ATP 4-31/MCRP 4-11.4A

Recovery and Battle Damage Assessment and Repair (BDAR)

August 2014

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Recovery and Battle Damage Assessment and Repair (BDAR)

Contents

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***This publication supersedes FM 4-30.31 dated 19 September 2006.**

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Army techniques publication (ATP) 4-31/Marine Corps Reference Publication (MCRP) 4-11.4A, *Recovery and Battle Damage Assessment and Repair*, provides techniques on how recovery and battle damage assessment and repair (BDAR) assets are employed during operations.

The principal audience for ATP 4-31/MCRP 4-11.4A is all members of the profession of arms. Commanders and staffs of Army headquarters serving as joint task force or multinational headquarters should also refer to applicable joint or multinational doctrine pertaining to recovery and BDAR operations. Trainers and educators throughout the Army and USMC will also use this publication.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and in some cases host-nation laws and regulations. Commanders at all levels ensure that their Soldiers operate in accordance with the law of war and the rules of engagement. (See FM 27-10.)

ATP 4-31/MCRP 4-11.4A implements the following standardization agreements (STANAG):

- STANAG 2375 - Battlefield Vehicle Recovery and Evacuation Guide (AEP-13).
- STANAG 2399 - Battle Recovery/Evacuation Operations.
- STANAG 2400 - Battlefield Vehicle Recovery User Handbook (AEP-17).
- STANAG 2418 Ed. 2 - Procedures for Expedient Repair, Including Battle Damage Repair.
- STANAG 4101- Towing Attachments.

ATP 4-31/MCRP 4-11.4A uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms for which ATP 4-31/ MCRP 4-11.4A is the proponent publication (the authority) are italicized in the text and are marked with an asterisk (*) in the glossary. Terms and definitions for which ATP 4-31 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

ATP 4-31/MCRP 4-11.4A applies to the Active Army, Active Marines, Army National Guard, United States Army Reserve, and Marine Corps Reserves unless otherwise stated.

The proponent of ATP 4-31/MCRP 4-11.4A is the United States Army Ordnance School. The preparing agency is the United States Army Combined Arms Command (CASCOM) G-3 Training and Doctrine Development Directorate. Send comments and recommendations on DA Form 2028 (*Recommended Changes to Publications and Blank Forms*) to Commander, United States Army CASCOM, ATTN: ATCL-TS (ATP 4-31), 2221 A Ave, Fort. Lee, VA 23801; or submit an electronic DA Form 2028 by e-mail to: usarmy.lee.tradoc.mbx.leee-cascom-doctrine@mail.mil. USMC readers of this publication are encouraged to submit suggestions and changes by email to doctrin@usmc.mil or by mail to the Deputy Commandant for Combat Development and integration, ATTN: C116, 3300 Russell Road, Suite 204, Quantico, Virginia 22134-5021.

Introduction

Soldiers and officers that perform recovery operations/battle damage assessment and repair for the Army perform a vital role of keeping their units and Army personnel safe while maintaining and providing the effective operational readiness rates needed to accomplish the mission. Recovery personnel, as identified in this publication, include every person that plays a role in recovery operations or battle damage assessment and repair. This includes professional recovery personnel, such as maintenance control officers, warrant technicians and maintenance teams.

All personnel involved in recovery operations/ battle damage assessment and repair need to understand the environment in which they operate. This manual provides information on recovery support to unit operations also including the Joint environment.

It is imperative for all personnel engaged in recovery operations/ battle damage assessment and repair support operations to have an understanding of the various staff organizations that have a role in recovery planning and support. It will be necessary for a recovery support activity to contact the higher, lower, or adjacent headquarters (both sustainment and operational) to coordinate support, report status, request technical assistance, or request additional resources. This manual will present the roles and mission of the various recovery organizations so that proper coordination can be conducted.

The guidelines in this publication should be followed as closely as possible within the constraints and restrictions of the tactical situation.

ATP 4-31, *Recovery and Battle Damage Assessment and Repair (BDAR),* is the revision of FM 4-30.31, *Recovery and Battle Damage Assessment and Repair*. ATP 4-31 provides an overview of the battlefield recovery, and battle damage assessment and repair for the fundamental purpose of returning combat assets to the battlefield as soon as possible. It also explains the difference between recovery operations with its different types and methods and the battle assessment and repairs. This publication also reviews the rigging procedures and the utilization of the mechanical advantage to accomplish the mission. Overviews the recovery methods, techniques and the safety precautions associated with each recovery operation. Major changes from FM 4-30.31 include an improved hand and arm signals for day and night recovery operations.

ATP 4-31 is comprised of four chapters:

- **Chapter 1** discusses the battlefield recovery with its various types and battle damage assessment and repairs; it discusses the various types of recovery and the responsibility of the owning units.
- **Chapter 2** explains the rigging methods and techniques**,** how to take advantage of the mechanical advantage during various rigging configurations with equipment readily available.
- **Chapter 3** covers huge varieties of recovery techniques for different obstacles, overturned, and mired situations and emphasizes safety during the recovery operations.
- **Chapter 4** covers the various improvised repair procedures in order to rapidly return disabled equipment to operational condition in wartime by expediently repairing, bypassing, and restoring minimum function to essential systems.

ATP 4-31 does not introduce, modify or rescind any Army terms or acronyms.

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Chapter 1

Introduction to Recovery and Battle Damage Assessment and Repair

Battlefield recovery and battle damage assessment and repair (BDAR) are separate and distinct subsets of maintenance. Both are the owning units' responsibilities and both have a fundamental purpose of returning combat assets to the battlefield as soon as possible. The purpose of recovery is to rapidly free mired equipment or remove disabled equipment from the battlefield. The purpose of BDAR is to apply expedient repairs allowing the equipment to self-recover and continue the mission.

RECOVERY

1-1. Recovery is defined as the process of freeing or retrieving immobile, inoperative, or abandoned equipment from its current position and returning it to service or to a maintenance site for repairs. These actions typically involve extracting, towing, lifting, or winching. Towing is usually limited to moving equipment to a field maintenance site or the nearest unit maintenance collection point. Depending on the mire level or the severity of battle damage, recovery is usually accomplished by the following methods: self-recovery, like-vehicle recovery, dedicated-recovery and expedients. Each of these recovery methods and mire levels will be discussed in more detail in later chapters.

1-2. Damaged and inoperable equipment on the battlefield can strain dedicated recovery resources. To effectively support battlefield recovery operations, dedicated recovery assets should be strategically placed for optimum support of the area of operations. Commanders must emphasize the use of self and like vehicle recovery methods to the greatest extent possible. These practices will minimize the use of dedicated recovery assets for routine recovery missions. Additional information and guidance can be found in ATP 4-33, *Maintenance Operations*.

1-3. Recovery operations on the battlefield and in general can be extremely hazardous. A risk assessment must be conducted and safety must remain a top priority for each recovery mission. Proper maintenance of recovery vehicles and serviceability of authorized rigging and other equipment is essential to ensure safe recovery missions. Operational variables must be considered prior to and during all recovery operations.

SELF-RECOVERY

1-4. Self-recovery starts at the location where the equipment becomes mired or disabled. The operator/crew uses the basic issue items (BII) and additional authorized list or on-vehicle equipment items to perform self-recovery.

1-5. When the equipment has a mechanical failure, the operator/crew will use the equipment's technical manual (TM) to perform troubleshooting procedures with the tools available in the BII and additional authorized list or on-vehicle equipment. When self-recovery fails, the operator/crew can request assistance from available like vehicles.

LIKE-RECOVERY

1-6. Like-vehicle recovery is used when self-vehicle recovery fails. The principle is to use another piece of equipment "of the same weight class or heavier" to extract the mired, disabled, or damaged equipment by using tow bars, chains, tow cables, and/or allied kinetic energy recovery rope. When self-recovery and like-recovery are not practical or are unavailable, use dedicated recovery assets.

DEDICATED RECOVERY

1-7. Dedicated recovery vehicles are those specifically designed and equipped for recovering other vehicles. Wheeled wreckers and tracked recovery vehicles are examples. These are used when self-recovery or like-vehicle recovery is not possible because of the severity of the situation, safety considerations, or the inability to use like-vehicle assets employed in their primary mission. In general, wheel recovery systems should recover wheel and track recovery systems should be used to recover track. However, wheel recovery vehicles may flat tow track vehicles under their weight, but track flat-tow recovery of wheel vehicles should be avoided due to potential damage to wheel vehicle front steering components largely due to track vehicles pivot turn. Recovery managers and supervisors must ensure recovery vehicles are used only when absolutely necessary. Dedicated recovery vehicles must be returned as quickly as possible to a central location to support the unit. In addition to its recovery mission, this equipment is often used for the heavy lifting required in maintenance operations. Recovery managers and supervisors must use all available resources carefully to provide sustained support.

BATTLE DAMAGE ASSESSMENT AND REPAIR

1-8. BDAR is the procedure used to rapidly return disabled equipment to the operational commander by field-expedient repair of components. BDAR restores the minimum essential combat capabilities necessary to support a specific combat mission or to enable the equipment to self-recover. BDAR is accomplished by bypassing components or safety devices, cannibalizing parts from like or lower priority equipment, fabricating repair parts, jury-rigging, taking shortcuts to standard maintenance, and using substitute fluids, materials or components. Depending on the repairs required and the amount of time available, repairs may or may not return the vehicle to a fully mission-capable status. Operators/crew, maintenance teams, or recovery teams may perform BDAR.

1-9. Based on a unit's standard operating procedures (SOP) and at the commander's discretion, anyone can perform BDAR depending on the extent of repairs required and operational variables. The commander decides whether or not to use BDAR instead of standard maintenance procedures. Expedient repairs may or may not return the vehicle to a fully mission-capable status.

Chapter 2

Rigging

Rigging is the process of assembling simple machines or tackle systems and using them to multiply the available force to overcome total resistance. The product of these machines is called mechanical advantage (MA). This chapter describes individual rigging components, methods of rigging and procedures for calculating mechanical advantage.

RIGGING EQUIPMENT

2-1. Rigging equipment using block and tackle has been used for centuries for lifting heavy objects. The increased mechanical advantage of using a pulley system can aid in lifting heavy objects with the ease of one person.

BLOCKS AND TACKLE SYSTEMS

2-2. Block and tackle is an arrangement of rope and pulleys that allows you to trade force for distance.

Blocks

2-3. Blocks are used primarily to reverse the direction of the rope in the tackle. Blocks take their names from the purpose for which they are used and the places they occupy. Blocks are designated as single or multiple depending on the number of sheaves in the block.

Snatch Blocks

2-4. The snatch block is a single sheave block made so that the shell opens on one side or pivots (swing block) at the center of the block to permit a rope to be slipped over the sheave without threading (reeving) the end of the rope through the block. These are the most common blocks used in rigging because of the flexibility over fixed blocks. Depending on their location in the rigging they are referred to as fixed, running, or floating blocks.

2-5. The housing of some snatch blocks is hinged on one side allowing it to open and placing the rope over the sheave without disassembling the block. A major design advantage of this snatch block is that it can remain attached to the rigging while removing or installing the rope. The major disadvantage of these hinged snatch blocks is the weight which increases as capacities and size increase.

2-6. The swing snatch block housing swings in opposite directions on the sheave pin exposing the sheave to attach the rope. (See figure 2-1 on page 2-2.) To close the block, both sides of the housing are rotated until the tackle openings on the block line up enclosing the rope. A major advantage of this type of block is that it's usually made from lightweight materials making it easier to handle and carry. One disadvantage is that, the swing snatch block must be disconnected from the rigging to enable the housing to swing open and insert the rope. However, the task does not consume a great deal of time.

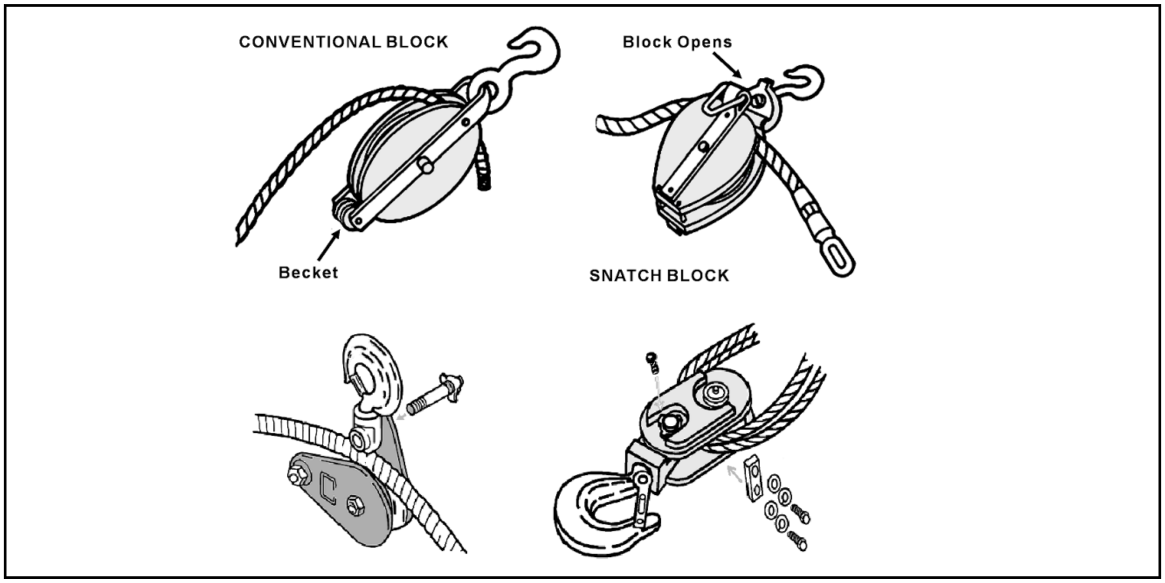

Figure 2-1. Block configurations

Conventional Block

2-7. A conventional block is generally used where it will remain as part of a rigging system. On recovery equipment, it is used with wire rope. To form a tackle with conventional blocks, lay out the blocks, and thread or reeve the wire rope through the blocks.

2-8. A fixed block is a block attached to a stationary anchor. The sheave of a fixed block permits the rope to change direction. A fixed block provides only a mechanical advantage during self-recovery operations.

2-9. A running block is attached to the load; the cable from the power supply runs around the sheave and returns to the power supply. This provides a mechanical advantage.

2-10. A floating block is used when the power force and load are not in alignment. Connect a tow cable to both tow hooks of the disabled vehicle. The tow cable runs in the sheave of the floating block allowing the power force and load "to self align" and equally distributes the load between tow hooks. A floating block does not provide a mechanical advantage (figure 2-2).

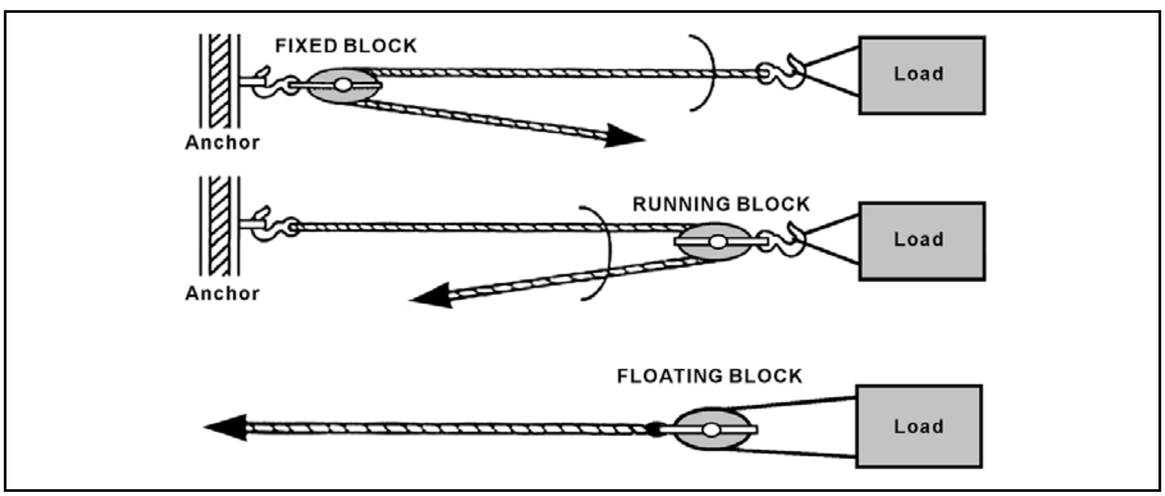

Figure 2-2. Block classifications

Multiple clevis snatch block rigging configurations

2-11. This is a rigging example which uses clevises to force the snatch block to operate vertically. Without the multiple clevises, the snatch block lays flat (horizontally) resulting in debris roll onto pulley which causes cable damage or cable walking off the pulley when sediment gets under cable. With multiple clevises configuration, the snatch block sits and stays in vertical position and does not collect sediment and debris. The upright clevis walks with the load as illustrated in (figure 2-3).

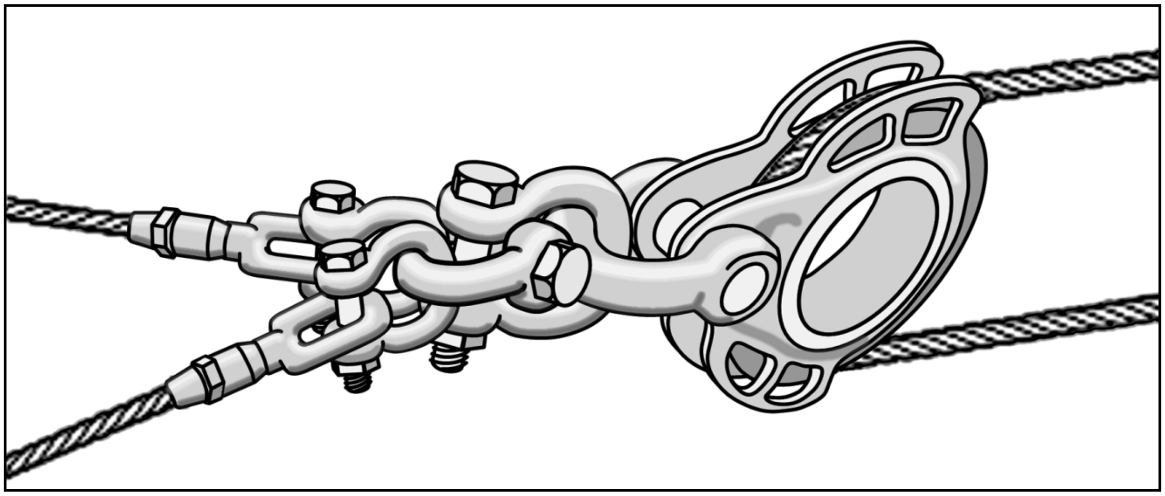

Figure 2-3. Multiple clevis snatch block rigging configurations

CORDAGE

2-12. There are different types of cords and ropes used in the rigging. The following paragraphs describe each.

Natural Fiber Rope

2-13. Fiber rope is used in many rigging and lifting applications. In recovery, it is primarily used for handling tackle, securing rigging and loading items onto trucks. Fiber rope is characterized by its size, weight and strength. The most common types of natural fiber rope used are Manila and Sisal.

2-14. Size of fiber rope is designated by its diameter up to 5/8 inch. Larger sizes up to 12 inches or more are designated by circumference. For this reason most tables give both the diameter and circumference of fiber rope. Weight of fiber rope varies due to several factors including, added preservatives, weather conditions and use. Strength of fiber rope depends on the type of properties that make up the fibers. The breaking strength (BS) is the greatest stress that a material is capable of withstanding without rupturing.

2-15. The minimum factor of safety (FS) for fiber rope is four (4). To obtain the working load limit (WLL) of fiber rope, divide the breaking strength (BS) by a minimum factor of safety (FS) of 4. The FS can always be increased by the user for an additional margin of safety when the condition is in question.

Example:

A new l-inch diameter, Number 1 Manila rope has a BS of 9,000 pounds. To determine the rope's WLL, divide the BS (9,000 pounds) by a minimum FS standard of 4.

WLL = BS/FS

WLL = 9000/4 = 2,250 lbs

WLL = 2,250

The result is a WLL of 2,250 pounds. This means that you can safely apply 2,250 pounds of tension to the new l-inch diameter, Number 1 Manila rope in normal use.

2-16. Always use factor of safety, because the breaking strength of rope is further reduced after repeated use and exposure to weather conditions. Shock loading, knots, sharp bends, and other stresses that rope may have to withstand during use may reduce its strength by as much as 50 percent. When the condition of the rope is in doubt, the factor of safety can be increased to 6 or 8 to minimize failures and maximize safety.

Synthetic Fiber Rope

2-17. Technological advances in materials and manufacturing processes led to the development of several strong synthetic fibers. The principal synthetic fiber used in earlier manufacture of synthetic rope is nylon which has a tensile strength nearly three times that of Manila fibers. Since that time other materials such as Polyester, Kevlar, Spectra, Dynema and others fibers have been developed. Kevlar and Dynema synthetic rope provide superior strength with minimal stretching and stored energy over the working load range when compared to other synthetic fibers, and wire rope.

2-18. There are several advantages of synthetic fiber rope over natural fiber rope. Synthetic rope is waterproof, has the ability to stretch, absorb shocks and resume normal length. Synthetic fibers also resist rot, decay, and fungus growth. Some disadvantages of synthetic rope include damage from abrasion, exposure to chemicals, high temperatures and prolonged exposure to ultra violet radiation depending on the protective outer layer. Synthetic fiber rope is commonly used in marine applications such as rigging equipment and winches, and is also found on some commercial vehicle winches.

Wire Rope

2-19. Until recently, wire rope was the most common type of rope used on winches and cranes. The basic element of wire rope is the individual wire which is made of steel or iron and comes in various sizes. The wires are laid together to form strands, and strands are laid together to form rope. Individual wires are usually wound or laid together in the opposite direction of the lay of the strands. The strands are then wound around a central core that supports and maintains the position of strands during bending and load stresses. The main characteristics of wire rope are size, weight, and strength. (See figures 2-4 and 2-5.)

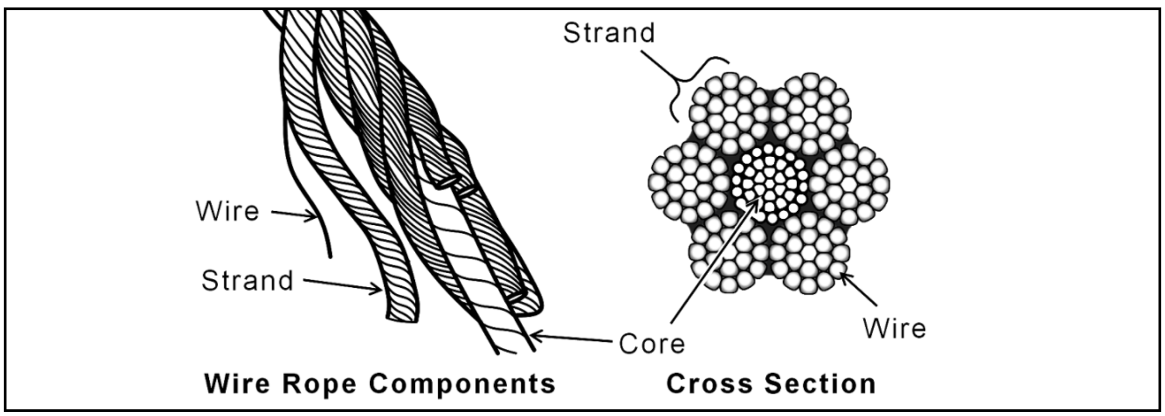

Figure 2-4. Wire rope characteristics

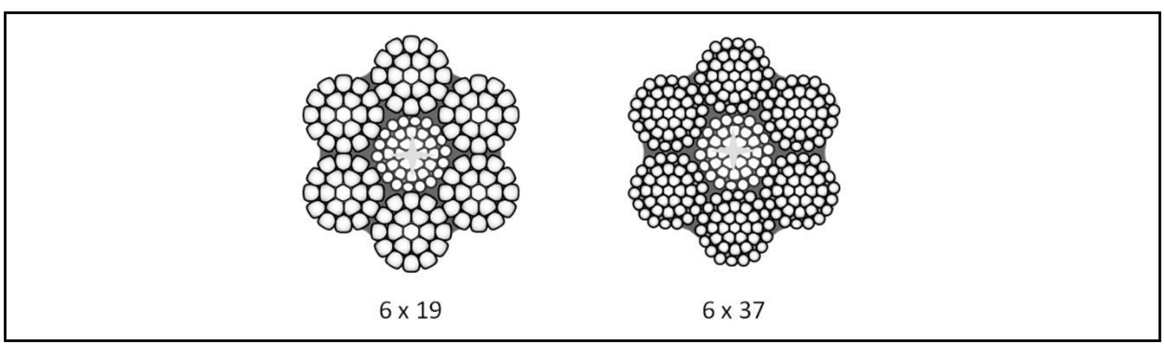

Figure 2-5. Strand and wire arrangements

2-20. The size of wire rope is designated by its diameter in inches. To determine the correct size of wire rope, measure its greatest diameter. (See figure 2-6.)

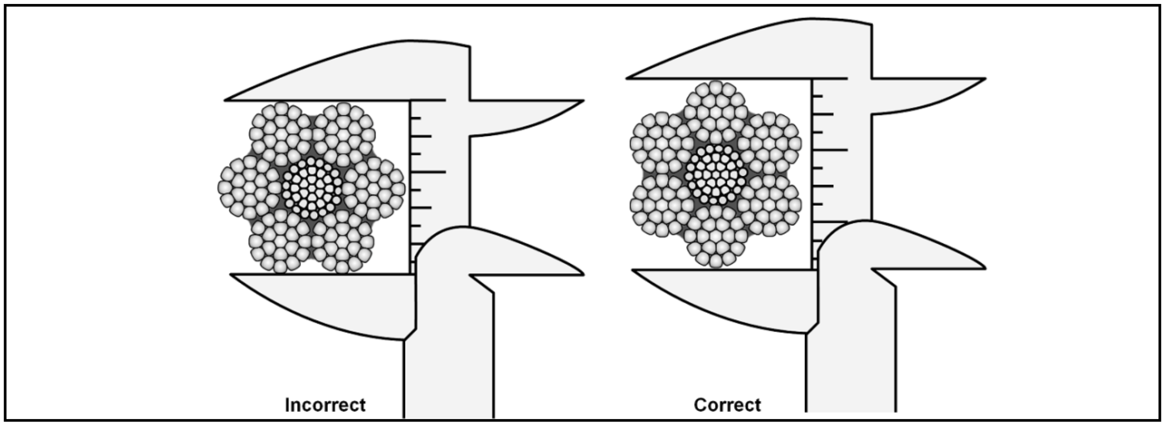

Figure 2-6. Measuring rope diameter

2-21. Due to various materials used in construction of wire rope, the weight varies with the size and the type of material. No rule of thumb can be given for determining the weight of wire rope.

2-22. Strength of wire rope on the other hand is determined by its size, grade and the method of fabrication. The individual wires are made from various materials, including traction steel, mild plow steel, improved plow steel, and extra improved plow steel.

CAUTION

Always wear leather gloves when handling wire or synthetic rope. Small frays in wire strands or rocks and debris picked up by synthetic rope can cause severe lacerations to hands. Never slide rope through hands, even when wearing leather gloves. Use the hand-over-hand method when inspecting or handling ropes. Wire ropes that are kinked, frayed, and synthetic ropes that have cuts, fused, melted, or have reduced-diameter, are unserviceable and should not be used.

2-23. Like fiber and synthetic rope, a suitable margin of safety must be used when applying a load to a wire rope. With wire rope the factor of safety varies depending on the application of the rope (table 2-1 on page 2-6). To obtain the WLL the BS is divided by the appropriate FS for the particular type of service. In all cases where the rope has been in service for a considerable time, the FS can be increased by the user to provide an additional margin of safety. When information is not available, as a rule of thumb, the WLL can be estimated by squaring the diameter of wire rope in inches, and multiply by 8 to obtain an estimated WLL in tons.

Example:

WLL = 8Diameter^2

Estimate the WLL of a one inch diameter wire rope as follows:

8Diameter^2

Diameter^2 = 1x 1 = $(1)^2$= 1

8 x $(1)^2$ = 8 x1 = 8

WLL = 8 tons = 16,000 lbs

Table 2-1. Wire rope factor of safety

Types of Service	*Minimum factor of safety (FS)*
Track Cables	3.2
Guys	3.5
Miscellaneous Hoisting Equipment	5.0
Haulage (Towing) Ropes	6.0
Derricks	6.0
Small electric and Air Hoists	7.0
Slings	8.0

2-24. There are several contributing factors for wire rope failures. The following failures are the most common:

- Sizing, constructing, or grading it incorrectly.
- Allowing the rope to drag over sharp and abrasive obstacles.
- Improper lubricating.
- Operating it over drums and sheaves of inadequate size.
- Over winding or cross winding it on drums.
- Operating it over drums and sheaves that are out of alignment.
- Permitting it to jump sheaves.
- Subjecting it to moisture or acid fumes.
- Permitting it to untwist.
- Kinking.

Chains

2-25. Chains are some of the most flexible and practical pieces of recovery equipment. Chains are often used for extracting mired equipment, rigging applications, lifting overhead loads and securing loads for transport. Although chains are very versatile and resilient, they can be easily damaged when subjected to shock loads and over stretching by exceeding the rated load capacity. Never use chains obtained from commercial sources unless the BS and WLL has been tested and verified by a government agency or the National Association of Chain Manufactures.

2-26. There are several types and grades of chains in use ranging from grade 30 through 100. To ensure safe recovery operations, only grades 80 or 100 chain shall be used. At a minimum, only grade 70 chains should be used to secure loads for transport and, only grades 80 or 100 alloy chains shall be used for overhead lifting. Chain grade is usually stamped on several links throughout the length of the chain (figure 2-7). For chain and binder specifications refer to Department of Transportation 49 CFR, Parts 392 and 393, paragraph 393.102.

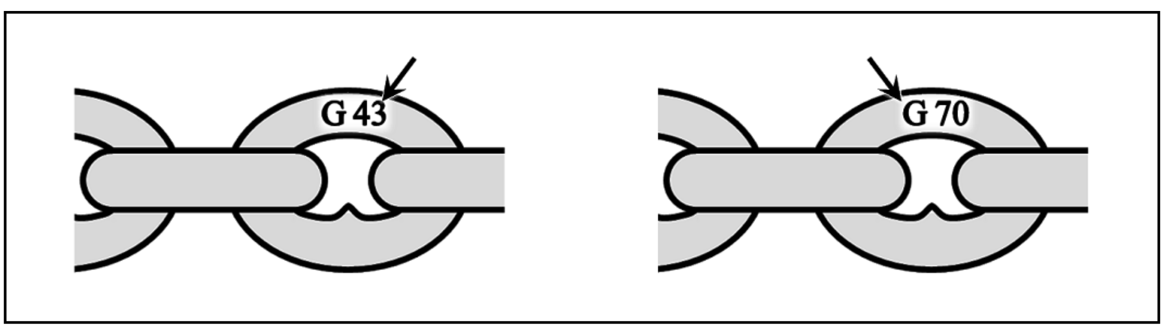

Figure 2-7. Typical chain markings

HOOKS, SHACKLES AND LOAD BINDERS

2-27. Hooks, shackles, and load binders are essential for many rigging applications, but can differ widely in design, strength and capacity.

Hooks

2-28. There are several types of hooks used with chains and slings. The most common in recovery are grab hooks, sling hooks and slip hooks are the most common and their application depends on which hooks are best suited for a particular task. Always select the proper hook and load rating for a specific task, and never exceed the WLL of the hook or chain.

2-29. Grab hooks are normally attached to chains and load binders allowing the chain length to be adjusted when needed by connecting to the chain links or to load binders for securing loads.

2-30. New style chains equipped with grab hooks should have a safety clip or shackle attached that prevents the hook from disconnecting should the chain loosen during use.

2-31. Hoist or sling hooks (figure 2-8) are commonly found on material handling equipment blocks, natural, synthetic and wire rope lifting slings. Hoist or sling hooks are also equipped with safety clips and should not be used if they are damaged or missing.

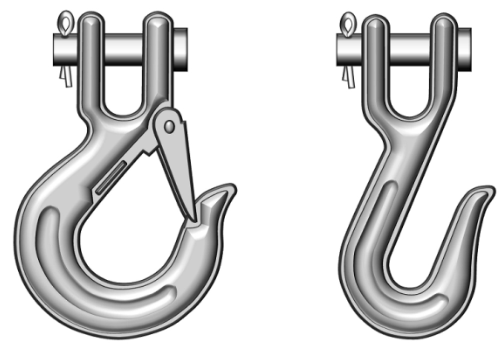

Figure 2-8. Typical hoist or sling hook

2-32. Slip hooks are more common on chain bridles and other recovery rigging. The wide opening of these hooks allows for easy connections to shackles, skid plates or convenient locations on the equipment being recovered.

Shackles

2-33. Another piece of equipment that is essential for recovery rigging is the shackle. These items are available in various sizes and load ratings. Recovery shackles are normally rated in tons and like any other piece of recovery equipment you must never exceed the WLL. When in doubt use the next size shackle. There are two basic types of shackles; anchor shackles, and chain shackles.

2-34. Anchor shackles are often used instead of chain shackles because they are the more common type found on recovery systems. These shackles have a more rounded (wider) chain area that can accommodate multiple chains (depending on size) and are available in three classes based on the type of pin used. (See figure 2-9 on page 2-8.)

> **WARNING**
>
> **Always ensure chains are used in a straight line, and not twisted or knotted. Twists in the chain can greatly reduce the safe working load.**

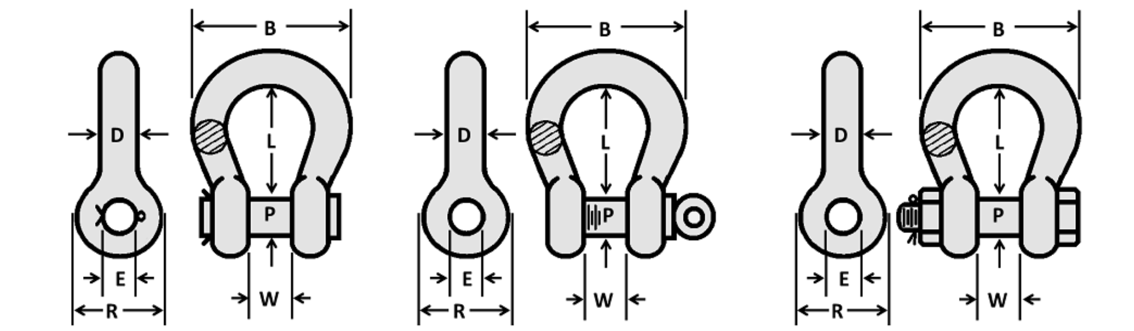

Figure 2-9. Typical anchor shackles

2-35. Until recently, chain shackles were less common on recovery systems. These shackles have a less rounded (narrower) chain area and usually can only accommodate one chain. They are also available in three classes based on the type of pin used. (See figure 2-10.)

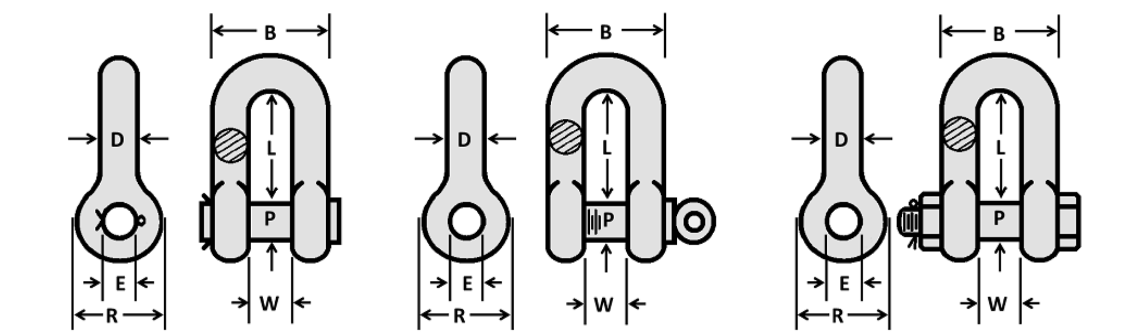

Figure 2-10. Typical chain shackles

SLINGS AND BRIDLES

2-36. Slings and bridles play a vital role during the rigging process. Without these important items many recovery operations would be difficult if not impossible. This equipment is what makes rigging connections possible for lifting or recovering equipment. These items are made from various materials including cordage, natural, synthetic or wire rope, and chains. They are available in single leg, multiple leg, or endless loop synthetic slings.

2-37. In rigging, slings or bridles are used extensively as deadlines attached to the vehicle being recovered or to anchors. Endless synthetic slings are color coded with each color representing a WLL. All slings and bridles must be rated to support the pulling force exerted on them during pulling or lifting a load. (See table 2-2.)

Table 2-2. Endless loop slings and screw-pin shackles

Size/Length	Sling color/Use shackle	Capacities in Pounds		
		Vertical	Choker	Basket
1” Alloy Shackle		**17,000**	**17,000**	**17,000**
4’	Yellow	8,400	6,720	16,800
6’	Yellow	8,400	6,720	16,800
1 1/4” Alloy Shackle		**24,000**	**24,000**	**24,000**
8’	Red	13,200	10,560	26,400
12’	Red	13,200	10,560	26,400
1 1/2” Alloy Shackle		**34,000**	**34,000**	**34,000**
12’	Blue	21,200	17,000	42,400
16’	Blue	21,200	17,000	42,400
1 1/4” Alloy Master Link	**Alloy**	**36,200**	**36,200**	**36,200**

WINCHES

2-38. Most recovery operations to extract or recover immobile equipment are accomplished with winches. Although there are some electrically driven winches on fielded equipment, the majority of recovery winches in use are hydraulically driven. Winch pulling capacities range from a few thousand pounds to several tons. There are two basic types of winches; constant pull capacity winches, and variable pull capacity winches. The latter type is more common but not necessarily the most desirable due to the changing capacity.

2-39. Constant pull winches are designed where the power drum has a constant maximum pull regardless of how much rope is reeled in. In capstan type constant pull winches, there is a rope storage drum where the rope is stored without tension (figure 2-11). In addition to the constant pulling force, the length of the rope can be increased by changing the capacity of the storage drum. The major advantage of this type of winch is that it does not require recalculating mechanical advantage as the rope is reeled in and stored in the drum. One disadvantage is that the storage drum occupies additional space on the equipment. In pressure-sensing type constant pull winches, sensors determine which layer of rope is being used, and increase hydraulic pressure as the number of layers increases, in order to maintain a constant line pull.

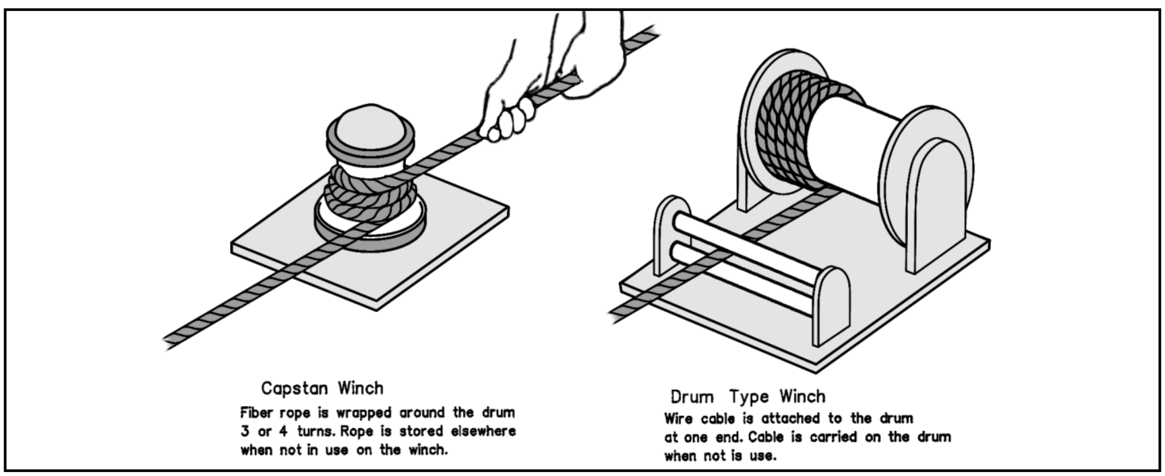

Figure 2-11. Typical constant pull winch

2-40. Winches can be very dangerous if not maintained and operated properly. Winch operation training is critical and must include operation of self recovery winches. Always refer to the equipment operator’s manual for proper operating procedures and maintenance.

2-41. Variable pull winches (figure 2-12 and figure 2-13) differ from Capstan type winches in design and capabilities. These winches do not have a rope storage drum; therefore the rope is stored on the power drum as the rope is reeled in (figure 2-12). There are two major disadvantages with the variable pull winches. One disadvantage is the loss of pulling force as the layers of rope increase on the drum. The other disadvantage is that recovery personnel must recalculate mechanical advantage to sustain the pulling force and may require re-rigging during the recovery operation.

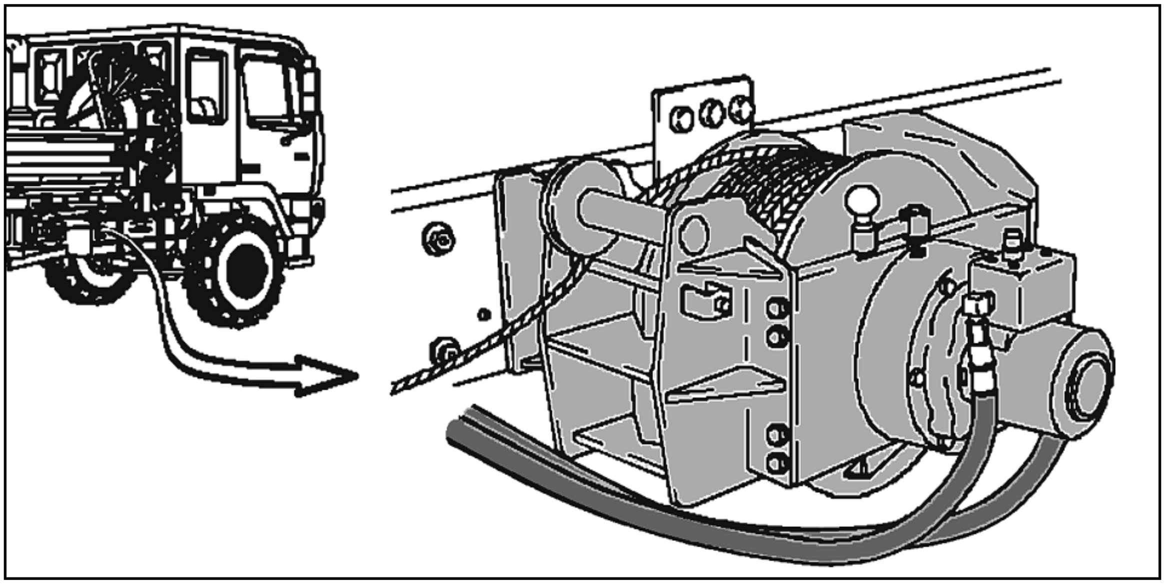

Figure 2-12. Typical variable pull winch

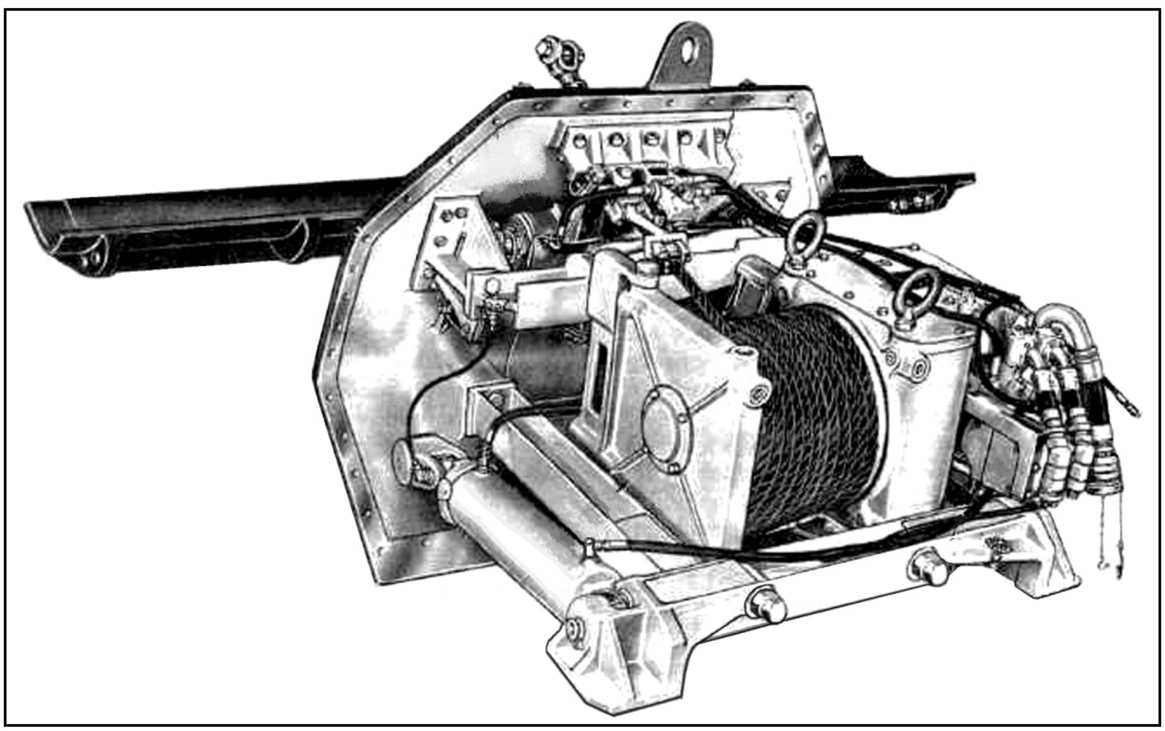

Figure 2-13. Typical M88 variable pull main winch

2-42. As illustrated in table 2-3, a 30 ton variable pull capacity winch looses nearly one third of its pulling force as the rope is reeled in onto the fourth layer. When the pulling force is less than the total rolling resistance the winch usually stalls and repositioning of the recovery vehicle or re-rigging will be necessary. This is not a desirable option if the recovery operation is taking place on gradients or inclines and the rigging has to be changed to increase mechanical advantage in the middle of the operation. Recovery specialists must consider these calculations during rigging.

Table 2-3. Variable pull capacity

Winch type	Cable layer	Cable on drum (Feet)	Capacity (Tons)
30 ton	1	0-55	30.00
	2	56-128	26.00
	3	129-208	23.00
	4	209-300	20.00

ANCHORS

2-43. Anchors are used to provide solid points of attachment for rigging during recovery operations. The number of anchors required for a recovery operation depends on the specific rigging required for that task. Multiple anchors may be required to provide additional points of attachment to achieve the desired mechanical advantage. Whenever possible or practical, natural anchors should be used to expedite the rigging and recovery process. Figure 2-14 illustrates the symbol for an anchor.

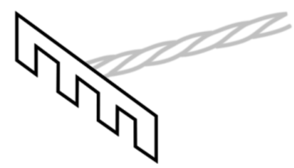

Figure 2-14. Anchor symbol

There are several types of anchors that are either readily available in nature or can be constructed depending on holding ability requirements. The type of soil required, the availability of materials, and operational variables will also dictate which type of anchor is needed. Vehicles, natural objects, and manmade devices can all be used as anchors. Regardless of which type is used, anchors must provide a holding force equal to or greater than the rolling resistance and the applied pulling force. Refer to TM 3-34.86, *Rigging Techniques, Procedures, and Applications,* for additional information on anchors.

Vehicle Anchors

2-44. Vehicles are the most readily available sources for anchors. When natural anchors are not available and manmade anchors require a great deal of effort to construct, a vehicle can be used as an anchor to assist in the recovery process as seen in (figure 2-15). To be effective, the selected anchoring vehicle must provide greater rolling resistance than the mired or disabled vehicle being recovered.

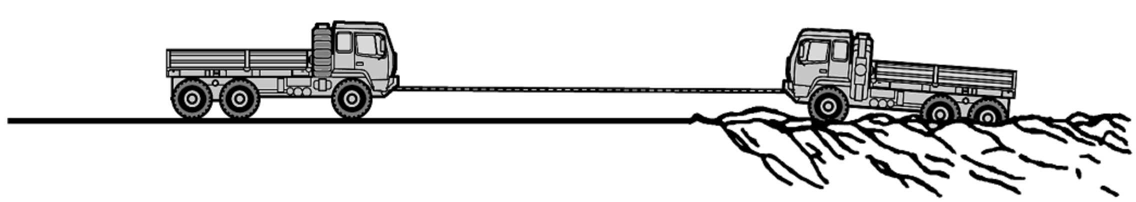

Figure 2-15. Single vehicle anchor

2-45. In situations where one vehicle does not provide the necessary resistance to affect recovery, multiple vehicles can be connected in tandem to achieve the desired effect (figure 2-16). The connecting cables or chains used must have the appropriate rated capacity and connected to the towing lugs not the tow pintle or vehicle bumpers. When multiple vehicles are not available or connecting them in tandem is not practical, a Scotch Anchor can be constructed using a strong log or pipe, chains and a vehicle.

