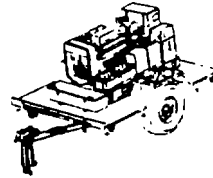


TECHNICAL MANUAL



**BATTLEFIELD DAMAGE
ASSESSMENT AND REPAIR**

FOR GENERATORS	CHAPTER 1	GENERAL INFORMATION
	CHAPTER 2	ASSESSING BATTLEFIELD DAMAGE
	CHAPTER 3	GENERAL REPAIR
	CHAPTER 4	ENGINE
	CHAPTER 6	FUEL SUPPLY SYSTEM
	CHAPTER 6	COOLING SYSTEM
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	APPENDIX C	EXPENDABLE/DURABLE SUPPLIES AND MATERIALS
	APPENDIX D	SUBSTITUTE MATERIALS/PARTS
	APPENDIX E	DBAR TRAINING PROCEDURES

**HEADQUARTERS, DEPARTMENT OF THE ARMY
28 SEPTEMBER 1990
Approved for public release; distribution is unlimited.**

CHANGE

NO. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 5 August 1991

**BATTLEFIELD DAMAGE ASSESSMENT
AND REPAIR
FOR GENERATORS**

Approved for public release; distribution is unlimited

TM 96115-624-BD, 28 September 1990 is changed as follows:

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

Remove pages

Insert pages

a and b

a and b

iii and iv

iii and iv

B-3 through B-6

B-3 through B-6

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

By Order of the Secretary of the Army:

Official:

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*Brigadier General, United States Army
The Adjutant General*

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

DISTRIBUTION:

To be distributed in accordance with DA Form 12-25E, (qty rqr block no. 5054).

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. Disconnect batteries on generator being repaired prior to welding.

WARNING

This technical manual contains non-standard maintenance procedures. All normal safety procedures should be observed when the tactical situation permits.

WARNING

The exhibits shown in the BDAR manual are typical examples of quick-fixes for the equipment when applicable. These exhibits are not all inclusive, so if these examples stimulate ideas for other repairs or quick-fixes, check with the senior person in charge for approval and processing.

WARNING

The standards contained herein allow use of generator with battle damage substantially in excess of peacetime limits. Under no circumstances shall this manual be used wholly or in part for peacetime maintenance of the generator. If at any stage of damage assessment shall be stopped at that point and repeated from the beginning.

WARNING

Corrosive Battery Electrolyte (Potassium Hydroxide or Sulfuric Acid). Wear rubber gloves, apron, and face shield when handling leaking batteries. If potassium hydroxide or Sulfuric Acid is spilled on clothing, or other material wash immediately with clean water. If spilled on personnel immediately start flushing the affected area with clean water. Continue washing until medical assistance arrives.

WARNING

Do not use open flame to repair fuel tanks as fumes could cause explosion and death or injury to personnel. Use soldering gun or soldering iron only.

WARNING

Do not weld on the fuel tanks unless they have been thoroughly drained and purged of fuel. Failure to heed this warning may result in an explosion and fatal injuries.

WARNING

Engine and associated systems may be very hot. Use caution when performing all BDAR actions to avoid being burned.

WARNING

Breathing exhaust gases can be fatal. Avoid direct exposure to exhaust gases. Do not perform maintenance with generator running in an enclosed area such as tents without adequate ventilation.

WARNING

Solvents, POL and other liquid chemicals may be hazardous to your health. Use only in well ventilated areas. Keep all sources of fire away.

WARNING

Use personal protective equipment such as eye goggles, gloves and hearing protection when performing BDAR actions. Serious injury can result when such equipment is not used.

WARNING

This voltage indicator can only be used safely below 37 volts DC.

TECHNICAL MANUAL

No. 9-6115-624-BD

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 28 September 1990

**Technical Manual
for
BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR
GENERATORS**

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

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

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*** This manual supersedes TM 5-6115-624-BD, 21 March 1988.**

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HOW TO USE THIS MANUAL

This manual is designed to help you accomplish your mission when your electrical generator has sustained battlefield damage or is malfunctioning for any other reason during a combat situation.

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

A logic chart provided in Chapter 2 guides you through the visual inspections, functional tests and performance assessment. Each of the assessment actions is contained in a block which leads to a decision diamond. A yes or no response to the question in the diamond leads to one or another action in the assessment process, until the total damage to the generator is determined.

If the decision to repair is made, this manual first covers repairs for such physical damage to the generator structure as broken brackets, gasket leaks, V-belts missing, etc. A procedure index in the beginning of the chapter provides a quick locator for the paragraphs that cover repair for various types of structural damage. For each repair procedure, the manual gives the effect on performance of the repair, the estimated time required to make the repair, materials and tools required, and other options available to accomplish the repair, or accomplish the mission without repair. Alternate procedures are provided, if applicable, to accomplish repair depending on materials available and the local situation.

Subsequent chapters cover detailed assessment and repair for the engine, the fuel supply system, the cooling system, and the electrical supply system. A decision logic diagram to locate damage, and a procedure index is provided for each of these subjects to facilitate returning to operational status.

To support operation under battlefield conditions, a list of commonly used parts is provided to allow repair by substitution of a part from other equipment that is compatible with your generator. Also, there is a list of fuel substitutes and fuel extenders for gasoline or diesel driven generators that may be used in case of fuel shortage. A similar listing of lubrication substitutes is provided.

NOTE

See Appendix C, Table C-1, for possible material NSN applications. See Appendix B, Table B-1, for possible tool NSN applications.

CHAPTER 1

GENERAL INFORMATION

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

Section I. INTRODUCTION

1-1. Purpose. The purpose of Battlefield Damage Assessment and Repair (BDAR) is to rapidly return disabled generators to the operational commander by expediently fixing, by-passing, or jury-rigging components to restore the minimum essential systems required for the support of the specific combat mission or to enable the generator to self-recover. These repairs may be temporary and may not restore full performance capability. This TM describes BDAR procedures of a general nature applicable to all generators. Expedient repairs applicable to systems or sub-systems of a specific generator are covered in system specific TM's. All possible types of combat damage and failure modes cannot be predicted nor are all effective field expedient repairs known. This TM provides guidelines for assessing and repairing battlefield failures of generator equipment and is not intended to be a complete catalog of all possible emergency repairs. The repairs described here will serve as guidelines and will stimulate the experienced operator or mechanic to devise expedients as needed to rapidly repair equipment in a combat crisis.

1-2. Scope. This technical manual (TM) is for use by operators, organizations, and direct support/general support maintenance personnel. It provides procedures and guidelines for battlefield repairs on generators under the forward support maintenance concept during combat.

1-3. Application. 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 generator 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.

a. Extent of Repair. 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.

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

1-4. Definitions. The following terms specific to BDAR are used in this TM:

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

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

- (1) Short cuts in parts removal or installation.
- (2) Installation of components from other generators that can be modified to fit or interchange with components on the generator.
- (3) Repair using parts that serve a non-critical function elsewhere on the same generator for the purpose of restoring a critical function.
- (4) Bypassing of non-critical components in order to restore basic functional capability.
- (5) Expeditious cannibalization procedures.
- (6) Fabrication of parts from kits or readily available materials.
- (7) Jury rigging.
- (8) Use of substitute fuels, fluids or lubricants.

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

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

d. Maintenance Team (MT). A Maintenance Team (MT) consists of organizational mechanics, who may be trained in assessing battlefield damage and field repair procedures. MT are called to out-of-action generators 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 generator to mission capability.

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

f. MT/MST Assessor. 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. Fully Mission Capable. The term fully mission capable (FMC) means that the generator meets the minimum functional combat capability requirements. Refer to system specific TM's for each generator's specific MFCC.

h. Combat Capable. The term combat capable means that the generator meets the minimum functional combat capability requirements.

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

j. Cannibalization. The term cannibalization as used in this TM means any use of repair parts or components obtained from another generator 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. New procedures and recommendations should be forwarded as follows:

a. New BDAR Procedures. Personnel originating new BDAR procedures should forward them directly to Commander, U.S. Army Troop Support Command, ATTN: AMSTR-ME, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. Personnel are encouraged to report new BDAR ideas, techniques and procedures.

b. Equipment Improvement Recommendations (EIR). 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. EIRs may be submitted on SF 368, Quality Deficiency Report. Mail these directly to Commander, U.S. Army Troop Command, ATTN: AMSTR-QX, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. A reply will be sent directly to you.

Section II. BDAR STANDARDS AND PRACTICES

1-6. BDAR Characteristics. BDAR capability requires simplicity, speed, and effectiveness. Some BDAR procedures include repair techniques that violate standard peacetime maintenance practices. In a combat emergency situation, greater risks are necessary and acceptable.

1-7. Waiver Precautions. Under combat conditions. BDAR may be performed on generators which are running with circuit breaker open. Other similar precautions may be waived at the discretion of the commander.

1 8. Operating Characteristics.

1-9. Training. The unit commander should insure that an adequate number of members of his organization, including supervisors, are trained in BDAR procedures applicable to his equipment. Each generator operator should be trained to perform initial battlefield damage assessment for his crew position. The commander may authorize use of BDAR procedures in this manual for peacetime training provided that:

- a. The peacetime training restrictions listed for a procedure are observed.
- b. The equipment is repaired by standard maintenance procedures after the training has been completed.

1-10. Environment. BDAR may be required in a chemically toxic environment or under other adverse conditions with severe limitations in personnel, facilities, equipment, and materials. Performance of repair tasks may be necessary while wearing protective gear. Decontamination procedures are described in FM 3-5. Decontamination Procedures.

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

Section III. BDAR TASKS AND RESPONSIBILITIES

1-12. General. Battlefield damage assessment and repair procedures are applicable at all levels from crew through intermediate 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 what ever action is necessary and possible to restore the generator to the combat ready condition required for continuation of the mission.

1-13. Commander and Crew. Operator/crew are responsible for first BDAR assessment and limited repair.

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

- (1) Generator damaged (out-of-action or impaired).
- (2) Location of generator.
- (3) Mobility status (where applicable).
- (4) Current and anticipated enemy action. ((f under hostile fire)

b. Assessment Checks. BDAR Forms discussed in Chapter 2, 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).

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

- (1) Have any combustibles such as fuel, hydraulic fluid, or oil accumulated?
- (2) Does wiring appear to be safe? Could arcing occur to stored ammo or leaking combustibles?

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

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

f. Crew Assistance. The commander will respond with directives and, if required, will call an MT to the location of the damaged generator for assistance. If possible, sufficient information will be provided to enable the MT to bring any needed repair parts or special tools.

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

1-14. Organizational Maintenance and Maintenance Teams (MT). The organizational maintenance team (MT) and assessor operate out of the company or battalion trains. The MT assessor performs his assessment and the maintenance team completes repairs 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 "

a. Personnel Safety Precautions. If the generator has been left unattended in the forward battle area, the immediate area of the generator should be checked for mines and the generator checked for booby traps before starting the battlefield damage assessment. The MT should also make the necessary safety checks.

b. MT Assessment Scope. The MT assessment is 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 operational tests, as necessary.

c. MT Assessment Procedure. 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 generator to the repair site.

d. MT Repairs. 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.

e. MT Assistance. 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.

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

g. Non-Repairable Generator. If the generator 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).

h. Contaminated Generator. If the generator is contaminated, the MT shall mark the generator with contamination markers and arrange for recovery to a decontamination site.

1-5. Direct Support/General Support Maintenance Team. 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 generator and make it ready for the MST to perform the BDAR when it arrives.

a. Repair Priority. Damaged generators 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. 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.

a. Estimate of Time to Effect Repair. Every assessment must include an estimate of total elapsed time for all tasks required to restore the generator. 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. Time Guidelines. 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 this best estimate of how the most responsive maintenance support can be provided. He must consider the tactical situation, maintenance backlog, personnel, tools, TMDE, and repair parts available. The guidelines are based on a defensive scenario and can be extended when applied to the offense.

Table 1-1. Summary of BDAR Time Guidelines.

Location	Elements performing BDAR	Time guidelines
Breakdown Site	1. Operator/Crew 2. Battalion Maintenance Team (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 Company 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

1-17. Tagging/Identifying BDAR Repairs.

a. Tag Record. All components of a generator 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 generator is subsequently returned for authorized permanent repair.

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

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

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

1-18. Reports. All BDAR repairs must be recorded and the record properly processed.

a. Recovery record. When the generator is recovered/evacuated for permanent standard repair, and DA Forms 2404 and 2407 are used, the notation "BDAR" shall be added in the space provided for description of deficiencies.

b. Forms disposition. DA PAM 738-750 provides for disposition of DA Form 2404 and copy number 3 of DA Form 2407. When "BDAR" is noted on these forms, they shall be mailed to Commander, US Army Troop Support Command, ATTN: ATMSTR-MES, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. The information on these forms will provide data for designing generators 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 OR FOR TRAINING
AT THE DISCRETION OF THE COMMANDER
(AUTHORIZED TRAINING FIXES ARE LISTED IN APPENDIX E)
IN EITHER CASE DAMAGES SHALL BE REPAIRED BY STANDARD
PROCEDURES AS SOON AS PRACTICABLE**

Section I. INTRODUCTION

2-1. Scope. This chapter provides guidelines to use to assess battlefield damage. It directs you to an expedient repair procedure, or to the standard system TM is an expedient repair procedure for your problem doesn't exist. Use this TM in conjunction with the operator's technical manual (TM) and Lubrication Order (LO). This chapter explains how to use this manual to assess and fix battlefield damage that prevents generator operation. This chapter contains the general fault assessment tables, general troubleshooting and maintenance instructions, including combat damage report forms. General fault assessment tables, specific fault assessment tables, and detailed assessment procedures are used to locate the damage; 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, use the assessment tables and procedures to find the fault.

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

- a. Do the Preventive Maintenance Checks and Services (PMCS) in the TM and LO. At the same time, look for obvious damage to the generator.
- b. If applicable, do the troubleshooting/repair recommended by the TM.
- c. If you find the problem, determine its effect on the operation of the generator.
- d. If the problem does not affect generator operation, the commander shall decide whether to attempt to fix the problem or continue with the mission.
- e. If the damage does affect generator 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.
- f. After repairing the damaged system, replace all lost fluids and/or lubricants. If the ones specified by LO or TM are not available, refer to Appendix D for a possible substitute.

Section II. GENERAL FAULT ASSESSMENT TABLES

2-3. General. This section provides an overall damage assessment procedure to evaluate the operability of individual generators.

- a. Assessment References. The assessment procedures are designed to assure that all necessary aspects of a generator's 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.

b. Procedure Content. 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 persons 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 generator.
- (5) the third is assessment of where and how to repair the damage.
- (6) 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).

c. Procedure index. 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.

d. Additional Data. Additional data is contained in the Appendices.

- (1) Appendix C lists alternate sources of supply to include foreign ownership of US generators and expendable supplies which are recommended for use to implement various BDAR repairs.
- (2) Appendix D lists special or fabricated tools used in performing BDAR repairs.
- (3) Appendix D lists substitutes for the petroleum, oil, and lubricants (POL).

2-4. Assessment Process. The assessment procedures are structured using the logic process shown in figure 2-1.

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

- (1) visually inspect (repair, if necessary).
- (2) functionally test (repair, if necessary) and,
- (3) assess the performance.

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

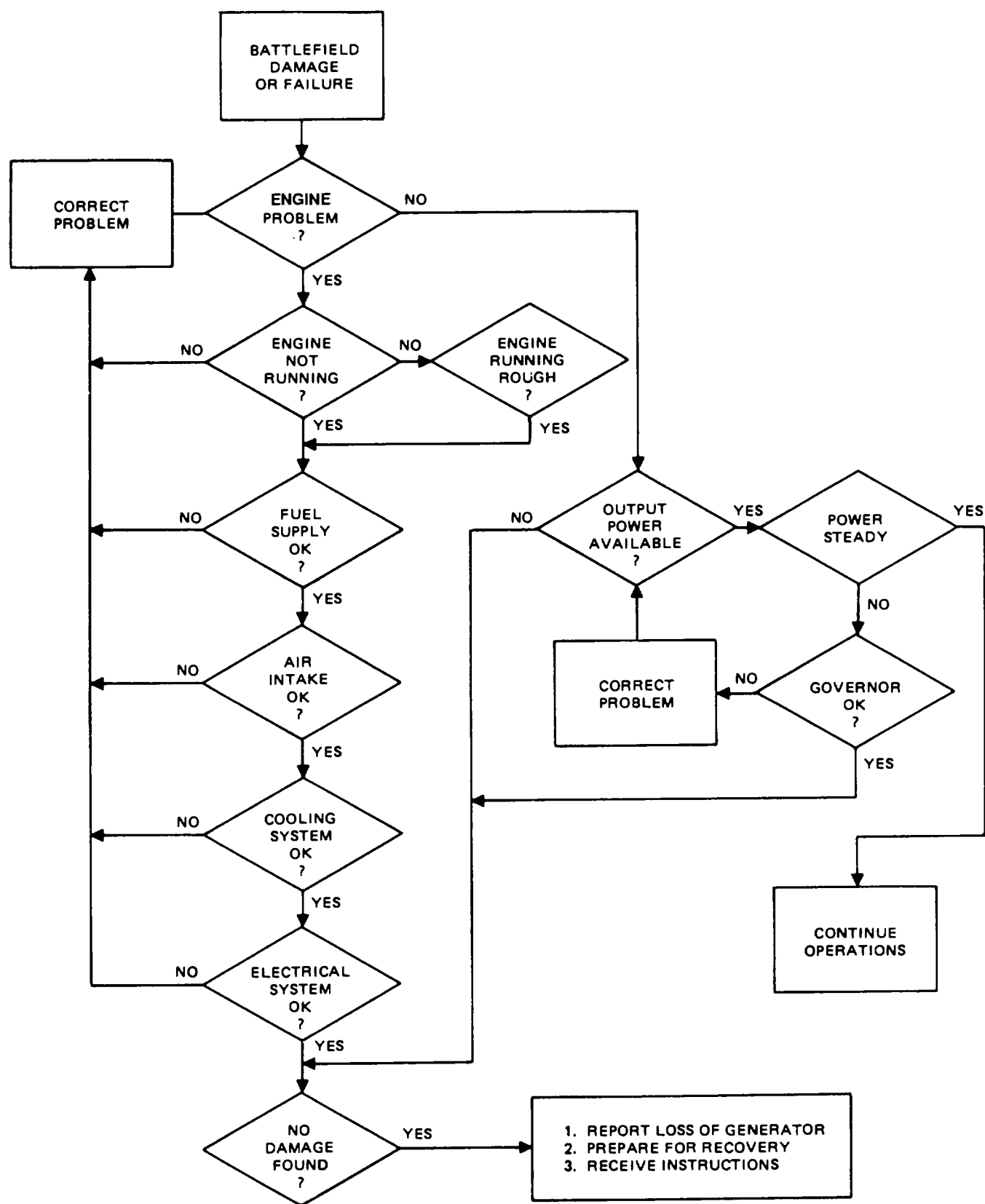


Figure 2-1. Battlefield Damage Assessment.

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

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

c. Assessment Levels. Assessments of damage may be made in turn by operator/crew, 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 to repair and when and how to repair the damage may be judgment 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 mission commander as they evaluate the generator 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 decision.

CHAPTER 3

GENERAL REPAIR

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

Section I. INTRODUCTION

3-1. Scope. This chapter describes quick fix procedures for those items common to systems and functional elements of a generator.

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

3-3. Repair Procedure Index.

Damage	Paragraph
Gaskets, Leaking	3-5
Gasket, Engine	3-6
Gaskets, Environmental	3-7
V-Belts, Missing or Broken	3-9
Engine Housing, Damage	3-11
Bracket, Broken	3-13
Mismatched Threads, Forcing	3-15
Thread Clean-up	3-16
Hardware Mounting	3-17
Push/Pull Rod, Damaged	3-18
Pin-Alignment, Clevis, Cotter, Dowels Quick Release	3-19

Section II. GASKETS

3-4. General. Gaskets may become damaged causing leakage from components. Procedures are available to make or repair gaskets if standard replacements are not available. Lift capability may be required to gain access to the gasket. Heat and pressure should be considered when selecting gasket materials.

3-5. Gaskets, Leaking. When some metal surfaces are bolted together a compressable gasket is required to reduce or eliminate the leakage of fluids or lubricants. Gaskets are also used to seal systems against fuel leakage or to keep contaminants from entering. Leaks can be tolerated if the fluid leaking does not constitute a fire hazard or does not leak at a rate which will deplete the required lubrication or coolant.

a. Limitations

Frequent inspections required

b. Personnel/time required.

1-2 soldiers/1.0-6.0 hours

c. Materials/tools. Gasket material such as:

Leather
Used gasket
Cardboard
Telfon tape (item 21, appx C)
Silicone gasket sealer (item 2, appx c)
Permatex type sealer (item 14, appx c)

d. Procedural Steps:

(1) *Option 1: Manufactured gasket.*

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

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

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

(b) Coat the gasket with a sealing compound.

(c) Join components and bolt.

(2) *Option 2: Used gaskets.*

(a) Coat mating surface with sealing compound.

(b) Place used gasket or sections or broken gasket onto mating surface.

(c) Coat other mating surface with gasket sealer.

(d) Join components and bolt.

(3) *Option 3: Gasket sealer.*

(a) Remove old gasket material and residue.

(b) Coat mating surfaces with silicone gasket sealer.

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

(d) Join components and bolt.

(4) *Other options: Continue operation, refilling fluids as required.*

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

3-6. Gaskets, Engine. Engine cylinder head gaskets seal both compression and fluid galleries. Leakages can be detected through:

lack of power,
rough, uneven engine operation,
abnormal pressure in crankcase or cooling system,
contaminants in oil or cooling system.

a. Limitations.

Degraded power output. BDAR procedures are more difficult to perform on cylinder head gaskets but limited operation can be restored. Frequent checks must be made for leakage and temperature change.

b. Personnel/time required.

1-2 soldiers/2.0-6.0 hours

c. Materials/tools.

Epoxy (item 3, appx c)
Copper wire (item 33, appx c)
Hardening gasket sealer (item 14, appx c)

d. Procedural Steps.

(1) *Option 1: Gasket sealer.*

- (a) Remove cylinder head.
- (b) Locate leaking area.
- (c) Liberally coat leaking area with hardening gasket sealer.
- (d) Replace cylinder head, tighten mounting bolts or studs.
- (e) Check engine operation.

(2) *Option 2: Wire and sealer.*

- (a) Remove cylinder head.
- (b) Remove gasket or O-rings.
- (c) Lay soft copper wire around each cylinder bore and trim to eliminate any overlap.
- (d) Reinstall old gasket coated with gasket sealer, varnish or paint.
- (e) Reinstall cylinder head, tighten mounting bolts or studs.

