MCI 1373A

MARINE CORPS INSTITUTE

BASIC ENGINEER: COMBAT OPERATIONS

MARINE BARRACKS
WASHINGTON, DC

UNITED STATES MARINE CORPS

MARINE CORPS INSTITUTE
912 CHARLES POOR STREET SE
WASHINGTON NAVY YARD DC 20391-5680

IN REPLY REFER TO:
1550
Ser 1373
15 Oct 05

From: Director
To: Marine Corps Institute Student

Subj: BASIC ENGINEER: COMBAT OPERATIONS (1373A)

1. Purpose. The subject course is published to provide instruction to privates through sergeants serving in the 1371 military occupational specialty field.

2. Scope. This course addresses the roles and responsibilities of the combat engineer serving in the Marine Corps Division. This course also discusses mobility, countermobility, survivability, and demolitions operations, and skill progression training for Marines in the 13XX MOS field.

3. Applicability. This course is intended for instructional purposes only. It is designed for Marines in the ranks of private through sergeants.

4. Recommendations. Comments and recommendations on the contents of the course are invited and will aid in subsequent course revisions. Please complete the course evaluation questionnaire at the end of the final examination. Return the questionnaire and the examination booklet to your proctor.

T.M. FRANUS
By direction

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Table of Contents

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Student Information

Number and Title	MCI 1373A BASIC ENGINEER: COMBAT OPERATIONS
Study Hours	12
Course Materials	Text
Review Agency	Commanding Officer, Combat Engineer Instruction Company (CEIC), Marine Corps Engineer School, Camp Lejeune, North Carolina 26542-0069
Reserve Retirement Credits (RRC)	3
ACE	Not applicable to civilian training/education
Assistance	For administrative assistance, have your training officer or NCO log on to the MCI home page at www.mci.usmc.mil. Marines CONUS may call toll free 1-800-MCI-USMC. Marines worldwide may call commercial (202) 685-7596 or DSN 325-7596.

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Study Guide

Congratulations

Congratulations on your enrollment in a distance education course from the Distance Learning and Technologies Department (DLTD) of the Marine Corps Institute (MCI). Since 1920, the Marine Corps Institute has been helping tens of thousands of hard-charging Marines, like you, improve their technical job performance skills through distance learning. By enrolling in this course, you have shown a desire to improve the skills you have and master new skills to enhance your job performance. The distance learning course you have chosen, MCI 1373A, *Basic Engineer: Combat Operations*, provides instruction to personnel in the ranks of private through sergeant in 13XX MOS.

Your Personal Characteristics

- **YOU ARE PROPERLY MOTIVATED.** You have made a positive decision to get training on your own. Self-motivation is perhaps the most important force in learning or achieving anything. Doing whatever is necessary to learn is motivation. You have it!

- **YOU SEEK TO IMPROVE YOURSELF.** You are enrolled to improve those skills you already possess, and to learn new skills. When you improve yourself, you improve the Corps!

- **YOU HAVE THE INITIATIVE TO ACT.** By acting on your own, you have shown you are a self-starter, willing to reach out for opportunities to learn and grow.

- **YOU ACCEPT CHALLENGES.** You have self-confidence and believe in your ability to acquire knowledge and skills. You have the self-confidence to set goals and the ability to achieve them, enabling you to meet every challenge.

- **YOU ARE ABLE TO SET AND ACCOMPLISH PRACTICAL GOALS.** You are willing to commit time, effort, and the resources necessary to set and accomplish your goals. These professional traits will help you successfully complete this distance learning course.

Continued on next page

Beginning Your Course

Before you actually begin this course of study, read the student information page. If you find any course materials missing, notify your training officer or training NCO. If you have all the required materials, you are ready to begin.

To begin your course of study, familiarize yourself with the structure of the course text. One way to do this is to read the table of contents. Notice the table of contents covers specific areas of study and the order in which they are presented. You will find the text divided into several study units. Each study unit is comprised of two or more lessons and lesson exercises.

Leafing Through the Text

Leaf through the text and look at the course. Read a few lesson exercise questions to get an idea of the type of material in the course. If the course has additional study aids, such as a handbook or plotting board, familiarize yourself with them.

The First Study Unit

Turn to the first page of study unit 1. On this page, you will find an introduction to the study unit and generally the first study unit lesson. Study unit lessons contain learning objectives, lesson text, and exercises.

Reading the Learning Objectives

Learning objectives describe in concise terms what the successful learner, you, will be able to do as a result of mastering the content of the lesson text. Read the objectives for each lesson and then read the lesson text. As you read the lesson text, make notes on the points you feel are important.

Completing the Exercises

To determine your mastery of the learning objectives and text, complete the exercises developed for you. Exercises are located at the end of each lesson, and at the end of each study unit. Without referring to the text, complete the exercise questions and then check your responses against those provided.

Continued on next page

Continuing to March

Continue on to the next lesson, repeating the above process until you have completed all lessons in the study unit. Follow the same procedures for each study unit in the course.

Preparing for the Final Exam

To prepare for your final exam, you must review what you learned in the course. The following suggestions will help make the review interesting and challenging.

- **CHALLENGE YOURSELF.** Try to recall the entire learning sequence without referring to the text. Can you do it? Now look back at the text to see if you have left anything out. This review should be interesting. Undoubtedly, you'll find you were not able to recall everything. But with a little effort, you'll be able to recall a great deal of the information.

- **USE UNUSED MINUTES.** Use your spare moments to review. Read your notes or a part of a study unit, rework exercise items, review again; you can do many of these things during the unused minutes of every day.

- **APPLY WHAT YOU HAVE LEARNED.** It is always best to use the skill or knowledge you've learned as soon as possible. If it isn't possible to actually use the skill or knowledge, at least try to imagine a situation in which you would apply this learning. For example make up and solve your own problems. Or, better still, make up and solve problems that use most of the elements of a study unit.

- **USE THE "SHAKEDOWN CRUISE" TECHNIQUE.** Ask another Marine to lend a hand by asking you questions about the course. Choose a particular study unit and let your buddy "fire away." This technique can be interesting and challenging for both of you!

- **MAKE REVIEWS FUN AND BENEFICIAL.** Reviews are good habits that enhance learning. They don't have to be long and tedious. In fact, some learners find short reviews conducted more often prove more beneficial.

Continued on next page

Tackling the Final Exam

When you have completed your study of the course material and are confident with the results attained on your study unit exercises, take the sealed envelope marked **"FINAL EXAM"** to your unit training NCO or training officer. Your training NCO or officer will administer the final examination and return the examination and the answer sheet to MCI for grading. Before taking your final examination, read the directions on the DP-37 answer sheet carefully.

Completing Your Course

The sooner you complete your course, the sooner you can better yourself by applying what you've learned! HOWEVER--you do have 2 years from the date of enrollment to complete this course.

Graduating!

As a graduate of this distance education course and as a dedicated Marine, your job performance skills will improve, benefiting you, your unit, and the Marine Corps.

Semper Fidelis!

STUDY UNIT 1

DEMOLITIONS AND EXPLOSIVES

Overview

Scope

This study unit covers the reconnaissance, formulas, target recognition, process, and theories involved in the effective use of demolitions and explosives as it pertains to the combat engineer serving with a Marine Division.

Purpose

The purpose of this study unit is to provide you with the skills and knowledge necessary to safely and successfully plan and implement the use of demolitions and explosives.

In This Study Unit

This study unit contains the following lessons:

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LESSON 1

ENGINEER RECONNAISSANCE

Introduction

Scope

This lesson describes the process and procedures for conducting an engineer reconnaissance and its required reports.

Purpose

The purpose of this lesson is to provide you with the knowledge to successfully conduct and record an engineer reconnaissance mission, as well as identify key features of both your route and target.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the three major components of a bridge.
- Identify the components in a building structure.
- Identify a bypass in respect to reconnaissance.
- Identify a Demolition Reconnaissance Record.
- Identify the two goals in bridge demolition.
- Identify different types of sketches.

Continued on next page

Introduction, Continued

In This Lesson

This lesson contains the following topics:

Bridge Reconnaissance

Bridge Definition

To conduct a reconnaissance of a bridge, you must understand what a bridge is and what its components are. A bridge is a structure that carries a roadway or railway over a depression or obstacle. A bridge that is completely supported by its two abutments (end supports on each embankment) is called a single span bridge. A bridge that has one or more supports between the abutments is a multi-span bridge. From a military standpoint, bridges either already exist in an area of operations or must be constructed for military purpose during the course of an operation. Since existing bridges vary in size and complexity, it is the military engineer who must reconnoiter and classify bridges. Military bridges that are constructed by the military engineers have classifications that have been predetermined and are built to accomplish a specific mission.

Bridge Components

The major components of a bridge are basically the same on any bridge; while they may look different, their purpose and nomenclature remain the same. The main components of a bridge are

- Approaches
- Substructure
- Superstructure

Approaches

The approaches are the sections of the route leading up to the bridge. Approaches serve as good areas for mines and booby traps and should always be thoroughly reconnoitered. They are always man made and must be considered along with the bridge itself as part of the structure. Approaches are constructed in two ways.

- Using fill that is used to bring the road up to the level of the bridge
- Making cuts to bring the road down to the level of the bridge

Substructure

The substructure is the portion of the bridge that lies beneath the roadway that transfers the weight of the bridge and any subsequent loads crossing the bridge to the ground. The substructure includes

- Abutments
- Intermediate supports

Continued on next page

Superstructure

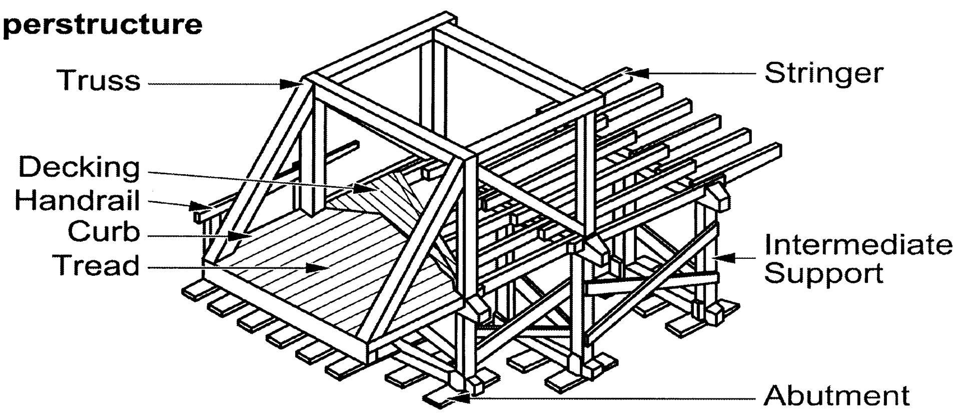
The superstructure is the upper portion of the bridge and consists of five basic components:

- Stringers
- Flooring
- Curbs
- Railings
- Trusses

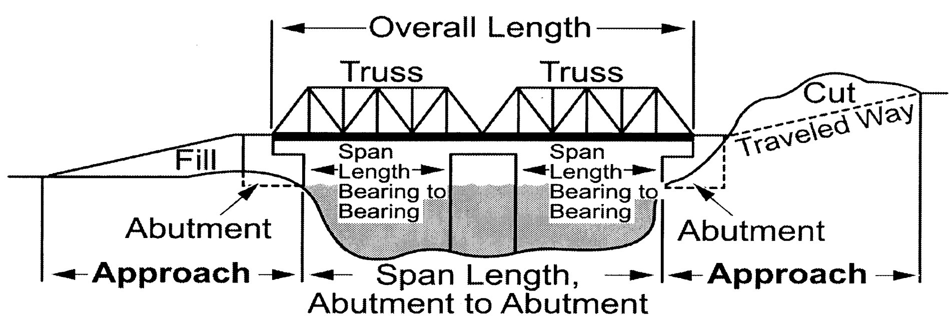
Bridge

The illustration shows a bridge depicting the three major components.

Superstructure



Substructure



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Stringers

Stringers are the main load-carrying components of the superstructure. They rest on and span the distance between the abutments and intermediate supports. Stringers receive the load from the flooring and transfer it to the substructure.

Flooring

Flooring consists of two parts: decking and tread. While this is not always the case, it is the most common style of flooring. The decking is laid at right angles to the bridge centerline and directly over the stringers. The tread is laid parallel to the centerline and directly on the decking. It protects the decking and adds strength to the superstructure.

Curbs

Curbs are usually placed at both edges of the tread to guide vehicles across the bridge. A vehicle with an axle wider than the curbs will not be allowed to cross over the bridge.

Railings

Railings are built along the edges of the bridge and are used to guide drivers and to protect both vehicular and foot traffic.

Trusses

Trusses can be located either above or below the traveled way and are designed to increase the load-carrying capacity. Trusses are structural elements made of several components joined together to form a series of triangles.

Required Information

The five areas from which measurements must be taken to complete a bridge reconnaissance are

- Number of stringers
- Length of each span
- Width of the traveled way
- The general condition
- Additional bridge information

Continued on next page

Number of Stringers in Each Span

Each stringer must be measured to complete any required calculations. Subsequently they must be measured for each span in order to determine if there is a weak span as a bridge can only be classified by its critical (weakest) span. Exact and complete dimensions must be taken for each stringer.

Span Length

Span length is measured from the center-to-center of supports. It is imperative that this be accurate because it is used to determine the critical span. Actual measurements are taken to prevent error. There will be occasions where the critical span can be determined by looking at a bridge, i.e. one span is twice the length of all the others. When this is the case, that is the only span that needs to be classified.

Width of the Traveled Way

This is the area between the inside faces of the curbs. The horizontal width on most bridges is measured one foot above the tread. On truss bridges with trusses above the tread, the measurement is taken 4 feet above the tread.

General Condition

The general condition of the bridge must be noted so that it can be taken into consideration when classifying the bridge. Pay particular attention to any evidence of damage, either natural (rot or rust), or combat related. Other areas may be cracks or erosion, basically anything that is no longer the same as when the bridge was built.

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Additional Information

The following list includes items of interest or unique to the target bridge:

- Are approaches described and is anything of note discussed?
- Its geographical features, e.g., is it over water and does it flood?
- What are the abutments made of and is there erosion?
- What is the intermediate support foundation condition and construction material?
- Is the bridge structure, tread condition, style of bridge mechanized?
- Repair information with estimates when applicable.
- Alternate crossing routes, bypasses, fords, and proximity to other bridges.
- Demolition information, number, placement and size of required charges.
- Does it need additional columns?
- Bridge sketches as required by mission.

Bridge Classification

To complete the reconnaissance, you must know how to classify a bridge. With this knowledge, you will understand what types of equipment and personnel the bridge will be able to handle.

Note: Refer to Appendix A, Metric Conversion Chart and Appendix B, Bridge Classification, taken from FM 5-170, for more information on bridge classification.

Continued on next page

Bridge Reconnaissance Report Form

The Bridge Reconnaissance Report (DA Form 1249) is used for an individual bridge. This is a standard form that has required information but also allows for continuation or expansion.

DA Form 1249

The illustration below shows what is required on each line of DA Form 1249.

Bridge Reconnaissance Report, DA Form 1249

BRIDGE RECONNAISSANCE REPORT
For use of this form, see FM 5-36; the proponent agency is USCONARC.

DATE: 17NOV03
SIGNATURE: John O. Doe

TO. *(Headquarters ordering reconnaissance)*: S2 554th ENG BN

FROM: *(Name, grade, and unit of officer or NCO making reconnaissance)*: John O Doe Capt. A Co. 554th EN BN

MAPS *(Country, scale, and sheet number or name)*: U.S., 1:25,000 V834S Edition 2 Nima

DATE/TIME GROUP *(Of signature)*: 170600Z Nov. 03

ESSENTIAL BRIDGE INFORMATION								ADDITIONAL BRIDGE INFORMATION *(Add columns as needed)* *(Military load class, overall length, roadway width, vertical clearance, bridge by-pass)*				
	LOCATION	CLEARANCE		SPANS			LENGTH AND CONDITION					
1	2	3	4	5	6	7	8	Mil Load Class	Overall Length	Truck Way Width	Overhead Clearance	Remarks
1	123456	∞	2.1	1	3	ak	13.1	9	10	11	12	None

DA FORM 1249, 1 JUL 60 — PREVIOUS EDITION OF THIS FORM IS OBSOLETE.

Components of a Building Structure

Components

The following are the components of a building structure:

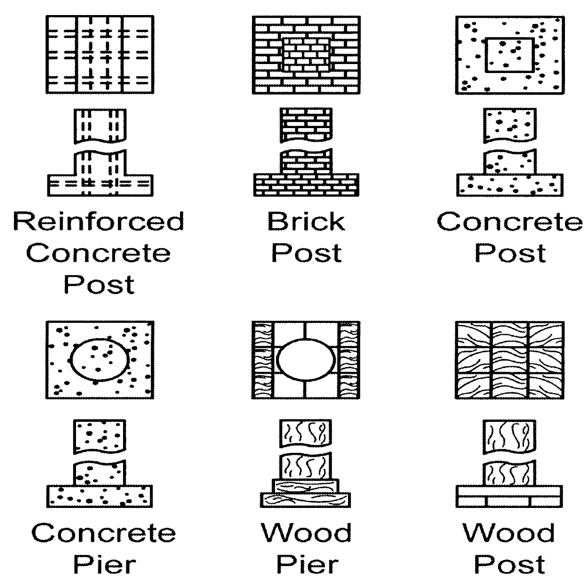
- Foundation
- Exterior Walls
- Interior Walls
- Header
- Roof

Foundation

All foundations have certain characteristics in common. Foundations are load bearing, which means that the weight of the structure is being supported on the foundation. Foundation types are dependant on the load-bearing capacity of the soil they are built on. Piers (posts in the ground) are used when the soil has little or no load-bearing capacity. Piers are commonly used in and around water. They extend down through the saturated or unstable soil to suitable load-bearing soil or bedrock. Most other foundations are a variation of a wall, which is supported on footers (a pad that is wider than the wall resting on it). Footers are usually concrete, equal in height, and twice the width of the wall they support i.e., an 8-inch wall would rest on an 8-inch thick, 16-inch wide footer.

Foundation with Footings

This illustration below shows the different types of foundations with footings.



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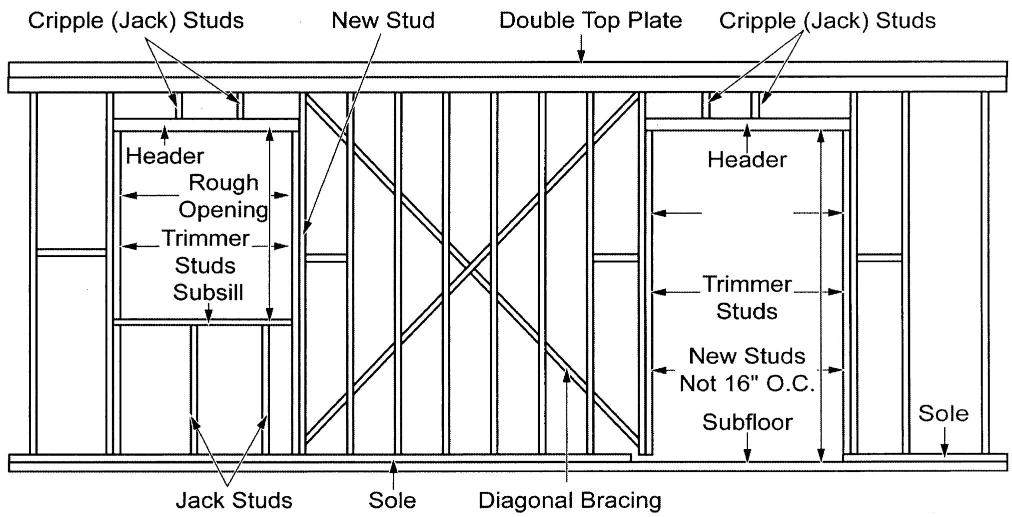
Exterior Walls

Exterior walls are load-bearing walls that transfer the weight of the building to the foundation of the building. Above each opening (doors and windows) in wood frame structures will be a header to transfer the weight around the opening. In a single story building, the exterior walls support the roof. In multiple level buildings, the exterior walls support the floors and walls above it, as well as the roof.

Wall Construction

The illustration below shows the typical wall construction with openings and headers.



Interior Walls

Interior walls can be either load bearing or non-load bearing. A non-load-bearing wall is nothing more than a partition within the building, which is used to create separate rooms within a building. Even though the wall is not a load-bearing wall, all the doors will have headers above them just like the exterior walls. The load-bearing interior walls support the structure above them and usually run from one exterior wall to another. There is support under these walls to transfer the weight to the foundation or ground, often in the form of a beam. There may be intermediate piers supporting these walls, which transfers the weight to the ground.

Header

Headers are over doors, windows, and openings in the walls in all wood frame construction. Headers are reinforced wall sections that rest on studs, which are located on either side of the opening. These studs transfer the weight to the floor below.

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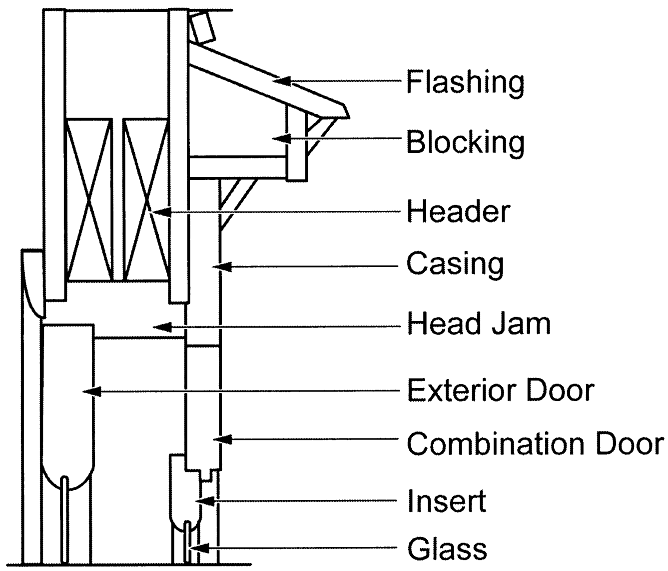
Components of a Building Structure, Continued

End View

The illustration below shows an end view of a typical header.



Roof

Regardless of the style, the roof includes all materials above the walls to include

- Trusses
- Sheathing
- Exterior weatherproof layer
- Joists

Critical Points in a Building Structure

Foundation

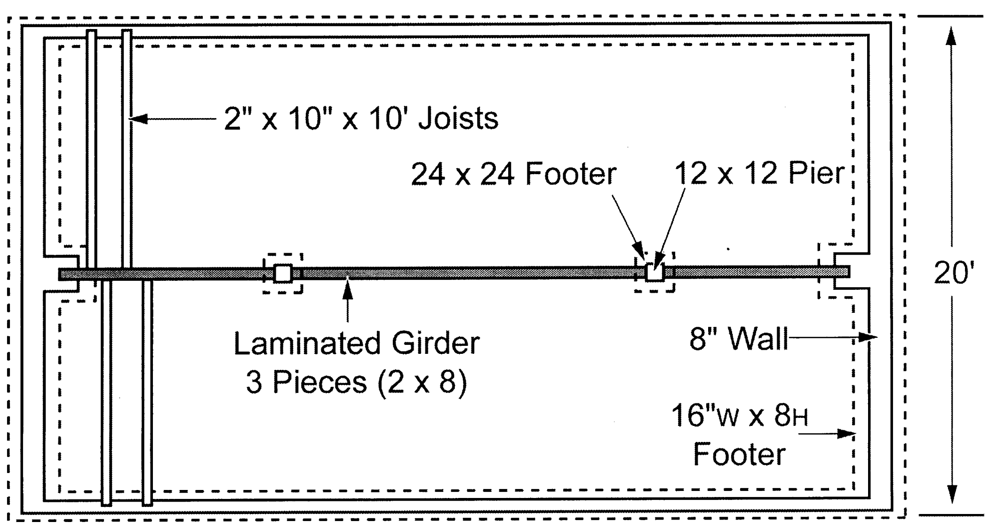
The foundation is a critical point in any structure. If the foundation fails, the structure fails. If the structure is going to be utilized i.e. billeting, storage, or headquarters, it must be inspected for structural integrity. The condition of the foundation is important. If the foundation is rotting or crumbling, depending on the material, it should not be used. Signs of rot mean that the weight the structure was designed to support is no longer being supported adequately. Using a structure with a damaged or failing foundation is dangerous and should be avoided.

Load-Bearing Walls

A load-bearing wall is also a critical point in a structure. Any wall that is determined to be a load-bearing wall should also be inspected to verify that it is still performing its designed purpose and will continue to support the required weight.

Foundation Plan

The illustration below shows a foundation plan with an interior load-bearing wall.



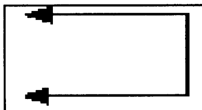
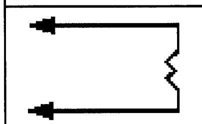
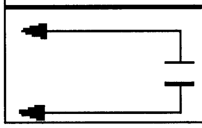
Bypasses

Bypass Requirements

Bypasses are alternate routes that allow you to reach your objective in an acceptable amount of time. Bypasses that are limited to specific vehicle types, such as those capable of swimming or deep-water fording, are noted on the reconnaissance report. Bypasses are classified as easy, difficult, or impossible. Each type of bypass is represented symbolically on the arrow extending from the tunnel, ford, bridge, or overpass symbol to the map location.

Bypass Symbol

The illustration below shows a bypass symbol.

	Bypass easy. Use when the obstacle can be crossed in the immediate vicinity by a US 5-ton truck without work to improve the bypass.
	Bypass difficult. Use when the obstacle can be crossed in the immediate vicinity, but some work to improve the bypass is necessary.
	Bypass impossible. Use when the obstacle can be crossed only by repairing or constructing a feature or by detouring around the obstacle.

