Gallon Drums. Add the blending fuel directly into a drum and mix by rolling the drum.

(3) Blending in Gravity Feed Tanks (Stationary) Not Equipped With Fuel Transfer Pumps. Blending fuel can be added manually or by using the pump and meter of a dispensing vehicle. Add the blending fuel and mix by recirculating from the tank outlet to the tank truck pump inlet.

**NOTE**

Blending in the fuel tanks of using equipment and vehicles should be undertaken only as a last resort. Add both fuels to the fuel tank at the same time with dual nozzles, or from fuel cans.

c. If expedient fuels are not used completely during the operation, they should be drained or pumped out. Fill the vehicle fuel tanks with 10-15 gallons of an approved primary fuel and run the engine for at least 1/2 hour. Operate the engine under a load or drive the vehicle a sufficient distance to bring the engine up to operating temperature.

### **C-3. LUBRICANTS AND HYDRAULIC FLUIDS.**

a. This section lists a few elementary characteristics of importance although there are no expedient means of measuring or predicting them. A list of basic fluids which can be used is provided in order of priority. Cautions on incompatible fluids are mentioned and a means suggested to flush the system.

b. Table C-2 provides a list of basic fluids which can be used as substitutes (alternate and expedient). It is structured around the vehicle lube order. Alternate products shown are NATO equivalents to the US specifications and can really be considered primary fluids. There are no corresponding ASTM designators. The expedients are emergency only substitutions. They may cause one of three problems either individually or in combination.

(1) They may not allow proper or efficient operations because of improper viscosity.

(2) They may cause high wear rate because of improper viscosity.

(3) They may cause seal damage or create deposits because of improper chemical composition.

c. There are no established time constraints on these expedients but the shorter the time used the better.

### **C-4. FLUSHING LUBRICANT AND HYDRAULIC SYSTEMS.**

a. Expedient lubricant and hydraulic fluids must be removed as soon as possible, and the system cleaned and inspected.

b. For those systems using oils, flushing involves draining, refilling with the proper product, operating to insure complete circulation and when possible stable operating temperature (this usually means at least 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 must as a minimum be removed and cleaned. As a last resort only, operate without filters. While systems should not be disassembled to inspect seals, maintenance organizations should be prepared to replace seals that show signs of leaking. Organizations must observe seals on these systems during subsequent operations.

c. For systems using grease, it is normally necessary to disassemble the system and wash the parts, especially the bearings, in a suitable solvent. The parts are then wiped dry, inspected for wear and pitting, replaced if needed and repacked with the proper product.

**APPENDIX C**

**SECTION II. Tables**

**TABLE C-1. FUELS AND SUBSTITUTE FUELS**

(Listed in Order of Priority)

Primary Fuels

1. VV-F-800 (Diesel Fuels) (DF-1, DF-2, DF-A)
2. NATO-F-54 (Diesel Fuel, Military)
3. ASTM-D-975 (Automotive Diesel) (1-D & 2-D)
4. NATO -58 (Kerosene)
5. ASTM-D3699 (Kerosene)
6. Any blend of the above.

**NOTE**

Kerosene fuel can only be used as a last resort. Then it can only be used at a 25 percent or less ratio. It must be drained at the earliest opportunity.

Alternate Fuels

1. MIL-T-5624 (Aviation Turbine Fuel) (JP-4 & JP-5)\*
2. NATO-F-40 (Aviation Turbine Fuel)
3. ASTM-D-1655 (Aviation Turbine Fuel) (Jet B)
4. NATO-F-44 (Aviation Turbine Fuel)
- 5\* MIL-T-83133 (Aviation Turbine Fuel) (JP-4)
6. NATO-F-34 (Aviation Turbine Fuel)
7. ASTM-D- 1655 (Aviation Turbine) (Jet A-1)
8. ASTM-D-2880 (Turbine Fuel) (O-GT, 1-GT, 2-GT, 3-GT, 4-GT)
9. MIL-F-16884 (Marine Diesel) (DFM)
10. NATO-F-76 (Navy Distillate Fuel)
11. MIL-F-815 (Navy Distillate) (FO-1 & FO-2)
12. NATO-F-75 (Navy Distillate) (Low Pour Point)
13. ASTM-D-396 (Fuel Oil) (No. 1 & 2)

\*Better than a 50 percent chance these will have acceptable cetane.