(3) *Other options: Continue operations.*

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

3-7. Gaskets, Environmental. Inspect for water or foreign matter in compartments or areas that should be sealed. Rubber weather/stripping from civilian vehicles or any rubber hose securely glued and sealed will stop leaks. Canvas or rubber inner tubes will also seal the system. These seals will prevent excessive water and air leaks but may not provide adequate NBC protection.

a. Limitations.

None

b. Personnel/time required.

1-2 soldiers/.33-1.0 hours

c. Materials/tools.

Rubber hose (items 8, 9, 10, appx c)
Copper wire (items 33 and 34, appx c)
Rubber weather-stripping
Inner tubes
Adhesive (item 2, appx c)
Canvas tarp
Poncho
Expoxy (item 1 or 3, appx c)

d. Procedural Steps.

- (1) Locate leak. Retorque bolts.
- (2) If still leaking, remove component or cover.
- (3) Remove defective gasket and clean the sealing surfaces.
- (4) Obtain material to fabricate sealing gasket.
- (5) Cut gasket to fit.
- (6) Apply available adhesive, follow instructions on container.
- (7) Place gasket in proper location.
- (8) Reinstall component or cover.
- (9) Check engine operation.

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

Section III. BELTS

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

3-9. V-Belt, Missing or Broken. Some vehicle subsystems are driven by V-belts. Most liquid cooling system coolant pumps and fans for moving air over or through a radiator require V-belts. Power generation is also belt driven. Worn or frayed V-belts can slip or break causing the system to fail. V-belts can be replaced or substituted to restore system functions.

a. Limitations.

Degraded output. Frequent adjustment may be required for substitute V-belts.

b. Personnel/time required.

1 soldier/.25-1.0 hours.

c. Materials/tools.

Adjustable link V-belts
Rope (item 12, appx c)
Wire (item 33 or 34, appx c)

d. Procedural Steps.

(1) *Option 1.*

- (a) Rope or wire can also be used but thin wire must be braided to ensure the needed friction is provided.
- (b) Assemble the rope or wire as close as possible to the original length of the correct belt.
- (c) Adjust with the tensioner assembly.

(2) *Option 2.*

- (a) Separable-link belts can be used, if available.
- (b) Assemble the belting as close as possible to the original length of the correct belt and adjust with a vehicle belt tensioner.
- (c) Install the belt as shown (figure 3-1). This prevents undue strain on the belt links. Belt data is given in table 3-1.

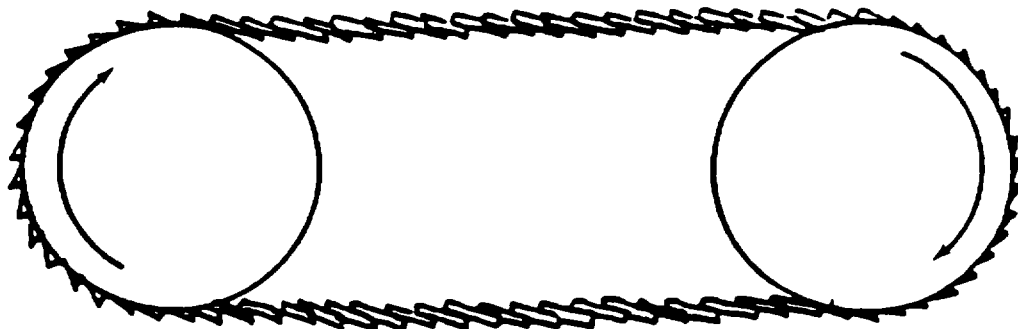


Figure 3-1. Direction of Rotation of Separable-Link Belts.

Table 3-1. Adjustable-Link V-Belt Data (figure 3-2)

BELTING, V, ADJUSTABLE LINK

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

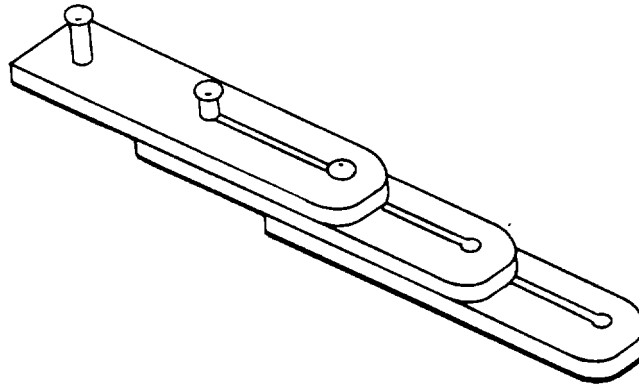


Figure 3-2. Adjustable-Link V-Belt (Enlarged).

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

Section IV. HOUSINGS, CASTINGS, PLATES

3-10. General. Castings or plates may be serviceable even with holes or cracks providing the internal structure is not significantly weakened. Internal structures such as crankshaft bearing journal webs are necessary to distribute loads within the casting. Some damage to these elements of the structure can be allowed but fatigue failures from crack growth cannot be predicted, and service life will depend on the extent of damage.

3-11. Engine Housing, Damage. Small cracks or holes may develop in a cylinder head, block or engine housing, caused by vibrations, overheating, or explosive shocks. Cracks that do not harm the structural strength of a housing can be deferred but cracks that allow coolant or oil to escape must be repaired. Large holes or cracks will require exchange of the component.

a. Limitations.

Degraded output. Frequent fluid level checks must be performed.

b. Personnel/time required.

3 soldiers/2.0-24.0 hours

c. Materials/tools.

Sandpaper
 Epoxy (item 1 or 3, appx c)
 Plastic steel
 Metal plate
 Bulk issue fiberglass or epoxy kit (item 1 or 3, appx c)
 Permatex (hardening)

d. Procedural Steps.(1) *Option 1: Repair of small crack or hole.*

- (a) Remove all paint from around the crack.
- (b) Cover the crack and 1/4 inch or more of the surrounding area with quick-drying epoxy plastic.
- (c) Allow the epoxy to harden before running an engine. Use heat (heat lamp) to speed up curing of epoxy.

(2) *Option 2: Repair of small crack or hole.*

- (a) Remove all paint from around the area where metal plate is to be positioned.
- (b) Cover the area with a plate from any available metal large enough to cover the crack or hole. Seal the edges of the plate with quick-drying epoxy.
- (c) Allow epoxy to harden before running engine.

(3) *Option 3: Repair of small crack or hole.*

- (a) Clean damaged area.
- (b) Fill small crack or holes in low stress area either with permatex, fiberglass, or epoxy.

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

Section V. BRACKETS AND WELDMENTS

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

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

a. Limitations.

None

b. Personnel/time required.

2 soldiers/1.0 hours

c. Materials/tools.

Welding equipment
Elastic cords
Wire or rope (item 12, 33, or 34, appx c)
BII tiedown straps

d. Procedural Steps.

- (1) *Option 1.* If bracket is broken off at the base metal, with component mounting holes unaffected, reweld in place (figure 3-3). Mounting holes may be elongated to compensate for misalignment of attaching item.
- (2) *Option 2.* If the bracket mounting holes cannot be used because of stripped threads or broken bolts cannot be removed, weld the bracket to the location.
- (3) *Option 3.* If brackets cannot be welded or bolted, tie the component in place using rope, commo wire, Bungee cords or BII straps.

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

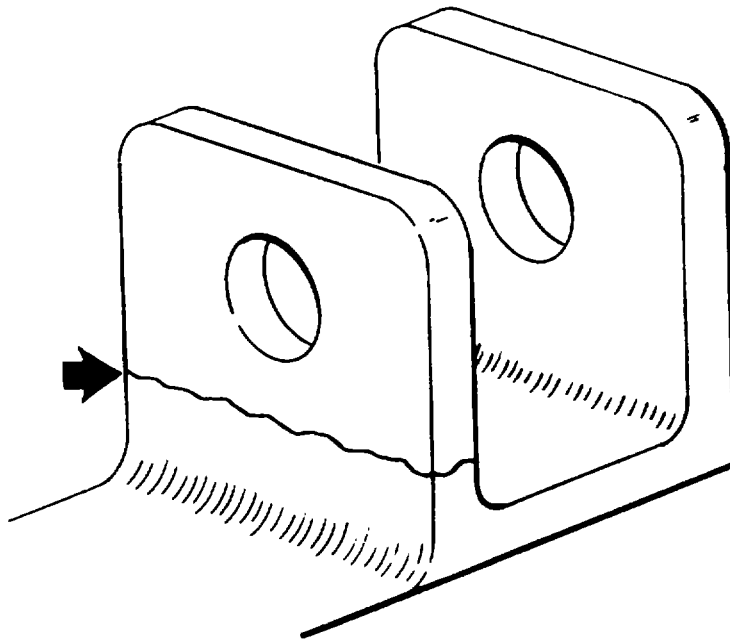


Figure 3-3. Bracket Broken.

Section VI. HARDWARE, MECHANICAL LINKAGES, CABLES AND PULLEYS

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

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

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

3-17. Hardware Mounting. Brackets and components can be connected or mounted without proper bolts. An iron rod or stud can be inserted through the connecting holes and peened over on each side. The mushroomed ends will keep the components together. A stud can be screwed into a threaded hole and a nut used to hold the component. If the proper size nut is not available, use a nut larger than the stud threads and peen the stud end to hold the nut in place. Linkages can also be connected by inserting a rod or bolt and peening the ends to keep it from dropping out of position.

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

a. Limitations.

Possible degraded output

b. Personnel/time Required.

1-2 soldiers/1.0-2.0 hours

c. Materials/tools.

Welding equipment
Drill
Hacksaw (item 1, appx 1)
Plate stock

d. Procedural Steps.

(1) *Option 1: Welding equipment available.*

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

(b) Measure rod length between connecting points.

- (c) Remove rod and weld.
- (d) Remove all metal fragments which would hinder rod operation.
- (2) *Option 2: Welding equipment is not available.*
 - (a) Cut needed material from bussie rack or hand rails to splint rod (figure 3-4).
 - (b) Measure rod length and drill holes through reinforcement and rod.
 - (c) Rivet or bolt reinforcement to damaged rod.
- (3) *Other options:* When push/pull damage is beyond repair, a substitute may be manufactured from plate stock.

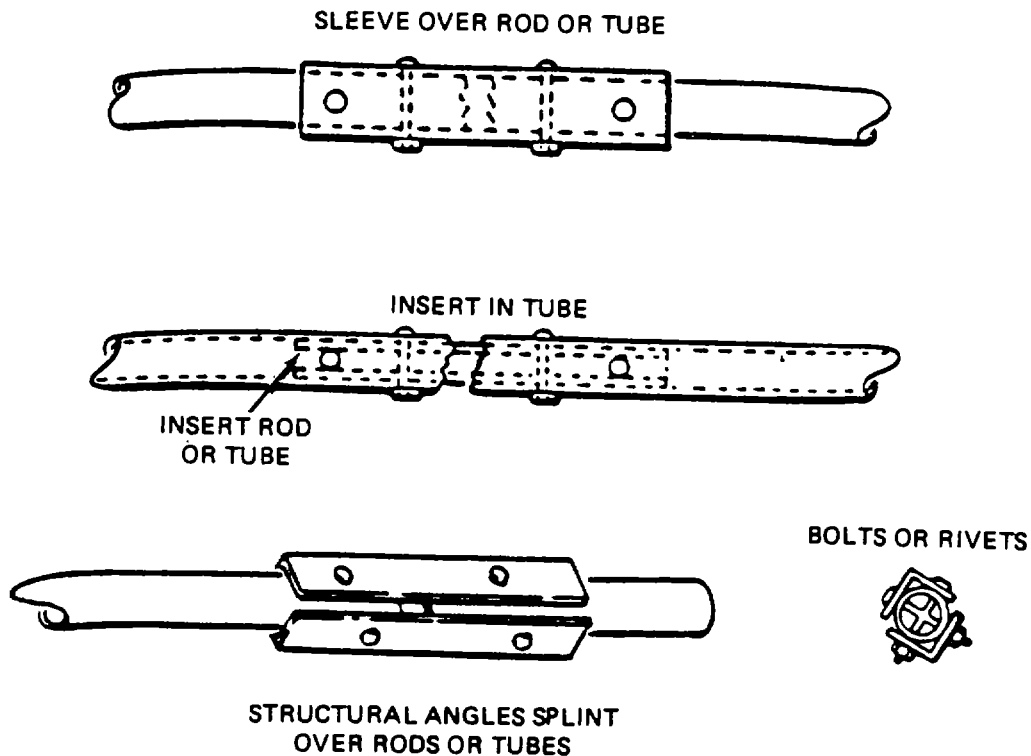


Figure 3-4. Push/Pull Rod Damage Repair with Splint.

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

3-19. Pin Alignment, Clevis, Cotter, Dowels, Quick Release, Etc. Most linkage have retainer devices, cotter keys, lacing wire or safety pins, to keep the connecting bolts or pins in place. During BDAR repairs, small pins may become lost or forgotten which will cause linkage or component failure. Repairing the generator by securing connecting bolts, or pins can be accomplished using wire, welding rod, bolts or nails. Place the item through the hole and bend the ends to keep it from falling out. Castelated nuts can also be retained using this method. Alignment pins or dowels can be replaced with cut bolts. Use a bolt that is a tight fit in the hole, tap the bolt in and cut to proper length.

CHAPTER 4

ENGINE

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

Section I. INTRODUCTION

4-1. Scope. Generator engines can be diesel, gasoline, or even turbine powered. Repair procedures on a diesel engine therefore might not apply to a gasoline engine and vice versa. Turbine engines are usually repaired at depot level since specialized training and tools are required. Engine damage can be detected by several different methods.

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

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

4-2. Assessment Procedure. Engine assessment procedures are structured using the logic process shown in figure 4-1.

WARNING

- **Engine and associated systems may be very hot. Use caution when performing all BDAR action to avoid being burned.**
- **Use personal protective equipment such as eye goggles, gloves, and hearing protection when performing BDAR actions. Serious injury can result when such equipment is not used.**

4-3. Repair Procedure Index.

Damage	Paragraph
Engine interchangeability	4-5
Engine Air Intake for Normally Aspirated Engines	4-6
Engine Air Intake for Turbocharged Engines	4-7
Air Cleaner, Clogged	4-8
Air Cleaner, Damaged/Leaking	4-9
Intake Manifold or Other Castings or Containers, Damaged	4-10
Exhaust Manifold, Damaged	4-12
Lubrication System Pump, Failure	4-14
Oil Level Low	4-15

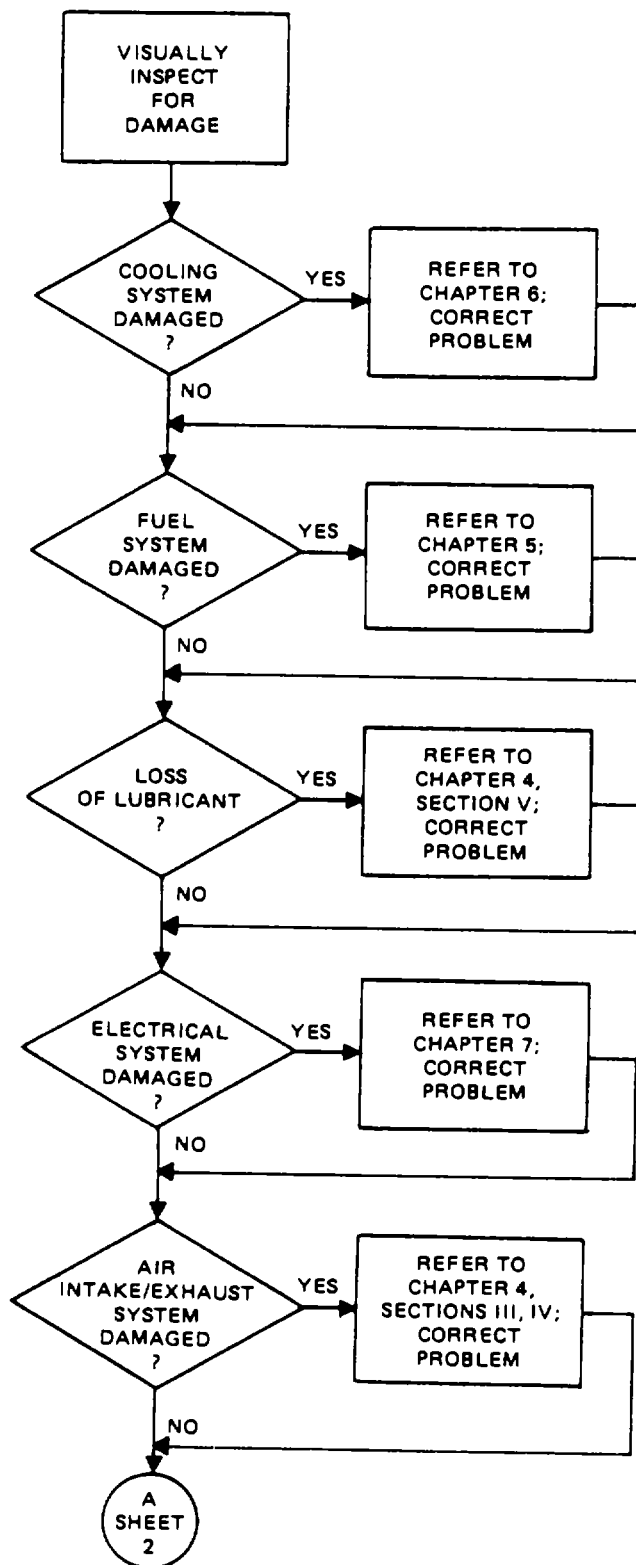


Figure 4-1. Engine Failure Assessment Procedure (Sheet 1 of 2).

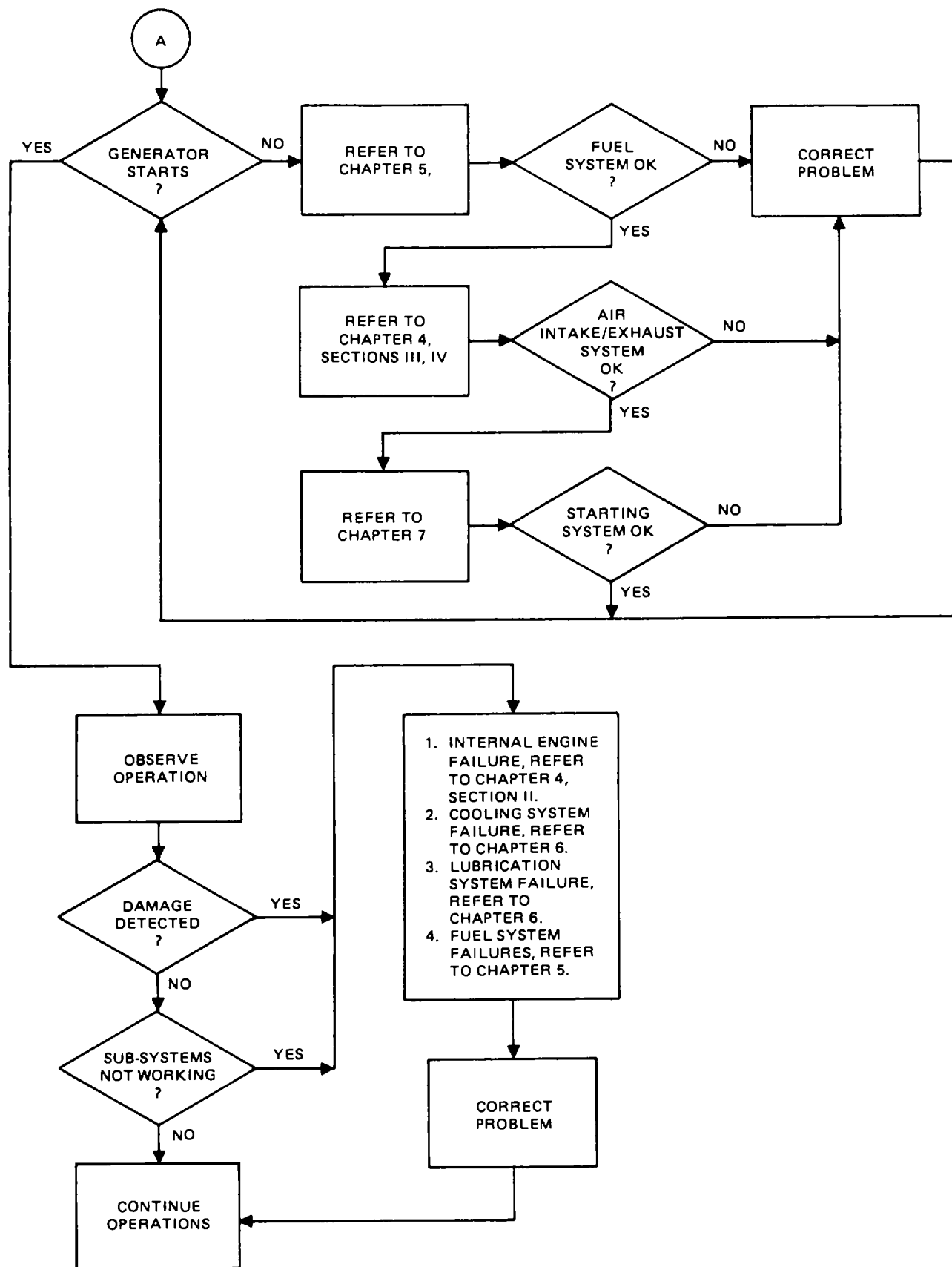


Figure 4-1. Engine Failure Assessment Procedure (Sheet 2 of 2).

Section II. ENGINE FAILURE

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

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

NOTE

Because there are so many engines procedures which vary depending on the generator being repaired, the operator should refer to the original maintenance technical manual for detailed instructions. A list of generator sets can be found in Appendix D, Table D-3.

Section III. ENGINE AIR INTAKE SYSTEMS

4-6. Engine Air Intake for Normally Aspirated Engines. Normally aspirated engines require that the first cycle piston movement is downward to create a vacuum drawing air into the intake system. The key to avoiding damage to this type of system is to prevent drawing unfiltered air into the engine. Repairs to this system should always be done with materials that do not block the air flow and are securely attached to prevent them being sucked into the engine intake manifold cylinder.

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

4-8. Air Cleaner, Clogged. The air cleaner is essential for keeping dirt and dust from getting into the engine. Under heavy dust conditions it can become clogged and restrict the air flow. Lack of air will result in incomplete fuel combustion resulting in reduced power and excessive exhaust smoke. Dirt should be blown out of the filter with compressed air directed from the inside of the filter element. The filter element should not be hit to dislodge dirt as this can deform the sealing element and let dirt into the engine, causing internal damage.

a. Limitations.

None.

b. Personnel/time required.

1 soldier/.25 hours

c. Materials/tools.

d. Procedural Steps.

(1) Remove air cleaner elements.