Demolition Reconnaissance Record

Demolition Reconnaissance

The Demolition Reconnaissance Record (DA Form 2203-R) should provide all the information required in relation to the target. It is the proper form used for a demolition reconnaissance report. There are also sketches attached to the form. These documents will be your primary source of information for preparing a target folder.

DA Form 2203-R (Page 1)

The illustration shows page 1 of a DA Form 2203-R with information.

DEMOLITION RECONNAISSANCE RECORD

For use of this form see FM 5-250; the proponent agency is TRADOC.

SECTION I - GENERAL

			NAME AND RANK	ORGANIZATION
1. FILE NO.				
2. DEMOLITION RECON REPORT NO.	5	RECON ORDERED BY	Col. John Doe	3rd Eng Bn
3. DATE 8 MAY 2003 / 4. TIME 1200	6	PARTY LEADER	GySgt Joe Marine	C Co 1st Eng Bn

7. MAP INFORMATION
- Name Quantico
- Scale 1:25000
- Sheet No. V8345
- Series No. 2-NIMO

11. GENERAL DESCRIPTION: (Attach sketches)
- Type Construction: ☐ Earth ☐ Timber ☒ Concrete ☐ Steel
- Other Data: ☐ Roadway width 18 M; ☐ Number bridge spans 8; ☐ Number of lanes 4; ☐ Bridge Class: W-100 T-100
- Condition: No visable Damage

8. TARGET AND LOCATION: Highway Bridge

12. NATURE OF PROPOSED DEMOLITION (Attach sketches.) Partial Destruction

9. TIME OBSERVED: 1730

13. UNUSUAL FEATURES OF SITE: ☐ High Tension ☐ Radar Installation ☐ Underwater Blasting ☒ water under bridge ☐ ☐

10. COORDINATES: 12345678

SECTION II - ESTIMATES

Determine availability of Items 14, 15, and 16 before conducting reconnaissance.

14. MATERIAL REQUIRED	UNIT OF ISSUE	CRATERING	CUTTING	OTHER/SPEC PURPOSE
Electric caps	EA			
Nonelectric caps	EA			
Detonating cord	FT			
Time Fuse	FT			
Fuse Lighters	EA			
Firing Wire	FT			
Firing Device (Specify type.)	EA			
Explosive:				
TNT, 1/4 - LB	EA			
TNT, 1/2 - LB	EA			
TNT, 1 - LB	EA		1200	
TNT, 2 1/4 - LB	EA			
(Other) C4	LBS		272	
(Other)				
Cratering:				
Cratering Charge, 40 - LB	EA			
Shape Charge, 15 - LB	EA			
Shape Charge, 40 - LB	EA			
M180	EA			
Other Demolitions				

15. EQUIPMENT AND TRANSPORT REQUIRED (*Examples: trucks, ram sets and cartridges, demolition sets, post-hole diggers, nails, adhesives, tape, sandbags, and lumber.*)
NOTE: Troops may not ride in vehicles transporting explosives.

Demo Sets (1)
Post Hole Digger (2)
2x Lumber For Bracing 100 Linear Feet
(Cont.)

16. PERSONNEL AND TIME REQUIRED FOR:	NCOs	ENL	Time
a. Preparing and placing charges	2	10	2hr
b. Arming and firing demolition	2	0	10min

17. TIME, LABOR, AND EQUIPMENT REQUIRED FOR BYPASS (*Specify location and method. Specify equipment to clear the site after demolition and the available bypasses that allow units to bypass the site.*)

Avaiable Bypass 1.6 miles North on I-95.

18. REMARKS

Crater placed Between north corner of Bridge and Existing Banks would enhance the obstacle

DA Form 2203-R, MAY 92 Edition of Aug 70 is obsolete.

Continued on next page

Demolition Reconnaissance Record, Continued

DA Form 2203-R (Page 2)

The illustration shows page 2 of a DA Form 2203-R with information.

DEMOLITION RECONNAISSANCE RECORD

Place additional comments in the appropriate blocks.

15. EQUIPMENT AND TRANSPORT REQUIRED (*Continued*)

HMMWV -(1) To transport Blasting caps
7-Ton Trucks - (1) Transport Demo
(1) Transport Personnel.

17. TIME, LABOR, AND EQUIPMENT REQUIRED FOR BYPASS (*Continued*)

To Bridge at Site: (1) Dozer, (1) Bucket Loader, 3.5 hrs - To clear and improve approach. Ribbon bridge (1) interior bay and 2 ramp Bays - 30 min, MCB - (1) company, 3 hrs.

18. REMARKS (*Continued*)

19. ADDITIONAL COMMENTS (*Specify block.*)

Page 2, DA Form 2203-R, May 92

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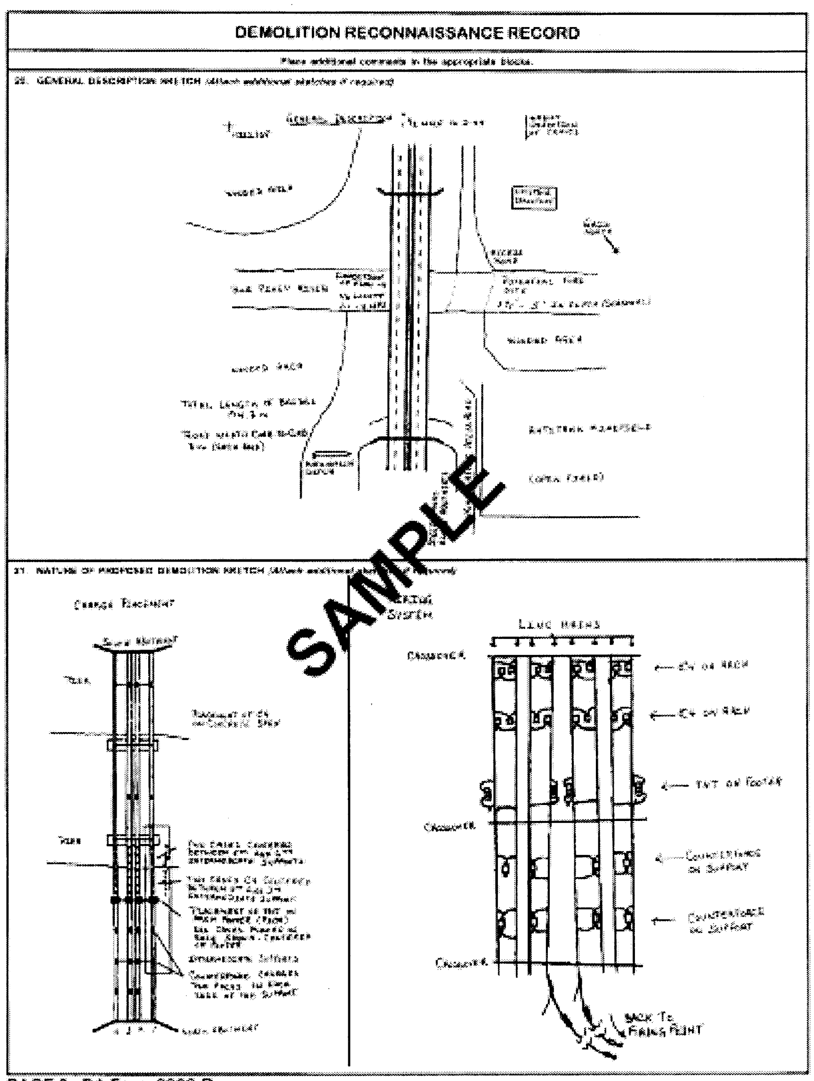
Demolition Reconnaissance Record, Continued

DA Form 2203-R (Page 3)

The illustration shows page 3 of a DA Form 2203-R with information.



PAGE 3, DA Form 2203-R

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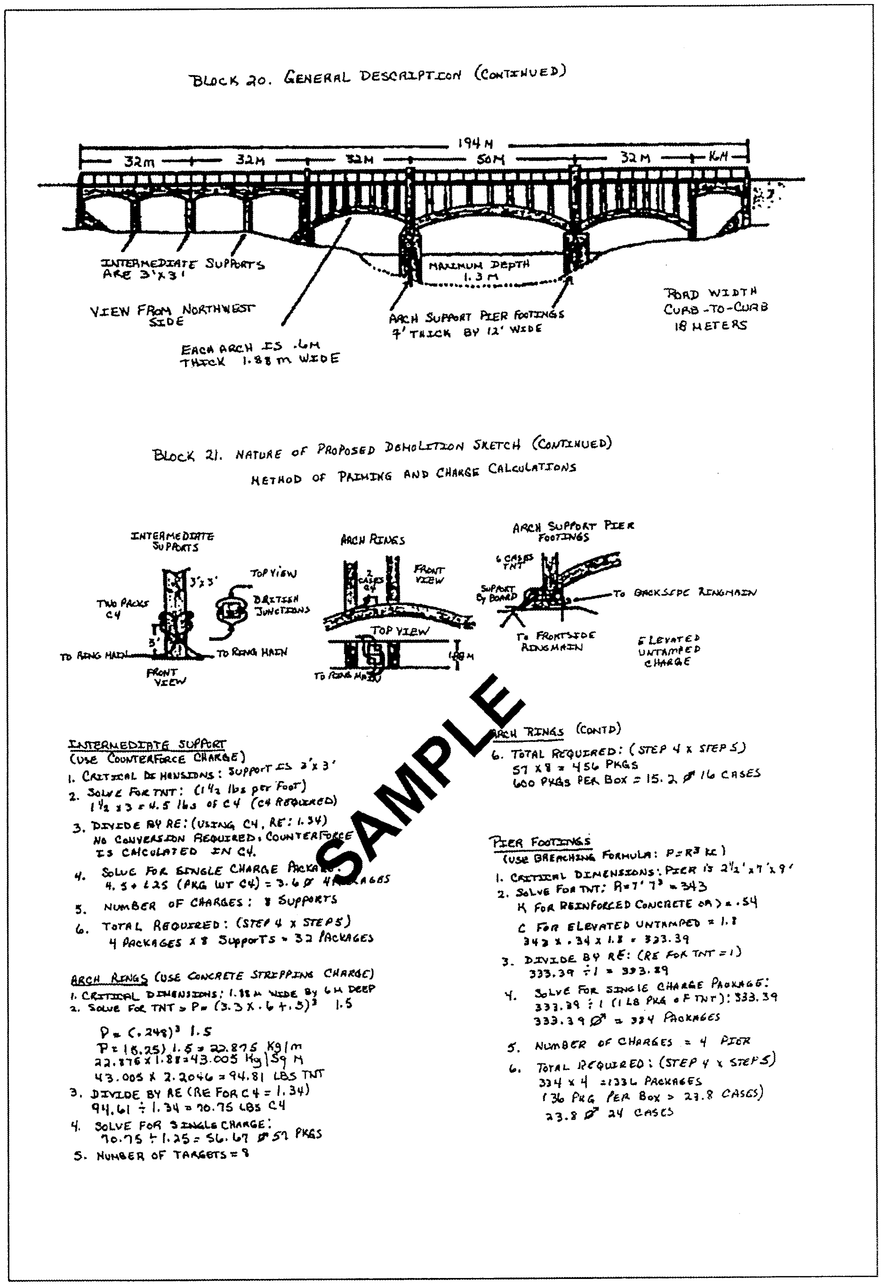
Demolition Reconnaissance Record, Continued

DA Form 2203-R (Block 20)

The illustration shows block 20 on a DA Form 2203-R with information.



Identification of Critical Points on a Demolition Target

Bridge Demolition

There are two goals in bridge demolition:

- Disable the bridge by creating a gap large enough to make repair uneconomical.
- Force the enemy to reroute or rebuild by destroying the bridge completely.

This usually involves destroying all components of the bridge. As previously discussed, stringers run lengthwise of the bridge and directly support the decking. Girders are two stringers running lengthwise along a bridge and serve as the main load bearing members. The following table shows the three components to trusses.

Lower	Lowest member in a truss panel and runs parallel to the deck
Upper	Upper member in a truss panel
Intermediate	Members between the upper and lower chords and transfers the load between the two

Types of Bridge Construction

There are 10 different types of bridge construction. Bridges may look aesthetically different but they will fit into one of these structural types. It is important to know these different types, as the demolition process is different for each type of bridge.

Simple Span Fixed Bridges

A simple span fixed bridge is only supported on the ends and is the most common type of fixed bridge. The stringer or girders are of a uniform depth and are supported only at the ends (abutments). If there are trusses on the simple span fixed bridge they are usually of uniform height or higher in the center of the span. The methods of demolition are:

- Cut the bridge at mid-span allowing the bridge to buckle and fall into the gap.
- Cut the truss or girder at the up-stream end of the bridge near the abutment using the appropriate formula for the construction material.

Continued on next page

Continuous Span Fixed Bridges

Continuous span fixed bridges are bridges that are simply supported bridges with one intermediate support (pier) in the middle. These bridges have superstructures that are continuous over the intermediate support. The trusses of these bridges are highest over the supports and are connected at both top and bottom chords. The methods of destruction for these bridges are to cut the span on either side of the intermediate support (complete destruction) using the rule of thumb that the charges are placed at a point three-fourths the total span length from the pier. If time and explosives are available, use breaching charges to destroy the pier as well.

Timber Stringer Superstructure

These bridges are used extensively in the theater of operations for short-span crossing or in multiples of short spans for longer crossings. They are commonly constructed and used by the military where the spans are rarely over 20 feet. The method used to destroy the bridge is to cut the timber stringer superstructure and the formula for determining the size of the charge is pounds of explosive equals diameter squared divided by 40.

$$P = \frac{D^2}{40}$$

Steel Stringer Superstructure

Steel stringers are used in simply supported span up to 90 feet and in continuous span bridges with clear span up to 120 feet. These steel stringers come in two variations, rolled shapes with spans to 90 feet and beams with welded steel plates with spans of between 60 and 120 feet. The method of destruction is to cut the steel stringer superstructure by utilizing steel cutting charges to each stringer. The formula for this is pounds of explosive equals three-eighths times the area.

$$P = 3/8\ A$$

Continued on next page

Steel Girder Superstructure

Steel girders are usually used for spans of 100 to 350 feet. They are used when spans are too long for standard roller shapes. They consist of two large built-up flexed members that support the decking. Girder bridges are normally continuous construction and often deepened above the intermediate supports. The method of destruction for this bridge is to cut the steel girder superstructure by the use of the steel cutting formula: Pounds of explosives equals three-eighths times the area.

$$P = 3/8 A$$

Composite Steel/Concrete Stringers

Reinforced concrete is attached to the top of the steel stringers. In steel stringer bridges, the only purpose of the concrete decking is to transfer the load to the steel stringers. It is difficult to recognize composite steel from a steel stringer bridge. The method of destruction for this type of bridge requires two separate formulas, one for the steel and one for the concrete decking. The composite steel/concrete stringer substructures by placing steel cutting charges and concrete breaching charges to cut the steel stringers and secondly breech the concrete deck above each stringer. The two formulas are

- Pounds of explosive equals three-eighths times the area for the steel
- Pounds of explosives equals breaching radius (cubed and measured in feet) times material factor (K) times the tamping factor (C) (see the illustration on the following page).

Steel formula-$P = 3/8 A$ Concrete formula-$P = R^3KC$

Continued on next page

Identification of Critical Points on a Demolition Target,
Continued

GTA Card

The illustration shows Table 8 from the GTA Card 5-10-33.

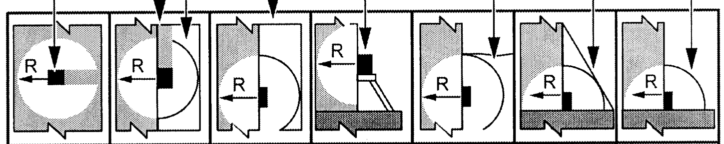
Material	**R (m)**	**K**
Earth	All Values	0.07
Poor masonry, shale, hardpan, good timber and earth construction	Less than 1.5 1.5 or more	0.32 0.29
Good Masonry, concrete block, rock	0.3 or less Over 0.3 to less that 0.9 0.9 to less than 1.5 1.5 to less than 2.1 2.1 or more	0.88 0.48 0.40 0.32 0.27
Dense concrete, first-class masonry	0.3 or less Over 0.3 to less than 0.9 0.9 to less than 1.5 1.5 to less than 2.1 2.1 or more	1.14 0.62 0.52 0.41 0.35
Reinforce concrete (concrete only; will not cut reinforcing steel)	0.3 or less 0.3 to less than 0.9 0.9 to less than 1.5 1.5 to less than 2.1 2.1 or more	1.76 0.96 0.80 0.63 0.54

Continued on next page

Identification of Critical Points on a Demolition Target,
Continued

Tamping Factor

The illustration shows the tamping factor illustration from the GTA card.



Reinforced Concrete Thickness (ft)	Placed In Center Of Mass	Tamped Or Stemmed	Deep Water	Elevated Untamped	Shallow Water	Earth Tamping	Ground Placed, Untamped
	C = 1.0	C = 1.0	C = 1.0	C = 1.8	C = 2.0	C = 2.0	C = 3.6
	Packages of M112 (C4)						
2.0	1	5	5	9	10	10	17
2.5	2	9	9	17	18	18	33
3.0	2	13	13	24	26	26	47
3.5	4	21	21	37	41	41	74
4.0	5	31	31	56	62	62	111
4.5	7	44	44	79	88	88	157
5.0	9	48	48	85	95	95	170
5.5	12	63	63	113	126	126	226
6.0	13	82	82	147	163	163	293
6.5	17	104	104	186	207	207	372
7.0	21	111	111	200	222	222	399
7.5	26	137	137	245	273	273	490
8.0	31	166	166	298	331	331	595

Conversion Factor for Table (Material Factor [k] Use with Table)		
Earth	Ordinary masonry, hardpan, shale, ordinary concrete, rock, good timber, and earth construction	Reinforce concrete, first class masonry
0.1	0.5	0.7

Continued on next page

Reinforced Concrete Slab Superstructure

The reinforced concrete slab is an efficient structure for spans of less than 25 feet. Spans can be continuous as long as they are over intermediate supports. The method of destruction is placing breaching charges across the width of the slab to breach it. The formula used is pounds of explosives (P) equals breaching radius (R)(cubed and measured in feet) times material factor (K) times the tamping factor (C).

$$P = R^3KC$$

Reinforced Concrete T-Beam Superstructure

Reinforced concrete T-Beam superstructures are used in simple spans of 30 to 60 feet and can be used for continuous spans over intermediate supports for spans up to 100 feet. The T-Beams provide greater depth over the intermediate supports. The method of demolition for these bridges is to place breaching chargers against the sides and bottom of each beam. Then place breaching charges on the deck above each beam. The charges are calculated by using the breaching formula pounds of explosives equals breaching radius (cubed and measured in feet) times material factor times the tamping factor.

$$P = R^3KC$$

Floating Bridges

These bridges are traditionally made of rubber and are pneumatic in nature. Regardless of the construction, i.e. aluminum, pneumatic, and wood, they all must be anchored to the shore or supported by boats. The method of destruction for floating bridges is to sever the anchor lines and cut the bridge at the midway point of the river utilizing the appropriate formula for the construction material. This method will allow the current to take the bridge away and render it useless. If the intent is to sink a pneumatic bridge, a single wrap of detonating cord will penetrate the rubber and sever the inlet valves.

Prepare Estimates for Explosives

Material Identification

Before calculations are performed, the destroyed material must be identified. The formulas used to perform the calculations vary by destroyed material. Some examples of materials are wood, steel, ice, soil, concrete, and reinforced concrete. When dealing with concrete, determine whether or not it is reinforced. If you are not sure, treat it as reinforced.

Types of Charges

The material the target is constructed from and the equipment available for placing the charges determine the type of charge required to perform the mission. It is impossible to perform an internal charge if you don't have a drill or other means of creating a hole for the explosives. The type of explosive available for use will also impact the charge selection. There are cutting charges, breaching charges, boring charges, cratering/ditching charges, and special demolition techniques.

Number of Charges

The number of charges required to accomplish the target destruction will depend on the target. If the charge to be implemented is for cutting stringers, the number of charges is multiplied by the number of stringers to be cut. For ditching or cratering the number is calculated the same way as breaching charges are. If breaching charges are being utilized, the width of the target will dictate the number of charges and is calculated by using the number of charges equals the width of a target divided by two times the breaching radius.

$$N = \frac{W}{2R}$$

Charge Size

The size of the charge will always be calculated using TNT as the explosive. If another explosive is used, a conversion from TNT to the other explosive must be performed. Charge size will be based on the target the calculations used and are designed to determine the correct amount of explosives to do the job without wasting explosives and over-doing the job. Once the size of the individual charge is determined, the amount from one charge is multiplied by the number of charges to get the total explosives required to accomplish the mission.

Continued on next page

Prepare Estimates for Explosives, Continued

Steel Cutting Charges

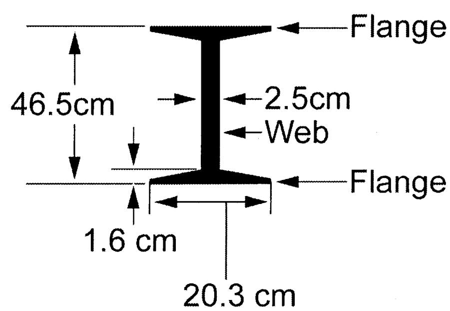
Steel cutting is one of the most common calculations performed by engineers. There are so many scenarios where steel is involved, i.e. bridge demolition, communication towers, steel gates, or disabling enemy artillery that this formula needs to be second nature. In any steel cutting, the area of steel in square inches to be cut must be determined to perform the calculation.

Determining the Area of Steel

When the area is discussed in relation to steel cutting, it is always expressed in square inches. When dealing with shaped steel, i.e. I-beam, cable, bar, or channel iron, the area is determined by viewing the cross section and measuring (in inches) the height and width of each section. The height and width measurements are multiplied by one another to give square inches.

Measurements

The illustration shows the measurements on shaped steel.



Steel Cutting Formula

The steel cutting formula is pounds of TNT equal three-eighths times the area (in square inches) of the steel to be cut.

$$P = 3/8\ A$$

Continued on next page

Steel Cutting Calculation

The following is an example of a steel cutting calculation. This calculation is for a steel I-beam with the following measurements; web height is 18 inches in height by 1 inch in width and the two flanges are 8 inches wide by 5/8 inches thick. The flanges and web are broken down into three separate rectangles and the area is figured for each rectangle. The three areas are then added together to get the total area of steel to be cut.

A = (8 x 5/8) + (8 x 5/8) + (18 x1), Convert 5/8 to a decimal by dividing 5 by 8 which equals .625 inches.

A = (8x.625) + (8x.625) + (18 x1)
A = 5 + 5 + 18
A = 28 Square inches

Complete the calculations by inserting the area into the steel cutting formula. P = 3/8 x 28, (3/8in decimal is .375). P = .375 x 28, which is 10.5. The 10.5 represents the number of pounds of TNT it will take to cut the I-beam.

Breaching Charges

The following is an example of a concrete breaching calculation. The target will be one of four reinforced concrete stringers on a bridge. The stringer is 36 inches thick and 24 inches wide. The formula that is used for determining the size of a breaching charge is $P = R^3KC$. P refers to pounds of explosives, R^3 refers to breaching radius cubed (in feet), K refers to the material factor and C refers to the tamping factor (found on page 9 of the GTA 5-10-33). This formula requires the measurements to be in feet, so our breaching radius is 3 feet vice 36 inches. The material factor is 0.8 and the tamping will be elevated and untamped, which is 1.8, making our formula for this stringer as follows:

- $P = 3^3 \text{ x } 0.8 \text{ x } 1.8$
- P = 27 x 0.8 x 1.8
- P = 38.88 pounds of TNT

Since TNT only comes in whole units, it will require 39 pounds of TNT to breech this one stringer. In this scenario, there were four stringers on the bridge so we will need four charges of 39 pounds to accomplish the mission. The required TNT for this mission is 156 pounds.

Continued on next page

Abutments

Abutments have two categories:

- Abutments less than 5-feet thick
- Abutments over 5-feet thick

The thickness of the abutment determines how the charges are placed to destroy the abutment. Height also becomes a consideration. If an abutment is over 20 feet in height, it will require breaching charges to be placed on the gap side of the abutment as well.

Abutments Less Than 5-Feet Thick

When the abutment is less than 5-feet thick, charges are placed using the triple nickel forty process. This process includes placing 40-pound cratering charges on 5-foot centers, 5-feet deep, and 5 feet from the face of the abutment. The number of charges depends on the width of the abutment. The first charge is placed 5 feet from either end of the abutment and the charges are placed every 5 feet after that until a distance of 5 feet or less remains to the other end.

Abutments Over 5-Feet Thick

When the abutment is over 5-feet thick, charges are placed against the rear face of the abutment at a depth equal to the thickness of the abutment. The size of the charge is determined using the breaching formula, and the spacing, i.e. the number of charges is determined by using the formula number of charges (N) equals the width of the abutment divided by two times the breaching radius. If the abutment is 6-feet thick, then our breaching radius is 6 feet. The abutment is 28-feet wide so the calculations are

- $P = 6^3 \times 0.63 \times 1$, so $P = 216 \times 0.63 \times 1$
- P = 136.08 or 137 pounds of TNT

Now the number of charges required needs to be determined. To do that, the formula of N = W divided by 2R would be

$$N = \frac{28}{2(6)}$$

$$N = \frac{28}{12}$$

N = 2.33; therefore, three charges of 137 pounds will be necessary to complete the mission.