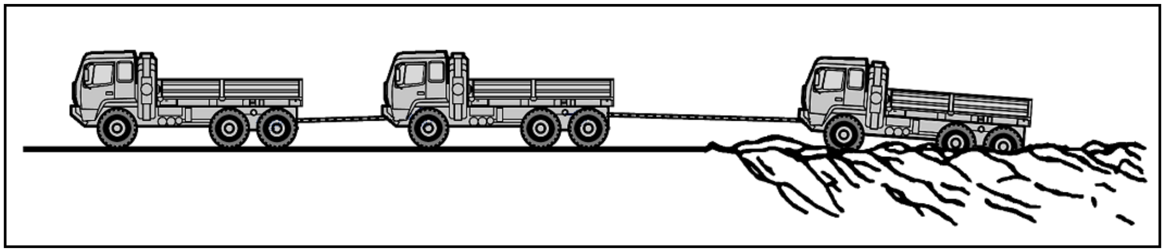

Figure 2-16. Tandem vehicle anchor

Scotch Anchors

2-46. A Scotch anchor (figure 2-17) is used to anchor a vehicle during winching operations when natural anchors are not available. A Scotch anchor is constructed as follows:

- Select a log or pipe at least 6 inches in diameter and 2 feet longer than the width of the vehicle.
- Dig a shallow trench (the length and width of the log and approximately 3 or 4 inches deep) parallel to the front axle, just ahead of the front wheels.
- Lay one or two chains across the center of the trench (width), place the log or pipe in the trench, and move the vehicle forward until both front wheels are against the log.
- Attach the ends of both chains to the towing/tie down lugs and remove all slack from the chains. As pressure is applied to the winch, the front wheels are pulled onto the log tightening the chains and anchoring the vehicle.

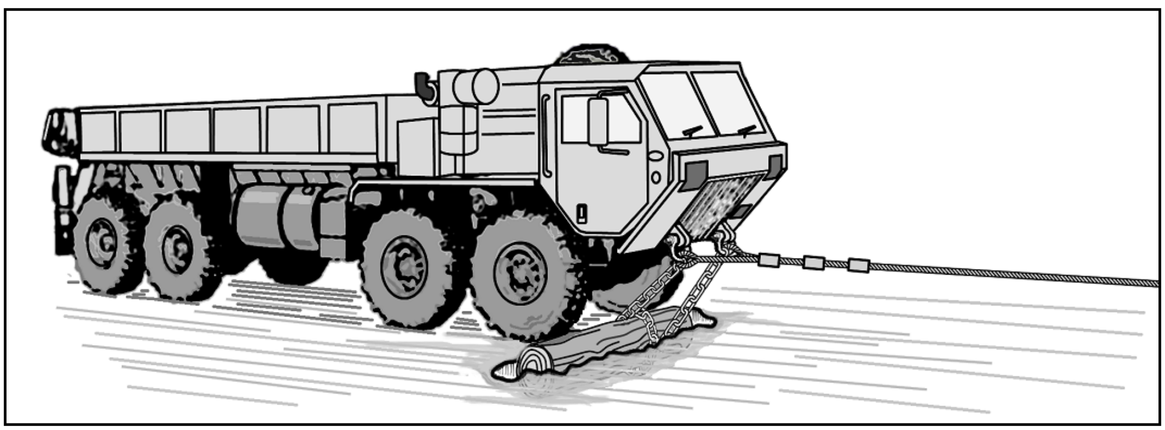

Figure 2-17. Typical Scotch anchor

Natural Anchors

2-47. An anchor that does not have to be constructed is considered a natural anchor. Examples of natural anchors are trees, tree stumps, and large rocks (figure 2-18). Avoid dead or rotten trees or tree stumps, and examine rocks and trees carefully to make sure they are large enough and embedded firmly in the ground. The anchor lines should always be fastened at a point as near to the ground as possible. The principal factor in the strength of most natural anchorage systems is the area bearing against the ground.

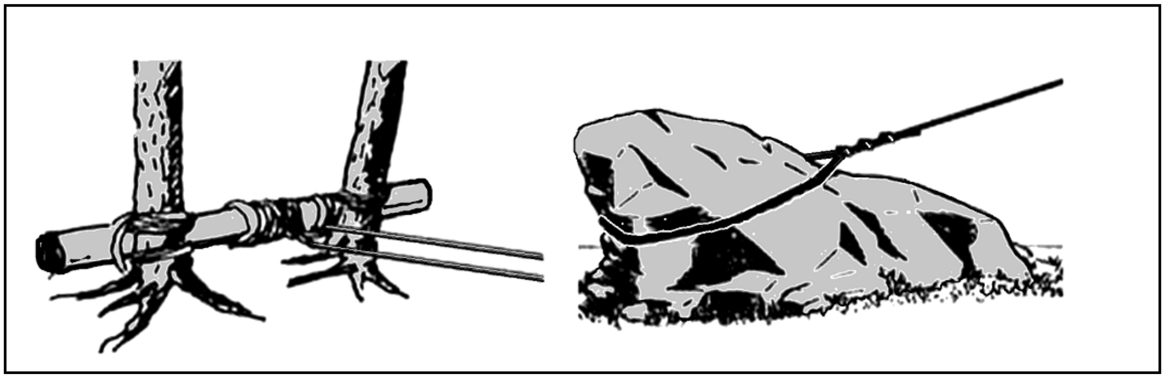

Figure 2-18. Typical tree or rock anchors

Manmade Anchors

2-48. When vehicles or natural anchors are not available, adequate or practical, it becomes necessary to construct anchors that are strong enough to enable recovery. Manmade anchors require time to construct therefore all operational variables must be carefully considered. The most common manmade anchors constructed include:

- Fabricated reusable anchors.
- Rock Anchors.
- Log Deadman.
- Combination Picket Holdfasts.
- Sand Parachute.

Fabricated Reusable Anchors

2-49. Assembling or constructing anchors on the battlefield can be a time consuming task. Pre-fabricated reusable anchors are compact and can be carried on recovery vehicles for quick deployment in recovery operations. They are constructed from thick metal or aluminum plates with holes drilled for metal pickets that are driven into the ground. These anchors can also be connected in tandem for additional holding force when needed.

Rock Anchors

2-50. Rock anchors have an eye on one end and a threaded nut, an expanding wedge and a stop nut on the other end. Construct a rock anchor as follows:

- Drill the holes for rock anchors 5 inches deep.
- Use an l-inch-diameter drill for hard rock and a 3/4-inch-diameter drill for soft rock.
- Drill the hole as neatly as possible so that the rock anchor can develop the maximum strength.
- In case of extremely soft rock, it is better to use some other type of anchor because the wedging action may not provide sufficient holding power.
- The wedging action is strongest under a direct pull; therefore, always set rock anchors so that the pull is in a direct line with the shaft of the anchor.

Log Deadman

2-51. A log deadman (figure 2-19 on page 2-14) is one of the best types of anchors for heavy loads. The deadman consists of a log buried in the ground with the dead line connected to its center. A deadman is constructed as follows:

- Place the deadman where the direction of pull is as horizontal as possible. Take advantage of sharp banks or crests to increase the holding power with less digging.

- Dig a trench large enough for the deadman and as deep as necessary for good load bearing. When digging, slant the trench in the direction of the pull at an angle of approximately 15 degrees from the vertical. To strengthen the anchor, drive stakes in front of the deadman at each end.
- Dig a narrow inclined trench for the dead line at the center of the deadman.
- Tie the dead line to the center of the deadman, so that the main or standing part of the line leads from the bottom of the deadman. This prevents the deadman from rotating out of the trench. If the dead line has a tendency to cut into the ground, place a small log under the line at the outlet of the trench. The strength of the deadman depends on the strength of the log and the holding power of the earth.

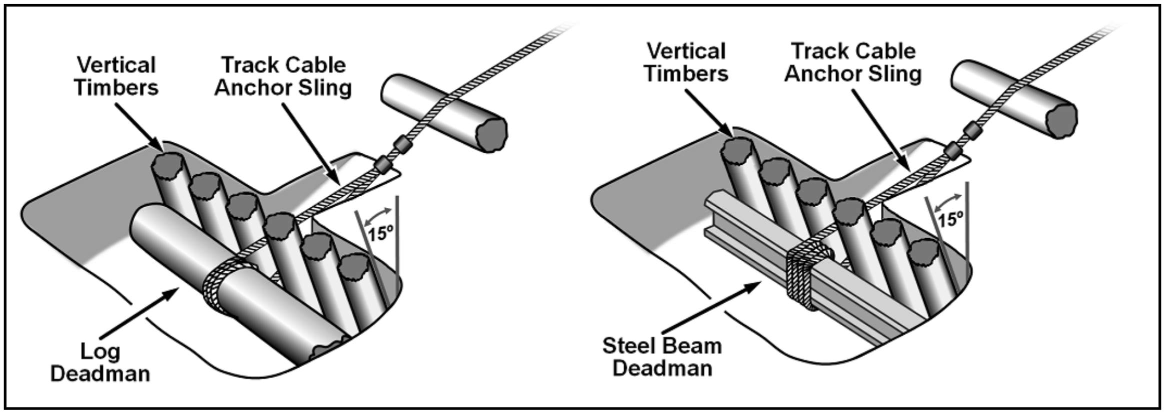

Figure 2-19. Typical log deadman

RESISTANCE

2-52. Resistance is defined as opposition to movement. In recovery operations, resistance is caused most often by terrain features; such as mud, sand, water, or the recovery tackle itself. This section will focus on vehicles disabled by terrain conditions.

2-53. Two factors that can be applied during recovery operations to help reduce resistance are direction of travel of recovery and power applied to tracks. (Applied reduction factors discussed in the following paragraphs do not apply to wheeled vehicles.) Once load resistance is determined, apply effort to affect recovery.

TYPES OF RESISTANCE

2-54. Five types of resistance may occur when recovering vehicles are disabled by terrain conditions. They are grade, overturning, mire, water, and tackle.

Grade Resistance

2-55. Grade resistance occurs when a vehicle moves up a slope (figure 2-20). Grade resistance (including nosed-in vehicles) is estimated as equal to the weight of the vehicle plus cargo. Even though actual grade resistance may be less than the weight of the vehicle, the most resistance encountered on a grade is the weight of the disabled vehicle plus cargo.

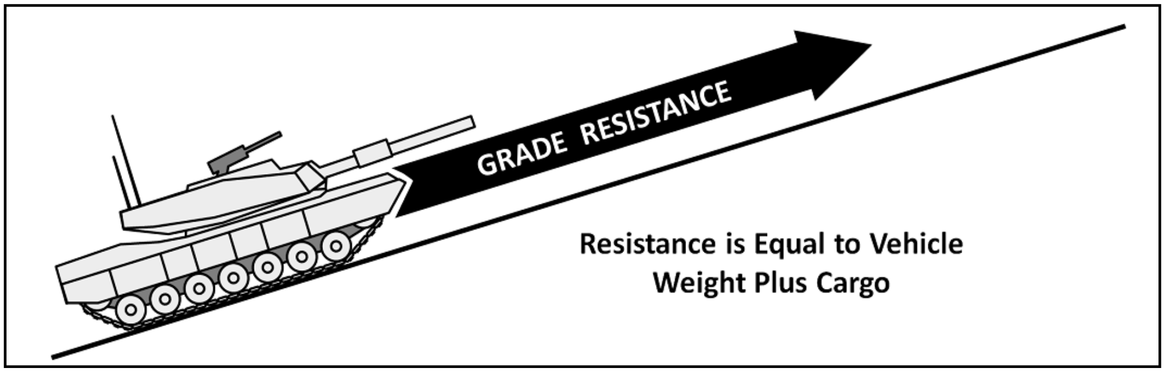

Figure 2-20. Grade resistance

Overturning Resistance

2-56. Overturning resistance is that weight of the vehicle that acts against the force exerted to bring it back on its wheels or tracks (figure 2-21). This force is approximately one-half of the vehicle's weight.

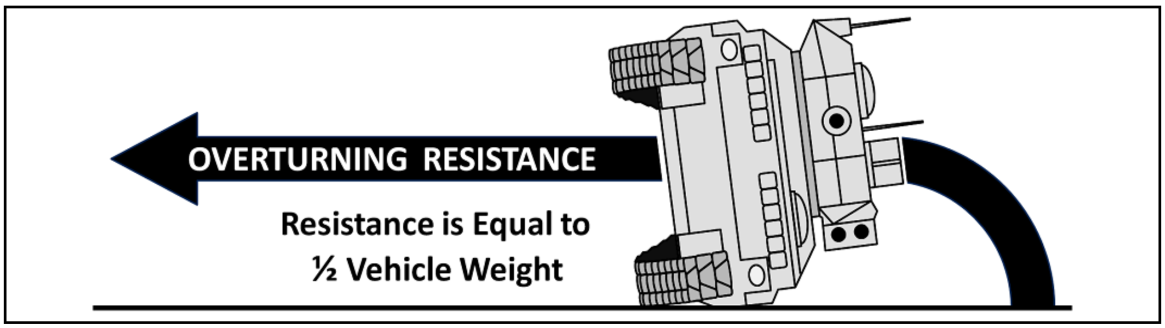

Figure 2-21. Overturning resistance

Mire Resistance

2-57. Mire resistance is created when mud, snow, or sand becomes impacted around the wheels, tracks, axle, gear housing, or hull of the vehicle. Mire resistance is described as wheel/track, fender, or turret/cab depth. (See figure 2-22 on page 2-16.)

2-58. Wheel depth mires occur when wheeled vehicles are mired up to the hub but not over the center. Tracked vehicles are mired up to the road wheels but not over the top. Estimate wheel-depth resistance as equal to the weight of the vehicle plus cargo.

2-59. Fender depth mires occur when wheeled vehicles are mired over the top of the hub but not over the fender. Tracked vehicles are mired over the top of the road wheels but not over the fender. Estimate fender depth mire resistance as twice the total weight of the vehicle plus cargo.

2-60. Turret or cab depth mires occur when vehicles are mired over the top of the fender. Estimate turret/cab depth mire resistance as three times the total vehicle weight plus cargo.

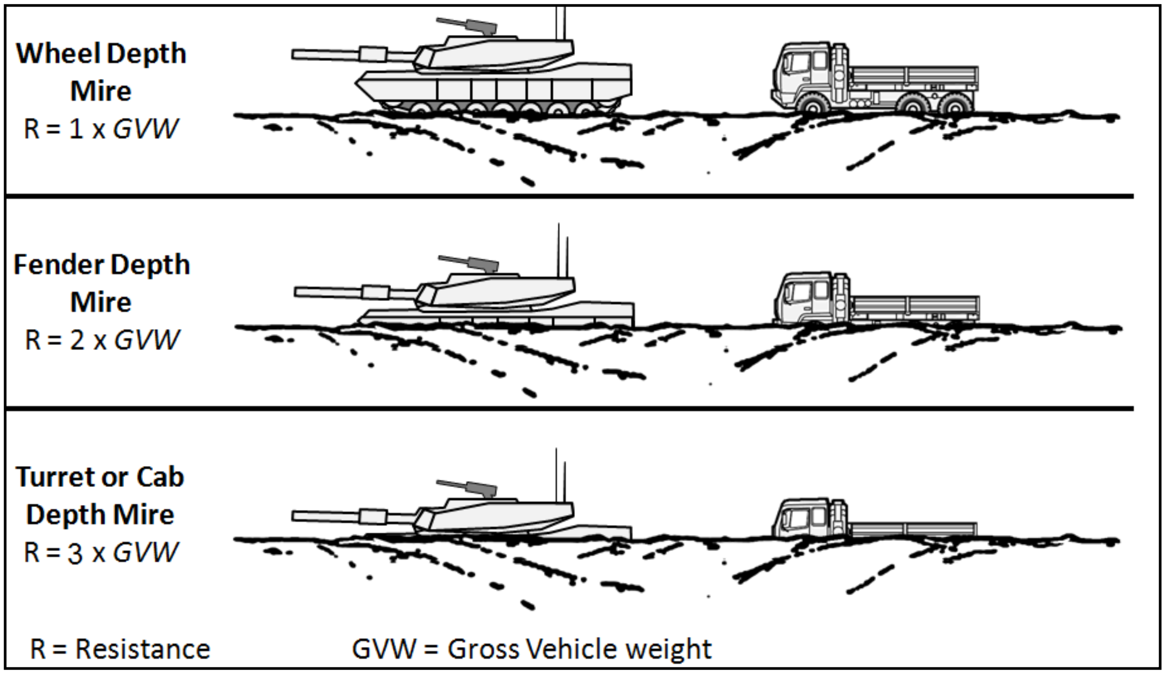

Figure 2-22. Mire resistance

Water Resistance

2-61. Water resistance occurs when submerged vehicles are pulled from water to land. Estimate the amount of resistance met in the same way as for land recovery. In some instances, the resistance to overcome is less than the rolling resistance of the same vehicle on land.

Tackle Resistance

2-62. Tackle resistance is that part of total resistance added to the recovery by friction in tackle. Tackle resistance is friction created by a sheave rotating in its pin, the rope flexing around the sheave, or the rope scuffing in the groove of the sheave, causing a loss in energy as the rope passes around the sheave. This loss is resistance and must be overcome before the load resistance can be overcome. Each sheave in the rigging will create resistance. To determine tackle resistance, multiply 10 percent (.10) of the load resistance by the number of sheaves (not blocks) in the rigging. For example, in the following calculations (figure 2-23), the load resistance is 40 tons (80,000 pounds) and two sheaves are used.

Load resistance (vehicle + cargo) = ---------------- 80,000 lb
Number of sheaves = -- 2

Tackle resistance = 0.10 x 80,000 x 2 = 16,000 lb

lb = pound

Figure 2-23. Tackle resistance

CAUTION

Friction in tackle causes a loss in energy that must be overcome before the load resistance can be moved.

Total Load Resistance

2-63. Because tackle resistance must be overcome before the load resistance can be moved, the load and tackle resistance are added. This resistance is referred to as total load resistance (TLR). TLR is the total amount of resistance the available effort (AE) must overcome. For example, in the previous example of tackle resistance, the load resistance of 80,000 pounds plus the tackle resistance of 16,000 pounds equals a total resistance (figure 2-24) of 96,000 pounds.

Load resistance (vehicle + cargo) = ---------------- 80,000 lb
Tackle resistance = ------------------------------------ 16,000 lb

Total resistance = 16,000 + 80,000 = 96,000 lb

lb = pound

Figure 2-24. Total load resistance

Resistance Reducing Factors

2-64. Situation and mechanical resistance affect the load resistance of mired vehicles. Resistance reducing factors do not apply to wheeled vehicles; they are only to be used for tracked vehicles.

Direction of Travel for Recovery

2-65. When a mired vehicle is recovered in the opposite direction of its travel, the tracks pass through ruts made by the vehicle when going into the mire. This reduces estimated resistance approximately 10 percent and is the preferred method of recovery. For example, a tank weighing 106,000 pounds is mired at wheel depth and can be recovered in the opposite direction of travel. Estimate resistance as 106,000 pounds and subtract 10 percent for recovery in the opposite direction of travel. The load resistance equals 95,400 pounds. (See figure 2-25.)

Vehicle weight = ------------------------------------ 106,000 lb
Reduction factor = ---------------------------------- x 0.10
Estimated reduction = ------------------------------ 10,600 lb

Estimated load resistance = 106,000 – 10,600 = 95,400 lb

lb = pound

Figure 2-25. Resistance reducing

Power Applied to Tracks

2-66. When power is applied to the tracks of a mired vehicle, the movement of the tracks helps to break the suction of mud against the belly of the vehicle. This reduces estimated resistance by approximately 40 percent. Before computing the 40 percent reduction, make sure the mire is not deep enough to prevent the operation of the vehicle's engine; that is, check the air intake and exhaust. For example, a tank weighing 106,000 pounds is mired at fender depth. It cannot be recovered in the opposite direction of its original travel, but it can apply power to its tracks. Estimated resistance (twice the weight of the vehicle) is 212,000 pounds minus 40 percent. The load resistance equals 127,200 pounds. (See figure 2-26.)

Vehicle weight =	106,000 lb
Mired factor (fender depth) =	x 2
Resistance =	212,000 lb
Reduction factor (40% for power to track) =	x 0.40
Estimated reduction =	84,800 lb

Estimated load resistance = 212,000 – 84,800 = 127,200 lb

lb = pound

Figure 2-26. Power applied to tracks

2-67. In another example, a tank weighing 106,000 pounds is mired at fender depth. If the tank can be recovered in the opposite direction of its original travel, and power can be applied to its tracks, the estimated resistance (twice the weight of the vehicle) is 212,000 pounds, less 50 percent (10 percent for opposite direction plus 40 percent for applying power to its tracks). The estimated load resistance equals 106,000 pounds. (See figure 2-27.)

Vehicle weight =	106,000 lb
Mired factor (fender depth) =	x 2
Resistance =	212,000 lb
*Reduction factor =	x 0.50
Estimated reduction =	106,000 lb

Estimated load resistance = 212,000 – 106,000 = 106,000 lb

*40% for applying power to track, plus 10% recovering in the opposite direction to the travel (50%)

lb = pound

Figure 2-27. Recovery in opposite direction and power applied to tracks

SOURCE OF EFFORT

2-68. Like vehicles are the quickest, most available sources of recovery effort. On dry, level hardstand in first gear or reverse, the average vehicle exerts a force equal to its own weight. Terrain conditions affect the towing capability of a vehicle. These conditions may require two or more vehicles to exert the same force one vehicle could under ideal conditions. A winch is used when the situation does not permit recovery by a like vehicle. (Most often, the approach to the disabled vehicle does not provide good traction.) A winch is a more positive source of effort since its towing capability does not depend on terrain conditions.

Winch Variable Capacities

2-69. A winch exerts its greatest force when it pulls by the first layer As each successive layer of cable is wound onto the winch drum, the diameter increases and winch capacity decreases.

2-70. An exception is the constant pull winch found on the M88A2—where the force of pull remains constant regardless of the cable layer. See table 2-4 for a listing of estimated winch variable capacities. Refer to the equipment operator's manual for specified capabilities.

Table 2-4. Estimated winch variable capacity

Winch Type	*Cable Layer*	*Cable on Drum (Feet)*	*Capacity (Tons)*
5 ton	1	0 – 39	5.000
	2	40 – 85	4.225
	3	86 – 138	3.670
	4	139 – 199	3.230
	5	200 – 266	2.890
10 ton	1	0 – 41	10.000
	2	42 – 91	8.450
	3	92 – 148	7.250
	4	149 – 213	6.400
	5	214 – 287	5.700
22.5 ton	1	0 – 42	22.500
	2	43 – 93	18.850
	3	94 – 153	16.250
	4	154 – 220	14.250
	5	221 – 296	12.650
	6	297 – 380	11.400
30 ton	1	0 – 55	30.000
	2	56 – 128	26.000
	3	129 – 208	23.000
	4	209 – 300	20.000
45 ton	1	0 – 41	45.000
	2	42 – 91	38.000
	3	92 – 149	32.500
	4	150 – 200	28.500
Note. The 70-ton recovery vehicle has a constant capacity of 70 tons anywhere on the cable.			

Note. Reduction factors do not apply to wheeled vehicles due to lack of traction. However, power applied to wheels may reduce resistance. Reduction factors are only a guide and apply more to wheel depth than to either fender or turret depth mire situations.

OVERCOMING RESISTANCE

2-71. Applying effort to overcome resistance has always been a challenge. Modern machinery makes this evident. Energy released by burning small amounts of fuel in a modern engine provides the effort to move vehicles weighing thousands of pounds. The vehicle engine, with various mechanical devices, can move the vehicle from a standstill through a wide range of speeds.

LEVERAGE PRINCIPLE

2-72. Using levers is the most basic means to overcome resistance. A wrench handle and the gears of a truck overcome resistance by applying the principles of leverage. The simplest form of a lever is a rigid bar free to turn on a fixed pivot called a fulcrum. When effort is exerted on one end of the bar, the bar rotates around the fulcrum. MA is increased by extending the distance between the point where effort is applied and the fulcrum.

Lever Classification

2-73. The location of the fulcrum with relation to effort and resistance determines the lever class.

First-Class Lever

2-74. The fulcrum is located between the effort and the resistance (figure 2-28). A crowbar is a good example of a first-class lever.

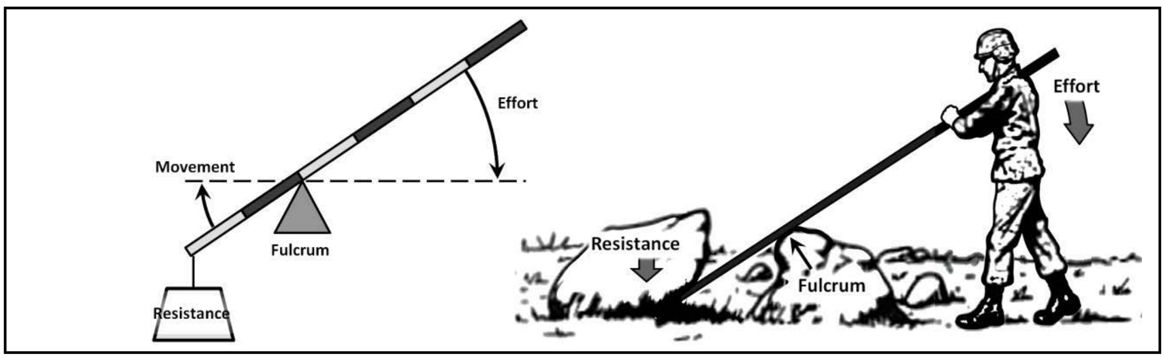

Figure 2-28. First-Class Lever

Second-Class Lever

2-75. The point of resistance is between the fulcrum and the effort (figure 2-29). A wheelbarrow is a good example of a second-class lever.

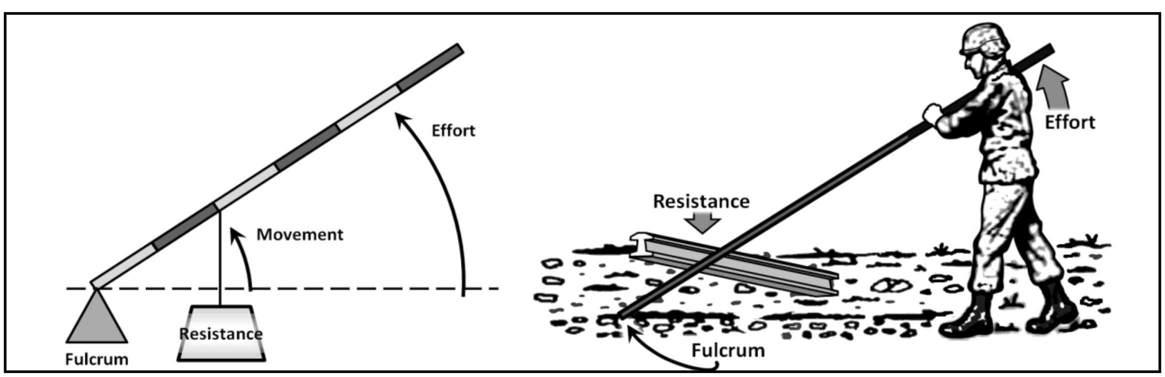

Figure 2-29. Second-class Lever

Tackle Systems

2-76. Tackle is a combination of cables and blocks used to gain an MA or to change the direction of pull and are classified as either simple or compound.

Simple Tackle System

2-77. Simple tackle is one cable with one or more blocks. (See figure 2-30.)

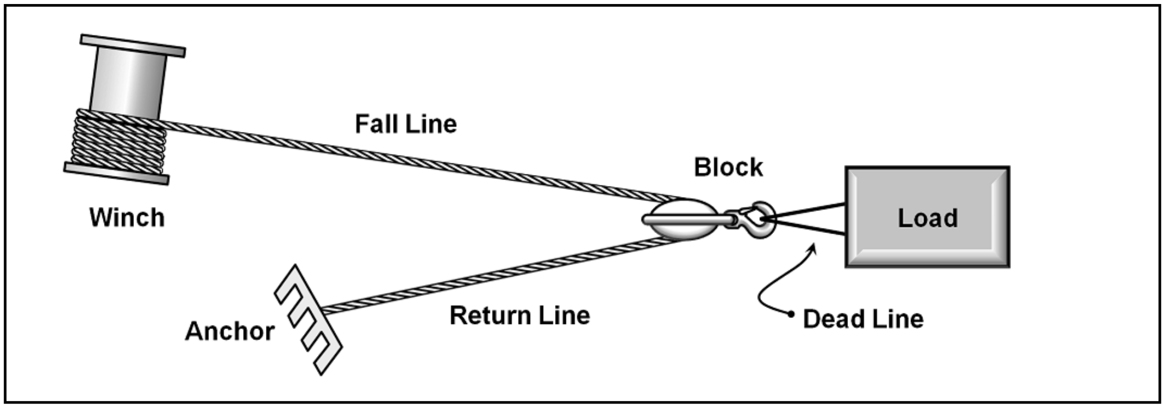

Figure 2-30. Simple tackle system

Compound Tackle System

2-78. Compound tackle is a series of two or more simple tackles (figure 2-31). The output of one simple tackle is used as the effort for the other. Because a winch has only one cable, simple tackle will be used during most recovery operations.

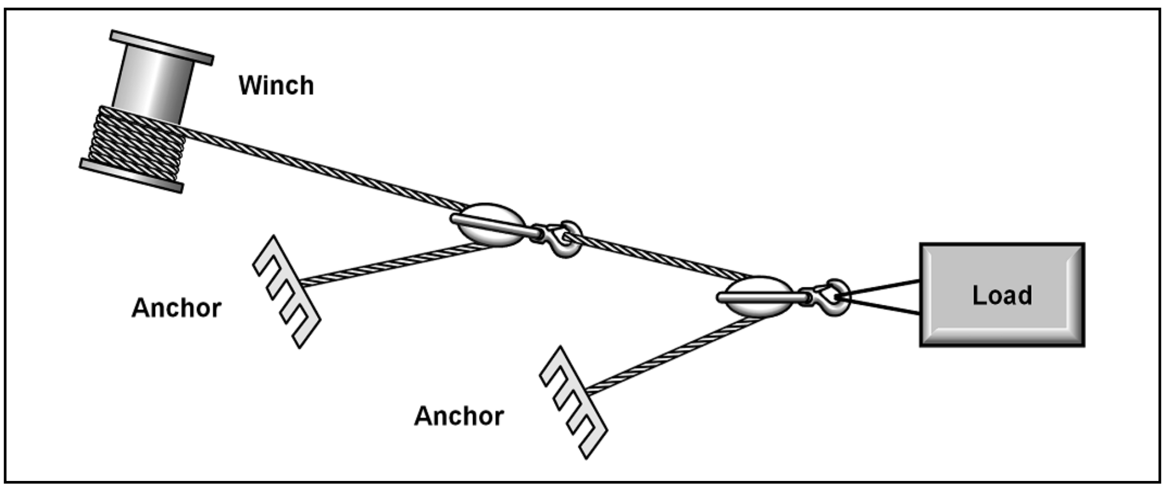

Figure 2-31. Compound tackle system

MECHANICAL ADVANTAGE

2-79. Mechanical advantage (MA) is a small amount of force applied over a long distance to move a heavy load a short distance. MA is needed whenever the load resistance is greater than the capacity of the AE.

2-80. To determine the amount of MA necessary in a recovery operation, divide the Total load resistance (TLR) by the AE and round any fraction to the next whole number. Rounding is required because only whole numbers can be rigged. (See figure 2-32 on page 2-22.)

MECHANICAL ADVANTAGE OF TACKLE

2-81. 2-82. Mechanical Advantage (MA) is needed whenever the TLR is greater than the AE. The amount of MA needed is estimated by dividing the TLR by the AE. The MA of any simple tackle system is equal to the number of winch lines supporting the load or the number of winch lines that become shorter as power is applied to the winch. The lines can be attached directly or indirectly through a block.

Total load resistance (TLR)=.. 106,000 lb (load)
Available effort (AE)=.. 90,000 lb (winch)
TLR / AE = 106,000 / 90,000 = ... 1.18

Round the fraction to the next whole number ≈ 2

Required Mechanical Advantage (MA) = 2:1

lb = Pound

Figure 2-32. Mechanical advantage

2-82. Placement of the block is critical to gaining MA. The block must be attached to the movable load and effort applied in the opposite direction to divide the effort equally over the two lines. The 1-to-1 ratio only changes the direction of effort. No mechanical advantage is gained in this configuration (figure 2-33).

2-83. Snatch blocks used for mechanical advantage or directional changes in the line experience more than just the fall line force. To determine the force on a snatch block, multiply the fall line force by the highest number of winch lines supported by the block. Make sure the snatch block you are using is rated to withstand the force it will actually experience.

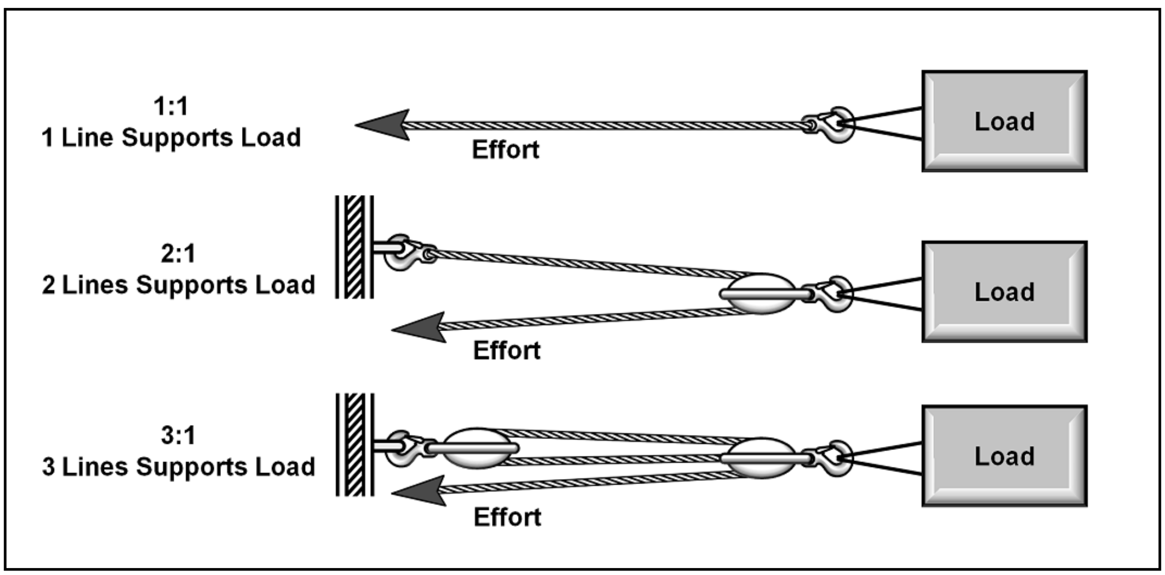

Figure 2-33. Winch line(s) mechanical advantage (MA)

DETERMINING LINE FORCES

2-84. The following paragraphs describe the methods to determine the line force.

Fall Line

2-85. The fall line is the winch line that runs from the source of effort to the first block in the tackle. There is only one fall line in a simple tackle system (figure 2-34). The amount of force that must be exerted on the fall line relative to the AE must be considered in every problem. The fall line force must be less than the capacity of the effort to accomplish the recovery.

2-86. To determine the fall line force, divide the total load resistance (TLR) by the mechanical advantage (MA) of the tackle. Calculate as follows:

Fall line force = TLR / MA of the tackle

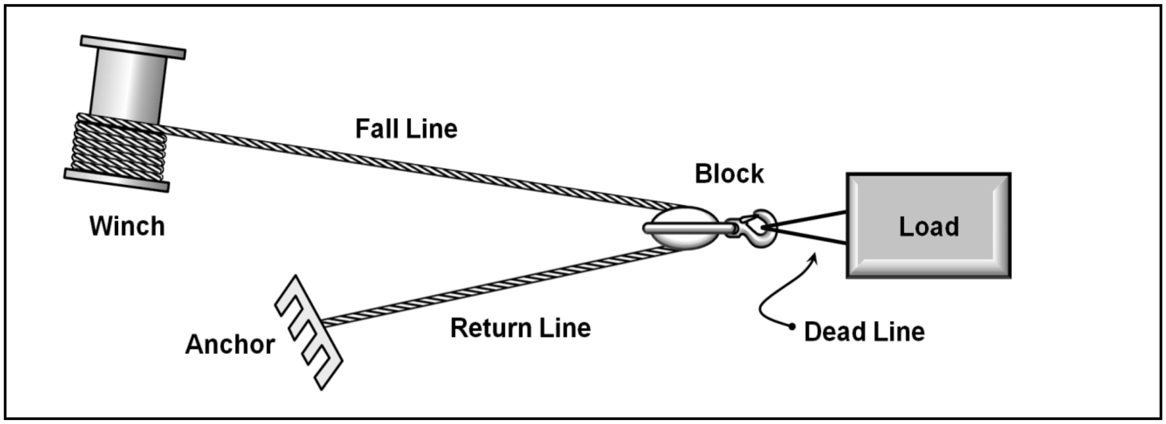

Figure 2-34. Terminology of simple tackle

Return Line

2-87. A return line is a winch line rigged between the block or the winch line from the sheave of a block to the point where the end of the line is attached to (anchor). This force is always the same as the fall line force.

Dead Line

2-88. A dead line is a line used to attach blocks or other equipment to the load or to an anchor. To determine the dead line force, multiply the fall line force by the highest number of winch lines supported by the dead line.

Fleet Angle

2-89. Achieving even winding of the winch cable on the drum is important for wire rope life and winch operations. If the rope is not wound smoothly and evenly, the rope crossing over itself can cause birdnesting, crushing, and other damage. Unless there is a special winding device attached to the winch assembly, proper winding is best accomplished by working with the proper fleet angle.

2-90. Too large a fleet angle can cause the rope to rub against the sides of the sheave, or crush and abrade against itself on the drum. All of these issues will shorten the life of the rope and the sheaves.

2-91. Figure 2-35 on page 2-24, displays the wire rope running from a fixed sheave, over floating sheaves, and then onto the surface of a smooth drum. The fleet angle is defined as the included angle between two lines.

- One line is drawn through the middle of the fixed sheave and the drum and perpendicular to the axis of the drum.
- A second line is drawn from the flange of the drum to the base of the groove in the fixed sheave.

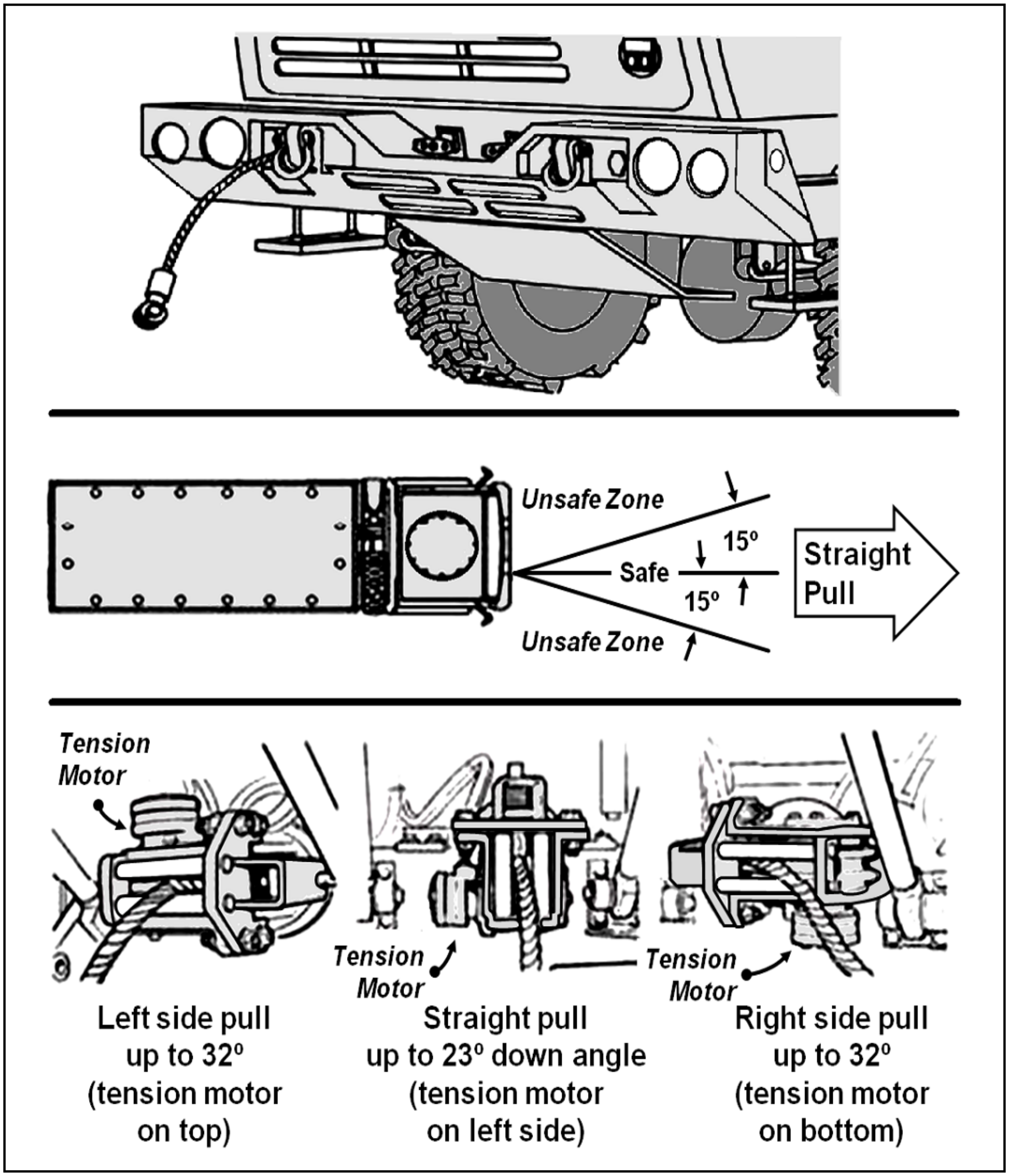

Figure 2-35. Fleet angle

2-92. There are left and right fleet angles, measured to the left and right of the centerline of the sheave. The fleet angle should be restricted when wire rope passes over a fixed sheave and onto a drum. For the most efficient method and best service, the angle should not exceed 1½ degrees, for most vehicles. Refer to the equipment operator's manual for specific information on fleet angles.

Note. Although many vehicles have winches that can safely operate at higher fleet angles, maximum stability and performance is achieved at lesser fleet angles.

FAIRLEADS

2-93. Fairleads are usually a combination of rollers and sheaves that maintain some alignment with the winch drum. Not all self recovery winches or dedicated recovery winches are equipped with fairleads. With exception of a rope tensioner; many of them are open face drums without any sort of rope guides. Some self recovery winches and dedicated recovery winches are equipped with some sort of fairleads or rope guide system. The fleet angle must still be maintained at less than 2° with fixed fairleads.

Powered Fairlead System

2-94. Some dedicated recovery winches have a powered rope feed and fairlead system. Because the distance between the winch drum and the fairlead system is great, so the fleet angle remains constant. The power fairlead also maintains tension on the rope. Recovery vehicles equipped with power fairlead systems allow the winches to operate with a horizontal fleet angle between 30° and 32°, and vertical fleet angle between 20° and 23°.

2-95. These values should never be exceeded and always consult the operators manual for the correct position of the fair lead system for right, left or vertical pulling angles. Again, not all recovery vehicle winches are equipped with fair lead systems.

2-96. The following example shows how to compute various line forces (figure 2-36 on page 2-26). A disabled vehicle had a load resistance of 14 tons (28,000 pounds). The AE is a winch with a maximum capacity of 5 tons (10,000 pounds). What MA must be rigged to recover this vehicle? What are the line forces?

EXAMPLE: Computing Line Forces

STEP 1 – Determine initial estimate.

$$\frac{\text{Total Load Resistance}}{\text{Available Effort}} \quad \frac{\text{TLR}}{\text{AE}} = \text{Required MA}$$

$$\frac{\text{Total Load Resistance}}{\text{Available Effort}} \quad \frac{28{,}000}{10{,}000} = 2.8$$

Required MA = 3:1

STEP 2 – Add tackle resistance and verify solution

MA of 3 requires 2 sheaves. To determine the tackle resistance, multiply 10% (0.10) of the load resistance by the number of sheaves.

(0.10 x 28,000) x 2 = Tackle Resistance

2800 x 2=5600

Then add the tackle resistance to the load resistance for the total load resistance.

5600 + 28,000 = 33,600

33,600 (TLR) /10,000 (AE) = 3.36

Required MA = 4:1 (This is not equal to the answer in step 1; the answer must be re-verified.)

STEP 3 – Re-verify solution

An MA of 4 requires 3 sheaves. Therefore, 3 x 0.10 (10% per sheave) must be added to the load resistance.

(0.10 x 28,000) x 3 = 8400

8400 + 28,000 = 36,400

36,400 (TLR) / 10,000 (AE) = 3.64

Required MA = 4:1 (This is equal to the answer in step 2; a solution has been achieved.

STEP 4 – Determine line forces

From the previous step, total resistance is equal to 36,400 pounds and the MA needed is 4:1.

Total resistance (TLR) / MA = Fall line force

36,400 / 4 = 9,100 lb

Note. Double check: The fall line force is less than the winch capacity.

Return line force = Fall line force
Fall line force = 9,100 lb
Return lines 1, 2, and 3 = 9,100 lb each
Dead line force equals the number of support winch lines times the fall line force.)
Lines 1, 2, 3 (and fall line) = 9,100 lb
Dead line I = 4 x 9,100 lb = 36,400 lb, Dead line II = 2 x 9,100 lb = 18,200 lb, Dead line III = 1 x 9,100 lb = 9,100 lb
Snatch block 1 = 4 x 9,100 lb = 36,400 lb
Snatch block 2 = 2 x 9,100 lb = 18,200 lb

Note. Ensure Y-slings used for dead lines and snatch blocks are rated to withstand the force applied to them.

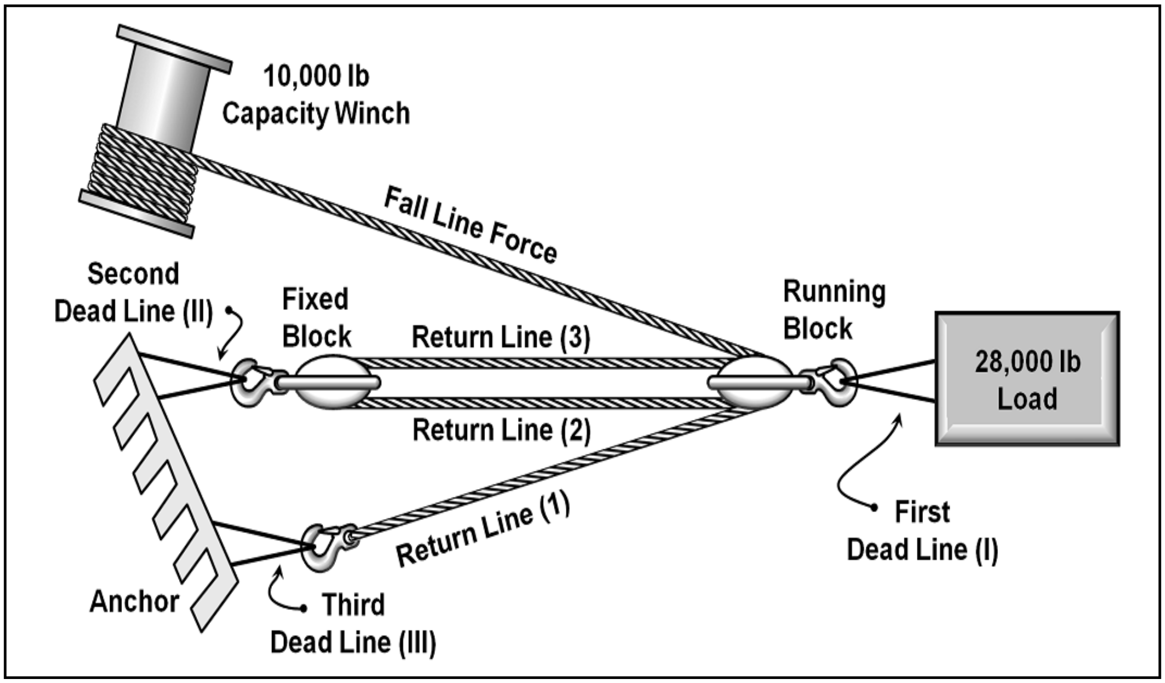

Figure 2-36. 4 to 1 MA, with two snatch blocks

Note. If field expedient slings are used as dead lines, refer to TM 3-34.86 to determine sling leg forces. Field expedient slings are considered slings that are constructed using materiel not part of the recovery vehicle's BII.