(2) Clean filters using one of the following possibilities:

- (a) Dismount a blower motor (such as dust exhausters), connect to power source with long leads, and blow dirt from air cleaner.
- (b) Disconnect exhaust hoses from all but one blower. Connect hoses together using tape to gain sufficient length to reach outside. Start engine and blower, blow dirt deposits from filters.
- (c) Use air from a disabled wheeled vehicle's tires. Remove valve stem and connect rubber hose to valve and proceed to blow out filters.
- (d) Use brake air tank from wheeled vehicle by connecting rubber hose or place filter directly under air flow from valve.
- (e) Other options: Use vacuum cleaner. Gently tap filter against hard surface.

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

4-9. Air Cleaner, Damaged/Leaking. The air cleaner must filter all incoming air for the engine. Damage or leaks that cause the air cleaner to be ineffective must be repaired. Any leaks in the filter housing or duct work can be taped over or covered by a rag that will filter any air coming through the leak. Sealing the leak is preferred. Only as a last resort should the air cleaner be bypassed or eliminated. Damage will occur as the engine ingests the dirt and dust in unfiltered air. If the only option is to eliminate the air filter, this procedure will allow a minimum amount of air filtration.

a. Limitations.

Possible degraded output

b. Personnel/time required.

1 soldier/.50 hours

c. Materials/tools.

Duct or electrical tape (item 22, appx c)

Section cut from blanket or shirt

d. Procedural Steps.

- (1) Disconnect the air hose at the attachment to the engine (figure 4-2).
- (2) Cover the air inlet with clean rag (use a shirt or blanket if no rags are available). Clean the rag whenever it gets dirty.
- (3) Anchor the cloth tightly to the air intake with a hose clamp or wire, otherwise the strong vacuum will suck the rag into the engine.
- (4) Other options: Bypass or eliminate air cleaner.

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

4-10. Intake Manifold or Other Castings or Containers, Damaged. Intake manifolds are difficult to repair. Autobody fillers, epoxys or gasket sealers can seal cracks. Holes will require welding because of irregular surfaces. Tape will provide a temporary seal on unpressurized air intake portions but has minimal value for pressurized systems without metal or wire re-enforcement. Epoxy kits will make an almost permanent repair, if time is available for curing. Follow the individual kit directions.

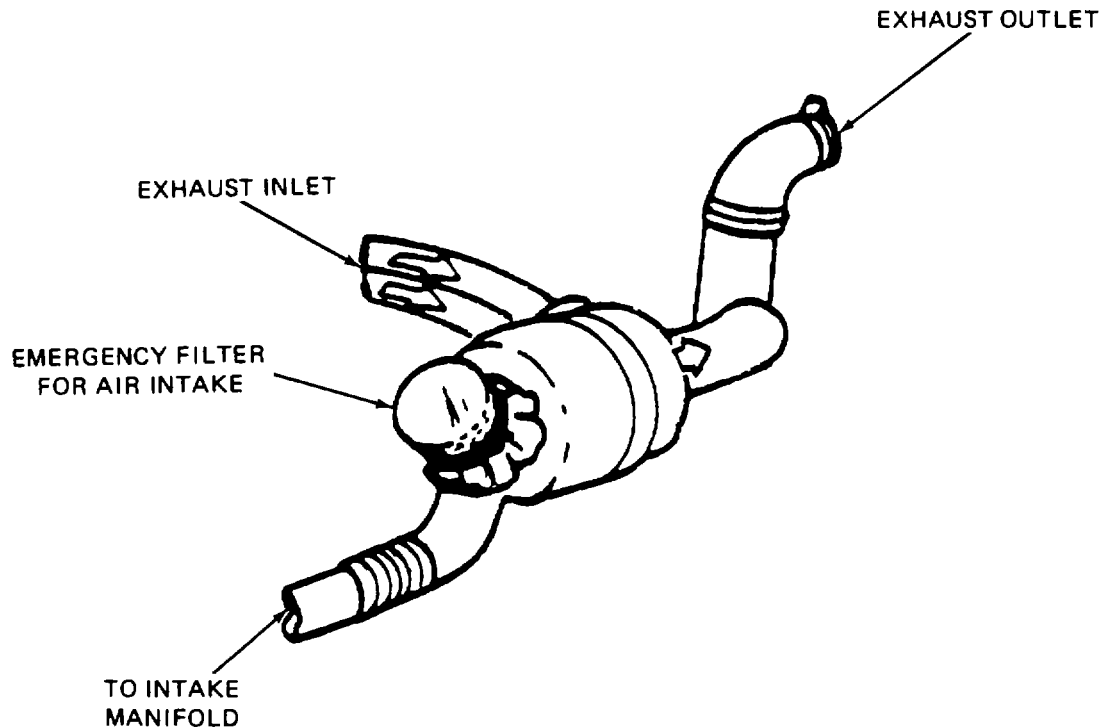


Figure 4-2. Emergency Filter for Air Intake.

Section IV. ENGINE EXHAUST SYSTEMS

WARNING

Breathing exhaust gases can be fatal. Avoid direct exposure to exhaust gases. Do not perform maintenance with generator running in an enclosed area such as tents without adequate ventilation.

4-11. General. The engine exhaust system consists of the exhaust manifold, muffler and pipes to route the gases to the muffler. Turbocharged engines have the exhaust gases routed through the turbocharger to drive the vanes. Damage to the muffler or pipes, not including the ducting for the turbocharger drive circuit, is inconvenient but the generator can still be operated. Care must be taken, however, to keep carbon monoxide away from the operator.

4-12. Exhaust Manifolds, Damaged. Damaged manifolds are indicated by loud noises. Any damage to the exhaust manifolds upstream of the turbocharger will degrade engine operation. Continued engine operation may set the fuel lines on fire.

a. Limitations.

None

b. Personnel/time required.

1 soldier/.25-.50 hours

c. Materials/tools.

Fiberglass sheet or sheet metal (item 5, appx c) or
Clamp (item 3, appx b)

d. Procedural Steps.

- (1) Gain access to the damaged manifold.
- (2) Obtain a sealing material (fiberglass sheet preferred), cut sheet to cover the hole or leak.
- (3) Secure the sheet in place using hose clamps.

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

Section V. ENGINE LUBRICATION SYSTEM

4-13. General. Engine lubrication is essential for all moving components, however, crankshaft bearings and diesel engine piston crowns are critical. The pressure lubrication of the bearings and the cooling spray to the piston crowns are examples of the dual purpose of the engine lubricant. Bypassing or rendering any portion of the lubrication system inoperative will degrade the length of the engine life.

4-14. Lubrication System Pump, Failure. The oil pump is needed to provide lubrication to engine components. Low or no reading of gage or warning light indicates a problem. The main and rod bearings as well as a minimal splash lubrication of the pistons is possible by overfilling the crankcase with oil. However, the turbocharger will not receive any lubrication from, overfilling. Valve train components will also lack lubrication but can operate for short time periods. Overfilling the crankcase with oil is a last resort option which should only be used in case of emergency. Engine failure will occur if used for normal or limited operation.

a. Limitations.

Severely degraded operation

b. Personnel/time required.

1 soldier/.25-.33 hours

c. Materials/tool.

Cooking oil
Engine oil
Transmission oil
Diesel fuel

d. Procedural Steps.

- (1) Check oil level.
- (2) Obtain enough engine oil or substitute to overfill crankcase.
- (3) Overfill the crankcase.

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

4-15. Oil Level Low. Oil levels can become low because of leakage or burning the oil through normal engine operation. If oils prescribed by the LO are not available, use substitutes listed in Appendix C. Oils other than those designed for use in engines will provide only limited lubrication. When using diesel fuel, do not dilute the lubrication more than approximately 3 parts diesel fuel to 1 part engine oil except in extreme emergencies. Operate a slower engine speed to prevent damage to the engine. DO NOT dilute lubricating oil with gasoline.

CHAPTER 5

FUEL SUPPLY SYSTEM

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

Section I. INTRODUCTION

5-1. Scope. Fuel supply systems consist of fuel storage tanks, fuel pumps, filters and the tubes and hoses needed to route the fuel to the engine. Some systems use electrical fuel pumps located in the tanks and a mechanized engine mounted fuel pump to move the fuel. Other systems mount the fuel storage tank in a location which allows gravity flow of the fuel to the engine assisted by an engine mounted mechanical pump. A diesel engine can be severely damaged by using unfiltered fuels. Two filters are mounted in series to provide a primary and secondary filtration system to trap dirt and other contaminants. Fuel filters must be checked for accumulations of dirt and water.

5-2. Assessment Procedure. Fuel supply assessment procedures are structured using the logic process shown in figure 5-1.

WARNING

- **Do not weld on fuel tanks unless they have been thoroughly drained and purged of fuel. Failure to heed this warning may result in an explosion and fatal injuries.**
- **Use personal protective equipment such as eye goggles, gloves, and hearing protection when performing BDAR actions. Serious injury can result when such equipment is not used.**

5-3. Repair Procedure Index.

Damage	Paragraph
Fuel Tank Leaks	5-5
Fuel Tank Substitute	5-8
Fuel Pump, Interchangeability	5-10
Fuel Pump, Mechanical Failure	5-11
Seals, Fuel System, Leak	5-13
Fittings, Leaking	5-14
Fuel Line (Low Pressure Rupture)	5-15
Fuel Injector Line, Rupture	5-16
Fuel Filter Clogged or Frozen	5-20

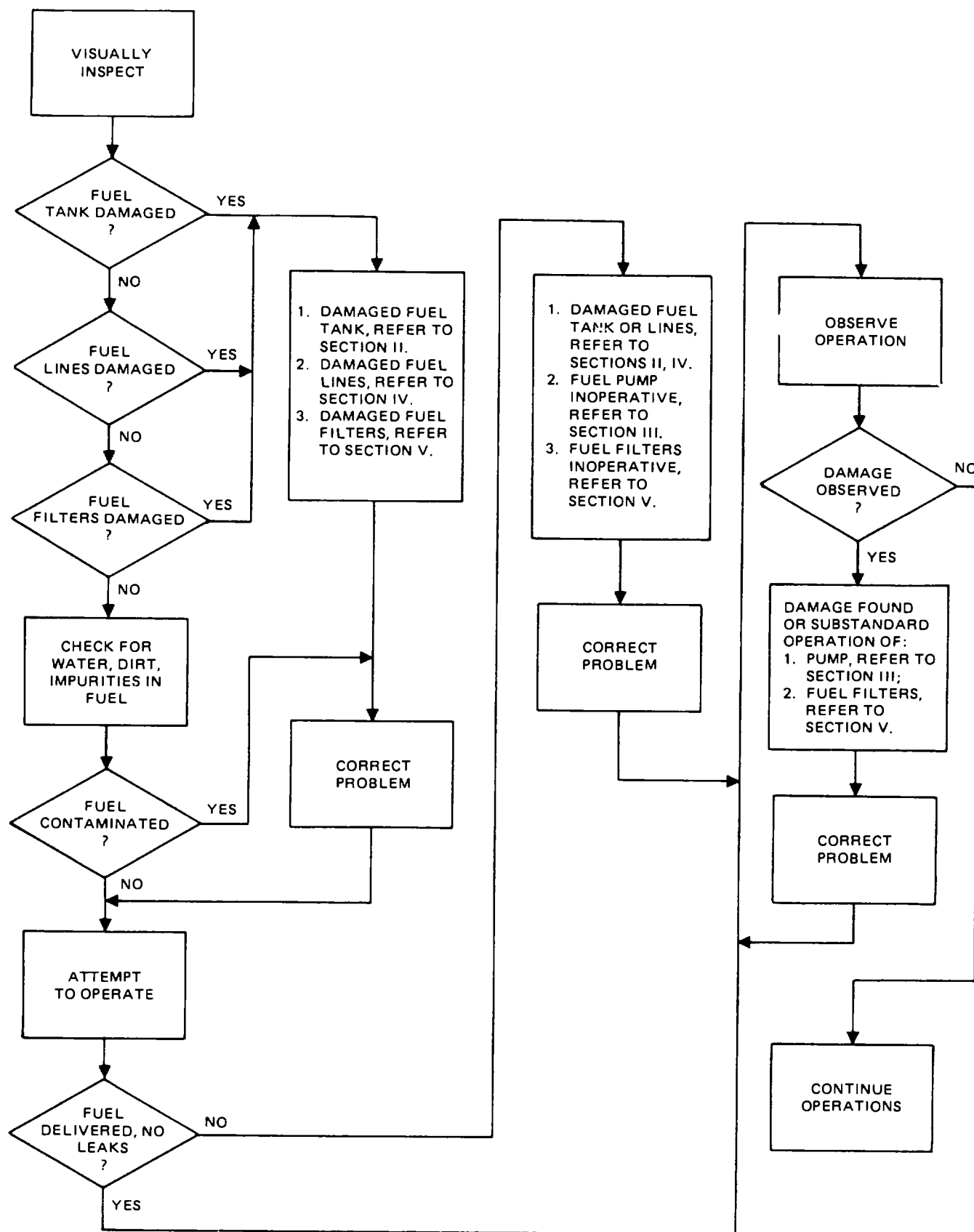


Figure 5-1. Fuel Supply System Failure Assessment.

Section II. FUEL STORAGE SYSTEMS

5-4. General. Fuel storage systems may be enclosed metal containers or nylon fiberglass tanks. All systems are susceptible to contamination from dirt or water. Metal tanks are susceptible to corrosion which will contaminate the stored fuel. Draining and purging fuel tanks of contaminants is of major-importance for long usage. Leakages caused by normal vibration or actual combat damage must be repaired before the generator can be used.

5-5. Fuel Tank, Leaks. Fuel tank leaks are difficult to repair in a battlefield environment. The repairs are also dictated by the type of material from which the fuel tank is manufactured. Fuel leakage is an indication that a fuel storage container is damaged. Time required for repairs will vary with the fuel tank location and ease of access for repairs. The area surrounding the damage must be cleaned to make a good repair.' Heat will hasten curing of fiberglass or epoxys.

5-6. Option 1: Repair of Fuel Tanks.

a. Limitations.

Should be checked for leaks frequently

b. Personnel/time required.

1-3 soldiers/2.06.0 hours

c. Materials/tools.

Epoxy (item 1 or 3, appx c)
Fiberglass repair kit
Gasket sealer (item 13, appx c)
Pop-rivets

d. Procedural Steps.

- (a) Gain access to fuel tank.
- (b) Drain fuel tank. and fill with water before drilling.
- (c) Clean oil and fuel residue from damaged area.
- (d) Rough up area around damage with sandpaper or a file.
- (e) Repair using one of the following:
 - 1 Apply fiberglass following kit instructions.
 - 2 Mix and apply epoxy following kit instructions.
 - 3 Cut sheet metal patch, drill tank and patch, coat patch liberally with fuel resistant gasket sealer. Attach Patch with pop-rivet heads with sealer.
- (f) Reinstall fuel tank, if removed.
- (g) Other options: plug hole.

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

5-7. Option 2: Plugging Holes, Metal or Fiberglass Tanks.**a. Limitations.**

Should be checked for leaks frequently

b. Personnel/time required.

1-3 soldiers/1.0-3.0 hours

c. Materials/tools.

Rubber hose (item 8, 9, or 10, appx c)

Bolt and nut

2 large flat washers (item 32, appx c)

d. Procedural Steps.

- (a) Gain access to fuel tank hole.
- (b) Drain fuel until level is below the hole.
- (c) Obtain hose the approximate size of the hole.
- (d) Using a round file, fill the hole to a size equal to the hose diameter.
- (e) Assemble the hose, bolt, nut and washers (figure 5-2).
- (f) Coat the hose assembly with sealer to aid in the repair.
- (g) Insert the hose assembly into the hole.
- (h) Tighten the bolt and nut to make the hose expand and seal the fuel tank hole.
- (i) Reinstall the fuel tank, if removed,

WARNING

Do not use open flame to repair fuel tanks as fumes could cause explosion and death or injury to personnel. Use soldering gun or soldering iron only.

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

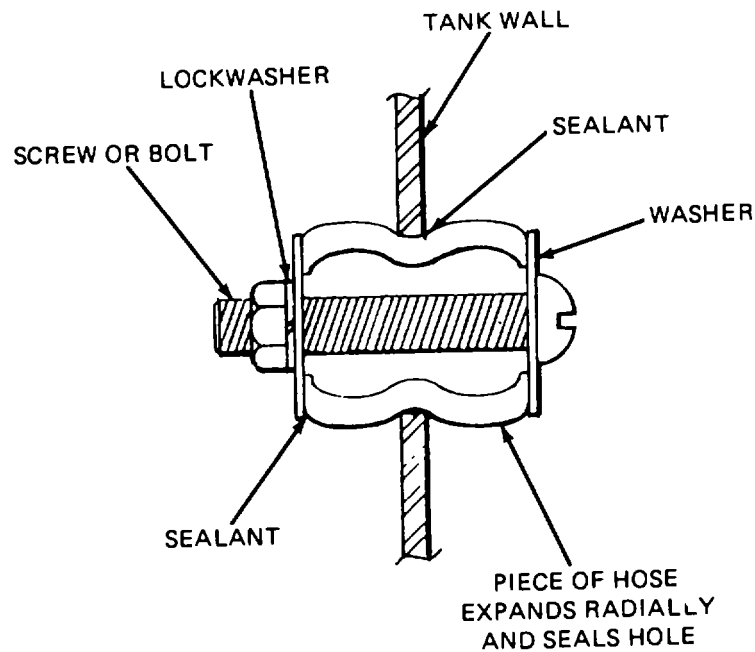


Figure 5-2. Plugging Holes in Metal or Fiberglass Tank.

5-8. Fuel Tank Substitute. Tactical operations may not allow sufficient time to make normal or expedient repairs to the generator's fuel tank. A more rapid repair can be improvised by installing a substitute fuel tank. The fuel tank should be mounted to avoid interfering with operating components. Use as large a container as possible. All DOD generator sets are equipped with an auxiliary fuel connection point in order to facilitate the use of any external fuel supply. A fuel hose of sufficient length must be fabricated to connect the external fuel tank to the auxiliary fuel connection point. If fittings will not go with jury rigged tank, fill hose with fuel and insert the end into the tank. Be sure the fuel tank is higher than the auxiliary fuel connection point to facilitate siphoning.

a. Limitations

Possible limited operating time

b. Personnel/time required.

1 soldier/0.5-1.00 hours

c. Materials/tools.

Fuel container (5 gallon gas or oil can, 55 gallon drum, etc.)
 Neoprene fuel line
 Hose clamp (item 5, appx c)
 Rope or strands (item 12, appx c)

d. Procedural Steps.

- (1) Locate a temporary fuel container.
- (2) Obtain a fuel line.
- (3) Connect fuel line to container.
- (4) Secure temporary fuel container to the outside of the generator in a position to allow gravity feed for the fuel.
- (5) Connect fuel line to the inlet side of the mechanical or electrical generator fuel pump.
- (6) Bleed the air from the fuel line.

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

Section III. FUEL PUMPS

5-9. General. It would be a tremendous duplication of effort to give procedures for changing fuel pumps in all generator configurations. These procedures are adequately described in the respective maintenance technical manuals. What is not given in these technical manuals is a list of alternate sources of supply for each respective fuel pump in case a spare is unavailable. See Appendix A for a list of alternate sources of supply.

5-10. Fuel Pump, Interchangeability. Electric fuel pumps on generators can be interchanged with other generators and sometimes combat vehicles. The difference in the pumps is normally the brackets used to locate the electrical unit. The electrical fuel pump can be dismounted from the brackets and installed in the bracket for the generator being repaired. The electrical fuel pump can be clamped using the existing clamps or using an adjustable clamp from an air cleaner ducting system. Use a strip of rubber or a rubber hose to aid in holding the pump in position. The generator/vehicle heater fuel pumps can be used to provide fuel to the engine.

5-11. Fuel Pump, Mechanical Failure. Electric fuel pumps will not supply the fuel pressure required by the injector system if the mechanical fuel pump fails. However, limited operation in a degraded mode is possible by replacing the mechanical pump with an electrical fuel pump. Mechanical pumps are substitutable with adequate operational capabilities within the same engine family.

Section IV. FUEL LINES AND VALVES

5-12. General. Fuel lines route the fuel from the storage tanks to the filters and the engine fuel system. Lines are a combination of hoses and metal tubes. Leaks and fuel line blockages are common failures. Clogged lines can be cleared by blowing compressed air through them. Broken or cracked lines must be repaired or bypassed.

5-13. Seals, Fuel System, Leak. O-rings are used in some systems to seal the fuel in the lines. BDAR as well as normal repairs will damage the O-rings. Fuel absorption will cause the O-rings to swell causing reinstallation problems since they no longer fit into the O-ring groove. Some repairs are possible if the O-ring is damaged. Swelled O-rings can be allowed to dry until they shrink in size enough to fit: Torn or cut O-rings can be replaced using a larger O-ring and cutting it to length. If an adhesive is available, glue the cut ends together. O-rings with small cuts can be coated with a silicone gasket sealer to seal the leakage caused by the cut. Leaking fittings should first be tightened to attempt an easy repair.

5-12. Fittings, Leaking. Flared fuel fittings will start to leak because of engine vibrations or overtightening. Leaking fittings should first be tightened to attempt to stop the leak. If tightening does

not stop the leak, string can be used to push the flared tubing more firmly against the connecting surface. Coating the string with a gasket sealing compound will aid in stopping leaks in a low pressure fuel line.

a. Limitations.

None

b. Personnel/time required.

1 soldier/0.5-1.0 hours

c. Materials/tools.

Fuel resistant sealant (silicone, neoprene or similar material) (item 2, appx c) String or light tie cord

d. Procedural Steps.

- (1) Remove coupling flange nut (figure 5-3).
- (2) Slide coupling flange nut up, away from flared end.
- (3) Clean grease, oil and fuel from flared end.
- (4) Wrap string around flared end of line.
- (5) Coat string liberally with fuel resistant sealant.
- (6) Reinstall line and tighten nut securely.
- (7) Check for leaks. If still leaking, repeat procedure using more string.

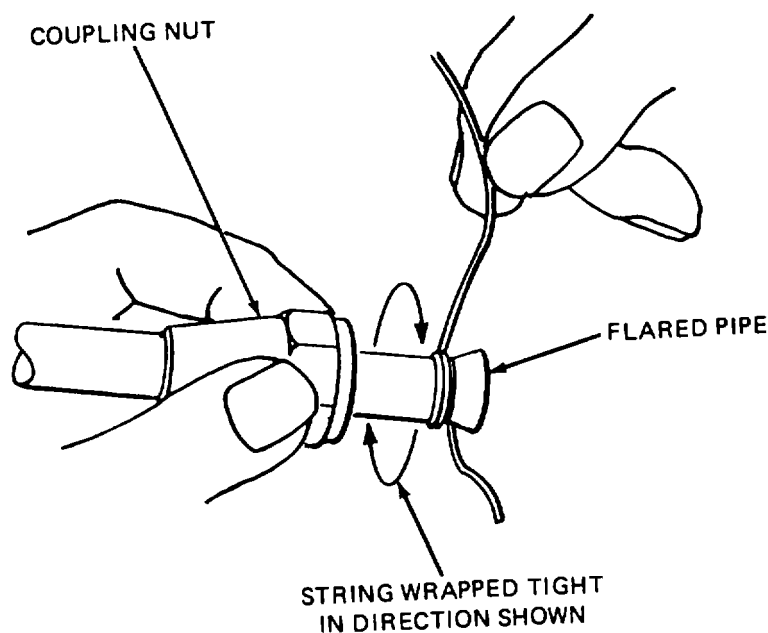


Figure 5-3. Stopping Leaks in Low Pressure Coupling.