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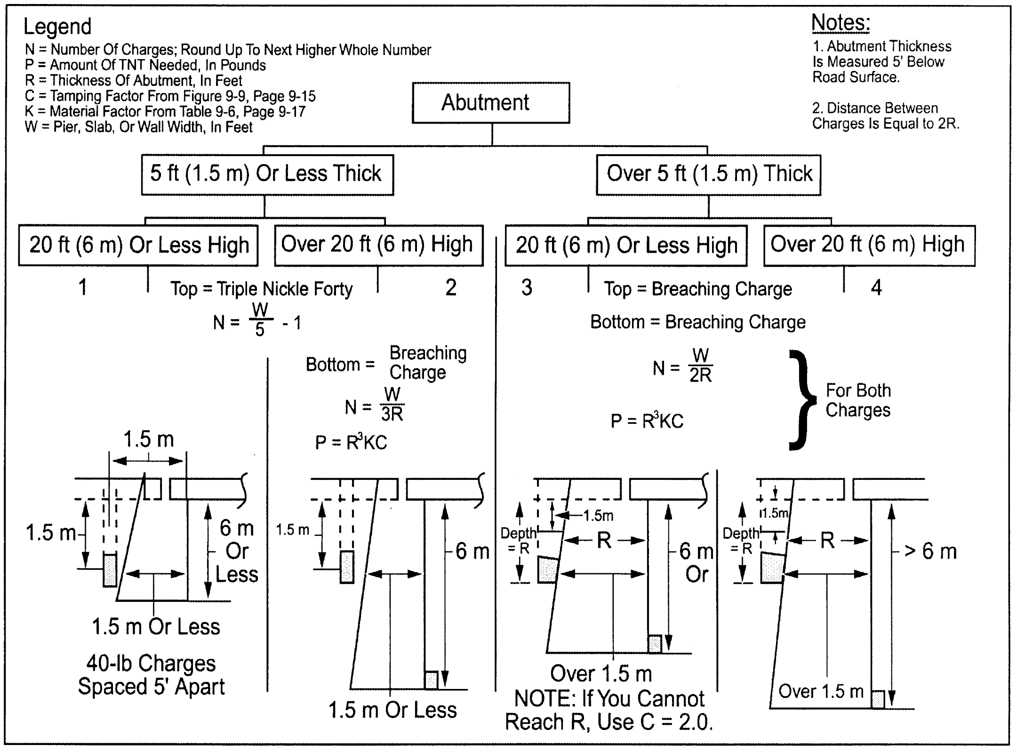
Placements of Charges and Diagrams

The illustration shows the placements of charges and diagrams.



Abutments of More Than 20 Feet in Height

All abutments whose height is over 20 feet will require secondary bottom breaching charges. These charges are used to enhance the primary breaching charges by providing a counterforce blast as well as weakening the bottom of the abutment. All of this aids in destroying the abutment and dropping it in the gap. These charges are calculated in the same manner as the breaching charge, except that the tamping factor C will always be 3.6. Using the same example, we get

$P = 6^3 \times 0.63 \times 3.6$, so $P – 216 \times 0.63 \times 3.6$, which means $P = 489.88$ or 490 pounds of TNT. The number of charges will remain the same as the primary breaching charges because the width remains the same.

Prepare Task Oriented Sketches

Types of Sketches

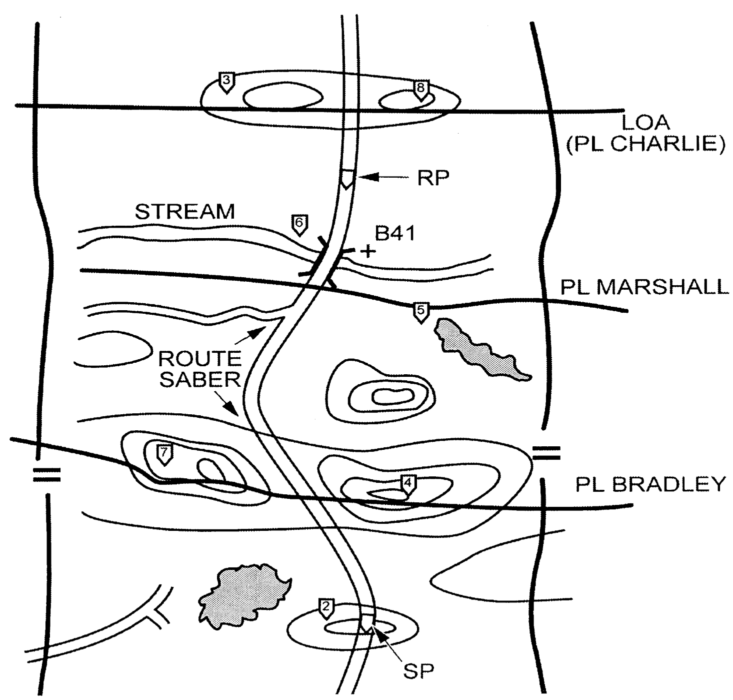
There are three basic sketches that may be involved in an engineer/ demolitions reconnaissance:

- Site plan/area
- Side elevation
- Cross-sectional

If the target is a bridge, the cross-sectional sketch is of the critical span and an additional sketch of the stringer of girder.

Site Plan/Area Sketch

This is a sketch that shows the area surrounding the target as well as the target. It will include any landmarks, roadways, bridges, and north orientation. If a river is present, show the direction of flow. The illustration below shows a completed site plan/area sketch.



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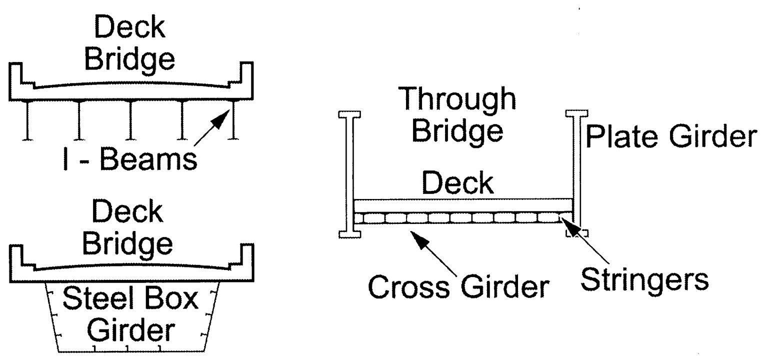
Cross-Sectional Sketch

This is the sketch of the target from which most of the calculations are made for destruction of the target. If the target is a bridge, the cross section will be of the critical span. This is done so that accurate calculations are made. If the target is a bridge, an additional cross-sectional sketch is required for the stringers. This is important for the proper calculation of demolition requirements. The illustration below shows a completed cross-sectional sketch.



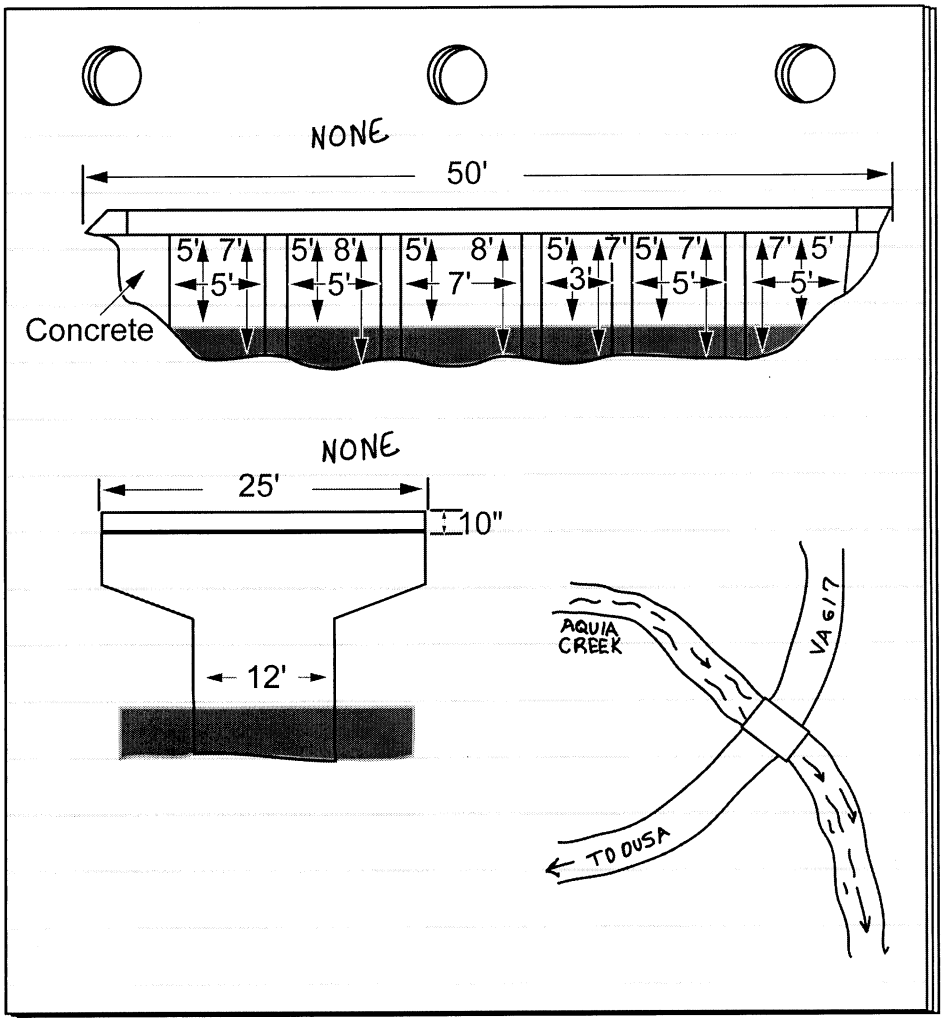
Side Elevation Sketch

This is a ground view of the target. This shows as much detail that can be included in the sketch. For a bridge, it would include bridge, abutments, intermediate supports, handrails, water level and location, ground contour, and measurements of each.

Continued on next page

Completed Side Elevation Sketch, continued

The illustration shows a completed side elevation sketch.



Lesson 1 Exercise

Directions

Complete exercise items 1 through 6 by performing the action required. Check your answers against those listed on the reference page.

Item 1

Which are the three components of a bridge?

a. Security, ambush, and economy of force
b. Truss, Deck, and Studs
c. Approach, substructure, and superstructure
d. Flashing, header, and foundation

Item 2

The components in a building structure are foundation, exterior walls, interior walls, roof, and

a. footer.
b. header.
c. joists.
d. door.

Item 3

A bypass is an alternate

a. route, which will allow you to reach your objective in an acceptable amount of time.
b. route around an obstacle, which allows the foot mobile Marines to continue the attack.
c. path to an enemy position allowing for an unobserved approach.
d. attack route that approaches the enemy from the flank.

Item 4

Which record is used to provide all information required in relation to the target?

a. Identification Record
b. Demolition Reconnaissance Record
c. Building Record
d. GTA

Continued on next page

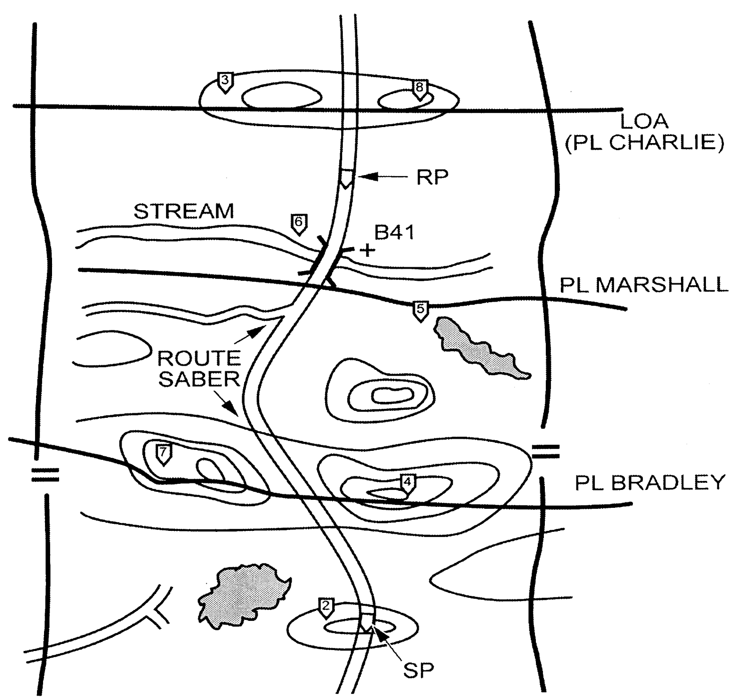
Lesson 1 Exercise, Continued

Item 5 The two goals in bridge demolition are to disable the bridge by creating a gap large enough to make repairs uneconomical and

a. force the enemy to reroute or rebuild by destroying the bridge completely.
b. enable the enemy to cross the water.
c. make the enemy give up.
d. force the enemy to make other plans.

Item 6 Which type of sketch is shown below?

a. Situational
b. Cross-sectional
c. Target
d. Site Plan/Area



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Solution

The answers to the exercise items are listed below. Check your answers against those listed on the reference page.

Item	Answer	Reference Page
1	c	1-5
2	b	1-11
3	a	1-15
4	b	1-16
5	a	1-20
6	d	1-31

LESSON 2

APPROPRIATE PROTECTIVE MEASURES

Introduction

Scope

This lesson describes the process and procedures for properly implementing appropriate protective measures when employing demolitions.

Purpose

The purpose of this lesson is to provide you with the skills and knowledge necessary to determine what appropriate protective measures are required while conducting demolition operations.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the safety precautions required to be in place during detonation.
- Identify the hazards of explosive detonations.
- Identify blast pressure and potential injuries.
- Evaluate an explosive charge for its minimum safe distance.

In This Lesson

This lesson contains the following topics:

Evaluation of an Explosive Charge

Available Explosives

There are several types of explosive available to the combat engineer in the Marine Corps. This is not an all-inclusive list as there are specialty demolitions, which will not be included. The explosives include

- Trinitrotoluene (TNT)
- Tetrytol
- Composition-4 (C-4 (M5A1 and M112))
- Sheet explosive (M118 and M186)
- Dynamite (M1)
- Detonating cord
- Pentaerythrite tetranitrate (PETN)
- Cyclotrimethlenetrinitramine (RDX)
- Cratering charges
- Bangalore torpedo
- Shaped charges (M2A4 and M3A1)

Characteristics of Military Explosives

Military explosives must be

- Relatively insensitive to shock or friction
- Capable of shattering
- Adequately energized (high energy output per unit volume) for demolitions
- Stable to retain their usefulness for a reasonable time when stored in temperatures between –80 and 165 degrees fahrenheit
- Composed of high-density materials (weight per unit volume)
- Suitable for underwater use in damp climates
- Minimally toxic when stored, handled, and detonated

Relative Effectiveness Factor

The relative effectiveness (RE) factor compares from one type of explosive to another. The explosive that serves as the base for these factors is TNT. All calculations are performed to determine the amount of TNT required and the results are converted to the explosive to be used. TNT has an RE factor of 1.0. Those explosives that detonate at a slower rate will have RE factors of less than one, while those that detonate at a higher rate will have RE factors of more than 1.0. Every explosive has its effectiveness rated against TNT and assigned a number, which is known as the relative effective factor.

Continued on next page

Evaluation of an Explosive Charge, Continued

Trinitrotoluene (TNT)

TNT is the most common military explosive. TNT is a standard explosive and has an RE factor of 1.0, therefore it is used to rate other military explosives. TNT is primarily used for breaching charges. It has a detonation velocity of 22,600 feet-per-second and has an excellent resistance to water. It comes in two sizes, one pound blocks (48 to 56/box) and ½ pound blocks (96 to 106/box) and ¼ lb for training..

Tetrytol

Tetrytol is commonly used as a demolitions breaching charge. It is a composite made from tetryl and TNT. Tetrytol is more powerful than its individual components. It is better at shattering than TNT and is less sensitive than tetryl. It has an RE factor of 1.2 and detonation velocity of 23,000 feet/second. Its resistance to water is excellent.

Composition-4 (C4)

Composition-4 (C4) is used as a breaching charge and cutting charge. It is made up of 91 percent RDX and 9 percent nonexplosive plasticizers. It functions in temperature that ranges from –70 to 170 degrees, however it loses plasticity at lower temperatures. The RE factor is 1.34 and the detonation velocity is 26,400 feet/second. Its resistance to water is excellent.

Sheet Explosive

Sheet explosive is used as a cutting charge. It is easily applied to irregular shapes and has an RE factor of 1.66. Its detonation velocity is 24,000 feet/second. Its resistance to water is excellent.

Continued on next page

Evaluation of an Explosive Charge, Continued

Dynamite (M1)

Military dynamite contains 75 percent RDX, 15 percent TNT, and 10 percent desensitizers and plasticizers. It is used mainly as a demolitions charge. Its RE factor is .92 and its detonation velocity is 20,000 feet/second. Its resistance to water is fair.

Detonating Cord

Detonating cord is made up of PETN inserted into a plastic casing. Its RE factor is not considered since this is primarily a primer, however PETN has an RE factor of 1.66. The detonation velocity is between 20,000 and 24,000 feet/second. Its resistance to water is excellent.

Pentaerythrite Tetranitrate (PETN)

PETN is used in detonating cord, blasting caps, and as a charge itself. It has an RE factor of 1.66. The detonation velocity is between 27,200 feet/second. Its resistance to water is excellent.

Cyclotrimethle Netrinitramine (RDX)

RDX is used in blasting caps and composite explosives. It has an RE factor of 1.6 and a detonation velocity of 27,400 feet/second. Its resistance to water is excellent.

Cratering Charges

Cratering charges are 40-pound canisters of Composition H6 or ammonium nitrate, with a composition TNT booster. It is used for creating craters and on bridge abutments. The RE factor of composition H6 is 1.33 and ammonium nitrate is 0.42. Detonation velocity is 23,600 foot/second for H6 and 8,900 feet/second for ammonium nitrate. While the water resistance of H6 is excellent, ammonium nitrate has poor resistance.

Bangalore Torpedo

The bangalore torpedo is made up of Composition B4 with Composition A3 boosters. It is mainly used for breaching. The RE factor is 1.17 and it has a detonation velocity of 25.600 feet/second. Its resistance to water is excellent.

Shaped Charges

The shaped charge is mainly used as a cutting charge. It is made up of Composition B with Composition A3 booster. They have an RE factor of 1.17 with a detonation velocity of 25,600 feet/second. Their resistance to water is excellent.

Safety Precautions During Detonation

General Safety Considerations

The following list explains the general safety procedures during detonation:

- Do not attempt to conduct a demolition mission if you are unsure of the demolition procedures; review references or obtain assistance.
- Prevent inexperienced personnel from handling explosives.
- Avoid dividing responsibility for demolition operations.
- Use the minimum number of personnel necessary to accomplish the demolition mission.
- Take your time when working with explosives; make your actions deliberate.
- Post guards at all times to prevent access inside the danger radius.
- Maintain control of the blasting machine or initiation source at all times.
- Use the minimum amount of explosives necessary to accomplish the mission while keeping sufficient explosives in reserve to handle any possible misfires.
- Maintain accurate accountability of all explosives and accessories. Always store blasting caps separately and at a safe distance from other explosives.
- Ensure that all personnel and equipment are accounted for before detonating a charge.
- Ensure that you give warnings before initiating demolitions; give the warning "Fire in the hole" three times.

Continued on next page

General Safety Considerations, continued

- Guard firing point at all times
- Assign a competent safety officer for every demolition mission.
- Dual initiate all demolitions, regardless of whether they are single or dual primed.
- Avoid using deteriorated damaged explosives.
- Do not dismantle or alter the contents of any explosive material.

Note: Avoid missing live and inert (dummy) explosives.

Blasting Caps

Blasting caps, both military and civilian, are extremely sensitive and can explode unless handled carefully. Blasting caps can detonate if exposed to extreme heat (cook-off). Military blasting caps are more powerful than their civilian counterparts.

Note: Do not use blasting caps underground. Use detonating cord to prime underground charges.

Continued on next page

Nonelectric

Use the following safety precautions for nonelectric.

- Use only authorized equipment and procedures when crimping nonelectric blasting caps to time fuse or detonating cord.
- Maintain blasting caps in the appropriate cap box until needed. Never store caps with explosives.
- Do not carry loose blasting caps in your pocket or place loose caps in a container; secure them.
- Do not blow into a nonelectric cap or attempt to remove any obstructions from the blasting-cap well. Remove obstructions that will dislodge by using the wrist-to wrist tap method.
- Do not insert anything but time fuse or detonation cord into a nonelectric-blasting cap. Do not twist time fuse of detonating cord while attempting to insert it into a blasting cap.
- Do not attempt to crimp a blasting cap that is inserted into an explosive. If the cap comes loose from the time fuse or detonating cord, remove the blasting cap from the charge, recrimp the cap, and reinstall the cap in the charge.
- Avoid striking, pinching, and mashing nonelectric caps during crimping activities. Use only the M2 crimpers for all crimping operations.
- Cut the fuse to allow an interval of not less than 10 seconds between firings when using nonelectric caps to dual prime demolition.

Continued on next page

Electric

Use the following safety precautions for electric:

- Do not remove the short-circuiting shunt unless you are testing or connecting the cap. The shunt prevents accidental initiation by static electricity. If the blasting cap has no shunt, twist the bare ends of the lead wires together at least three times (180° turns) to provide a proper shunt.
- Use proper grounding procedures when static electricity is present.
- When transporting electric blasting caps near vehicles (including aircraft) equipped with a transmitter, protect the blasting caps by placing the in a metal can with a snug fitting cover (1/2 inch or more of cover overlap). Do not remove caps from their containers near an operating transmitter unless the hazard has been judged acceptable.
- Keep electric blasting caps at least 155 meters from energized power lines. If using electric caps near power lines, temporarily cut the power to the lines during operation.
- Be sure to use at least the minimum current required to fire electric caps.
- Cover connection between cap and blasting wires with tape not cardboard.
- Remove firing-wire loops and, if practical, bury blasting wires.

Continued on next page

Safety Precautions During Detonation, Continued

Time Fuse

To conduct a test, burn off at least 3 feet for each roll of time fuse, use the following steps:

Step	Action
1	Divide the burn time by three to get the seconds per foot rate of burn for that role of time fuse. If you do not use the fuse within 24 hours of the test burn, perform another test before using the fuse.
2	Do not cut the fuse until you are ready to use it and never use the first or last 6 inches of a roll.
3	Always cut the end of the fuse square. Rough or crooked cuts may lead to misfires.
4	Avoid sharp bends, loops, or kinks in the time fuse, as this may result in a break in the powder train and result in a misfire.

Detonating Cord

Do not carry or hold detonating cord by placing it around your neck. Do not cut 6 inches off of detonating cord because 6-inch tails are standard from taping and on knots to avoid moisture infiltration. Avoid sharp bends, loops, or kinks in the detonating cord, as this may change the path of detonation or cause the cord to cut itself.

Toxicity

Allow sufficient time for blast fumes, dust, and mists to clear before inspection of occupying a blasting area. Most military explosives are poisonous if ingested and will produce lethal gases if detonated in confined spaces. Wash your hands after working with explosives and avoid touching sensitive areas of your body prior to washing.

Cutting Explosives

Cut explosives, including time fuse and detonating cord, with a sharp knife on a nonsparking surface. Never use shears on plastic and sheet explosives.

Hazards of Detonating Explosives

Missile Hazard

Explosives can propel lethal missiles great distances. The distances these missiles will travel in air depend on the relationship between the missiles' weight, shape, density, initial projection angle, and initial speed. Under normal conditions, the missile-hazard area of steel-cutting charges is greater than those of cratering, quarrying, and surface charges.

Noise

Permanent hearing loss can be caused from the noise and pressure wave from blasts. Hearing protection should be worn during all blasting operations. Personnel observing from the minimum safe distance should not be in danger from the blast effects.

Incendiary

The incendiary thermal effect produced by the detonation of high explosives varies greatly from one explosive to another. In general, a high explosive will produce a short (fractions of a second) bright flash or fireball at the instant of detonation. Unless highly combustible materials are involved, the thermal effect plays an insignificant part in an explosion.

Should highly combustible materials be present and a fire started, the debris resulting from the explosion may provide additional fuel and contribute to spreading the fire. Incendiary thermal effects are generally the least damaging of the primary detonation effects.

Blast Pressure

When an explosive charge is detonated, very hot, expanding gases are formed in a period of microseconds. These gases exert pressures of about 700 tons per square inch on the atmosphere surrounding the point of detonation and rush away from the point of detonation at velocities of up to 7,000 miles per hour, thus compressing the surrounding air. This mass of expanding gas rolls outward in a circular pattern from the point of detonation like a giant wave, weighing tons, smashing and shattering any object in its path. The further the pressure wave travels from the point of detonation, the less power it possesses until, at a great distance from its creation, it dwindles to nothing.

Continued on next page

Blast Pressure Wave

The wave of pressure is commonly referred to as the blast pressure wave. The blast pressure wave has two distinct phases, which will exert two different types of pressures on any object in its path. These phases are the positive pressure phase and the negative or suction phase. The entire blast pressure wave, because of its two distinct phases, actually delivers a one-two punch to any object in its path.

The blast pressure effect is the most powerful and destructive of the explosive effects produced by the detonation of high explosives. The surrounding environment has a dramatic effect on the blast pressure wave. A blast pressure from a detonation in the open environment will dissipate at a significantly lesser distance than a blast pressure wave that is reflected and focused off of the surroundings like building or walls.

Subgrade Blast Wave

When an explosive charge is buried in the earth or placed underwater and detonated, the same violent expansion of gases, heat, and shock results. Since earth is more difficult to compress than air, and water is uncompressible, the detonation will seem less violent from the surface. Nevertheless, the same energy released as compared to the same detonation in the open air.

This shock wave will pass through earth and water just as it does through air, and when it strikes an object such as a foundation, the shock wave will impart its energy into the structure, which may cause damage much like an earthquake would. An explosive charge detonated underwater will produce damage at greater distances because water is uncompressible and cannot absorb energy. As a result, the blast transmits the shock wave much faster and farther, and consequently produces greater damage within a larger area.