RIGGING TECHNIQUES

2-97. Rigging techniques used depend on terrain, the types of recovery and inoperable vehicle, the distance between the recovery vehicle and the casualty vehicle, and weight of the tackle. Manpower, backup, and lead methods are the most common used for rigging. All of the methods apply to both land and water recovery operations. Depending on the water depth, recovery operations may require specialized equipment to transport the heavy tackle to the recovery site, or the use of qualified divers to attach rigging to the submerged vehicle.

SAFETY

2-98. Rigging and tackle equipment can be extremely heavy, whenever possible deliver the equipment with the aid of vehicle power. When manhandling the heavy gear and equipment make sure multiple individuals assist in dragging or carrying the equipment to prevent injuries.

2-99. When rigging in water make sure at least three individuals are present to assist in the event that the rigger becomes stuck in the mud or is knocked down from the current or the heavy gear. Always insure the buddy system is used especially during water recovery operations.

TECHNIQUES OF RIGGING ON LAND

2-100. The following methods apply to both wheeled and tracked recovery vehicles.

Manpower Method

2-101. The manpower method is used when the winch cable and other rigging equipment are light enough to be carried by the recovery or casualty vehicle crew to where they are needed. This method depends entirely on manpower.

Backup Method

2-102. Backup method is used when the recovery vehicle can be safely positioned within 20 to 25 feet of the disabled vehicle. Figure 2-37 shows a tracked recovery vehicle in position to perform the winching operation using the following steps:

- Pull out enough main winch cable to attach to the casualty vehicle.
- Place the main winch snatch block in the loop of the cable and attach the block to the disabled vehicle.
- Slowly back up the recovery vehicle while paying out the main winch cable until sufficient cable is removed to obtain maximum pulling force (variable capacity winch).

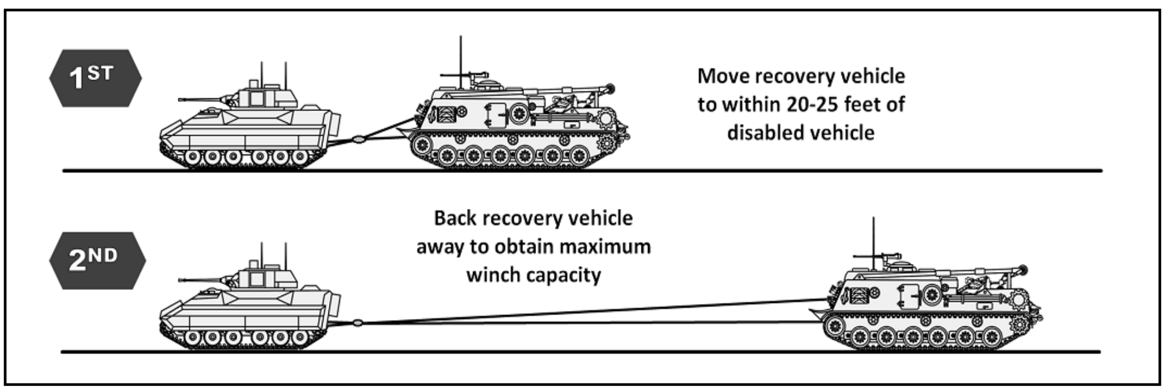

Figure 2-37. Backup method of rigging

Lead Method

2-103. The lead method (figure 2-38 on page 2-28) is used when terrain conditions do not permit close access to the casualty vehicle. Use the boom winch or auxiliary winch rope to drag the main winch rigging to the casualty vehicle. Since the boom or auxiliary winch rope weighs less than the main winch rope, it is easier to carry it to the disabled vehicle.

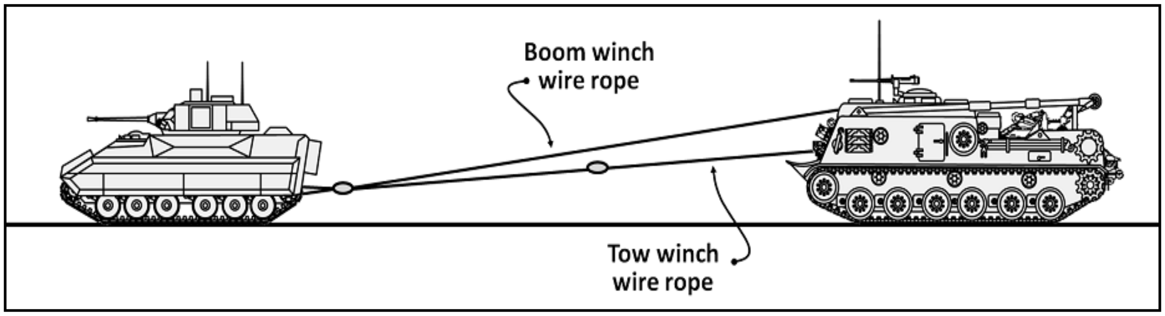

Figure 2-38. Lead method of rigging

2-104. To rig for the lead method, assemble the main winch tackle just in front of the recovery vehicle as in preparation for the backup method. Then do the following:

- Attach the boom and crane or auxiliary winch cable to the main winch snatch block.
- Manually pull out the loop formed by the boom and the crane or auxiliary winch cable, and place it into a snatch block attached to the disabled vehicle.
- Lastly, attach the cable to the rigging. (By paying in the boom and the crane or auxiliary winch cable, the main winch tackle will be pulled to the disabled vehicle).

TECHNIQUES OF RIGGING IN WATER

2-105. The rigging methods for underwater recovery are normally restricted to the manpower and/or lead methods. Towing from water is recommended only if the inoperable vehicle is located in very shallow water. The method of rigging depends on the distance from the inoperable vehicle; the type of inoperable vehicle; the type of recovery vehicle available; the equipment available (floats, air bags, tackle); and the condition of the inoperable vehicle.

Manpower Method

2-106. The manpower method is much the same regardless of whether it's on water or land. However, flotation devices can be attached to the rope cable every few feet or to snatch blocks and other tackle to aid in getting the rigging equipment to the inoperable vehicle.

Lead Method

2-107. The lead method of rigging is also performed the same in water as on land. If the water is deep, a boat or an amphibious vehicle can transport tackle to the inoperable vehicle. If the water is shallow, the manpower method can be used to carry the rigging and tackle to the inoperable vehicle.

ATTACHING TACKLE

2-108. In recovery operations, tackle should be attached in a manner that does not cause damage to an inoperable or mired vehicle, or does not cause additional damage to a repairable battle damaged vehicle. Ensure that the tackle, shackles, chains, cables or ropes used for rigging are properly rated for the pulling force and load they will be subjected to during recovery.

Wheeled Vehicles

2-109. Tackle should always be connected to the front or rear towing lugs of a wheeled vehicle. When the towing lugs are not available connect the rigging to tie down lugs only if they are rated the same as the towing lugs. Otherwise, attach the rigging to solid main frame structures. Always use a V chain, cable, or bridle to spread the load evenly to both attachment points during winching. A floating block requires the use of a cable but is an ideal method for maintaining an even pull during the entire recovery process.

2-110. The rigging must never be attached to bolt on vehicle components, suspension, or axles. These components may not support the force applied to them and can easily detach, fall or become dangerous flying objects.

Tracked Vehicles

2-111. On tracked vehicles, always attach rigging to the towing lugs at the front or rear of the vehicle. The lifting eyes are not designed to withstand the lateral pulling forces exerted during recovery.

2-112. When a disabled tracked vehicle does not require MA it can be recovered by attaching the winch cable directly to one of the towing lugs. To distribute the load more evenly it is highly recommended that cables or a V chain be attached to the towing lugs and the winch rope connected to the apex of the chains or cables.

2-113. The best method for maintaining even pulling force is with a floating block. As with wheeled vehicles this type of rigging provides better distribution of applied forces throughout the recovery operation (figure 2-39). This hookup is easy to rig and uses tow cables found in BII. The floating block is rigged as follows:

- Attach the ends of the tow cable to the two tow hooks.
- Place the snatch block in the loop formed by the tow cable.
- Attach the winch rope to the snatch block.
- Ensure that cables and attachments can withstand forces as shown in figure 2-39.

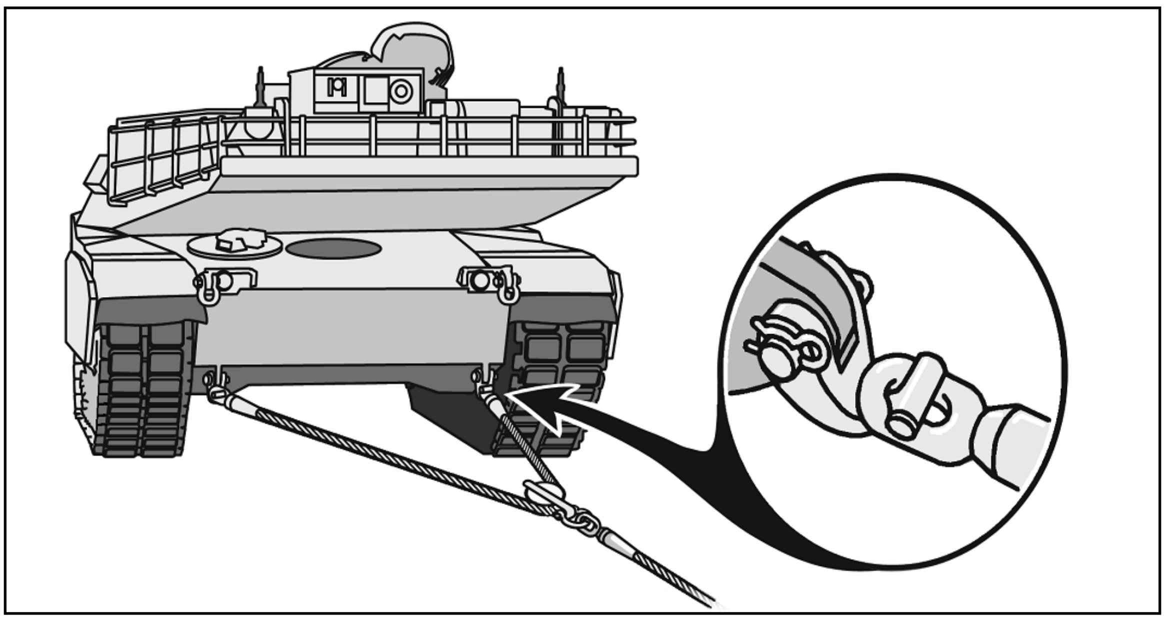

Figure 2-39. Floating block

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Chapter 3
Recovery

A successful recovery operation is done quickly and safely. Care must be exercised when erecting and using equipment to prevent damage to vehicles and equipment and to prevent injury to personnel.

> **CAUTION**
>
> Think Safety
>
> Recovery is a big job. Before any recovery operation, do calculations, inspect tackle, and keep rigging references handy. A haphazard approach to recovery can lead to dismemberment, death, and/or damaged equipment.

GENERAL SAFETY PRECAUTIONS

3-1. Safety must be observed at all times during any recovery operation.

ACCELERATION IMPACT

3-2. Failure occurs when a weight is allowed to fall for a distance and is suddenly stopped. A similar strong force occurs when power is engaged suddenly to recovery vehicles when connected to a towed or mired vehicle. Do not apply loads suddenly (shock load). This puts excessive strain on the equipment, and it may fail. Shock loads may also occur if tow adapters or pins do not fit tightly to their attachment points. If there is slop in the connection, use chains to secure the attachment and prevent shock loading during towing operations.

> **CAUTION**
>
> A winch line makes a deadly slingshot. If the dead line of a snatch block breaks, a 200-pound snatch block can travel as far as 300 yards in the air. All personnel observing should stand at least one length of the whole payed- out cable away from and opposite of the angle of pull (or the distance designated by the recovery personnel) (figure 3-1) when the cable is under stress. This will allow greater reaction time for personnel to move out of the path of flying objects if a cable or other attaching hardware breaks.

BACKLASH

3-3. Make every effort to stand clear of wire rope that is under tension. The recommended safe distance is one length of the payed-out cable (a + b) as in (figure 3-1 on page 3-2). When wire rope is drawn taut and then released suddenly by a break, its recoil (or backlash) may cut a person into two pieces. A winch line under load stretches like a rubber band and stores up tremendous potential kinetic energy. In fact, a steel winch cable weighing 50 to 500 pounds has more spring to it than rubber.

CROSSED CABLES

3-4. Make sure the rigging lines are not crossing each other before the winching operation is continued. Crossed rigging lines can rub against each other causing damage to the cable or an increased amount of tackle resistance. Crossed cables are only recommended for towing a disabled vehicle when a tow bar is not available. Cross cables are additionally used to provide second track vehicle hold-back and second vehicle pulling missions.

GROUND GUIDES

3-5. To safely control a recovery operation, use two ground guides—one ground guide in the front and one in the rear. Only one ground guide gives the signals to the operator. The ground guides should stand apart from other personnel at the recovery site and be in a position where the vehicle operators can easily observe the signals. The vehicle operators must know the meaning of the signals and act only on those signals.

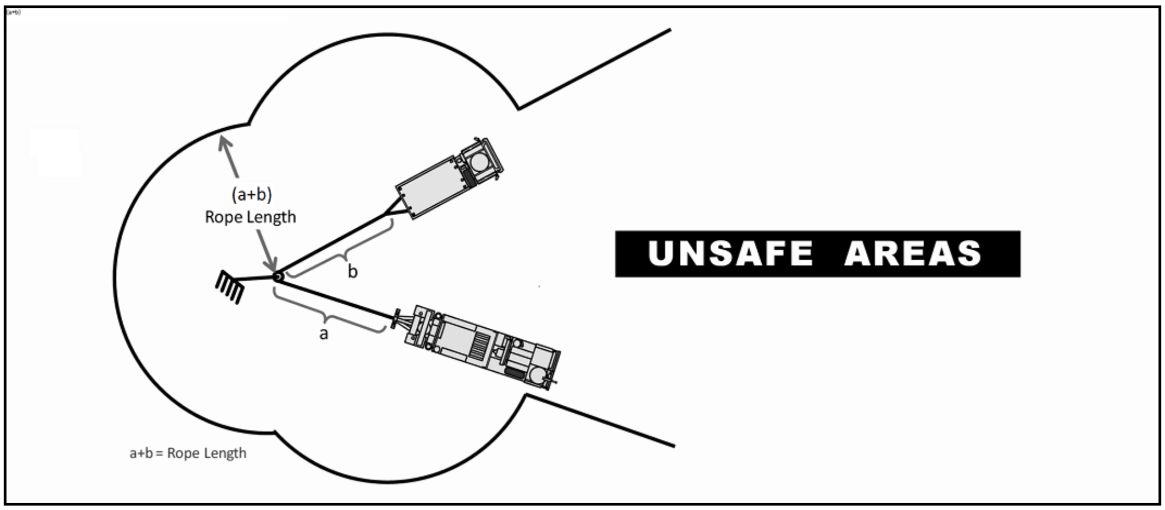


Figure 3-1. Unsafe areas during an angle pull

HOOK POSITIONS

3-6. For rigging, position the hook with the open part (throat) upward (figure 3-2). If the hook should straighten out from overload, the rigging would be forced downward. If the hook were positioned with the open part (throat) down, the rigging would travel upward unrestricted and possibly cause injury to personnel or damage to vehicles.

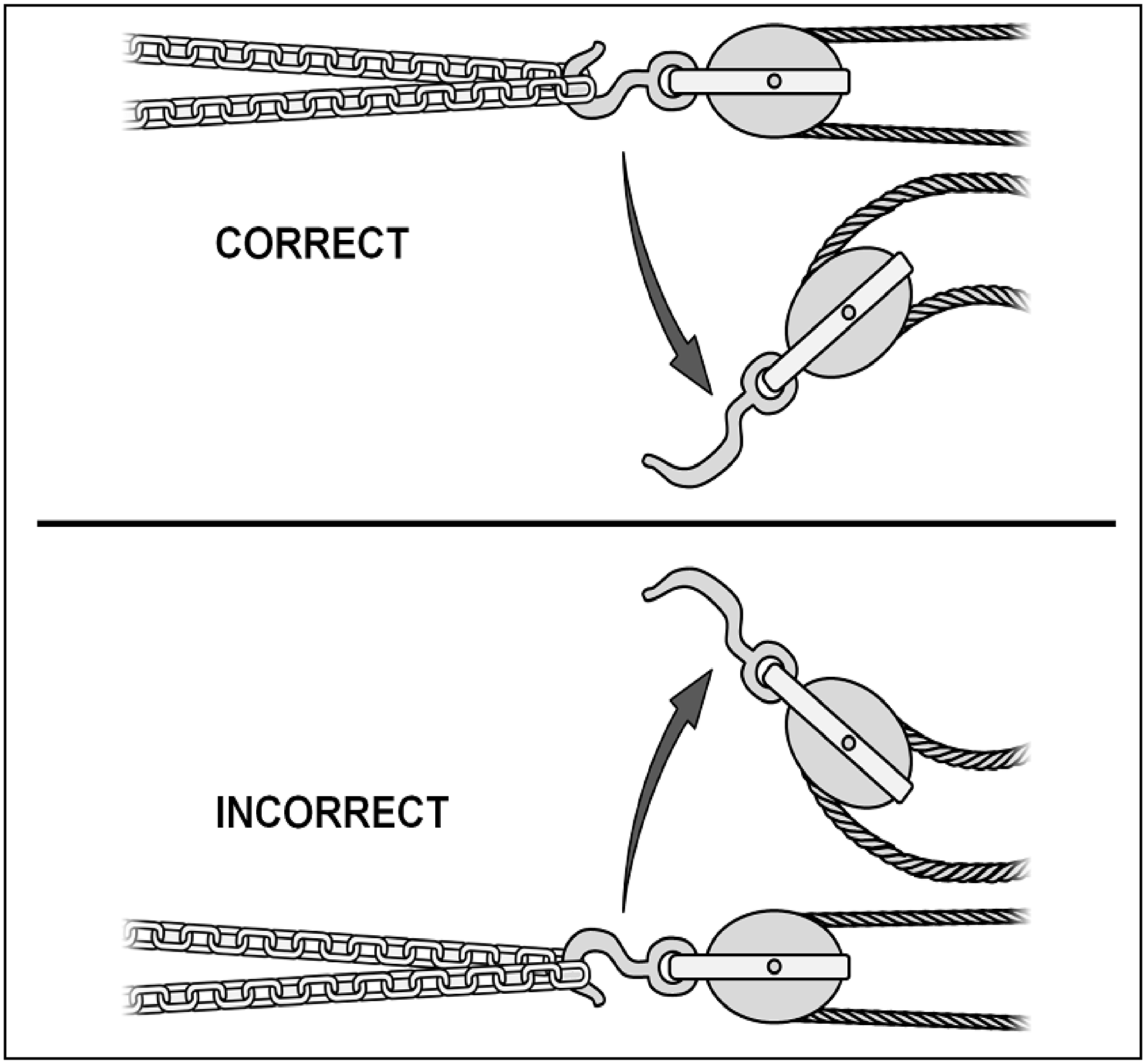


Figure 3-2. Hook positions

HOLDBACK VEHICLES

3-7. Towing tracked vehicles may require using a holdback vehicle.

- A holdback vehicle or braking vehicle is mandatory when using tow cables.
- When using tow bars, a holdback vehicle or braking vehicle may be necessary if the recovery vehicle is lighter than the disabled vehicle and risk assessment is done and shared by commander.

CAUTION

Inspect rigging thoroughly at every connection to ensure that safety pins are installed correctly and that proper shackles, pins, and hooks are used. Ensure that tow cables are not crossed and are reeled correctly in the snatch block.

INSPECTING RIGGING

3-8. Inspect equipment thoroughly before the recovery operation starts. Direct the recovery vehicle operator to apply power to the winch to remove the slack from the rigging, and then stop the operation so the rigging can be inspected without endangering personnel. When inspecting the rigging, never place the hands or body between cables under tension.

OPERATOR/DRIVER SAFETY

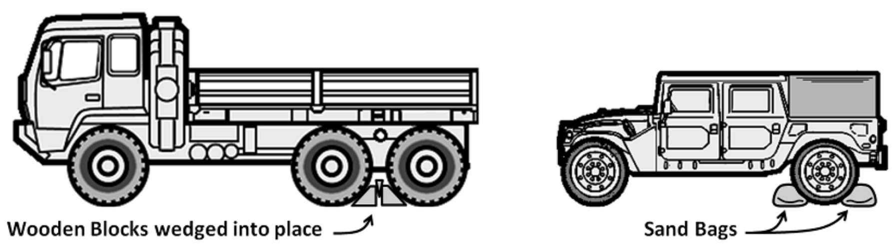
3-9. Operators and other personnel, in both the recovery and disabled tracked vehicles, must keep their hatches closed during winching and allied kinetic energy recovery rope operations. Operators should use their periscopes to view hand and arm signals.

POSITIONING GUN TUBES

3-10. During tank or tracked howitzer recovery, position the main gun tube so it will not be damaged. If the gun tube of a disabled tank or tracked howitzer is involved in a collision (this might occur on a nosed or overturned tank), maintenance support personnel should always check the gun tube before firing.

RIGGING BETWEEN VEHICLES

3-11. While rigging is being erected between vehicles, turn off the engines and apply the brakes. This prevents possible injury to recovery personnel and/or damage to the vehicles. When riggings are erected using a recovery vehicle that must have its engine running to operate the equipment, position the spade or chocks (wheeled vehicle) and apply the brakes to prevent movement (figure 3-3). The driver remains in position.



HOOKING UP TO A VEHICLE:
Before hooking up to a tow bar or before disconnecting the drive or parking break, chock the vehicle wheels with blocks so that it cannot move. (Place a block of wood or other suitable object between the rear tires or in front of and in back of one tire.) Make sure the chock extends the full width of the tire.

UNHOOKING FROM A VEHICLE:
Before unhooking from a tow bar or before connecting the drive or parking break, chock the vehicle wheels with blocks so that it cannot move. (Place a block of wood or other suitable object between the rear tires or in front of and in back of one tire.) Make sure the chock extends the full width of the tire.

CAUTION
Failure to remove the blocks could result in damage to the vehicle.

Figure 3-3. Chocking/blocking wheeled vehicles

SAFETY KEYS AND SHACKLE PINS

3-12. Safety keys and shackle pins should be in place on all tow hooks, shackles (figure 3-4). Even though the safety key and shackle pin supports no great load, its absence can allow a pin to move which places excessive force on only a part of a connection. Some shackles use a threaded-type pin. If the pin is not completely inserted into the shackle threads, the shackle or pin can be bent or broken when force is applied.

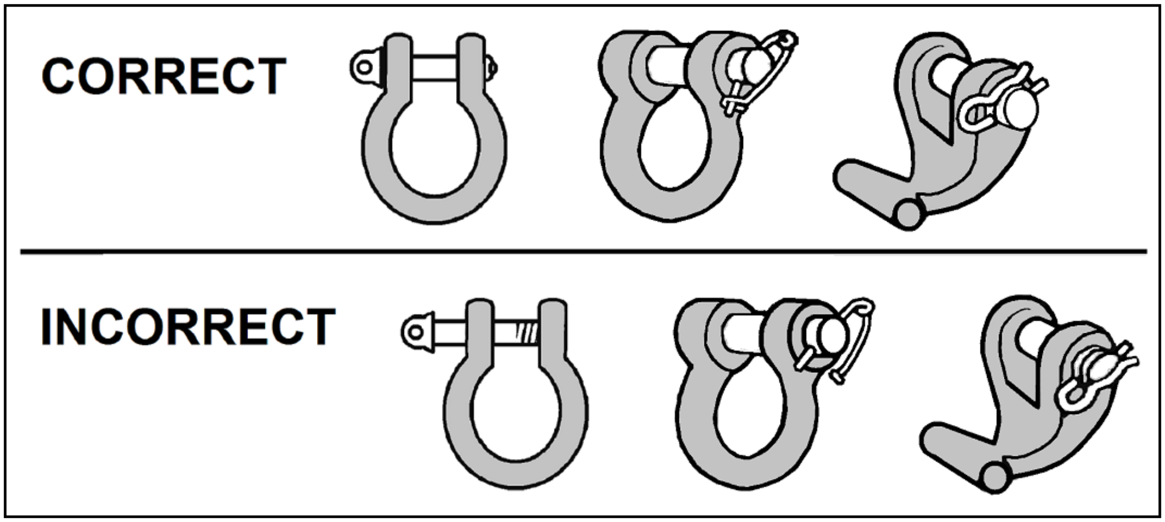


Figure 3-4. Safety keys and shackle pins

3-13. When using shackle pins with safety keys, such as the type used in tow bars, all shackle pins in a vertical plane should have their heads pointing upward. Should the safety key break or fall out, the shackle pins will remain in position if the load shifts.

SPEED

3-14. Maintain the correct speed when towing vehicles. Consider the terrain, weather, and road conditions when determining speed. Never exceed the tow speeds listed in the operator's manuals for the towed or towing vehicle.

RECOVERY PROCEDURES

3-15. In any recovery operation, (see table 3-1), use the following eight-step method:

Table 3-1. Eight step recovery method

STEP 1. Reconnoiter area. • Check the terrain for the best approach to the load; then determine the method of rigging and the availability of natural anchors. A recovery crew must know the problem before making decisions. • Conduct a complete ground survey of the area; then select the best route of approach to the disabled vehicle to prevent possible disablement of the recovery vehicle. When selecting the evacuation route, ensure that the military route classification number will support the combination vehicle classification (recovery plus towed vehicles). Refer to FM 3-34.170, *Engineer Reconnaissance*, for further information.
STEP 2. Estimate situation. • Estimate the resistance created by the load and determine the capacity of the AE. For most recovery operations involving winching, the AE would be the maximum capacity of the winch. In some recovery operations, the maximum distance between the winch and the disabled vehicle could be restricted, making the AE as little as half of the winch capacity.
STEP 3. Calculate ratio. • Compute an estimated MA for the rigging by dividing the resistance of the load (step 2) by the AE (the capacity of the winch).
STEP 4. Obtain resistance. • Compute the tackle resistance and total load resistance. Multiply the percent of the load resistance (as determined in step 2) by the number of sheaves in the rigging. The determined resistance of the tackle added to the load resistance

Table 3-1. Eight step recovery method

equals the total resistance. • Total effort available is winch capacity multiplied by the MA (as computed in step 3). If effort available is more than total resistance, proceed to step 5. If it is less, return to step 3 and add MA.
STEP 5. Verify solution. • Compute line forces to compare with the winch and dead line capacities. Divide the total load resistance (step 4) by the MA (step 3). The result is the fall line force. The fall line force must be less than the capacity of AE. Therefore, this step of the recovery procedure is the key step to solving the problem. Note. When verifying the solution, if the computed fall line force is greater than the effort, the MA must be increased. Note that no physical work has occurred up to this point. As a result, no time is lost moving equipment or having to re-erect rigging equipment. • Compute the dead line force, determine the required strength of equipment capacity, and choose the correct equipment to use as dead lines.
STEP 6. Erect rigging. • Orient the crew, instruct them on how to assemble the tackle, and then move to a safe location. • Advise the crewmembers of the plan, direct them to erect the tackle, and assign specific tasks for desired MA. (Crewmembers that have finished their tasks should assist those who are having difficulty. The crewmembers can save time by having a thorough knowledge of the tackle to be erected and by helping each other.) • Observe all safety precautions.
STEP 7. Recheck rigging. • Make sure that the tackle is rigged for proper and safe operation. • Direct the operator to remove most of the slack from the lines and to inspect for correct assembly. If any corrections must be made, direct the crewmembers to make them. • Explain the details of the operations to the operators of the recovery vehicle and the other vehicles involved. Direct operators to watch for signals and be prepared to act on them. Then move to a safe location where signals can be observed by all vehicle operators.
STEP 8. You are ready. • Signal the operators to apply winch power and recover the load. Be alert; make sure that nothing obstructs the operations of the equipment and that all personnel on the ground remain at a safe location.

RECOVERY METHODS USING WHEELED RECOVERY VEHICLES

3-16. The following paragraphs describe the different methods of recovery using wheeled recovery vehicles.

Types and Usage

3-17. Trained recovery personnel must perform recovery operations. Trained recovery personnel use special purpose vehicles for recovery when methods used by the operator, crew, or platoon do not fit the situation or when their efforts have had no success. The methods of recovery performed with special purpose vehicles are winching, lifting, and towing.

> ***Note.*** This section summarizes winching, lifting, and towing procedures. For more in-depth information, refer to the equipment operator's manual, which relates to the operation of the equipment and its specific capabilities.

Winching

3-18. During the recovery of a mired truck using a wrecker, consider the following factors: the resistance of the load, the approach to the load, and the distance between the wrecker and mired vehicle. Mired trucks may have a resistance greater than the winch capacity of the wrecker. Also, the wrecker may not be able to align itself with the truck because of the terrain. If so, use a 2-to-1 MA and a change of direction block (figure 3-5).

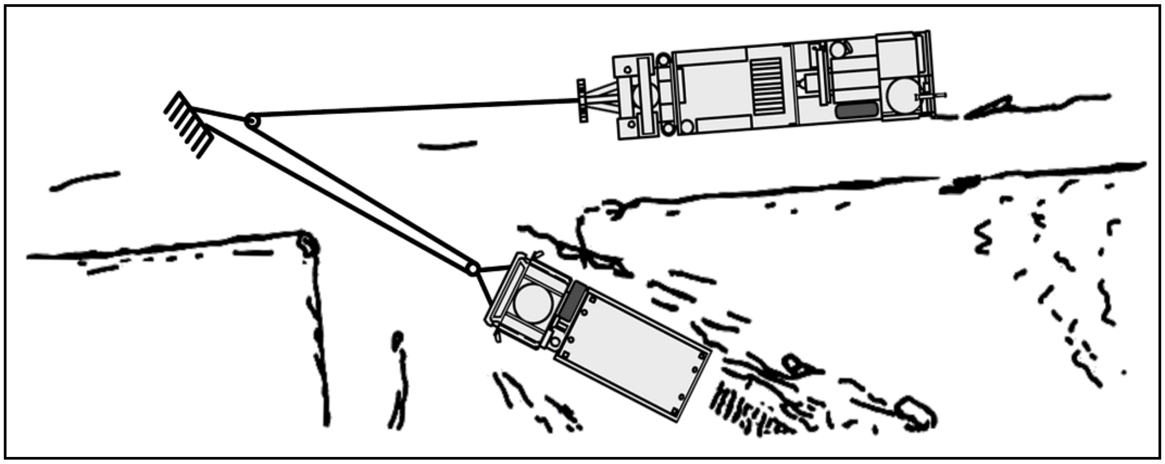


Figure 3-5. Winching using a 2-to-1 MA and a change of direction block

> **WARNING**
>
> **When wheel vehicle towing, the recovery vehicle must be equal or greater weight than the vehicle being towed.**

Wheeled Towing

3-19. Recovered vehicles will be towed to the nearest maintenance collection point where repairs can be performed or other recovery, evacuation, or retrograde actions can take place. The method of towing used is situational dependant based on terrain, mechanical condition, and other operational variables. A wrecker is capable of conducting towing operations in the following ways: flat tow, lift tow, and hasty lift tow.

Flat Tow

3-20. To use a flat tow:

- Always refer to applicable TM, FM, and/or ATP for proper towing procedures.
- When possible, always use the retrieval system and multi use adaptors (provided in the BII of the wrecker) to conduct flat tow operations.
- When possible, use the airlines in the BII to supply air from the wrecker to the towed vehicle for additional braking.
- When the retrieval system on the wrecker cannot be used, attach one end of the tow bar to the disabled vehicle's tow points or lifting eyes and the other end of the tow bar to the towing pintle (figure 3-6 on page 3-8) of the wrecker. All wheels of the towed vehicle will be on the ground and no driver in the towed vehicle.
- Determine the terrain features and route prior to movement. If a hill will be encountered that requires the brakes to be used to reduce speed, shift into the next lower gear at the crest of the hill and use the engine compression to assist in slowing the vehicles.

- Take extreme care to prevent excessive engine speed while descending a hill. Determine the suitable gear and shift, if necessary, at the crest of the hill before speed has increased from downhill movement. Ordinarily the gear required to ascend a hill is proper to use to descend it. Refer to the vehicle operator's manual for additional information.

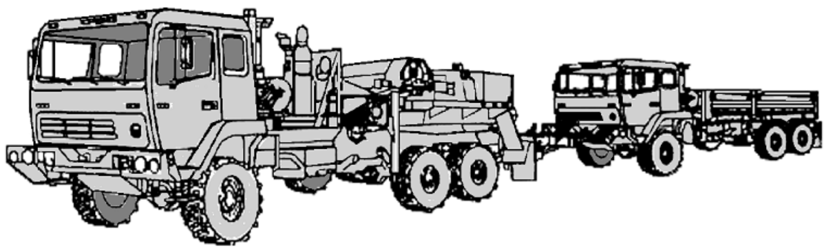


Figure 3-6. Flat towing

CAUTION

Safety chains must be used in addition to the tow bar. Properly used, safety chains will retain a towed vehicle should the tow bar fail or become disconnected. Cross the chains under and around the tow bar. Fasten it to the shackles of the towing vehicle around a structural member or the underside of the vehicle to be towed. Leave sufficient slack for turns, but not enough to encounter road surface.

Lift Tow

3-21. If damage to the front or rear of the vehicle requires that the disabled vehicle be lifted, use the lift-tow procedure even when the disabled vehicle is being towed on the highway.

- Always refer to applicable TM, FM, and/or ATP for proper lift towing procedures.
- When possible, always use the retrieval system and multi use adaptors (provided in the BII of the wrecker) to conduct lift tow operations (figure 3-7).
- When possible, use the airlines in the BII to supply air from the wrecker to the towed vehicle for additional braking.
- Connect the adaptors to the towed vehicle and the retrieval device on the wrecker.
- Use safety chains connected between the wrecker and the towed vehicle.
- Lift the towed vehicle high enough to provide enough clearance so that the tires on the towed vehicle will not come in contact with the ground during movement. The actual height is terrain dependent but will typically be 12-18 inches.
- Refer to the wrecker operator manual for additional information.

Figure 3-7. Cross-country towing

Hasty Lift Tow

3-22. If the front or rear end of the vehicle is damaged and the multi use adaptors cannot be used, use the hasty lift-tow procedure, even when the disabled vehicle is being towed on the highway.

- Always refer to applicable TM, FM, and/or ATP for proper lift towing procedures.
- Attach the axle clamps to the axle of the disabled vehicle or route chains through solid points on the disabled vehicle at points to avoid causing further damage.
- If possible, use the retrieval system to connect the axle clamps or chains to the wrecker. Use sufficient chains and binders to ensure that the towed vehicle will not move or “ride up” the retrieval system when braking.
- Caution should be used when using the hasty lift tow procedures and should only be used to recover the damaged vehicle to a safe location where other recovery methods can be used.

3-23. In the case where a boom style wrecker is being used for the hasty lift tow and the retrieval system cannot be used.

- Always refer to applicable TM, FM, and/or ATP for proper lift towing procedures.
- Attach the axle clamps to the axle of the disabled vehicle or route chains through solid points on the disabled vehicle at points to avoid causing further damage.
- Use sufficient chains and binders to ensure that the towed vehicle will not move or might come free during towing.
- If possible, a tow bar should be inserted between the wrecker and the towed vehicle.
- Extend the boom as little as possible to remove the slack from the tow chain to keep the towed vehicle from ramming into the rear of the wrecker truck. Support the boom with the shipper

braces, boom cradle, or other solid resting point that the boom would normally ride in during transport mode to prevent damage to the hydraulic components on the wrecker.

- Caution should be used when using the hasty lift tow procedures and should only be used to recover the damaged vehicle to a safe location where other recovery methods can be used.

Note. Procedures are the same as cross-country lift towing except speed will be reduced.

WARNING

Extreme caution should be exercised to avoid damage to the towed vehicle. If possible, use the lift-tow procedure before using cross-country tow or highway tow procedures. Refer to the equipment operator's manual for lift-tow restrictions, vehicle preparation, precautions that must be taken, and vehicle speed when performing lift-tow operations.

RECOVERY METHODS USING TRACKED RECOVERY VEHICLES

3-24. Different methods of recovery using tracked recovery vehicles are described as follows.

Winching

3-25. One recovery vehicle is used for recovering most mired tracked vehicles. To prepare for winching, position the recovery vehicle in line (as much as possible) with the mired vehicle keeping in mind fleet angle.

Variable Winch

3-26. When using a variable type winch, the maximum winching capacity is gained when the cable is almost fully payed out but still has at least three to five wraps remaining on the drum. Always refer to the operator's manual for guidance on achieving maximum winch effectiveness.

Constant Pull Winch

3-27. Vehicles with constant pull winch can be positioned as close as practical to the mired vehicle. Always allow distance for the mired vehicle to get on solid ground. Testing has shown that the flat, smooth hull of the Abrams-series tank provides less resistance than expected. This should allow most of the mired tanks to be recovered using a single line pull. Recovery with two recovery vehicles (figure 3-8) is used only when the load resistance of a mired tracked vehicle is so great that the calculated fall line force is more than the winch capacity of one recovery vehicle with a 3-to-1 MA.

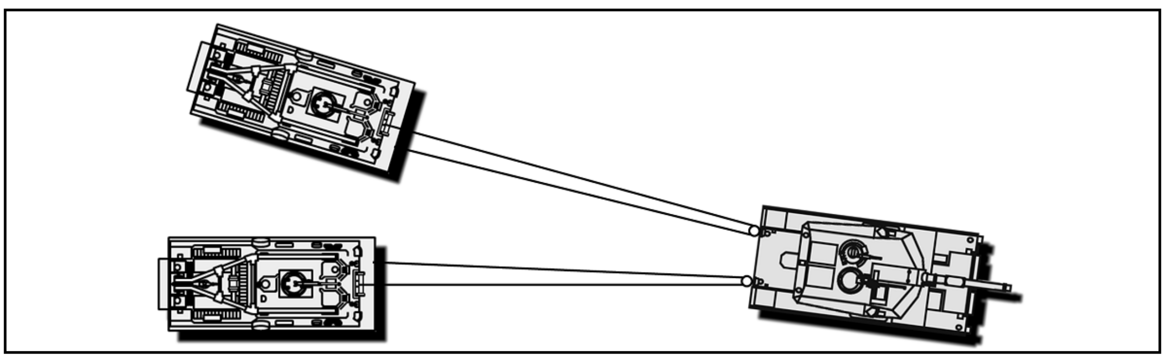


Figure 3-8. Winching with two recovery vehicles

3-28. To take full advantage of their winch capacities, the recovery vehicles are positioned side by side (figure 3-8). The same length of winch cable can then be used. Rig each recovery vehicle for a 2-to-1 MA (figure 3-9). Attach each rigging snatch block to a tow lug on the mired vehicle. To synchronize winch speeds, both recovery vehicle operators should use the hand throttle to set the engine speed at the desired revolutions per minute and compensate with the winch control lever to maintain tension on cables.

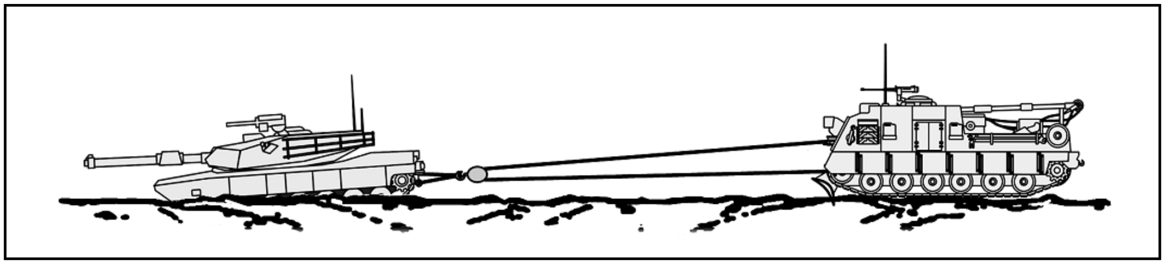


Figure 3-9. 2-to-1 MA

Tracked Towing

3-29. Although towing can be done with similar vehicles, it is often necessary for the recovery vehicle to tow a disabled vehicle to the unit maintenance collection point where repairs can be made or evacuation effected. The towing method used will depend on the type of terrain and available assets.

> ***Note.*** An observer will be used to assist the operator during towing operations. The observer will be located on the recovery vehicle and will have direct communication with the operator. The observer's responsibilities are to verify the tow connection throughout towing operations and alert the driver of unsafe conditions of the towed vehicle, including but not limited to, disconnect and/or jack knife. This may require that the recovery vehicle halt occasionally for the observer to exit the vehicle and examine the condition of the rigging. At no time will the observer ride on the exterior of the recovery vehicle or the towed vehicle during towing operations. The observer must be positioned to use observation windows and rearview mirrors.

Towing with the M88A1

3-30. When towing an Abrams family of vehicles or M88A1 series recovery vehicle, always use another M88A1 or M1 series recovery vehicle as a holdback vehicle–even when using a tow bar.

- Never allow anyone to ride in or on an M1 while it is being towed.
- Never make sharp turns in first gear; make gradual wide turns.
- Never make sudden stops.

Towing with the M88A2

3-31. There are operational restrictions when towing an Abrams family of vehicles.

- Use an M88A2 recovery vehicle or, if dictated by the operational risk assessment, use another Abrams family of vehicles as the braking or holdback vehicle.
- Use crossed tow cables as the method for attaching the braking or holdback vehicle.
- Use the tow bar provided with the M88A2 for the tow vehicle.
- When towing cross-country under extreme conditions, use crossed cables for the towing and braking or use a holdback vehicle.

Highway Tow

3-32. For highway tows:

- Attach the recovery vehicle's tow bar to the tow lugs of the disabled vehicle.

- Place the lunette of the tow bar in the recovery vehicle's tow pintle. (This could be done using a small block and tackle—attaching one part to the tow bar and the other to a place on the recovery vehicle higher than the tow pintle. This will allow a single Soldier to raise the tow bar to the pintle without getting between the two vehicles).
- Secure the pintle in the closed position.

Note. A driver is not required in the towed vehicle.

3-33. If the recovery vehicle is lighter than the disabled vehicle, a holdback vehicle of the same weight class as the disabled vehicle and cross tow cables are required so the towed vehicle will not overrun the recovery vehicle. Figure 3-10 shows the holdback vehicle positions.

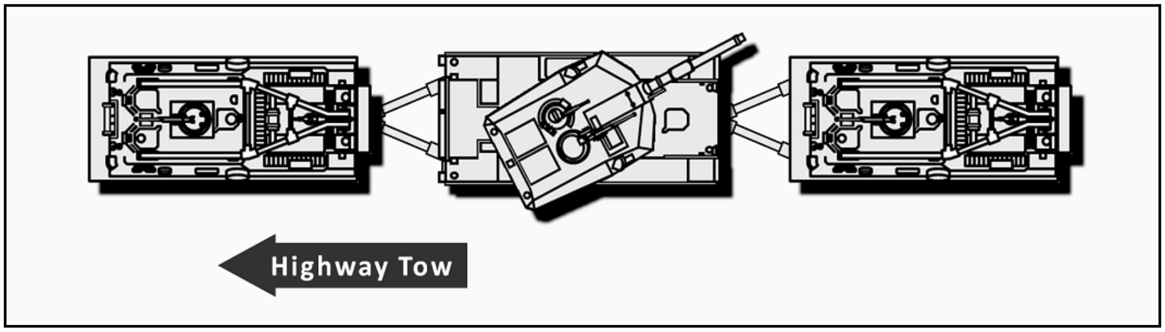


Figure 3-10. Tracked towing with holdback vehicle

Cross-Country Tow

3-34. Only in extreme cases, or as a backup, will crossed tow cables be used as a method of towing cross-country (figure 3-11). Use crossed tow cables between the recovery vehicle and the disabled vehicle when towing similar vehicles. A holdback vehicle is required so the towed vehicle will not overrun the recovery vehicle.

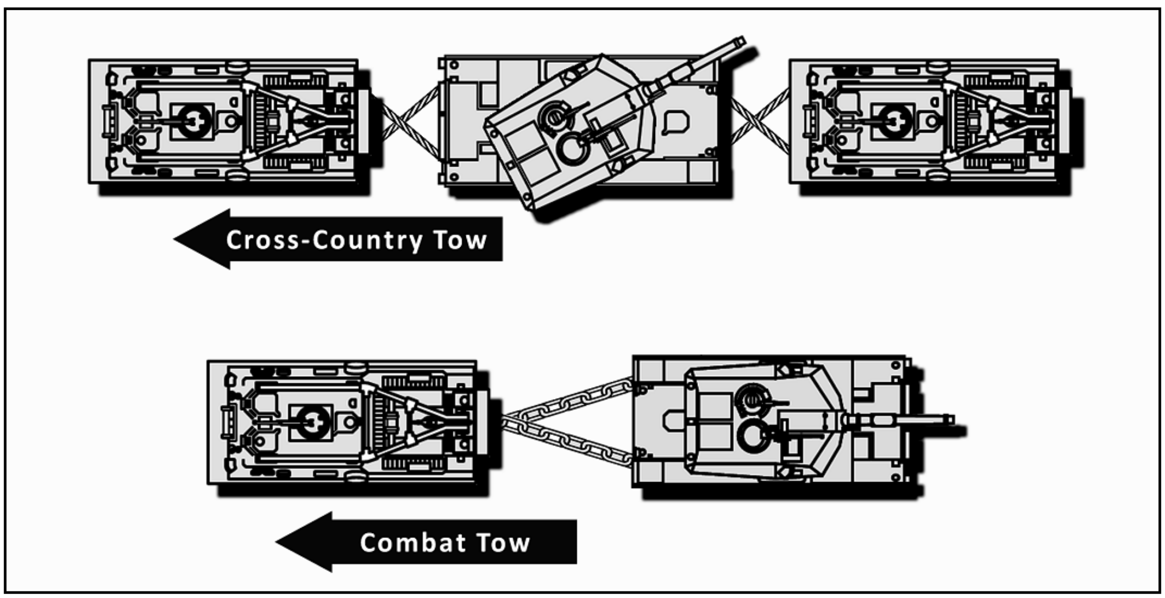


Figure 3-11. Tracked towing

Combat Tow

3-35. Use a combat tow to make a towing connection under small-arms fire to provide the least possible exposure of personnel. (Figure 3-11)

- Attach the lifting V-chain to the recovery vehicle's tow pintle before moving it to the disabled vehicle; wrap legs over tow bar.
- Move the recovery vehicle into the danger area.
- Back it up until contact is made with the front of the disabled vehicle. (If possible, a crewmember in the disabled vehicle can connect the V-chain legs to the front tow hooks of the disabled vehicle).
- Move out the recovery vehicle, towing the disabled vehicle.

TOW BAR HANDLING

3-36. Before attempting to tow a disabled vehicle, be familiar with the location, features, and operation of all components of the tow bar. (Some tow bars have operator's instruction decals mounted on them.) Ensure the proper tow bar is used for the equipment being towed. Tow bars can be used to tow any vehicle up to the gross weight of the tow bar's towing capacity.

3-37. Before attaching a tow bar to a disabled vehicle, chock the wheels/tracks (figure 3-12) and/or set the emergency brake. After attaching the tow bar to a disabled vehicle, remove the chocks and/or release the emergency brake before moving.

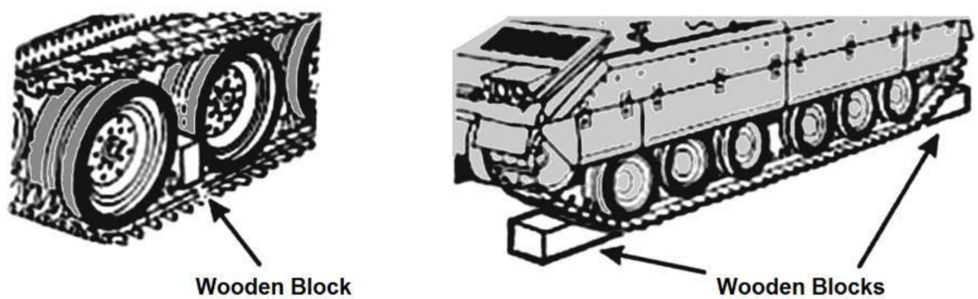


Figure 3-12. Chocking/blocking tracked vehicles

HOOKING UP TO A CARRIER

3-38. Before hooking up the tow bar or disconnecting the drive between the differential and final drive, chock the vehicle with blocks so that it cannot move. (Place a block of wood or other suitable object between the track guides and the two sets of road wheels or one in front of and one in the rear of the track, see figure 3-12.) Make sure the object extends the full width of both road wheels.