With Fuel Extenders (Blends up to half and half -50 percent extender)

<u>Base</u>	<u>Extender</u>
14. Any Primary Fuel	Any Alternate Fuel
15. Any Alternate Fuel	Any Alternate Fuel
16. MIL-F-815	Any lighter primary or alternate
17. NATO-F-76	Any lighter primary or alternate
18. Any Diesel Fuel	PD-680 (Type I & 11) (Dry Cleaning Solvent)
	ASTM-D-484 (K, I, II, III, IV) (D.C.S.)
	ASTM-D-235 (I thru IV) (Pet. Spirits)

**TABLE C-1. FUELS AND SUBSTITUTE FUELS (Continued)**

Expedient (Emergency) Fuel

Blends with other fuels or extenders (Note blend rates stated).

<u>Base</u>	<u>Extender</u>
1. Any Primary Fuel	
2. Any Alternate Fuel	Any Gasoline 11- up to 25%
30 Any Primary Fuel	New engine oil - up to 50%
4. Any Alternate Fuel	New engine oil - up to 75%
5. Any Primary Fuel	Used engine oil
6. Any Alternate Fuel	Used engine oil
	Strained & filtered through charcoal or cloth. Any significant quantity of water must be removed.

Gasolines

1. MIL-G-3056 (Motor Gasoline) (Combat)
2. NATO-F-46 (Auto Gasoline) (91 RON) (Military)
3. NATO-F-49 (Auto Gasoline) (95 RON) (Military)
4. NATO-F-50 (Auto Gasoline) (91 RON)
- 50 VV-G-1690 (Auto Gasoline)
6. ASTM-D-439 (Auto Gasoline) (Any Grade)
7. MIL-G-53006 (Auto Gasoline)
8. MIL-G-5572 (Aviation Gasoline) (100/130)
9. NATO-F- 18 (Aviation Gasoline) (100/130)
10. ASTM-D-910 (Aviation Gasoline) (100)
11. MIL-G-5572 (Aviation Gasoline) (115/145)
12. NATO-F-22 (Aviation Gasoline) (115/145)

**NOTE**

Gasoline fuel can only be used as a last resort, then it can only be used at a 25 percent or less ratio. It must be drained at the earliest opportunity.