Blast Injuries

Selected Blast Injuries

The following blast injuries are caused by many things:

- Lung
- Ear
- Abdominal
- Brain

Lung

Blast lung is a direct consequence of the HE over-pressurization wave. It is the most common fatal primary blast injury. Signs of blast lung are usually present at the time of initial evaluation, but they have been reported as late as 48 hours after the explosion. Blast lung is characterized by the clinical triad of apnea, bradycardia, and hypotension. Pulmonary injuries vary from scattered petechae to confluent hemorrhages. Blast lung should be suspected for anyone with dyspnea, cough, hemoptysis, or chest pain following blast exposure.

Ear

Primary blast injuries of the auditory system cause significant morbidity, but are easily overlooked. Injury is dependent on the orientation of the ear to the blast. Perforation is the most common injury to the middle ear. Signs of ear injury are usually present at time of initial evaluation and should be suspected for anyone presenting hearing loss, ringing tinnitus, vertigo, bleeding from the external canal, or middle ear rupture.

Abdominal

Gas-containing sections of the gastro intestinal tract are most vulnerable to primary blast effect. This can cause immediate bowel perforation, hemorrhage (ranging from small petechiae (small pin hole) to large hematomas (large tears)), solid organ lacerations, and testicular rupture. Blast abdominal injury should be suspected in anyone exposed to an explosion with abdominal pain, nausea, vomiting, rectal pain, and testicular pain.

Brain

Primary blast waves can cause concussions or mild traumatic brain injury (MTBI) without a direct blow to the head. Consider the proximity of the victim to the blast particularly when given complaints of headache, fatigue, poor concentration, lethargy, depression, anxiety, insomnia, or other constitutional symptoms.

Protective Measures

Cover

Overhead cover is always recommended when available. If minimum safe distance cannot be reached, overhead and line of site cover must be utilized. Bunkers are the best source of cover. Buildings can be utilized (depending on distance from the blast). Walls and ditches are expedient line of site protection but they provide no overhead cover from falling debris.

Charges Under 500 pounds

For charges of less than 500 pounds, the safe distances are provided on the GTA 5-10-33, page 1. This chart provides the safe distance for personnel in the open and is calculated using surface laid charges.

Minimum Safe Distance Chart Under 500 Pounds

Explosives (lbs)	Safe Distance (m)	Explosives (lbs)	Safe Distance (m)
27 or Less	300	150	534
30	311	175	560
35	327	200	585
40	342	225	609
45	356	250	630
50	369	275	651
60	392	300	670
70	413	325	688
80	431	350	705
90	449	375	722
100	465	400	737
125	500	425	750
		500	800

Notes:

1. **For explosives over 500 pounds, use the following formula to calculate the safe distance:**

   Safe Distance (m) = 100 x $\sqrt[3]{}$ Pounds of explosives

2. **The minimum safe distances for personnel in a missile-proof shelter is 91.4 m.**

Continued on next page

Charges Between 500 to 2000 Pounds

There is a chart provided in FM 5-250, Table 6-3 on page 6-8. Use this if available. If not, utilize the same formulas provided for 2000 pounds or more explosives.

Minimum Safe Distance Chart for Charges Between 500 to 2000 Pounds

Explosives (lbs)	Safe Distance (m)	Explosives (lbs)	Safe Distance (m)
525	805	1275	1,082
550	819	1300	1,089
575	830	1325	1,096
600	842	1350	1,103
625	853	1375	1,109
650	864	1400	1,116
675	875	1425	1,123
700	886	1450	1,129
725	896	1475	1,136
750	907	1500	1,142
775	917	1525	1,148
800	926	1550	1,154
825	936	1575	1,161
850	945	1600	1,167
875	954	1625	1,173
900	963	1650	1,179
925	972	1675	1,185
950	981	1700	1,191
975	989	1725	1,196
1000	998	1750	1,202
1025	1,006	1775	1,208
1050	1,014	1800	1,213
1075	1,022	1825	1,219
1100	1,030	1850	1,225
1125	1,038	1875	1,230
1150	1,045	1900	1,235
1175	1,053	1925	1,241
1200	1,060	1950	1,246
1225	1,067	1975	1,251
1250	1,075	2000	1,257

Continued on next page

Protective Measures, Continued

Charges Over 2000 pounds

To calculate the minimum safe distance, use the following formulas:

Distance in meters: (meters = $100^3 \sqrt{\text{pounds of explosive}}$)
Distance in feet: (feet = $300^3 \sqrt{\text{pounds of explosive}}$).

An explosive weight of 1,000 pounds would be calculated as

Safe distance (m) = $100^3 \sqrt{1000}$. This will work out to be 998 meters.

Lesson 2 Exercise

Directions

Complete exercise items 1 through 5 by performing the action required. Check your answers against those listed on the reference page.

Item 1

For safety precautions during detonation, ensure that you give warning before initiating demolitions by giving the warning "_______" three times.

a. Water in the hole
b. Explosives in the hole
c. Fire in the hole
d. Get out

Item 2

What are the types of hazards from explosive detonations?

a. Noise, blast pressure, thermal and broken bones
b. Noise, blast pressure, missile, and incendiary
c. Fire, noise, blast pressure, and incendiary
d. Incendiary, noise, missile, and thermal

Item 3

What are the different types of blast injuries?

a. Lung, ear, abdominal, brain
b. Nose, ear, lung, mouth
c. Lung, nose, abdominal, spine
d. Ear, spine, nose, brain

Item 4

What is the most common fatal injury caused by the blast wave?

a. Lung
b. Concussion
c. Ear
d. Contusions

Item 5

What is the required information to compute minimum safe distance for a surface laid charge with no cover available?

a. Pounds of explosive and cover
b. Pounds of explosives only
c. Available cover
d. Net explosive weight and pounds of explosive

Continued on next page

Lesson 2 Exercise, Continued

Solution

The answers to the exercise items are listed below. Check your answers against those listed on the reference page.

Item	Answer	Reference Page
1	c	1-41
2	b	1-46
3	a	1-48
4	a	1-48
5	b	1-51

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LESSON 3

NET EXPLOSIVES WEIGHT

Introduction

Scope

This lesson describes the process and procedures for calculating and converting required explosive weight, when employing demolitions.

Purpose

The purpose of this lesson is to provide you with the skills and knowledge necessary to perform the required calculations used to convert the required quantity of explosives for various types of explosives to conduct demolition operations.

Learning Objectives

At the end of this lesson, you should be able to

- Convert explosive weights from tri-nitro-toluene (TNT) equivalents.
- Find the net explosive weight in pounds.

In This Lesson

This lesson contains the following topics:

Relative Effective Factor

Where to Find the RE Factor

The relative effective (RE) factor can be found on the GTA 5-10-33 Page 1 under characteristics of block demolition charges. It can also be found in the FM 5-250, in Table 1-1, Page 1-2.

How to Use the RE Factor

The RE factor is used when TNT is either not available or inappropriate for the job. It is a value assigned to each explosive based on its effectiveness as compared to TNT. If the required amount of TNT to complete a mission is 85 pounds and the only explosive available is dynamite, the calculation would be 85 divided by .92 (the RE of dynamite) = 92.4 pounds of dynamite. Utilizing only whole numbers, it rounds up to 93 pounds.

When to Use the RE Factor

The RE factor is used any time the explosive to be used is other than TNT. It is also used when TNT is not the best explosive for the mission. Composition C4 is much better for cutting steel than TNT so a conversion may be required.

Converting From TNT to Other Explosives

Basic Formula

The basic formula for conversion from TNT to other explosives is pounds of TNT divided by the RE factor of the chosen explosive.

Steel Cutting Example

The following is an example of steel cutting:

Pounds of TNT = 3/8A
P = .375 x 18
P = 6.75 pounds of TNT
6.75 pounds of TNT divided by 1.34 (RE for C4) = 5.03
5.03 pounds of C4 is equal to 6.75 pounds of TNT

Breaching Example

The following is an example of breaching:

Pounds of TNT = R3KC
P = 1.53 x .48 x 3.6
P = 3.375 x .48 x 3.6
P = 5.83
5.83 pounds of TNT divided by .42 (RE ammonium nitrate) = 13.88 pounds of ammonium nitrate.
13.88 pounds of ammonium nitrate = 5.83 pounds of TNT

Net Explosive Weight

Definition

The net explosive weight is the total weight of a specific explosive required to perform the demolition mission.

Required Information

You must have certain information to compute the net explosive weight. The information includes

- What the target is
- What explosives are available for use
- How to calculate required pounds of TNT for the target
- How to convert from TNT to the available or appropriate explosive for the job

Converting from TNT

To convert from TNT to the available explosive, you must know the relative effective factor (RE). Once the required amount of TNT is calculated, you must divide that per charge total by the RE of the explosive to be used.

Example

The required amount of TNT is 100 pounds and the only available explosive is C4, which has an RE factor of 1.34. So, 100 divided by 1.34 = 74.6 pounds, rounded up becomes 75 pounds of C4.

Individual Charges

Each charge must be calculated independently unless they are exactly the same target and the target requires multiple charges. The examples for steel cutting and breaching, which were previously discussed, were for individual charges.

Multiple Charges

A target requires more than one charge; therefore, the individual charge is multiplied by the total number of charges required to accomplish the mission. An example of this is a bridge, which has multiple girders that are exactly the same dimensions. There might be eight stringers for the steel cutting example. If it takes 6 pounds of C4 to cut one of the stringers in question and there are 8 stringers, it will take 48 pounds of C4 to destroy the target. Six pounds of C4 per girder times 8 stringers equals 48 pounds of C4. That is the net explosive weight for the mission. The net explosive weight = 48 pounds of C4.

Lesson 3 Exercise

Directions

Complete exercise items 1 through 3 by performing the action required. Check your answers against those listed on the reference page.

Item 1

If the required amount of TNT to complete a mission is 85 pounds and the only explosive is dynamite, the calculation would be 85 divided by

a. .92
b. .94
c. .96
d. .99

Item 2

How many pounds of TNT divided by .42 = 13.88 pounds of ammonium nitrate?

a. 5.83
b. 6.75
c. 9.25
d. 9.50

Item 3

What is the net explosive weight for 6 pounds of C4 per girder times 8 stringers?

a. 24
b. 32
c. 48
d. 54

Continued on next page

Lesson 3 Exercise, Continued

Solution

The answers to the exercise items are listed below. Check your answers against those listed on the reference page.

Item	Answer	Reference Page
1	a	1-56
2	a	1-57
3	c	1-58

LESSON 4

IMPROVISED DEMOLITION CHARGES

Introduction

Scope

This lesson describes the process and procedures for constructing and utilizing improvised demolitions charges.

Purpose

The purpose of this lesson is to provide you with the skills and knowledge necessary to perform the required actions with explosives and other materials to conduct improvised demolition operations.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the components for an expedient claymore charge.
- Identify the purpose of an expedient shaped charge.
- Identify the components of an expedient flame fougasse.
- Identify the required items used to construct an expedient bangalore torpedo.

In This Lesson

This lesson contains the following topics:

Improvisation

Improvised vs. Expedient

Improvised and expedient are terms that are mostly interchangeable. Today the world deals with improvised explosive devices (IED) almost daily. Improvised has become the more common term. Expedient is a term used to create a specific explosive device from demolitions that were not necessarily intended for that use. As an example of expediency: there is a wire obstacle that has to be breached and you do not have the time to wait for a supply run to get bangalore torpedos. The only explosive you have is composition C4, so you make a bangalore torpedo to breach the wire. This is expedient because it can be made quickly and on the spot and will effectively do the job.

Common Types of Expedient Charges

There are several types of expedient charges that are more common than others. The expedient claymore mine, which is a directional command detonated weapon, is designed for use against enemy personnel. The expedient shaped charge will come in handy when you need a borehole for a breaching charge. The expedient bangalore has already been mentioned above and is designed to breach the same obstacles as a standard bangalore torpedo. The expedient flame mine can be used to destroy equipment or as an initiator for burning.

Boobytraps

Boobytraps are usually expedient in nature and are limited only by the imagination of the individual building and placing them. With a power source, initiator, and an explosive, anything that can be moved or stepped on can be booby-trapped. This course will cover boobytraps in a later lesson.

Expedient Claymore/Grapeshot

Purpose

The purpose of a claymore mine, whether expedient or manufactured, is to inflict damage to enemy personnel and equipment. This charge is also called grapeshot. This type of device should only be used when claymores are not available.

Required Components

The expedient claymore/grapeshot charge is made with a container (ammo can or large can), projectiles (nails, scrap metal, bolts, glass, rocks), buffer material (leaves, soil, felt, cloth, cardboard, or wood), a charge (C4), and an initiator, (blasting cap or detonating cord).

Assembly

Follow the steps below to assemble the expedient claymore:

Step	Action
1	Use a quantity of explosives equal to one half the total weight of the projectiles.
2	Cut a hole in the center of the container large enough to accommodate the initiator you will be using.
3	Place the components into the container in the following order.
4	If initiating with detonating cord, pull the cord through the hole and tie five knots, one the middle and one in each of the four corners.
5	Place the plastic explosive uniformly in the bottom of the container (packed firmly with a non sparking instrument).
6	Place the buffer in next; place 2 inches of buffer material directly on top of the explosive.
7	Place the projectiles directly on the buffer material and then apply a cover to keep the projectiles from falling out during movement and placement.

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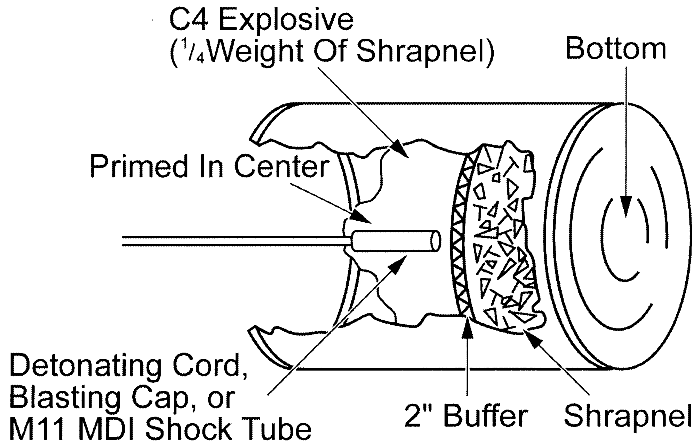
Illustration

The illustration below shows the expedient claymore/grapeshot charge.



Priming

The expedient claymore is primed if you used a detonating cord during the construction. If it is not, make a cap well for the blasting cap and cover any part of the cap that is exposed. It must be covered with C4 (on the outside as well).

Expedient Shaped Charge

Purpose

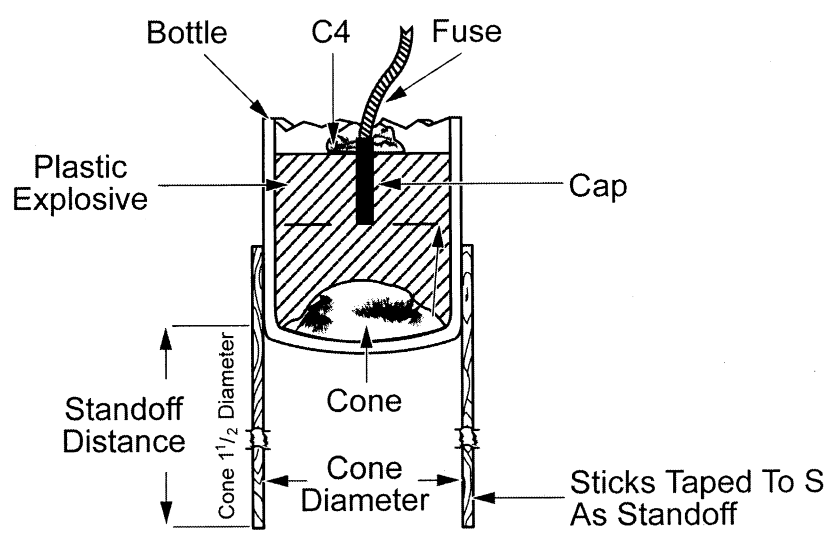
Shaped charges concentrate the energy of the explosion released on a small area, making a tubular or linear fracture in the target. The shaped charge is effective against many targets due to its versatility. They are especially effective against concrete and armor plating.

Standoff

A standoff is the distance between the bottom of the shaped charge and the top of the intended target. Standoffs will vary in distance, depending on the size (diameter) of the charge. The standoff distance is usually 1.5 times the diameter of the cone. Standoff can be achieved by taping sticks to the side of the container.

Illustration

The illustration below shows the expedient shaped charge.



Assembly

When assembling the expedient shape charge, obtain a container for the shaped charge and remove both ends. Almost any kind of container will work (cans, jars, bottles, drinking glasses). Some containers come equipped with built-in cavity liners, such as champagne or cognac bottles with the stems removed. With the ends removed, the container is ready for a cavity liner and explosive.

Continued on next page

Removing

To remove the narrow neck of a bottle or the stem of a glass, follow the steps below:

Step	Action
1	Wrap the neck of the bottle with a piece of soft, absorbent twine.
2	Place two bands of adhesive tape, one on each side of the twine to hold it securely in place.
3	Soak the string in gasoline and light it.
4	Heat the glass uniformly; turn the bottle continuously with the neck up.
5	After the twine has burned, submerge the neck of the bottle in water and tap it against some object to break it off.
6	Tape the broken end of the bottle to prevent cutting your hands while tamping the explosive in place.

Cavity Liner

Make a cone-shaped cavity liner for the container using copper, tin, zinc, or glass. Funnels or bottles with a cone in the bottom are excellent. However, if the material is not available for a cavity liner, you can make a workable but less effective shaped charge by cutting a cone-shaped cavity in a block of explosive.

Cavity Angle

Expedient charges will work with cavity angles between 30 and 60 degrees. Most high-explosive antitank (heat) ammunition has a cavity angle between 42 and 45 degrees. The optimum angle is 45 degrees.

Explosive Height

The explosive height (inside the container) is two times the cone height, measured from the base of the cone to the top of the explosive. Press the explosive into the container, being careful not to alter the cavity angle of the cone. Ensure the explosive is tightly packed and free of any air pockets.

Detonation Point

The exact top center of the charge is the detonation point. Cover the blasting cap with a small quantity of C4 if any part of the blasting cap is exposed or extends above the charge.

Expedient Flame Fougasse

Description

The expedient flame fougasse can be used in the defense or offensive operations for its incendiary, illuminating, and signaling effects. This charge is made up of a 55-gallon drum of thickened fuel, a kicker charge, a trip flare, and detonating cord. A 55-gallon drum containing a fougasse mixture is effective for a controlled-direction burst.

Assembly

To assemble the expedient flame fougasse, follow the steps below:

Step	Action
1	Make the fougasse mixture by mixing 3 ounces of M4 thickening compound per gallon of gasoline or jet petroleum 4 (JP4) fuel. Depending on the temperature, the thickening time will vary. The desired viscosity is that of applesauce. For a 55-gallon drum, vigorously mix 150 ounces of M4 thickening compound with 50 gallons of fuel.
2	Dig an angled trench for the drum that will allow the best coverage and dispersion of the flame fougasse. Do not build the trench steeper than 45°. Make a small cutout area in the back of the trench for the kicker charge (2 pounds of TNT or 1 block of C4).
3	Prime the kicker charge with detonating cord, leaving 6 to 10 feet of the detonating cord free to tie into a ring main.
4	Wrap the top end of the drum with five to seven wraps of detonating cord, leaving 6 to 10 feet of detonating cord free to tie into a ring main.
5	Lay the drum in the trench and place the kicker charge in the small cutout. Push the drum against the back of the trench so that the kicker charge seats firmly against the bottom of the drum. It may be necessary to tamp soil around the charge to properly center the kicker charge against the bottom of the drum. Ensure that the running ends of the detonating cord for the kicker charge and drum top extend from the trench. Avoid kinks or sharp bends in the detonating cord.
6	Lay out a ring main of detonating cord around the 55-gallon drum and tie the detonating cord from the kicker charge and wrap to the ring main.
7	Cover the entire drum with a minimum of 3 feet of tamped soil, leaving the front of the drum exposed.
8	Using a length of detonating cord, tape one end under the spoon handle of an igniter trip flare (M49). Tape the spoon handle down securely, attach the trip flare to a stake, and position the stake 3 to 4 feet in front of the drum. Attach the free end of the detonating cord secured to the trip flare to the ring main. During combat, a white phosphorous grenade (M34) will work in place of the trip flare.
9	Attach initiation sets to the ring main.

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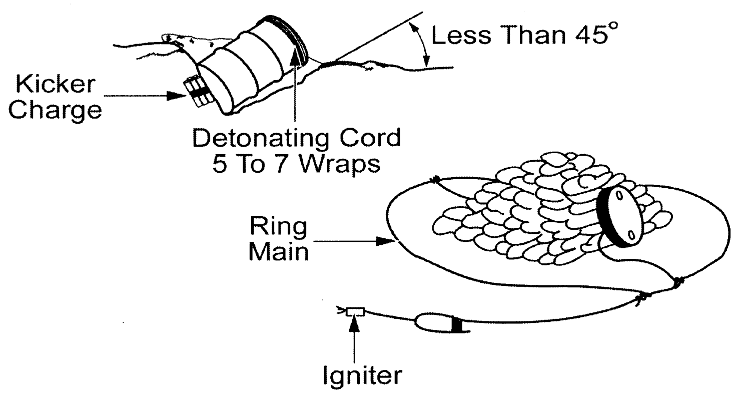
Illustration

The illustration below shows the expedient flame fougasse.



Alternate Ignition Sources

If trip flares of grenades are unavailable, there are two additional methods to ignite the fuel mixture.

Method 1

Method 1 uses steel wool. Use the same amount of explosive for the kicker charge and prime them with detonating cord. Place a buffer material around the kicker charge and tape it in place. Attach steel wool to the buffer charge so that it covers the entire width of the kicker charge. The steel wool will ignite the fuel in the drum once the kicker charge is propelled through the bottom of the drum. The steel wool must be in contact with the bottom of the drum.

Method 2

Method 2 takes a 2-liter plastic bottle and fill it half full with raw gasoline or JP4 (un-thickened). Punch a hole in the cap of the bottle, and thread one end of detonating cord through the hole. Tie a single overhand knot in the detonating cord to prevent it from being pulled back out of the cap. Place the detonating cord with the knot inside the bottle, and secure the cap onto the bottle. Attach the opposite end of the detonating cord to the ring main.

Initiation

When initiated, the ring main initiates the detonating cord to the trip flare, the drum top, and the kicker charge. The wraps cut the top of the drum off, the kicker charge propels the thickened fuel outward, and the trip flare ignites the fuel as it travels down range. This all results in a gout of flame that spreads down range for about 100 meters.

Expedient Bangalore

Purpose

The expedient bangalore is used to defeat wire obstacles and antipersonnel mines. It should only be used if bangalore torpedos are not available. The items used to construct an expedient bangalore torpedo are four U-shaped pickets; C-4; detonating cord, tape, or wire; and a firing system.

Assembly

To assemble the expedient bangalore, follow the steps below:

Step	Action
1	Separate the packaging material from C4 (M112).
2	Using a nonsparking tool, mold the C4 in the entire length of the concave portion of two U-shaped pickets that are not bent or damaged.
3	Place a line of detonating cord that has single overhand knots tied every 6 to 8 inches the entire length of the C4 packed picket leaving enough detonating cord sticking out of the end to tie into a firing system.
4	Place the other C4 packed picket on top of the picket with the detonating cord on it. The C4 from each picket will be touching with the detonating cord in the middle.
5	Secure the two pickets together with tape or wire.

Expedient Breaching Charges

Improvised Cratering Charge

The expedient breeching charge is used to supplement the 40-pound cratering charge or as an improvised cratering charge when the 40-pound cratering charge is not available. It consists of a mixture of ammonium-nitrate fertilizer (at least 33.33% nitrogen) and diesel fuel, motor oil, or gasoline. The ratio of fertilizer to fuel is 25 pounds to 1 quart. Avoid using fertilizer that is damp. Follow the steps below to detonate the charge:

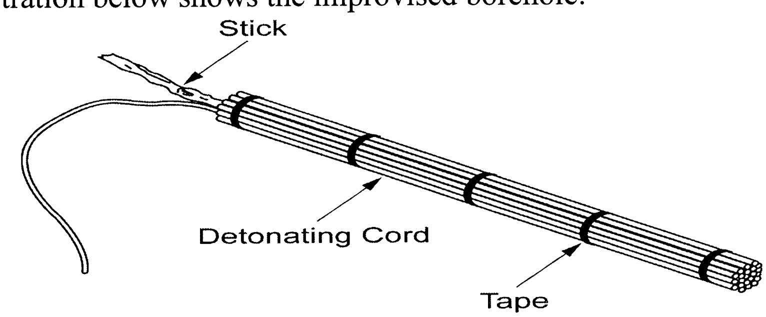
Step	Action
1	Measure the fertilizer and fuel for the size charge you require. Add the fuel to the fertilizer and mix thoroughly. Allow the fuel to soak into the fertilizer for an hour.
2	Place half the ammonium-nitrate mixture in the borehole.
3	Place two 1-pound primed blocks of explosives in the borehole, and add the remainder of the ammonium nitrate. Note: Do not leave the charge in the ground for extended periods of time as it will absorb moisture and be less effective. Boreholes should receive 10 pounds of explosives for every foot of depth and must be duel primed.
4	Detonate the charge.

Improvised Borehole Method

The improvised borehole method is used to enlarge boreholes in soil. Taping together several strands of detonating cord 5 to 6-feet long creates this. The general rule is that one strand of detonating cord enlarges the holes diameter by 1 inch. Make a hole by driving a 2-inch steel rod into the ground and inserting the strands into the hole, leaving a tail of detonating cord to be tied into a firing system. Use 10 strands for a 10-inch hole. The strands must extend the full depth of the hole. Check the holes for excessive heat before placing cratering charge in the hole.

Illustration

The illustration below shows the improvised borehole.



Lesson 4 Exercise

Directions Complete exercise items 1 through 4 by performing the action required. Check your answers against those listed on the reference page.