UNHOOKING FROM A CARRIER

3-39. Before unhooking the tow bar or connecting the drive between the differential and final drive, chock the vehicle with blocks so that it cannot move. (Place a block of wood or other suitable object between the track guides and the two sets of road wheels or one in front of and one in the rear of the track, see figure 3-12.) Make sure the object extends the full width of both road wheels.

CAUTION

Failure to remove the blocks could result in damage to the vehicle.

3-40. Refer to the disabled vehicle's TM for proper towing procedures (for example, automatic versus standard transmission). Ensure that the proper pin assemblies are in the clevis holes, and always be sure the quick-release pins (which snap automatically) are properly secured.

Note. Use extreme care when lift-towing or flat-towing disabled vehicles. Check the disabled vehicle's technical manual for vehicle preparation, precautions that must be taken, and maximum vehicle speed.

TOWING OPERATIONS ON GRADES

3-41. Towing a disabled vehicle is never easy, but towing up or down a grade can be even more difficult and dangerous. While towing a disabled vehicle, do not attempt to negotiate a grade (either up or down) before doing a risk assessment which must be signed by the commander.

CAUTION

Under NO circumstances will a slope that is greater than 30 percent ever be negotiated while towing a vehicle.

3-42. To know which grades to avoid, an operator must know how grades are classified. Grades are defined in terms of percent or the amount of a grade's vertical height (rise) over its horizontal length (run). If a road gains 25 feet of height over 100 feet of length, it is classified as a 25 percent grade (figure 3-13).

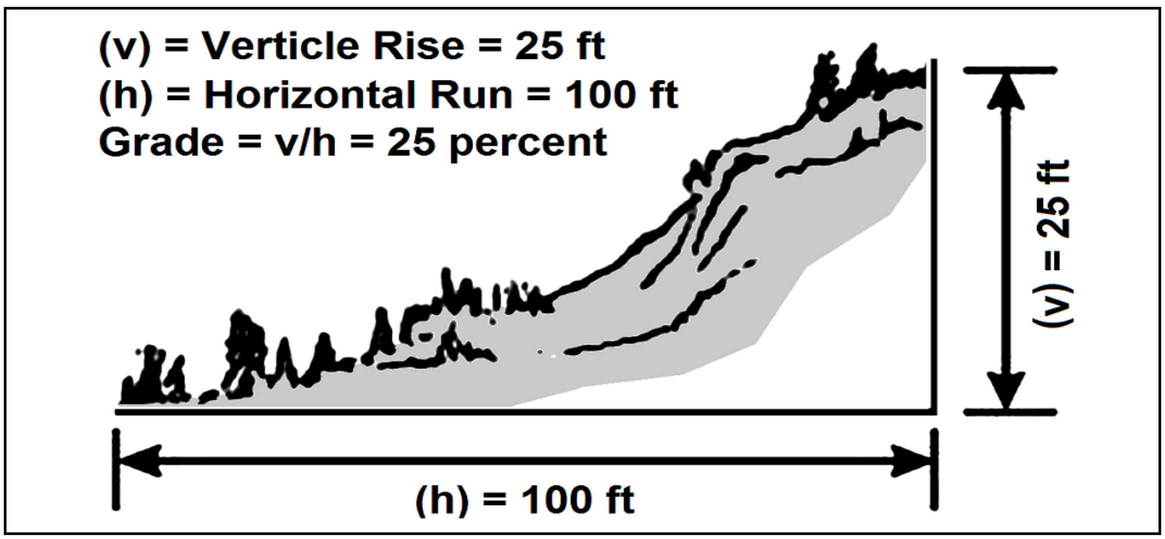


Figure 3-13. Classifying a grade

3-43. The best way to classify a grade is with a surveying level (figure 3-14), which is a BII on the M88A2. The operator stands at the top (or bottom) of the hill and chooses a point as close as possible to the bottom (or top) of the hill where he will be traveling. The operator then looks through the sight of the level at the point he has chosen and turns the level knob until he sees the level bubble centered between the witness marks. Then the operator reads the percent grade on the indicator.

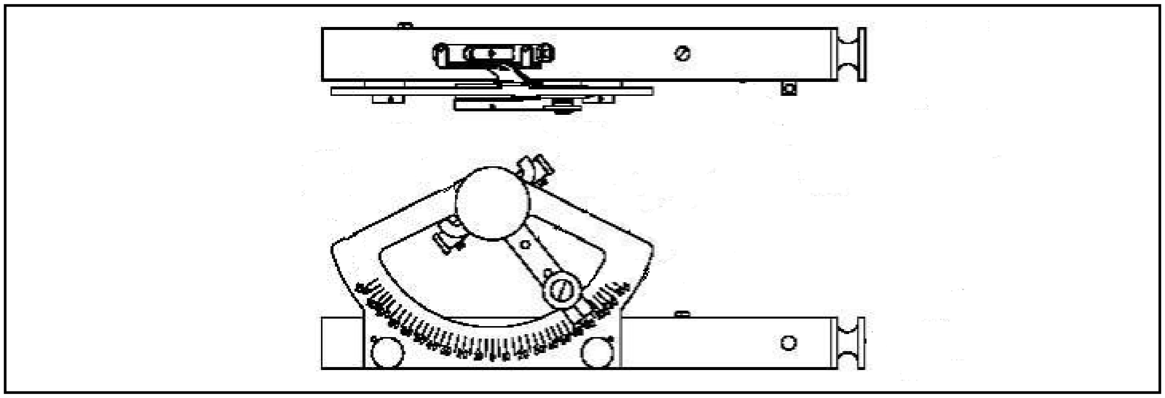


Figure 3-14. Slope surveying level

3-44. An improvised or field expedient method uses a small level, a 10-inch piece of flat wood, and a ruler

- Lay the piece of wood on the steepest part of the grade, with the length of wood running up and down hill.
- Put the level on the piece of wood and start to raise the downhill side of the wood up, until the bubble in the level is between the witness marks.
- Measure the distance between the road and the bottom of the wood. If it is 3 inches, there is a 30 percent slope; if it is 2.5 inches, there is a 25 percent slope; and so forth.

3-45. Another method is the eyesight and pace method (figure 3-15). The Soldier needs to know his height and the length of his stride. If a Soldier is 6 feet tall and his step is 2 feet long.

- He stands at the bottom of the hill and picks a spot on the hill that is the same height as his head.
- Once he reaches that spot, he multiples his steps by his stride (2 feet) and then divides his height (6 feet) by that number multiplied by 100 and adds 1.
- He then walks to that spot, counting his steps.

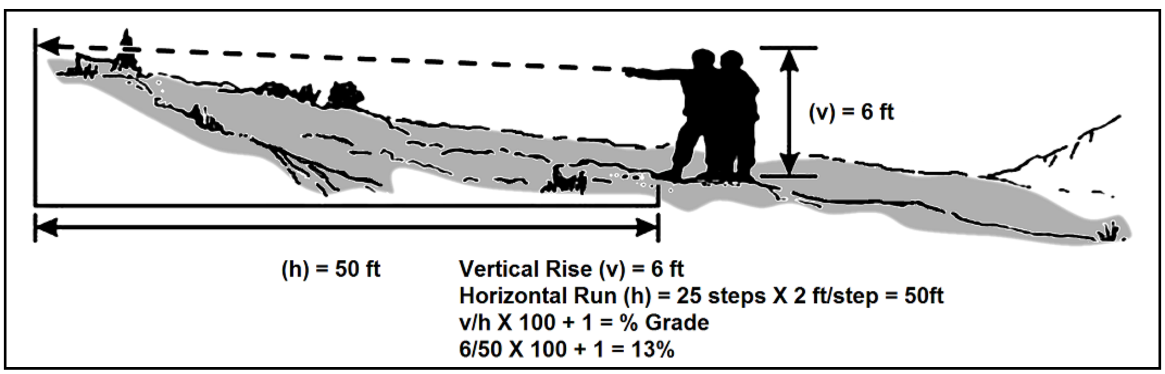


Figure 3-15. Eyesight and pace method

3-46. The following items must be considered while performing terrain analysis:

- Trails/grades with sharp curves mean additional control is needed during ascending and descending. There is no safety zone in case of a runaway load.
- Dry and dusty soil or wet and muddy soil can cause a loss in traction. Pay close attention to the soil conditions that may alter as weather conditions change.

Note. Inclement weather (rain, snow, ice) will naturally affect the road conditions, making loss of traction more probable.

3-47. If the operator has to shift into first gear to climb a grade, there is a good chance that it is too steep to descend with a towed load. Measure the downhill grade before attempting to descend any hill that required first gear to climb. Other options may include:

- Using a braking or holdback vehicle behind the towed load.
- Winching the disabled vehicle downhill, if possible.

3-48. If a way can be found to detour the steep grades, use it. If not, notify the commander. Inform him of the grade percentage of the road, weather visibility, and road conditions (wet, dry, muddy, pavement). The recovery vehicle driver's experience and the type of load being towed will play an important role in the commander's decision. If the driver does not feel confident in negotiating the grade, he must inform the commander. The best course of action may be to get the most experienced wrecker/recovery vehicle operator on the site to handle the mission.

3-49. In summary, ensure a good route reconnaissance is conducted on the way to the disabled vehicle's site. When possible, avoid all hills or roads with a grade of 25 percent or greater while towing a load. If not, notify your commander and take proper precautions. Ensure that no one rides in a towed vehicle.

FIFTH WHEEL TOWING RECOVERY DEVICE

3-50. The fifth wheel towing device is a heavy-duty, under lift towing device that uses the fifth wheel coupling as a pivotal connection between the pulling tractor and the truck in tow. (See figure 3-16.) The weight of the towed vehicle is transferred evenly to all axles of the towing tractor. The front axle of the towing tractor actually gains weight as the towed vehicle is lifted.

3-51. The 30,000 pounds lift capacity allows the fifth wheel towing device to be used in recovering mired vehicles. The boom assemblies can be extended under the mired vehicle and the mast rose to allow for rigging attachments. This helps reduce the mired condition of a vehicle while transferring some of the weight to the recovery tractor.

3-52. The fifth wheel towing device is equipped with an onboard winch to aide in coupling the disabled vehicle to the fifth wheel towing device. Once the disabled vehicle is coupled to the fifth wheel towing device, the system functions are similar to a semi-trailer. The fifth wheel towing device transports wheeled vehicles on highways, unimproved roads (graded level), and cross-country.

CAUTION

The small 18,000 pound winch between the booms on the fifth wheel towing device is not designed to recover vehicles in mired conditions. It is to be used only to assist in loading a disabled vehicle.

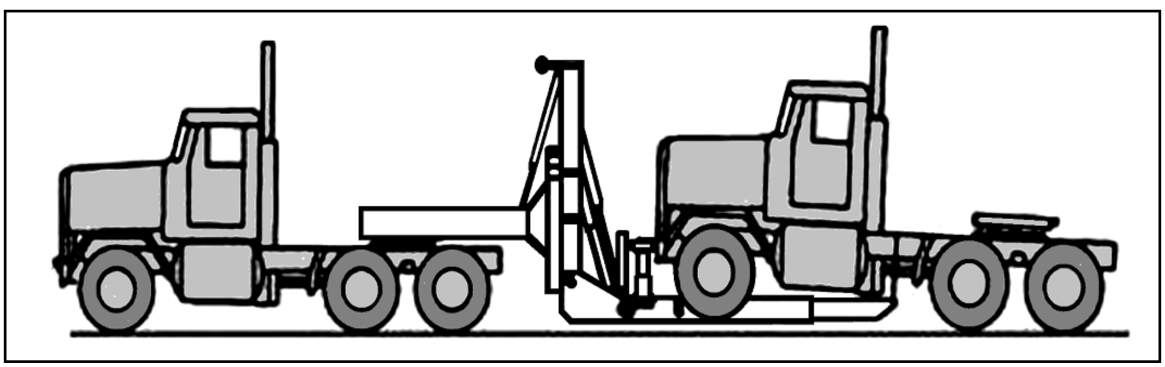


Figure 3-16. Fifth wheel towing device

3-53. Remember the following important safety considerations when using the fifth wheel towing device to transport or recover disabled vehicles:

- Towing a single vehicle with nonfunctioning brakes must be limited to not more than 25 miles per hour on the highways and 15 miles per hour off roads.
- Stopping distances greatly increase when the towed vehicle has nonfunctioning brakes.
- Towing of vehicle combinations (tractor with trailer) with nonfunctioning brakes is prohibited.
- Visibility from the prime mover is significantly reduced when backing, whether the fifth wheel towing device is loaded or not.
- All wheels remaining on the ground of the towed vehicle should be serviceable to increase system stability and reduce the risk of further damage.
- Never stand between the prime mover and fifth wheel towing device when the prime mover is being backed up to the fifth wheel towing device. Serious injury or death may result.
- Proper procedures must be followed and extreme caution used when backing to prevent damage to equipment and injury or death to personnel. See operator's manual for additional cautions for the fifth wheel towing device.

3-54. Prime movers for the fifth wheel towing device are listed in table 3-2.

Table 3-2. Prime movers for fifth wheel towing device

Prime Mover	***Authorized Towed Vehicles***	***Gross Combination Weight Rating***
*M915, A1, A2, A3, A4	M915s, M818, M931 and M932 Models, family of medium tactical vehicles (FMTV) Series, palletized load system (PLS) Series	105,000 lb 47,641 kg
M916, A1, A2, A3	M915s, M916s, M818, M931 and M932 Models, FMTV Series, PLS Series	120,000 lb 54,446 kg
M920	M915s, M916s, M920, M931 and M932 Models, FMTV Series, PLS Series	120,000 lb 54,446 kg
M1088	M911, M915s, M916s, M920, M818, M931 and M932 Models, FMTV Series, PLS Series	80,775 lb 36,649 kg
M983	M911, M915s, M916s, M920, M818, M931 and M932 Models, M983, FMTV Series, PLS Series	100,000 lb 45,372
Note. M1074 and M1075 (PLS series) can be transported only without a payload		

Allied Kinetic Energy Recovery Rope

3-55. The allied kinetic energy recovery rope kit consists of a multi-strand, woven nylon rope, two large shackles, four small shackles, and a canvas bag. The concept of operations behind the allied kinetic energy recovery rope is that the stretch of the rope and its subsequent attempt to return to its normal length will provide a sudden snatch effect. This effect provides additional recovery force.

3-56. The allied kinetic energy recovery rope is restricted to recovering full tracked, full armored vehicles. Only vehicles using the proper attaching equipment listed in *Operators Manual for Allied Kinetic Energy Recovery Rope*, TM 9-4020-200-10, may participate in allied kinetic energy recovery rope recoveries as either the recovering vehicle or the vehicle to be recovered.

3-57. Any full track, full armored vehicle can be recovered. However, maximum effectiveness will be achieved when the vehicle being recovered is within the same general weight range or lighter than the recovering vehicles. Vehicles that are authorized by the technical manual to be the recovering vehicle are listed in table 3-3 on page 3-18.

WARNING

The allied kinetic energy recovery rope and emergency extraction ropes are similar in appearance, both being woven nylon ropes, but they are very different in operation. Applying a shock load to the allied kinetic energy recovery rope will cause it to stretch and apply force to the mired vehicle, but applying a shock load to the emergency extraction rope will cause it to break, and possibly cause damage to equipment or injury to personnel.

Table 3-3. Vehicle weights

Vehicle Type	***Vehicle Weight***
M109A6	61,000 lb (27,500 kg)
M2/M2A1-M3/M3Al	43,600 lb (19,777 kg)
M992	57,500 lb (26,082 kg)
M551/M551A1(with 1 1/4 inch tow cables)	36,000 lb (16,330 kg)
Legend: *lb=pound* ***Note.*** Only M5511M551Al vehicles with 1 1/4 inch diameter tow cables are authorized to be recovering vehicles. Those with 3/4-inch tow cables are not authorized to be recovering vehicles.	

CAUTION

The allied kinetic energy recovery rope may fail during use. If metal attachments fail or the rope breaks while the rope is under tension, personnel may be injured or killed. All personnel must either remain inside vehicles with hatches closed or stay to the side at least 100-125 feet away from the vehicles during recovery.

3-58. To use the allied kinetic energy recovery rope, the towing vehicle travels in reverse as closely as possible to the mired vehicle. The rope is connected and snaked to allow tangle-free deployment. For situations where it is not possible to get close to the mired vehicle, extension cables may be used. (Rigging for individual vehicles is shown in TM 9-4020-200-10.) The allied kinetic energy recovery rope must be connected directly to the vehicle.

Note. The gears are engaged in the mired vehicle to allow for travel in the same direction.

3-59. On a prearranged signal, the recovery vehicle will accelerate at maximum speed. At the same time, the mired vehicle (if possible) will accelerate to assist the recovery effort. Maximum acceleration is continued until the recovery vehicle is stopped or the mired vehicle is recovered. (See figure 3-17)

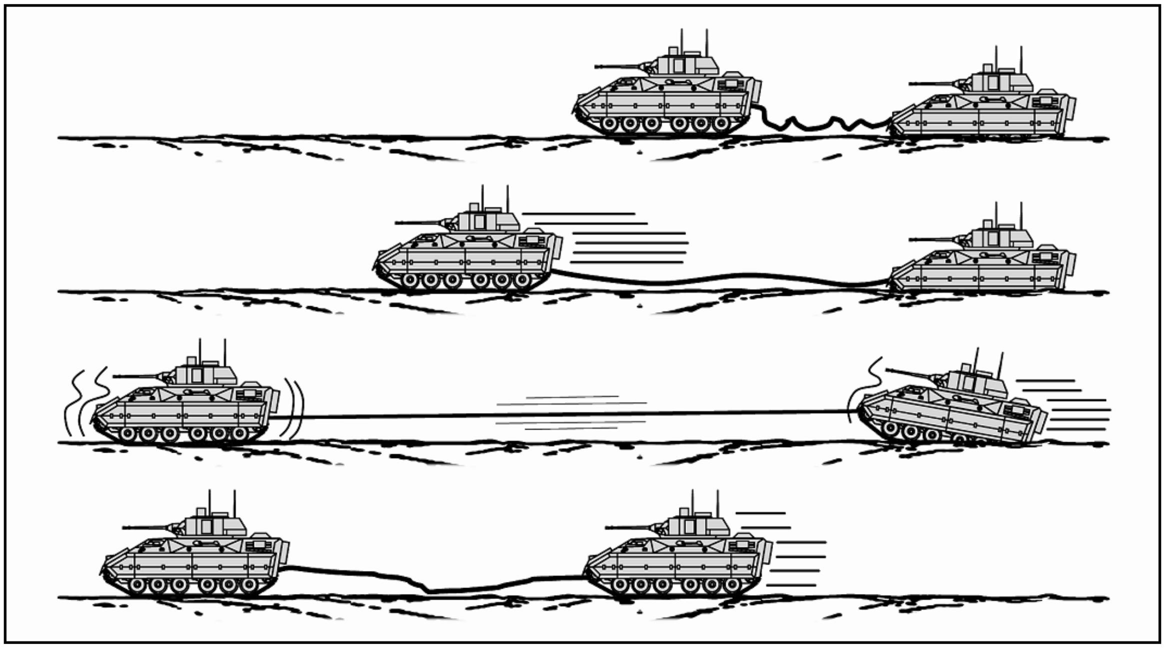


Figure 3-17. Recovery with allied kinetic energy recovery rope

3-60. After acceleration, the recovering vehicle will slow or halt; its kinetic energy is converted into potential energy as the rope stretches. The rope transfers the energy into the mired vehicle. After a slight pause, the mired vehicle rises free. If the vehicle is not freed by the first attempt, the process should be repeated. After recovery is complete, remove the allied kinetic energy recovery rope, wash it with low-pressure water, and allow it to dry before stowage.

Emergency Extraction Rope

3-61. Emergency extraction ropes are multi-strand, woven, nylon ropes used for like-vehicle recovery. The rope is connected between the mired vehicle and the towing vehicle. The towing vehicle slowly applies tension to the rope, avoiding shock loads, and gradually pulls out the mired vehicle. The emergency extraction rope is not built to withstand sudden loads from a rapidly accelerating recovery vehicle, and is not meant to be used as a long-distance towing device.

SPECIAL RECOVERY SITUATIONS

3-62. For nosed and overturned wheels, tracks, engineer, material handling equipment, and armored vehicles.

NOSED TRUCK

3-63. The recovery of a nosed truck using a wrecker may require only a towing operation. However, some situations may require using all three of the wrecker's capabilities (winching, lifting, and towing) to complete the recovery.

3-64. Figure 3-18 on page 3-20 shows an example of a 2½-ton cargo truck that is pulled off of a narrow road and mechanically disabled. Although the apparent fleet angle of the winch cable in the figure is greater than 1½ degrees, the wrecker winch has a level winding device which offsets the difference. (Not all vehicles with winches have this device.) When possible, position the wrecker at the least possible fleet angle and on the most solid surface to improve stability.

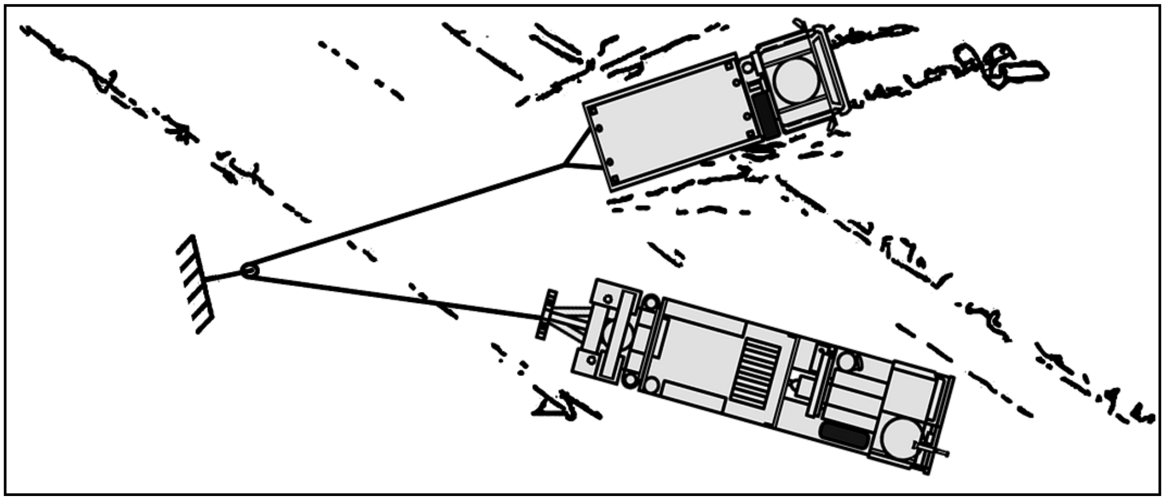


Figure 3-18. Recovery of a nosed cargo truck

3-65. To perform the recovery

- Position the wrecker truck on the road so the frontend of the nosed truck, when pulled back up on the road, will be in line with the rear of the wrecker truck.
- Make a change of direction pull, using the wrecker's rear winch to pull the truck onto the road.
- Lift the front of the truck with the wrecker's outriggers in place and turn the crane to place the truck directly behind the wrecker truck to prepare for towing.

OVERTURNED TRUCK

3-66. To upright an overturned truck using the wrecker (figure 3-19), a sling method of attachment must be used because a pulling force applied to only one point of the frame may result in a bent frame. Vehicle total weight should always be considered; using cranes to control the overturn should always use the factor that the "crane can only support half the vehicles gross weight at that extension and elevation level".

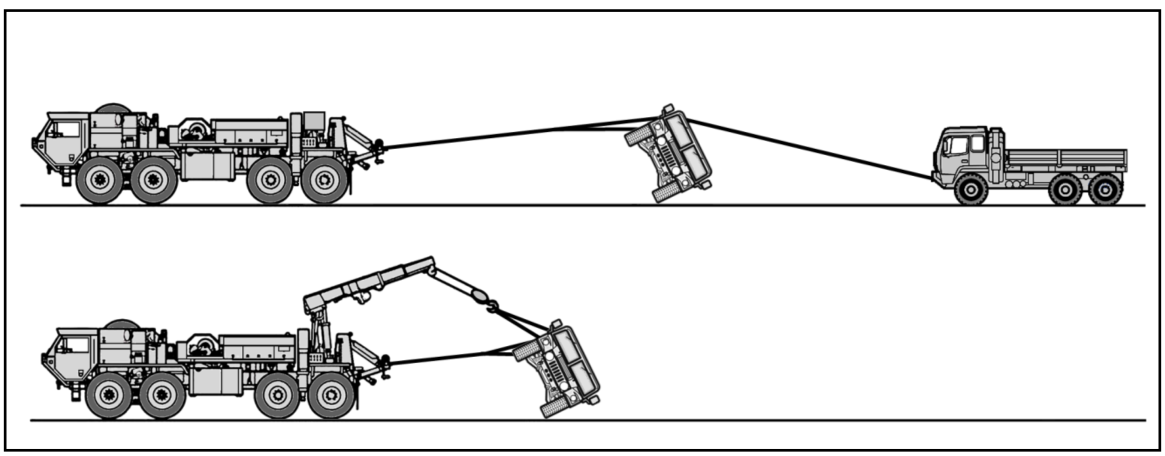


Figure 3-19. Recovery of overturned and upright with one vehicle

3-67. A sling attachment is made of two utility chains. The sling ends are attached to the front and rear lifting shackles on the high side of the overturned truck. Then the winch cable is attached to the center of the sling.

3-68. A holding effort will be required to prevent the overturned vehicle from crashing onto its wheels. (The holding force could be another vehicle, the wrecker boom, or a rope block and tackle with manpower.) The attachment for the holding force is a holding sling attached to the same points on the overturned truck as the pulling sling. The holding sling is then attached to the holding force with cable, rope, or chain—making sure the holding force is attached to the center of the sling. If a holding vehicle is not available, use the wrecker boom to hold the load.

3-69. Apply power gradually to the winch until the overturned truck is past the vertical position. Then, lower the truck on its wheels with the hoist winch. This method should make maximum use of the boom jacks and outriggers.

WARNING

Because of the danger of igniting spilled fuel and oil, smoking or open flames are not allowed near the overturned vehicle.

OVERTURNED TRACKED VEHICLE

3-70. To upright an overturned tracked vehicle with a recovery vehicle, position the recovery vehicle so it is facing the bottom of the overturned vehicle. It should be at a distance equal to the width of the overturned vehicle, plus 2 feet for safety. Two tow cables to form a sling. Pass the opposite ends of the sling under the track. Attach them to the front and rear tow hooks on the high side of the overturned vehicle. (See figure 3-20.)

3-71. For the uprighting source of power:

- Use a utility chain to attach the main winch cable to the center road-wheel arm support housing on the high side.
- Apply power to the main winch until the vehicle pulls past its point of balance and is supported by the hoist rigging.
- Lower the hoist winch rigging slowly to lower the overturned vehicle onto its suspension system.

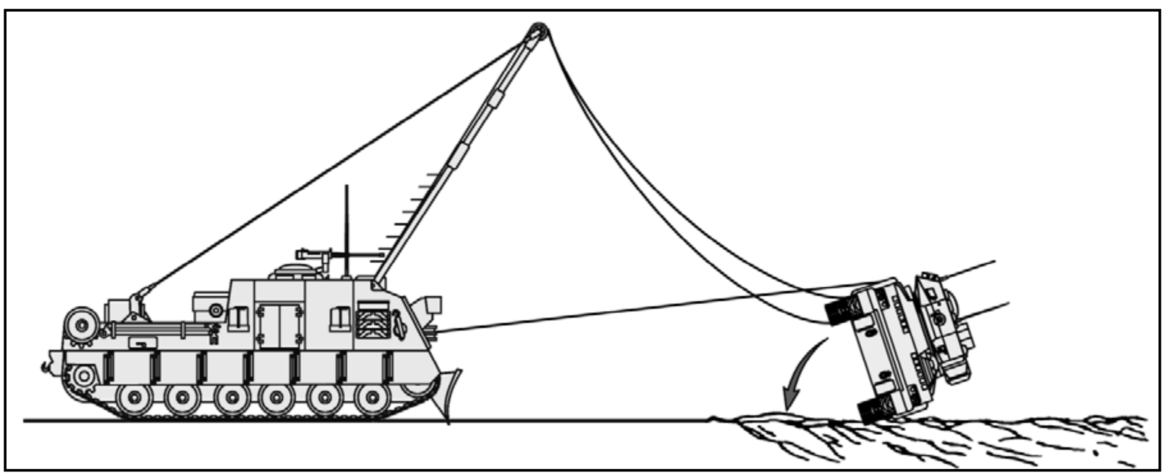


Figure 3-20. Recovery of overturned track vehicle

HOWITZER

3-72. When uprighting a howitzer, follow procedures similar to uprighting a wheeled vehicle.

- Attach the tow cable or chain to the lifting loops on the shoulder of the howitzer.
- Ensure a holdback vehicle is used to slowly lower the howitzer to the ground.

Note. If the prime mover is also overturned, disconnect the howitzer from the vehicle and upright the vehicle first. If the howitzer is positioned so the prime mover cannot be uprighted, upright the howitzer first.

FORKLIFTS

3-73. Forklifts can only be towed from the rear. Towing forklifts forward poses a serious overturn risk if the forks make contact with the ground and dig in. Refer to the equipment operator's manual for specific towing instructions. To upright an overturned or mired forklift, use the overturned vehicle recovery procedure or the mired-vehicle procedure.

ARMORED VEHICLE-LAUNCHED BRIDGE

3-74. When recovering the armored vehicle-launched bridge, the bridge has to be removed by another armored vehicle-launched bridge using a hydraulic slave procedure. (The bridge cannot be removed by the M88 hydraulic system because the couplings differ in design.) Once the armored vehicle-launched bridge is removed from the prime mover, refer to the operator's manual for towing and hookup procedures.

COMBAT ENGINEER VEHICLE

3-75. Make sure the road wheels are chocked before disconnecting the final drives. When a tow bar or cables are used, a second vehicle is required when descending a grade of 20 degrees or more. A second vehicle is also required when the road conditions dictate. A combat engineer vehicle should be towed only from the rear and only after the removal of the blade from the front of the vehicle.

MINE PLOW AND MINE ROLLER

3-76. Vehicles with mine plows and mine rollers attached cannot be towed from the front until the mine rollers or mine plows have been removed. These vehicles can be towed from the rear with the rollers in "full float" or "free float" mode provided the terrain and situation permit. Once it is determined how the vehicle will be towed, refer to the operator's manual for towing and hookup procedures.

CRANE, WHEEL-MOUNTED

3-77. This vehicle can be towed but information on road conditions and possible restrictions along the route must be obtained.

- Use a vehicle with an air brake system capable of producing 120 pounds per square inch in the system.
- Place the boom over the front; the most stable position for towing.
- If towing more than one-fourth of a mile, disconnect the propeller shafts from the front and rear axles.
- Caution must be used when turning and traveling through towns. For information on safely using cranes and similar equipment, refer to TB 385-101, *Safe Use of Cranes, Crane-Shovels, Draglines and Similar Equipment near Electric Power Lines*.

ROAD GRADER

3-78. When towing the road grader for distances greater than half a mile, maintenance personnel must remove the tandem drive chains. If the distance is less than half a mile, it is not necessary to remove the tandem drive chains, but the speed must be kept below 5 miles per hour. When maintenance personnel are not available to remove the tandem drive chains and the distance is more than half a mile, trailers must be used to recover the road grader.

SCOOP LOADER

3-79. This vehicle should not be pushed or towed. A flatbed trailer must move this vehicle. In the event of an emergency where the scoop loader must be towed, the maximum distance the loader may be towed or pushed is half a mile—at low speed not to exceed 5 miles per hour. Refer to the operator's manual.

M9 ARMORED COMBAT EARTHMOVER

3-80. The M9 armored combat earthmover must be towed from the rear and the final drives must be disconnected to prevent damage to the steering unit. When turning with the armored combat earthmover in tow, turn in a wide arc to prevent undue strain on the suspension of the disabled vehicle and tow bar. Make sure the disabled vehicle is in the SPRUNG position. Refer to the operator's manual for additional towing information.

NOSED TRACKED VEHICLE

3-81. Various factors must be considered before recovering a tracked vehicle nosed in a deep trench or ravine. If the terrain behind the nosed vehicle is level, recover by towing. If the terrain is not suitable for towing, perform a winching operation (figure 3-21) as follows:

- •Move the recovery vehicle to the opposite side of the trench or ravine (to the front of the nosed vehicle).
- Using the recovery vehicle's boom with its maximum MA rigging, attach its hoist block to the front lifting eyes on the nosed tank with a V-chain.

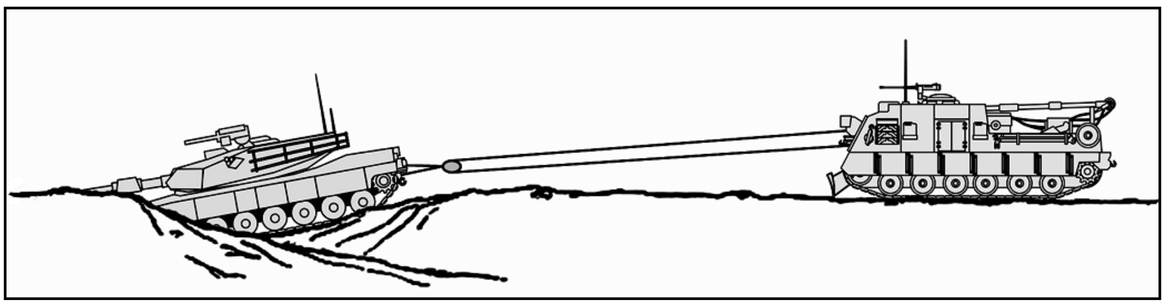


Figure 3-21. A recovery vehicle winching a nosed tracked vehicle

- Lift the vehicle to a horizontal position and pull it to the opposite side of the ditch where towing or winching can complete the recovery. (See figure 3-22 on page 3-24.)

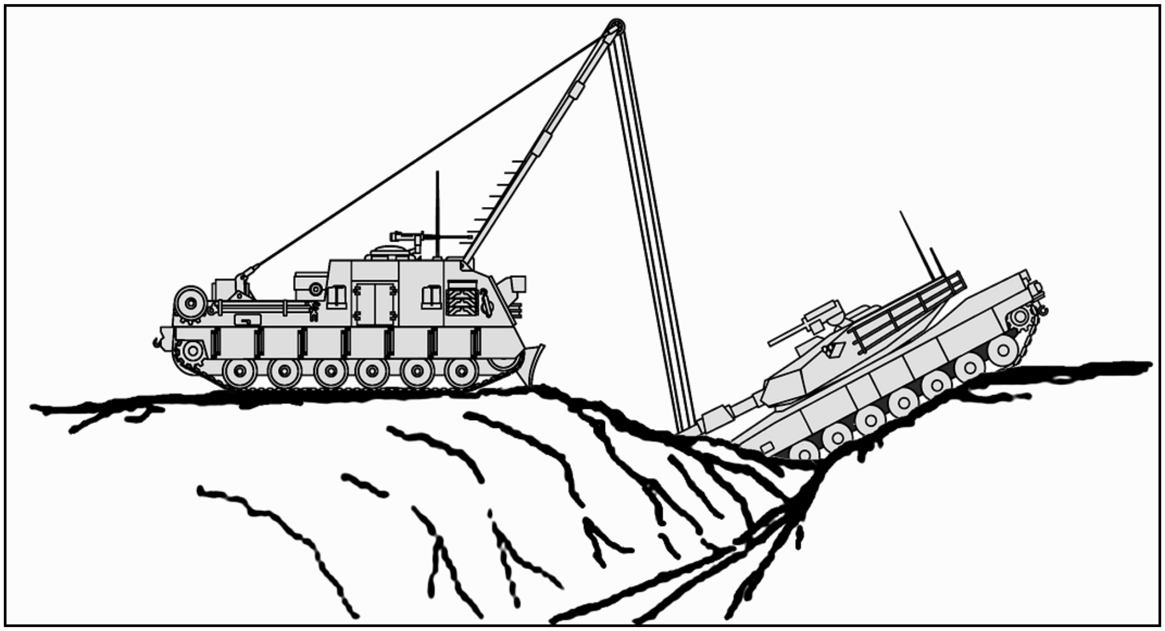


Figure 3-22. Lifting operation

Note. Nosed vehicles may be recovered by towing, winching, or lifting operations. If the tow hooks are accessible on the nosed vehicle, use rigging to attach them to the winch. Recover the nosed vehicle with a combination of winching and hoisting. Control the weight and movement of the disabled vehicle during the entire recovery operation by coordinating the hoist winch and the main winch.

SELF-RECOVERY AND LIKE-VEHICLE RECOVERY

3-82. . Drivers and crews should evaluate the situation and determine if they can safely self recover the vehicle with the available resources or using a like vehicle before calling on support from a higher level.

SOURCE OF EFFORT

3-83. The amount and type of equipment used as the source of effort during any recovery operation depends on the level of recovery. Drivers and crews should evaluate the situation and determine if the crew can recover the vehicle before calling on support from a higher level. During combat, it may be imperative that cargo reach its destination at a definite time, that the personnel or cargo be picked up at a given time, or that a combat vehicle be at a given place at a specific time.

3-84. Using like vehicles is usually the quickest method of recovery because they are readily available. Call for recovery support only when self-recovery or like-vehicle recovery techniques cannot support the recovery operation. A mired vehicle with no winch may be freed by using recovery expedient measures discussed previously.

3-85. Combat vehicles, which need fuel, ammunition, or repairs not related to mobility (for example, a fire control malfunction), can tow disabled vehicles to the refuel, rearm, or maintenance site. However, if combat vehicles are engaged in like-vehicle recovery, these vehicles are no longer available for combat operations.

3-86. Use like-wheeled vehicles as the source of effort to perform recovery by towing and winching. (For vehicles not equipped with lifting shackles, attach a tow chain to the main structural members.) Before towing or recovering a disabled vehicle, check the vehicle’s TM to ensure all physical and safety features are considered (for example, automatic transmissions, fail-safe braking systems, and articulation). This must be done so the disabled vehicle is not damaged further.

RECOVERING A MIRED TRUCK

3-87. To recover a mired truck by towing with a like vehicle, use a tow chain, cable, or bar between the towing vehicle and the mired vehicle.

- Attach a tow chain, cable, or bar to one lifting shackle (both, if possible) of the mired vehicle and the tow pintle on the towing vehicle. If a greater working distance is required to enable the towing vehicle to get better traction, use the towing chains or other device from both vehicles.
- Apply power slowly to prevent placing an impact load on the towing device and lifting shackles. Chains and cables are not designed to stretch and can be broken easily by impact loading. If one towing vehicle cannot attain sufficient towing effort to overcome the resistance, use another towing vehicle in tandem with the first vehicle. (See figure 3-23.)

WARNING

Rigging should include a chain or Y-sling attached to both lifting shackles whenever possible to minimize damage and create an even pull effort. The risk of tearing off lifting shackles, bending the rear cross member, or distorting the frame of a mired vehicle is even greater if a second vehicle is used in tandem.

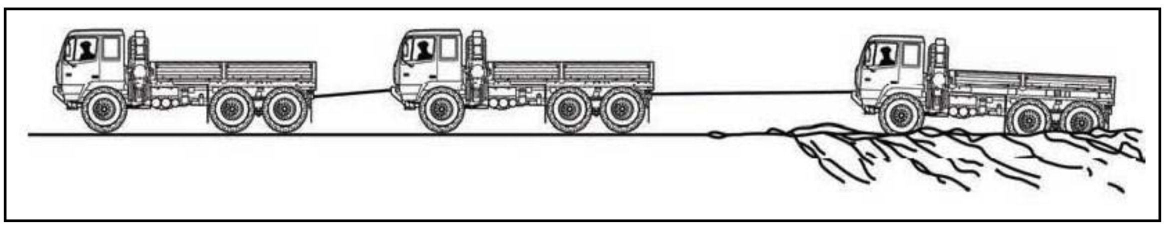


Figure 3-23. Recovering a mired cargo truck in tandem

PROPER HOOKUP WITH A LIKE VEHICLE

3-88. To recover a mired cargo truck, use a truck of an equal or heavier vehicle class as an anchor vehicle (figure 3-24). Use the winch (if equipped) mounted on the mired vehicle to perform the winching operation. A mired 2½-ton cargo truck may be winched with either a 2½-ton or a 5-ton vehicle only under emergency conditions and a snatch block must be used in the rigging. All winch-equipped trucks are authorized a single sheave snatch block and one tow chain for rigging.

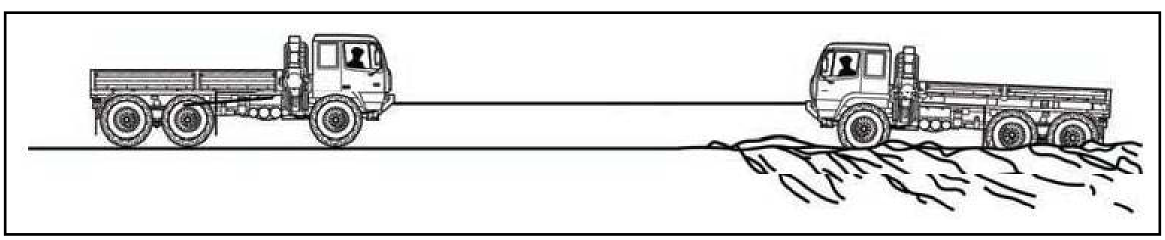


Figure 3-24. Winching with like or heavier class wheeled vehicle

3-89. Determine if the resistance of the mired truck is greater than the winch capacity. If it does not exceed the winch capability, MA is not required. Proceed as follows:

- Position the anchor vehicle in line with the mired vehicle so the correct fleet angle is obtained.
- Free-spool the winch cable from the drum.
- Attach a Y-sling or chain to both front lifting shackles of the anchor vehicle, and attach the winch cable clevis to the apex of the sling or the center of the chain. The angle of the Y-sling must be less than 30 degrees to reduce strain on the lifting shackles.

3-90. If MA is required, proceed as follows:

- Attach a snatch block to the center of the chain or apex of the Y-sling and the winch cable routed through the snatch block back to the mired vehicle.
- Place the loop formed in the winch cable in the snatch block.
- Apply power to the winch to remove the slack from the cable.

3-91. If the anchor vehicle must be anchored by more than just its weight, place wheel blocks, chocks, or natural material in front of the anchor vehicle's front wheels.

SELF-RECOVERY

3-92. A winch-equipped, mired vehicle can perform self-recovery using an anchor (figure 3-25). Attach the snatch block to a suitable anchor, and attach the free end of the cable to a chain sling connected to both of the mired vehicle's front lifting shackles. A fixed block can be used to gain MA when performing a self-winching operation.

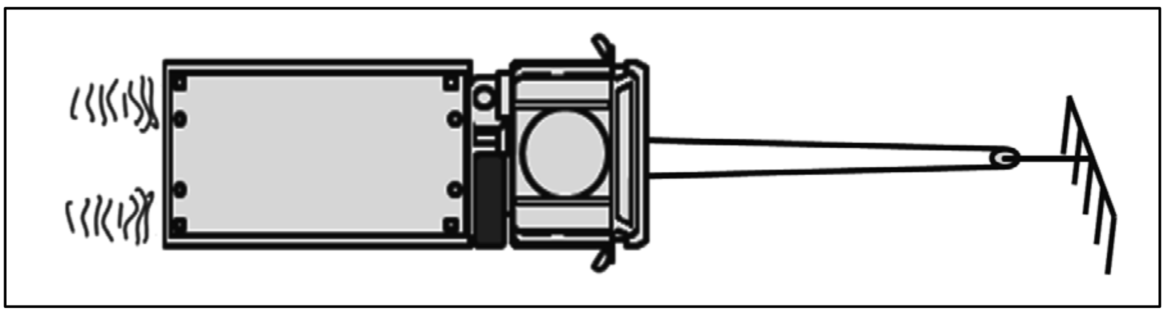


Figure 3-25. Self-recovery operation

USE OF LIKE-TYPE TRACKED VEHICLES FOR RECOVERY

3-93. The number of tracked vehicles required for a specific recovery depends on the resistance to be overcome, the type of disablement, and the terrain conditions. To rig for recovery, attach the tow cables to the tow hooks of both vehicles. All main battle tanks carry two tow cables. Light-tracked vehicles carry one tow cable.

3-94. When a vehicle with a main gun cannon tube is recovered or towed, rotate or elevate the gun tube. This prevents serious damage if the rigging fails or the towed vehicle rams the towing vehicle.

3-95. When using two tow cables between two vehicles, make sure the cables are crossed (figure 3-26). If a greater working distance between the pulling vehicle and the mired vehicle is required, join the tow cables together with tow hooks.

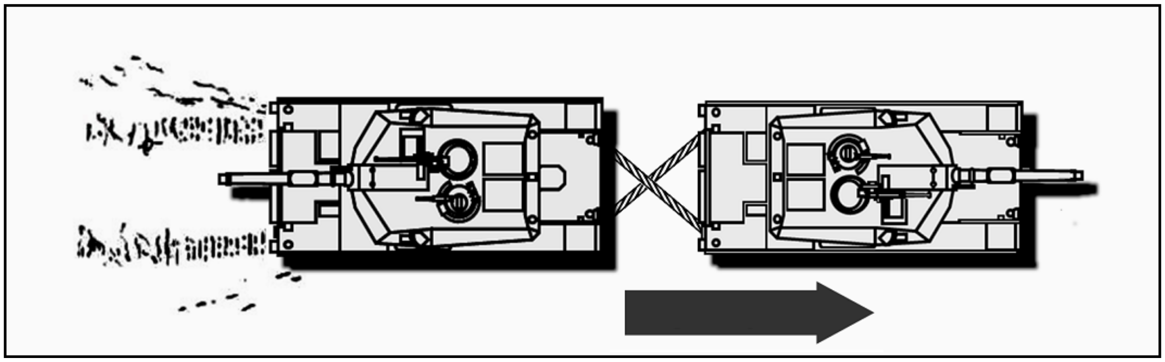


Figure 3-26. Recovery of a mired tank using one like vehicle

3-96. If two vehicles are required for an operation, one tow cable is enough because the strength of one tow cable is slightly greater than the pulling effort of the second pulling vehicle. However, use two tow cables, when available, to maintain alignment and equalize the pulling effort. When using two vehicles, turn the gun tube of the center vehicle to the side to prevent contact and possible damage.

RECOVERING A NOSED TRACKED VEHICLE WITH LIKE VEHICLES

3-97. As many as three like vehicles may be needed to recover a nosed-tracked vehicle (figure 3-27). This depends on the degree to which the vehicle is nosed and the terrain conditions on which the pulling vehicles must operate. In extreme instances, another resource may be required to lift the front of the nosed vehicle.

- Position the lifting vehicle to face the nosed vehicle.
- Connect the cables of the pulling vehicles in the same way as for recovering a mired vehicle.
- Apply power to all assisting vehicles at the same time. The front of the nosed vehicle will rise and move toward the rear.
- Slowly move the lifting vehicle forward.
- Support the vehicle until it is recovered.
- If any oil or fuel has spilled in the nosed vehicle, do not run the engine until the spill is cleaned.

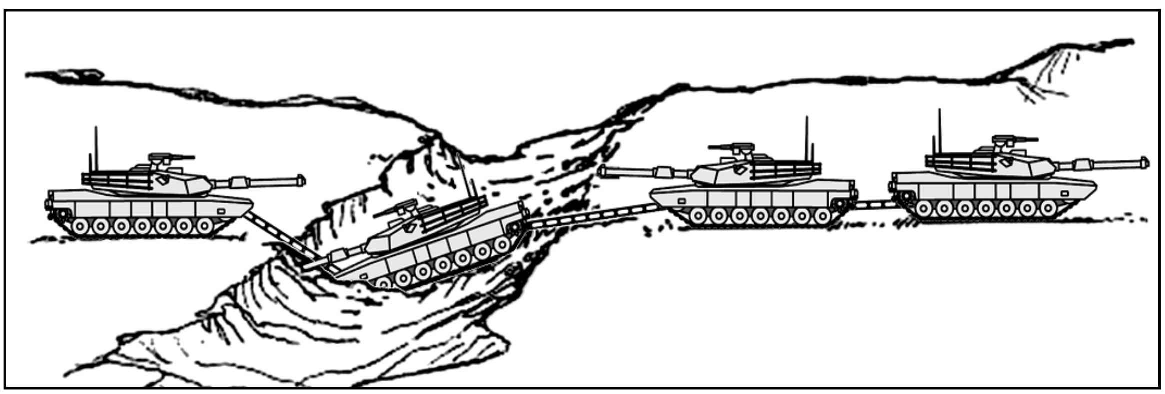


Figure 3-27. Recovering a nosed tracked vehicle with like vehicles

RECOVERING AN OVERTURNED TRACKED VEHICLE WITH LIKE VEHICLES

3-98. An overturned tracked vehicle can be uprighted by using three like vehicles (figure 3-28 on page 3-28). Use one vehicle to pull the overturned vehicle upright. Use the other two vehicles to hold and retard the fall of the overturned vehicle so it does not crash down on its suspension system.