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

5-15. Fuel Line (Low Pressure Rupture). Low pressure fuel lines can rupture or crack for various reasons. Frozen water in the lines, vibrations, rubbing against other components or impact can all cause the line to rupture or crack. Repairs can be performed rapidly to stop the leakage and continue the mission.

a. Limitations.

None

b. Personnel/time required.

1 soldier/0.5-10 hours

c. Materials/tools.

Tape (item 21, 22, or 23, appx c)
 Wire (item 33 or 34, appx c)
 Fuel hose (item 8, 9, or 10, appx c)
 Hose clamps (item 5, appx c)
 Sealant (item 14, appx c)
 Metal tubing (mirror arms, old hydraulic line, or similar material)
 Thin sheet metal (coffee can, can, or similar material)
 Shell casing, 5.56 mm or 7.62 mm

d. Procedural Steps:

(1) *Options 1: Repair of damaged fuel hose.*

(a) Cut out damaged portion of hose (figure 5-4).

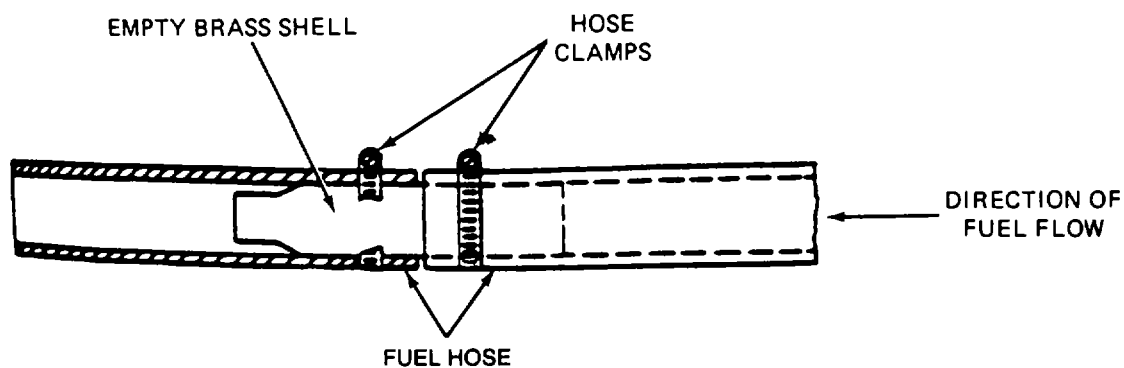


Figure 5-4. Fuel Hose Repair.

(b) Cut a piece of metal tubing longer than the length of the hose section removed. If tubing is not available, cut the ends from a 5.56 or 7.62 mm shell casing.

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

(d) Insert the metal tubing into the hose ends.

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

(2) *Option 2: Repair of metal tubing cracks.*

(a) Clean all dirt and grease from around the crack (figure 5-5).

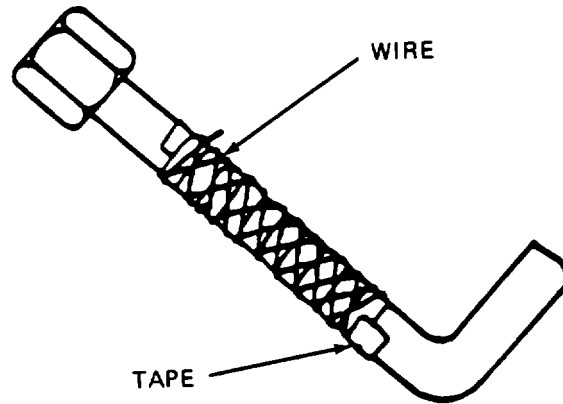


Figure 5-5. Metal Tubing Cracks Repair.

(b) Coat the crack with sealant.

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

(d) Clamp the sheet directly over the crack.

(e) If clamps are not available, wrap the tubing with tape.

(f) Wrap wire around the tape as re-enforcement.

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

(3) *Option 3: Repair of holes in metal tubing.*

(a) Cut out damaged portion of metal tubing (figure 5-6).

(b) Clean both ends of tubing.

(c) Cut a piece of neoprene hose two inches longer than the length of removed tubing.

(d) Apply sealant to both ends of tubing.

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

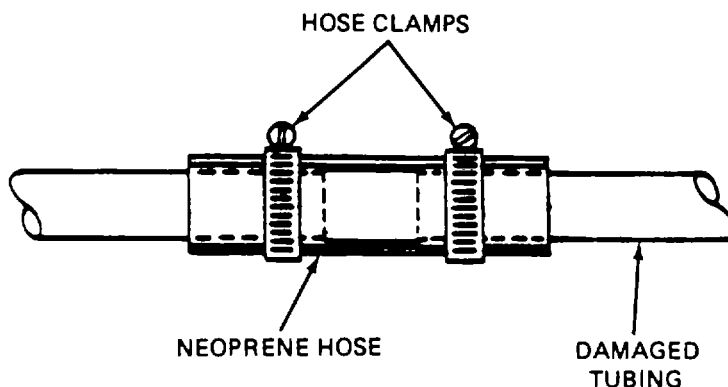


Figure 5-6. Metal Tubing Holes Repair.

- (f) Secure with hose clamps or tightly twisted wire.
- (g) If the hose is too large, the tubing can be flared or sleeved to fit.
- (4) *Option 4: Patching large metal lines.*
 - (a) Smooth damage areas to remove rough edges (figure 5-7) .

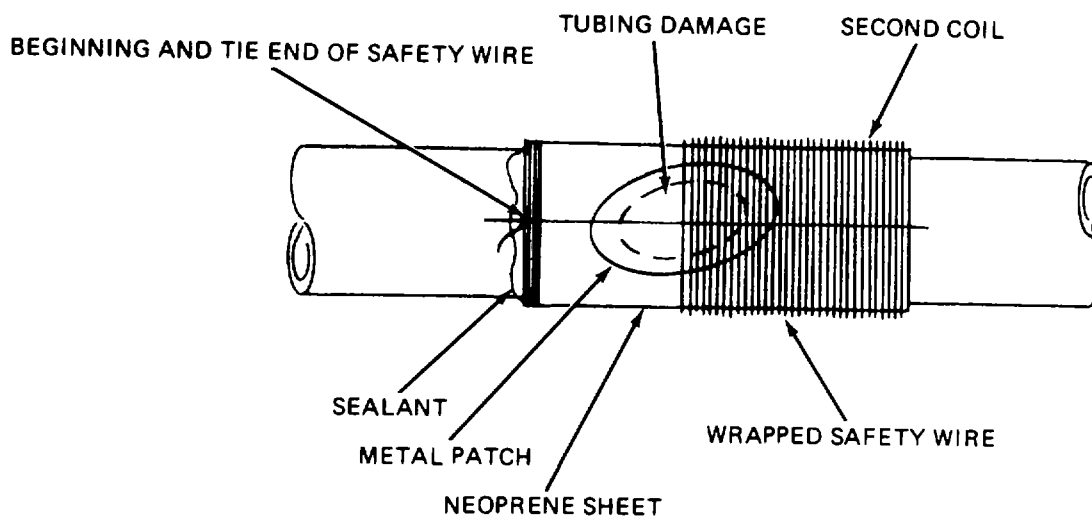


Figure 5-7. Large Metal Lines Patch.

- (b) Clean dirt and oil from damaged area.
- (c) Cut a metal patch from sheet metal.
- (d) Coat the metal patch and tubing with sealant and place over damaged area.
- (e) Cut a patch from neoprene or other fuel resistant material and wrap over metal patch.
- (f) Wrap neoprene patch with wire to equalize the pressure over the repair.

(5) *Option 5: Repairing damaged bends.*

- (a) Cut a bend from an old hydraulic line, mirror arm or similar material (figure 5-8).
- (b) Remove the damaged bend from the line.
- (c) Clean the cut tubing ends.
- (d) Apply sealant to tubing ends.
- (e) Using two, 2-inch sections of neoprene hose, install the replacement bend.
- (f) Clamp with hose clamps or tightly twisted wire.

(6) *Other options: Seal the crack with epoxy.*

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

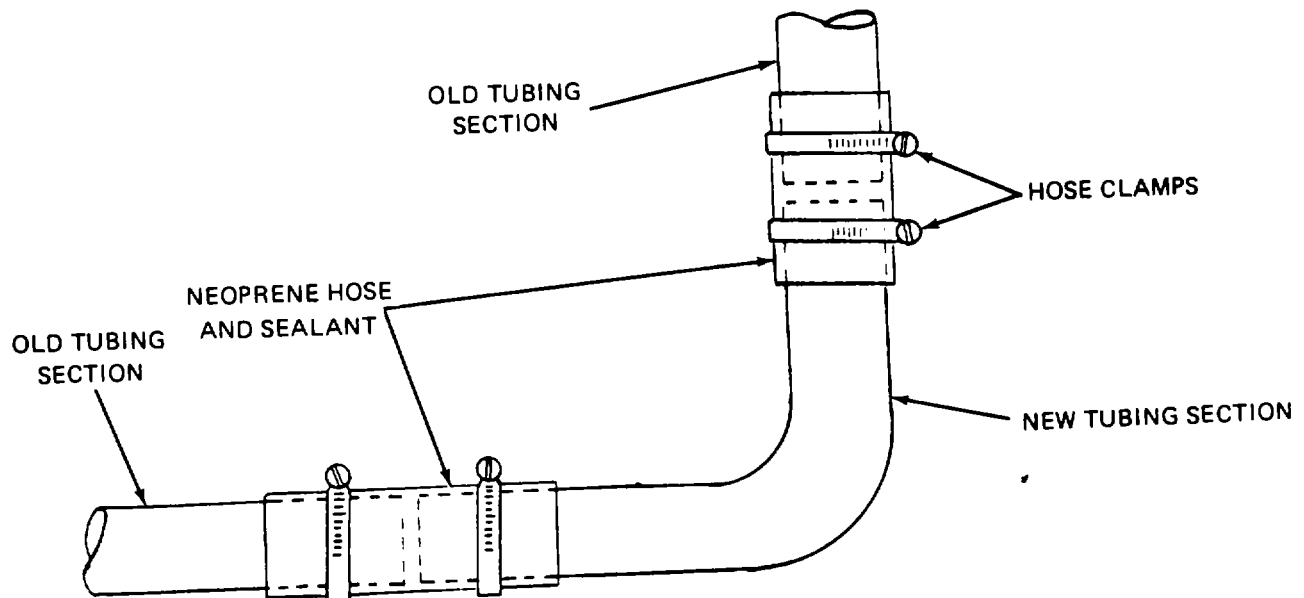


Figure 5-8. Damaged Bends Repair.

5-16. Fuel Injector Line, Rupture.

5-17. Option 1: Cut Out Line. If a high pressure fuel line is damaged and there is not time for a better repair, cut the line and weld or crimp shut the injector pump side. The engine will run for a limited time on fewer cylinders.

5-18. Option 2: Repair Line. If a replacement line is not available, repair the defective line. Remove it from the generator and clean it. Braze pin holes closed. If the hole is too large for this procedure, cut out the section of line. Use a piece of slightly larger metal tubing as a sleeve, overlapping both cut ends of the injector line. The sleeve should fit tightly over the injector line; if it is too loose, crimp to get a tight fit. Then braze or silver solder both ends of the sleeve to the fuel line.

Section V. FUEL FILTERS

5-19. General. Fuel filters are needed to remove dirt and water from the fuel. Dirt and water will cause damage to the fuel injectors if fuel is not filtered. Fuel filters are normally mounted in series, a primary and a secondary filter. Fuel filters should only be by passed as a last resort.

5-20. Fuel Filter Clogged or Frozen. The first indication of clogged or frozen fuel filters will be a failure of the engine to start or degraded performance due to insufficient fuel. Fuel filters if drained periodically should not freeze. Clogged filters must be cleaned or changed to correct the problem.

a. Limitations.

Possible engine internal damage if filters are bypassed.

b. Personnel/time required.

1-2 soldiers/0.25-0.33 hours

c. Materials/tools.

d. Procedural Steps.

(1) Option 1: Cleaning filters.

- (a) Gain access to fuel filters.
- (b) Remove the fuel filter from the canister.
- (c) Rinse the filter in a pan of fuel or blow out with compressed air; if frozen thaw out.
- (d) Reinstall the fuel filter.
- (e) Start the engine.

(2) Option 2: Bypassing the filters.

- (a) If the engine will not start, disconnect the fuel inlet line.
- (b) Disconnect the fuel outlet line and reconnect it to the fuel inlet line.

(3) Other Options: Remove filter elements.

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

CHAPTER 6

COOLING SYSTEM

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

Section I. INTRODUCTION

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

6-2. Assessment Procedure.

a. Air Cooling System Assessment. Air cooling system assessment procedures are structured using the logic process shown in figure 6-1.

b. Liquid Cooling System Assessment. Liquid cooling system assessment procedures are structured using the logic process shown in figure 6-2.

6-3. Repair Procedure Index.

Damage	Paragraph
Shrouds, Ducts, Engine Compartment Cover, Air Cooling, Damaged	6-5
Coolant Substitutes	6-6
Thermostat, Stuck	6-7
Engine Coolant, Frozen	6-8
Radiator, Leaking	6-9
Hose Clamp, Broken	6-13
Hose, Leakage	6-14
Hose, Collapse	6-15
Hose Improvisation (Low Pressure)	6-16

Section II. AIR COOLING SYSTEMS

6-4. General. Cooling system failures can result in engine failure and therefore must be dealt with if the engine is expected to operate for any length of time. Cooling system problems most often are indicated on the operator's instrument panel. While temporary overheating indications may result from excessive workload on the engine, repeated overheating indication or constant indication of overheating is almost always followed by a major cooling problem.

6-5. Shrouds, Ducts, Engine Compartment Cover, Air Cooling Damaged . Shrouds are used to direct the cooling air over the hot engine. Bent or torn shrouds will upset the flow-of air and cause hot spots to occur which can cause internal engine failures. The engine compartment is designed to direct airflow via the shrouds and ducts and if damaged, can also cause hot spots or excessive noise. Torn shrouds can be bent back into shape and patched with sheet metal, epoxy kits or tape to restore the proper air flow. At a minimum, they must be bent to prevent contact with moving components. If the existing shrouds cannot be repaired, new shrouds must be fabricated from sheet metal. The same applies to engine compartments, covers, and ducts.

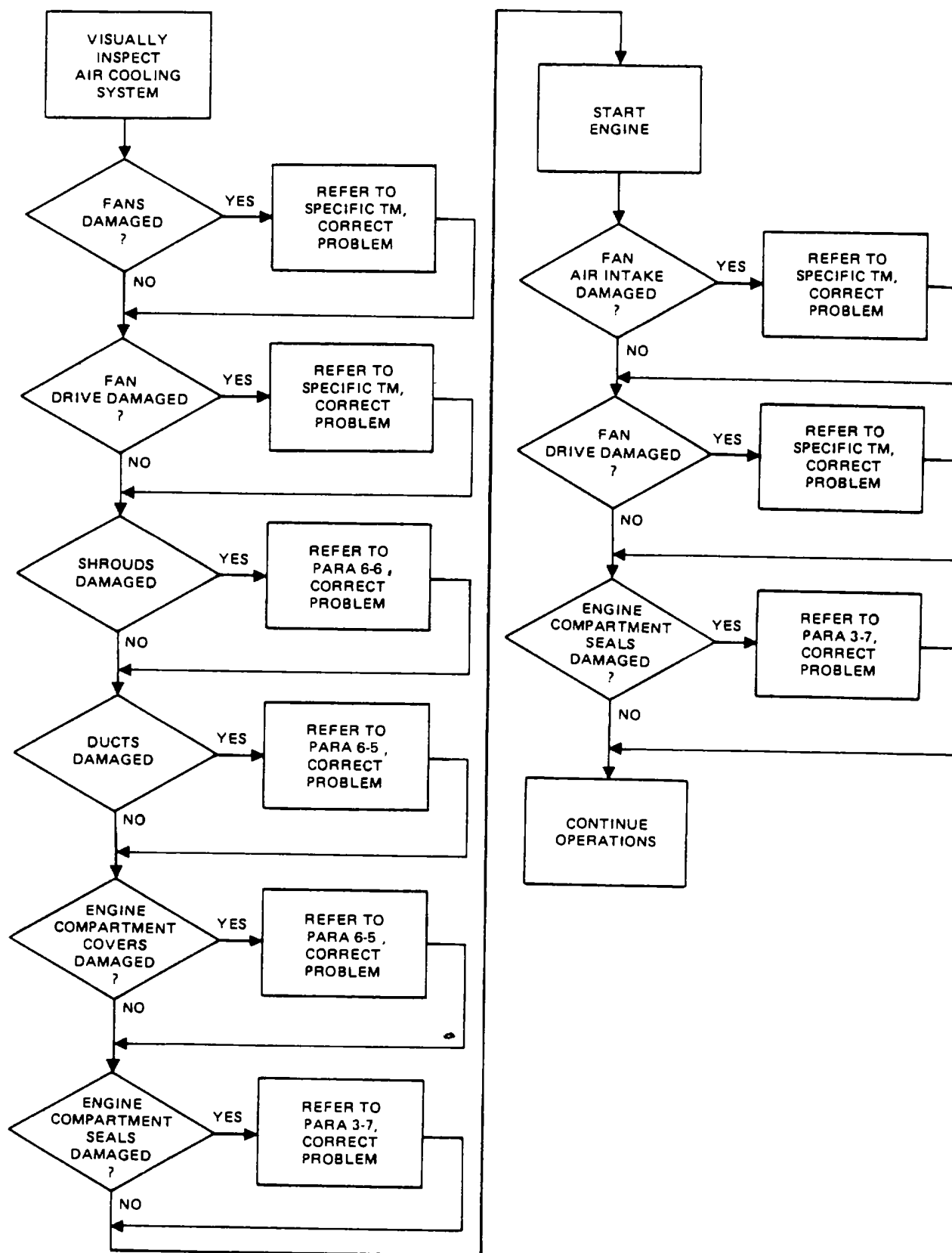


Figure 6-1. Air Cooling System Failure Assessment.

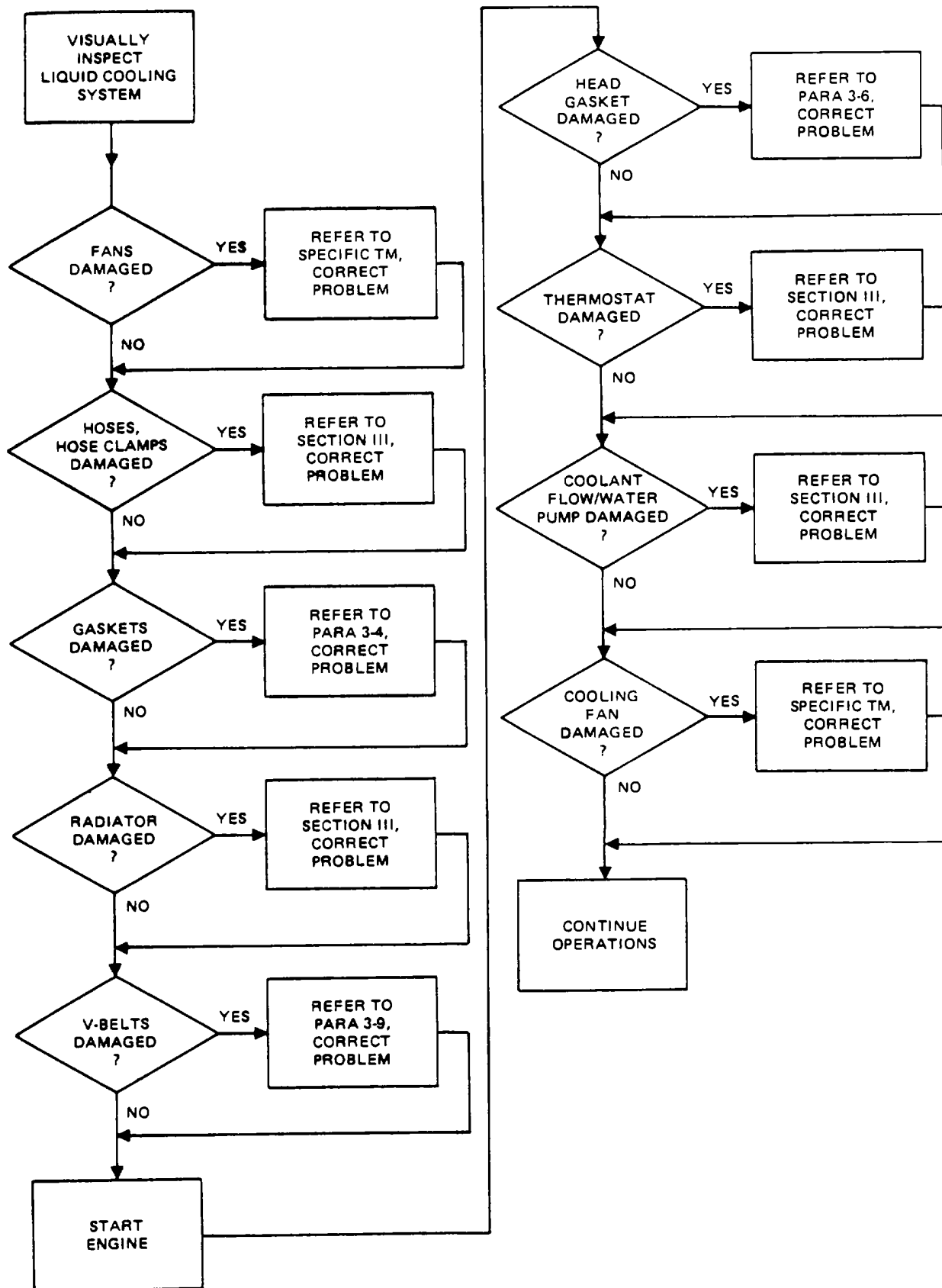


Figure 6-2. Liquid Cooling System Failure Assessment.