Item 1 The expedient claymore charge is made with a container, _________, buffer material, a charge, and an initiator.

a. projectiles
b. tape
c. gasoline
d. screws

Item 2 The purpose of the expedient shaped charge is to

a. inflict damage to enemy personnel and equipment.
b. defend or offend operations for its incendiary effects.
c. defeat wire obstacles.
d. concentrate the energy of the explosion released on a small area.

Item 3 What are the components of an expedient flame fougasse?

a. 55 gallon drum, 50 gallons of gasoline, cratering charge, trip flare, and blasting cap
b. 55-gallon drum, 50 gallons of thickened fuel, a kicker charge, a trip flare, and detonating cord
c. gasoline, trip flare, blasting cap, detonating cord, and kicker charge
d. 55-gallon drum, 50 gallons of thickened fuel, kicker charge, blasting cap, and gasoline

Item 4 What are the required items for constructing an expedient bangalore torpedo?

a. Two U-shaped pickets; C4; detonating cord, tape, or wire; and a firing system
b. Two U-shaped pickets; TNT; detonating cord, tape, or wire; and a firing system
c. Four U-shaped pickets; C4; detonating cord, tape, or wire; and a firing system
d. Four U-shaped pickets; TNT; detonating cord, tape, or wire; and a firing system

Continued on next page

Lesson 4 Exercise, Continued

Solutions

The answers to the exercise items are listed below. Check your answers against those listed on the reference page.

Item	Answer	Reference Page
1	a	1-63
2	d	1-65
3	b	1-67
4	c	1-69

LESSON 5

PRIMING DEMOLITIONS

Introduction

Purpose

The purpose of this lesson is to provide you with the skills and knowledge necessary to perform the required actions when priming explosive charges.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the purpose of the priming system.
- Identify the components in the electrical initiation set.
- Identify the common series circuits.
- Identify the leapfrog series circuits.
- Identify the components of a nonelectric firing system.
- Identify the components of a firing system utilizing MDI (shock tubes).

In This Lesson

This lesson contains the following topics:

Priming Systems

Purpose

The purpose of a priming (firing) system is to initiate the detonation of an explosive charge at a designated time. This can be accomplished through the use of a time fuse or by electrical means.

Control

The priming system that is used will allow the individual in charge of the demolition project to maintain control of the detonations. This control allows for accountability of personnel and safety. The person in charge will keep the priming mechanism with them at all times if it is command detonated (electric mechanism), and, if nonelectric mechanism is used, the command to light the time fuse is given by the person in charge.

Components

There are common components in all priming systems:

- Initiation sources (fuse igniter for nonelectric and power source for electric)
- Intermediate connection (time fuse (nonelectric) or firing wire (electric))
- Connectors or tape
- Blasting caps for either electric or nonelectric initiation

Electrical Initiation Sets

Purpose

The purpose of an electrical initiation is to allow for command detonation without any delay. An electrical initiation set can detonate a charge at the push of a button. This allows for greater control, safety and flexibility.

Components

There are three main components in an electrical initiation set:

- Electric blasting cap (provides shock adequate to detonate the explosive)
- Firing wire (connects the power source)
- Power source (a blasting machine that provides a minimum of 1.5 amperes of electricity to the blasting cap)

Preoperational Tests

There are three items which need to be tested prior to use:

- Blasting machine
- Firing wire
- M51 test set

Blasting Machine

The blasting machine provides the power source (electrical impulse) required to initiate electric blasting caps. The M32 will fire 10 caps in series while the M34 will fire 50 caps in series. They look alike except that the M34 has a black band around the base and a reinforced-steel actuating handle.

Continued on next page

Electrical Initiation Sets, Continued

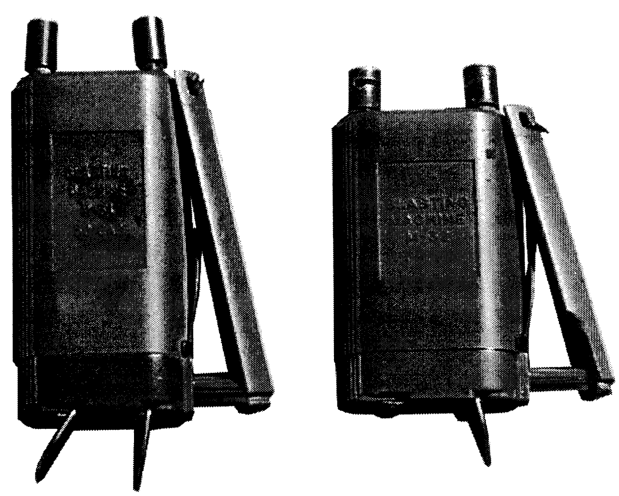
Testing the Blasting Machine

To test the machine, do the following:

Step	Action
1	Release the handle, then activate the machine by depressing the handle rapidly three to four times until the neon indicator lamp flashes. The lamp can't be seen until it flashes and is located between the terminal posts. If the lamp is nonoperational, insert the firing wire and hold the other ends of the wire where you can see them.
2	Activate the machine until the charge fires (a spark jumps between the wires).
3	Hold the machine by placing the handle in the palm of the hand and grasp the body with the fingers, then squeeze rapidly. <u>Note</u>: Be sure to hold the machine correctly as the handle is easily broken.

M32 and M34

The illustration below shows the M32 and M34 blasting machines.



M32 (10 caps) M34 (50 caps)

Continued on next page

Electrical Initiation Sets, Continued

Firing Wire

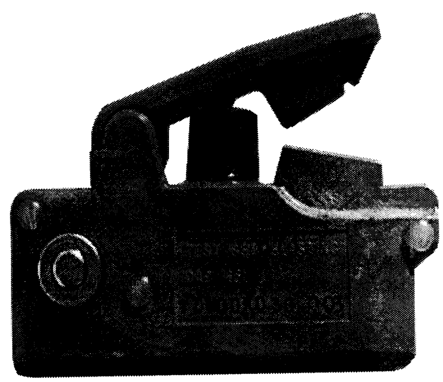
The firing wire connects the power source (blasting machine) to the blasting cap and allows the current to travel through it. It is a number 18 American Gauge Wire (AWG) with a plastic or rubber coating.

Testing the Firing Wire

Test fire wiring with either the M51 test set or a galvanometer shown in the illustration below.

M51 Test Set

The M51 test set is a self-contained unit that tests the system and flashes a light when squeezed if a complete circuit has been made. It will not flash if there is not a complete circuit.



Galvanometer

The galvanometer is used to verify the existence of a circuit. To test the meter, lay the M2 crimpers across both posts. The face gauge should read a completed circuit. If no reading exists, change batteries.

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Laying Out The Firing Wire

After locating a firing position a safe distance away from the charges, lay out the firing wire from the charges to the firing position. Firing wire must always be laid flat on the ground or buried. Do not allow vehicles to cross or personnel to walk on firing wire. The firing wire must be kept as short as possible and must not have any loops in it (laid in as straight a line as possible). The wire should be cut to length and not connected to a blasting machine through the unused portion on the reel.

Retest the firing wire. The open and closed circuit tests must be performed again. Unreeling the wire may have separated broken wires not noticed when the wire was tested on the reel.

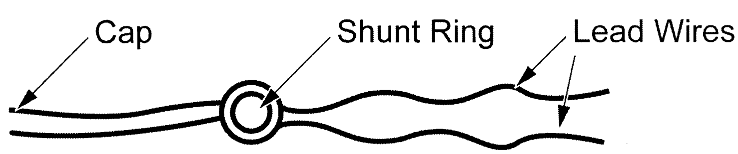
Testing the Blasting Cap

Follow the steps below to test the blasting cap:

Step	Action
1	Completely remove the blasting cap lead wires from the cardboard spool.
2	Place the blasting cap under a sandbag or helmet. The blasting cap should be tested away from extra personnel and the tester should have his back to the blasting cap.
3	Remove the short circuit shunt from the lead wires.
4	Test the cap with the galvanometer or M51 test set. If you do not get a reading (flash), the cap is defective and should not be used.

Shunt

The illustration below shows a shunt.



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Connect the Blasting Cap to the Firing Wire

The free leads of the blasting cap must be connected to the firing wire before a charge is primed. Make the connections with a western union pigtail splice.

Retest the Entire Circuit

Before the charge is primed, test the entire circuit from the firing end. After the test is complete, shunt the ends of the firing wire at the firing end. At this point, the initiation system is complete and the charges are primed.

WARNING: Do not connect the blasting machine until all personnel are accounted for and the charge is ready to fire.

Definitions

The following terms are important when using electrical initiations sets:

Term	Definition
Closed Circuits	Allow current to flow.
Open Circuits	Will not allow current to flow.
Shunt	Lead wires are crossed to prevent electric current from detonating the cap.

Common Series Circuit

Common series circuits use two or more electric blasting caps to fire from a single blasting machine. Prepare a common series circuit by connecting one blasting cap lead wire from the first cap to one lead wire of the second cap until only two ends are free. Connect the free ends of the cap lead wires to the ends of the firing wire. Use connecting wires (usually 22 AWG) when the distance between caps is greater than the length of the cap lead wires.

Continued on next page

Leapfrog Series Circuits

Leapfrog series circuits are useful for firing a long line of charges. Start at one end of a row of charges and prime every other charge (i.e. odd number charges) to the end of the row. The opposite charges (i.e. even numbered charges) are connected on the return path. This method eliminates laying a long return lead from the far end of the line of charges back to the firing wire. This circuit is rarely needed, since the detonating cord can be used instead.

Initiation

At this point, all circuits are complete and ready to detonate. Account for personnel and proceed.

Nonelectric Initiation Sets

Purpose

The purpose of a nonelectric initiation set is to initiate an explosive at a predetermined time, using a nonelectric blasting cap.

Components

There are three basic components to a nonelectric initiation set.

- Ignition source (M60 fuse igniter, matches, or a cigarette lighter)
- Time fuse (delivers a flame that detonates the blasting cap after a time delay)
- Nonelectric blasting cap (provides shock adequate to detonate the explosive)

Assembly

The following steps are performed to assemble the nonelectric initiation set:

Step	Action
1	Check the fuse.
2	Prepare the fuse.
3	Attach the fuse igniter.
4	Install the priming adapter.
5	Prepare the blasting cap.

Check the Fuse (Step 1)

Check the time fuse for burn rate by conducting a test burn of 3 feet for each roll of time fuse. Divide the burn time by three to get the seconds per foot rate of burn for that roll of time fuse.

Notes: If you do not use the fuse within 24 hours of the test burn, perform another test before using the fuse to ensure that moisture hasn't affected the burn time.

Do not cut the fuse until you are ready to use it and never use the first or last 6 inches of a roll. Always cut the end of the fuse square. Rough or crooked cuts may lead to misfires.

Avoid sharp bends, loops, or kinks in the time fuse. This may result in a break in the powder train and result in a misfire.

Continued on next page

Prepare the Fuse (Step 2)

Calculate the length of the fuse by using the following formula:

$$\frac{\text{Time required (min) x 60 (seconds per minute)}}{\text{Burning Rate (Seconds per foot)}} = \text{Fuse Length (Feet)}$$

Example

If you need a 6-minute fuse, and you have calculated the burn rate to be 42 seconds per foot, the equation would be:

$$\frac{\text{6 (min) x 60 seconds per minute)}}{\text{42 (seconds per foot burn rate)}}$$

a. 6 x 60 = 360 seconds
b. Fuse length = 360 (seconds) divided by 42 (burn rate) = 8.571 feet
c. Fuse length = 8 feet 6 inches (multiply .571 x 12 to convert the decimal to inches)

Continued on next page

Attach the Fuse Igniter (Step 3)

To attach the fuse igniter to the time fuse, unscrew the collar two to three turns (do not remove the collar), then push the shipping plug in (to release it) and discard the plug. Insert the time fuse into the opening vacated by the plug (ensure the time fuse goes all the way in). Tighten the collar to hold the time fuse in place.

Install the Priming Adapter (Step 4)

Follow the steps below to install the priming adapter:

Step	Action
1	Install the adapter onto the time fuse before putting the cap in place.
2	Insert fuse into cap.
3	Crimp the cap.
4	Secure the cap with the adapter.

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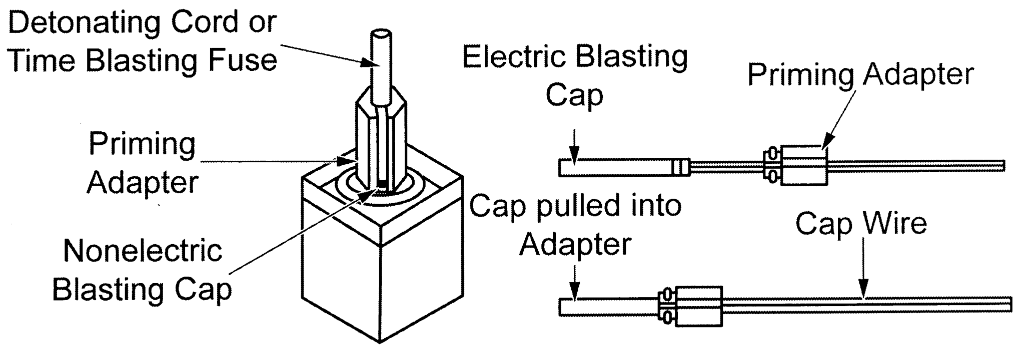
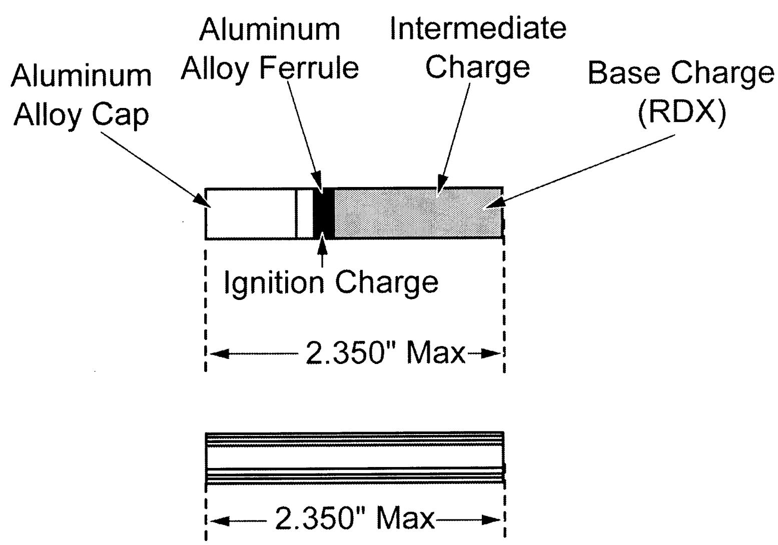
Priming Adapter

The illustration below shows the priming adapter.



Nonelectric Blasting Cap

The illustration below shows a nonelectric blasting cap.



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Prepare the Blasting Cap (Step 5)

Follow the steps below to prepare the blasting cap:

Step	Action
1	Remove the cap from the cap box (illustration on the following page) and close it.
2	Inspect the blasting cap by looking into the open end.
3	Hold the cap between the thumb and ring finger of one hand and the forefinger of the same hand on the closed end of the blasting cap. You should see the yellowish ignition charge.
4	If there is dirt or foreign matter present, • Aim the open end of the cap at the palm of the second hand. • Gently bump the wrist of the cap-holding hand against the wrist of the other hand. Do not use the cap if the foreign matter does not dislodge.
5	Hold the time fuse vertically with the square-cut end up, and slip the cap gently down over the fuse so the flash charge in the cap touches the fuse.
6	Grasp the fuse with the thumb and ring finger while applying slight pressure with the forefinger on the closed end of the cap.
7	Use the opposite hand to operate the crimpers.
8	Place the crimping jaws around the cap at a point 1/8 to 1/4 inch from the open end.
9	Extend both arms straight out while rotating the hands so the closed end of the cap is facing away from your body and other personnel.
10	Crimp the blasting cap by firmly squeezing the M2 crimper handles together, maintaining eye contact with the blasting cap.
11	Inspect the crimp.

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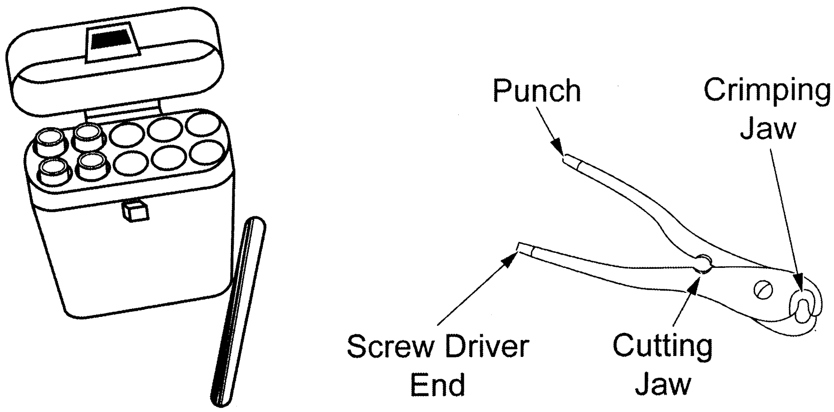
Blasting Cap Box and M2 Crimpers

The illustration below shows the blasting cap box and the M2 crimpers.



Placement of the Blasting Cap

The nonelectric blasting cap is placed in the cap well of a charge or taped to the detonating cord.

CAUTION: Under no circumstance will the nonelectric blasting cap be used underground. Placing it underground makes checking for misfires potentially dangerous. Adding air to the fuse may allow it to cook off and you can't see the smoke from the time fuse until it is too late.

Fuse Initiation

Perform the following steps to fire the assembly:

Step	Action
1	Hold the M60 igniter in one hand and remove the safety pin with the other.
2	Push the pull-ring in, give it a quarter turn, and pull. Note: In case of a misfire, reset the M60 igniter by pushing the plunger all the way in and rotating 180° left or right, and attempt to fire again.

Modernized Demolition Initiators (MDI)

Characteristics

The modernized demolition initiators (MDI) are a new family of nonelectric blasting caps and associated items. MDI supplement the current nonelectric blasting caps and time fuse. The snap-together components simplify initiation systems and some types of explosive priming. MDI will raise reliability and safety, as they do not easily degrade in water, since the components are all sealed. The components of the MDI firing system are

- Shock Tube
- Blasting Caps
- M81 (Time Blasting Fuse Igniter)

Shock Tube

The shock tube is a thin, plastic tube with a layer of cyclotertramethylene tetramitramine (HMX) in its center. This explosive powder propagates a detonation wave that travels along the tube until it reaches a factory attached, sealed blasting cap. The shock tube medium is extremely reliable. Shock tubes may be extended by using the splicing tubes (provided) and leftover pieces of shock tube. The shock tubes should not be cut unless absolutely necessary.

Blasting Caps

There are a variety of blasting cap configurations. There are both high-strength and low-strength caps.

High-Strength Caps

The high-strength caps include the M11, M14, M15, M16, and M18. The system either actuates the cap through flame or shock depending on the style and mission.

Cap	Shock Tube Length	Time Fuse	Method of Actuation
M11	30 ft	N/A	Shock
M14	N/A	5-minutes, 7 ½ ft	Flame
M15	70 ft	N/A	Shock
M16	10 ft	N/A	Shock
M18	N/A	20 minute	Flame

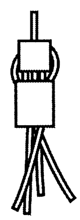
Continued on next page

Low-Strength Caps

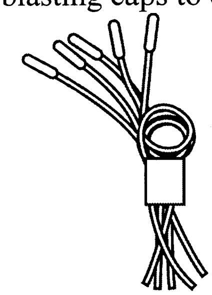
The two low-strength caps are the M12 and M13 and are larger than the standard blasting caps. The size prevents them from being inserted into standard military demolitions. They are not powerful enough to reliably detonate explosives.

Blasting Cap Holder

Plastic blasting cap holders allow the connection of several shock tubes to a high-strength blasting cap. The M9 holder helps secure the connection of up to five shock tubes to the high-strength detonation M11 or M14 blasting cap. The M9 can also be used to connect the blasting caps to detonating cord.



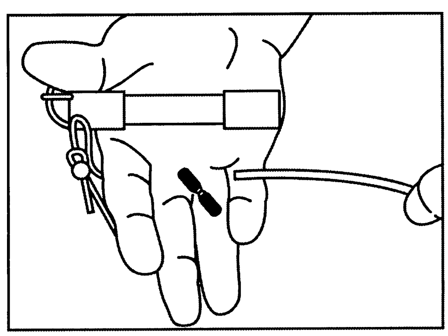
One to Two Shock Tubes



Three to Five Shock Tubes

Time-Blasting-Fuse Igniter (M81)

The M81 is almost identical to the M60 igniter except that the M81 has a screw-end cap with a green shipping plug and a silicon shock tube reducer. The cap allows the M81 to accommodate either the shock tube or the standard time fuse.



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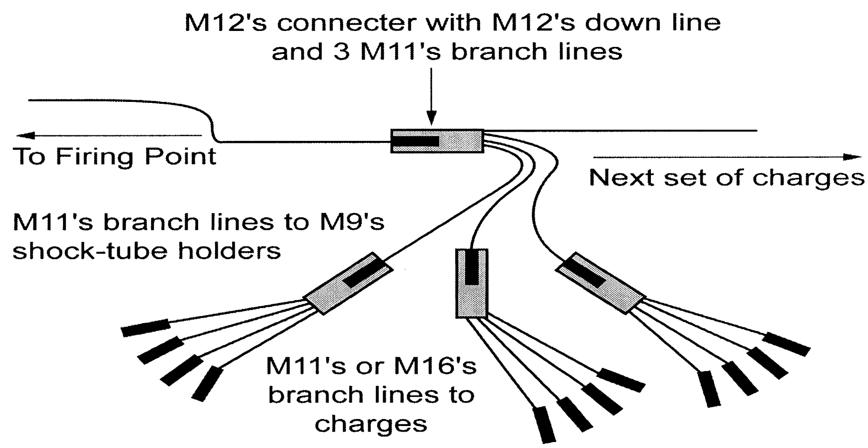
Single Priming

Single priming is not recommended for the MDI firing system. Single priming raises the risk of misfires.

Single Primed MDI Firing System

The illustration below shows a single primed MDI firing system.

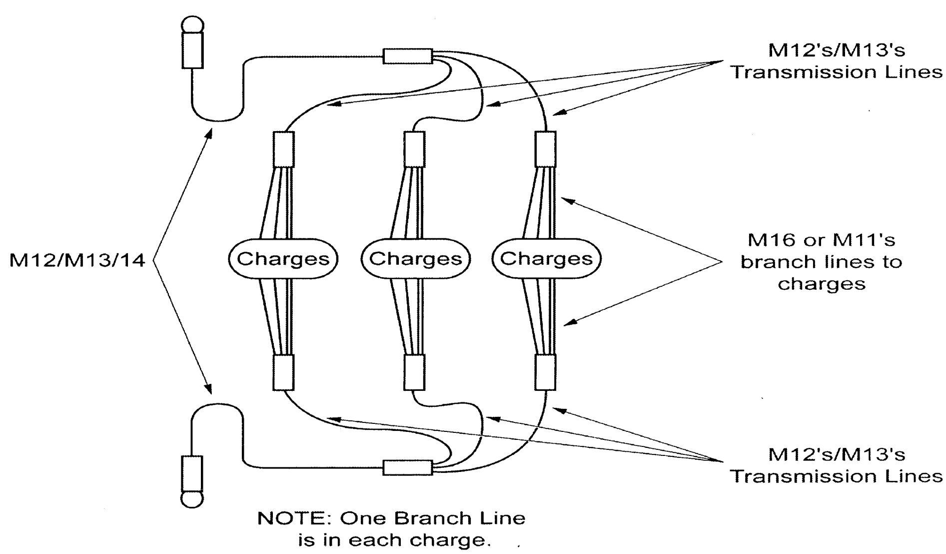


Dual Priming

Dual priming is recommended. It reduces/eliminates the risk of misfires. This is accomplished by connecting two separate initiation charges to the firing system.

Dual Primed MDI Firing System

The illustration below shows a dual primed MDI firing system.



Lesson 5 Exercise

Directions

Complete exercise items 1 through 8 by performing the action required. Check your answers against those listed on the reference page.

Item 1

The purpose of a priming system is to _______ the detonation of an explosive charge at a designated time.

a. ignite
b. prepare
c. eliminate
d. initiate

Item 2 Through Item 4

Matching: For items 2 through 4, match the component in the electrical initiation set in column 1 to its definition in column 2.

Column 1	**Column 2**
Electrical Initiation Set	**Definition**
_____ 2. Electric blasting cap	a. Provides power source required to initiate electric blasting caps
_____ 3. Firing wire	b. Provides shock adequate to detonate the explosive
_____ 4. Blasting machine	c. Connects the power source to the blasting cap and allows the current to travel through it

Continued on next page

Lesson 5 Exercise, Continued

Item 5

To prepare a common series circuit, connect ______ blasting cap lead wire(s) from the first cap to a lead wire of the second cap until only two ends are free.

a. one
b. three
c. four
d. six

Item 6

Leapfrog circuits are used for _____ a long line of charges.

a. firing
b. laying
c. installing
d. attaching

Item 7

The three components of a nonelectric initiation set are __________, time fuse, and nonelectric blasting cap.

a. ignition source
b. firing wire
c. pigtail splice
d. shock tube

Item 8

What are the components of an MDI firing system?

a. M81, blasting cap, and firing wire
b. M60 fuse igniter, blasting machine, and shock tube
c. M81, shock tube, and blasting cap
d. M9 fuse igniter, shock tube, and blasting cap

Continued on next page

Lesson 5 Exercise, Continued

Solutions

The table below provides the answers to the exercise items. If you have any questions, refer to the reference page listed for each item.

Item	Answer	Reference Page
1	d	1-74
2	b	1-75
3	c	1-75
4	a	1-75
5	a	1-79
6	a	1-80
7	a	1-81
8	c	1-87

LESSON 6

THEORY AND OPERATION OF A SHAPED-CHARGE

Introduction

Scope

This lesson describes the theory and operation of a shaped charge.