- Connect tow cables together in pairs to allow a safe working distance.

- Connect the cable used to upright the overturned vehicle to the nearest center road-wheel arm support housing on the upper side of the overturned vehicle. Never connect to any other part of the suspension system, turret, or the tie-down eyes.
- Position the two vehicles used for holding at a 30-degree to 45-degree angle from the overturned tracked vehicle, with their cables connected to the tow hooks on the high side of the overturned vehicle. The holding vehicles must be positioned in this way to prevent damage to the cables, fenders, or lights of the overturned vehicle as it is uprighted.

3-99. Drivers of the holding vehicles must shift to low range. The pulling vehicle gradually applies power in reverse, while the holding vehicles move forward only enough to keep their cables taut until the overturned vehicle passes through the point of balance. As the overturned vehicle passes through the balance point, the holding vehicles move forward slowly, supporting the overturned vehicle and lowering it onto its suspension system.

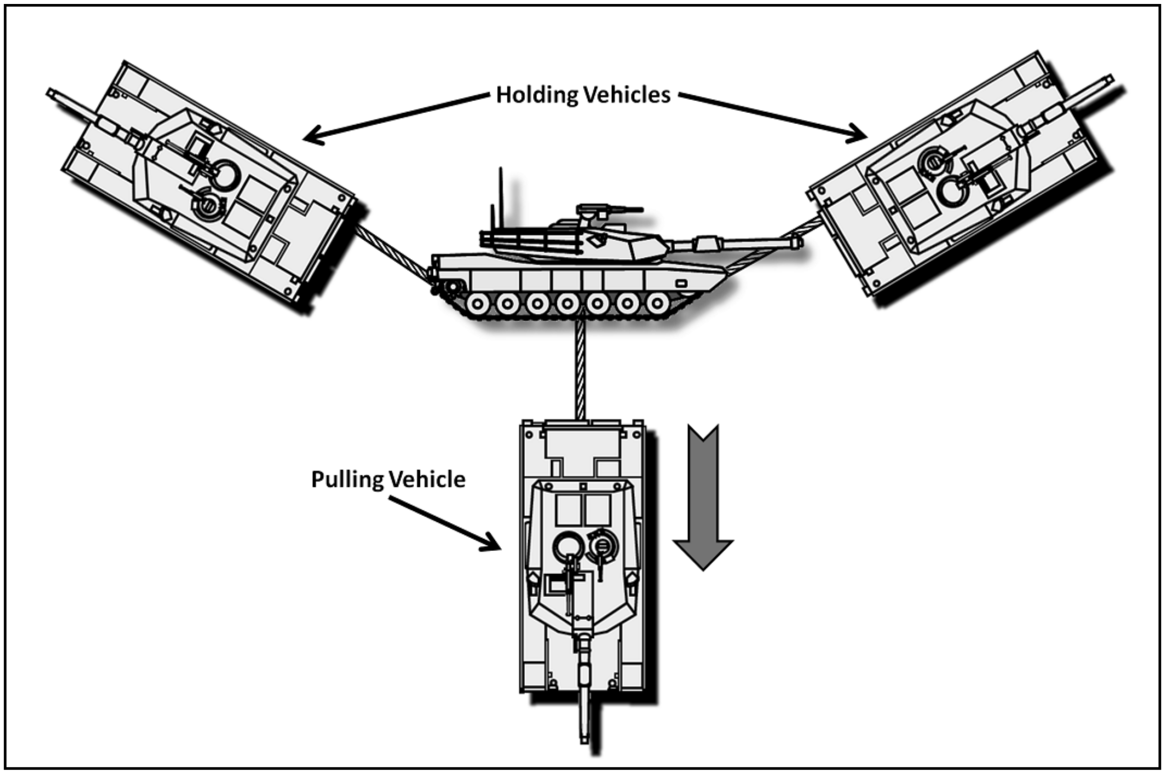


Figure 3-28. Recovering an overturned tracked vehicle with like vehicles

TOWING DISABLED TRACKED VEHICLES

3-100. Tow a disabled tracked vehicle with a like vehicle of the same weight class or heavier weight class with a tow bar or two tow cables (figure 3-29). When using a tow bar on vehicles lighter than the 70-ton class, no holdback vehicle is required, unless the terrain interferes. A holdback vehicle will be used when

- Tow cables are used.
- The towed vehicle is heavier than 70 tons.
- Terrain grades are more than 20 percent.

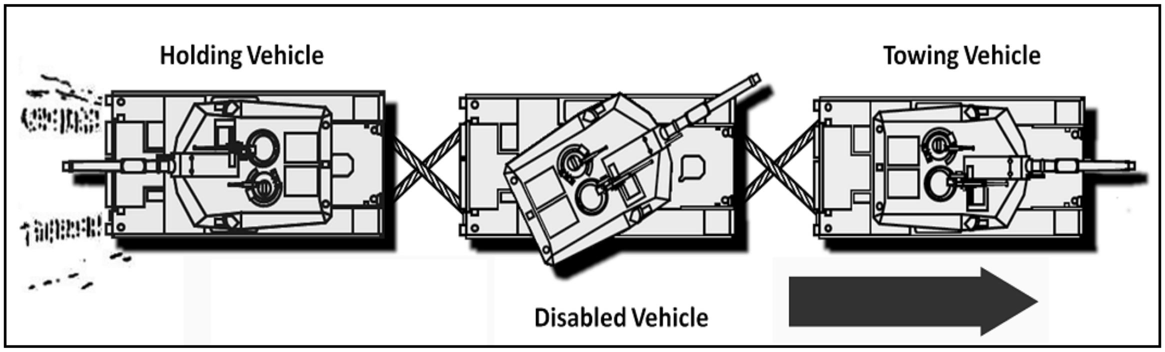


Figure 3-29. Towing a disabled tracked vehicle

3-101. Cross the tow cables to keep them from being tangled with the tracks. When towing tracked vehicles with only one track, there will be a difference in resistance and steering capability between a complete track on one side and road wheels on the other side. As a result, the towed vehicle will pull in the direction of the side lacking the track. Compensate for this pull by properly attaching the towing cables. Check the TM pertaining to the towed vehicle to determine the necessary preparations and precautions to be used to prevent further damage. Never exceed the towing speed stated in the TM.

3-102. If the disabled vehicle has defective brakes or its universal joints are disconnected, use another similar vehicle for holding (figure 3-30). Use crossed cables between the holding and disabled vehicles when available. With vehicles that are issued only one tow cable, the vehicles will be connected with crossed cables between the towing vehicle and the disabled vehicle. Connect a single tow cable between the disabled vehicle and the holding vehicle.

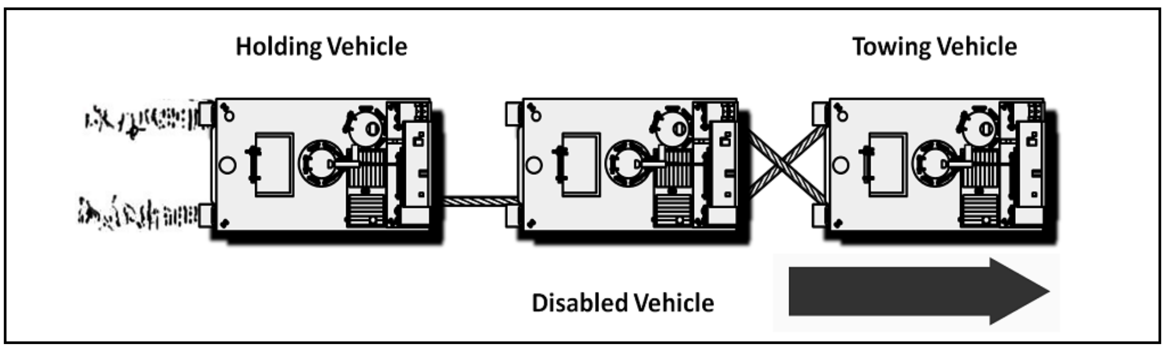


Figure 3-30. Towing with vehicles issued one tow cable

Note. Use crossed tow cables between the holding and disabled vehicles when enough cables are available.

MARINE RECOVERY

3-103. Many vehicles can now swim or ford. Some of these vehicles will fail while waterborne and will need recovery. Situations may be as simple as stalled, floating vehicles or as complex as submerged vehicles. The same methods of recovery apply to these situations but with a few unique considerations.

3-104. In the case of floating vehicles, swiftly moving current can carry the vehicle and crew downstream. Water safety must be stressed to both vehicle and recovery crews. Current and stream bottom conditions interact effectively to bury a vehicle, thereby increasing resistance. When operating on beaches or rivers with soft bottoms, time is critical. Recover the vehicle as quickly and safely as possible.

Fording Vehicle

3-105. Vehicles may become mired, nosed, and overturned during fording operations. As a result, estimate resistance in the same way by considering vehicle weight and type of disablement.

Swimming Vehicles

3-106. A mechanically disabled swimming vehicle offers little resistance while floating. Compared with its rolling resistance on land, it can be recovered with little effort. The same rigging is applied in floating vehicle recovery as in land recovery. The only exception is that the attachments are made to the lifting eyes instead of the tow lugs. This prevents the crew from having to work in the water. (See figure 3-31)

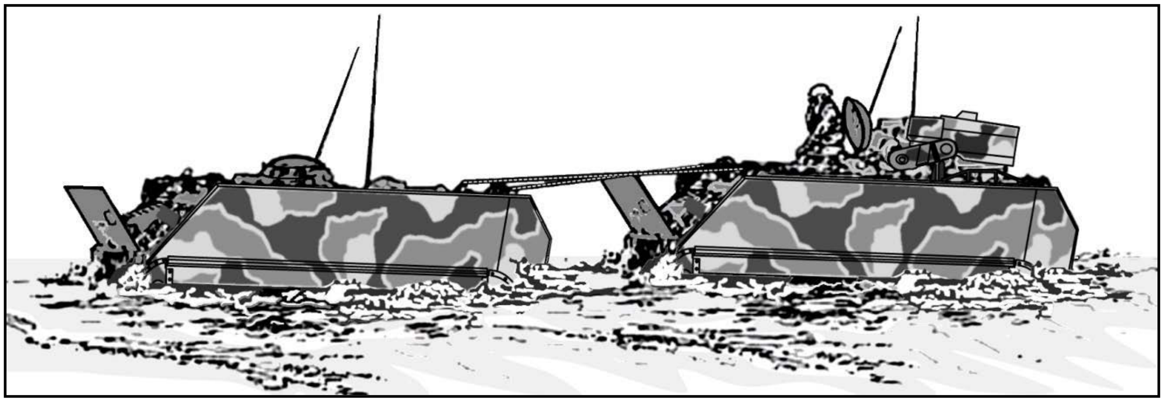


Figure 3-31. Marine recovery with tow hooks and ropes attached to lifting eyes

3-107. For example, if a like vehicle is used for this operation:

- Attach its tow hooks to the lifting eyes before entering the water.
- Cross the towropes and attach to the lifting eyes until the disabled vehicle is towed to shore. (Using cables will prevent the quick disconnect of the towing vehicle if the towed vehicle begins to submerge. The axe that must be with the rope is used to cut the rope in an emergency).
- Once the vehicle is close to the shore and the tow lugs are exposed, move the tow cables to the tow lugs on both vehicles to pull the disabled vehicle ashore. (See figure 3-32)

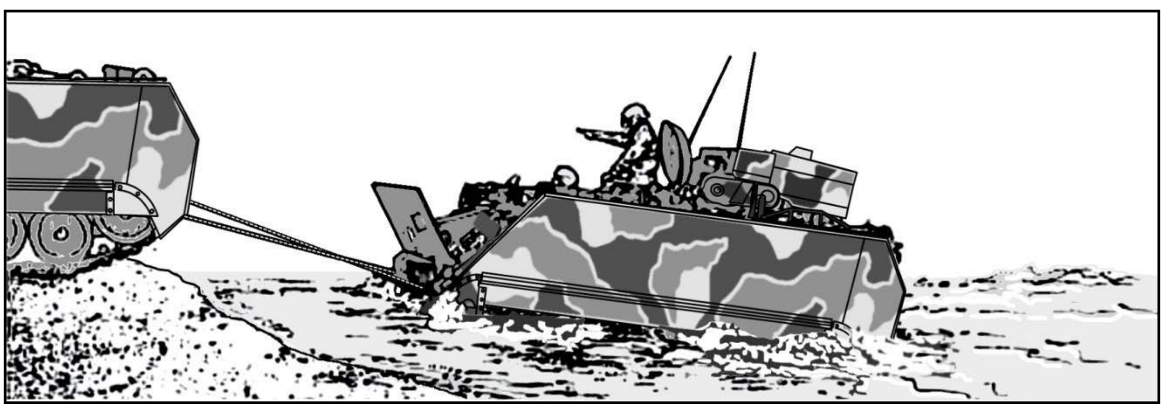


Figure 3-32. Recovery to shore with tow hooks and cables attached to tow lugs

Submerged Vehicles

3-108. If a vehicle is flooded and submerged, determine the resistance on the river bottom in the same way as on land. Consider the weight of the vehicle, the cargo, and the river bottom, which may be sand, gravel, or mud. In addition, when pulling flooded vehicles from water to land, consider the weight of the water when determining the resistance. Water weight is estimated to be equal to the vehicle's weight. For example, a tracked vehicle weighing 52,000 pounds sank. The vehicle is mired in the riverbed (mud) to fender depth. The effort required to retrieve it is 156,000 pounds (2 x 52,000 - pound mire factor + 52,000 - pound water weight).

3-109. The first problem in underwater recovery is locating the disabled vehicle in deep water. It may be easier to use dragging devices to locate the vehicle. Divers can then determine the location of the vehicle's rigging and mark the location of the vehicle using lines and floats. Special purpose vehicles, such as wrecker trucks and recovery vehicles are readily adaptable to recovery operations on submerged vehicles. In most situations, the winch cables of the recovery vehicles are long enough to allow winching operations from water to land.

WATER OPERATIONS

3-110. Most vehicles currently in the inventory of the U.S. military have either a swim or fording capability. Vehicles involved in fording, swimming operations sometimes become disabled from mechanical or mobility malfunctions. A vehicle that has swim capability will usually remain afloat even if the main engine fails. This is possible because amphibious vehicles are usually equipped with an auxiliary engine and bilge pumps.

3-111. If a vehicle is completely disabled during water operations, it must have power restored using BDAR or any other means available. Amphibious vehicles are at the mercy of the surf or river current when power is lost. If left afloat without power, vehicles are at risk of sinking, causing further damage to the vehicle and serious water contamination. If sinking does occur, all practicable efforts should be made to avoid environmental contamination. Contamination over 1 gallon should be reported through the chain of command. Should a vehicle become submerged (out of sight), qualified scuba personnel should be called to assist in locating and rigging the vehicle for recovery.

Resistance in Water

3-112. Water resistance occurs when submerged vehicles are pulled from water to land. Water resistance is estimated as additional resistance equal to the vehicle weight. Therefore, a vehicle weighing 25 tons (including cargo) would require 50 tons of effort to winch it from the water. In the same situation, resistance would increase if the vehicle went down in the surf and the sand was partially covering the vehicle. Vehicles completely submerged, even for a short period, will usually be in a mired condition from sand, if in the ocean, or mud, if in a river. If in doubt, rig for the greater resistance.

3-113. Whether the vehicle is upright or overturned will also be a factor in determining the total resistance. Again, qualified divers should be used to locate and rig a vehicle for recovery. They will also be able to recommend direction of recovery, depending on obstacles. Following are some examples of resistance encountered when recovering floating-type vehicles:

- Amphibious vehicle afloat, minimal – 1/64th of vehicle weight.
- Amphibious vehicles completely submerged – equal to the weight of the vehicle. If the vehicle is mired on a river or ocean bottom, calculate the additional resistance the same as for land mire.
- Amphibious vehicles completely submerged and filled with water, the submerged vehicle weight is the vehicle weight times two.

3-114. Fording-type vehicles that have become disabled must also be considered for weight of water but only an additional 1/8th of the vehicle weight; that is, a 70-ton tank would be calculated to weigh approximately 79 tons plus any mire encountered. The mire factor in this case is figured using 79 tons.

3-115. During underwater recovery operations, air bags can be placed inside the submerged vehicle and inflated to provide buoyancy and decrease resistance. To employ air bags in this type of situation, qualified divers are recommended. The air bags or 55-gallon drums need to be placed inside the vehicle in a location where they will not escape the vehicle or cause additional damage. Once the air bags are in position, inflate to the recommended capacity.

Methods Of Rigging

3-116. The rigging methods for underwater recovery are normally restricted to the manpower and/or lead methods. Towing from water is recommended only if the disabled vehicle is located in very shallow water. The method of rigging depends on the distance from the disabled vehicle; the type of disabled vehicle; the type of recovery vehicle available; the equipment available (floats, air bags, tackle); and the condition of the disabled vehicle.

Lead Method

3-117. The lead method of rigging is performed the same in water as on land. If in deep water, a boat or an amphibious vehicle can transport tackle to the disabled vehicle. If the water is shallow, the tackle can be manually carried to the disabled vehicle.

Manpower Method

3-118. The manpower method is much the same regardless of whether on water or land. However, flotation devices can be attached to the cable every few feet or to snatch blocks and other tackle to aid in getting the recovery equipment to the disabled vehicle.

Note. Underwater recovery is usually limited to the manpower or lead methods.

EXPEDIENT RECOVERY TECHNIQUES

3-119. An expedient measure is any method by which a task is done using on-hand materials. For example, vehicles may be required to operate in remote areas where assistance in recovery operations is not readily available. Under these conditions, the operator or crew must attempt self-recovery by using methods similar to those described previously in this manual.

PRY BAR

3-120. A pole can be used to pry a lightweight truck out of a ditch by:

- Using the pole to lift the front end of the truck.
- Applying power to the truck while in reverse gear.

SUBSTITUTE JACKS TO REMOVE FRONT AND REAR WHEELS

3-121. To raise the front wheel of a cargo truck:

- Locate a timber (approximately 5 feet long) to use as a pry bar.
- Place the bottom of the timber in a shallow hole.
- Secure the timber to the front bumper at an angle with a chain or rope.
- Move the vehicle forward until the timber is in a vertical position and the wheel clears the ground.
- Set the brakes and chock the wheels.

WARNING

This method cannot be used with vehicles with aluminum front bumpers, such as the USMC MK-23. If this method is used, it will damage the front end of the vehicle and possibly cause injury to personnel.

3-122. When an outside rear dual tire is flat and a jack is not available, run the inside dual wheel up on a small log or rock. This takes the weight from the outside wheel, which can then be removed for replacement.

3-123. Another substitute jack is a piece of timber longer than the distance from the axle to the ground. (See figure 3-33.)

- Place one end of the timber against the axle at an angle and the other end in a shallow hole.
- Drive the vehicle forward against the angled timber, which will cause the timber to stand straight and lift the axle off the ground.
- Set the brakes and block the vehicle securely.

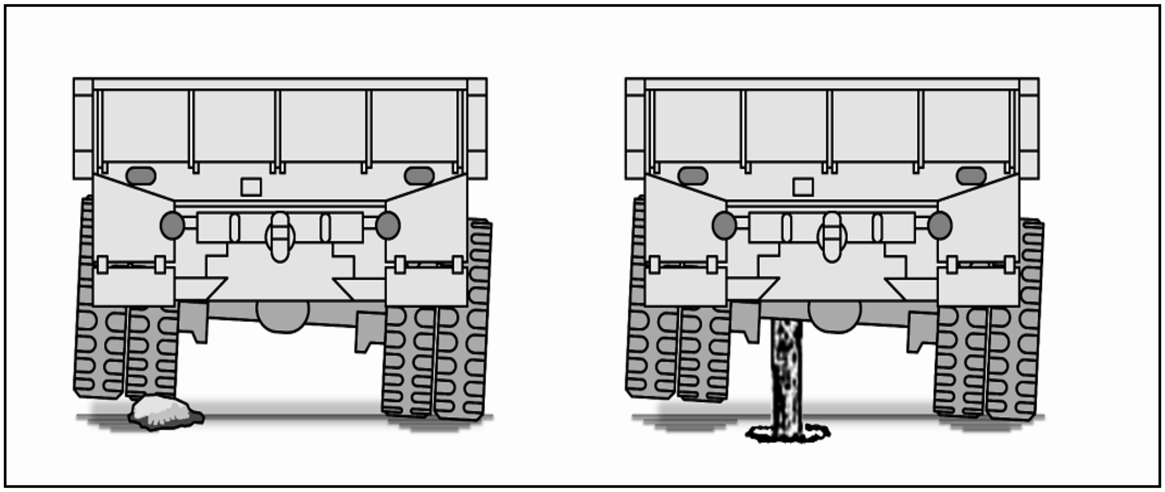


Figure 3-33. Substitute jack (rear or tandem wheels)

USING AN A-FRAME

3-124. Frequently, a truck will become nosed in a shallow hole, narrow ditch, or munitions crater where both lifting and pulling forces are required to make the recovery. If the nosed wheeled vehicle is equipped with a winch, use the winch to supply the pulling force and an A-frame for the lifting force.

> **CAUTION**
>
> This method cannot be used on vehicles with aluminum front bumpers such as the Marine Corps MK-23 series trucks.

3-125. To build an A-frame, use two long poles.

- Lash the poles together at the top using a figure eight or girth hitch.
- Place the lower end of the poles in the ground 10 to 12 inches deep to prevent them from sliding when power is applied.
- Lay the upper end of the A-frame against the front of the vehicle. Attach the A-frame to the vehicle.

3-126. A nosed wheeled vehicle's winch and an A-frame can supply the lifting and pulling forces needed to recover the vehicle.

- Rig the winch cable for a 2-to-1 MA.
- Secure the end of the cable to the apex of the A-frame. As the winch is wound in, the A-frame lifts and pulls the truck forward.
- Suspend the truck over the ditch or hole.

- Fill the ditch with rocks, dirt, or other material so the vehicle can be driven forward or backward.

CAUTION

Do not wrap chains around the bumper or vehicle frame. Attach chains to the vehicle by lifting shackles only.

REMOBILIZING TRACKED VEHICLES

3-127. Vehicles often become bellied (high-centered) on stumps, rocks, dry ridges, or mire. When this occurs, they become immobilized due to lack of traction.

ANCHORING TRACKS

3-128. To recover a bellied vehicle, obtain a log long enough to span the width of the vehicle and of sufficient diameter to support the vehicle weight (figure 3-34).

- Place the log against both tracks.
- Place a tow cable so that one end of the cable goes under the log and through the tracks from the inside.
- Place the other end of the tow cable underneath the log and connect the ends of the cable together with a tow hook on the outside of the track to make disconnecting easier.

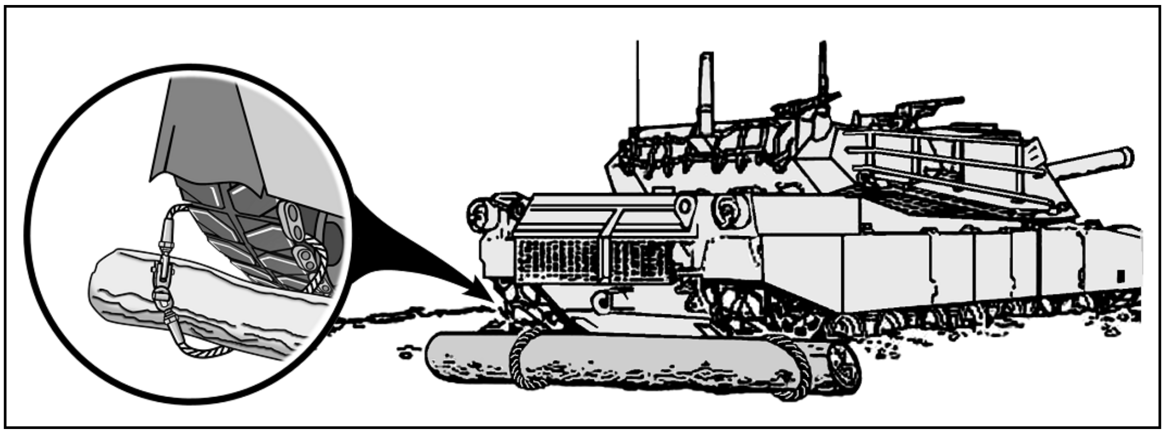


Figure 3-34. A log used to anchor tracks

3-129. Follow the same procedure to attach the log to the track on the opposite side of the vehicle. Take up the slack in the tow cable by gradually applying power to the tracks. This pulls the log underneath the tracks until it comes into contact with the obstacle, thereby anchoring the tracks and causing the vehicle to move.

CAUTION

To prevent damage to the fenders and tow cables, stop the vehicle before the log reaches the fenders or the cable reaches the drive sprocket.

3-130. For a bellied disablement (other than mire), anchor the tracks by using two tow cables (figure 3-35). Connect the tow cables together with a tow hook and attach the cables to both tracks by passing the ends of the cables through the tracks from the outside and attaching them to the standing parts of the cables with tow hooks. When power is applied to the tracks, the cable will contact the obstacle and anchor the tracks.

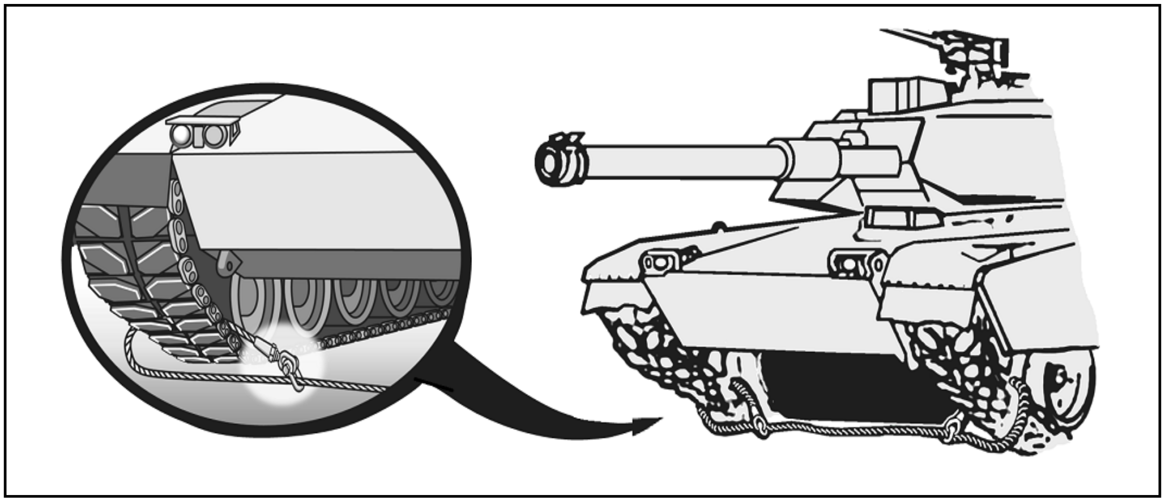


Figure 3-35. Cables used to anchor tracks

Moving a Vehicle With Both Tracks Broken

3-131. When both tracks are thrown, they may need to be separated before the vehicle can be moved to remount the tracks (figure 3-36).

- Break one track and attach a cable from the drive sprocket hub to an anchor. This will support the vehicle so that the other track can be separated.
- Chock the vehicle to keep it from rolling out of control.
- Apply engine and steering power to the drive sprocket attached to the cable. When this is done, the vehicle will move by the winching action of the drive sprocket hub.

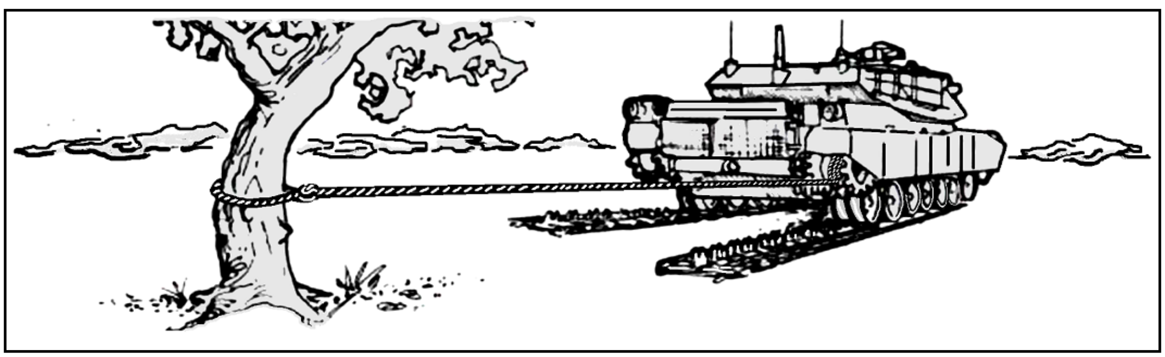


Figure 3-36. Moving a vehicle with both tracks broken

Moving a Vehicle Onto a Track

3-132. Align the vehicle with the track and position a plank-type ramp on the end of the track (figure 3-37 on page 3-36). When a ramp is not available, dig a shallow ditch where the end of the track can lie.

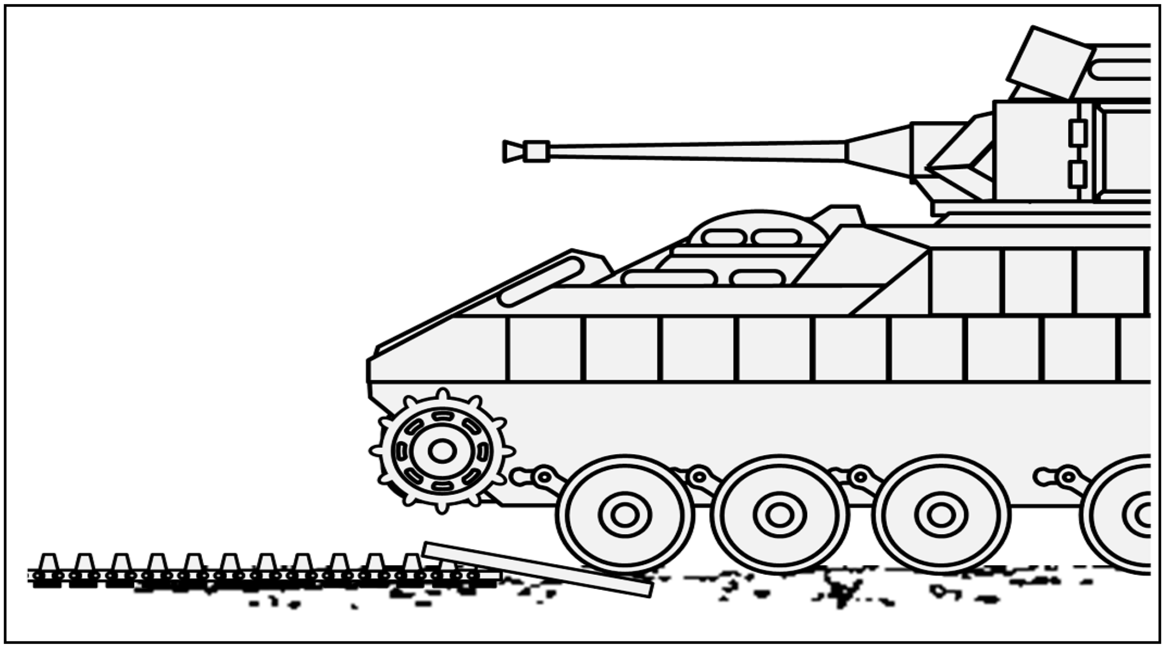


Figure 3-37. Moving a vehicle onto a track

INSTALLING A TRACK

3-133. To install a track

- Align the track with the road wheels so that the center guide(s) will pass between the road wheels when the vehicle is moved (figure 3-38).
- Stop the vehicle when the rear road wheel is resting forward far enough for the entire track to pass over the sprocket.

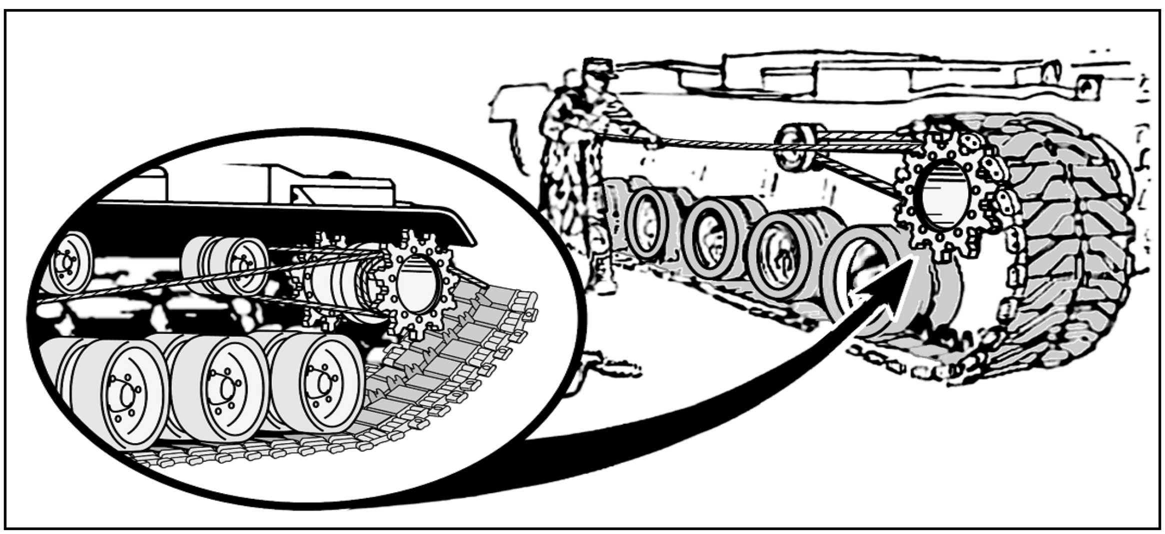


Figure 3-38. Installing a track

- Tie a rope to the center of the track pin on the rear track link.
- Pass the rope over the center guide groove of the sprocket hub, around and between the rear support roller wheels, and back around the sprocket hub, making two turns.

3-134. As power is applied to the sprocket, and the free end of the rope is held taut, the end of the track is pulled up to the sprocket. Once the sprocket has engaged a minimum of three track links

- Stop the sprocket, lock the brakes, and shut off the vehicle engine.
- Remove the rope from the sprocket hub and extend it forward over the compensating idler wheel.
- Restart the vehicle and move forward.
- When the end of the track has passed over the compensating idler, connect the track.

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Chapter 4

Battle Damage Assessment and Repair

The purpose of BDAR is to rapidly return disabled equipment to operational condition in wartime by expediently repairing, bypassing, and restoring minimum function to essential systems. These improvised repair procedures are used at the operator/crew and maintenance levels to restore a vehicle to limited or full capabilities. This chapter outlines BDAR techniques and considerations. Army Regulation (AR) 750-1 is the regulatory guidance for BDAR.

BDAR INTRODUCTION

4-1. BDAR procedures apply to field maintenance procedures only and depend on operational variables, the extent of damage, time allowances, and available personnel with required skills, availability of parts, tools, and materials. Personnel performing BDAR must act quickly to restore the vehicle to the combat-ready condition required to continue the mission or allow the vehicle to self-recover. BDAR procedures are non standard maintenance practices. Whenever possible standard maintenance should always be considered over BDAR.

4-2. To be effective, personnel applying BDAR techniques should:

- Ensure standard maintenance practice is always the first consideration.
- Base decisions of using BDAR versus standard maintenance on the operational environment and situation.
- Provide an accurate assessment.
- Ensure economy of maintenance effort (use maintenance personnel only when necessary).
- Train multifunctional skills.
- Repair only what is necessary to regain combat capability.
- Remain flexible about repair priorities.

4-3. Commanders should address the use of BDAR in the logistics section of their operation order. This will provide the crews and maintainers with a clear understanding of when and at what risk level they are authorized to perform BDAR. Local command policy will direct the degree of BDAR to apply and when to use standard maintenance.

4-4. Maintenance assets will be heavily taxed on the battlefield. Because resources are limited (personnel, tools, and parts), it is imperative that maintenance resources are not wasted. Crewmembers must do repairs within their capabilities immediately rather than requesting maintenance personnel to do simple mechanical tasks.

4-5. Personnel shortages and battlefield casualties mandate that maintenance team members have some knowledge of other skills needed to achieve critical repairs. A lack of key repairmen must not deter a team from doing repairs. Whenever possible, on-the-job training or cross-training of personnel should be done.

4-6. On the battlefield, the objective is to return the system to an operational condition with enough combat capability to get the mission accomplished. Cosmetic repairs are not necessary and are a poor use of time and resources. If a broken component does not affect the ability to shoot, move, or communicate, and does not pose a serious safety concern, it should not be repaired until the equipment is returned to maintenance where standard repair procedures can be performed.

BDAR DEFINITIONS

4-7. BDAR is a set of simple, expedient repairs that can be rapidly implemented on disabled equipment to return it to an operational condition in wartime by expediently repairing, bypassing, and restoring minimum function to essential systems with minimal resources used.

Short Cuts

4-8. Shortcuts are inherent to BDAR. When the removal, installation and repair of components are not performed in sequence or to standard as outlined in the technical manuals, they are considered shortcuts.

Bypassing

4-9. Bypassing consists of eliminating a device or component from the system in which it plays a role. For example, a damaged fuel filter can be bypassed allowing the fuel system to function in a degraded mode. In this situation the fuel will not be filtered which could lead to clogged fuel system components at a later time but allow the weapon system to continue the immediate mission. Another example, is when an electrical switch is damaged it can be eliminated from the circuit by connecting the wires together to bypass the switch. In this case the circuit will remain active and may deplete battery power when the vehicle is not in use. Before attempting to bypass any component an assessment of the repair must conducted to determine the risks associated with the procedure.

Expedient Repairs

4-10. Expedient repairs are temporary in nature and more reliable repairs should be performed as soon as possible. Examples of expedient repairs include using safety wire to temporarily replace a broken exhaust hanger; using duct tape or bungee cords to secure a partially detached fender or section of slat armor.

Fabrication

4-11. Fabrication involves using readily available materials and fashioning them by bending, cutting or welding them in the place of a damaged component. Examples include fabricating a radiator overflow reservoir using a suitable plastic container to temporarily replace the damaged overflow tank. A broken suspension tie rod can be temporarily repaired by welding metal stock or pipe to the damaged unit.

Substitution

4-12. In some instances repair parts serving a non critical function on the vehicle can be used to replace a critical component on the same equipment. As an example, a bad circuit breaker for the engine starter can be replaced with a good breaker controlling internal lighting. This type of substitution can be used to quickly restore function to the starting circuit. Substitution can be done to replace a bad starter. These substitutions may require some modifications for the application to work and additional time to prepare.

Controlled Exchange

4-13. Battle damaged and inoperable equipment classified as economically reparable are often used for controlled exchange when the needed part or component is not readily available through normal supply channels with the commander’s authorization per AR 750-1. This simply means that any part removed to repair mission essential equipment must be replaced with the unserviceable part from that equipment. Any part or component acquired through controlled exchange must be reported through the supply system to generate a parts demand. Regardless of the source used to acquire the repair parts, recorded demands establish proper stockage demand levels in the supply system.

Cannibalization

4-14. Shortages of repair parts and spares to maintain equipment during wartime establishes the need for alternate parts sources. Equipment that is extensively damaged and is not economically repairable is usually designated as salvage. In spite of the damage, many serviceable parts and components can be found.

Cannibalizing destroyed equipment whether friendly or captured provides an alternate source of repair parts. The Guidance for establishing and operating cannibalization points is outlined in AR 710-2, *Supply Policy below the National Level,* and ATP 4-33, *Maintenance Operations*.

4-15. Unlike controlled exchange, a serviceable part acquired through cannibalization from a salvage piece of equipment does not require an unserviceable part to replace the one removed. However, all repair parts needed to repair any piece of equipment should be recorded to establish a parts demand through the supply system regardless of how the part was acquired. Documenting all repair part demands ensures the supply system will maintain needed items on hand.

4-16. The term fully mission-capable refers to systems and equipment that are safe and have all mission-essential subsystems installed and operating as designated by applicable Army regulation. A fully mission-capable vehicle or system has no faults that are listed in the “not fully mission-capable ready if” columns of the TM XX–10 and XX–20 series preventative maintenance checks and services tables and AR 385–10 provisions that apply to the vehicle and/or system or its sub-system required by AR 700–138. The equipment must perform all tactical and combat missions safely and without endangering the life of the operator or the crew (AR 750-1). BDAR expedient repairs may bring a weapon system to a fully mission-capable status.

Not-Mission Capable

4-17. The term not-mission capable means the damage to the equipment or failure of components rendered it inoperable (NOT READY/AVAILABLE) and expedient repair procedures will not restore the equipment to combat capable or combat emergency capable status (wartime only) requiring the application of standard maintenance and/or repair parts.

BATTLE DAMAGE ASSESSMENT

4-18. The first and most important phase of BDAR is battle damage assessment. A quick and accurate assessment is critical in determining the extent of the damage and what is needed to make expedient repairs or to recover the equipment. A poor battle damage assessment can result in overlooked secondary damage or unnecessarily result in equipment recovery. Battle damage assessment must take place at the site of the breakdown. An accurate battle damage assessment determines the extent of primary damage and secondary damage to the subsystems and components including the type of repair and the risks involved. The assessment should also include an estimate of required personnel, time and materials required to perform expedient repairs.

4-19. Performing battle damage assessment on several pieces of damaged equipment should be accomplished using the “equipment triage” concept. This concept establishes the order in which battle damaged equipment will be repaired and whether spare parts acquisition through controlled substitution or cannibalization will be required. Major weapons systems should have top priority for repairs unless the immediate mission dictates otherwise.

BASIC RULES OF ASSESSMENT

4-20. Always consider the safety of the crew and personnel performing BDAR on a piece of equipment. The following safety checks are performed to identify any obvious hazards.

- Is there a round of ammunition in the gun tube?
- Is any ammunition in a critical state due to shock, fire, or physical damage?
- Have any combustibles such as fuel, hydraulic fluid, or oil accumulated?
- Does wiring appear to be safe? Could an arc occur to stored ammunition or leaking combustibles?
- Is the fire extinguishing system operational? If not, station a crewmember in the vehicle, prepared either to use a handheld fire extinguisher or to operate the onboard fire extinguishing system manually. Station a second crewmember outside the vehicle with an additional fire extinguisher.

- For systems with built-in self-test procedures, has a functional/operator test been performed on those systems that appear undamaged?

4-21. Abandoned equipment, or equipment left unsupervised by friendly forces may have been booby trapped. Booby traps and improvised explosive devices present unique challenges when conducting damage assessments or recovery of abandoned vehicles. To ensure the safety of individuals during BDAR/recovery operations, carefully inspect equipment for evidence of tampering before attempting to perform repairs or move the equipment. Explosive ordnance disposal must be requested to render safe any identifiable improvised explosive device or booby trap.

4-22. Unexploded ordnance in the immediate area, on top, or inside the equipment should not be disturbed. EOD personnel must be contacted to dispose of the ordnance prior to BDAR or recovery operations.

4-23. If chemical, biological, radiological, and nuclear (CBRN) weapons were deployed in the area or transported on the damaged equipment, adopt the proper protection and check the area for contamination. The equipment must be decontaminated at designated decontamination sites prior to evacuation to the maintenance collection point.

4-24. Depleted uranium is found in several munitions and vehicle armor panels. Although depleted uranium poses a greater risk as a heavy metal poison than radiation poison, recognizing the hazard and adopting depleted uranium contamination reduction practices are extremely important. Placing a piece of cloth over the nose and mouth, covering any open wounds and good personal hygiene are sufficient measures to reduce particle ingestion and absorption. A radiac meter must be used to determine if depleted uranium is present in damaged ammunition or vehicle armor panels.

4-25. In the forward battle area an attempt should be made to move the damaged equipment to a covered or concealed position away from enemy fire. The distance to be moved will be determined based upon the current tactical situation. Be aware of loaded weapons, damaged ammunition, and damaged wiring which pose a safety hazard during battle damage assessment.

4-26. Familiarization with the operation of damaged equipment is extremely important to prevent further damage to the equipment or injury to personnel. During battle damage assessment and functional checks, only experienced individuals will operate the systems. The following battle damage assessment steps should always be considered for all damage assessments:

BATTLE DAMAGE INDICATORS

4-27. Battle damage indicators play an important role in battle damage assessment. Damage can occur as the result of enemy contact, accidents or mechanical failures. During an incident it may not be possible to focus on what just happened. However, immediate recognition and attention by operators/crewmembers is important because some battle damage indicators may not be apparent once the equipment stops functioning. For example, if the operator notices engine oil pressure dropping rapidly due to a perforated oil pan, the operator can pull over and turn the engine off before it seizes due to lack of lubrication. The oil pan when accessible can be expediently repaired and the crankcase refilled. This action will return the asset to operational status instead of requiring recovery and replacement of the engine.

4-28. Battle damage indicators include smoke, fire, unusual odors, unusual mechanical noise, leaking fluids, warming lights and alarms, and loss of mobility or system function. Most fluids have distinct colors and odors. Familiarization with the characteristic of each type of fluid is extremely important for quick identification of which system is damaged. Other battle damage indicators include loss of power, system function, control, or degraded system performance.

PERFORM AN ASSESSMENT

4-29. The senior Soldier present decides when and if BDAR is performed during combat. This decision is based on analysis of current operational variables and the appropriate risk repair level.

4-30. Do not attempt to operate systems or subsystems until the crew has performed an assessment to prevent further damage to equipment or personnel. For example, if all circuit breakers are tripped, including the main circuit breaker, the assessment process should lead to determining the best method or sequence required to restore power to the vehicle. This could be done by initially resetting the main circuit breaker followed by resetting the remaining circuit breakers one at a time. In the forward battle area, the crew must attempt to move the vehicle to a covered or concealed position to prevent additional damage. The best technique is to move the vehicle at least one terrain feature or one kilometer away from enemy contact.

4-31. If the vehicle is not self-recoverable, use any like or heavier class vehicle to recover the vehicle or to conceal it. If this is not possible, turn the turret (if the vehicle is equipped) in the direction of engaging fire to limit damage and provide return fire capability.

4-32. To enable a systematic assessment, crews and maintenance personnel should use the 11 basic steps to battle damage assessment. The 11 basic steps in this manual include:

- Visually inspect interior and exterior for damaged parts and systems.
- Visually determine if vehicle main systems appear to be operable.
- Perform equipment self-test function–using a built-in test, built-in test equipment, and a function test.
- Assess system performance (exercise each system if engine can be safely started).
- Determine which subsystems are affected.
- Determine if crewmembers can repair the damage. (Are there enough crewmembers with the required skills available? And does the current tactical situation allow repairs at the current location?).
- Estimate the repair time (by crew and by a maintenance team).
- Estimate the number and type of repair personnel needed and the associated risk. Ensure command approval to perform repairs.
- Determine what materials are required.
- Determine what the vehicle limitations will be after repairing using BDAR or standard repair.
- Determine the recovery status, self/like/dedicated.

4-33. Based on the current tactical situation and mission variables , the maintenance team uses the assessment check information to:

- Determine if the current risk repair level assigned is appropriate for the required repairs.
- Conduct tests with maintenance test equipment, if required.
- Perform additional vehicle operational tests, if necessary.
- Determine what must be repaired or replaced.
- Estimate repair times for each repair task.
- Determine the sequence and priority of the repair action.
- Determine the repair location and, if other than on-site, arrange for recovery of the vehicle to the repair site.

BATTLE DAMAGE ASSESSMENT GUIDELINES

4-34. This section gives guidelines for battle damage assessment. Use these guidelines to rapidly assess battle-damaged equipment and systematically determine which subsystems are affected, to include the time, personnel, and materials required for repair.

4-35. These guidelines will also assist in performing "equipment triage." Equipment triage is the process used to decide the order that battle-damaged equipment will receive repairs. This determination is based on combat or combat support equipment, time, urgency, materials, and personnel required to do the required repairs.

4-36. Units can develop locally produced forms or checklists that best support authorized equipment and unit maintenance structure, and list personnel authorized by the command to approve BDAR actions based on the battle damage assessment. Consider the following guidelines (table 4-1 on page 4-6) when assessing battle damage. These guidelines can be tailored to fit your specific vehicle.