Section III. LIQUID COOLING SYSTEM

6-6. Coolant Substitutes. During performance of repairs, or as a result of leakage, the coolant may become lost. A liquid cooled engine cannot operate for long without coolant. When normal coolants are not available a substitute may be used. Any liquid, except gasoline or jet fuels, can be used as a substitute but some liquids will deteriorate the cooling system rubber components. Petroleum products will not transfer the heat as efficiently as a water-based coolant, but will work if nothing else is available. Old engine oil or fluids drained from damaged vehicles, transmission oil, hydraulic systems, may be a possible source of fluids. The cooling system must be drained and flushed as soon as possible if petroleum-based fluids are used.

6-7. Thermostat, Stuck. The thermostat regulates the engine operating temperature, from 180 to 195 degrees F., by controlling coolant flow through the engine. When the thermostat is stuck in the closed position it prevents coolant from circulating and causes engine overheating. BDAR repair is to remove the thermostat and operate the generator. If the thermostat is stuck in the open position or removed, it may degrade engine performance and increase fuel consumption.

6-8. Engine Coolant, Frozen. During cold weather, inadequate antifreeze protection will cause the coolant to freeze. Care must be taken when thawing the cooling system that further damage is avoided. The water pump may be unable to turn which will damage drive belts as well as the pump itself. The thawing procedure must include frequent inspections for leaks which will indicate cracked or broken components. Engine temperature must also be monitored to prevent overheating damage.

a. Limitations.

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

b. Personnel/time required.

2 soldiers/0.5-1.0 hours

c. Materials/tools.

d. Procedural Steps.

- (1) Gain access to radiator and power pack.
- (2) Inspect for amount of ice and obvious cracks in coolant system components.
- (3) If coolant is solid, remove or disengage the water pump drive belts.
- (4) Start the engine and allow to warm up, but not get hot.
- (5) Shut down the engine and allow the heat to radiate into and melt the ice.
- (6) Attempt to turn water pump pulley.
- (7) When the water pump pulley can be turned reinstall the drive belts.
- (8) Restart the engine and allow to warm up but not overheat.
- (9) Other options: Route air from fuel vehicle heater over the radiator. Route a vehicle's exhaust over the radiator.

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

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

6-10. Option 1: Repair of Small Hole.

a. Limitations.

None if leak is stopped and operating temperature does not increase

b. Personnel/time required.

1 soldier/0.25-0.5 hours

c. Materials/tools.

Stop leak chemical
Tobacco
Pepper
Eggs
Oatmeal
Farina (cream of wheat)
Corn meal

d. Procedural Steps.

CAUTION

If radiator is hot, start engine before adding coolant.

- (a) Remove radiator cap and add coolant to bring coolant to the proper level. Leave cap off.
- (b) Start engine.
- (c) Sprinkle or pour one of the materials listed above into the coolant.
- (d) Inspect the hole for evidence of reduced or eliminated leakage.
- (e) Add more material if leak has not stopped or been reduced to an acceptable limit.
- (f) Leave radiator cap loose.

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

6-11. Option 2: Repair of Radiator Leak.

a. Limitations.

None if cooling capabilities are not reduced

b. Personnel/time required.

1 soldier/1.0-4.0 hours

c. Materials/tools.

Wire brush
Solvent
Epoxy (item 1 or 3, appx c)

d. Procedural Steps.

- (a) Gain access to radiator.
- (b) Inspect the radiator and pinpoint the leak location.
- (c) Drain the coolant into a container for reuse.
- (d) Clean the leak area with solvent or available cleaner.
- (e) Scrape or rough up the damaged surface with a wire brush or knife as shown (figure 6-3).
- (f) Mix epoxy according to kit instructions and fill the hole with the mixture. Work the epoxy well into the crack.

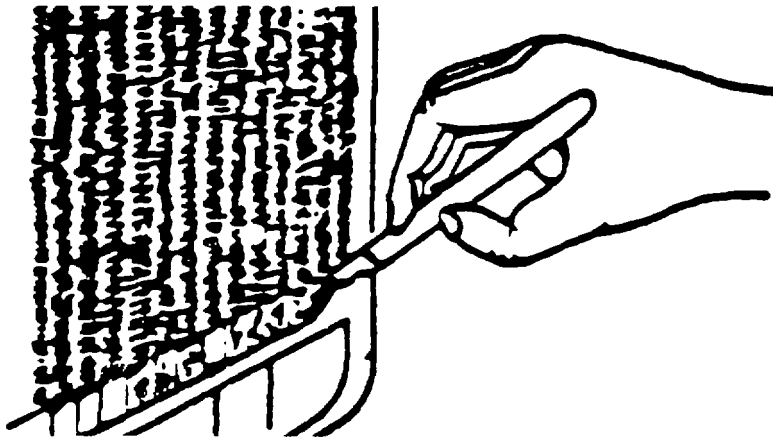


Figure 6-3. Radiator Hole Epoxy Fix.

- (g) Allow epoxy to cure. A heat lamp will speed the curing.
- (h) Refill radiator and check for leaks.
- (i) Install radiator cap in pressure release position.

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

6-12. Option 3: Core Punctured Repair.a. Limitations.

Possible reduced cooling.

b. Personnel/time required.

1 soldier/30-60 minutes

c. Materials/tools.

Side cutters
Sandpaper
Epoxy or solder (item 1, 3, 16, or 17, appx c)
Propane torch or soldering iron

d. Procedural Steps.

- (a) Gain access to radiator.
- (b) Inspect the radiator and pinpoint the leak location.
- (c) Drain the coolant.
- (d) Using side cutters, cut or break away the cooling fins from the coolant tubes, 1 to 2 inches each side of the leak.
- (e) Cut the coolant tube at the leak location, take care not to tear or puncture the other tubes.
- (f) Sand metal clean and tie each end.
- (g) Squeeze the tube ends together and fold each end over on itself approximately 1/2 inch (figure 6-4).

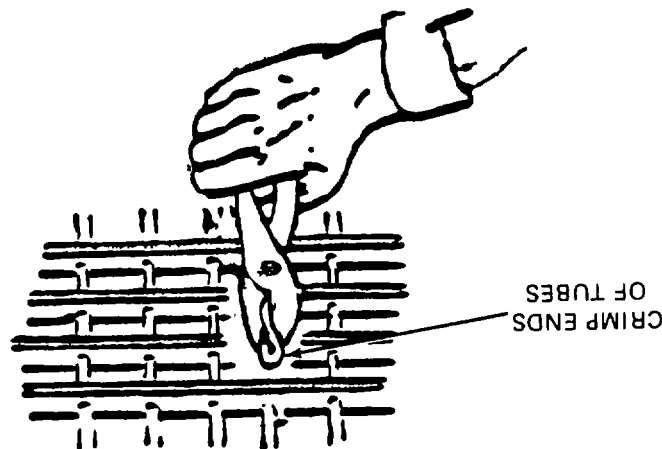


Figure 6-4. Radiator Core, Puncture Repair.

- (h) If epoxy or solder is available, seal the coolant tube ends.
- (i) If no epoxy or solder is available, fold the tube once more 1/2-inch to restrict the coolant leaks.
- (i) Reinstall the coolant. Inspect radiator for leaks.
- (k) Install radiator cap in pressure release position.

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

6-13. Hose Clamp, Broken. A broken hose clamp will allow the hose to leak coolant and--cause engine overheating. The clamp must be replaced or a substitute improvised to regain a sealed cooling system. If a replacement clamp is not available wire can be used as a substitute. Care must be taken that the wire does not loosen.

a. Limitations.

None

b. Personnel/time required.

1 soldier/5-10 minutes
30 minutes

c. Materials/tools.

Wire, safety (lacing) or common (item 33 or 34, appx c)
Tape (item 21, 22, or 23, appx c)

d. Procedural Steps.

- (1) Make a loop in one end of a wire. Twist the wire so that a permanent loop is formed (figure 6-5).

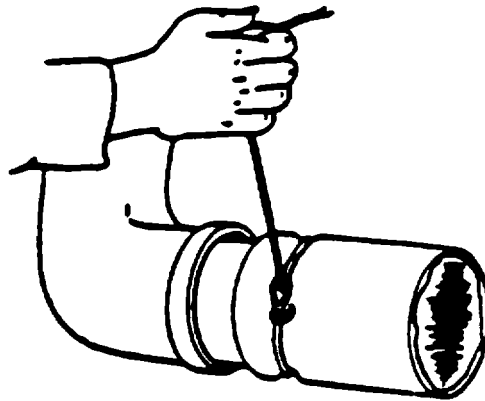


Figure 6-5. Hose Clamp Repair.

- (2) Loosely wrap the wire once around the hose and pull the other end through the loop.
- (3) While pressing the loop tightly against the hose, pull the wire through the loop as tight as possible. Bend the wire back on itself, crimping it, so that the wrap will be tight and secure.
- (4) Secure the loose end by making more wrap, opposite direction of the first.
- (5) Install radiator cap in pressure release position.
- (6) Other options: Wrap the hose with wire. Using a stick, twist wire ends together like a tourniquet. Tape ends of stock to hose.

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

6-14. Hose, Leakage. A leaking hose can be detected by obvious wet areas or engine overheating. Weak hoses feeling soft and spongy should be reinforced with metal if repaired. The soft spongy feeling indicates the rubber is deteriorated and will not withstand normal cooling system pressures. Below are two procedures for repairing a small leak in a hose and also how to correct a larger split in a hose.

a. Limitations.

None if leak is completely stopped

b. Personnel/time required.

1 soldier/0.5 hours
30 minutes

c. Materials/tools.

String or wire (item 33 or 34, appx c)
Non-porous material (rubber, poncho, raincoat)
Thin sheetmetal (cans)
Gasket sealer (item 13, appx c)
Clamps (item 5, appx c) or (item 3, appx b)

d. Procedural Steps.

(1) *Option 1: Hose, small leak.*

(a) Gain access to leaking hose (figure 6-6).

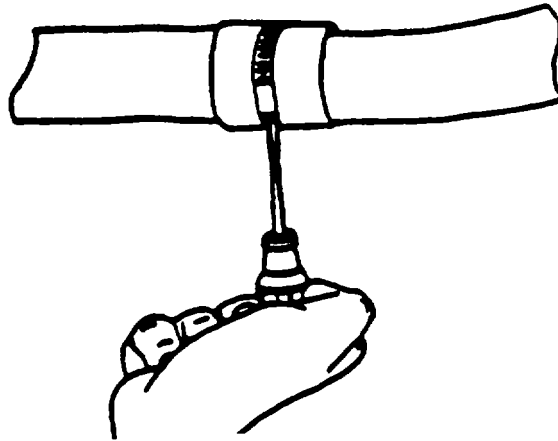


Figure 6-6. Hose, Small Leak.

- (b) Clean dirt and oil from damaged hose.
- (c) Coat the damaged area with gasket sealer.
- (d) Wrap a non-porous material (poncho, rubber mat) over the leak.
- (e) Secure the material with a clamp.
- (f) Install radiator cap in pressure release position.

(2) *Option 2: Hose, small leak.*

- (a) Gain access to leaking hose.
- (b) Clean dirt and oil from damaged hose.
- (c) Cover the damage with a rubber mat section.
- (d) Wrap the patch with electrical or duct tape.

- (e) Re-enforce the patch with wire or string to distribute the patch sealing pressure evenly over the damaged area.
- (f) Install radiator cap in pressure release position.

(3) *Option 3: Hose, large leak.*

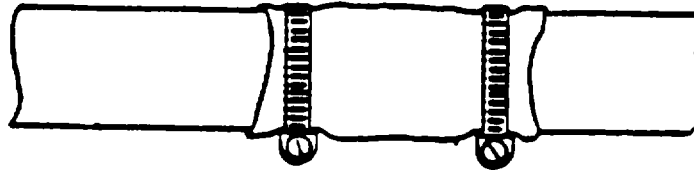


Figure 6-7. Hose, Large Leak.

- (b) Clean dirt and oil from damaged area.
- (c) Coat the damaged area with gasket sealer.
- (d) Cut a metal patch from a tin can or other thin metal.
- (e) Bend the metal into a cylindrical shape the size of the damaged hose and coat the inside with sealer.
- (f) Wrap the metal patch over the damaged hose.
- (g) Secure the patch with adjustable clamps or tape.
- (h) Check for leaks.
- (i) Install radiator cap in pressure release position.

(4) *Other options:* Use a tire patch repair kit.

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

6-15. Hose, Collapse. When the rubber in the coolant hoses starts to deteriorate it becomes soft and has a spongy feeling which may result in hose collapse. The hose can be reinforced by inserting a rigid hollow object like a can or wire coiled to prevent the hose from collapsing. The inserted item will help the hose remain open even though the suction is trying to close it.

a. Limitations.

None

b. Personnel/time required.

1 soldier/0.25-1.0 hours

c. Materials/tools

Tin can
Stiff wire (coat hanger, welding rod)

d. Procedural Steps.

- (1) Gain access to hose.
- (2) Drain coolant into container for reuse.
- (3) Loosen and remove clamp from one end of the hose.
- (4) Insert a can with ends removed or bent wire into the hose (figure 6-8).

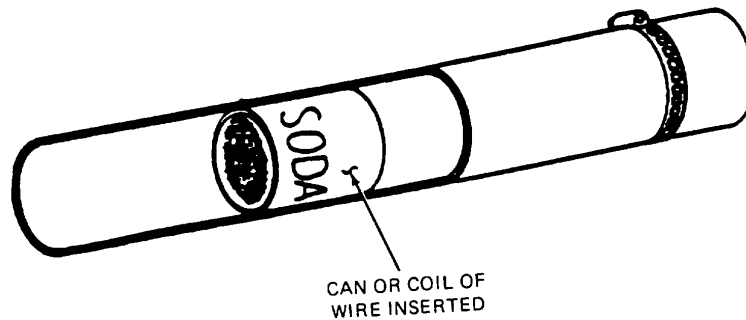


Figure 6-8. Reinforce Collapsed Hose.

- (5) Reconnect and tighten the hose.
- (6) Refill coolant to proper level.
- (7) Check for leaks.

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

6-16. Hose Improvisation (Low Pressure). Coolant hose or tube damage will sometimes be such that a patch will not stop the leak. The damaged portion must be removed and replaced with a substitute. Several repairs can be made using one of the following procedures.

a. Limitations.

None

b. Personnel/time required.

1 soldier/i 5-60 minutes.

c. Materials/tools.

Gasket sealer (item 13, appx c)
 Garden hose, heater hose
 Pipe
 Clamps or wire (item 5, 33 or 34, appx c)
 Hacksaw

d. Procedural Steps.

(1) Option 7: Pipe insert.

- (a) Cut out damaged hose section.
- (b) Cut a section of pipe longer than the removed hose.
- (c) Coat the pipe ends with gasket sealer.

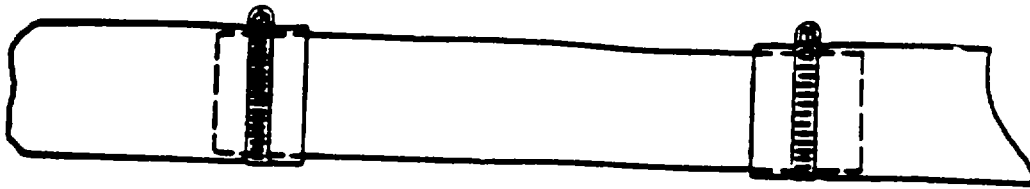


Figure 6-9. Pipe inserted into Damaged Hose.

- (e) Secure the hose ends with clamps or twisted wire.
 - (f) Refill coolant to proper level and check for leaks.
 - (g) Install radiator cap in pressure release position.
- (2) Option 2: Substitute hose.
- (a) Cut out damaged hose section.
 - (b) Cut a section of substitute material longer than the removed section.
 - (c) Coat ends of damaged hose or tube with gasket sealer.
 - (d) Slip the substitute hose over the ends of the damaged hose or tube (figure 6-10.).

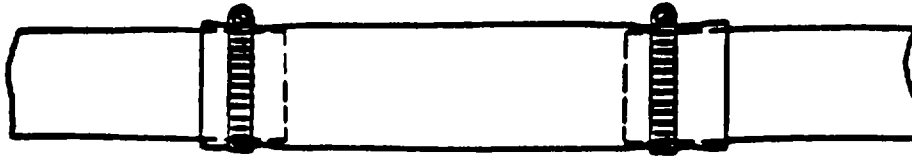


Figure 6-10. Substitute Hose as Sleeve.

- (e) Secure the substitute hose with clamps or twisted wire, do not overtighten and restrict the coolant flow.
 - (f) If the damaged hose inside diameter equals the outside diameter of the substitute hose, the hose can be inserted into the damaged hose and secured. This, however, will not work with tubing.
 - (g) Refill coolant to proper level and check for leaks.
 - (h) Install radiator cap in pressure release position.
- (3) Option 3: Short hose fabrication.
- (a) Use a short section of innertube, or rubber sheet cut to required length.
 - (b) Coat the tubing ends with sealant.
 - (c) Slip the material over the tubing ends.
 - (d) Wrap the innertube as tightly as possible on the tubing (figure 6-1 1).

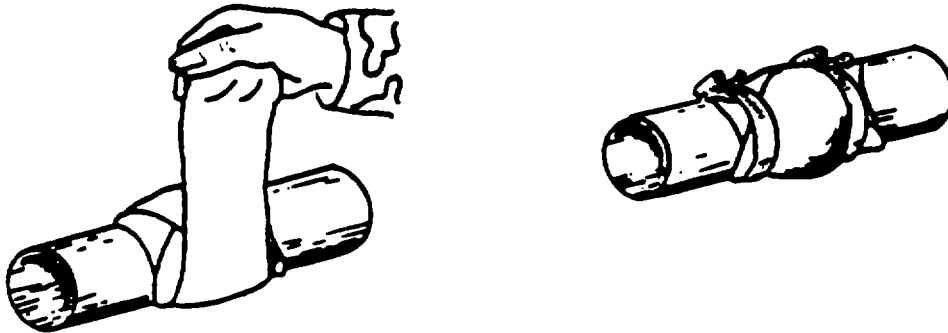


Figure 6-1 1. Short Hose Fabrication.

- (e) Secure the innertube using hose clamps or tightly wound wire.
- (f) Refill coolant to proper level and check for leaks.
- (g) Install radiator cap in pressure release position.

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

CHAPTER 7

DC ELECTRICAL SYSTEM

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

Section I. INTRODUCTION

7-1. Scope. DC Electrical systems on most generators (figure 7-1) are 24 volt negative ground, direct current systems. Electrical storage for starting and standby circuits is provided by batteries. The batteries are connected in a series-parallel configuration to provide 24V dc current. In most of the larger generators there are many safety circuits to prevent accidental damage to the generator through mechanical failure. For example, if the oil pressure drops too low, a safety circuit will shut down the generator. These safety circuit will shut down the generator. These safety circuits can be bypassed with one master switch called the "Battle Short" switch. Use of this switch is to be limited to absolute necessity because severe damage to the generator may ensure. The "Battle Short" switch on the DOD 15-200KW Diesel Engine Driven Generator Sets bypasses all of the safety devices except the overspeed switch and the short circuit relay.

7-2. Assessment Procedure. DC Electrical system assessment procedures are structured using the logic process shown in figure 7-2. Visually inspect the system for damage to components. Then start up the generator and observe operation.

7-3. Repair Procedure Index.

Damage	Paragraph
Battle Short Switch, Defective	7-5
Switch, Starter Inoperative	7-6
Fuse or Circuit Breaker Failure	7-7
Wiring Harness Damage	7-9
Connector Pin, Damaged (Broken or Missing)	7-10
<u>Wires Broken</u>	7-11
<u>Cable, Heavy Duty, Damaged</u>	7-12
Brush, Electrical, Alternator/Starter-Motor, Worn	7-14
Starter Solenoid Defective, Delco-Remy Only	7-15
<u>Battery Terminal Post, Broken</u>	7-17
<u>Battery Cracks</u>	7-18