Purpose

The purpose of this lesson is to provide you with the skills and knowledge necessary to effectively utilize the shaped charge.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the proper method for setting up a shaped charge.
- Identify different effects that materials can have on a shaped charged penetration.
- Identify the proper priming procedures for the shaped charge.

In This Lesson

This lesson contains the following topics:

Theory of a Shaped Charge

Description

The shaped charge is a concave metal hemisphere or cone (known as a liner) backed by high explosive, all in a metal case. They are always primed/ initiated from the exact center on the opposite side of the explosive from the cone.

Background

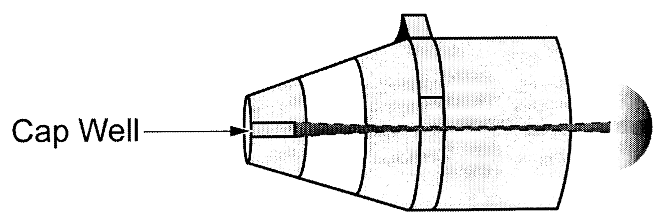
The shaped charge was originally developed during World War I to penetrate tanks and other armored equipment. Because of the focused effect of the jet that is created upon detonation, the shaped charge was designed and used for penetration. The amount of penetration is only limited by the amount of explosives. Used in 1997, Lawrence Livermore successfully tested a shaped charge that penetrated 3.4 meters of high-strength armor steel.

Theory

When the explosive is detonated, the metal liner is compressed and squeezed forward, forming a jet whose tip may travel as fast as 10 kilometers a second (about 6.22 miles per second).

Illustration

The illustration below shows the initial forming of a jet at detonation.



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Theory of a Shaped Charge, Continued

Purpose

The shaped charge is used mainly for making boreholes into which breaching charges may be laid. It can also be used for destroying equipment.

Setup

The shaped charge is very versatile and can be aimed at a specific point. It can be suspended from pickets to get the right standoff distance and set up on an angle. It is always wise to ensure it is securely fastened. The proper method for setting up a shaped charge is to use the appropriate standoff for the charge.

Tamping

Tamping is the act of placing material on the explosive to fill in any gaps or weak spots in the charge. This keeps the shock wave from the explosives contained and going in the desired direction. Sand, sandbags, clay, and mud are examples of tamping materials.

Block Tamping

Block tamping a shaped charge is not recommended. It does not improve performance and may cause problems. If any of the tamping material gets between the cone and the target, it will reduce the effectiveness of the charge. The shaped charge won't work underwater for that reason. Any water in the conical cavity will prevent the high intensity jet from even forming. Never use tamping while preparing a shaped charge.

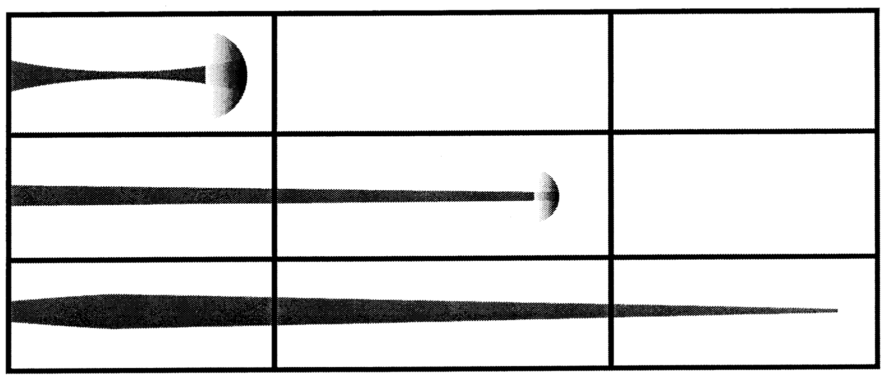
Effects of a Shaped Charge

Effects

The effects of detonating a shaped charge are the focused force of high explosives. The jet that is formed by the cone moves everything out of its way; boring through steel, rock, dirt, concrete, and block. The effect the target has on the penetration of a shaped charge is the density of the target, which will affect the width or depth of the borehole.

Radiographs

The illustration below shows three radiographs of the resulting jet from a shaped charge detonation.



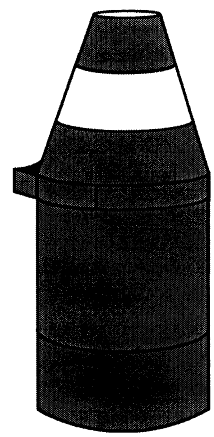
Borehole

The borehole left behind after detonation will vary in size and depth depending on the density of the target it penetrated. The size of the shaped charge will also affect the borehole dimensions.

Continued on next page

15-Pound M2A4 Shaped Charge

The 15-pound M2A4 shaped charge (shown below) contains a 0.11-pound booster charge of composition A3 and an 11.5-pound main charge of composition B. It is packed in a box of three. This charge has a moisture-resistant, molded-fiber container. A cylindrical fiber base slips onto the end of the charge to provide a 6-inch standoff. The cavity liner is a cone of glass. The charge is 15 inches high and 7 inches in diameter.



40-Pound M3A1 Shaped Charge

The 40-pound M3A1 shaped charge contains a 0.11-pound booster of composition A3 and a 29.5-pound main charge of composition B. It is packaged as one charge per box. The cone and the container are both metal. The legs provide a 15-inch high standoff; the charge itself is 15 ½ inches tall, and 9 inches in diameter.

Continued on next page

Effects of a Shaped Charge, Continued

Characteristics The table below shows the characteristics of the boreholes made by shaped charges.

Material	Specifications	M2A4 Shaped Charge* (15 lbs)	M3A1 Shaped Charge** (40 lbs)
Reinforced concrete	Maximum wall thickness	36.00 in	60.00 in
	Penetration depth in thick walls	30.00 in	60.00 in
	Average hole diameter	2.75 in	3.50 in
	Minimum hole diameter	2.00 in	2.00 in
Concrete pavement (10 in with 21-in rock-base course)	Optimum standoff	42.00 in	60.00 in
	Minimum penetration depth	44.00 in	71.00 in
	Maximum penetration depth	91.00 in.	109.00 in
	Minimum hole diameter	1.75 in	6.75 in
Concrete pavement (3 in with 24-in rock-base course)	Optimum standoff	42.00 in	--
	Minimum penetration depth	38.00 in	--
	Maximum penetration depth	90.00 in.	--
	Minimum hole diameter	3.75 in	--
Permafrost	Hole depth (30-in standoff)	72.00	--
	Hole depth (42-in standoff)	60.00	--
	Hole depth (50-in standoff)	--	72.00 in
	Hole diameter (42-in standoff)	1.50 to 6.00 in	--
	Hole diameter (50-in standoff)	--	5.00 to 8.00 in
	Hole diameter (normal standoff)	4.00 to 30.00 in	7.00 to 30.00 in
Ice	Hole depth (42-in standoff)	7.00 ft	12.00 ft
	Hole depth (42-in standoff)	3.50 in	6.00 in
Soil	Hole depth (30-in standoff)	7.00 ft	--
	Hole depth (48-in standoff)	--	7.00 ft
	Hole depth (30-in standoff)	7.00 in	--
	Hole depth (48-in standoff)	--	14.50 in
Graveled Roads	Hole depth (30-in standoff)	7.00 ft	--
	Hole depth (48-in standoff)	--	9.00 ft
	Hole depth (30-in standoff)	7.00 in	--
	Hole depth (48-in standoff)	--	7.00 in

* A dash in the column indicates that an M3A1 shaped charge is required.
**A dash in the column indicates that an M2A4 shaped charge is sufficient.

Priming a Shaped Charge

Location

When priming a shaped charge, the cap well must be used. Both shaped charges comes with a cap well that is located in the exact center of the explosives opposite the cone. This is where shaped charges must be primed for the jet to form correctly.

Dual Priming

Never dual prime a shaped charge, as it will affect its operation. It is designed for one blasting cap. Wrapping detonating cord around the shaped charge may get it to detonate, but the jet will be highly degraded if it forms at all.

Priming

Shaped charges can be primed with an electric, nonelectric, or MDI blasting cap. They posses a blasting cap well and an adapter (preferred) or tape to hold the cap in place. The caps can be initiated through their respective measures.

Lesson 6 Exercise

Directions

Complete exercise items 1 through 4 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

What is the proper method for setting up a shaped charge?

a. Six inches above the target
b. Fifteen inches above the target
c. Using proper standoff for the size of the charge
d. Suspended 16 inches above the target

Item 2

When would you use tamping while preparing a shaped charge?

a. Every time
b. Only when it is underwater
c. Never
d. Only when priming nonelectrically

Item 3

What effect does the target have on the penetration of a shaped charge?

a. The density of the target will affect the width and depth of the borehole.
b. The density of the target will not affect the width or depth of the borehole.
c. The denser the target the larger the hole and deeper the penetration.
d. The softer the target the smaller the hole and the deeper the penetration.

Item 4

The proper method for priming a shaped charge is by using only the

a. cap well provided and three wraps of detonating cord around the top.
b. cap well provided.
c. detonating cord taped into the cap well and three wraps around the top.
d. electric initiation sets.

Continued on next page

Solutions

The table below provides the answers to the exercise items. If you have any questions, refer to the reference page listed for each item.

Item	Answer	Reference Page
1	c	1-95
2	c	1-95
3	a	1-96
4	b	1-99

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STUDY UNIT 2

FIELD FORTIFICATION AND CAMOUFLAGE

Overview

Scope

This study unit covers the construction and design of wire entanglements, field fortification, revetment, and camouflage as it pertains to the combat engineer serving with a Marine division.

Purpose

The purpose of this study unit is to provide you with the skills and knowledge necessary to successfully plan and emplace wire entanglements and field fortifications, as well as camouflaging positions and equipment.

In This Study Unit

This study unit contains the following lessons:

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LESSON 1

WIRE ENTANGLEMENTS

Introduction

Scope

This lesson describes the process and procedures for constructing wire entanglements.

Purpose

The purpose of this lesson is to provide you with the knowledge and skills to successfully construct wire entanglements, as well as identify key features.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the purpose of wire entanglement installation.
- Identify the classification of obstacle employment.
- Identify the three basic methods for wire entanglements.
- Identify the physical components of wire entanglements.
- Identify the purpose of concertina entanglements.
- Identify the steps to install concertina wire in a concertina entanglement.

In This Lesson

This lesson contains the following topics:

Installation

Introduction

As a division engineer, you will be required to install wire entanglements in support of various missions. You must know which entanglement is best suited to the mission and how it is constructed. Additionally, you must know the components for the individual obstacle. While this is not all-inclusive, it will aid you in performing your mission successfully and more effectively.

Purpose of Wire Entanglement Installation

Wire entanglements are used to support the tactical plan in both offensive and defensive operations. Reinforcing obstacles, including entanglements, support the maneuver commander's plan, and must be covered by observation and fire. They are integrated with observed fires as well as existing obstacles (natural or manmade) and other reinforcing obstacles. Wire entanglements are employed in depth and can be employed for surprise. These entanglements can be used to channel the enemy, and depending on the method of employment, can slow both foot personnel and vehicle traffic.

Direct Fire Assessment

Marines and construction equipment can be exposed to enemy fire while emplacing wire entanglements. They should be emplaced before the start of a battle. If that is not possible, they should be installed on a terrain feature away from any direct fire weapons area to reduce the possibility of disruption of the emplacement process by enemy fire.

Observation

Engagement areas can be developed through effective placement of obstacles, especially in areas where proper placement can restrict and slow enemy maneuver. By slowing enemy movements, the probability of friendly direct and indirect fires increases the hit. The obstacle site is determined by the tactical commander and his senior engineer to offer the best relative advantage. Consideration must be given to the terrain and effective weapons range.

Special Attention

Special attention should be given to locating obstacles that will complement the fires of dragon, tanks, and tube-launched optically-tracked wire-guided (TOW) antitank missile system. Since TOWs have a greater maximum effective range than threat tanks, it is advantageous to site part of the tactical obstacle system to capitalize on that advantage.

Continued on next page

Observed Indirect Fires

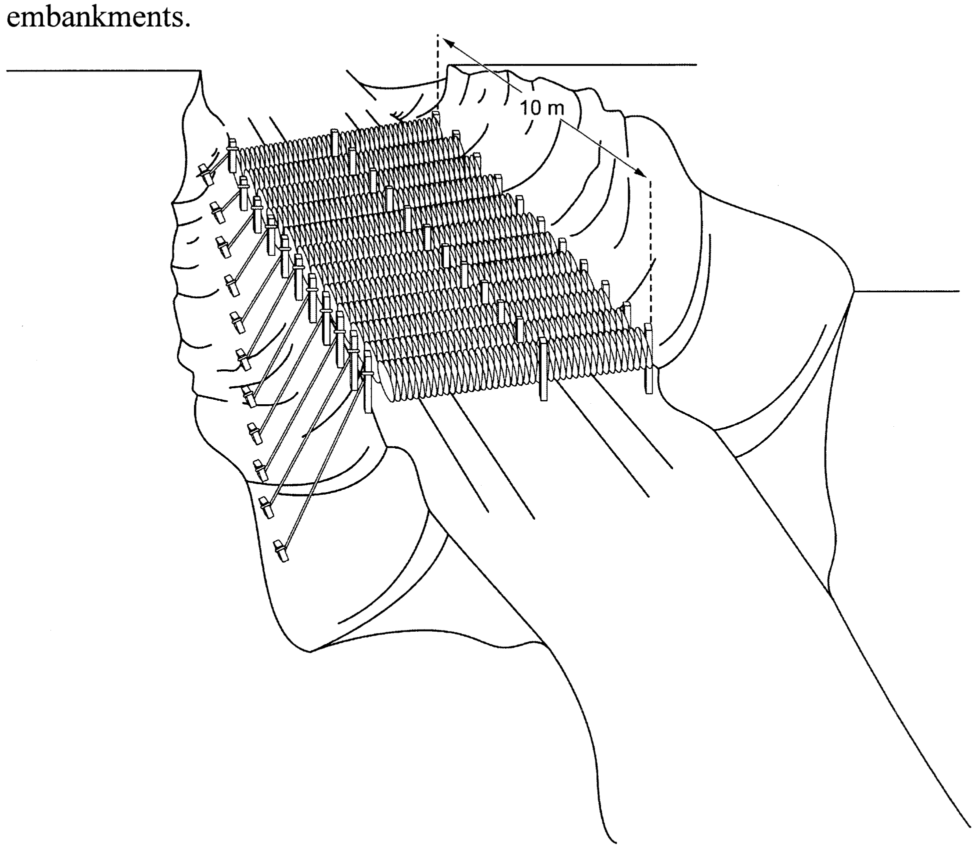
Observed indirect fires are also used in conjunction with obstacles. Observation of the target area and adjustment of fires is essential to take full advantage of the use of indirect fires. Indirect fires serve to protect the obstacle by making it too costly to breach.

Support Other Obstacles

Wire entanglements are used to take maximum advantage of existing obstacles, manmade or natural. They are placed where gaps between existing obstacles can be closed or channeled and will close any passage through them. Obstacles are integrated with each other to ensure that probable bypass routes are closed as well. It does little good to close one avenue of approach if another exists nearby.

Anti-Vehicular Wire Obstacle

The illustration below shows an anti-vehicular wire obstacle that consists of a wire entanglement supporting existing natural obstacles of the steep embankments.



Classification of Objects

Three Types

There are three classifications of obstacle employment:

- Belt
- Band
- Zone

Belt

A belt is a single line of obstacles such as a wire entanglement one fence in depth.

Band

A band consists of two or more belts in depth, with no interval between them. The belts may be fences of the same type, or the band may be composed to two or more fences of different types.

Zone

A zone consists of two or more bands or belts in depth, with intervals between them.

Employment In Depth

Simple obstacles (a single wire entanglement) arranged one behind the other along a probable avenue of approach can be far more effective then a large, elaborate obstacle, and in many cases faster to construct. Placement of obstacles is important. They cannot be located too close to one another. By keeping obstacles far enough apart, the enemy must deploy their counter obstacle forces and/or equipment for each obstacle. The distance between obstacles will depend on the terrain and the obstacle effort available. Additionally, the use of smaller obstacles will force the enemy to expose to loss his limited counter obstacle equipment and personnel. The destruction of counter obstacle resources that were initially allotted to the enemy's leading elements will slow the enemy's movement until new counter obstacle units can be brought forward. Slower movement allows greater opportunity for direct and indirect fires to destroy targets.

Classification of Entanglements

Basic Methods

Entanglements are classified by how they are employed. The three basic employment methods for wire entanglements are

- Tactical
- Protective
- Supplementary

Proper employment is shown schematically in your FM 5-34.

Tactical

Tactical wire is sited parallel to and along the friendly side of the final protective line. They are used to break up enemy attack formations and hold the enemy in areas covered by the most intense defensive fire. Tactical wires extend across the entire front of a position, but are not necessarily continuous.

Protective

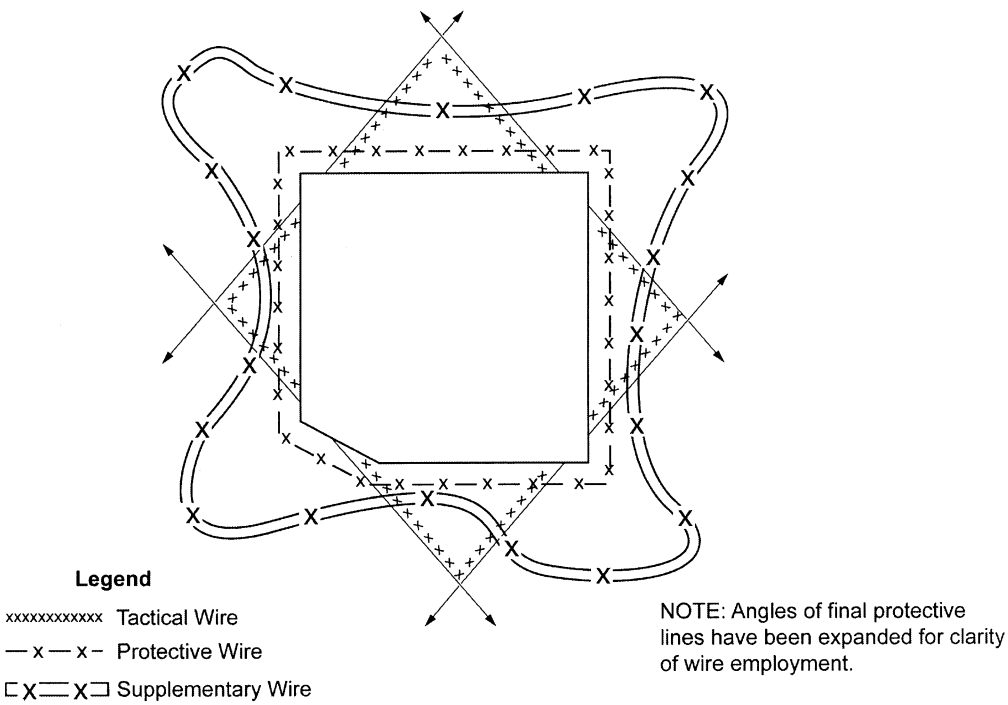
Protective wire is constructed to prevent surprise assaults from points close to the defense area. All antipersonnel obstacles are close enough to the defense area for day and night observation and far enough away to prevent the effective use by the enemy i.e. setting up positions just beyond the obstacle, and out of hand grenade range, normally 40 to 100 meters (131 to 328 ft). Protective wires surrounds the individual units of a command, to enclose entire defensive positions, and are erected around rear-area installations in the same manner.

Continued on next page

Classification of Entanglements

Supplementary Supplementary wire is located in front of the forward edge of the battle area (FEBA) are used to conceal the exact line of the tactical wire. To the rear of the FEBA, supplementary wire is used to enclose the entire defensive position by connecting the protective wire entanglements. Supplementary wire entanglements used to break up the line of tactical wire should be identical to the tactical wire entanglements and constructed simultaneously with them whenever possible.

Diagram The illustration below shows a wire entanglement diagram.



Components

Physical Components

The purpose and placement of obstacles are major considerations of an obstacle. There are physical components common to any wire obstacle installation. Those components are

- Wire material
- Picket material
- Personnel

Wire Material

The Marine Corps uses two basic types of wire material in the construction of wire entanglements:

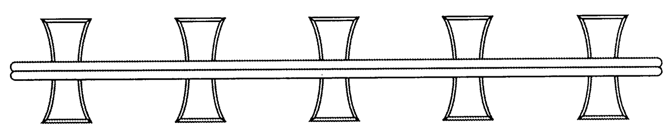
- Concertina wire
- Barbed wire

Concertina Wire

Concertina wire is prefabricated spiral wire with a 36-inch diameter. Attached to this spiral are thousands (every 2 to 3 inches) of very sharp protrusions which are shaped like boat cleats.

Boat Cleat Shaped Protrusions

The illustration below shows the boat cleat shaped protrusions found on concertina wire.



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Components

Barbed Wire

Barbed wire consists of two strands of wire twisted together with knots of wire placed every 6 to 8 inches along its length. The ends of the knots are cut at angles making them sharp.

Picket Material

A picket serves as a fence post or stake driven vertically into the ground. The most common picket used throughout the Marine Corps is the U-shaped picket. This picket comes in a variety of lengths. Wire obstacles call for the use of both short (2 foot) and long (5-6 feet) pickets. Notches are cut into the side flanges of the U-shaped pickets every 8 inches on alternating sides. These notches are used to secure the wire and prevent it from sliding or being slid down the post.

Personnel Requirements

When constructing wire entanglements, engineers will layout the obstacle and ensure the wire is laid and attached to the pickets properly.

The security team should be provided by the requesting unit and will vary in size depending on the size of the obstacle. There should be enough security personnel to provide covering fire for the laying teams to seek cover and return fire in the case of enemy attack.

Ideally, the laying party will be broken down into teams. The number of teams and site will vary. All personnel do not have to be engineers since anyone can be used to drive posts, stage wire, and carry posts.

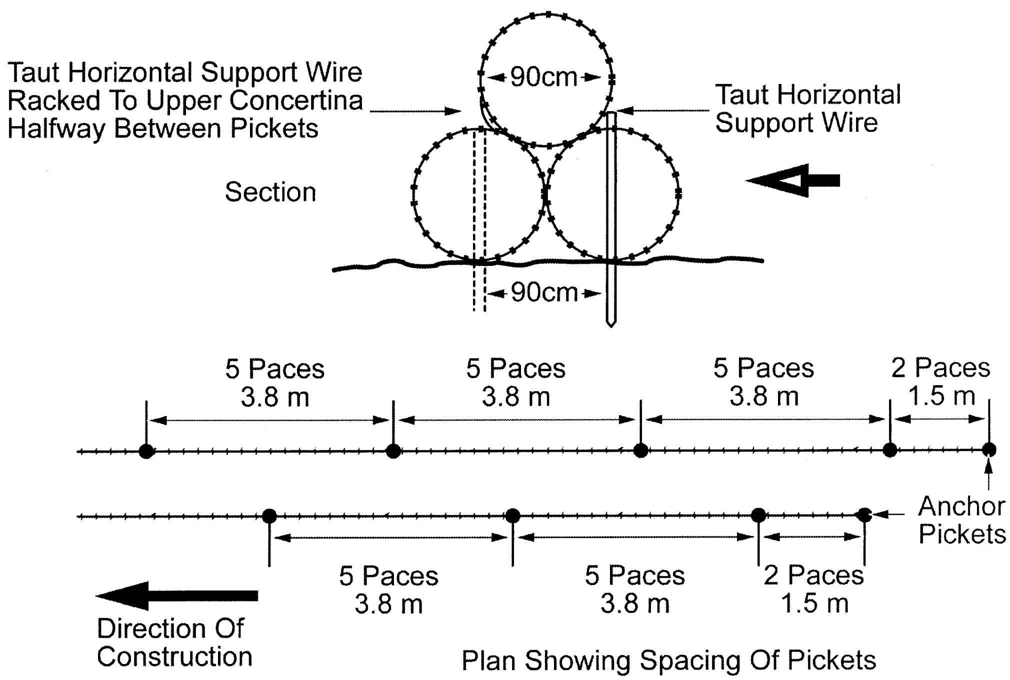
Concertina Entanglements

Purpose

A concertina entanglement is designed to channel and slow enemy personnel. This obstacle is constructed through the placement of three strands or rows of concertina wire. Two rows are laid side-by-side with a third row resting on top of the valley between the original two. All rows are installed with staggered joints. Each line is completed before the next is started so that a partially completed concertina entanglement presents some obstruction. This obstacle is erected quickly and is difficult to cross, cut, or crawl through.

Triple-Stranded

The illustration below shows the layout of a triple-stranded concertina entanglement with row and picket placement.



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Stage One of Installation

During stage one, available Marines are divided equally into three teams. Each team performs the following tasks:

Team	Task
1	Lay out front row (enemy side) long pickets at five pace intervals with points of the pickets on line and pointing toward the enemy. The rear row long pickets are then laid out on line and 3 feet to the rear of the front row pickets. Center these pickets between the front row long pickets. An anchor picket is laid out at the end of each row. It is placed 5 feet from the end long picket.
2	Install pickets beginning with the front row (enemy side). Concave side of U-shaped pickets face toward the enemy.
3	Lay out concertina rolls along the rows of pickets. One roll is placed on the enemy side in front of the third picket. A roll is then placed on the enemy side every third picket thereafter. Sixteen staples accompany each front row concertina. Two rolls are placed on the friendly side starting at the second picket and then at every third picket thereafter. As each roll is placed in position, its binding wires are unfastened but are left attached to the hoop at one end of the roll.