TABLE C-2. SUBSTITUTE LUBRICANTS

Lubrication Point	Temp. Range	LO Authorized				Alternates			Incompatible or Ineffective Fluids	Notes
		LO Ref (Page #)	Lube	US Specification	NATO Product	US Spec or Use Equiv NATO Prod	Soviet	Expedient		
Final Drive	Above 32°F +40°F to -10°F, 0°F to -65°F	1	OE/HDO 30 OE/HDO 10 OEA	MIL-L-2104 MIL-L-2104 MIL-L-46167	0-238 0-238 0-183	Next Grade 2104	M-8GI, M-10-GI M-8V, M10-V, M8A, M10-A, AS-9, AS-10, AS-11	Any Hydraulic Fluid	Below 0°F Soviet OEA Equiv, M6V, M66, M6A, AS-3, AS-4, AS-5, AS-6	
Roadwheel Arm Pivot Bearing	Above 32°F +40°F to -10°F, 0°F to -65°F	1	OE/HDO 10 OE/HDO 10 OEA	MIL-L-2104 MIL-L-2104 MIL-L-46167	0-238 0-238 0-183	Next Grade 2104	See Above			
Roadwheel and Idler Wheel Bearing	Above 32°F +40°F to -40°F, 0°F to -65°F	1	OE/HDO 10 OE/HDO 10	MIL-L-2104 MIL-L-2104	0-238 -0238	Next Grade 2104	See Above			
Idler Arm	Above 32°F +40° to -10°F, 0°F to -65°F	1	OE/HDO 10 OE/HDO 10 OEA	MIL-L-2104 MIL-L-2104 MIL-L-46167	0-238 0-238 0-183	Next Grade 2104	See Above			
Idler Arm Housing	All	1	GAA	MIL-G-10924	G-403	All C-2105	TS/ATIM-201 TS/ATIM-221 UNIINP-232 UNIINP-279 UNIINP-221 UNIIUP-220 LITOL-24			
Evacuator Valve	Above 32°F +40°F to -10°F, 0°F to -65°F	1	GGP GGP GAA	MIL-G-23549 MIL-G-23549 MIL-G-10924	G-403					
Evacuator Ball	All	1	GAA	MIL-G-10968	G-403		See Above			
Track Hydraulic Adjuster	All	1	GAA	MIL-G-10921	G-403		See Above			
Recuperator	All	1	OHC or OHT	MIL-H-5606 MIL-H-6023	H-515 C-635	MIL-H-46170 (NATO H549)				
Transmission	Above 32°F +40°F to -10°F, 0°F to -65°F	2	OE/HDO 10 OE/HDO 10 OEA	MIL-L-2104 MIL-L-2104 MIL-L-46167	0-238 0-238 0-183	Next Grade 2104 Any Hydraulic Oil	See Above	Commercial Heavy Trans- mission Fluid		
Engine	Above 32°F +40°F to -10°F, 0°F to -65°F	2	OE/HDO 30 OE/HDO 10 OEA	MIL-L-2104 MIL-L-2104 MIL-L-46167	0-238 0-238 0-183	Next Grade 2104	See Above			

TABLE C-2. SUBSTITUTE LUBRICANTS (CONT.)

Lubrication Point	Temp. Range	LO Authorized				Alternates		Expedient	Incompatible or Ineffective Fluids	Notes
		LO Ref (Page #)	Lube	US Specification	NATO Product	US Spec or Use Equiv NATO Prod	Soviet			
Tachometer Adapter Housing	All	2	GAA	MIL-G-10924	G-403		See Above			
Final Drive Universal Joint	All	2	GAA	MIL-G-10924	G-403		See Above			
Speedometer Adapter Housing	All	2	GAA	MIL-G-10924	G-403		See Above			
Cooling Fan	All	2	GIA	MIL-G-23827	G-354					
Gear Case Cannon Bore	All	3	PL	VV-L-800	0-190					
Variable Recoil Cylinder and Center Buffer	All	3	OHC or OHT	MIL-H-5606 MIL-H-6083	H-515 C-635	MIL-H-46170				
Equilibrator	All	3	OHC or OHT	MIL-H-5606 MIL-H-6083	H-515 C-635	MIL-H-46170				
Replenisher	All	3/5	OHC	MIL-H-5606 MIL-H-6083	H-515 C-635	MIL-H-46170				
Elevating Cylinder	All	3	PL-S	VV-L-800	0-190					
Cradle Bearings	All	3	GSP or GAA	MIL-G-23549 MIL-G-10924	G-403					
Replinisher Accumulator	All	3	GHC or OMT	MIL-H-5606 MIL-H-6083	H-515 C-635	MIL-H-46170				
Gunman Breech and Firing Mech	All	3	PL-S	VV-L-800	0-190					
Hydraulic Reservoir	All	3	OHT	M-H-5606	H-515	MIL-H-6083 MIL-H-46170				
Towing Pintle	All	3	GAA	MIL-G-10924	G-403	See Above	See Above			

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TABLE C-2. SUBSTITUTE LUBRICANTS ( CONT. )