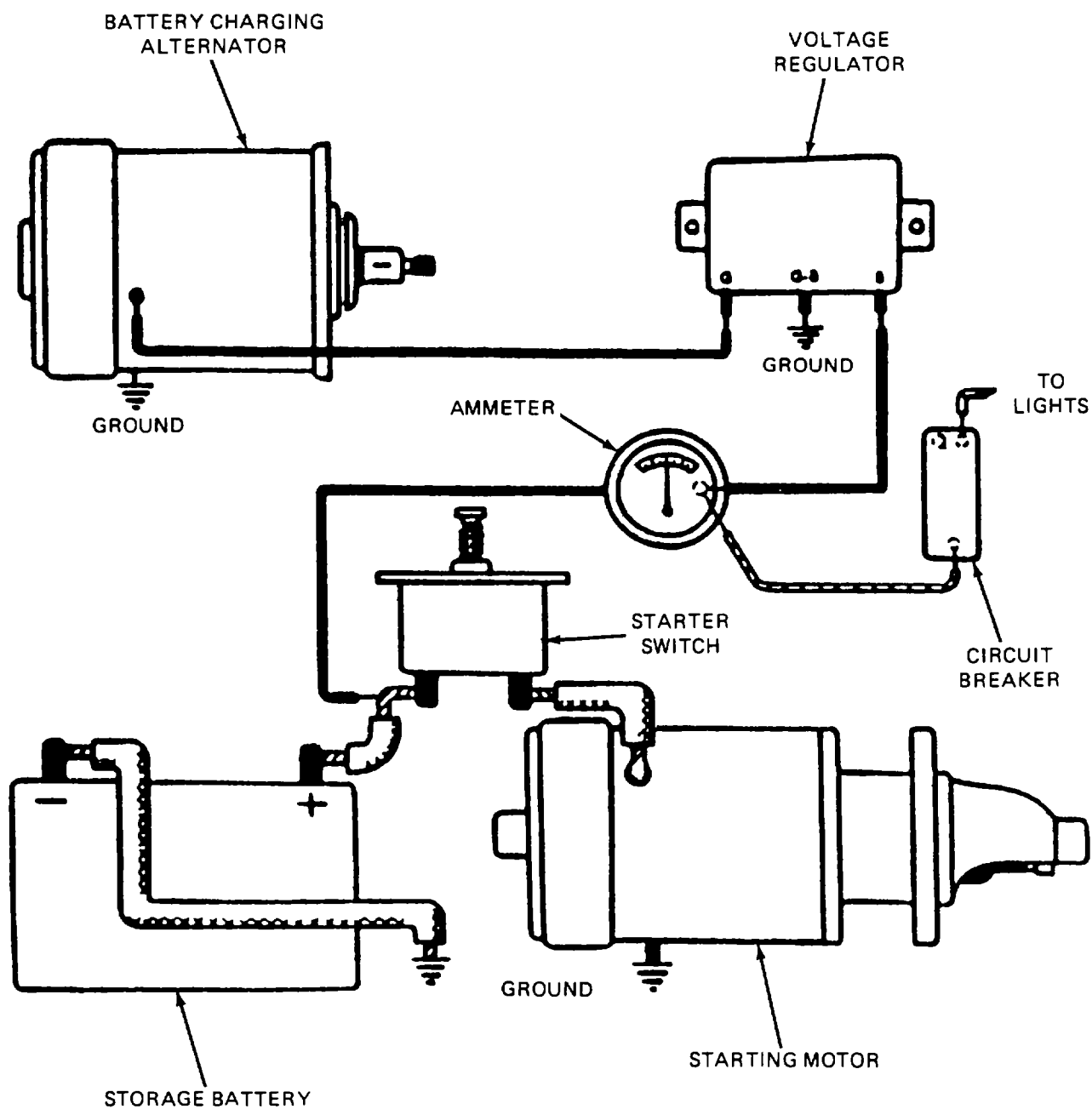


Figure 7-1. Basic Engine DC Electrical System

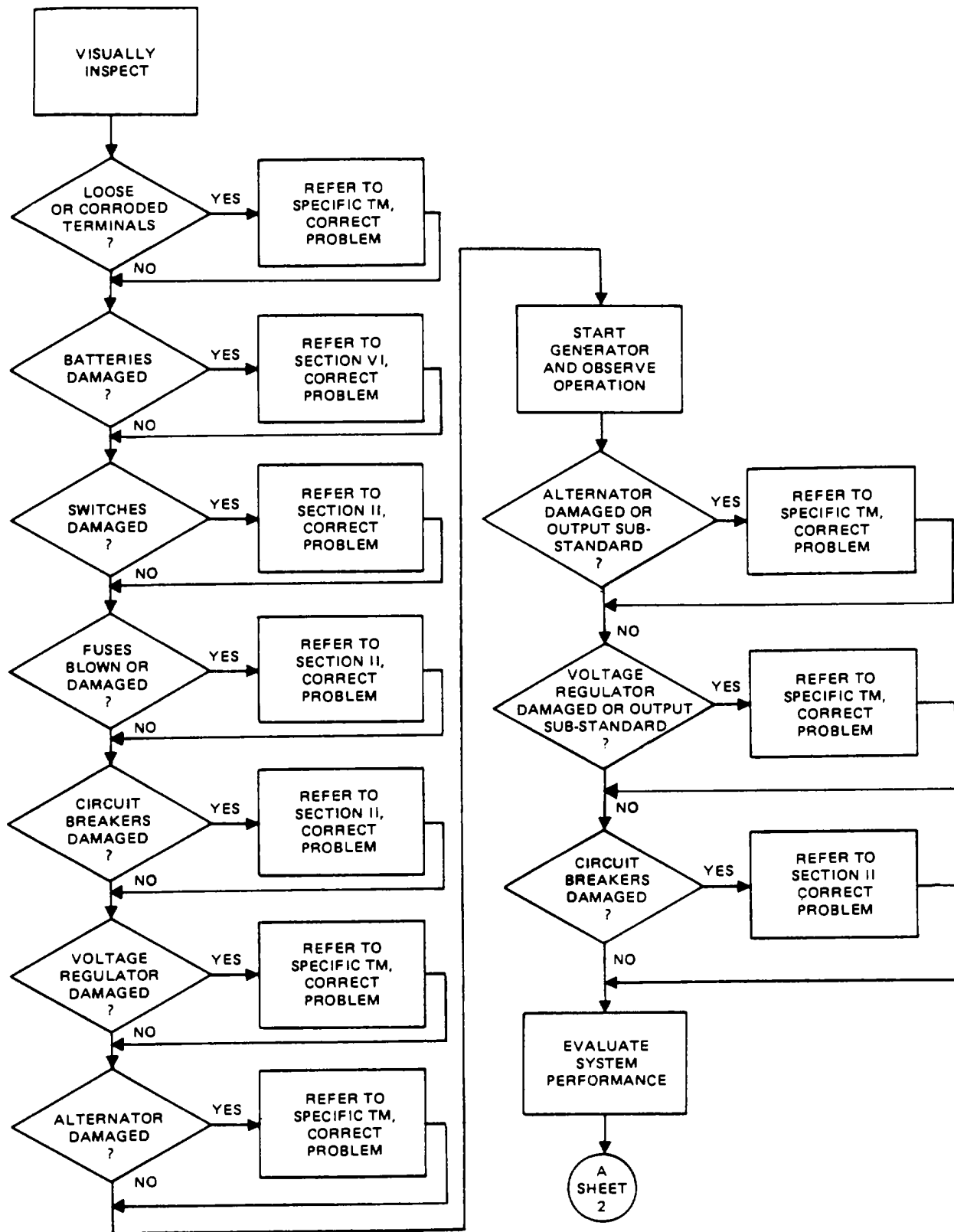


Figure 7-2. DC Electrical System Failure Assessment (Sheet 1 of 2)

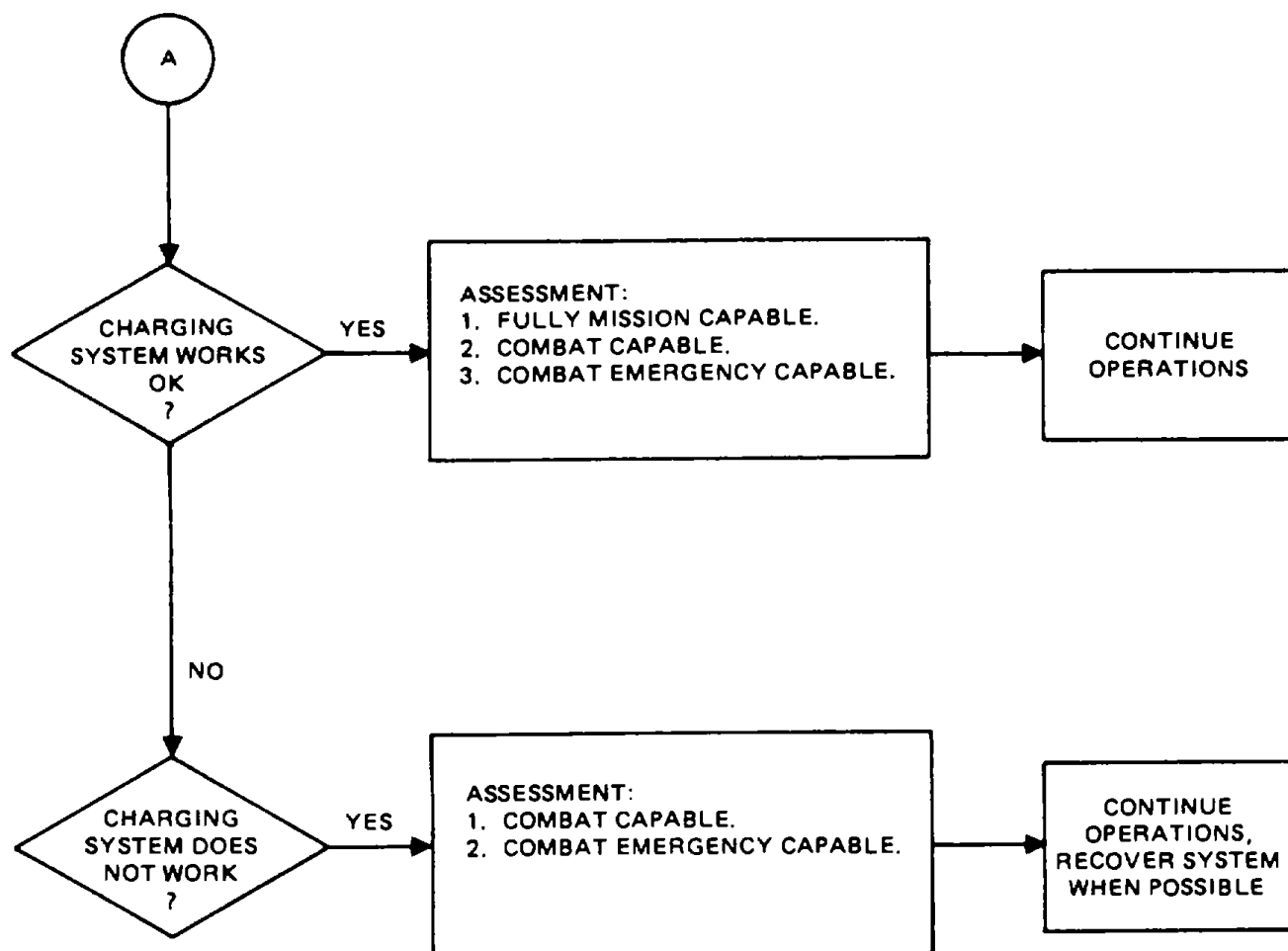


Figure 7-2. DC Electrical System Failure Assessment (Sheet 2 of 2)

Section II. DC ELECTRICAL COMPONENTS

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

7-5. Battle Short Switch, Defective. Engine starter will not energize due to safety shutdown circuitry being activated. This procedure will allow the generator to operate until ultimate possible destruction from damage related to the particular safety circuit.

a. Limitations.

Generator should be monitored carefully because safety circuits would be bypassed

b. Personnel/time required.

1 soldier/0.25 hours

c. Materials/tools.

Electrical tape (item 22, appx c)
Duct tape (item 21 or 23, appx c)
Bandaid
Shoelace

d. Procedural Steps.

- (1) Locate battle short switch.
- (2) Disconnect both wires.
- (3) Slide protective insulation boots back on the wires to expose the electrical connectors.
- (4) Lay the two connectors side by side and secure with tape.

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

76. Switch, Starter, Inoperative. If the engine will not crank, bypass the starter switch and jump the starter terminals.

a. Limitations.

None

b. Personnel/time required.

1 soldier/0.25 hours

c. Materials/tools.

Piece of wire (item 33 or 34, appx c)
Tape (item 21,22, or 23, appx c)

d. Procedural Steps.

- (1) Option 1: Bypass starter switch.
 - (a) Locate the starter switch.
 - (b) Remove the wire from the starter switch.
 - (c) Use a jumper wire or touch the wires, removed in step (b), together.
 - (d) After engine starts, disconnect jumper, or leads.
 - (e) Insulate lead with tape.
- (2) Option 2: Jump starter terminals.
 - (a) Gain access to engine starter.
 - (b) Using a piece of wire or suitable object, connect the main power terminal to the solenoid terminal.
 - (c) After engine starts, disconnect jumper.

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

7-7. Fuse or Circuit Breaker Failure. A short or overload in a circuit will cause the fuse to burn out or the circuit breaker to trip. The circuit becomes inoperative. A temporary repair can be made by bypassing the protection device with straight wiring or by replacing the fuse with tinfoil, wire, ball point pen springs, or similar conductor. Use of solder will provide some amount of circuit protection. Damage to the equipment can occur when the circuits are not properly fused. Section III. WIRING HARNESS

7-8. General. Wiring harnesses are normally replaced when extensive damage occurs. Because of improvements or different configurations, replacement harnesses from other generators of the same family may use some different style connectors. Try to obtain harnesses from an identical model; however, connectors can be exchanged with the damaged harness. The same procedure is followed to change a complete connector or splice a complete harness. If a wire is damaged but the fault cannot be located, it should be replaced with a jumper wire.

7-9. Wiring Harness Damage. Wire harness repairs are generally a series of single wire repairs. Establishing circuit continuity in a bundle of wires is difficult because individual wires are not color coded. Wires must be identified before they are connected. Most essential electrical functions can be rapidly restored by using jumper wires. An alphanumeric code is imprinted onto the outer insulating jacket of each wire. A point to point run of each wire can be determined from the troubleshooting diagram plate and the alphanumeric code.

- a. Limitations.
None
- b. Personnel/time required.
1 soldier/1.0-2.0 hours.
- c. Materials/tools.

Wire (item 33 or 34, appx c)
 Splices (item 18 or 19, appx c)
 Electrical tape (item 22, appx c)
 Soldering iron
 Plastic ties

d. Procedural Steps.

(1) Option 1: Wire bundle repairs.

- (a) Repair the first wire and tape. Leave the tape hanging from the repair.
- (b) Repair the next wire, lay it on top of the first repair.
- (c) Continue wrapping with insulation tape.
- (d) Repeat these steps as often as necessary to repair the wire bundle without cutting or breaking the tape until the repair has been completed (figure 7-3).

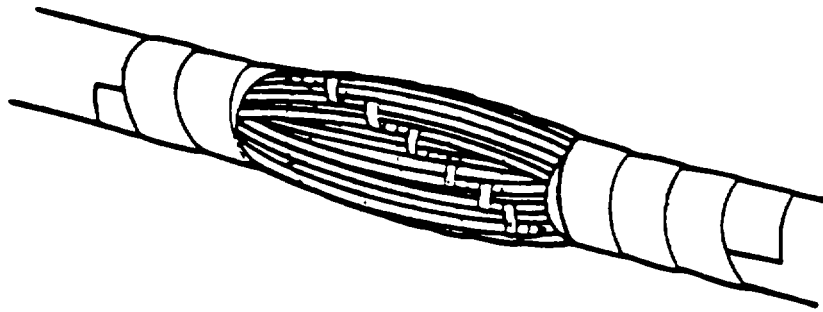


Figure 7-3. Wire Bundle Repair of Wiring Harness.

- (e) Stagger splices, when possible, at least one splice length.
 - (f) Insure that minimum essential cable clamps have been replaced.
 - (g) Clamp cushions can be replaced by tape.
- (2) Option 2: Jumper wire.
- (a) Identify the connector pin at each end of the harness.
 - (b) Cut off the end of the defective wire.
 - (c) Thread the jumper wire along the path of the cable harness passing the wire through the clamps.
 - (d) Attach the jumper wire.
 - (e) Tape the jumper wire securely to the harness at intervals that will provide protection from vibration or sagging.

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

7-10. Connector Pin, Damaged (Broken or Missing). If the pins are too small, or time is insufficient, the entire connector should be replaced. A replacement connector complete with a pigtail removed from another generator can be spliced to the generator wiring harness as shown (figure 7-4). If the connector is attached to shock mounted equipment, the wires should be long enough to insure free movement of the equipment on its shock mounts. Procedures are the same as repairing a wire bundle, see paragraph 7-11.

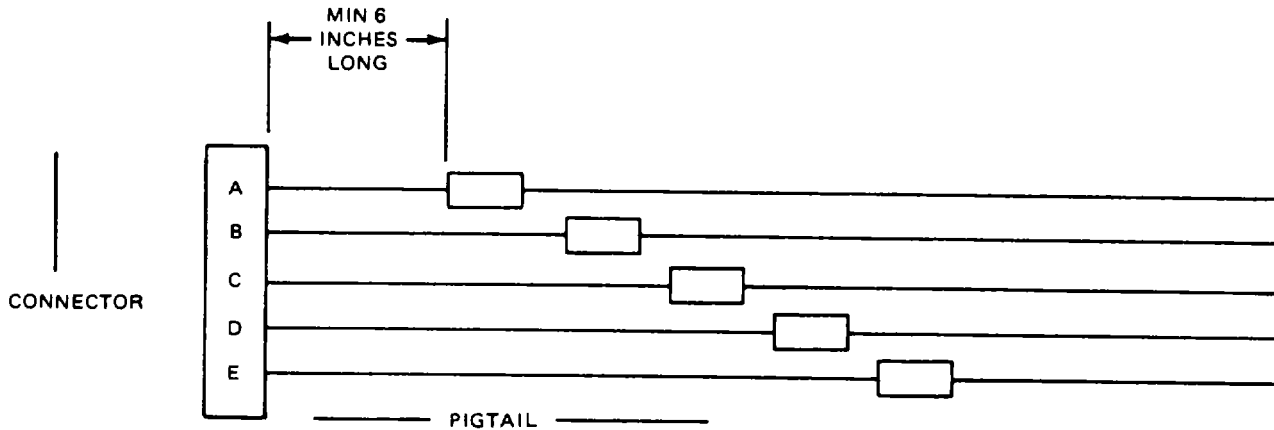


Figure 7-4. Connector Spliced to Generator Wiring.

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

a. Limitations.

None

b. Personnel/time required.

1 soldier/0.16-0.33 hours

c. Materials/tools.

Crimping tool (item 4, appx b)
Solder, resin-core (item 17, appx c)
Wire splice (item 18 or 19, appx c)
Heat shrink tubing
Soldering iron

d. Procedural Steps:

(1) Option 1: Solder wire method.

(a) Strip end of broken wires (Detail A, figure 7-5).

- (b) Install a section of plastic sleeving or shrink tubing, if available, over one end of the broken wire.
- (c) Lay the stripped ends side by side.
- (d) Twist the wire ends together (Detail B, figure 7-5).
- (e) Solder wires together using resin-core solder (Detail C, figure 7-5).
- (f) Slide sleeve or tubing over the soldered wires or tape to insulate the conductor (Detail D, figure 7-5).

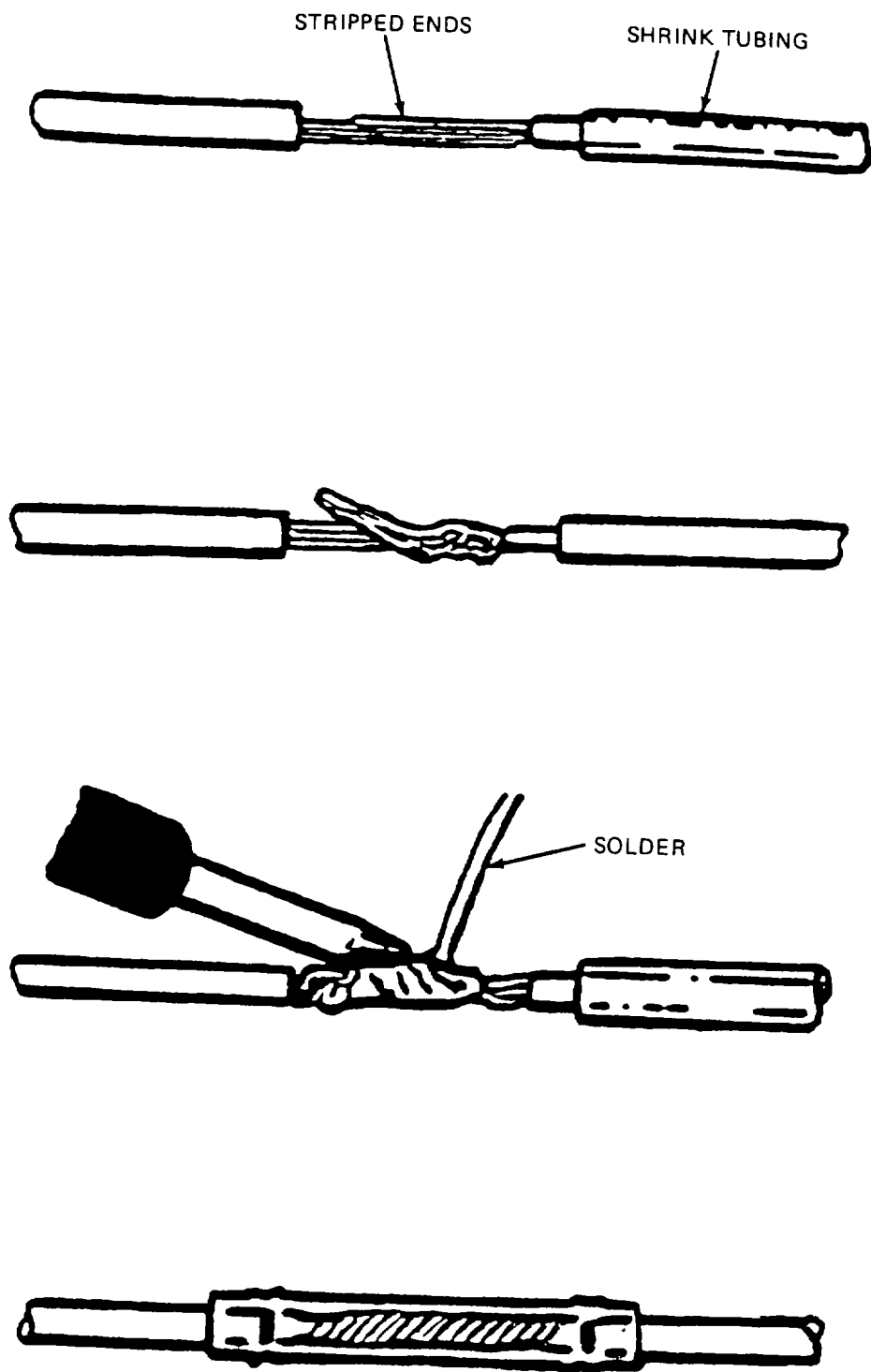


Figure 7-5. Solder Method to Repair Wires.

(2) Option 2: Wire splice method.

- (a) If terminal lug barrel is used for splicing, select barrel diameter large enough to accept both wires (1, figure 7-6).
- (b) Cut off terminal flush with pre-insulation (2, figure 7-6).
- (c) Cut insulating sleeve one inch longer than the barrel (3, figure 7-6).
- (d) Strip end of broken wires (4, figure 7-6).
- (e) Install insulating sleeve or shrink tubing, if available, over one end of broken wire (5, figure 7-6).
- (f) Insert wires into the prepared splice barrel and crimp to secure the wires (6, figure 7-6). Use crimp tool matching the size of the barrel.
- (g) Slide sleeve or tubing over the splice or use tape to insulate the conductor and apply heat to shrink material. Ends of non-shrink sleeve must be tied (7, figure 7-6).