Table 4-1. Battle damage assessment guideline sample check list

Chapter 5System Assessment Summary Determine vehicle status Can the vehicle shoot, move, and communicate? Can the vehicle be repaired to shoot, move, and communicate? Can the vehicle be self-recovered, towed, or transported? Check engine, transmission, fuel system, electrical system, wheels and suspension, hydraulic system, armor/ammunition storage, armament/fire control, and communications to see if they can be repaired or recovered and identify any limitations. Identify expendables, parts, and tools and national stock number if applicable. Estimate the time and personnel needed.
Chapter 6Hull Damage Assessment and Repair Record applicable national stock number for exchanged and cannibalized parts. Check engine system, for example, starter, oil tank, air induction system, air cleaner, oil filter, drain valve, accessory drive, shaft, low oil pressure. Check transmission and final drive systems for faults, for example, transmission will not shift, broken linkage, vehicle will not steer, final drive locked, transmission leaks, parking and service brake serviceability, and oil cooler. Check fuel systems, for example, fuel tanks, fuel lines, fuel filters, fuel pumps. Check electrical systems, for example, wiring harness, slip ring, batteries, circuit breakers and power distribution box. Check track and suspension systems, for example, compensating idlers, track adjusting link, road wheel arms, road wheels, support rollers, sprockets, shock absorbers, torsion bars, and track assembly. Check hydraulic systems lines and fluids, driver controls, and instruments.
Chapter 7Communications Damage Assessment and Repair Record applicable national stock number for exchanged and cannibalized parts. Check serviceability of intercommunications, receiver, transmitter, antennas, cables, and security.
Chapter 8Turret Damage Assessment and Repair Record applicable national stock number for exchanged and cannibalized parts. Check electrical system: turret power, slip ring, circuit breaker, and wiring harness. Check armament: bore evacuator, gun tube, breech group, and main gun mount. Check fire control system: commander control handle and weapon sight, gunner primary and auxiliary sight, range finder, crosswind sensor, wiring system, gunner control handle, stabilization system, manual traverse and elevation, and loader’s panel. Check hydraulic system: auxiliary hydraulic pump, hydraulic fluid, and hydraulic reservoir.

4-37. BDAR may enable the equipment to either self-recover or continue the mission. The battle damage assessment will provide the commander with necessary information to make efficient decisions concerning whether to continue the fight or recover the equipment to the appropriate maintenance location.

4-38. Always report battle damage as soon as possible. Ensure that the damage is reported according to the local SOP and this publication.

EXPEDIENT REPAIRS

4-39. On the battlefield equipment damage can occur through various means. Enemy contact contributes to the majority of the damage inflicted on equipment. Accidents are another source which often causes serious damage to equipment. Extensive use of equipment and poor maintenance practices can lead to premature failures from fatigued and worn out components leaving personnel stranded. During the battle damage assessment phase the extent of damage will determine if the equipment is a BDAR candidate or if it requires recovery assets. Always consider the current tactical conditions before attempting expedient repairs.

4-40. Maintenance assets will be heavily taxed on the battlefield. Because resources are limited (personnel, tools, and parts), it is imperative that maintenance resources are not wasted. Operators/crew must perform expedient repairs within their capabilities immediately rather than requesting maintenance personnel to perform simple mechanical tasks. Most expedient repairs are not found in technical manuals. Flexibility and ingenuity are the keys to successful BDAR.

4-41. On the battlefield, the objective is to return the system into battle with enough combat capability to accomplish the mission. Repair only what is necessary to restore function. Cosmetic repairs are a waste of time and resources. If a broken item does not affect the ability to shoot, move or communicate, and does not pose a serious safety concern, it should not be repaired until the equipment is returned to maintenance where standard repair procedures can be performed.

BDAR Tools and Equipment

4-42. Special kits are available to support crew and maintainers to perform BDAR with access to basic issue items and components of end items. These kits are allocated to the crew, maintenance teams, and maintainers. This chapter provides general information about the BDAR kits and the national stock number for both crew and maintainer kits. BDAR kits allow repair in numerous areas: such as fuel, hydraulics, cooling, tires, electrical systems, and hull repair.

4-43. When possible, BDAR should first be performed by the crew using the crew/operator BDAR kit, BII, components of end-items, and additional authorized list or on-vehicle equipment. Maintenance personnel will have access to the same items available to the crew/operator, as well as additional components.

Classification of Expedient Repairs

4-44. All expedient repairs are classified based on the risk level associated with each repair. The risk levels are "High, Medium, and Low". Repairs are also classified as temporary or permanent. Only a qualified maintenance inspector can classify the expedient as either temporary or permanent regardless if the operator/crew or maintenance personnel performed the repairs.

- Expedient repairs that may cause further damage to equipment or cause injury to personnel are classified as "High Risk" repairs. For example, a damaged or faulty neutral safety switch will prevent the vehicle's engine from starting. Bypassing the switch will result in the engine starting in any gear which can lead to vehicle damage or injury to personnel. These types of repairs should only be performed in extreme emergencies and corrected at the earliest opportunity with standard maintenance.
- Expedient repairs that may cause further damage to equipment but poses no risk to personnel are classified as "Medium Risk repairs. For example, a hole in the radiator resulted in a coolant leak. After repairing the radiator there was not enough coolant or water to completely fill the cooling system. Potential exists for damaging the engine due to overheating but the condition should not pose a hazard to individuals in the crew compartment. Operating the equipment at lower speeds and loosening the radiator cap may minimize the damage and the cooling system must be replenished at the earliest opportunity.
- Expedient repairs that will not contribute to further damage to equipment or increase the risk to personnel are classified as "Low Risk" repairs. For example, a wiring harness on a vehicle chassis sustained cut wires. After splicing the wires together and insulating them the circuits should be restored. If properly spliced and insulated no further damage to equipment or risk to personnel should occur.

Conducting Field Expedient Repairs

4-45. The operator/crew prepares and provides the initial damage assessment and reports to the vehicle commander. They describe inoperable conditions, to include CBRN conditions and circumstances. (When the inoperable equipment is subject to or in danger of hostile fire, another vehicle can be used to recover it to a secure location.) The operator/crew assesses the situation and determines which type of maintenance support is required.

4-46. If directed, the crew shall proceed to make any field expedient repairs possible. Usually these repairs will consist of restoring firepower, communications, and/or vehicle mobility within the limit of their skills and the availability of materials and tools. They must also consider repairing items to make the equipment self-recovery capable. If repairs are beyond crew capabilities, they request assistance per the unit's SOP.

4-47. The vehicle commander will report the results of the crew/operator damage assessment to the platoon leader. He will name the major known causes of the vehicle's immobility and/or lack of firepower and/or communication failures. If repairs by the crew are possible, the vehicle commander will report the appropriate risk repair level, a total estimated repair time, and a list of functions that may be restored.

4-48. The platoon leader will respond with directives and, if required, will call a maintenance team to the location of the damaged vehicle for assistance. If possible, he will provide sufficient information to enable the maintenance team to bring any required repair parts, special tools, or recovery assets to the site.

4-49. Maintenance personnel will assess the equipment to verify the operator's/crew's damage assessment for accuracy or reconsideration of repair methods. Based on the maintenance assessment, the decision will be made to either attempt an on-site repair or request recovery assets to move the vehicle to a maintenance collection point. The current tactical situation will determine if on-site repair or evacuation is necessary.

4-50. The maintenance team will perform t, using the BDAR kits and any other field expedient material on hand. Because standard maintenance repairs usually offer the best repair, maintenance personnel will strive to perform standard repairs if the current tactical situation permits.

4-51. Equipment that is damaged but mobile may be used to move disabled equipment. If recovery vehicles are not available (and as the tactical situation permits), like or heavier classed vehicles may be used to recover disabled equipment.

4-52. If all critical repairs can be done with the skills, tools, and equipment on hand, the maintenance team (assisted by the crew) will proceed with the on-site repair.

4-53. If the vehicle is not reparable, the maintenance team will provide:

- Recovery to the maintenance collection point for evacuation to the rear.
- On site cannibalization, if approved by the commander and coordinated with support maintenance.
- Other needed replacement parts.

4-54. If the vehicle is contaminated, the maintenance team will mark the vehicle with the appropriate contamination markers and arrange for recovery to a decontamination site.

Hull And Metal Component Repair

4-55. It is critical to maintain hull integrity, especially during fording operations and when faced with a CBRN threat. Epoxies and polymers in the BDAR kit can be used to ensure hull integrity for small- to medium-sized holes (figure 4-1). Other components in the crew and maintainer BDAR kits: such as reinforcement tape and aluminum tape which can assist in patching armor tiles, vehicle fuel tanks, vehicle hulls, and any other metal surface or components on the vehicles. This capability allows military personnel to quickly reduce the effects of CBRN and other contaminants from entering their vehicle within minutes. Hull patches do not provide any additional ballistic protection; they are designed to maintain hull integrity (air/water tight).

Figure 4-1. Hull and metal component repair materials

Fluid Line Components And Repair

4-56. Fluid line repair items are in both kits. Hose clamps, duct tape, aluminum tape, and Belzona Elastomer can be used to repair low-pressure rubber hoses (figure 4-2, left). Fittings needed for fluid line repair are found in the maintainer BDAR kit (figure 4-2, right). These fittings enable the maintainer to repair low- to high-pressure lines on most equipment.

Figure 4-2. Fluid line repair item

Leaking Low-Pressure Line Fitting

4-57. To repair a leaking low-pressure line fitting

- Wind a string or rag tightly around the line behind the flare (figure 4-3 on page 4-10). Wind the string clockwise in the same direction the coupling nut is turned for tightening.
- Slide the coupling nut over the material, screw it onto its connection, and tighten it securely against the packing string with a wrench. The string will act as a gasket and seal the leak.

4-58. Anti-seize tape is also available in the BDAR maintainer kit. Anti-seize tape prevents threads from seizing, but multiple wraps of this tape can serve as packing to seal damaged flared fittings and help seal threaded fittings. Polymers included in BDAR kits may also be used to repair leaking or damaged fittings because of their ability to flow into small spaces that caused the leak.

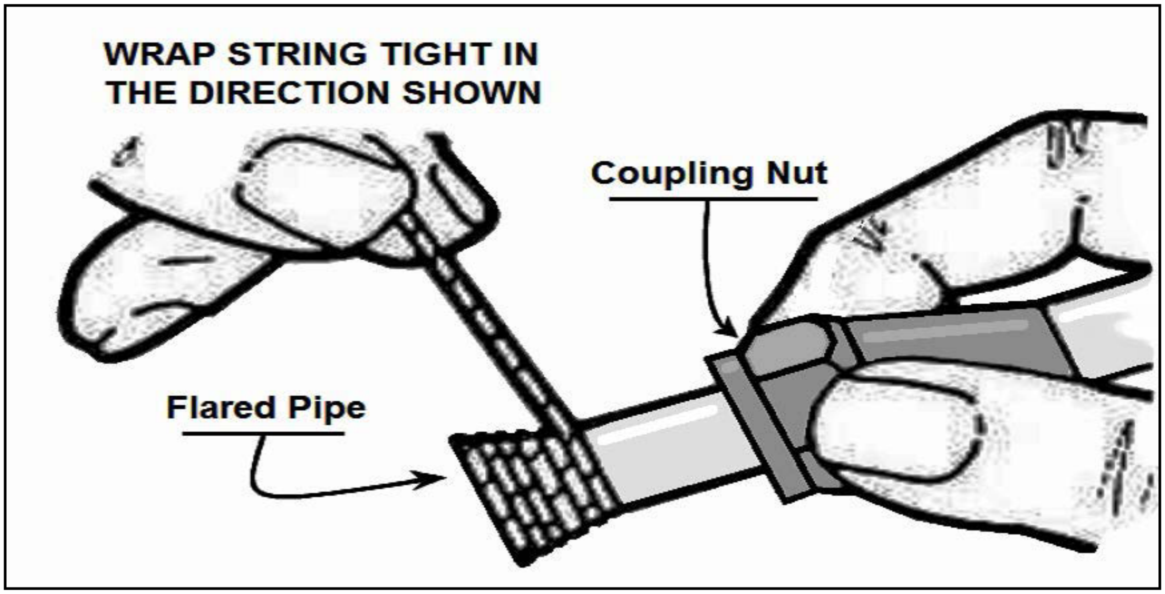


Figure 4-3. Low-pressure line fitting repair

Cracked Low-Pressure Oil Or Fuel Lines

4-59. Cracked low-pressure oil or fuel lines are usually caused by vibration or defective metal. If this occurs, stop the leak by wrapping the line tightly with friction tape held in place by wire. The wire helps the tape withstand pressure and usually stops the leak until a permanent repair can be performed.

4-60. Aluminum or electrical tape may also work if the surface can be cleaned to allow adhesion.

- Clean the surface of the line and cover just the crack with a couple wraps of rubber electrical tape.
- Follow up with multiple wraps of aluminum tape.
- Wrap wire around the tube or use hose clamps over the aluminum tape (figure 4-5 on page 4-12) to reinforce the repair.

4-61. Another quick method to repair a cracked line is with a small piece of hose.

- Use a piece of reinforced hose with an inside diameter equal to the outside diameter of the tube.
- Split the hose lengthwise.
- Coat the inside of the hose with sealant, if available.
- Install the hose over the leak with the split opposite the leak.
- Secure over the leaking area with hose clamps (figure 4-4). Additional clamps may be added to further reinforce the repair.

4-62. Polymers are also available in both BDAR kits to perform this repair. Polymers can be applied over the patch to provide additional reinforcement, or be included in the process before applying aluminum tape to ensure a better seal. Polymers do not require air to cure so the tape can be applied immediately after applying polymers.

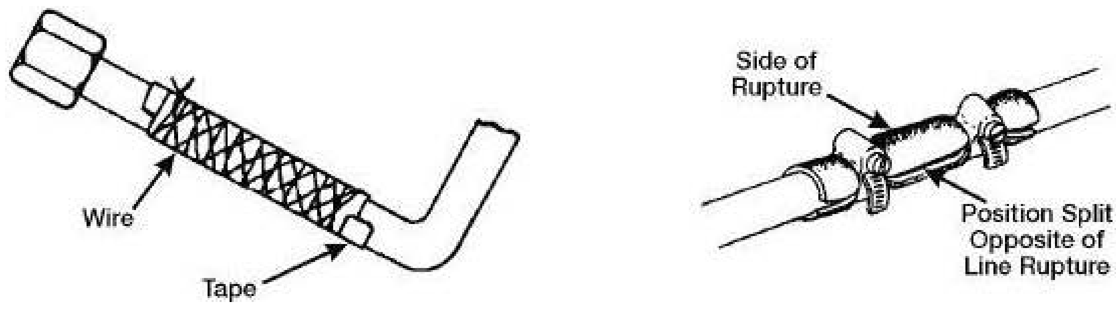


Figure 4-4. Low-pressure line repair

> ***Note.*** If polymer is used before applying aluminum tape, the tape must be applied before the polymer is allowed to fully cure. Failure to quickly apply the tape will result in irregular surfaces and create a poor bonding surface for the aluminum tape.

Collapsed Flexible Fuel Line

4-63. To repair a collapsed flexible fuel line

- Make a support for the inside of the fuel line by wrapping a thin wire around a pencil or another object slightly smaller than the flexible line inside diameter.
- Slide the coiled wire off the pencil and place it into the flexible line. Fuel will be able to flow and the fuel line will not collapse.

4-64. Applying external structure support may also repair a collapsed flexible line. If the line collapses during flow, but regains shape when flow stops, the following method may be used.

- Clean the exterior of the line with Elastomer conditioner included in the BDAR kit.
- Wrap the exterior of the line with wire, but allow at least 1/8 inch between successive wraps.
- Coat the entire affected area with Elastomer from the BDAR kit and allow it to cure. The Elastomer will bond to the flexible line and to the wire coil and provide external support to prevent collapse without restricting internal flow.

4-65. If the line does not regain shape when flow stops, remove the line from the closest source to the collapse and insert an object such as a pencil inside the hose to expand the collapsed hose. Then perform the repair listed in the above paragraph. Remove the object from the hose once Elastomer cures and reattach the hose to its original connection.

Electrical Components And Repair

4-66. Electrical repair capabilities are in both crew and maintainer BDAR kits. Electrical items and consumable materials can repair numerous electrical connections used in current equipment. Simple electrical repairs can be done with electrical tape, wire-nut connectors, 16-gauge or 22-gauge wire, and wire ties (figure 4-5 on page 4-12). Pliers commonly found in most BII can act as cutters, crimpers, small bolt cutters, and wire strippers.

CAUTION

Vehicle power must be disconnected before working on any electrical wire.

4-67. Silicone sealant (included in the BDAR kits) should be applied to the inside of wire-nut connectors before installing them to seal the connection from moisture and corrosion.

4-68. When a battery cable clamp becomes loose and cannot be tightened:

- Remove the clamp; clean the post and the clamp as much as possible.
- Place the clamp on a flat surface and strike it with a hammer. This will compress the lead and close the hole on the inside of the clamp.
- Replace the clamp and tighten. If the clamp is still loose, use a nail or other metal object between the clamp and the post as a wedge to make contact between the battery post and the battery clamp.
- Loosen the clamp, insert the wedge between the battery posts, and tighten the clamp. If the clamp cannot be repaired, use a universal replacement battery clamp provided in the BDAR kit. The clamps in the kit are for positive battery posts, but they can also close tight enough to fit a negative post.

WARNING

When working around batteries and battery clamps, take care to prevent tools and jewelry from arcing. This could cause damage to vehicle electrical components and personnel injury. DO NOT smoke or permit an open flame near the batteries because gas from battery acid is explosive.

Figure 4-5. Electrical repair materials

Tire Repair

4-69. There are two methods of tire repair. Tire repair capabilities (figure 4-6) are in both crew and maintainer BDAR kits. Fast, efficient tire repair is done with this kit if the hole is due to a nail or similar item causing small gashes. The tire plug kit is used in this case. If the tire damage is from fragments, the Belzona Elastomer 2311 and reinforcement tape is used to patch the larger damage. Tire damage larger than 4 inches cannot be patched with this kit. Tire repairs can be made while mounted on the vehicle; however, the tire should not be under air pressure while patching.

Figure 4-6. Tire patch materials and tire plug kit

Cooling Systems

4-70. Large holes in radiator reservoirs, fuel tanks, and oil reservoirs may be repaired using the environmental plugs shown in (figure 4-7 on page 4-14). These plugs serve to slow down leakage until a metal plug and other patching material are applied to the damaged area. The link belt, included in the BDAR kit is used as a replacement for fan, alternator, air compressor, and other belt-driven engine components. Radiator sealant can be used to seal small pinholes or seam leaks by pouring the sealant into the leaking radiator and replacing the radiator cap. Unit personnel are encouraged to add other items they feel are needed in their unit's BDAR kit.

Figure 4-7. Environmental plugs, radiator sealant, and a link belt

Leaking Radiator Or Heater Hoses

4-71. To repair a leaking radiator or heater hose:

- Allow the engine to cool so the hoses can be safely handled.
- Patch the leak by wrapping it with standard issue electrical or reinforcing tape.
- Refill the radiator with coolant and leave the radiator cap loosened.
- Operate the vehicle at a reduced speed until the hose can be replaced.
- Polymers and radiator sealer are available in both BDAR kits to perform alternate methods of repair or reinforcement.

Punctured Tube-Type Radiator Core

4-72. Radiators are often punctured when vehicles are operating in wooded or combat areas. When this occurs:

- Cut the cooling fins and push them away from the leaking tubes.
- Cut the leaking tube in half and fold the ends of the tube back approximately three-fourths of an inch.
- Close the tube ends by pressing them flat with pliers. (See figure 4-8.)

4-73. Cooling system efficiency is reduced when several tubes are cut, causing the engine to overheat. When field expedient radiator repairs are made, loosen the radiator cap. This keeps the radiator pressure from building up and breaking the repair. High strength polymer kits are included in the crew and maintainer kit to cover the damaged core tubes after bending them over. Ensure the damaged area is very clean before applying polymer agents to ensure proper bonding. When these products are properly applied and cured, the radiator cap can be installed. Radiator sealer should be added after any major repairs are made to ensure small holes are sealed.

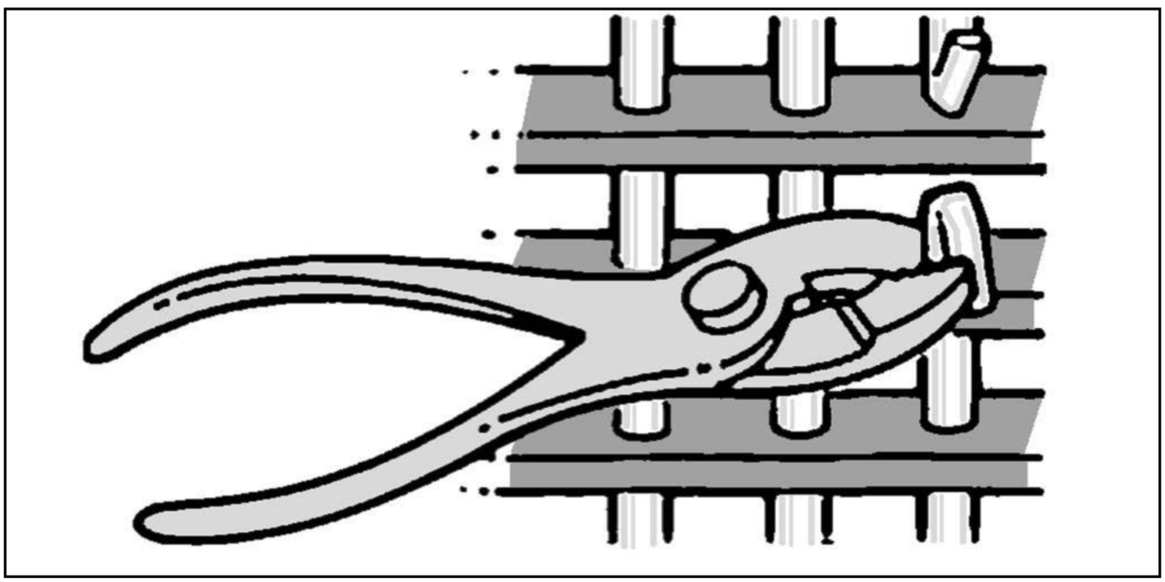


Figure 4-8. Tube-type radiator core repair

Broken Fan Belts

4-74. When a fan belt breaks and a replacement is not available, mend or substitute it. To mend a broken fan belt:

- Punch holes in both ends of the broken belt and put a small gauge wire or bootlace through each hole.
- Secure the wire or laces.

- Replace the belt with just enough tension to drive the vehicle accessories.

4-75. To substitute for the broken fan belt:

- Use fiber rope from the vehicle tarpaulin or a piece of field telephone wire.
- Loop the wire or rope around the pulleys several times, pull as taut as possible, and tie with a square knot.

4-76. In both cases, operate the engine at low speed. This will prevent breakage or loss of the substitute belt. Both BDAR kits contain a link belt to temporarily replace a broken belt. Add or remove links from the belt to achieve the desired length.

Broken Fan Blades

4-77. A broken fan blade will cause the engine to vibrate and make it dangerous to operate.

- On fans with an equal number of blades equally spaced, remove the remainder of the broken blade, and then remove the blade located opposite the removed broken blade. The vehicle can then operate, but be careful that it does not overheat.
- On fans with unequally spaced blades, the entire fan can operate under the light load for short periods of time. Trimming a small amount of fan blades opposite of the broken blade may also help to reduce vibration.

Defective Tandem Axle

4-78. A tandem axle with a burned-out bearing or damaged wheel can disable a vehicle or cause further damage if operation continues.

- Move the wheel of the disabled axle onto a rock, log, or similar object to raise the wheel as high as possible.
- While the wheel is raised, tie the axle as tightly as possible to the frame using heavy wire, ratchet strap, or a tow chain (figure 4-9). Do not let the chain, strap or wire cause damage to the brake lines.
- If the wheel bearing is burned out, or for some other reason the wheel does not turn, remove the axle shaft from the axle housing.
- Stuff the hole in the hub with rags to keep out foreign matter.
- This expedient method allows the other wheels to drive. Reposition any cargo over good axles or transfer cargo to a second vehicle.

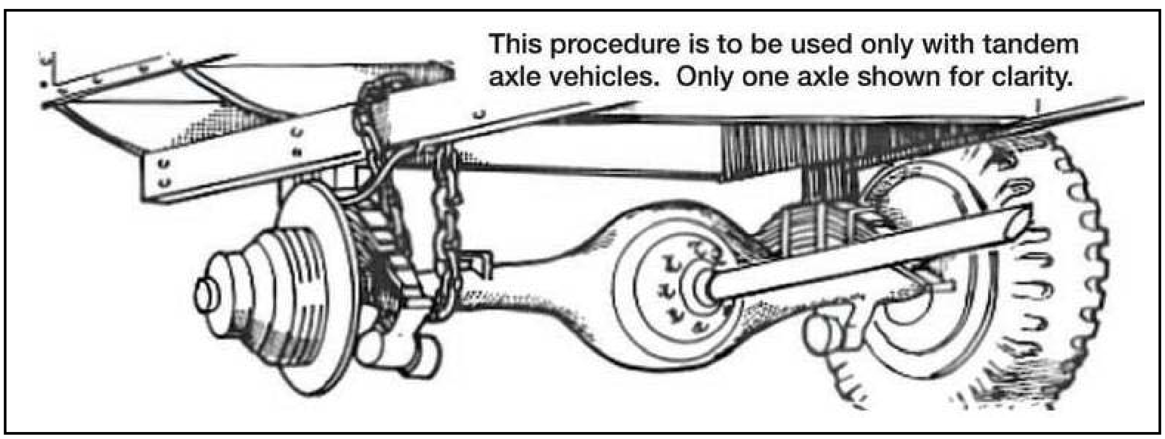


Figure 4-9. Attaching tandem axle to frame

4-79. Use the same technique on both ends of the axle if both wheels are defective. Since both ends of the axle are tied up, do not load the vehicle too heavily.

Defective Differential

4-80. If the defect is in the differential of a 4 by 4, 6 by 6, or 8 by 8 vehicles, remove the propeller shaft and drive axles (figure 4-10). For example, if the front rear differential is defective and the rear propeller shaft is removed, the vehicle can still be powered by the front wheels. When the axle shafts are removed, cover the openings securely to keep out dirt and foreign matter.

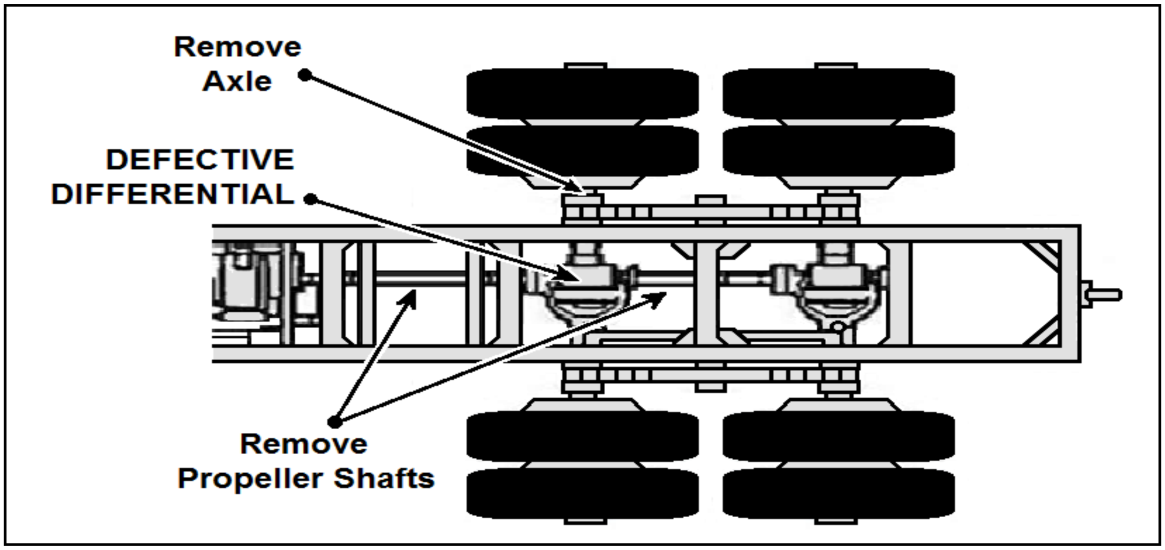


Figure 4-10. Defective differential

> **CAUTION**
> Avoid unnecessary oil spills by applying materiel from the BDAR kit over the holes. This also helps retain as much lubricating fluid as possible.

Damaged Front Axle Brake System

4-81. When damage has occurred to the front axle brake system, close the line from the junction block to the axle. If other damage to the air system exists, remove or repair leaking lines, install plugs where lines are removed, bypass brake components, or interconnect brake hoses to stop air loss. This helps the driver maintain steering control while braking and allows pressure to buildup to make rear brakes functional.

> **CAUTION**
> Report all corrective actions taken to stop air loss to maintenance personnel before disconnecting from the recovery vehicle.

Damaged Road Wheel Components

4-82. To repair a vehicle with a damaged road wheel, spindle, or road-wheel arm

- Position the vehicle across a ditch.

Note. The ditch should be narrow enough to permit the front and rear road wheels to support the weight of the vehicle and deep enough to permit the track to sag away from the defective road wheel (figure 4-11). This will remove the tension from the torsion bar. If a ditch is not available, dig a trench.

- Tie the road-wheel arm up out of the way.

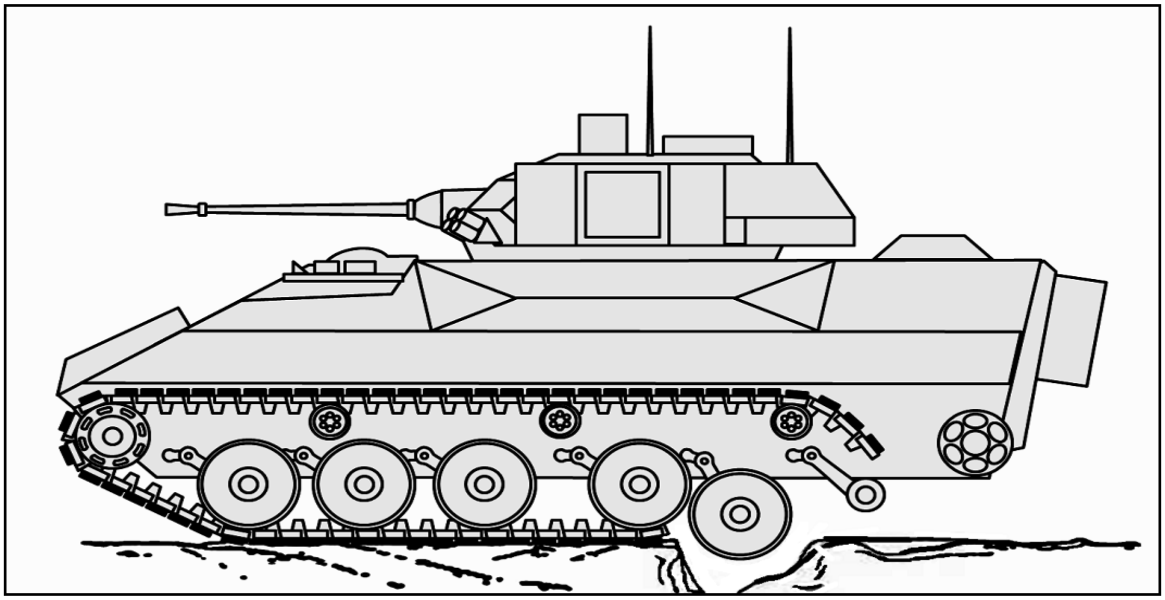


Figure 4-11. Suspending road wheel

- Remove the torsion bar by removing its cap screw and end plug, replacing the cap screw in the torsion bar, and prying behind the cap screw head with a tanker's crowbar.
- Reposition the vehicle on level ground.
- Remove the road wheel.
- Position a tanker's crowbar across two torsion bar support housings, and, using a rope from the vehicle tarpaulin, tie the road-wheel arm to the tanker's crowbar (figure 4-12).

Note. Use this expedient method with intermediate road wheels only.

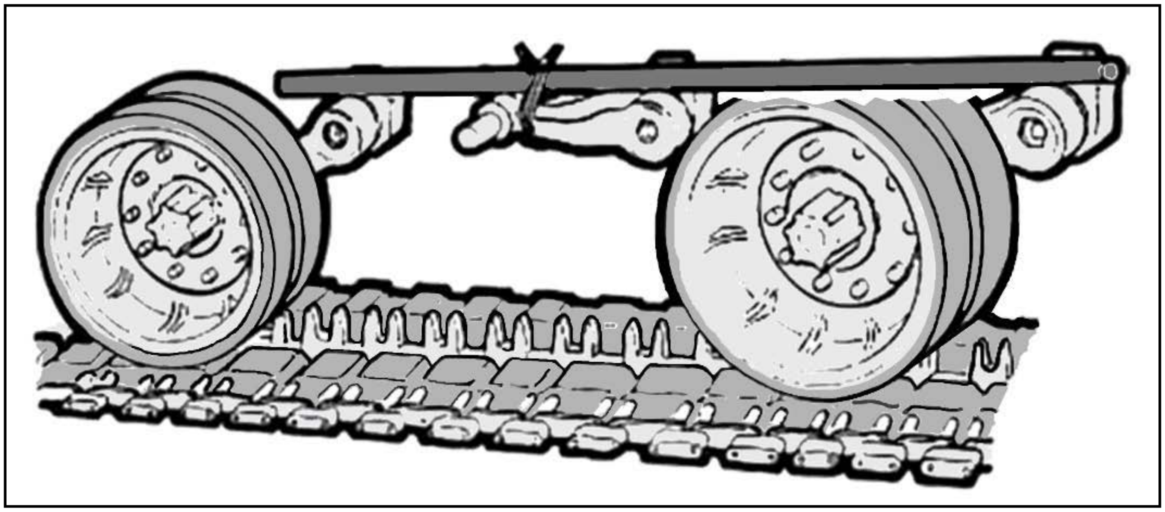


Figure 4-12. Road wheel expedient technique

Damaged Suspension Components

4-83. A tracked vehicle with a damaged track, rear road-wheel arm, or idler wheel can be operated, using the short track expedient method (figure 4-13). However, the hull must not interfere with the shortened track.

Note. This method is not recommended for armored vehicle-launched bridge or M1 family of vehicles.

4-84. To apply this expedient repair, remove the companion components to the damaged suspension parts—such as the rear shock absorber, track adjuster, road-wheel arm, and torsion bar. Before applying short track expedient methods, check the procedures outlined in the appropriate TM.

CAUTION

This procedure is time-consuming and may cause injury to personnel when performed.

4-85. The short track method is designed to regain mobility after component failure or combat damage. If the idler wheel and road arms number 5 and number 6 are damaged beyond repair, it is possible to short track to the number 4 road wheel. Whether damaged or not, the number 5 road wheel, road arm, and torsion bars must be removed to allow short tracking to the number 4 road wheel. If possible, reinstall the number 6 road wheel to improve vehicle stability. Sufficient track blocks must be removed to permit the track to be connected.

Note. If both sides of vehicle must be short tracked, remove all damaged road arms and idler wheels.

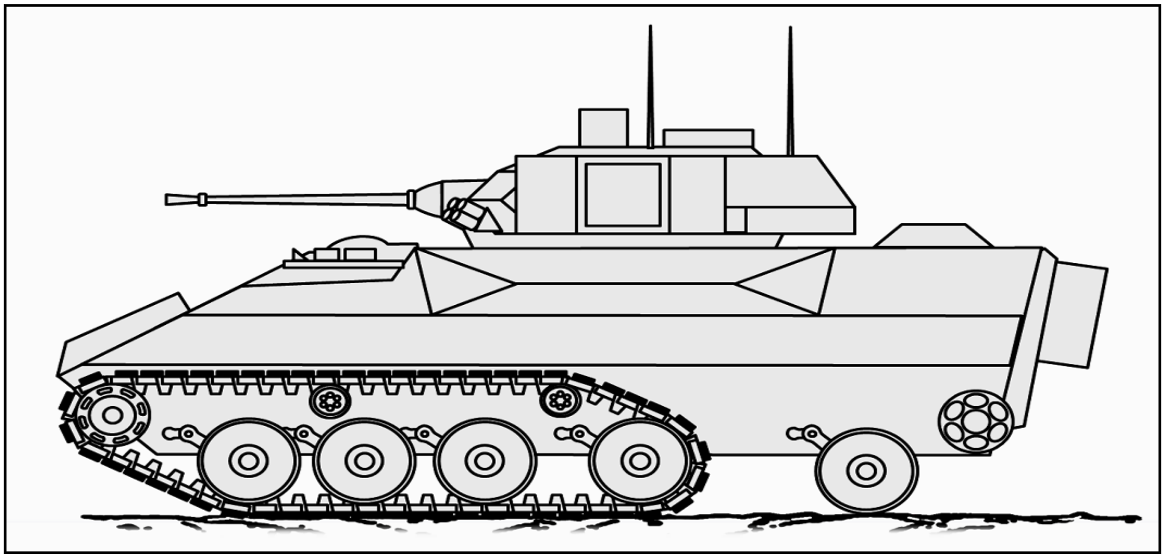


Figure 4-13. Short track expedient technique

Shear Pin Substitute

4-86. Make a substitute for a broken shear pin:

- Punch out the remains of the broken shear pin, cut the remains in half, and insert the two shear pin halves with a short, wooden dowel between them (figure 4-14).
- Wrap friction tape around the shaft to cover the shear pinhole and prevent the end of the substitute shear pin from dropping out.

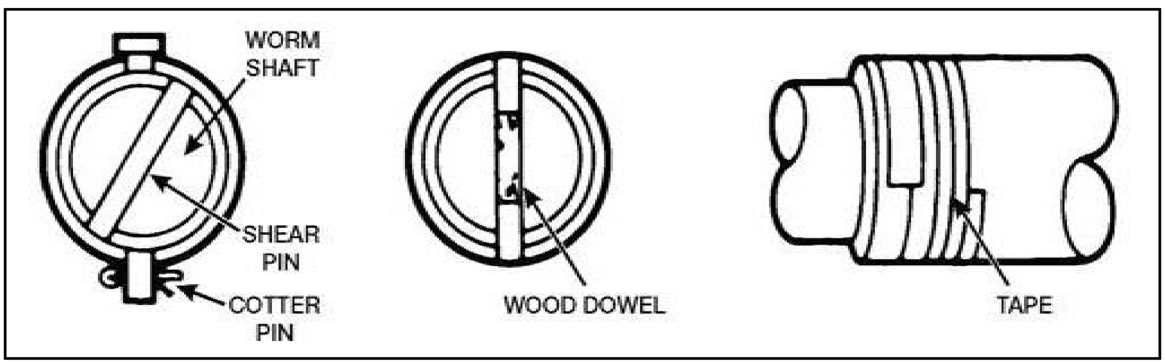
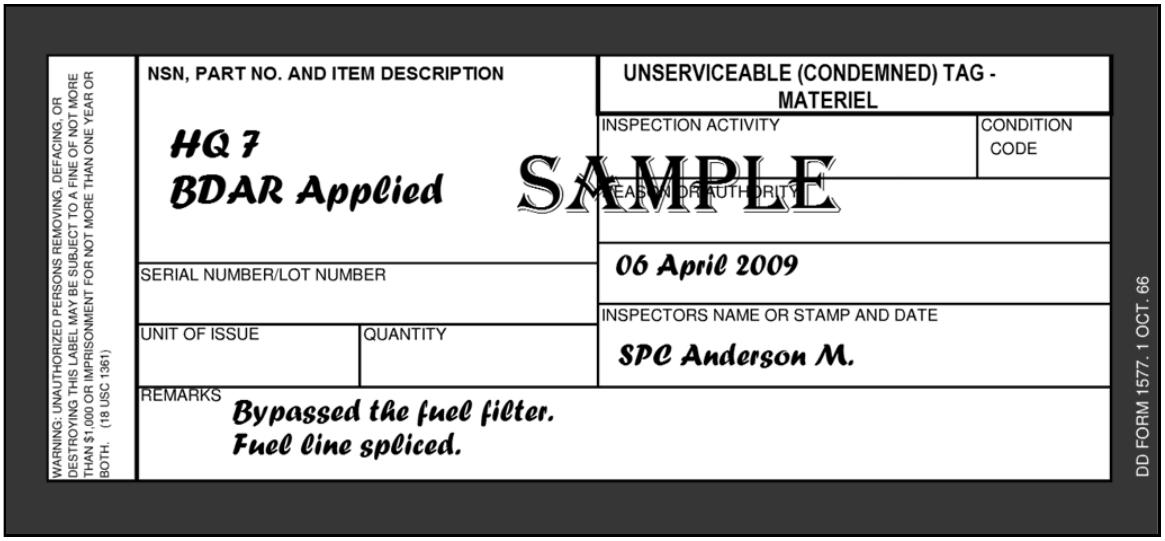


Figure 4-14. Shear pin substitute

Note. Do not use a steel bolt, spike, nail, or screwdriver blade as a substitute shear pin because it could damage the winch and cable.

RECORDING BATTLE DAMAGE REPAIRS

4-87. Anytime BDAR is performed on a piece of equipment it must be recorded. The recording process begins at the site where the initial repairs were made. Attach a DD Form 1577 (*Unserviceable [Condemned] Tag-Materiel*) available in the BDAR kits (figure 4-15 on page 4-20) or a suitable tag which identifies the damage, type of repair made, repairer and date. The purpose for marking the component is to alert the crew and maintenance personnel that an expedient repair action was taken and needs to be inspected and repaired to 10/20 standards. Under emergency conditions it is not necessary to complete the tag however, the location and type of repair should be annotated at the earliest convenience.



WARNING: UNAUTHORIZED PERSONS REMOVING, DEFACING, OR DESTROYING THIS LABEL MAY BE SUBJECT TO A FINE OF NOT MORE THAN $1,000 OR IMPRISONMENT FOR NOT MORE THAN ONE YEAR OR BOTH. (18 USC 1361)

NSN, PART NO. AND ITEM DESCRIPTION

HQ 7
BDAR Applied

SAMPLE

UNSERVICEABLE (CONDEMNED) TAG - MATERIEL

INSPECTION ACTIVITY

CONDITION CODE

REASON OR AUTHORITY

06 April 2009

SERIAL NUMBER/LOT NUMBER

UNIT OF ISSUE

QUANTITY

INSPECTORS NAME OR STAMP AND DATE

SPC Anderson M.

REMARKS
Bypassed the fuel filter.
Fuel line spliced.

DD FORM 1577. 1 OCT. 66

Figure 4-15. DD form 1577

4-88. In some cases it may be impractical to attach tags to repairs located on the outside of the vehicle. The completed tag can be placed in the equipment record book/folder or in a conspicuous place in the driver's compartment. When an expedient repair cannot restore full function and one or more systems are operating in a degraded mode, the tag must indicate the operation limitations and must be placed in the drivers and commanders area (where applicable) to alert them of limitations and cautions.

4-89. The expedient repair must also be recorded in DA Form 2404, *Equipment Inspection and Maintenance Worksheet*. Faults requiring BDAR action are annotated in block 10c with "BDAR APPLIED" marked across blocks 10c and 10d. If the computer generated DA Form 5988-E, *Equipment Inspection/Maintenance Worksheet* is used, the acronym "BDAR" must be written across the corrective action section in the lower right corner of the form.

REPORTING BATTLE DAMAGE REPAIRS

4-90. All BDAR actions must be reported through the unit maintenance facility. When reporting a BDAR action, list the details of the damage, the BDAR action taken and the success of the repair. All details should be annotated on DA Form 2404 (figure 4-16)/DA Form 5988-E (figure 4-17 on page 4-22), and entered in the Standard Army Maintenance System-Enhanced system. BDAR actions must also be forwarded to the Survivability/Vulnerability Information Analysis Center (SURVIAC, ATTN: AF-FDLFES-CDIC), Wright-Patterson Air Force Base, OH 45433.

4-91. BDAR reporting documents provide valuable information which serve as examples that can be tested to prove principle and may be used to develop new reliable techniques for BDAR training and updating publications. Ensure all information provided is as accurate and detailed as possible.

EQUIPMENT INSPECTION AND MAINTENANCE WORKSHEET

For use of this form, see DA PAM 750-8; the proponent agency is DCS, G-4.

1. ORGANIZATION					2. NOMENCLATURE AND MODEL	
HHC, 659th Maint. Co.					TRK, LMTV M1078 A1	
3. REGISTRATION/SERIAL/NSN	4a. MILES	b. HOURS	c. ROUNDS FIRED	d. HOT STARTS	5. DATE	6. TYPE INSPECTION
RPK 7043	14963				12 Mar 09	D

7. APPLICABLE REFERENCE			
TM NUMBER	TM DATE	TM NUMBER	TM DATE
TM 9-2320-391-10-1	Jan 05		

COLUMN a – Enter TM item number.
COLUMN b – Enter the applicable condition status symbol.
COLUMN c – Enter deficiencies and shortcomings.
COLUMN d – Show corrective action for deficiency or shortcoming listed in Column c.
COLUMN e – Individual ascertaining completed corrective action initial in this column.

SAMPLE

STATUS SYMBOLS

"X" – Indicates a deficiency in the equipment that places it in an inoperable status.

CIRCLED "X" – Indicates a deficiency, however, the equipment may be operated under specific limitations as directed by higher authority or as prescribed locally, until corrective action can be accomplished.

HORIZONTAL DASH "(-)" – Indicates that a required inspection, component replacement, maintenance operation check, or test flight is due but has not been accomplished, or an overdue MWO has not been accomplished.

DIAGONAL "(/)" – Indicates a material defect other than a deficiency which must be corrected to increase efficiency or to make the item completely serviceable.

LAST NAME INITIAL IN BLACK, BLUE-BLACK INK, OR PENCIL - Indicates that a completely satisfactory condition exists.

FOR AIRCRAFT - Status symbols will be recorded in red.

ALL INSPECTIONS AND EQUIPMENT CONDITIONS RECORDED ON THIS FORM HAVE BEEN DETERMINED IN ACCORDANCE WITH DIAGNOSTIC PROCEDURES AND STANDARDS IN THE TM CITED HEREON.

8a. SIGNATURE *(Person(s) performing inspection)*	8b. TIME	9a. SIGNATURE *(Maintenance Supervisor)*	9b. TIME	10. MANHOURS REQUIRED
PFC Joe, 1234	1425	SSG Robert 5678	1535	

TM ITEM NO. a	STATUS b	DEFICIENCIES AND SHORTCOMINGS c	CORRECTIVE ACTION d	INITIAL WHEN CORRECTED e
2	X	Fuel filter housing is	BDAR, Bypassed	
		cracked, CL III fuel	fuel filter, rerouted	
		leak.	the fuel lines.	
	X	BDAR applied		

DA FORM 2404, FEB 2011 PREVIOUS EDITIONS ARE OBSOLETE. APD PE v1.00ES

Figure 4-16. Example of a DA Form 2404

```
DATE:  20010817        EQUIPMENT MAINTENANCE AND          DA FORM 5988-E
                          INSPECTION WORKSHEET

       W45U7D              D TROOP, 6TH CBAC
------------------------------ EQUIPMENT DATA-------------------------------
  ADMIN NUM:  D89                        EQUIP SERIAL NUM:  042092
EQUIP MODEL:  M998                       REGISTRATION NUM:  NG2Y1R
 EQUIP NOUN:  TRK UTL CGO 1.25T 4X4       TYPE INSPECTION:  D
  EQUIP NSN:  2320011077155               CURRENT READING:  M 010880

                     NUMBER                      DATE    CHANGE NUMBER
PUBLICATION:  TM 9-2320-280-10-HR                0?/99        00
PUBLICATION:  TM 9-2320-280-10                   0?/96        03

INSPECTORS LIC #:________ TIME:____ SIGNATURE:_______________ TIME:______
---------------------------- SERVICE DUE DATA------------------------------
                                 TYPE        DATE          MI/ KM/ HR
            TYPE PMCS DUE:        A        20020416        M    16558
      NEXT OIL ANALYSIS DUE:               --------                0
       NEXT LUBRICATION DUE:               --------                0
    NEXT SPECIAL SERVICE DUE:              --------                0
---------------------------- PARTS REQUESTED-------------------------------
                                                                     P D
                                                QTY      STATUS DATE R L
FAULT  DOC NUM  NIIN               NOUN      DUE/REC      DATE  COMP I C

0114  1205 0029 011899725      DOOR, VEHIC  00001 ----- BB20010729 ---- 12 N
0111  1227 0025 013147834      CUSHION, SE  00001 -----  -------- ---- 12 N
---------------------------- MAINTENANCE FAULTS----------------------------
 ITEM    FAULT    FAULT        FAULT             CORRECTIVE      OPER
 NUM     DATE     STATUS     DESCRIPTION           ACTION      HRS LIC #

 0111  20010815    /    PASSENGER SEAT BACK MISSI                 __ _____
 0114  20010724    /    R/S DOOR WINDOW SPLIT                     __ _____
 0004  20010817    X  L/F GEARED HUB DAMAGED   BDAR, gear removed __ _____
 0005  20010817    X   Fuel filter housing cracked  BDAR, fuel filter bypassed
```

SAMPLE

Figure 4-17. Example of computer generated DA Form 5988-E

SPECIAL OPERATING ENVIRONMENTS

4-92. Recovery personnel must be trained on conducting recovery operations with other services in extreme weather condition and different terrain.