Continued on next page

Stage Two of Installation

After stage one is completed, the groups are organized into teams of four. To open and install the concertina wire, follow the steps below:

Step	Action
1	Open the front row concertinas on the enemy sides of the double line of pickets.
2	Lift each front row concertina in turn and drop it over the long pickets, then join concertina ends.
3	Fasten the bottom of the concertina to the ground by driving a staple over each pair of end hoops, one over the bottom of a coil at each long picket, and one at the 1/2 and 1/4 points of the picket spacing. Securing the front concertina to the ground is essential and must be done before installing the concertina behind it.
4	Stretch a barbed wire strand along the top of each front row and fasten it to the tops of the long pickets. These wires are stretched as tightly as possible to improve the resistance of the fence against crushing.
5	Install the rear row concertina in the same fashion as the front row without attaching it to the ground. Ensure that the ends or joints do not match up, and fasten the end hoops of 15-meter (50-ft) sections with plain steel wire ties.
6	Begin the row top midway between the ends of the lower rows, thus breaking all end joints. Rack (tie) the top concertina to the rear horizontal wire at points halfway between the long pickets. If there is safe access to the enemy side of the fence, similarly rack the top concertina to the forward horizontal wire.

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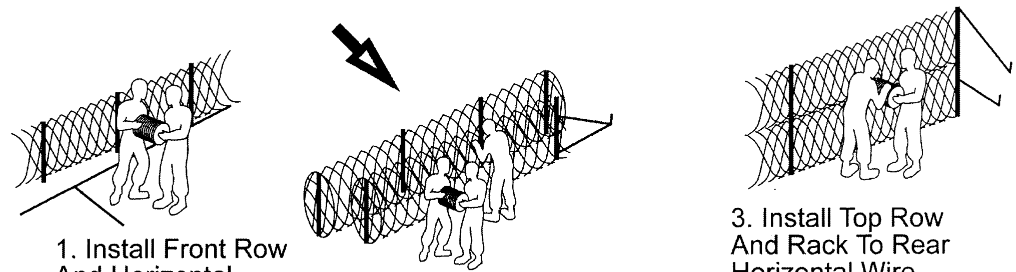
Proper Installation

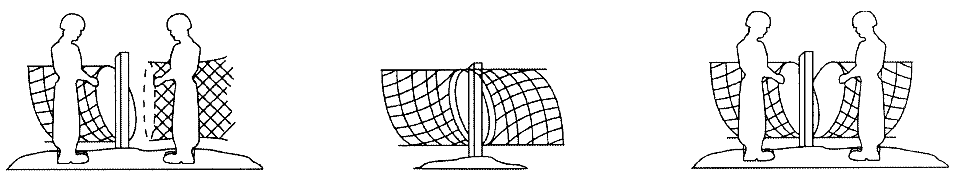
The illustration below shows the proper installation of concertina wire.



1. Install Front Row And Horizontal Wire.

2. Install Back Row And Horizontal Wire.

3. Install Top Row And Rack To Rear Horizontal Wire.



1. Place bottom portion of first coil over picket.

2. Place both bottom and top portion of second coil over picket.

3. Place top portion of first coil over picket.

Barbed Wire Entanglements

Antipersonnel Obstacle

Barbed wire entanglements, trip flares, noisemakers, and antipersonnel mines are constructed to warn against enemy patrol action or infiltration at night, to prevent the enemy from delivering a surprise attack from positions close to the defenders, and to hold, fix, channel or delay the enemy and provide an effective kill zone for defenders. Such obstacles should be located close enough to defensive positions for adequate surveillance by the defenders during both night and day, but far enough away to keep the enemy outside of hand grenade range.

Double Apron Fence

There are two methods used for constructing double apron fencing, the four- and two-pace fence and the six and three-pace fence. The four- and two-pace fence is the more effective obstacle of the two. This is due to the shorter span between pickets. The shorter span makes it more difficult to raise the low wires and crawl under them (less slack). Therefore, the four- and two-pace fence is the type more commonly used. With this fence, the center pickets are placed four paces apart and the anchor pickets are placed two paces from the line of the center pickets and opposite the midpoint of the space between center pickets.

The six- and three-pace fence follows the same pattern with pickets placed at six- and three-pace intervals. For this fence, less material and construction time are required, but since the longer wire spans makes it easier to raise the lower wires and crawl under them, which substantially reduces its effectiveness. Both fences are constructed in the same manner.

Stage 1: Layout and Install Pickets for Double-Apron Fence

During the first stage, the pickets are laid out and installed. To do this efficiently, there should be three equal groups, preferably 10 to 13 Marines in each team.

Team	Task
1	Lay out all the long pickets at an interval of four paces, with the end of each picket facing toward the enemy and located where it is to be installed.
2	Lay out the short pickets at four-pace intervals. There are two rows, one in front (enemy side) of the center picket line and one on the friendly side. They are placed two paces away from the centerline of the fence and they are centered between the long pickets.
3	Install all the pickets. The other two groups will assist as they finish their respective tasks.

Continued on next page

Stage 2: Install Wire for Double-Apron Fence

During the second stage, the wire is installed onto the pickets. Care must be taken to ensure that Marines do not get trapped on the enemy side of the fence. All personnel will be involved in laying the wire. The wires are laid in numerical order. The first wire is attached and, when there is room, start the second wire. Continue this process until all wires are laid. The table below gives you a description of all the wires. The illustration that follows shows the layout of the fence.

Wire	Description
1	This is the diagonal wire on the enemy side. It is secured to all pickets. It is important to keep this wire tight.
2	This is the tripwire on the enemy side of the fence. It is secured to the diagonal wire just above the anchor picket. This wire must be tight enough and close enough to the ground to make passage over or under the wire difficult.
3	This wire is an apron wire on the enemy side of the fence. It is secured to the first diagonal wire (# 1), and thereafter to each alternate diagonal, and then to the last diagonal wire. This wire is placed approximately 1/3 of the distance between the number two wire and the top of the center post.
4	This wire is attached to the first diagonal wire (#1) and thereafter to the diagonal wires which are not tied to the # 3 wire, and then to the last diagonal wire. This wire is placed approximately 1/2 of the distance between the number 3 wire and the top of the center post.
5	This is the bottom wire of the standard cattle fence. It is also the first wire to start on a long picket vice the anchor stake. It is started at the first long picket, and ended at the last long picket. It is stretched tightly to prevent passage over or under it.
6	This wire is part of the center portion of the fence and is secured to the long picket in the next higher notch in the picket above (#5). It also starts at the first long picket and ends at the last long picket.
7	This wire is part of the center portion of the fence. It is secured to the long picket in the next higher notch in the picket above (#6). It also starts at the first long picket and ends at the last long picket.
8	This wire is the top of the center portion of the fence. It is secured to the top of the long picket. It also starts at the first long picket and ends at the last long picket. Wire #6, #7, and #8 are the wires that provide the strength to the fence and as such must be drawn tight in order to hold the pickets in place.
9	This is the diagonal apron wire on the friendly side. It is secured to all pickets. Numbers 10 and 11 are apron wires and #12 is the tripwire on the friendly side of the fence. Wire #12 is installed in the same manner as wire #2 above.
10	This wire is an apron wire on the enemy side of the fence. It is secured to the diagonal wire (#9) and thereafter to each alternate diagonal, and then to the last diagonal wire. This wire is placed approximately 1/3 of the distance down from the top of the center post (#8) and the small pickets.
11	This wire is attached to the diagonal wire (#9) and thereafter to the diagonal wires, which are not tied to the (#10) wire, and then to the last diagonal wire. This wire is placed approximately 1/2 of the distance between the number nine wire and the small pickets.
12	This is the tripwire on the friendly side of the fence. It is secured to the diagonal wire just above the anchor picket, and continues along the friendly side of the fence being tied just above all the short pickets. This wire must be tight enough and close enough to the ground to make passage over or under the wire difficult.

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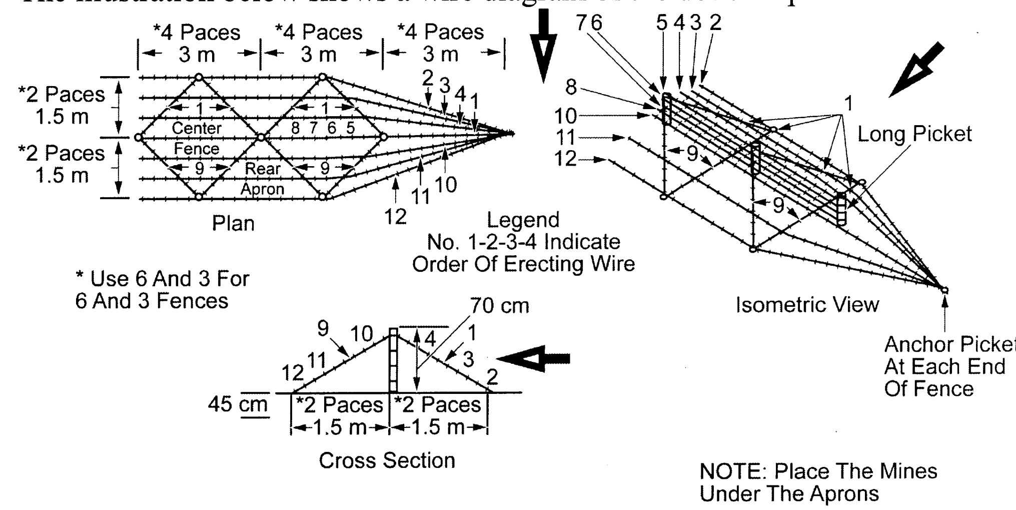
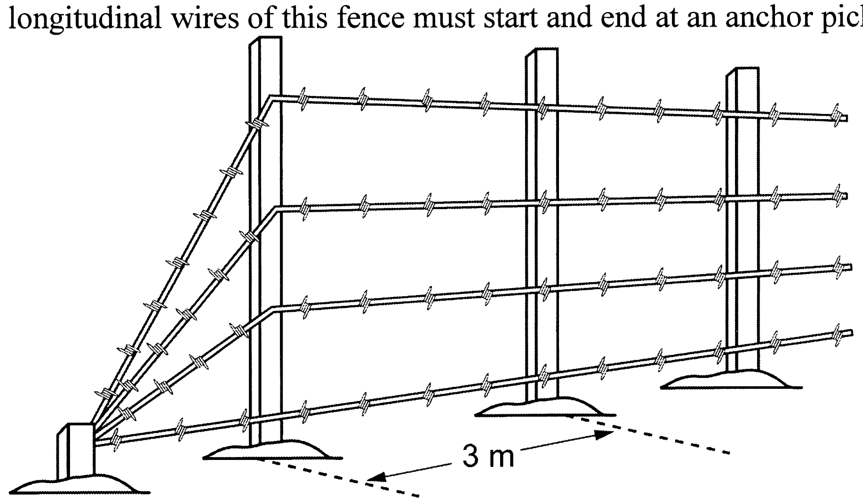
Wire Diagram

The illustration below shows a wire diagram of the double apron fence.



Four-Strand Cattle Fence

The four-strand cattle fence is the center section of a double apron fence and can be installed rapidly to obtain some obstacle effect. Aprons can be added later to develop it into a double apron fence. In a country where farmers use wire fences, obstacles in the form of four-strand cattle fences will blend with the landscape. Their design should follow as closely as possible the local custom, usually wooden pickets at about two- to four-pace intervals with four horizontal strands of barbed wire fixed to them. They should be sited along footpaths and edges of fields or crops where they will not look out of place. If conditions permit, this fence may be improved by installing guy wires in the same manner as the diagonal wires of the double apron fence. All longitudinal wires of this fence must start and end at an anchor picket.



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Construction

Eight Marines should be used to install short sections of this fence and up to 16 Marines to install 300-meter (984-ft) sections. The layout and installation consists of two stages.

Stage 1: Layout and Install Pickets for Four-Strand Cattle Fence

Each group is responsible for the following:

Team	Task
1	Carry and lay out long pickets at 3-meter (9.8 ft) intervals along the centerline of the fence, beginning and ending the section with an anchor picket and including anchor pickets for guys if needed.
2	Install the pickets.

Stage 2: Install Wire for Four-Strand Cattle Fence

Both groups are involved in installing the wire. Follow the steps below to install the wire:

Step	Action
1	Marines individually move to the head of the fence and are organized into teams of two or four to install wires.
2	For four-man teams, two men carry the reel and two men make ties and pull the wire tight.
3	For two-man teams, the wire must first be unrolled for 50 to 100 meters (164 to 328 ft) and return to the head of the work and make the ties, or the wire may first be made up into bobbins to be carried and unwound by one man while the other man makes the ties.
4	The first team installs the bottom fence wire, and draws it tight and close to the ground.
5	Succeeding teams will install the next higher wire in order.

Lesson 1 Exercise

Directions

Complete exercise items 1 through 10 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

The purpose of wire entanglement installation is to support the

a. tactical plans in both offensive and defensive operations and the maneuver commander's plan.
b. tactical plan in defensive operations only, as well as the maneuver commander's plan.
c. tactical plan in offensive operations, while reinforcing the maneuver commander's plan.
d. maneuver commander's plan, and must be covered by observation and fire.

Item 2 Through Item 4

Matching: For items 2 through 4, match the classification of obstacle employment in column 1 with its definition in column 2.

Column 1	**Column 2**
Classification of Obstacle Employment	**Description**
___2. Belt	a. Consists of two or more bands or belts in depth with intervals between them
___3. Band	b. An entanglement one fence in depth
___4. Zone	c. Consists of two or more belts in depth with no interval between them.

Continued on next page

Item 5 Through Item 7

Matching: For items 5 through 7, match the classification of wire entanglements in column 1 with its use in column 2.

Column 1	**Column 2**
Classification of Wire Entanglements	**Use**
___5. Tactical ___6. Protective ___7. Supplementary	a. Used to conceal the exact line of the tactical wire. b. Used to break up enemy attack formations and hold the enemy in areas covered by the most intense defensive fire c. Constructed to prevent surprise assaults from points close to the defense area

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Item 8

The three physical components for constructing wire entanglements are wire material, picket material, and

a. triple-stranded concertina.
b. personnel.
c. four-strand cattle fence.
d. barbed wire.

Item 9

The purpose of a concertina entanglement is to channel and _____ enemy personnel.

a. kill
b. locate
c. slow
d. catch

Continued on next page

Item 10 What is the first step when installing a concertina wire onto its picket?

a. Open the front row concertinas on the enemy sides of the double line of pickets.
b. Install back row and horizontal wire.
c. Install top row and tack to rear horizontal wire.
d. Place top portion of first coil over picket.

Continued on next page

Lesson 1 Exercise, Continued

Solutions

The table below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page.

Item Number	Item Answer	Reference Page
1	a	2-4
2	b	2-6
3	c	2-6
4	a	2-6
5	b	2-7
6	c	2-7
7	a	2-8
8	b	2-9
9	c	2-11
10	a	2-13

LESSON 2

REVETMENT

Introduction

Scope

A revetment is a facing used for sustaining an embankment or a barricade to provide protection against bombs, splinters, strafing, direct fire weapons, and fragmentation. It serves mainly to support excavated surfaces from the effects of weather and use by personnel. This reduces cave-ins, and provides for long-term use of trench lines. This lesson describes the process and procedures for the proper placement of revetment materials.

Purpose

The purpose of this lesson is to provide you with the knowledge to successfully identify and place revetment material in field fortification applications.

Learning Objectives

At the end of this lesson, you should be able to

- Identify suitable revetment materials.
- Identify the components of a revetment.
- Identify the required placement of revetment materials.
- Identify the factors that affect the holding power of deadmen anchoring systems.

In This Lesson

This lesson contains the following topics:

Revetment Materials

Suitable

A high degree of imagination is essential to ensure the best use of available materials. Many different materials that exist on the battlefield and prefabricated materials found in industrial and urban areas can be used for position construction. Depending on the local area, materials that may be available are

- Corrugated metal sheets
- Plywood
- Doors
- Logs
- Brush
- Timber
- Dimensional lumber
- Sandbags

Natural

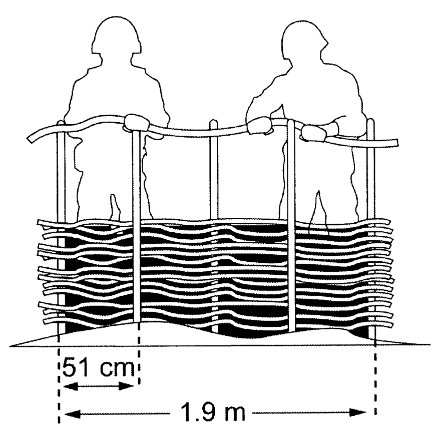
Brush, branches, and logs are naturally occurring materials that are used in revetments.

Continuous Brush

A continuous brush revetment is constructed in place and runs the length of the earthwork being reveted. It consists of 3-inch diameter uprights with brush being placed behind them.

Brushwood Hurdle

A brushwood hurdle is a woven revetment of brush pieces or branches. Each unit is usually 6 ½-feet long and as high as the earth wall they are meant to support. The illustration below shows the construction of a brushwood hurdle.



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Revetment Materials, Continued

Log

Log revetments consist of log uprights with logs laid horizontally between the uprights and the earth.

Manmade

Manmade revetment materials are anything that can be held in place with uprights to hold back earth. Some of these materials are

- Timbers
- Dimensional lumber
- Sandbags
- Corrugated metal
- Plywood

Timber

Timbers are pieces of milled lumber that are over 6 inches on a side. Timbers would only be used on a permanent position. This revetment consists of vertical timber uprights holding horizontal timbers, or planks in place against the earth's wall.

Dimensional Lumber

Dimensional lumber is wood that has been milled and it is less than 6 inches on a side. A revetment made with this material consists of vertical uprights holding horizontally laid lumber in place against the earth's wall.

Sandbags

Sandbags are synthetic bags designed to resist deterioration for 2 years. They can be filled with earth soil that is dug out of the earthwork or other available material.

Corrugated Metal Sheets

A revetment of corrugated metal sheets is durable, rapidly deployed, and easily adaptable to any size job. It consists of uprights that hold the corrugated sheets in place against the earth's wall.

Plywood

Plywood is only suitable if it is one-inch thick or can be supported with enough uprights to keep it from failing. It is laid between the vertical uprights and the earth.

Construction of Revetment Material

Components

Revetments, regardless of which materials are used, have several common components:

- Uprights
- Horizontally laid material
- Anchor system

Uprights

Uprights are the vertical members of the revetment, and extend both into the ground as well as above the earthworks. They are braced or backfilled at the bottom and attached to an anchoring mechanism at the top.

Horizontally Laid Material

Horizontally laid material holds the earth back and is placed between the upright and the earth where it acts as a barrier to cave-ins.

Anchor System

The anchor system is normally stakes and/or holdfasts. If the revetment is deep enough or the soil is loose enough, deadmen (one of the best types of anchorages for heavy loads or permanent installations because of its great holding power) may be required to hold the revetment in place. Stakes and holdfasts are installed at a distance equal to or greater than the depth of the revetment, from the top of the revetment. If the revetment is 5-feet deep, the stakes will be driven at least 5-feet away from the top of the upright to which it is attached. The stakes are attached with wire or wire rope (cable).

Stability

Stability of revetments is achieved through placement support and anchoring. Revetments are placed in areas where they will perform as designed. Placing uprights in holes and backfilling the holes or bracing between two uprights directly across from one another (allowing for mutual support) will provide stability and strength to a revetment. Using the proper spacing of uprights for the type of revetting material you have is also critical to stability. The anchor system provides additional support for uprights and uses the weight of the soil to hold back the soil.

Continued on next page

Brushwood Hurdles

Brush pieces or branches that are about 1 inch in diameter are woven into a framework of sharpened pickets placed at 20-inch intervals. When completed, the 6 ½-foot lengths are carried to the position where the pickets are driven in place. The tops of the pickets are tied back to stakes or holdfasts, and the ends of the hurdles are wired together. This process allows you to build the hurdles near the source of brushwood and transport the hurdle to the revetment site and place it. This way the site does not get congested with personnel.

Continuous Brush

Sharpened pickets 3 inches in diameter are driven into the bottom of the trench at 30-inch intervals and about 4 inches from the reveted earth's face. The space behind the picket is packed with small, straight brushwood laid horizontally. The tops of the pickets are anchored to stakes or holdouts. The uprights are larger (3-inches) in this type of revetment because the revetment material itself is smaller and weaker than that used in the brushwood hurdles. This type of revetment is constructed in the earthworks and can cause some congestion if there is foot traffic in the earthworks.

Corrugated Metal and Plywood

Corrugated metal and plywood revetments are constructed in the same manner. Uprights are installed and the corrugated metal (or plywood) is placed between the upright and the earth. It is laid horizontally. If the earthworks being reveted are deeper than one row of corrugated metal, a second row is added above the first. Ensure that there is overlap and that the new layer is behind the original one. This can be continued until the desired height is reached. This means both corrugated metal and plywood are durable, rapidly deployed, and is easily adaptable to the size job. It can be overlapped to obtain any height or length.

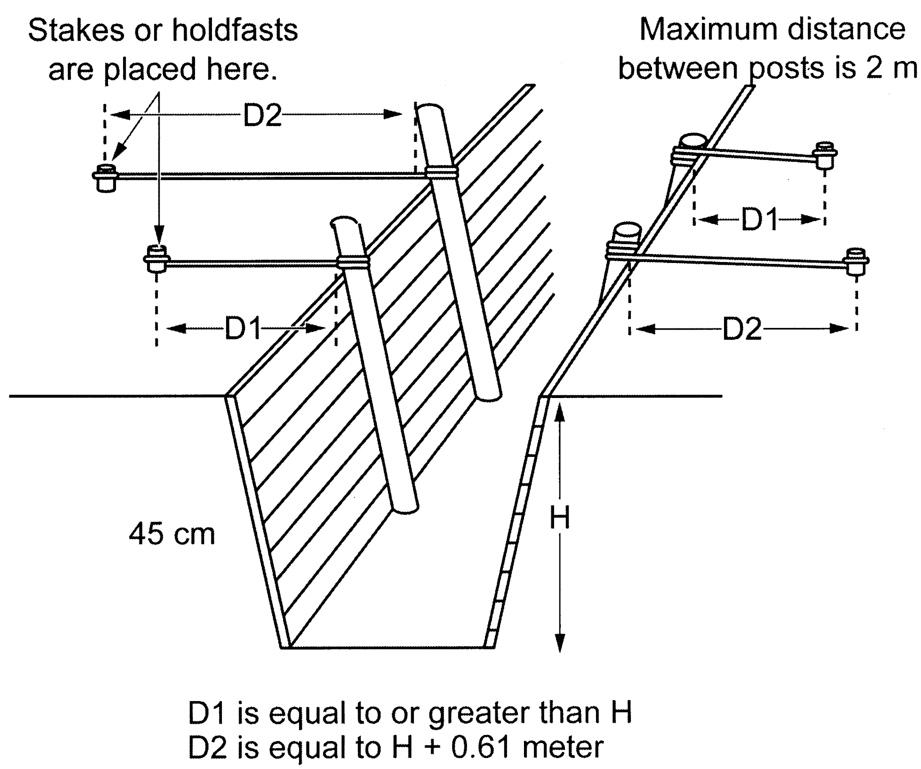
Continued on next page

Timber and Dimensional Lumber

Timber and dimensional lumber revetments are constructed the same way. The timber and lumber are laid horizontally against the earth walls, within the earthwork, and are held in place by upright lumber/timbers that go below ground and rise above the top of the earthwork. Uprights must cover the seams created by putting two pieces of the revetting lumber together to prevent collapse. If the seams are between uprights, a weak spot is created. Depending on the depth of the revetment and the soil, you may want to place an upright on each side of the joint.

Illustration

The illustration below shows a trench line that has been reveted with dimensional lumber.



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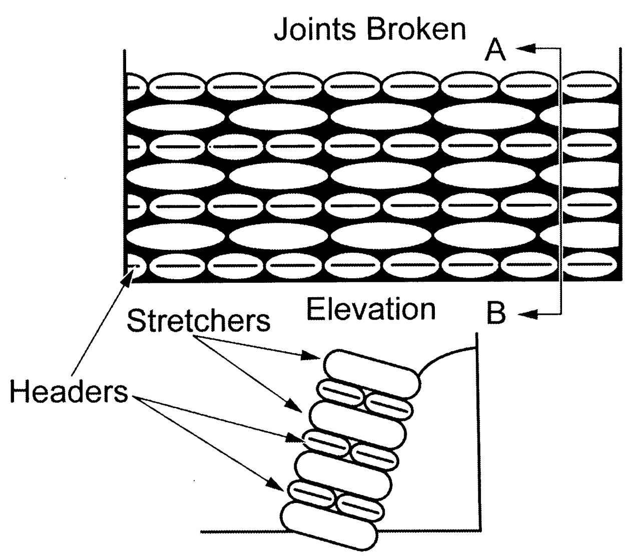
Sandbag Revetment

Sandbags are filled about 3/4 full with earth and the choke cords tied. Choke cords are the tie cords that are either attached to the individual bag or come in a bundle with the bags. The bottom corners of the bags are tucked in after filling. The bottom row of the revetment is constructed by placing all bags as headers. The wall is built using alternate rows of stretchers and headers with the joints broken between courses. The top row of the revetment wall consists of headers. A row of headers consist of two rows of sandbags, side-by-side, perpendicular to the earth wall, equaling the width of a stretcher. Stretchers are the sandbags that run parallel to the earth wall. The sides of the earthwork being sandbagged must be sloped at a ratio of 1:4 and lean against the earth to hold in place. All bags are placed so that side seams are on stretchers and choked ends on headers are turned toward the reveted face. As the revetment is built, it is back filled to shape the reveted face to this slope.

Placement of Sandbags

The illustration below shows the proper placement of sandbags by alternating between headers and stretchers.