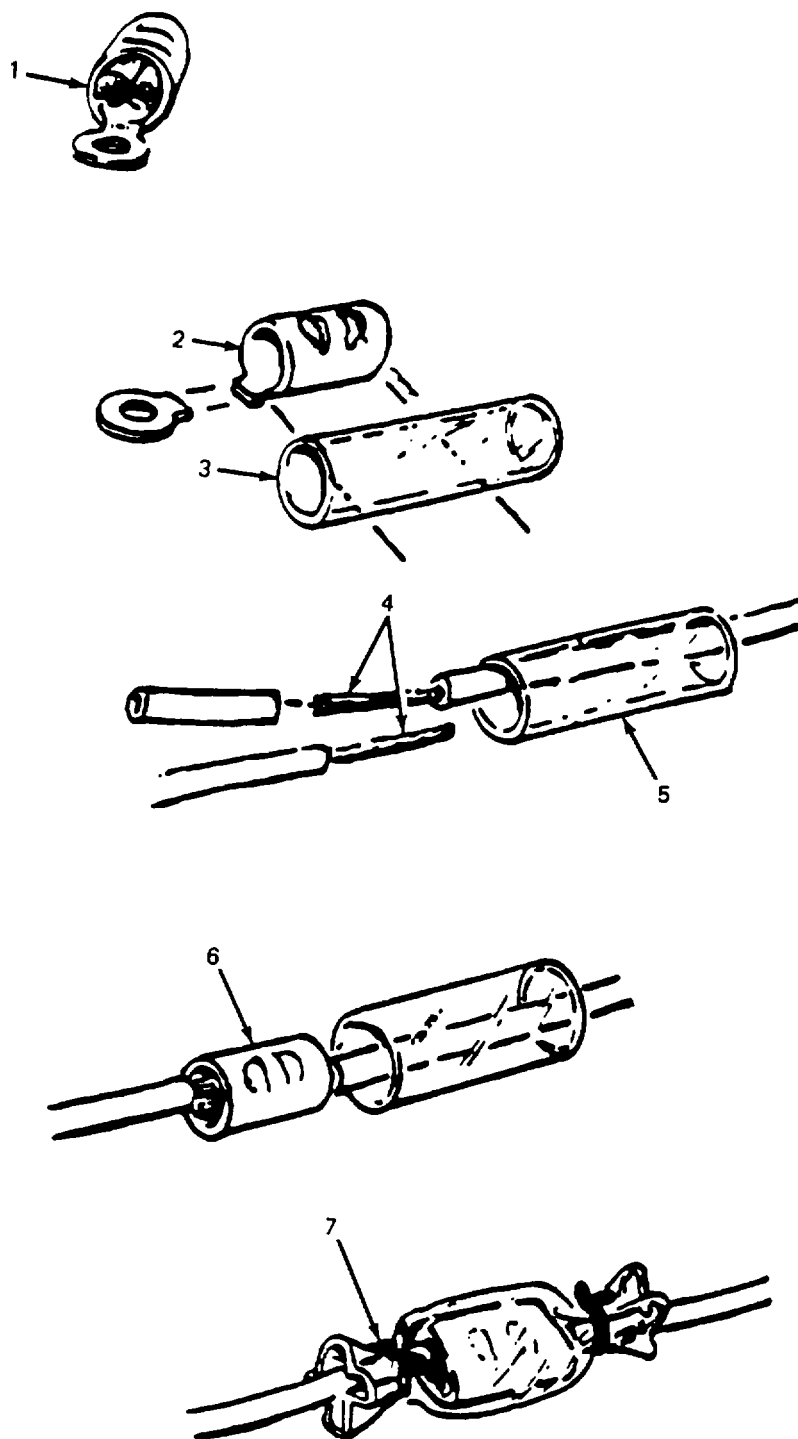


Figure 7-6. Splice Method to Repair Same Size Wire.

(3) Option 3: Splicing different size wires.

- (a) Strip broken wire ends, strip enough insulation to allow the smaller wire to be doubled as shown (Detail A, figure 7-7).
- (b) Install plastic sleeve or shrink tubing, if available, over one end of broken wire.
- (c) Connect wires by using a splice or terminal lug prepared as in Option 2.
- (d) Crimp splice or lug to secure the wires.
- (e) Slide the sleeve or tubing over the splice or tape to insulate the conductor (Detail B, figure 7-7).

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

DOUBLE EACH WIRE



TWO THIN WIRES INTO #16 SPLICE

OPEN STRANDS AND TWIST TOGETHER

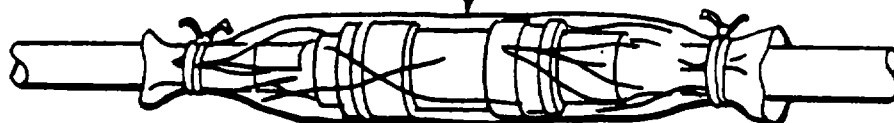


TWO THIN WIRES INTO ONE HEAVY WIRE



ONE THIN WIRE INTO ONE HEAVY WIRE

EXTRA SLEEVE MUST BE USED



COMPLETED SPLICE

Figure 7-7. Splicing Various Size Wires.

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

a. Limitations.

None

b. Personnel/time required.

1 soldier/0.25-1.0 hours

c. Materials/tools.

Terminal lugs, screw clamp or small hole clamp (item 24, 25, 26, 27, or 28, appx c)

Insulating sleeve or electrical tape (item 22, appx c)

Soldering iron or torch and solder

Short bolt with matching nut

Safety wire

Clamp cable (item 3, appx b)

d. Procedural Steps.

(1) Option 1: Splicing cable with terminal lugs.

(a) Clean area to be repaired.

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

(c) Strip wire and crimp an insulated terminal lug to each wire end (figure 7-8).

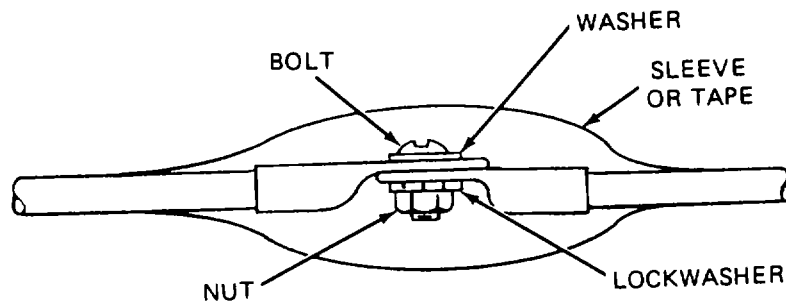


Figure 7-8. Splicing Cable with Terminal Lugs.

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

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

(2) Option 2: Splicing stranded cable.

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

- (b) Split the ends of cable into manageable strands and join the two ends by twisting like strands together.
 - (c) Bend the twisted end parallel to the cable and insulate with tape.
- (3) Option 3: Clamp, Splicing.
- (a) Remove one inch in insulation from each end
 - (b) Fan out the strands on each end.
 - (c) Ram the two ends together as far as possible, so that the strands intermesh (figure 7-9).

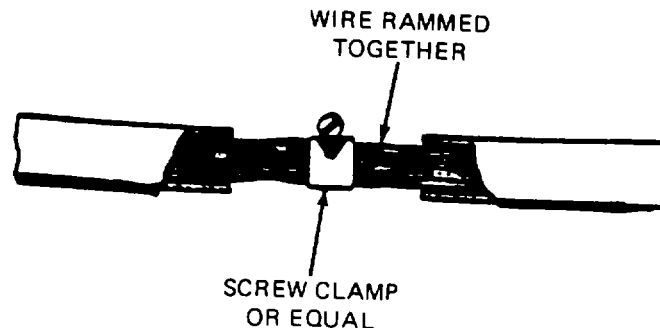


Figure 7-9. Splicing Cable with Clamp.

- (d) Solder the intermeshed wires together. If a soldering iron is not available, the two intermeshed ends may be secured with a screw clamp, cable clamp, or safety wire.
- (e) Insulate with tape.

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

Section IV. ELECTRICAL MOTORS

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

7-14. Brush, Electrical, Alternator/Starter-Motor, Worn. Many electrical motors use a carbon composition brush to transfer electrical energy to or from the armature commutators. The transfer of energy creates an electrical arc which will burn the brushes. Arcing the normal friction will cause the brushes to become worn and inefficient for electrical power transfer. The brushes can be substituted with the carbon core from a BA30 or BA31 battery. Care must be taken when opening the battery; the contents are corrosive. Brush retaining springs can be used to transfer the energy or to hold the old brush wires in place.

- a. Limitations.
Shorter motor life
- b. Personnel/time required.
1-3 soldiers/1.0-8.0 hours

c. Materials/tools.

BA30 or BA31 battery
Hacksaw
Sandpaper

d. Procedural Steps.

- (1) Gain access to motor.
- (2) Remove electrical brush plate.
- (3) Obtain a BA30 or BA31 battery.
- (4) Using a hacksaw or other available tool, split the battery open, taking care not to damage the carbon core.
- (5) Clean and cut the carbon core to fit the brush plate receptacles.
- (6) Insert the core into the brush plate and position the old brush wires under the retaining springs to ensure electrical continuity.
- (7) Seal the brushes.
 - (a) Cut a strip of sandpaper slightly wider than the commutator surface.
 - (b) Tape the sandpaper strip over the commutator.
 - (c) Install the brush plate.
 - (d) Rotate the armature in the normal direction of rotation until the carbon core face conforms to the armature surface curvature.
 - (e) Remove sandpaper and blow out dust and sand.
- (8) Reassemble motor and test operation.
- (9) Reinstall motor.
- (10) Other options. Modify and use other electrical brush sets.

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

7-15. Starter Solenoid Defective, Delco-Remy Only. With uneven wear of the solenoid plunger shaft, a lip will form on one side of the shaft and the engine starter will not engage. Temporary repair can be made by removing the solenoid and rotating solenoid plunger shaft 180 degrees.

a. Limitations.

Starter solenoid life is shorter than new part.

- b. Personnel/time required.
1-3 soldiers/1.0-6.0 hours
- c. Materials/tools.
None
- d. Procedural Steps.
- (1) Disconnect power. (Unhook negative battery terminal.)
 - (2) Gain access to engine starter; remove if required.
 - (3) Remove solenoid from starter (figure 7-10).
 - (4) Rotate solenoid plunger shaft 180 degrees.
 - (5) Install solenoid on starter.
 - (6) Reconnect power.
 - (7) Test starter operation.

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

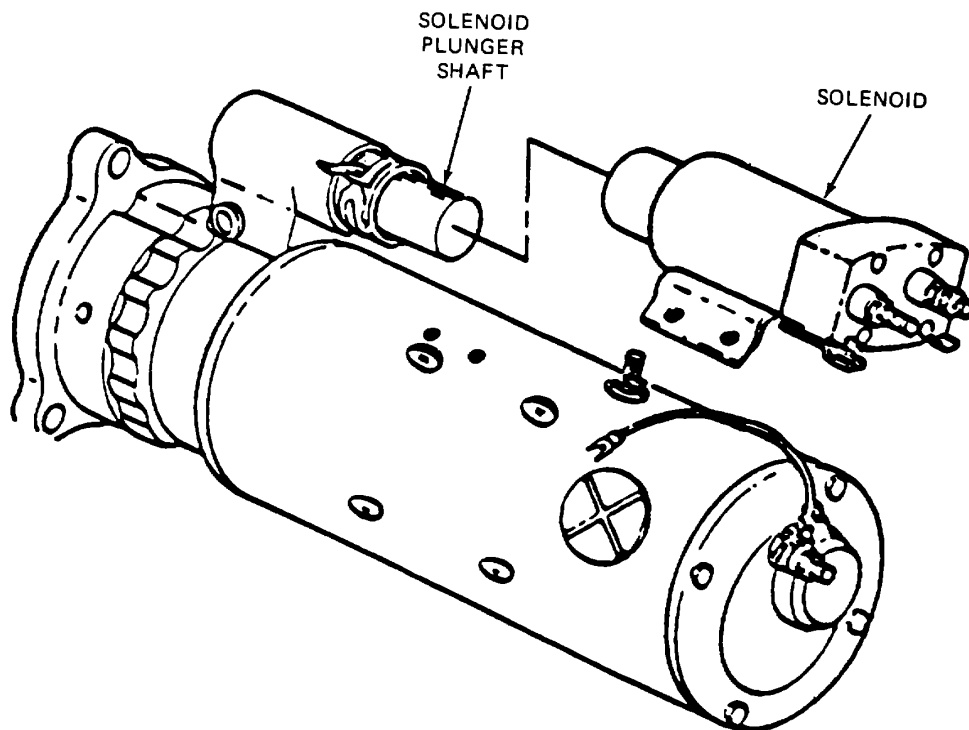


Figure 7-10. Starter Solenoid Defective.

Section V. BATTERIES AND BATTERY CABLES

WARNING

Corrosive Battery Electrolyte (Potassium Hydroxide). Wear rubber gloves, apron, and face shield when handling leaking batteries. If potassium hydroxide is spilled on clothing, or other material, wash immediately with clean water. If spilled on personnel immediately start flushing the affected area with clean water. Continue washing until medical assistance arrives.

7-16. General. The batteries store electrical energy to start the engine and to supply energy for accessory systems to operate without requiring engine operation. The batteries also act as a buffer for the electrical charging system. Without a battery in the circuit, the charging system will charge at its maximum rate and rapidly burn out. The DOD Generator Sets were designed to be able to operate without batteries and starting can be accomplished through the use of the slave receptacle. The battery cables' end terminals must be securely wrapped and taped with electrical insulating materials if they are not to be secured to the appropriate battery terminals.

7-17. Battery Terminal Post, Broken. Battery terminal posts can be repaired if they are broken. The stub can be built back up with lead (figure 7-11). If melting facilities or tools are not available a post can be secured with a self-tapping screw or bolt. The battery should be replaced as soon as possible if the post is only screwed or bolted in place. Corroded or loose terminals are frequently a cause of starting system failure. See specific TM for corrective action.

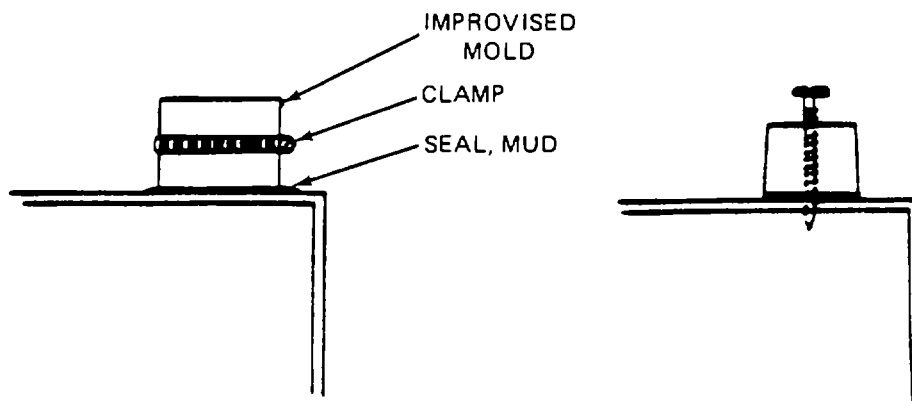


Figure 7-11. Battery Terminal Part Repair.

7-18. Battery Cracks. Batteries can become cracked from vibration, impact or freezing. Cracks can be repaired or sealed until replacements can be obtained. Most epoxies will not shrink and are resistant to acid. Epoxies make a semi-permanent repair and should be used as a first option.

Section VI. GOVERNOR SYSTEM

7-19. General. The governor system on a generator regulates the engine speed to produce an even output of power. When the speed fluctuates enough that power output is affected. The governor is not functioning properly. To counter this, the throttle linkage can be adjusted manually until the engine RPM produces the desired frequency. The output can be observed with another soldier at the control gauges. Then the linkage can be wired into position with a paper clip or piece of wire or other binding. This will work where a relatively constant load is applied to the generator. Load changes will cause RPM changes necessitating throttle adjustment.

APPENDIX A

REFERENCES SYSTEM

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

A-1. Scope. This appendix lists all pamphlets, forms, technical manuals, specifications and miscellaneous publications pertinent to this manual.

A-2. Forms and Records.

Recommended Changes to Publications and Blank Forms	DA Form 2028
Depreservation Guide for Vehicles and Equipment	DA Form 2258
Equipment Inspection and Maintenance Worksheet	DA Form 2404
Maintenance Request	DA Form 2407
Consolidated Index of Army Publications	DA Form 25-30
The Army Maintenance Management System (TAAMS)	DA PAM 738-750
Quality Deficiency Report	SF 368

A-3. Military Specifications.

Treatment and Painting of Material	MIL-T-704
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A-4. Technical Manuals.

NBC Decontamination Procedures	FM 3-5
Electrical Power Generator Field Operations	FM 20-31
Installation Practices for Aircraft Electric and Electronic Wiring (TO 1-1A-14)	TM 55-1500-353-24
Procedures for Destruction of Equipment to Prevent Enemy Use (Mobility Equipment Command)	TM 750-244-3
Processing and Inspection of Non-Mounted, Non-Aircraft Gasoline and Diesel Engines for Storage and Shipment	TO 38-1-5

A-5. Technical Bulletins.

Solder and Soldering (TO 31-3-64)	TB SIG 222
Preservation of USAMECOM Mechanical Equipment for Shipment and Storage	TB 740-97-2
Maintenance of Supplies and Equipment: Army Test, Measurement and Diagnostic Equipment (TMDE) Calibration and Repair Support Program	TB 750-25

APPENDIX B

SPECIAL AND FABRICATED TOOLS

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

Section I. INTRODUCTION

B-1. Scope. This appendix lists items recommended for the support of the generator in a combat environment. The items listed may be required for Battlefield Damage Assessment and Repair at maintenance levels from crew through DS. Also listed are expeditious 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 expeditious manner. Some tools listed may already be on hand in the unit. Other equivalent tools may be available which are not listed in Table B-1.

a. Explanation of Symbols for Level. The column marked "Level" indicates the maintenance level at which it is recommended these items be stock 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.

b. Explanation of Symbols for Repair Items. The items marked "C" (Crew) are recommended to be carried for use in combat emergencies at the discretion of the unit commander. Those units 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 "MSI" are recommended to be carried by the DS maintenance support teams (MST).

Table B-1. Tools.

Item number	Level	NSN	Description
1	C	5110-00-277-4591	Blade, hand hacksaw: 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

Table B-1. Tools.-CONT.

Item number	Level	NSN	Description
5	C	5120-00-227-8074	Extension, socket wrench: 1/2 in. sq dr 10 in. lg
6	C	5110-00-241-9153 5110-00-241-9156	File, hand: half rnd 10 in.
7	C	5110-00-234-6559	File, hand: rnd style
8	C	5110-00-289-9657	Frame, hand hacksaw, 10 in. and 12 in. blade accommodated
9	C	5110-00-263-0349	Handle, file
10	C	5110-00-240-5943	Knife, pocket: w/clevis, screwdriver, wire scraper and cutting blade
11	C	5120-00-221-1536	Knife, putty
12	C	5120-00-239-8251	Pliers: linemans w/side cutter, 8 in.
13	C	5120-00-247-5177	Pliers, 1 rnd noze w/cutter, 6 in.
14	C	5120-00-278-0352	Pliers, slip joint: angle nose, multiple tongue and groove, 10 in.
15	C	5120-00-624-8065	Pliers, slip joint: conduit w/o handl. w/removable plastic inserts, 9 in lg
16	C	5120-00-293-0448	Punch, aligning: 3/16 in. pt, 8 in. lg, 3/8 in. dia
17	C	5120-00-595-9531	Punch, aligning: 1/4 in. pt, 12 in. lg
18	C	5120-00-242-5966	Punch, drive pin: 1/8 in.
19	O	4931-01-119-7103	Repair Kit, electrical connector: PN 12285360
20	MT	5120-00-017-2849	Riverter: blind, hand
21	C	5120-00-234-8913	Screwdriver, cross tip: No. 2
22	C	5120-00-237-0982	Socket, socket wrench, 1/2 sq d, 12 pt opening, regular length, 3/8 in.

Table B-1. Tools.-CONT.

Item Number	Level	NSN	Description
23	C	5120-00-189-7924	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 7/16 in.
24	C	5120-00-237-0984	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 1/2 in.
25	C	5120-00-189-7932	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 9/16 in.
26	C	5120-00-189-7946	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 5/8 in.
27	C	5120-00-235-5870	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 11/16 in.
28	C	5120-00-189-7985	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 3/4 in.
29	C	5120-00-189-7933	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 13/16 in.
30	C	5120-00-189-7934	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 7/8 in.
31	C	5120-00-189-7935	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 15/16 in.
32	C	5120-00-189-7927	Socket, socket wrench, 1/2 sq dr, 12 pt opening, regular length, 1 in.
33	C	8120-00-242-3349	Socket, deepwell, 1/2 in. dr., 3/4 in.
34	MT	6625-01-102-6878	TA-1 Continuity and Test Probae Kit: PN 12303622
35	C	5140-00-498-872	Tool Box, portable: steel w/removable tray 21 in. lg, 8-1/2 in. w, 7-38 in. h
36	MT	5120-01-128-5511	Tool Set, supplement, organizational: PN 12310894
37	C	5120-01-121-4981	Wrench, plug, straight bar hex: PN 12284998
38	C	5120-00-240-5328	Wrench, adjustable: 8 in.

Table B-1. Tools.-CONT.

Item number	Level	NSN	Description
39	C	5120-00-277-4244	Wrench, plier: straight jaw, 8-1/2 in.
40	C	5120-00-148-7917	Wrench Set, combination box with open end, 12 components, 5/16 in.-1 in.
41	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. 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 generator 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.

WARNING

This voltage indicator can only be used safely below 37 volts DC.

a. **Making a Voltage Indicator.** A voltage indicator can be made from a light bulb and two pieces of wire (figure B-1). 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 tested. For voltages in the 18 to 30V dc 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 5V dc or less a two-battery cell flashlight 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 wires to voltage source when ready to test for voltage.

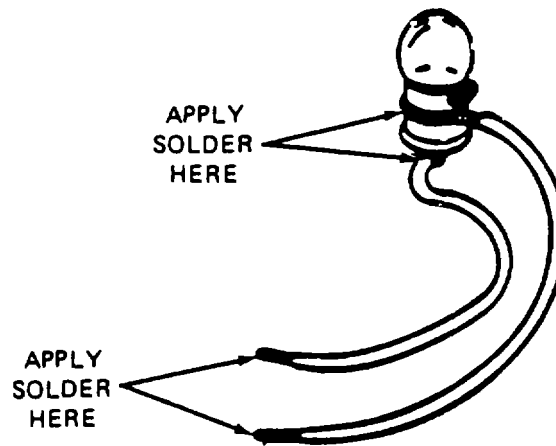


Figure B-1. Voltage Indicator Made from Light Bulb.

b. Continuity Tester. A continuity tester can be made from a flashlight bulb, flashlight battery, and three pieces of wire (figure B-2). 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.

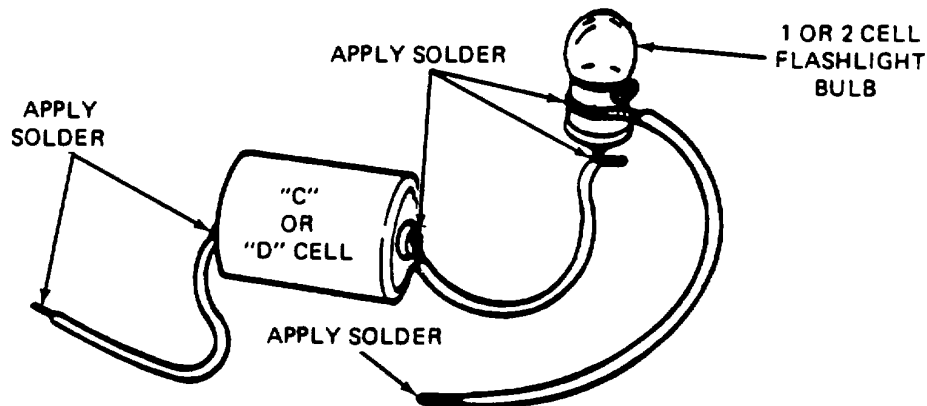


Figure B-2. Continuity Tester Made from Flashlight Bulb.