BDAR IN MULTI SERVICE OPERATIONS

4-93. Military units can expect to deploy as a component of a multi service task force. Maintenance personnel should work closely with other services to make collective use of tools and capabilities to perform BDAR. Despite differences in equipment and doctrine, the services have much in common that can be shared. Navy Seabees, Air Force maintenance activities, and most Navy ships have machine shops and fabrication capabilities that will prove useful in supporting BDAR. Prior multi-service agreements should be further developed to use this capability between services. The same cooperation can be developed with allied nations. Most armed forces in the North Atlantic Treaty Organization have a BDAR program under standardization agreement (STANAG). Many of the allied tools, materials, and techniques are similar to those of the United States. In addition, some foreign countries use our equipment (especially vehicles) which provides a possible source for repair parts through controlled substitution or cannibalization. These actions require agreements and prior approval from allies or host nations. These agreements should outline which BDAR or other maintenance services can be provided and the procedures required for obtaining support.

BDAR IN EXTREME OPERATING ENVIRONMENTS

4-94. BDAR techniques may be more difficult in certain environments, such as extremely hot, dry or humid, and extremely cold or wet conditions. Rubber and plastic products become brittle in extremely cold environments and break easily. Fluids may gel and slow down the operation of systems. Fluids tend to expand in extremely hot environments resulting in low viscosity and overfull conditions. Metals also expand which can result in pressure losses in hydraulic and lubrication systems. During repairs for example, certain molecular compounds (polymers) may take longer to cure in a cold environment but may cure very rapidly in hot environments. These polymers may not be the best choice under these extreme conditions. Instructions for best performance, limitations and application of these compounds are provided in the BDAR Smart Book (GTA 01-14-001, *Battle Damage Assessment & Repair Smart Book*).

BDAR TRAINING

4-95. Successes of BDAR actions depend entirely on the level of training individuals receive at the unit level. Individuals trained on multifunctional skills become valuable assets for the unit. Command emphasis on peacetime BDAR training is the key to success in wartime. Cross training and "on the job" training for operators/crew and maintenance personnel on BDAR techniques to support mission essential combat equipment is extremely important. Live-fire testing and evaluation has shown that personnel without a maintenance background can learn effective BDAR skills with minimal training.

4-96. Unit commanders must develop sustainment training in which vehicle operators/crews and field maintenance mechanics conduct BDAR and recovery training as outlined in AR 750-1 and ATP 4-33. Skills required to perform BDAR are found in individual and collective training tasks. Unit commanders must identify which military occupational specialties require knowledge of BDAR.

4-97. AR 750-1, *Army Maintenance Management Policy* requires that BDAR training be conducted annually. Commanders must incorporate low risk BDAR training during annual unit training exercises. Operators and crew must be familiar with the components in the BDAR kit that enable many repairs which otherwise would not be possible. Each operator/crewmember must be familiar with the process for performing battle damage assessment on assigned equipment and reporting procedures.

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Appendix A

Multinational Recovery and BDAR Operations

Today's military missions increasingly call for multinational recovery and BDAR operations to be part of a multinational force. For BDAR managers and operators, there are many opportunities and requirements to recover multinational vehicles. This appendix provides guidance for coordinating and executing such operations. It also briefly discusses BDAR operations concerning captured or abandoned enemy equipment.

COORDINATION CONSIDERATIONS CHECKLIST

A-1. When participating in an operation in which U.S. assets may be used to support multinational assets or vice versa, check the existing STANAG and SOP. Make contact with the affected multinational unit to exchange information. Although coordination at initial phases of a multinational operation will start at the highest level, as the relationship matures, coordination or information exchanges should routinely occur at tactical unit levels. This should be encouraged until continuous information exchange happens at the lowest level possible. The questions listed will become mission detractors if not clearly resolved before initiating BDAR missions. The following critical information should be exchanged, understood, and established during multinational operations.

- Clearly establish command and control. Does a U.S. element revert to multinational command and control for the duration of support to that multinational unit, or does the U.S. parent organization retain command and control?
- Identify who establishes priorities for BDAR assets in an area where more than one command exists.
- Determine where recovered assets should be towed to and by whom. Potential multinational supporting units need the U.S. maintenance collection point locations. U.S. forces need the locations of other collection points established by the supported multinational unit.
- Identify the point of contact for questions and guidance. One point of contact is established for multinational forces, and one for U.S. forces. U.S. elements need to contact these point of contacts.
- Establish the extent to which BDAR can be applied to multinational units.
- Identify specifics regarding the primary vehicles that each nation might recover for the other.
- Exchange technical information regarding towing, preferred hookup locations for winching or overturned vehicles, and any other information that would assist in avoiding unsafe or dangerous BDAR operations.
- Exchange information regarding special actions required to secure sensitive items, such as radios, maps, signal operating instructions, or high cost or scarce components.
- Determine what the multinational unit doctrine is concerning the use of the disabled crew on-site. Multinational doctrine may be different from U.S. doctrine, which requires crews to assist in BDAR operations, as well as provide local security.
- Ascertain which type of coordination will be required concerning the passage of lines, if required. Clearly established point of contacts must be contacted for such passages.
- Exchange operational plans and graphics to preclude inadvertent distracters to combat operations or placing U.S. assets in unnecessary danger.
- Clearly establish recognition signals. These signals include challenges and passwords, as well as identifying vehicle markings. Recognition markings are especially important in operations where multinational units and enemy forces use the same type of vehicle or in the case where the enemy may be using U.S. vehicles.

- Be aware of any special operational hazards, such as the use of CBRN elements or minefields. As necessary and where possible, arrange for multinational guides or provide guides to U.S. supporting elements.
- If possible, provide multinational units with U.S. BDAR kits for effecting BDAR on U.S. vehicles.
- If time and situation permit, arrange for mutual training or orientation sessions with counterpart personnel.
- If translations are critical for ongoing BDAR operations, arrange to have translators available. A better arrangement would be to have a technical advisor available from the nation owning the equipment.

EXECUTION CONSIDERATIONS CHECKLIST

A-2. The primary consideration is returning equipment to battle as quickly as possible while creating as little collateral damage as possible. Equally important is surviving to complete the mission. The following considerations involve approaching the site; local security, camouflage, and actions taken on contact:

- Before beginning recovery or BDAR operations on multinational vehicles, ensure authorization has been given and obtain any necessary guidance.
- Attempt to locate a member of the crew or a technical representative to provide technical guidance.
- Before starting BDAR operations, obtain applicable manuals to determine proper BDAR actions. Even where language is a problem, pictures and diagrams may prove useful.
- Do not begin any operation until technical information has been obtained. Acting too quickly or prematurely might cause damage.
- Report completion of the mission to the U.S. chain of command. The U.S. chain of command will pass that information to the command and control at the liaison officer level.

SECURITY OF SENSITIVE ITEMS AND SALVAGE OF DAMAGED EQUIPMENT

A-3. Only divisional or higher commanders have the authority to order the destruction of equipment. With operation orders, this authority is usually delegated to subordinate commanders. When a piece of equipment is destroyed, it must be reported through proper command channels.

SAFETY CONSIDERATIONS

A-4. Hazards that exist on the battlefield will also be present during the demolition of equipment (for example, toxic fumes and spilled fluids). Safety is an important consideration. BDAR personnel must become completely familiar with all aspects of the equipment being used. Applicable equipment technical manuals provide necessary warnings, cautions, and hazards. Classified documents, notes, and instructions of any kind are removed from the vehicle before demolition. Classified materials must be rendered completely useless to the enemy.

Appendix B

Hand and Arm Signals

Visual signals are any means of communication that require sight and can be used to transmit prearranged messages rapidly over short distances. This includes the devices and means used for recovery operations.

VOICE CONTROL

B-1. Ground guides controlling all tracked vehicle recovery operations will use electronic voice means whenever available, supplemented by minimal hand and arm signals as the primary means of ground control during recovery and lift operations. Ground guides must also be familiar with recovery operations during hours of darkness—using a flashlight to augment hand and arm signals. Until a wireless system is developed, units will use clear voice capture cables to link the ground guide with the vehicle operator via the vehicle intercom system for operations within 30 feet of the recovery vehicle.

B-2. An alternative means, especially for operations in excess of 30 feet of the recovery vehicle, is to connect a digital non secure voice telephone (using an optional headset for hands-free operation) to the control box via wire. If voice means cannot be established, hand and arm signals will continue to be used.

B-3. Restrictions for using hand and arm signals are as follows:

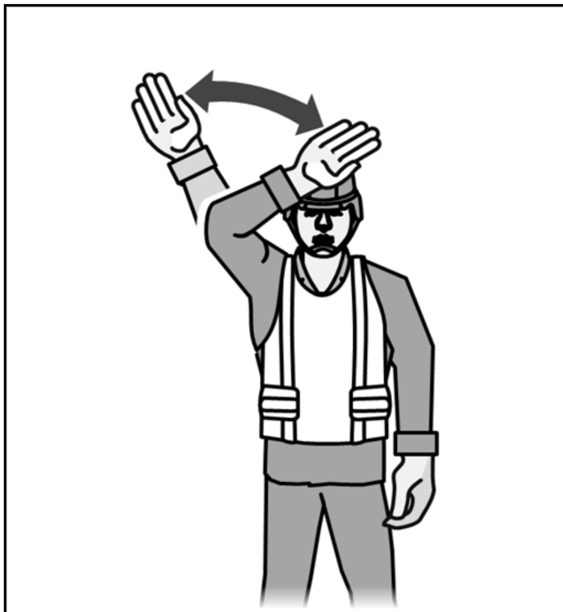
- Units must acquire extended clear voice capture cables and/or other items needed in BDAR operations.
- Units are responsible for conducting familiarization training—stressing potential hazards for an extended cable or field telephone wire to become snagged or severed during operations. The ground guides must be careful that the cable or wire does not become wrapped or entangled while moving. Therefore, if movement of the components is required, the wire or cable should be disconnected during such movements and reconnected when the ground guides are positioned safely.
- The crew must be informed that if voice cannot be established or fails at any time, they will return to hand and arm signals.
- The clear voice capture cable assembly can be connected to any Intercommunication Control box in a vehicle, except for the driver's box.
- When using either clear voice capture cable or field telephone wire with winching operations, the length must be such that the ground guide can be located safely and sufficiently outside any hazard area as required.
- Voice communications between the operator and the ground guide will make for safer operations by removing the doubt associated with hand and arm signals. These communications are particularly safer and more effective for limited visibility and night operations. They also remove doubt as to who is controlling the operator.

HAND AND ARM SIGNALS

B-4. All hand and arm signals are outlined in FM 21-60, *Visual Signals*. The most common types of visual signals are hand and arm (ground and crane), flag, pyrotechnic, and ground-to-air signals. Soldiers are not limited to the types of signals discussed and may use whatever mean available. Chemical light sticks, flashlights, and other items can be used, provided their use is standardized within the unit and understood by all Soldiers and units working in the area. Some common hand and arm signals that might be used for recovery operations are shown in the following figures. (See figure B-1 on page B-2 to figure B-42 on page B-23).

GROUND GUIDE HAND AND ARM SIGNALS

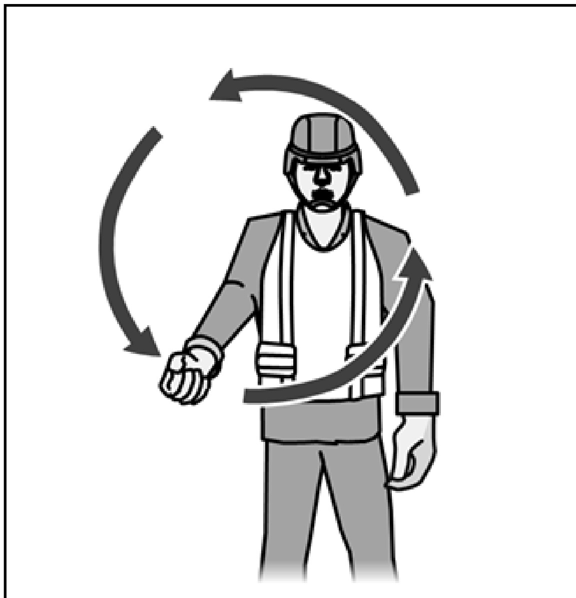
B-5. These signals are to be used for ground guiding wheeled and tracked vehicles day or night.



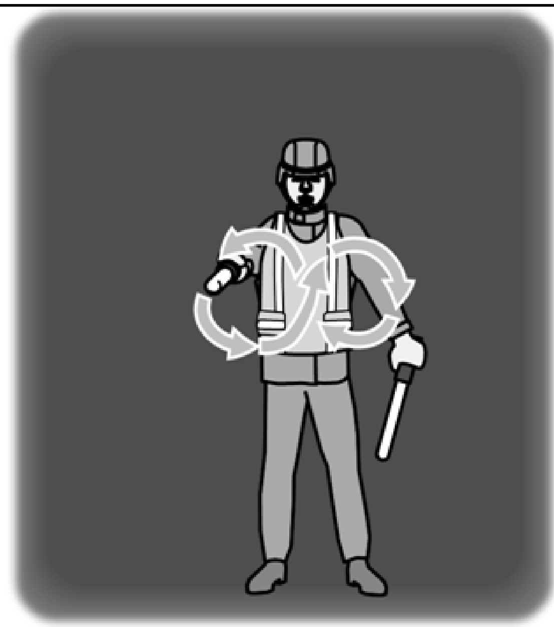
ATTENTION: Raise and extend the arm overhead. Move it to the left and right.
(Do not make a circular motion)

ATTENTION (Night): Raise and extend the arm overhead with the light pointed up. Move the light to the left and right.
(Do not make a circular motion.)

Figure B-1. Signal for attention

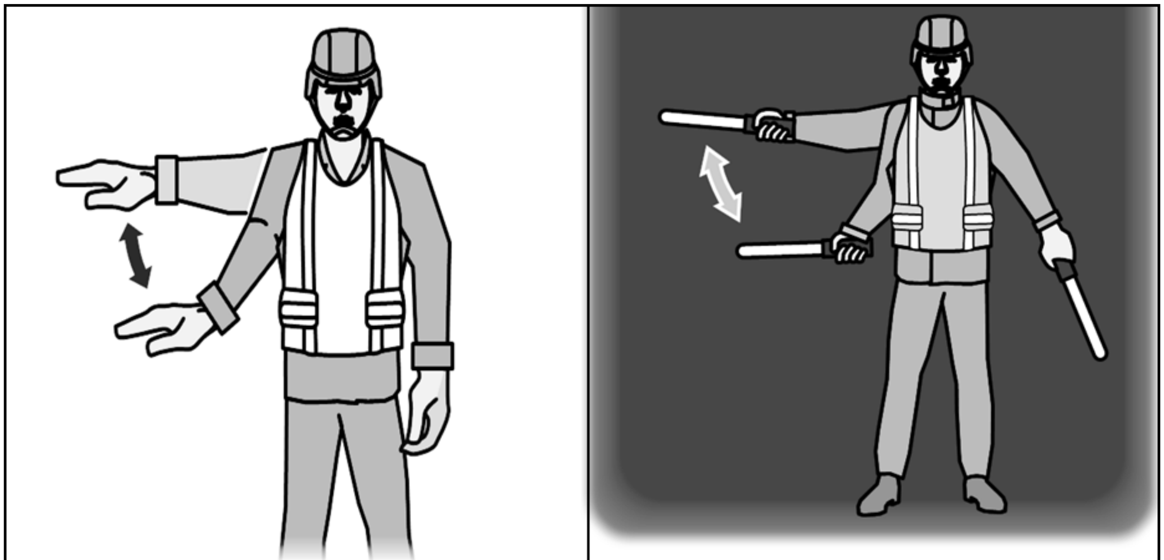


START ENGINES: Move the arm with fist in a large circular motion, simulating the motion of crank starting an engine.



START ENGINES (Night): Move the light in a horizontal figure 8, at waist level.

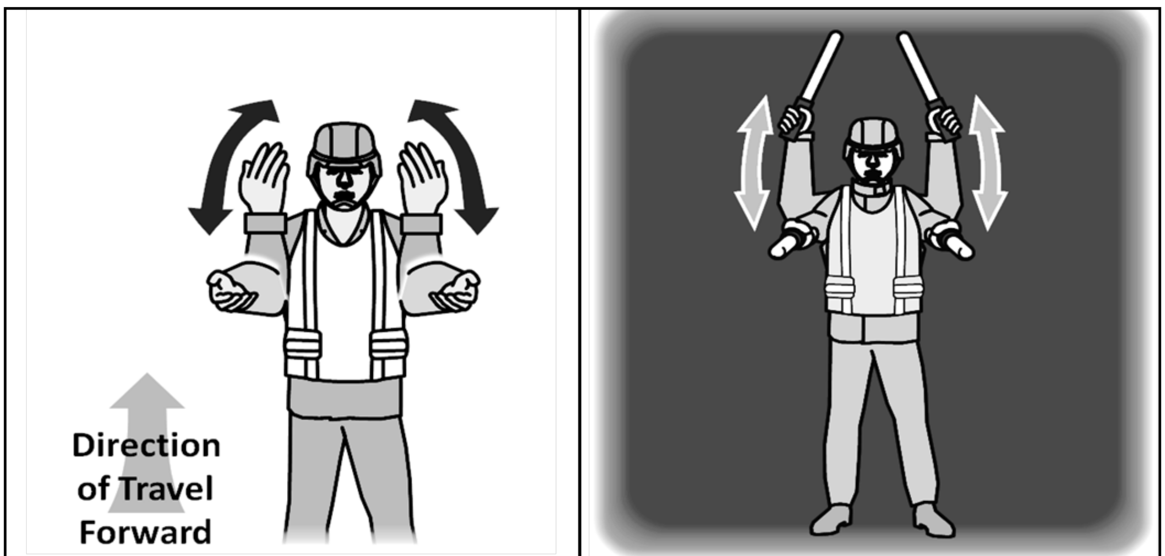
Figure B-2. Signal for start engine



DECREASE SPEED, SLOW DOWN (Day): Extend the arm horizontally sideward, palm facing down, and wave arm downward several times, keeping the arm straight. (The arm is not moved above the horizontal plane.)

DECREASE SPEED, SLOW DOWN (Night): Face the vehicle, and hold the right wand out to the side, horizontal at shoulder level. Swing the wand to waist level, holding it horizontal. Repeat the swinging motion until the vehicle has slowed to the appropriate speed.

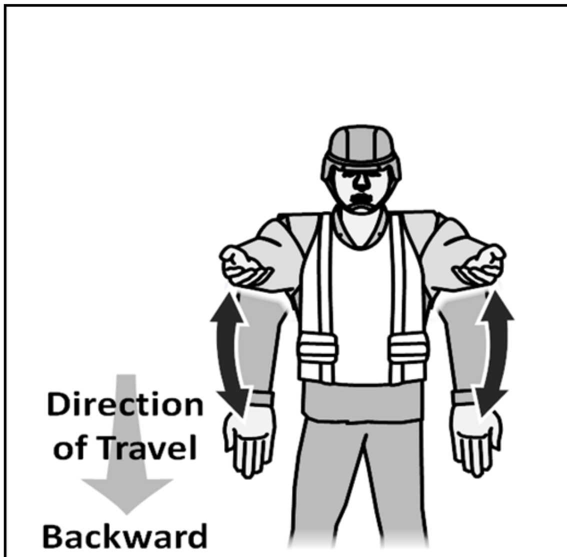
Figure B-3. Signal for decrease speed and slow down



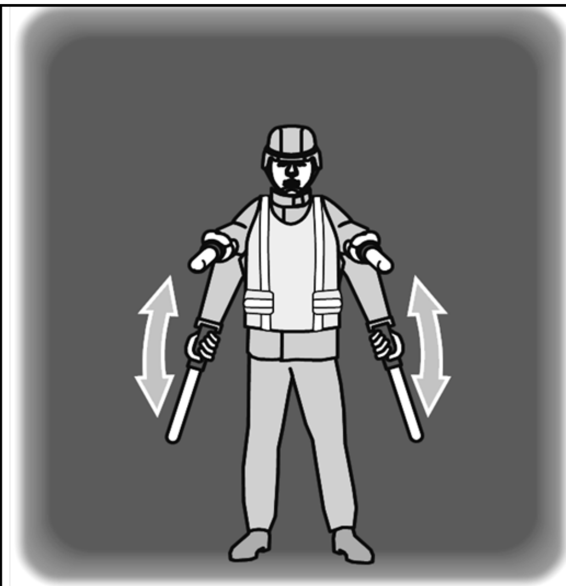
MOVE FORWARD (Day): With both hands, palm up, both arms horizontally to the front, point toward vehicle operator. Then signal by repeatedly motioning upward, moving the hands to the side of the head.

MOVE FORWARD (Night): Hold both lights With both hands, arms horizontally to the front, point toward vehicle operator. Then signal by repeatedly motioning upward, moving the lights to the side of the head.

Figure B-4. Signal for move forward

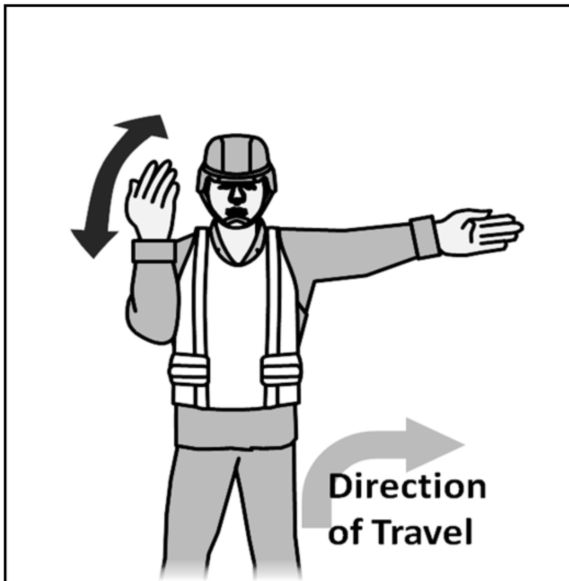


MOVE BACKWARD (Day): Raise the hands repeatedly form sides to chest level with the thumbs out and palms upward. (Sweep the hands in a slight forward and backward pushing motion.)

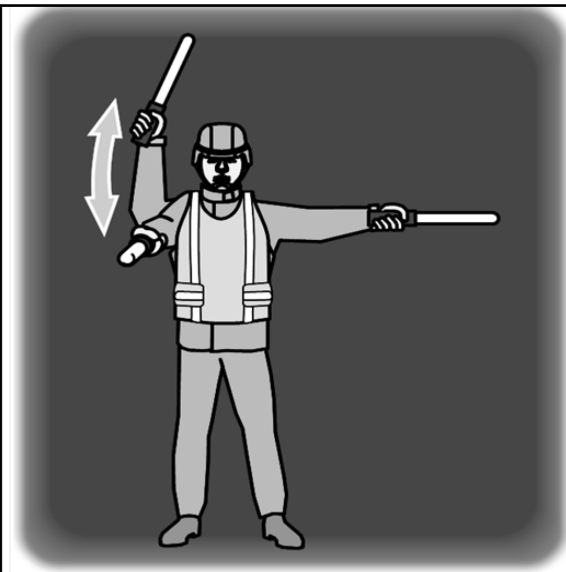


MOVE BACKWARD (Night): Raise the lights repeatedly form sides to chest level. (Sweep the lights in a slight forward and backward pushing motion.)

Figure B-5. Signal for move backward

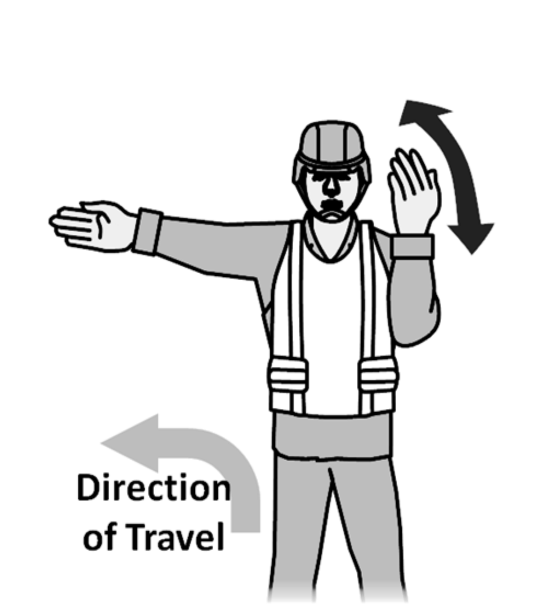


TURN RIGHT (Day): Extend the arm to the direction of travel horizontally, palm towards traffic to the indicated direction of the turn. With the other hand, make the Come Forward signal.

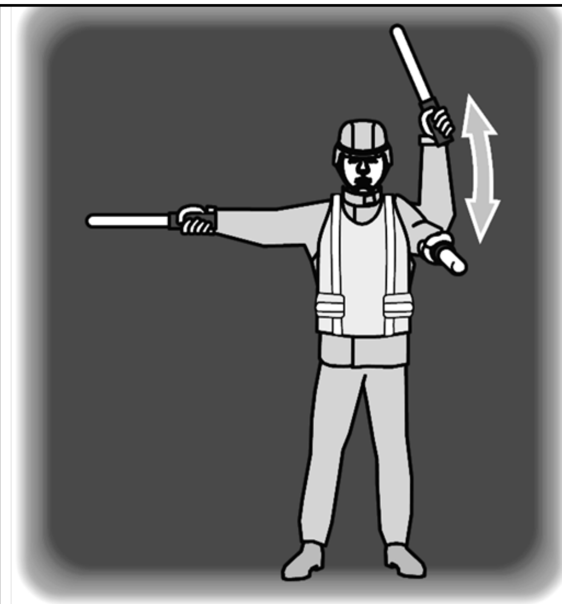


TURN RIGHT(Night): Extend the arm to the direction of travel horizontally, with the light pointed to the direction of the turn. With the other light, make the Come Forward signal.

Figure B-6. Signal for turn right

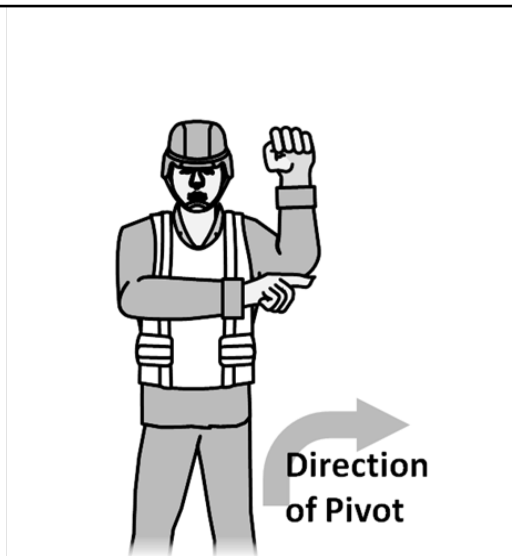


TURN LEFT: Extend the arm to the direction of travel horizontally, palm towards traffic to the indicated which way to turn. With the other hand, make the Come Forward signal.

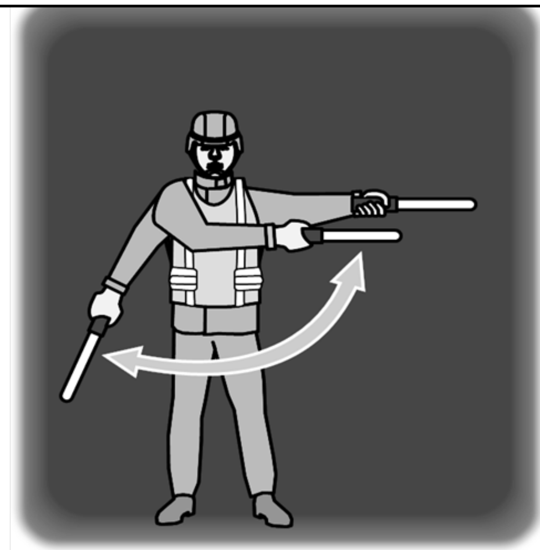


TURN LEFT(Night): Extend the arm to the direction of travel horizontally, with the light pointed to the direction of the turn. With the other light, make the Come Forward signal.

Figure B-7. Signal for turn left

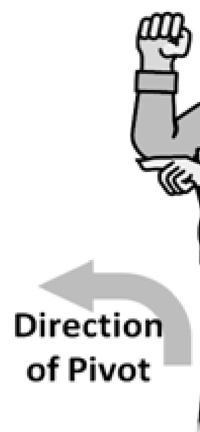


PIVOT RIGHT, Track Vehicles: Clench the left fist at head level, and point the index finger of the right hand in the direction of steer.

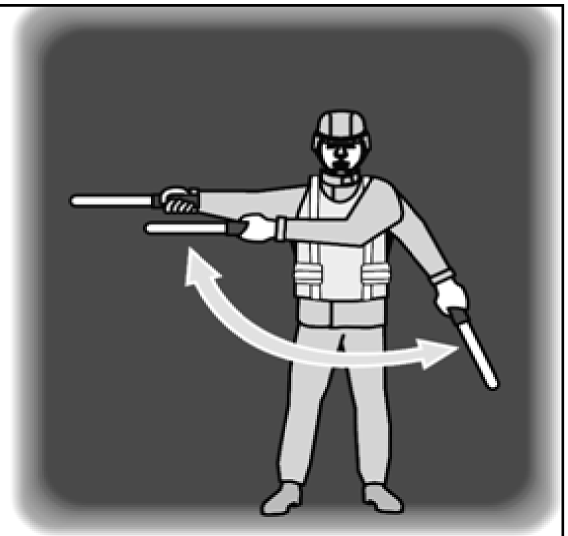


PIVOT RIGHT, Track Vehicles (Night): Extend the arm closest to the direction of travel horizontally, with the light pointed to the direction of turn. With the other light, make a repeated swing from the side of the leg to just under the extended arm with light.

Figure B-8. Signal for pivot right



PIVOT LEFT, Track Vehicles: Clench the right fist at head level, and point the index finger of the left hand in the direction of steer.



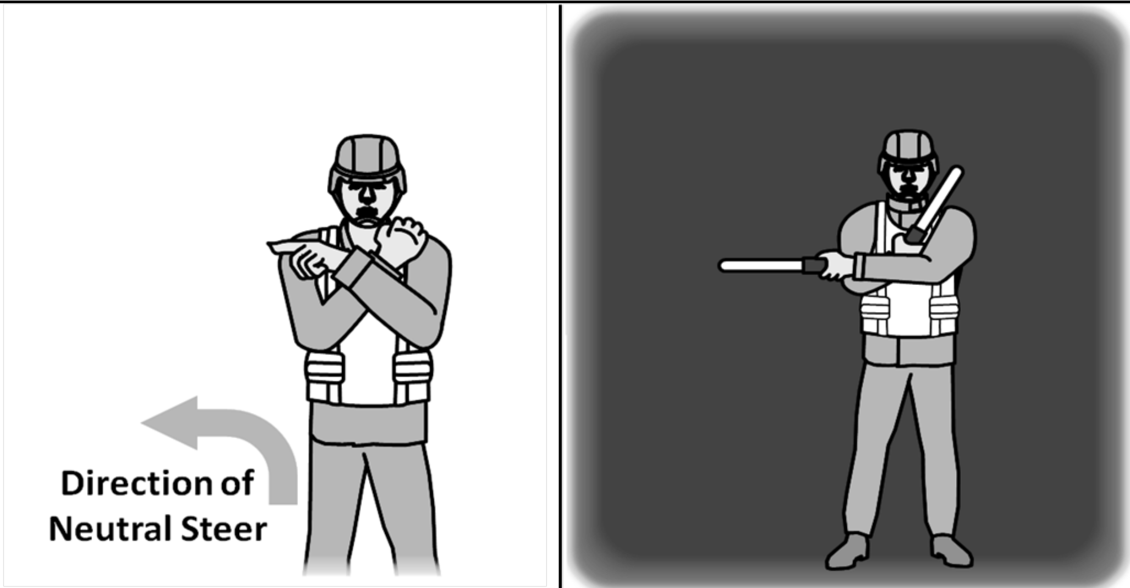
PIVOT LEFT, Track Vehicles (Night): Extend the arm closest to the direction of travel horizontally, with the light pointed to direction of turn. With the other light, make a repeated swing from the side of the leg to just under the extended arm with light.

Figure B-9. Signal for pivot left

NEUTRAL STEER RIGHT, Track Vehicles: Cross the wrists at the throat; point the index finger of the right hand toward the left. Make a fist with the left hand.

NEUTRAL STEER RIGHT, Track Vehicles (Night): Place the left light against the right side of the throat; Extend the right arm with the light horizontally toward the direction of turn.

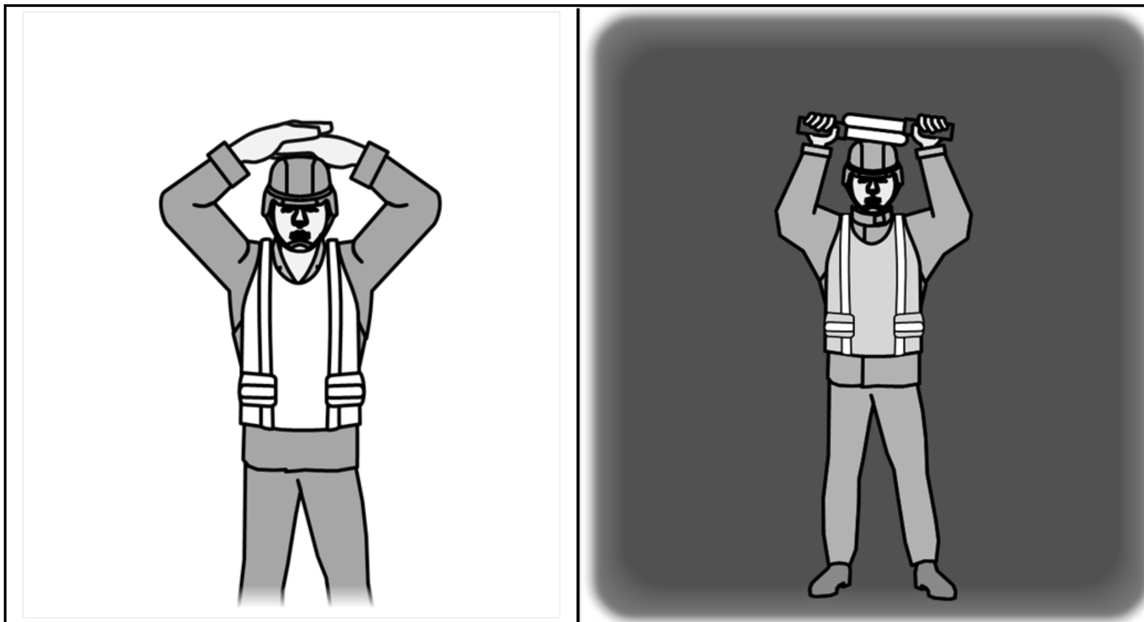
Figure B-10. Signal for neutral steer right



<u>NEUTRAL STEER LEFT, Track Vehicles:</u> Cross the wrists at the throat; point the index finger of the left hand toward the right. Make a fist with the right hand.

<u>NEUTRAL STEER LEFT, Track Vehicles (Night):</u> Place the right light against the left side of the throat; Extend the left arm with the light horizontally toward the direction of turn.

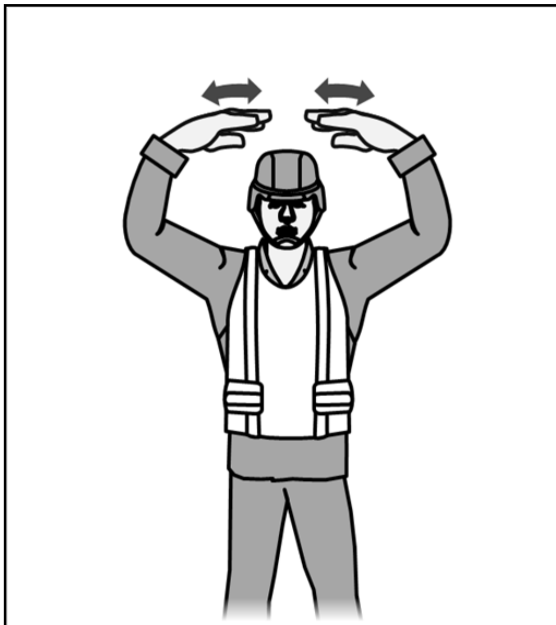
Figure B-11. Signal for neutral steer left



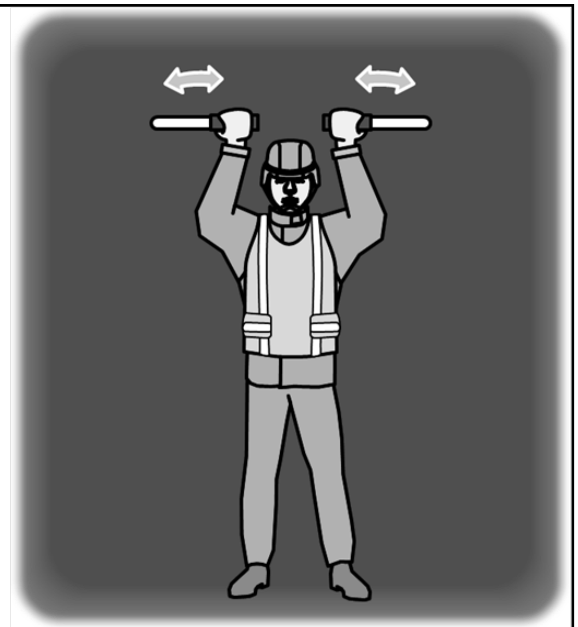
<u>BUTTON-UP:</u> Place both hands, one on the top of the other, palms down, one on top of the helmet.

<u>BUTTON-UP (Night):</u> Place both lights, one on the top of the other, horizontally on top of the helmet.

Figure B-12. Signal for button-up

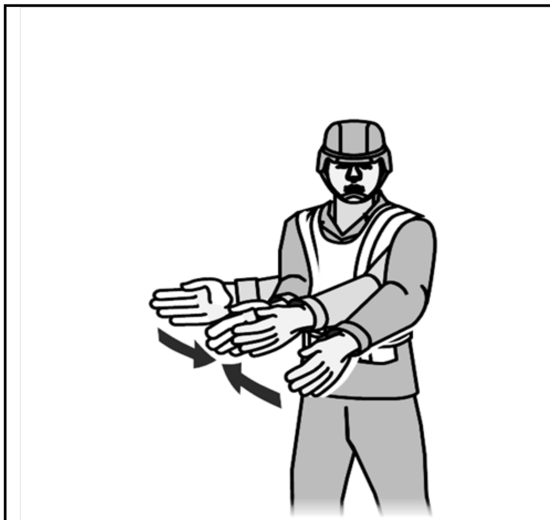


UNBUTTON: Start from the button-up signal; then separate the hands, moving them to each side. Repeat..

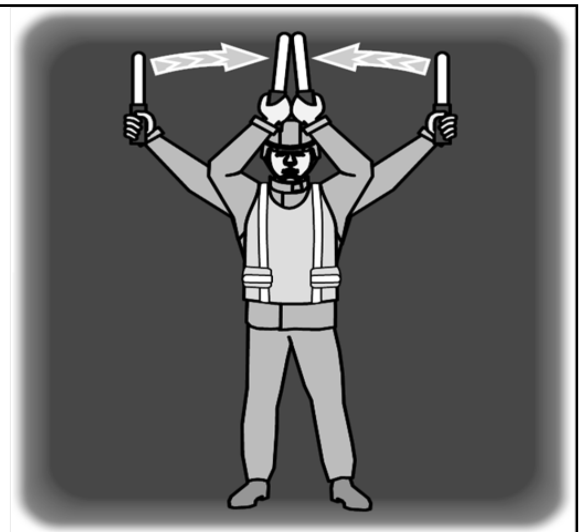


UNBUTTON (Night): Start from the button-up signal; then flip the lights outwards, moving them slightly back and forth. Repeat

Figure B-13. Signal for unbutton

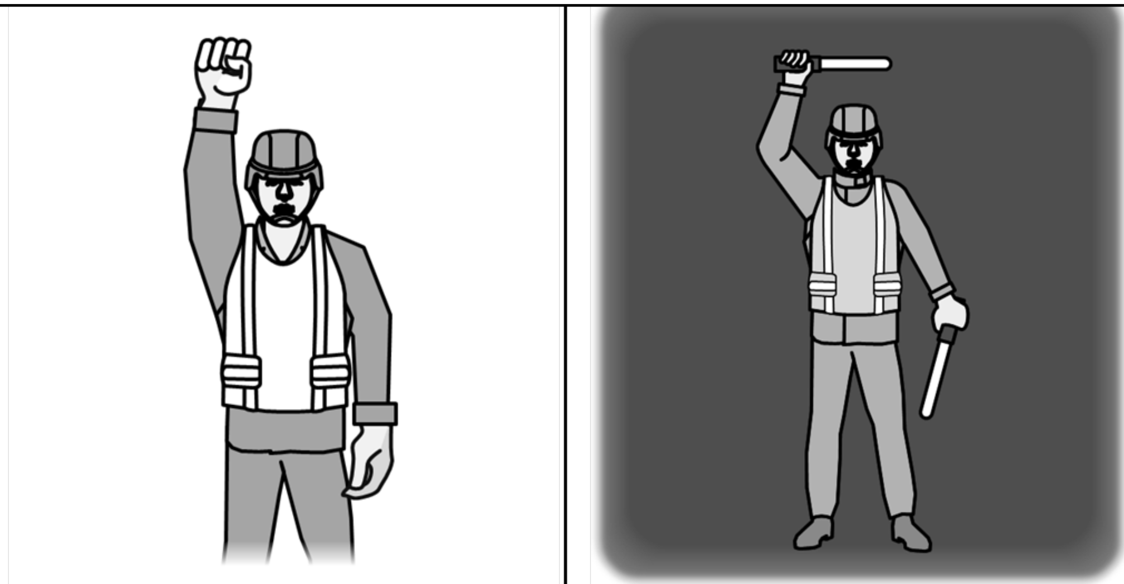


CLOSE THE DISTANCE & STOP: This Far To Go - Extend the forearms to the front, palms inward and separated (about 3 feet). Bring palms together as the driver approaches the target stop point. The driver stops when palms come together.



CLOSE THE DISTANCE & STOP (Night): This Far To Go - Extend the lights over head, tips pointed upward and separated (about 3 feet). Bring lights together as the driver approaches the stop point. The driver stops when lights touch.

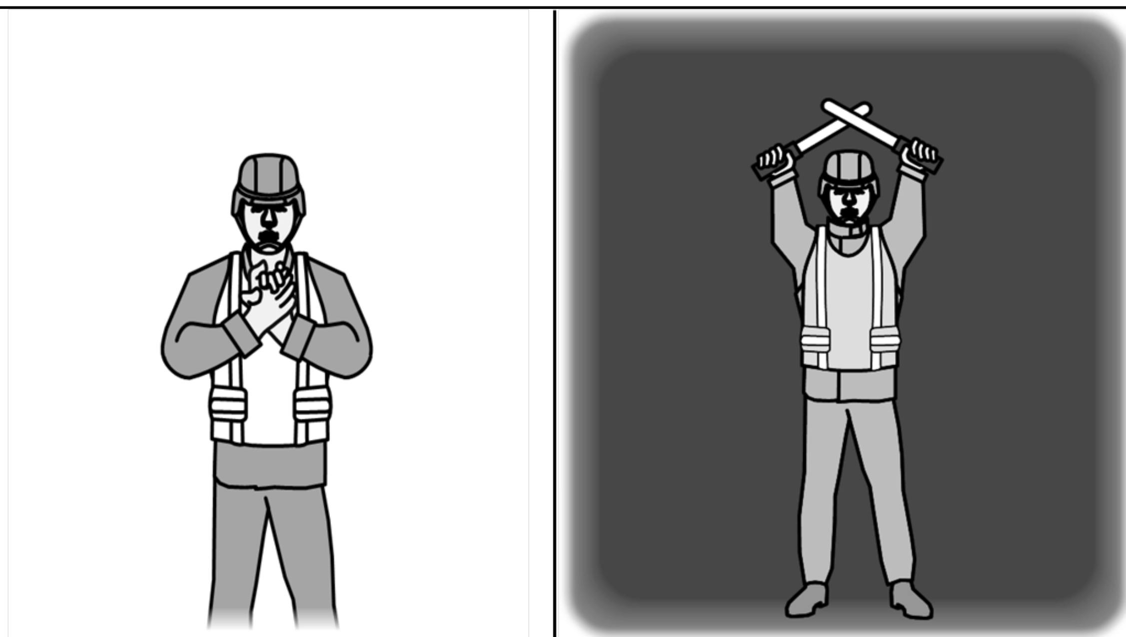
Figure B-14. Signal for close the distance and stop



EMERGENCY STOP: Raise either arm with clenched fist. The other hand may briefly point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation)*

EMERGENCY STOP (Night): Raise either arm with light held horizontally. The other hand may briefly point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation)*

Figure B-15. Signal for emergency stop

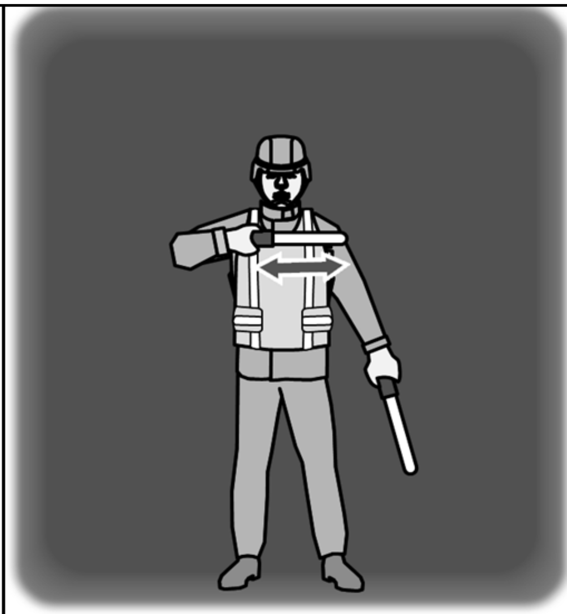


STOP: Clasp hands together palm to palm just below the chin.

STOP (Night): Cross lights over the head.

Figure B-16. Signal for stop

STOP ENGINES: Extend an arm horizontally under the chin, hand open, palm down, and move the arm across the body in a throat-cutting motion.



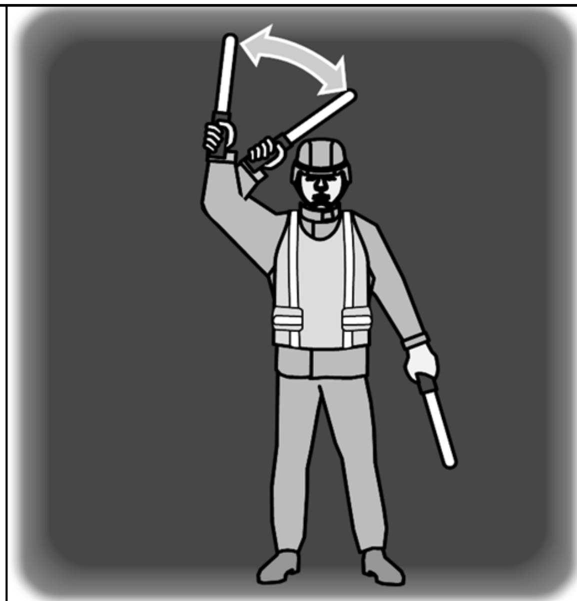
STOP ENGINES (Night): Hold the light horizontally under the chin, and move the arm across the body in a throat-cutting motion.

Figure B-17. Signal for stop engine

MOBILE CRANE OPERATION GUIDE HAND AND ARM SIGNALS

B-6. These signals are to be used during crane operations day and night.

ATTENTION: Raise and extend the arm overhead. Move it to the right and left. *(Do not make a circular motion)*



ATTENTION (Night): Raise and extend the arm overhead with the light pointed up. Move it to the left and right. *(Do not make a circular motion.)*

Figure B-18. Signal for attention

START ENGINES: Move the arm with fist in a large circular motion, simulating the motion of crank starting an engine.