Lubrication Point	Temp. Range	LO Authorized				Alternates			Incompatible or Ineffective Fluids	Notes
		LO Ref (Page #)	Lube	US Specification	NATO Product	US Spec or Use Equiv NATO Prod	Soviet	Expedient		
Cab Traversing Ring	All	4	GAA	MIL-G-10924	G-403	MIL-L-2105	See Above			
Traversing Mech Top Bearing	All	4	GAA	MIL-G-10924	G-403	MIL-L-2105	See Above			
Traversing Mechanism	Above 30°F 40°F to -10°F, 0°F to -65°F	4	GO 90 GO 80 GOS	MIL-L-2105 MIL-L-2105 MIL-L-10324	G-226 G-226	MIL-L-2104 OE 50 MIL-L-2104 OE 50 MIL-L-2104 OE 10 MIL-L-46167 OEA				
Cab Runner	All	4	OE/HDC Any Grade	MIL-L-2104	0-238		See Above			
Cradle Cam and Grooves	All	4	GAA	MIL-G-10924	G-403	See Above	See Above			
Cab Race Ring	All	4	GAA	MIL-G-10924	G-403	MIL-L-2105	See Above			
Cannon Breech Ring	All	4	PL-S	VV-L-800	0-190					
Weapon Mtd Runner	All	4	GAA	MIL-G-10924	G-403		See Above			
Cannon Tube and Recoil Sleeve	All	5	GAA	MIL-G-10924	G-403		See Above			
Elevating Mech Gear and Piston	All	5	GAA	MIL-G-10924	G-403		See Above			
Cab Race Ring	All	5	GAA	MIL-G-10924	G-403	MIL-L-2105	See Above			
Cab Red and Mt Bracket Pivot	All	6	PL-S	VV-L-800	0-190					
Cab Hull Inf Seal Head	All	6	AHT	MIL-H-5606	H-515	MIL-H-6083 MIL-H-46167				

**APPENDIX D**

**BDAR FIXES AUTHORIZED FOR TRAINING**

**BDAR TRAINING FIXES SHALL BE USED ONLY AT THE DISCRETION OF THE COMMANDER. DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE PROCEDURES AS SOON AS PRACTICABLE.**

BDAR training fixes during peacetime shall be the same as BDAR wartime fixes.

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# THE METRIC SYSTEM AND EQUIVALENTS

## WEIGHT MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches  
 1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches  
 1 Kilometer = 1000 Meters = 0.621 Miles

## WEIGHTS

1 Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces  
 1 Kilogram = 1000 Grams = 2.2 lb.  
 1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

## LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces  
 1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

## SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches  
 1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet  
 1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

## CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches  
 1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

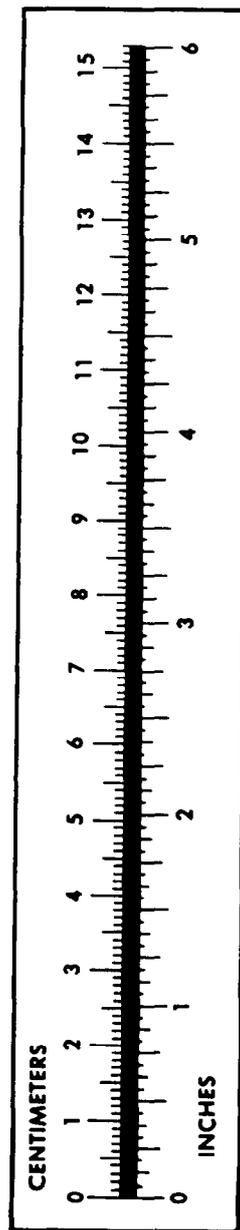
## TEMPERATURE

$5/9(^{\circ}\text{F} - 32) = ^{\circ}\text{C}$   
 212° Fahrenheit is equivalent to 100° Celsius  
 90° Fahrenheit is equivalent to 32.2° Celsius  
 32° Fahrenheit is equivalent to 0° Celsius  
 $9/5^{\circ}\text{C} + 32 = ^{\circ}\text{F}$

## APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
its	Liters	0.473
arts	Liters	0.946
allons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
ers	Gallons	0.264
ms	Ounces	0.035
ograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pounds-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
ometers per Liter	Miles per Gallon	2.354
ometers per Hour	Miles per Hour	0.621



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