Section IV. WELDING EXPEDIENTS

WARNING

- Do not weld on fuel tanks unless they have been thoroughly drained and purged of fuel. Failure to heed this warning may result in an explosion and fatal injuries.
- Use personal protective equipment such as eye goggles, gloves, and hearing protection when performing BDAR actions. Serious injury can result when such is not used.

B-4. Controlled Amperage. 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.

a. Limitations.

None

b. Materials/tools.

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

c. Personnel/time required.

2 soldiers/1.0-2.0 hours

d. 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 to (+) and (-) output posts. Tighten terminals securely.
- (2) Connect negative () cable to generator frame 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. Disconnect batteries on generator being repaired prior to welding.

- (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 generator using standard maintenance procedures.
- (5) Other options: Use uncontrolled amperage.

B-5. Uncontrolled Amperage. 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.

a. Limitations.

None

b. Personnel/time required.

2 soldiers/1.0-3.0 hours

c. 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

d. 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 generator frame with clamp close to area to be welded. Connect welding rod to positive (+) cable with vise grip and insulate area against heat with gloves, rags, or several layers of dry paper.

WARNING

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

- (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 generator using standard maintenance procedures.

B-7/(B-8 blank)

APPENDIX C

EXPENDABLE/DURABLE SUPPLIES AND MATERIALS

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

Section I. INTRODUCTION

C-1. Scope. This appendix lists recommended for the support of generators in a combat environment. The list includes expendable/durable 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. Other equivalent materials may be available which are not listed.

Section II. SUPPLIES

C-2. Explanation of Columns

- a. Column (1)-Item Number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., "Use cleaning compound, item 5, App. D").
- b. Column (2)-National Stock Number. This is the National stock number assigned to the item; use it to request or requisition the item.
- c. Column (3)-Description. Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the Commercial and Government Entity Code (CAGEC) in parentheses followed by the part number.
- d. Column (4)-Unit of Issue (U/I). Is the abbreviation of the types of units under which material is issued.

C-3. Table. Expendable/durable supplies and materials are listed in table C-1.

Table C-1. Expendable/Durable Supplies and Materials.

Item number	NSN	Description	U/I
1	8040-00-831-3403	Adhesive, epoxy 1 pt	kt
2	8040-00-828-7385	Adhesive/sealant, silicone rubber, GE TRV 103	tu
3	8040-00-738-6429	Adhesive, epoxy	kt
4	5999-00'661-0416	Cap, electrical: crimp style	pkg

Table C-1. Expendable/Durable Supplies and Materials--CONT.

Item number	NSN	Description	U/I
5	4730-00-289-5909	Clamp, hose: 3/8 in. to 1 in.	ea
6	5350-00-192-5047	Cloth, abrasive: al-oxide 1/09 in. w. 11 in. lg (50 sheets)	pkg
7	5315-00-598-5916	Cotter pin assortment	At
8	4720-00-623-9178	Hose, non-metallic, 1/4 in. ID	ft
9	4720-00-169-5112	Hose, non-metallic, 1/2 in. ID	ft
10	4720-00-288-9873	Hose, non-metallic, 3/4 in. ID	ft
11	5310-00-297-3751	Nut assortment	at
12	4020-00-968-1352	Rope, polypropylene (600 ft roll)	roll
13	8030-00-656-1426	Sealing compound, gasket, non-hardening	Pt
14	8030-00-965-2004	Sealant, synthetic rubber 1 pt	kt
15	5305-00-275-4073	Set screw assortment	at
16	3439-00-247-6961	Solder, acid-core	roll
17	3439-00-243-1882	Solder, resin-core	roll
18	5940-00-840-0139	Splice, conductor: crimp style, wire size 10	ea
19	5940-00-500-8723	Splice, conductor: crimp style, wire size 10	ea
20	9905-00-537-8957	Tag, blank, white	bd
21	8030-00-889-3535	Tape, anti-seizing pipe plug, teflon, 1/2 in. wide	ea
22	5970-00-543-1005	Tape, electrical	roll
23	7510-00-802-8311	Tape, filament-reinforced: 3/4 in., 50 yd roll	roll
24	5940-00-813-0698	Terminal, lug: crimp style, stud sz 6, wire sz, 22-18	ea

Table C-1. Expendable/Durable Supplies and Materials-CONT.

Item number	NSN	Description	U/I
25	5940-00-577-3711	Terminal, lug: crimp style, stud sz 10, wire sz 22-18	hd
26	5940-00-283-5280	Terminal, lug: crimp style, stud sz 6, wire sz 16-14	ea
27	5940-00-143-4780	Terminal lug: crimp style, stud sz 10, wire sz 16-14	ea
28	5940-00-143-4794	Terminal lug: crimp style, stud sz 10, unspec	ea
29	5940-00-804-9185	Terminal, quick disconnect, wire sz 18	pkg
30	5940-00-804-9184	Terminal, quick disconnect, wire sz 14-16	pr
31	5310-00-209-2312	Washer, lock, assortment	at
32	5310-00-275-4290	Washer, flat, assortment	at
33	6145-00-152-6499	Wire, wire size 14	ft
34	6145-00-435-8613	Wire, wire size 18	ft
35	5315-00-271-4251	Woodruff key assortment	at

C-3/(C-4 blank)

APPENDIX D

SUBSTITUTE MATERIALS/PARTS

**BDAR FIXES SHALL BE USED ONLY IN COMBAT OR FOR TRAINING
AT THE DISCRETION OF THE COMMANDER
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Section I. INTRODUCTION

WARNING

Solvents, POL and other liquid chemicals may be hazardous to your health. Use only in well ventilated areas. Keep all sources of fire away.

D-1. General. 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 both significant reduction in performance and in serious harm to the system with continued use.

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

b. *NATO POL Products.* 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.

c. *Fuel Usage.* 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.

d. *Fuel Mixing.* Table D-1 identifies fuels or products that can be used as fuels. One of the best means to increase the available fuel is to use potential substitutes as extenders by mixing them with the primary fuels and not using them as the sole fuel source. This allows some products which could not ordinarily be burned (or pumped) to be used by diluting them. Because of the dangers of varying combustability

of fuels, increased by vaporization during filing, the blending process is very important. The most direct and expeditious procedure to mix fuels is to add the two fuels at the same time from two separate fuel lines. If added directly to the vehicle fuel tanks as separate fuels there is not sufficient turbulence in filling or shaking by normal driving to provide a properly mixed fuel. In vehicles with more than one tank, you could end up with a distinct fuel type in each tank.

D-2. Fuel Blending. 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.

a. 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 fuel dispensing vehicle. Add the blending fuel and mix by recirculating from the tank outlet to the tank truck pump inlet.

NOTE

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

b. Elimination of POI Substitute Fuel After Use. 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.

D-3. Lubricants and Hydraulic Fluids. 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.

a. Substitute Lubricants and Hydraulic Fluids. Table D-2 provides a list of basic fluids which can be used as substitutes (alternate and expedient). It is structured around the vehicle lube order. Alternate products shown are NATO equivalents to the US specifications and can really be considered 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.

b. Time Limit on Use of Substitute Lubricants and Hydraulic Fluids. There are no established time constraints on these expedients but the shorter the time used the better.

D-4. Flushing Lubricant and Hydraulic Systems. Expedient lubricant and hydraulic fluids must be removed as soon as possible, and the system cleaned and inspected.

a. Flushing Oil Systems. For those systems using oil, 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 a 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 system should not be disassembled to inspect seals, maintenance organizations should be prepared to replace seals that show signs of leaking. Organizations must observe seals on these systems during subsequent operations.

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

Section II. POL SUBSTITUTES

**Table D-1. Fuels and Substitute Fuels.
(Listed in Order of Priority)**

a. 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.

b. Alternate Fuels.

1. MIL-T-5624 (Aviation Turbine Fuel) (JP-4 & JP-5) *
2. NATO-F-4- (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, I-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)

c. Fuel Mix with Fuel Extenders (Blends up to half and half-50 percent extender)

Base	Extender
1. Any Primary Fuel	Any Alternate Fuel
2. Any Alternate Fuel	Any Alternate Fuel
3. MIL-F-815	Any lighter primary or alternate
4. NATO-F-76	Any lighter primary or alternate
5. Any Diesel Fuel	PD-680 (Type I & II) (Dry Cleaning Solvent)
	ASTM-D-484 (K, I, II, III, IV) D.C.S.)
	ASTM-D-235 (I thru IV) Pet. Spirits)

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

Table D-1. Fuels and Substitute Fuels-CONT.

d. Expedient (Emergency) Fuel. Blends with other fuels or extenders (Note blend rates stated).

Base	Extender
1. Any Primary Fuel	Any Gasoline ** - up to 50%
2. Any Alternate Fuel	Any Gasoline II - up to 25%
3. Any Primary Fuel	New engine oil - up to 50%
4. Any Alternate Fuel	New engine oil - up to 75%
5. Any Primary Fuel	Used engine oil
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)
5. VV-G-1690 (Auto Gasoline)
6. ASTM-D-439 (Auto Gasoline) Any Grade)
7. MIL-G-53006 (Auto Gasoline)
8. MIL-G-5572 (Aviation Gasoline) 100/130)
9. NATO-F-18 (Aviation Gasoline) (100/130)
10. ASTM-D-910 (Aviation Gasoline) (100)
11. MI L-G-5572 (Aviation Gasoline) (115/145)
12. NATO-F-22 (Aviation Gasoline) (115/145)

Table D-2. Lubrication Substitutes

LO authorization				Alternates		
Temp range	Lube	USNATO specification	product	US spec or use equiv NATO prod	Soviet	Expedient
Above 32°F + 40° F to -10°F to -65°F	OE/HDO-50 OE/HDO-30 OE-HEO-10 OEA	MIL-L-2104 MIL-L-2104 MIL-L-2104 MIL-L46167	0-238/739 0-238/739 0-238/739 0-183	Any Hydraulic Oil	M8GI, M1091, M-8V, M10V M-8A, M10OA AS-9, AS-10, AS-1 1 Below 0°F Soviet Products M6V, M6A, AS-3, AS-4, AS-5, AS-6	Commercial Heavy Transmission or any Hydraulic Fluid Turbine
Above 32°F + 40°F to -10°F 0°F to -65°F	HB HB HBA	VV-B-680 VV-B-680 MIL-H-13910				
All	OHT	MIL-H-6083D	C-635	MIL-H-5605 (NATO H-515) MIL-H-46170 (NATO) H-549)		Commercial Heavy Transmission Fluid
All	GA1	MIL-G-23827		MIL-G-10924		
Above 32°F + 40°F to -10°F 0°F to -65°F	OE/HDO OE/HDO-10 OEA	MIL-L-2104 MIL-L-2104 MIL-L46167	0-238/739 0-238/739	Any Hydraulic Fluid	See Above	Cooking Oil Water
	OHA	MIL-H-5606	H-515	MIL-H-6083 MIL-H46170		
Above 32°F +40°F to -10°F 0°F to -65°G	GGP GGP GAA	MIL-G-23549 MIL-G-23549 MIL-G-10924	G-403	All C-2105 LITOL-24	TS/ATIM-201 TS/ATIM-221 UNIINP-232 UNIINP-279 UNIINP-221	
Above 30°F 40°F to -10°F	GO 90 GO 80 GOS	MIL-L-2105 MIL-L-2105 MIL-L-10324	G-226 G-228	MIL-L-2104 OE 50 MIL-L-2104 OE 50 MIL-L-46167 OEA		

Table D-3. Generator Application Substitutes.

Stock number	Nomenclature	Manufacturer	Model
1	2	3	4
6115-00-940-7862	Generator Set 0.5KW/400 Hz	Military Design	MEP-019A
6115-00-940-7867	Generator Set 0.5KW/28V	Military Design	MEP-024A
6115-00-923-4469	Generator Set 0.5KW/60Hz	Military Design	MEP-014A
6115-00-017-8236	Generator Set 1.5KW/28V	DOD, Military Design	MEP-025A
6115-00-889-1446	Generator Set 1.5KW/60Hz	DOD, Military Design	MEP-015A
6115-00-017-8237	Generator Set 3KW/60Hz	DOD, Military Design	MEP-016A
6115-00-017-8238	Generator Set 3KW/400Hz	DOD, Military Design	MEP-021A
6115-00-017-8239	Generator Set 3KW/28V	DOD, Military Design	MEP-026A
6115-00-017-8240	Generator Set 5KW/60Hz	DOD, Military Design	MEP-017A
6115-00-017-8241	Generator Set 5KW/400Hz	DOD, Military Design	MEP-022A
6115-00-738-6337	Generator Set 5KW/60Hz	Signal Corps	PU618
6115-00-738-6338	Generator Set 5KW/60Hz	Eng Research & Development Lab	PU 409A/M
6115-00-738-6340	Generator Set 5KW/60Hz	Signal Corps	PU620
6115-00-033-1373	Generator Set 5KW/60Hz	DOD, Military Design	PU751
6115-00-738-6339	Generator Set 10KW/60Hz	Signal Corps	PU619M

Table D-3. Generator Application Substitutes-CONT.

Stock number	Nomenclature	Manufacturer	Model
1	2	3	4
6115-00-033-1398	Generator Set 10KW/60Hz	DOD, Military Design	AN/MJQ-18
6115-00-889-1447	Generator Set 10KW/60Hz	DOD, Military Design	MEP-018A
6115-00-926-0843	Generator Set 10KW/400Hz	DOD, Military Design	MEP-023A
6115-00-118-1240	Generator Set 30KW, 50/60Hz	DOD, Military Design	MEP-005A
6115-00-118-1247	Generator Set 30KW, 50/60Hz	DOD, Military Design	MEP-104A
6115-00-118-1248	Generator Set 30KW, 400Hz	DOD, Military Design	MEP-1 14A
6115-00-118-1243	Generator Set 60KW, 50/60Hz	DOD, Military Design	MEP-006A
6115-00-118-1252	Generator Set 60KW, 50/60Hz	DOD, Military Design	MEP-105A
6115-00-118-1253	Generator Set 60KW, 400Hz	DOD, Military Design	MEP-1 15A

Section III. PARTS COMMONALITY

D-5. General. Repair parts are expected to be in short supply. Parts may be available from other damaged generators which may or may not be from identical equipment. The following tables identify parts commonality within the DOD standard family of generators. These parts should be given cannibalization priority in case the generator cannot be recovered.

Table D-4. Parts Commonality (15 thru 200KW DOD STD Diesel Engine Driven Sets).

Generator Parts	Parts commonality
Air Filter Element	Same on all sets
Fuel Transfer Pumps	Same on all sets
Protective Relays (Except Under Frequency)	Same on all sets
Under Frequency Relay	Same on all 50/60 Hz Sets Same on all 400 Hz Sets
Control Box Assembly (Except Frequency Meter)	Same on all sets
Frequency Meter	Same on all 50/60 Hz Sets. Same on all 400 Hz Sets
Batteries	Same (Type 6TN) on all sets
Fuel Float Switch	Same on all sets
Fuel Solenoid Valve	Same on all sets
DC Alternator	Same on MEP Models 103, 004, 113, 005, 114, 105, 006 and 115. Some on MEP Models 106, 007, 116, 108 and 009.

Table D-4. Parts Commonality (15 thru 200KW DOD STD Diesel Engine Driven Sets)-CONT.

Generator Parts	Parts commonality
Starter Motor	Same on MEP Models 103, 004, 113, 1U4, 005, 114. Same on MEP Models 106, 007, 116, 108 and 009.
Excitation Assemblies	Same on MEP Models 103, 004, 104 and 005. Same on MEP Models 113 and 114
Load Measuring Unit	Same on all sets

Table D-5. Parts Commonality (0.5 thru 10KW MI L STD Gasoline Engine Driven Sets).

Generator Parts	Parts commonality
Starter	Same on MEP Models 017, 022, 018 and 023
Air Filter Element	Same on MEP 014, 024, 015, 020 and 025. Same on MEP 017, 022, 018 and 023
Carburetor	Same on MEP Models 014, 019, 024, 015, 020, 025, 016, 021 and 026. Same on MEP Models 017, 022
Battery Charging Alternate	Same on MEP Models 017, 022, 018 and 023
Fuel Pump	Same on MEP Models 014, 019, 024, 015, 020 and 025. Same on MEP Models 017, 022, 018 and 023
Points and Cond.	Same on MEP Models 014, 019, 024, 015, 020, 025, 016, 021 and 026
DC Voltage Regulator	Same on MEP Models 017, 022, 018 and 023
AC Voltage Regulator	Same on MEP Models 016, 021, 026, 017, 022, 108 and 023
Frequency Meter	Same on MEP Models 014, 015, 016, 017 and 018. Same on 019, 020, 021, 022 and 023
AC Volt Meter	Same on MEP Models 014, 015, 016, 107 and 018. Same on 019, 020, 021, 022 and 023
Batteries	Same (Type 2HN) on MEP Models 017, 018, 022 and 023

**Table D-6. Parts Commonality ((5KW, 60HZ (MEP-002A), 10KW, 60HZ (MEP-003A).
10KW, 400HZ (MEP-1 12A) DOD STD Diesel Engine Driven Sets)).**

Generator Parts	Parts commonality
Starter	Same on all sets
Air Cleaner Assembly	Same on all sets
Air Cleaner Element	Same on all sets
Battery	5kW (2HN same as 5 and 10kW GED Sets) 10kW (6TN same as 15 thru 200KW DED Sets)F
Fuel Tanks	Same on both 10kW Sets
Fuel Level Float Switch	Same on all sets
Fuel Pickup Assembly	Same on all sets
Fuel Gage	Same on all sets
Control Box Assembly	Same on all sets except Frequency Meters and Converters
Voltage Regulator	Same on all sets
Load Terminal Assembly	Same on all sets
Current Transformer	Same on all sets
Current/Voltage Transformer	Same on 5 and 10kW, 60Hz Sets
Rheactor	Same on 5 and 10kW, 60Hz Sets
Circuit Breaker Assembly	Same on 5 and 10kW, 60HZ Sets
Reconnection Switch	Same on all sets
Exciter Bridge Rectifier Assembly	Same on 5 and 10OkW, 60HZ Sets
Auxiliary Fuel Line	Same on all sets
Fuel Filter Assembly	Same on all sets
Fuel Transfer Pump Assembly	Same on all sets
Generator End Bell Assembly	Same on 5 and 10kW, 60Hz Sets
Generator Fan	Same on all sets
Exciter Rotor Assembly	Same on all sets

Table D-6. Parts Commonality ((5KW, 60HZ (MEP-002A), 10KW, 60HZ (MEP-003A), 10KW, 400HZ (MEP-1 12A) DOD STD Diesel Engine Driven Sets))-CONT.

Generator Parts	Parts commonality
Exhaust Muffler	Same on all sets but 5kW has one (1), 10kW Sets have two (2)
Engine Flywheel	Same on all sets
Engine Generator Adaptor	Same on all sets
Manifold Heater	Same on all sets
Battery Charging Regulator/Rectifier	Same on all sets
Battery Charging Alternator Stator	Same on all sets
Battery Charging Alternator Rotor	Same on all sets
Blower Wheel Assembly	Same on 5 and 10kW, 60Hz Sets
Governor Linkage Assembly	Same on all sets
Governor Control Assembly	Same on all sets
Governor Control Cable	Same on all sets
Starter Lockout Switch	Same on all sets
Fuel Stop Solenoid	Same on all sets
Oil Filter Assembly	Same on all sets
Oil Filter Adapter Assembly	Same on all sets
Oil Pressure Switch	Same on all sets
Oil Pump, Engine	Same on all sets
Gear Case Assembly	Same on all sets
Piston and Connecting Rod Assembly	Same on all sets
High Temperature, Thermo Switch	Same on all sets
Control Box Support	Same on all sets
Slave Receptacle Assembly	Same on all sets

APPENDIX E

BDAR TRAINING PROCEDURES

BDAR TRAINING FIXES SHALL BE
USED ONLY AT THE DISCRETION OF THE COMMANDER
DAMAGES SHALL BE REPAIRED BY STANDARD MAINTENANCE
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By Order of the Secretary of the Army:

CARL E. VUONO
General United States Army
Chief of Staff

Official:

THOMAS F. SIKORA
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:

To be distributed in accordance with DA Form 12-25A, Operator Maintenance requirements for:

Generator Set, Diesel Driven, Tactical Skid Mounted, 120/208V, 240/416V, 30KW, 3PH, 4 Wire (50/60HZ:MEP-005A, MEP-104A; 400HZ: MEP-114A)

Generator Set, Diesel Driven, Tactical, Skid Mounted, 120/208V, 240/416V, 3PH, 4 Wire (50/60HZ: MEP-006A, MEP-105A; 400HZ: MEP-115A)

Generator Set, Gas Driven, 120/240V, 0.5KW, 1 PH, (60HZ AC: MEP-014A; 400HZ AC: MEP-019A; 28V DC: MEP 024A)

Generator Set, Gas Driven, Skid Mounted, 120/240V, AC, 28V DC, 1.5 KW, 1 PH (60HZ AC: MEP-OISA; 60 HZ DC MEP-025-A)

Generator Set, Gas Driven, 120/208V, 120/240V, 10KW, 1 & 3 PH, (60HZ: MEP 018A; 400HZ: MEP 023A)

Generator Set, Gas Driven, Tactical, Skid Mounted, 120/240V, 1 PH, 120/208V, 3PH, 5KW, (60HZ: MEP-017A; 400HZ: MEP-022A)

Generator Set, Diesel Engine Driven, Trailer Mounted

Generator Set, Gas Driven, 120/208V, 120/240V, 28V DC, 3KW, 60/400HZ, 3PH (MEP-016A,MEP-021A,MEP 026A)

[illegible]

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
 1 decimeter = 10 centimeters = 3.94 inches
 1 meter = 10 decimeters = 39.37 inches
 1 dekameter = 10 meters = 32.8 feet
 1 hectometer = 10 dekameters = 328.08 feet
 1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
 1 decigram = 10 centigrams = 1.54 grains
 1 gram = 10 decigrams = .035 ounce
 1 decagram = 10 grams = .35 ounce
 1 hectogram = 10 decagrams = 3.52 ounces
 1 kilogram = 10 hectograms = 2.2 pounds
 1 quintal = 100 kilograms = 220.46 pounds
 1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounce
 1 deciliter = 10 centiliters = 3.38 fl. ounces
 1 liter = 10 deciliters = 33.81 fl. ounces
 1 dekaliter = 10 liters = 2.64 gallons
 1 hectoliter = 10 dekaliters = 26.42 gallons
 1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

<i>To change</i>	<i>To</i>	<i>Multiply by</i>	<i>To change</i>	<i>To</i>	<i>Multiply by</i>
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29.573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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PIN: 068101-000