START ENGINES (Night): Move the light in a horizontal figure 8, at waist level.

Figure B-19. Signal for start engine

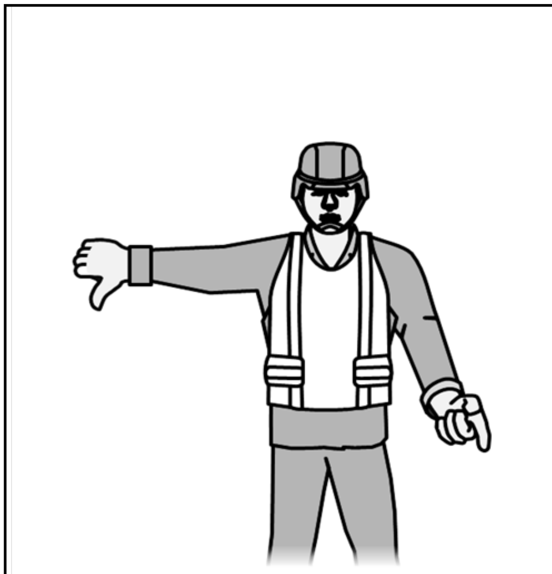
	
LOWER SPADE/OUTRIGGERS: First, point at the spade with the index finger of the left hand. Then, extend the right arm to the side, clenching a fist, and point the thumb downward.	LOWER SPADE/OUTRIGGERS (Night): First, point at the spade with the light on the left hand. Then, extend the right arm to the side, and point the right light downward.

Figure B-20. Signal for lower spade/outriggers

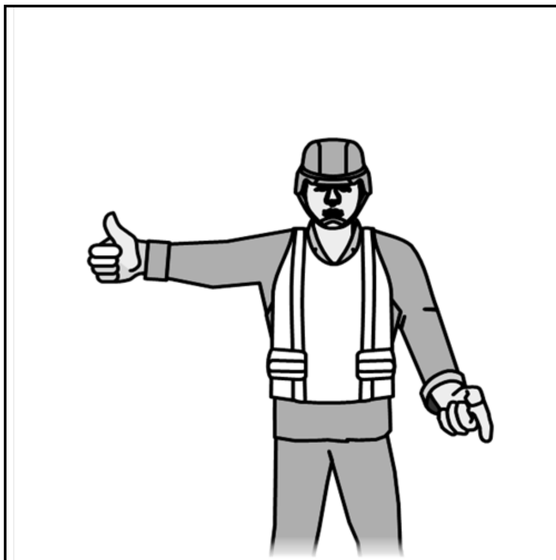
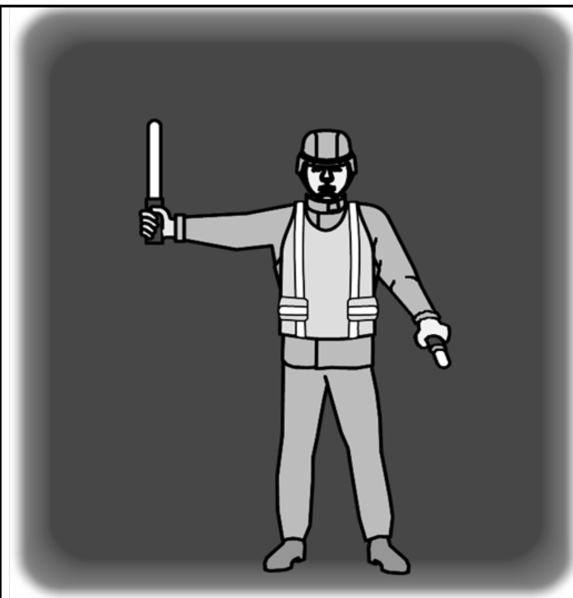
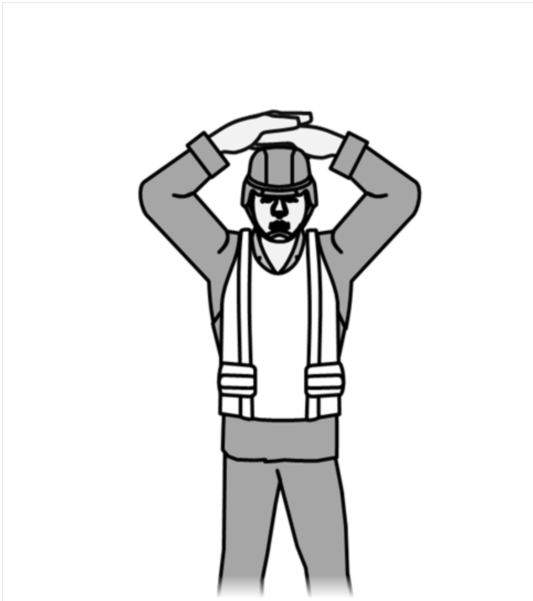
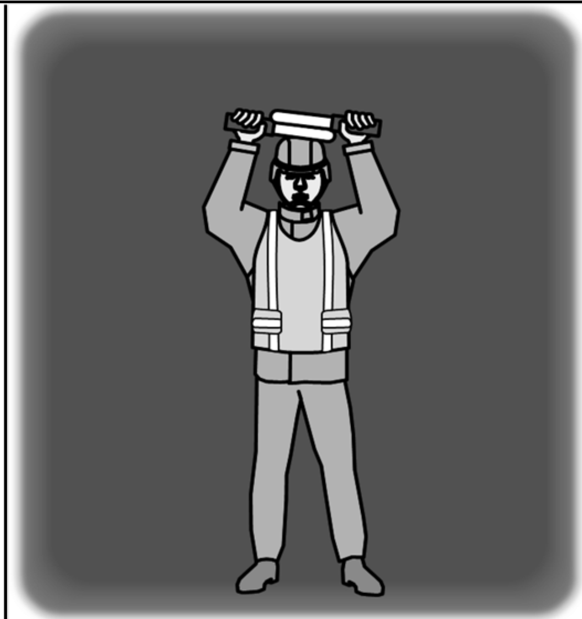
	
RAISE SPADE/OUTRIGGERS: First, point at the spade with the index finger of the left hand. Then, extend the right arm with the arm slightly bent upward at the elbow while clenching a fist, and point the thumb upward.	RAISE SPADE/OUTRIGGERS (Night): First point at the spade with the light on the left hand. Then, extend the right arm to the side, and point the right light upward.

Figure B-21. Signal for raise spade/outriggers

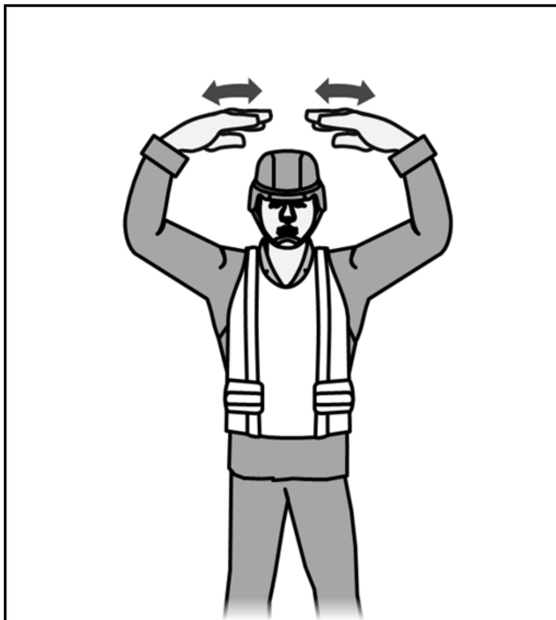


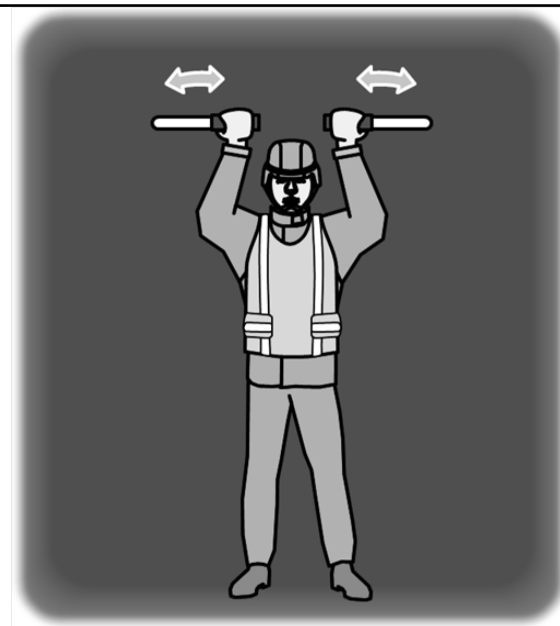


BUTTON-UP: Place both hands, one on the top of the other, palms down, one on top of the helmet.

BUTTON-UP (Night): Place both lights, one on the top of the other, horizontally on top of the helmet.

Figure B-22. Signal for button-up

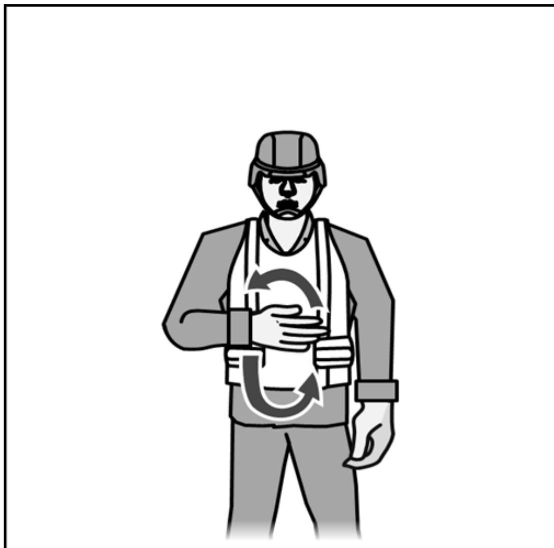




UNBUTTON: Start from the button-up signal; then separate the hands, moving them to each side. Repeat..

UNBUTTON (Night): Start from the button-up signal; then flip the lights outwards, moving them slightly back and forth. Repeat

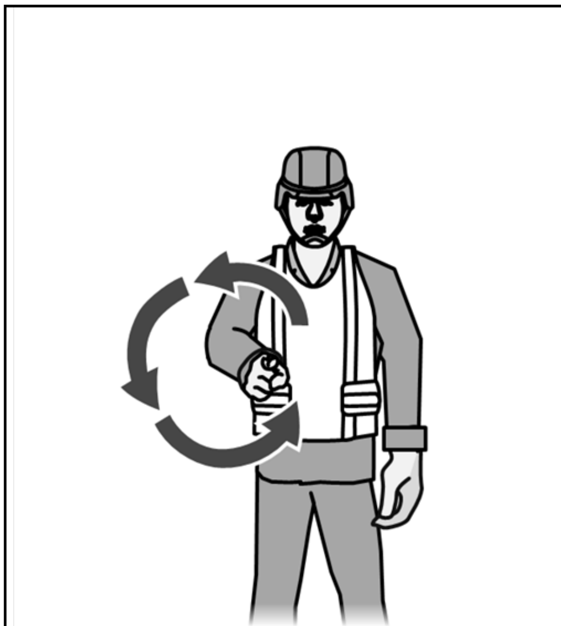
Figure B-23. Signal for unbutton



PAYOUT THE WINCH CABLE: With the arm bent, bring the hand in front of the chest. Move the hand down and away from the body at belt level, circling back to the chest. The circular motion is continued until the stop signal is given.

PAYOUT THE WINCH CABLE (Night): With the arm bent, bring the light in front of the chest. Move the wand down and away from the body at belt level, circling back to the chest. The circular motion is continued until the stop signal is given.

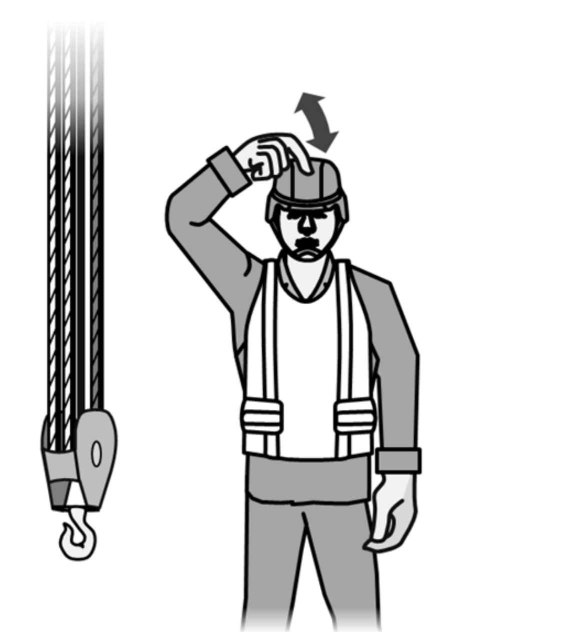
Figure B-24. Signal for payout the winch cable



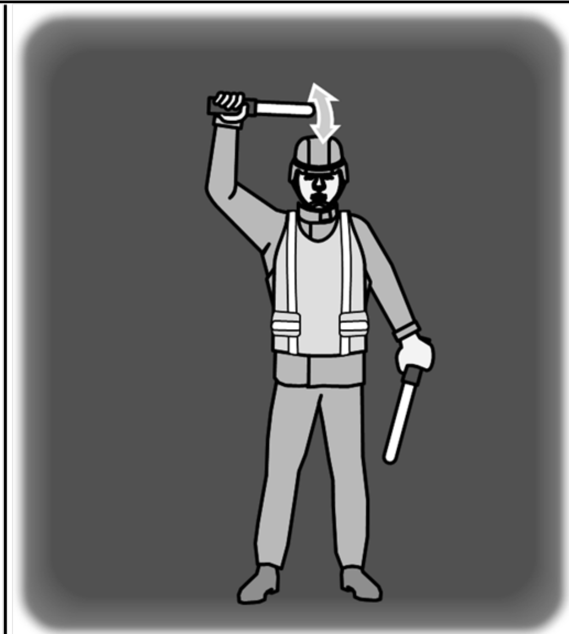
INHAUL THE MAIN WINCH CABLE: Point at the operator with the index finger and rotate the arm in circular motion.

INHAUL THE MAIN WINCH CABLE (Night): Point at the operator with the light, and rotate the arm in circular motion.

Figure B-25. Signal for inhaul the main winch cable

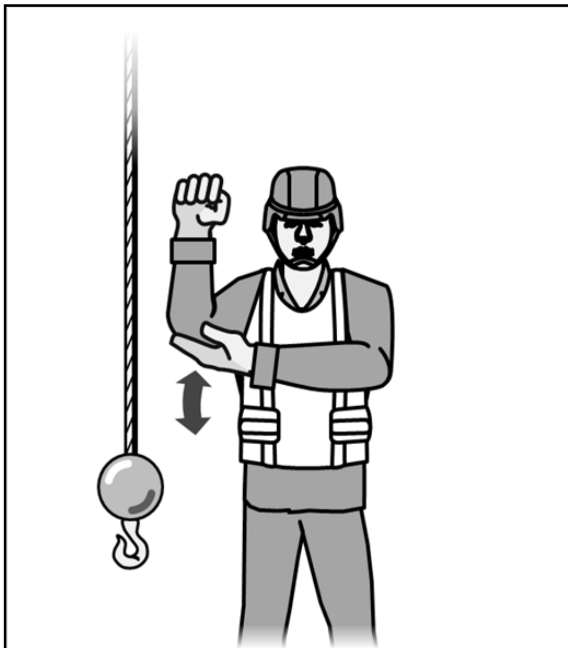


USE MAIN LINE: Tap the top of the helmet with the forefinger, three or four times.

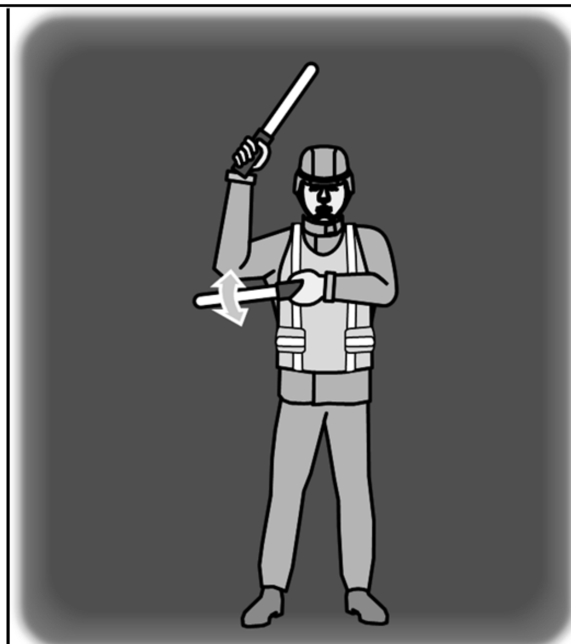


USE MAIN LINE (Night): Tap the top of the helmet with the tip of the light, three or four times.

Figure B-26. Signal for use the main line

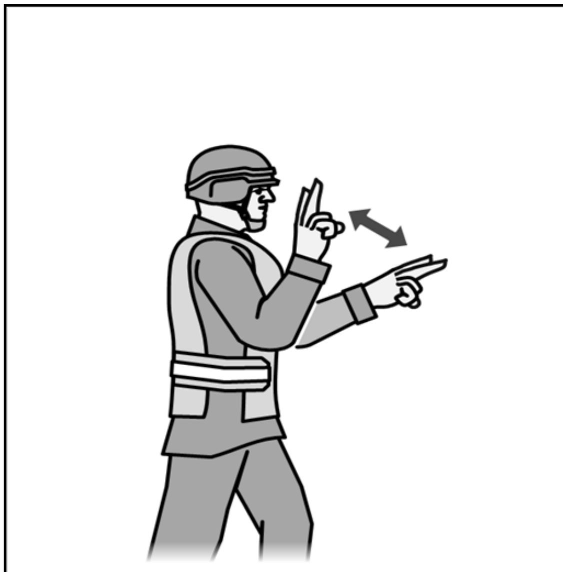


USE WHIP LINE: Tap the elbow of the raised forearm, three or four times.



USE WHIP LINE (Night): Tap the elbow of the raised forearm, three or four times with the light.

Figure B-27. Signal for use the main line



RETRACT THE BOOM: Extend the index and center finger upward, with the palm of the hand facing the operator. Move the hand back and forth away from the chest, bending at the elbow slowly in a pumping action.

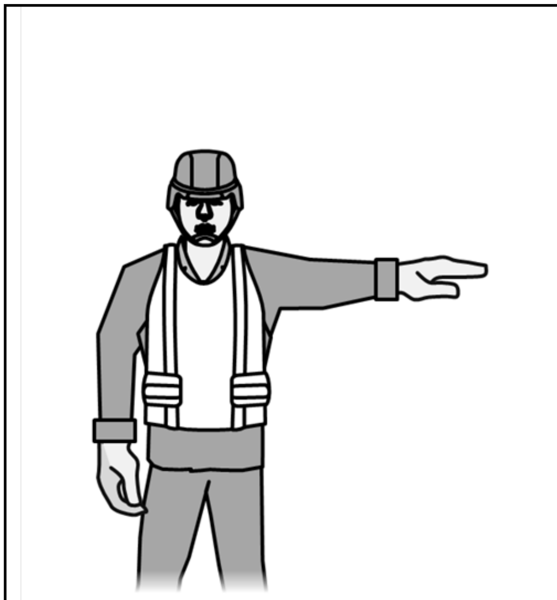
RETRACT THE BOOM (Night): Hold the light against the chest, with the bright end pointing outward. Move the light back and forth from the chest, bending at the elbow slowly in a pumping action.

Figure B-28. Signal for retract the boom

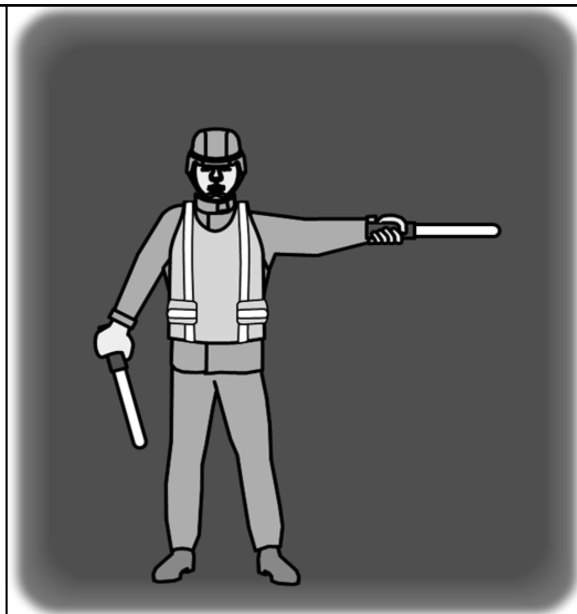
EXTEND THE BOOM: Extended the index and center fingers upward, with the back of the hand facing the operator. Move the hand back and forth from the chest, bending the elbow slowly in a pumping action.

EXTEND THE BOOM (Night): Hold the light against the chest, with the bright end touching the chest. Move the light back and forth from the chest, bending at the elbow slowly in a pumping action.

Figure B-29. Signal for extend the boom

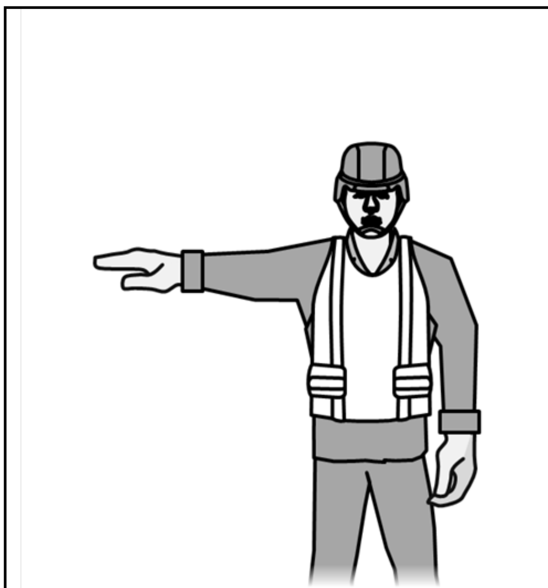


SWING BOOM, RIGHT: Extend the left arm to shoulder level, with the whole hand horizontally pointing in the direction the operator must traverse.

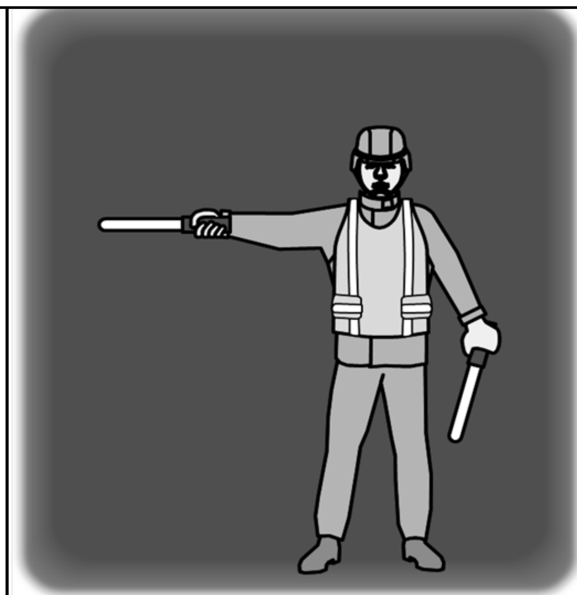


SWING BOOM, RIGHT (Night): Extend the left arm to shoulder level, holding the light horizontally in the direction the operator must traverse.

Figure B-30. Signal for swing the boom to the right

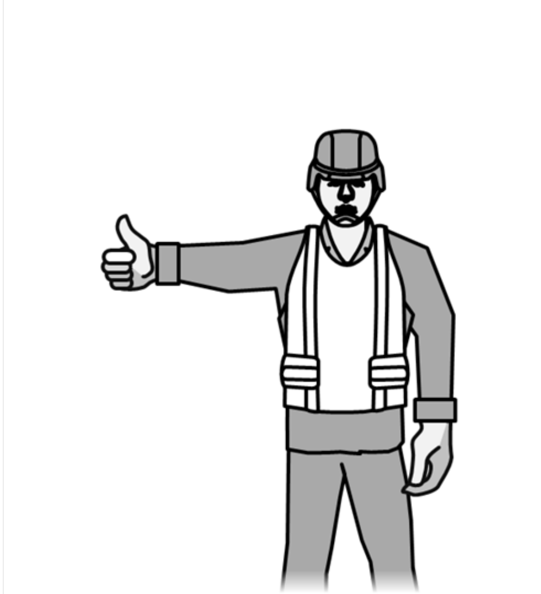


SWING BOOM, LEFT: Extend the right arm to shoulder level, with the whole hand pointing horizontally in the direction the operator must traverse.

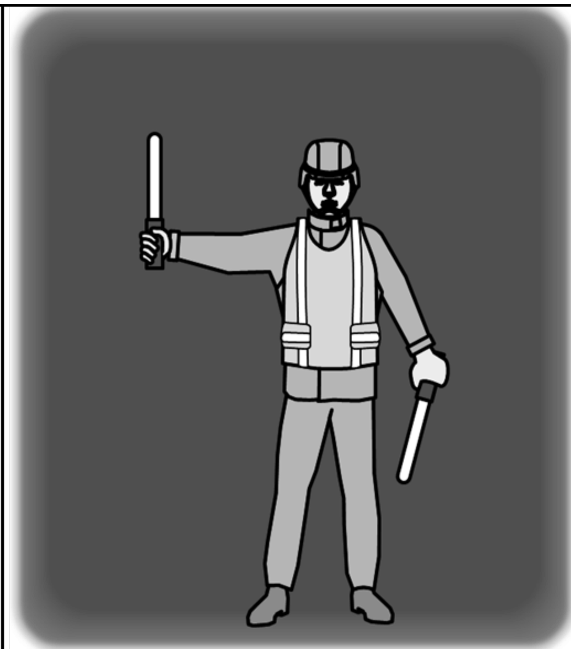


SWING BOOM, LEFT (Night): Extend the left arm to shoulder level, holding the light horizontally in the direction the operator must traverse.

Figure B-31. Signal for swing the boom to the left

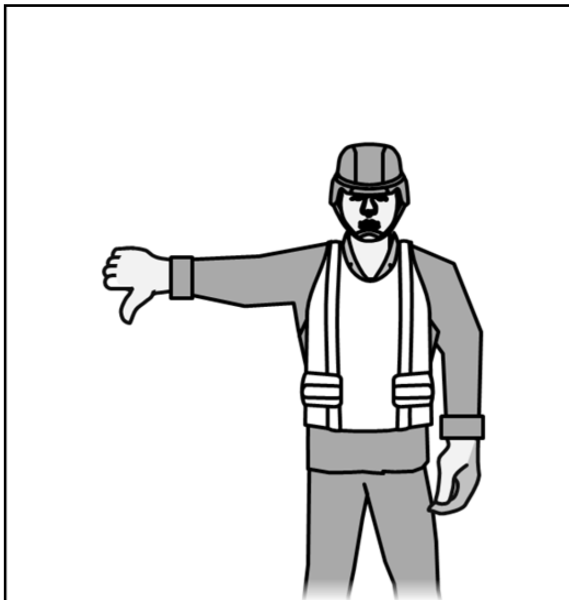


<u>RAISE THE BOOM:</u> Extend an arm to the side, with the fist clenched, and point the thumb upward. This signal may be made with either hand.



<u>RAISE THE BOOM (Night):</u> Extend an arm to the side, with light pointed upward. This signal may be made with either hand.

Figure B-32. Signal for raise the boom



<u>LOWER THE BOOM:</u> Extend the arm to the side, with the fist clenched, and thumb pointed downward. This signal may be made with either hand.

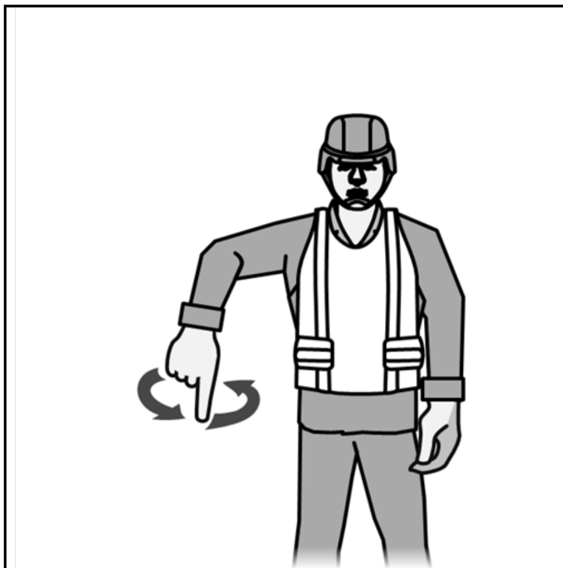
<u>LOWER THE BOOM (Night):</u> Extend an arm to the side, with light pointed downward. This signal may be made with either hand.

Figure B-33. Signal for lower the boom

RAISE THE HOIST CABLE: Extend out the arm to the side, bent upward at the elbow, extend the index finger from a fist. Rotate the hand slowly. This signal may be made with either hand , rotation made in either direction .

RAISE THE HOIST CABLE (Night): Hold out the arm to the side, bent upward at the elbow, and point the light upward. Rotate the hand slowly. This signal may be made with either hand with rotation made in either direction.

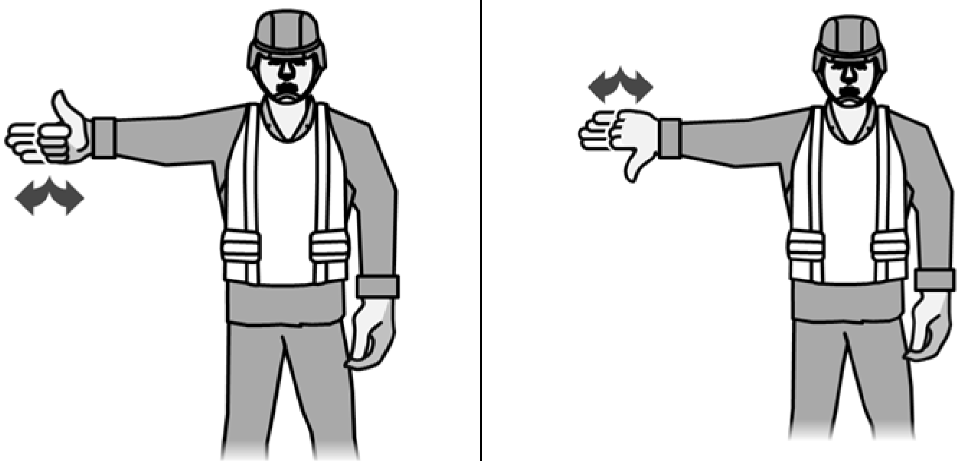
Figure B-34. Signal for raise the hoist cable



LOWER THE HOIST CABLE: Hold the arm downward and out slightly from the side, extend the index finger from a fist, and rotate the hand slightly. This signal may be made with either hand , rotation made in either direction.

LOWER THE HOIST CABLE (Night): Hold the arm downward and out slightly from the side, with the light pointed down, rotate the light slightly. This signal may be made with either hand with rotation made in either direction.

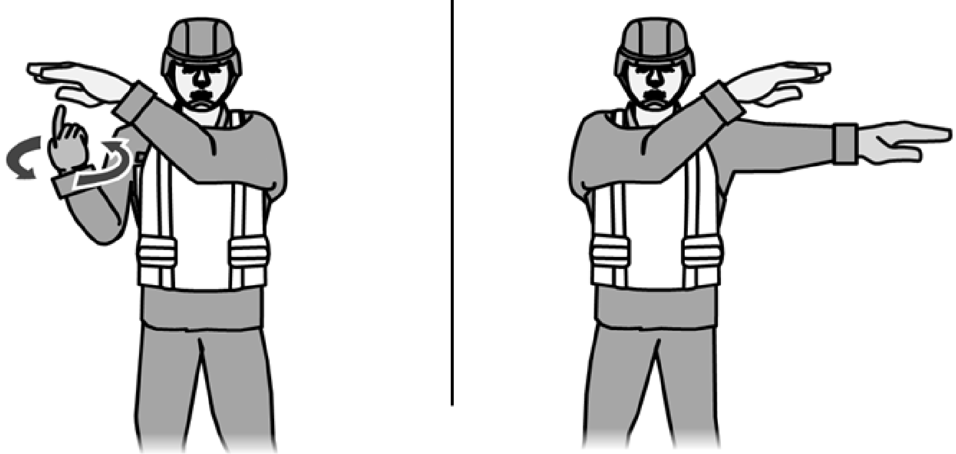
Figure B-35. Signal for lower the hoist cable



RAISE BOOM & LOWER THE LOAD: Extend arm, thumb pointed up, flex fingers in and out as long as load movement is desired. *(This moves the load horizontally toward the crane.)*

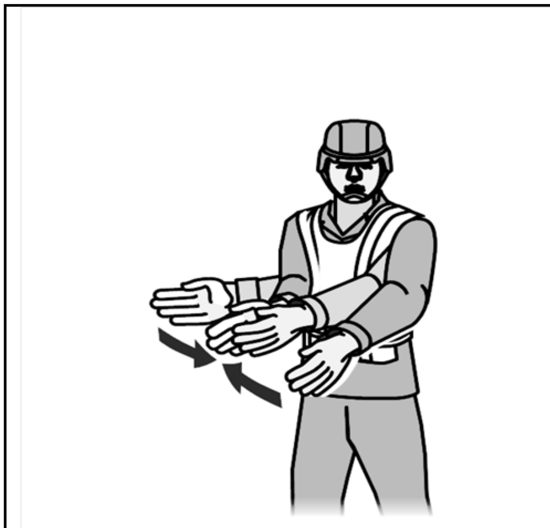
LOWER BOOM & RAISE THE LOAD: Extend arm, thumb pointed down, flex fingers in and out as long as load movement is desired . *(This moves the load horizontally away from the crane.)*

Figure B-36. Signal for raise boom, lower load & lower boom, raise load

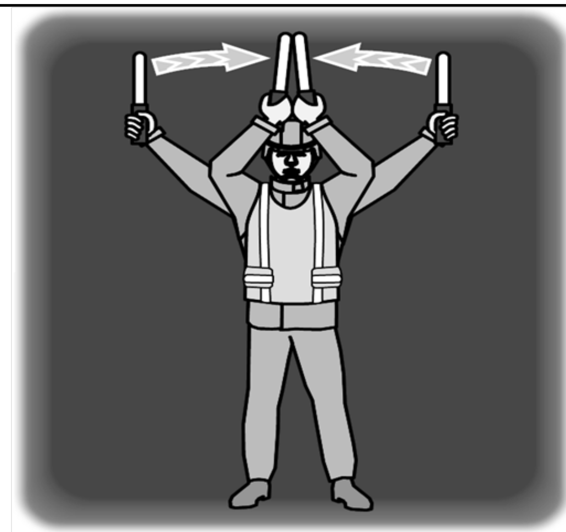


MOVE SLOWLY: Use one hand to give any motion signal, and hold the other hand motionless palm down just above the signaling hand (e.g., Hoist UP - Slowly, and Swing Boom Right - Slowly).

Figure B-37. Signal for move slowly



CLOSE THE DISTANCE & STOP: This Far To Go - Extend the forearms to the front, palms inward and separated (about 3 feet). Bring palms together as the driver approaches the target stop point. The driver stops when palms come together.



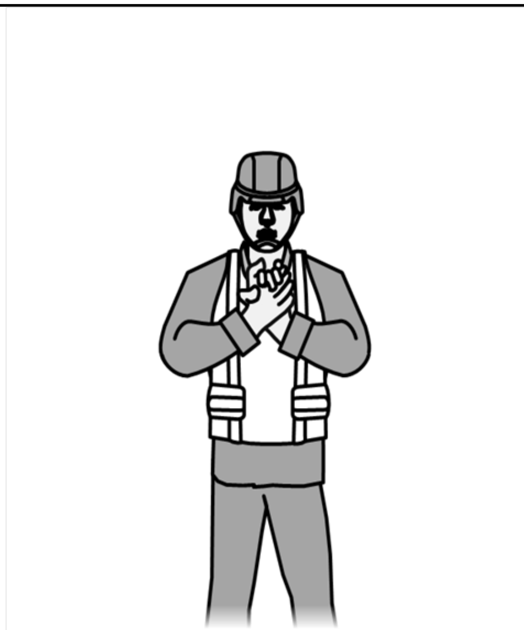
CLOSE THE DISTANCE & STOP (Night): This Far To Go - Extend the lights over head, tips pointed upward and separated (about 3 feet). Bring lights together as the driver approaches the stop point. The driver stops when lights touch.

Figure B-38. Signal for close the distance and stop

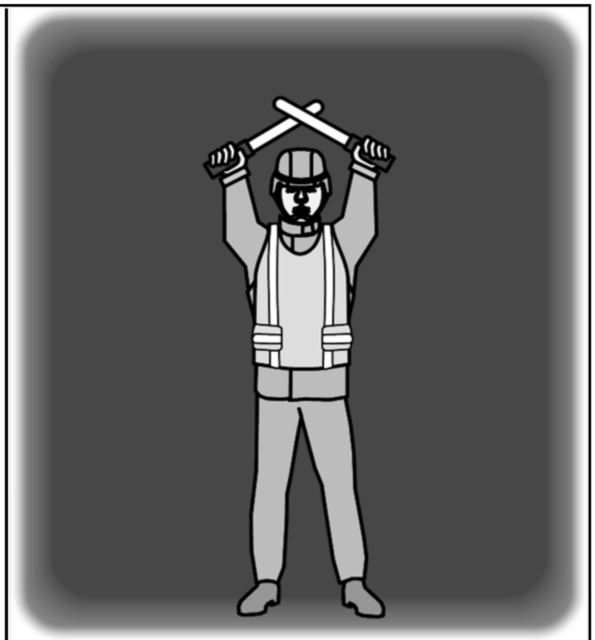
EMERGENCY STOP: Raise either arm with clenched fist. The other hand may briefly point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation)*

EMERGENCY STOP (Night): Raise either arm with light held horizontally. The other hand may briefly point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation)*

Figure B-39. Signal for emergency stop

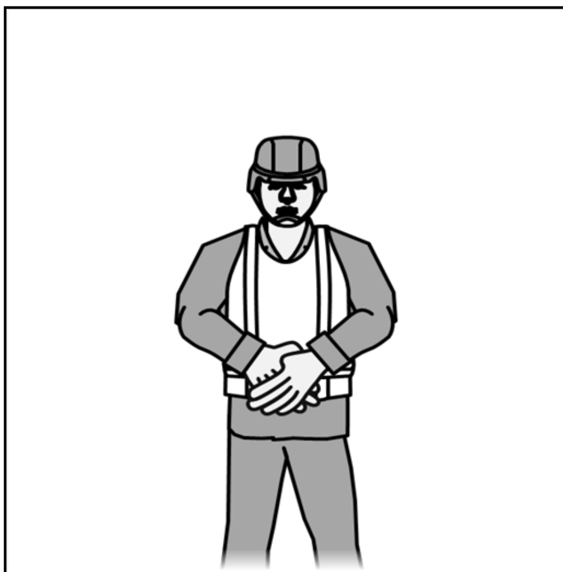


STOP: Clasp hands together palm to palm just below the chin.

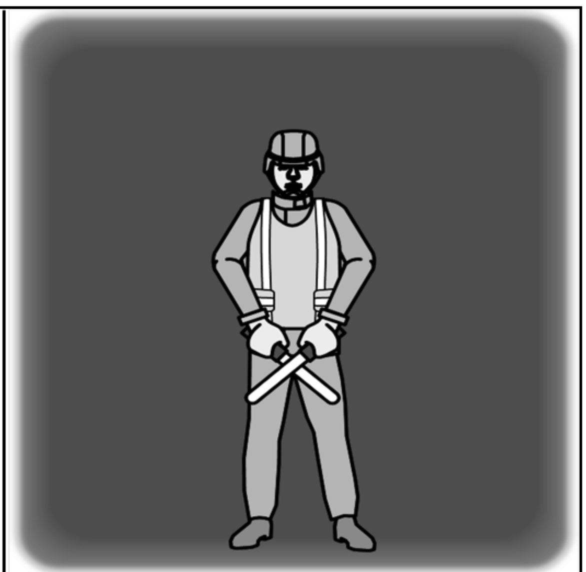


STOP (Night): Cross lights over the head.

Figure B-40. Signal for stop

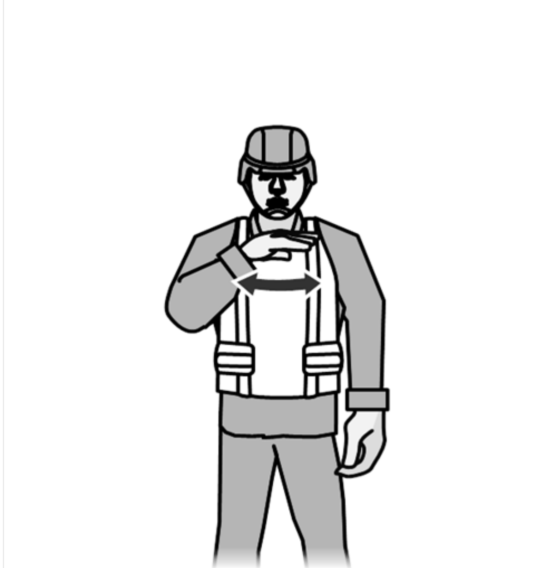


DOG EVERYTHING: Clasp hands in front of the lower body. Stop, shift to park, set brakes, and lock all other systems to prevent further movement. (Turning off the engine or power is a separate signal.)

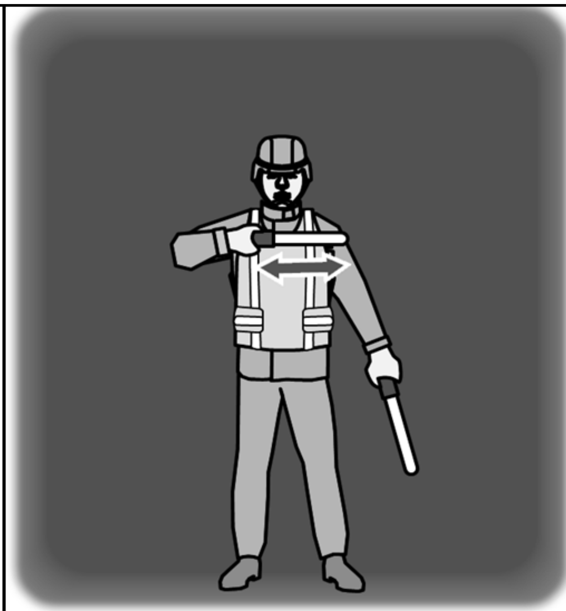


DOG EVERYTHING (Night): Cross lights in front of the lower body. (Stop, shift to park, set brakes, and lock all other systems to prevent further movement. (Turning off the engine or power is a separate signal.)

Figure B-41. Signal for dog everything



STOP ENGINES: Extend an arm horizontally under the chin, hand open, palm down, and move the arm across the body in a throat-cutting motion.



STOP ENGINES (Night): Hold the light horizontally under the chin, and move the arm across the body in a throat-cutting motion.

Figure B-42. Signal for stop engine

Note. Refer to FM 21-60 for more information on hand and arm signals and using flashlights during night operations.

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Appendix C

Recovery Guidelines for Operators/Leaders

Mission success on the battlefield may be linked to a unit's ability to perform vehicle recovery, to return immobilized equipment to operation, and to continue with the mission. Commanders must take aggressive actions to retrieve damaged equipment and return it to use. However, for a recovery operation to be successful, operators and leaders at all levels must be trained on recovery operations.

OPERATOR AND CREW

C-1. When the operator/crew detects disabled equipment, the damage is assessed and actions are initiated based on analysis results and the tactical situation. The crew/operator informs the chain of command of the status of the disabled equipment. Unit SOPs should prescribe notification procedures since these vary based on the type of unit, equipment, communications, and location of equipment.

C-2. The operator/crew will be trained to perform self-recovery and like-recovery on assigned equipment. This training will be practiced during garrison/field training exercises as prescribed in the unit's SOP.

C-3. The operator/crew normally remains with the disabled equipment to provide local security and until assistance arrives. When the maintenance personnel arrive, the operator/crew assists with the repair or recovery and stays with the vehicle until it reaches support maintenance.

Note. When the maintenance personnel arrive, the operator/crew assists with the repair or recovery and stays with the vehicle until it reaches support maintenance.

C-4. The following is a list of key items the operator/crew should know before requesting recovery from support elements:

- Location, map coordinates, and type of terrain.
- Nature of the disability.
- Tactical situation.
- Can BDAR be applied?
- Has BDAR been applied?
- Repair parts required, if known.
- Alternate radio frequencies.

RECOVERY PERSONNEL

C-5. Recovery equipment operators are usually highly trained mechanics and very familiar with the mechanical functions of equipment they must recover. These personnel must be skilled in the technical aspects of recovery, such as equipment rigging, towing, and uprighting procedures. They must also be skilled in related tasks—such as using the specialized BII on assigned equipment and operating in a tactical environment. Recovery equipment operators are assigned to company maintenance teams and to the recovery support section of the maintenance platoon. Personnel participating in recovery operations must be trained to check for and clear or disarm weapon systems of supported equipment. Specific procedures for the disposition of contaminated equipment, contingency plans, and any special tactical or security considerations should be covered in the unit SOP.

C-6. Recovery personnel are mechanics who perform repairs when not engaged in recovery missions. The following is a list of key items recovery personnel must know.

- Oxygen and acetylene tank operations for welding.
- Cutting torches.

- .50-caliber machine gun.
- Communications (both radio, and hand and arms signals).
- Map reading, compass use, and global positioning system.
- Chemical and biological agents.

C-7. Those conducting repair or recovery need to have a plan for recovery operations. The unit SOP will contain detailed checklists to assist in preparing for on-site support. Preparation should include:

- A verification of location and the status of disabled equipment.
- An update on the current tactical situation.
- A selection of primary and alternate routes.
- The availability of communications, to include communications checks, applicable call signs, and primary and alternate frequencies.
- Individual clothing and equipment, with emphasis on CBRN equipment.
- A basic load of rations and ammunition to support a 24-hour continuous operation.
- A selection of appropriate support equipment, vehicles, and personnel required for the mission.

C-8. Recovery teams need to be aware of classified communications devices and components, and other classified materials. This will assist with maintaining proper security and reducing chances of compromise.

LEADERS

C-9. Platoon leaders and platoon sergeants have the responsibility for coordinating recovery assets and manpower requirements for disabled equipment. This effort is performed simultaneously with the mission, and if the recovery mission interferes with combat operations or in any way compromises security, it must be coordinated with the tactical commander.

C-10. Leaders should be trained on the same tactical procedures as recovery personnel so they can periodically check the rigging and equipment for proper hookups and adjustments. (Special attention must be given to weight and clearance limitations when using bridges or underpasses.) The following is a list of factors that leaders should determine before supervising or requesting recovery support.

- Equipment identification.
- Alternate radio frequencies.
- Location (map coordinates if possible).
- Alternate routes (when possible).
- The condition of the disabled vehicle.
- On site repair capability.
- Repair parts required.
- The organic recovery capability.
- Tactical situation and security requirements, and risk level.
- Cargo, road, and movement restrictions.

C-11. The recovery manager and leader must be alert to new situations and changing requirements. Planning and prior preparation are needed for continued effective recovery support.

C-12. Specific leader, mechanic and operator BDAR training should encompass the following:

- Group equipment.
- Suspension systems (short tracking).
- Electrical systems (bypassing components, wire repair).
- Cooling systems (radiator bypass and repair).
- Fuel systems (patching holes, replacing or making lines sections).
- Hydraulic/oil systems (repair high pressure lines, repair oil lines).
- Tire and track repair.
- Risk assessment procedures.

- BDAR assessment procedures.
- BDAR TM familiarization.
- BDAR kit familiarization.

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Glossary

SECTION I – ACRONYMS AND ABBREVIATIONS

AE	available effort
AR	Army regulation
ATP	Army techniques publication
BDAR	battle damage assessment and repair
BII	basic issue item
CBRN	chemical, biological, radiological, and nuclear
BS	breaking strength
DA	Department of the Army
DD	Department of Defense
FS	factor of safety
FM	field manual
GTA	graphic training aid
lb	pound
MA	mechanical advantage
MCRP	Marine Corps reference publication
PLS	palletized load system
SOP	standing operating procedure
STANAG	standardization agreement (NATO)
TB	technical bulletin
TLR	total load resistance
TM	technical manual
U.S.	United States
USMC	United States Marine Corps
WLL	working load limit

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These documents must be available to intended users of this publication.

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27 AUGUST 2014

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