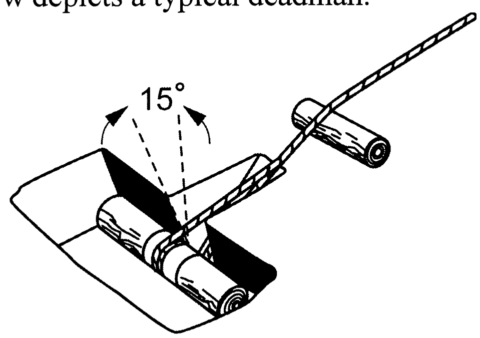
Deadman Anchoring System

Description

A deadman is one of the best types of anchorages for heavy loads or permanent installations because of its great holding power. They can be constructed from a log, a rectangular timber, a steel beam, or a similar object buried in the ground with a guy line or sling attached to its center. The guy line leads to the surface of the ground along a narrow upward sloping trench.

Typical Deadman

The illustration below depicts a typical deadman.



Holding Power

The holding power of a deadman is affected by

- Frontal bearing area
- Mean depth
- Slope ratio/angle of pull
- Deadman material
- Soil condition

Frontal Bearing Area

The frontal bearing area is required to hold the same weight as the breaking strength of the particular cable in use.

Mean Depth

Mean depth is the distance from ground level to the center of the deadman.

Continued on next page

Slope Ratio/ Angle of Pull

The angle of pull represents the slope ratio as a degree, i.e. a 1:4 slope ratio is also a pull angle of 14°.

Deadman Material

Deadman materials are basically anything that can be buried, has a cable attached to it, and withstands the pressure applied by the cable. It can consist of

- Logs
- Timbers
- Metal beams
- Concrete

Soil Condition

Soil condition refers to the composition and stability of the soil, as well as moisture content. The composition is the type of soil it is, i.e. sand, gravel, or clay. The stability comes directly from the type of soil you are dealing with. Sand will never be considered stable soil but some clay-based soils are very stable. Use the soil test kit to find out what is available to you and what is in the tool inventory for your platoon.

Lesson 2 Exercise

Directions

Complete exercise items 1 through 7 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1 through Item 4

Matching: For items 1 through 4, match the material in column 1 with its description in column 2.

Column 1	**Column 2**
Material	**Description**
___1. Brushwood hurdle	a. Designed to resist deterioration for 2 years
___2. Timber	b. Wood that has been milled and is less than 6 inches on a side
___3. Dimensional lumber	c. Pieces of milled lumber that are over 6 inches on a side
___4. Sandbags	d. Woven revetment unit usually 6 ½-feet long and as high as the earth wall it supports

Item 5

The components of a revetment are the uprights, horizontal laying system, and

a. slope ratio.
b. anchor system.
c. earthworks.
d. runners.

Continued on next page

Item 6

When placing a timber and dimensional lumber revetment, lay them _____ against the earth's walls within the earthworks.

a. vertically
b. horizontally
c. topside
d. backside

Item 7

The holding power of a deadman is affected by frontal bearing area, mean depth, slope ratio/angle of pull, deadman material, and soil

a. compaction.
b. condition.
c. density.
d. moisture content.

Continued on next page

Lesson 2 Exercise, Continued

Solutions

The table below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page.

Item Number	Answer	Page Number
1	d	2-27
2	c	2-25
3	b	2-25
4	a	2-25
5	b	2-26
6	b	2-28
7	b	2-30

LESSON 3

SURVIVABILITY POSITIONS

Introduction

Scope

This lesson describes the process and procedures to design and construct survivability positions.

Purpose

The purpose of this lesson is to provide you with the knowledge to successfully design and construct survivability positions for various missions.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the common traits of survivability positions.
- Identify the purpose of survivability positions.
- Identify the information required on a bill of materials list.
- Identify the steps to produce a materials estimate list for a project.
- Identify the two types of fighting positions.
- Identify the dimensions of fighting positions.

In This Lesson

This lesson contains the following topics:

Survivability

Introduction

Battlefield survival critically depends on the quality of protection afforded by the positions. The full spectrum of survivability encompasses

- Planning and locating position sites
- Designing adequate overhead cover
- Analyzing terrain conditions and construction materials
- Selecting excavation methods
- Countering the effects of direct and indirect fire weapons

Concept

The survivability concept on today's battlefield includes all aspects of protecting personnel, weapons, and supplies while deceiving the enemy. Division engineers should be knowledgeable in building a good defense using concealment, deception, and camouflage as well as constructing fighting and protective positions for both individuals and equipment. Properly designed and built survivability positions decrease personnel and equipment losses by reducing exposure to threat acquisition, targeting, and engagement. Protective construction also boosts the confidence of Marines in fighting positions, enabling them to use their weapons or weapons system more effectively.

Common Traits

There are common traits among all types of survivability positions:

- Overhead cover
- Protection from fragmentation and direct fire weapons
- Camouflage

Continued on next page

Survivability Doctrine

Survivability doctrine addresses five major points in today's battlefield.

- Maneuver units are responsible for developing, positioning, and building their positions.
- The maneuver commander defines the engineer's role in survivability.
- Engineer support will supplement units as determined by the supported commander's priorities.
- Engineer support will concentrate on missions requiring unique engineer skills or equipment.
- Survivability measures begin with using all available concealment and natural cover, followed by simple digging and constructing fighting and protective positions. As time and the tactical situation permit, these positions are improved.

Direct Fire Weapons

Direct fire is delivered on a target using the target itself as a point of aim for either the weapon or the individual firing the weapon. The enemy uses direct fire weapons in offensive maneuvers. Massive amounts of firepower are used to enhance their maneuverability, mobility, and agility and produce the shock of its weaponry. The tank is the primary ground combat weapon, which is supplemented by armored personnel carriers. The enemy will focus their attack at a perceived weak point in our defensive formation. Therefore, in the defense, extensive survivability operations are conducted. Initial focus is primarily on deliberate position construction and hardening for both weapons positions and command and supply positions. Alternate and supplementary positions are also located and prepared as time allows.

Indirect Fire Weapons

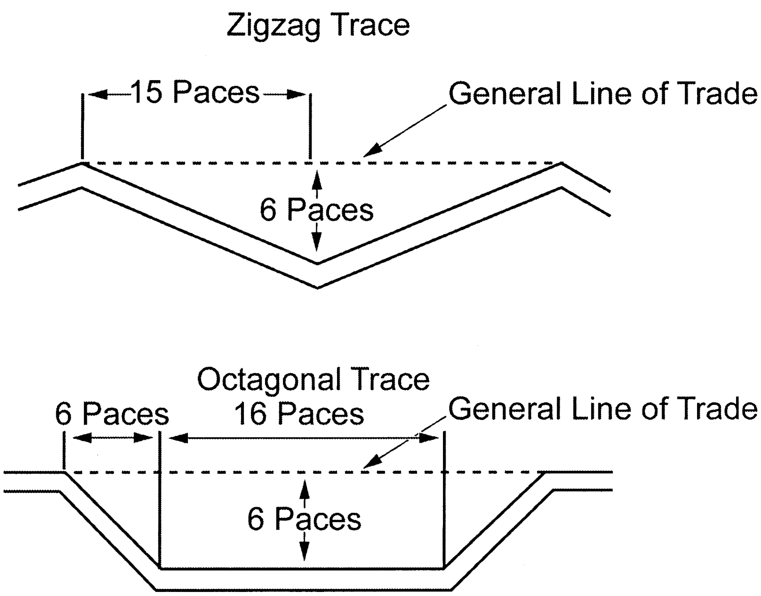
Indirect fire is delivered on a target that is not used as a point of aim for the weapons or the individual firing the weapon: i.e. artillery or mortars. In combination with air strikes and direct fire weapons, indirect fire seeks to accomplish one of the three levels of personnel and equipment destruction:

- Harassment is 10%.
- Neutralization is 25 to 30%.
- Total destruction is 50% or more.

Continued on next page

Protection From Indirect Fire

Protection from the effects of indirect fire requires a great deal of time and equipment. Maneuver units under the supervision of attached engineers usually construct covered, dismounted firing positions, and shelters adjacent to large weapons emplacements. Construction upgrades and maintenance are continuous in permanent or semi-permanent defensive positions. As an example, trench lines have to be carefully laid out and constructed to be effective.



NOTES: 1. Delete the rear berm
2. Ensure that the front berm is at least 3 feet at the top.

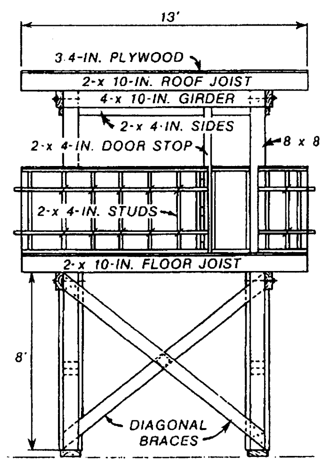
Survivability Positions and Their Dimensions

Survivability Positions

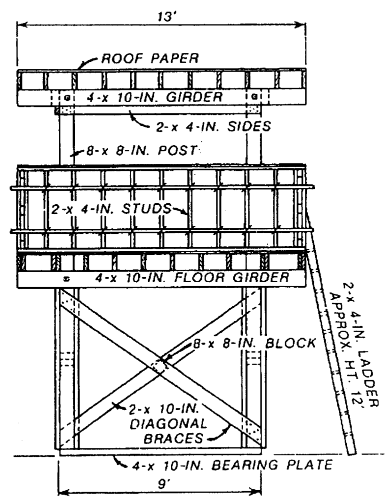
Survivability positions are built to withstand hits from both indirect and direct fire weapons and weapons systems. They range from above ground perimeter bunkers to below ground structures, and are as large or small as the mission requires. Large positions may be designed for housing a vehicle and a position can be as small as a position for two Marines to sleep in. The available materials determine the shape and the construction method for each position.

Plywood Perimeter Tower

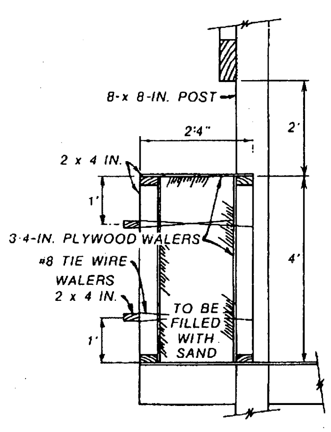
The plywood perimeter tower position (shown below) is used as an above ground protective security position. It can be built on posts or directly on the ground. The walls are earth filled in either case.



FRONT ELEVATION



TYPICAL SIDE ELEVATION



TYPICAL WALL SECTION

BILL OF MATERIALS

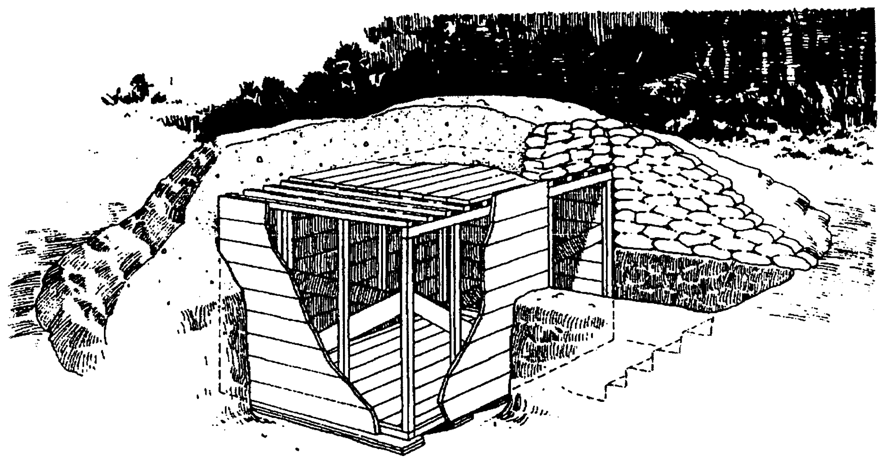
ITEM	UNIT	QUANTITY
2"x4"x12'	EA	120
2"x4"x14'	EA	30
2"x10"x14'	EA	40
4"x10"x14'	EA	17
8"x8"x16'	EA	4
4'x8'x3/4" PLWD	EA	32
NAILS, 20d	LB	50
NAILS, 60d	LB	25
BOLTS, 3/4"x14"	EA	8
ROOF PAPER	SF	200

NOTE: THIS BUNKER CAN BE ELEVATED AS SHOWN OR BUILT DIRECTLY ON THE GROUND.

Continued on next page

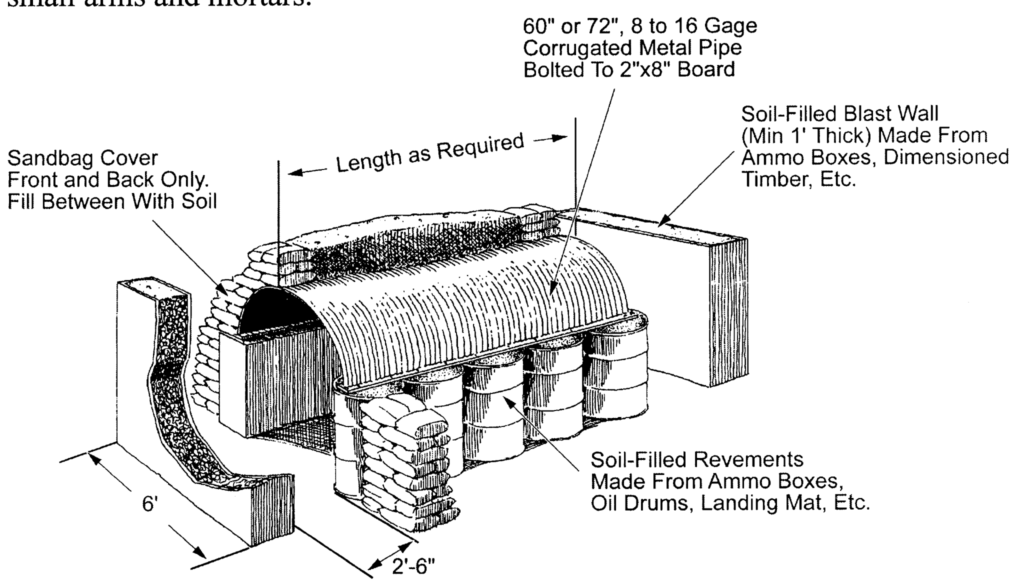
Timber Frame Buried Shelter

The timber frame buried shelter (shown below) is installed either partially buried or completely belowground. When built below ground, it provides excellent cover from indirect fire fragmentation and direct fire. When properly constructed, the overhead cover will shield against direct hits from indirect fire weapons up to 82mm.



Metal Culvert Shelter

The metal culvert shelter (shown below) is quickly constructed above ground and is used in areas where personnel are billeted, but may need to take cover, e.g. outside mess halls or barracks. This shelter provides protection from small arms and mortars.



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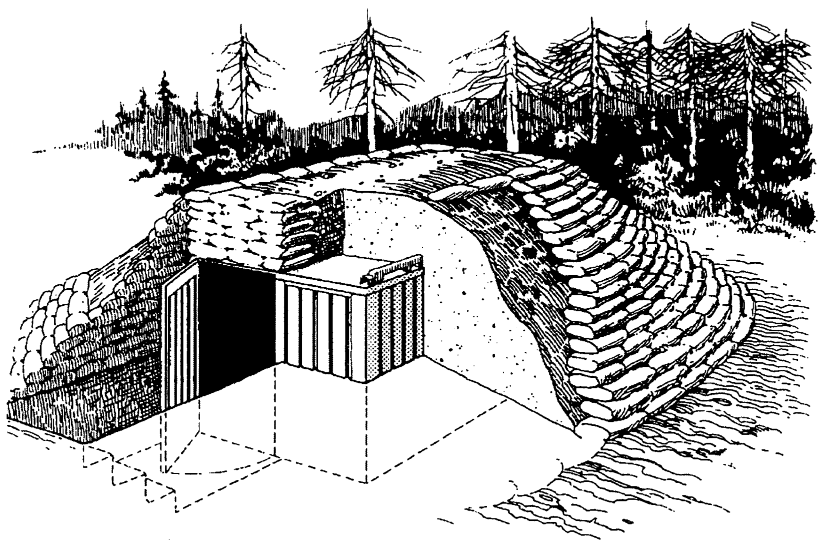
Metal Shipping Container Shelter

Large metal shipping container shelters (shown below) are like consolidated express containers (CONEX). Since the floor of the CONEX box is stronger than the roof and will withstand blast and weight better, the box is inverted. The most effective way to build it is to place the inverted box in a hole dug to about half the height of the CONEX box and cover with earth and sandbags.



Bill of Material Preparation

Introduction

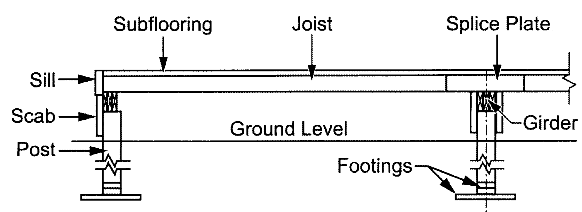
A bill of material (BOM) is a list needed to complete a project. It is based on takeoffs and materials needed. It includes item number (parts and materials), name, description, unit of measure, quantity, and the stock size and national stock numbers. The weight of items may be required for transportation purposes. The engineer uses the BOM to order the materials needed to complete a project.

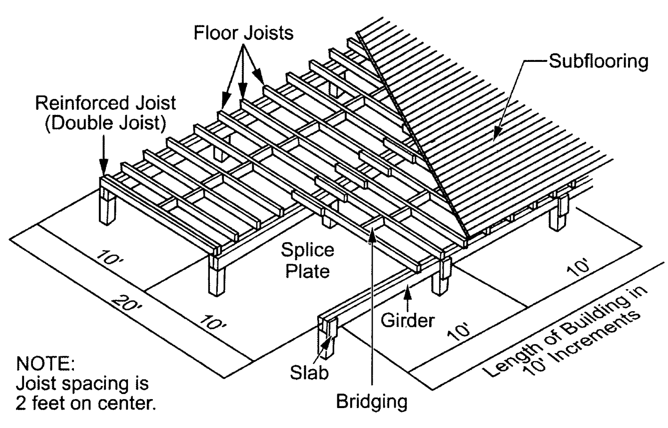
Materials Takeoff List

The materials takeoff list is a list of materials taken from a set of plans. The table below is an example takeoff list derived from the illustration below.

Description	Number of Pieces	Unit	Length of Item	Size	Length	Number per Length	Quantity
Footers	45	PC	1'-5"	2x6	10'	7	7
Foundation Post	15	PC	1'-4"	6x6	8'	4	4
Scabs	20	PC	1'-0"	1x6	8'	8	3
Girders	36	PC	10'-0"	2x6	10'	1	36
Joists	46	PC	10'-0"	2x6	10'	1	46
Joist Splices	21	PC	2'-0"	1x6	8'	4	6

The illustration below is a typical drawing for footings and joists of a building.





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Materials Estimate List

The materials estimate list is the next step towards creating an accurate bill of material. This list is where the most economical length of materials for the project is determined and noted. It is compared to the available lengths in order to request the required materials that will produce the least amount of waste. All materials of the same dimension go on one line. The following steps show you how to produce a materials estimate list.

Step	Action
1	Compute or measure the most economical length of material for each item used in the project.
2	Record the most economical length of material for each item in the "Size and Length" column.
3	Add the length of material of the same dimension in the column "Board Feet."

Example

Use 2x6 material and 15 footers (each footer has three 1'-5" in length pieces of 2x6 material in it). Seven pieces can be cut from a 10' piece of lumber, so it will take seven pieces of 10' lumber for the footers. The same process is used for determining the required numbers of 2"x 6"x10' for the girders and joists. These totals are added together and a final total for 2"x 6"x 10' is recorded on the materials estimate list. Waste and breakage are accounted for on this list as well, which gives a total for the required material that is transferable to the BOM. The table below shows you how to fill out an accurate materials estimate list using this example.

Item	Size & Length	Unit	Takeoff Quantity	Waste Allowance Usually 10%	Additional Requirements	Total	Board Feet
1	6x6x12	PC	4	1	None	5	180
2	2x6x10	PC	89	9	None	98	980
3	1x6x8	PC	9	1	2 for batter boards	12	48
4	16d	Lb	_	_	36, Nails, Framing	36	_

Continued on next page

Nail Estimation

Based on the size of the nail required, there are two formulas for estimating nail requirements:

Formula 1	Formula 2
Formula for 2 penny through 8 penny nails (material under 2")	Formula for 10 penny through 60 penny nails (material larger than 2")
Number of pounds = $\frac{\text{penny}}{4} \times \frac{\text{board ft measurement}}{100}$	Number of pounds = $\frac{\text{penny}}{6} \times \frac{\text{board ft measurement}}{100}$

Board Foot Estimations

One board foot is 1"x 12"x 12" (144 cubic inches). Multiplying length in inches by width in inches by thickness in inches, and dividing that total by 144 calculates board feet. A 2"x 8"x 16' board is calculated as (2x8x192) divided by 144, which is 3,072 cubic inches divided by 144. The total board feet in one 2x8x16 are 21.33.

Bill of Materials Format

The information contained on the BOM is taken directly from the materials estimate list. DA Form 2702 is the standard form for bill of material. The materials estimate list contains more detail than is necessary for ordering materials. Therefore, the information is transferred to DA Form 2702 for ordering purposes.

Fighting Positions and Their Dimensions

Fighting Positions

A fighting position provides cover from direct fire weapons while allowing the individual to return fire to the front and oblique. It can be improved to provide cover from indirect fire weapons. There are two basic categories for fighting positions:

- Hasty
- Deliberate

Hasty

A hasty position is used when time and materials are limited, and when in contact with the enemy. It could be no more than a shell or bomb crater 1 to 3 feet deep, as long as it provides cover from direct fire and allows for return fire to the front and oblique.

Deliberate

A deliberate fighting position may start out as a hasty position until the decision is made to remain in the area. Hasty positions may then be upgraded and improved to deliberate positions. Deliberate positions may provide overhead cover from indirect fire or they may not, but they are a standardized type of position, depending on the Marine's mission that occupies the position: i.e. machine gunner, SMAW gunner, and mortars.

Hasty Fighting Position

There are three basic hasty fighting positions:

- Crater Position
- Skirmishers Trench
- Prone Position

Crater Position

Crater position is created by digging a 2 to 3-feet wide steep face on the enemy side of a crater.

Skirmishers Trench

Skirmishers trench is created by lying on your side in the prone position and scraping dirt in front of you, forming a small parapet for protection from small caliber weapons. This provides a shallow trench the length of the body to lie in.

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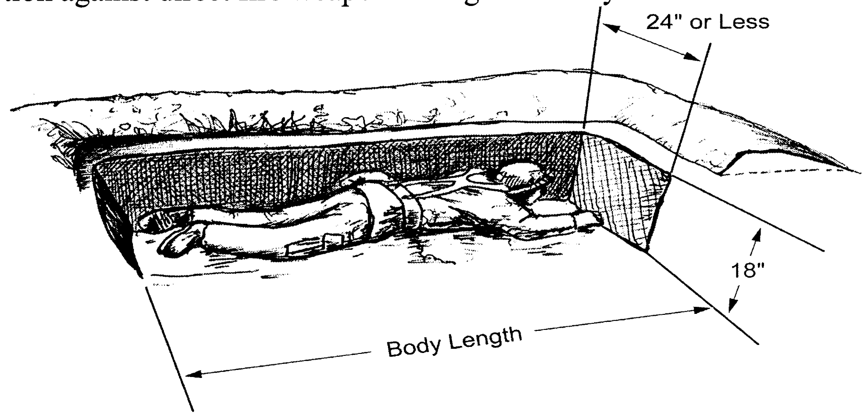
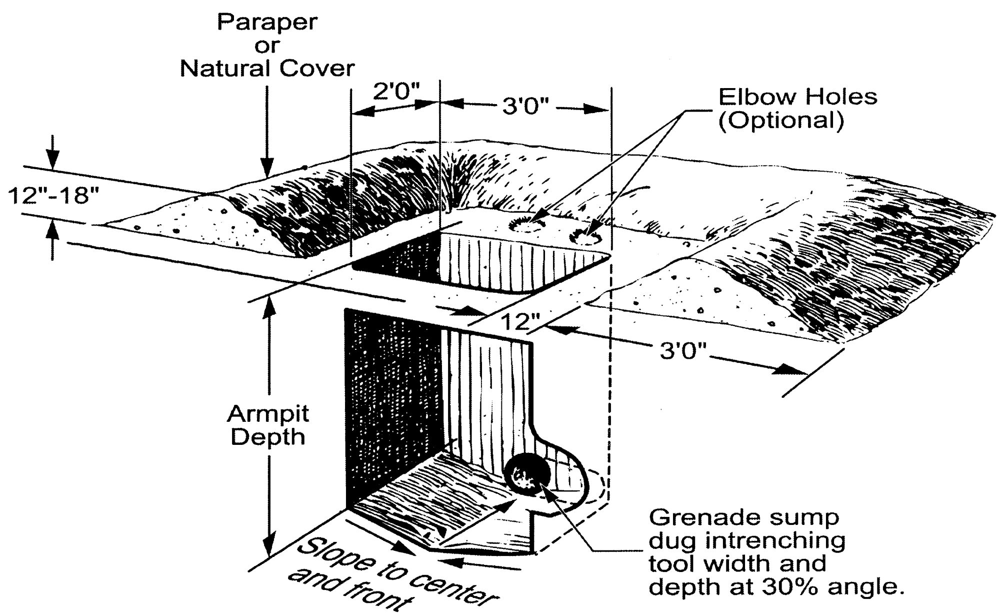
Prone Position

Prone position (shown below) is a further refined skirmishers trench. It is deeper and has a parapet to the front and side. This position provides for better protection against direct fire weapons and gives a very limited silhouette.



One-Man Fighting Position (Deliberate)

A standard one-man fighting position (shown below) is a rectangular hole in the ground measuring 2 feet front to back and 3 feet side-to-side. The position is dug to armpit depth on the Marine digging the hole i.e., when the Marine stands in the hole, the original ground level should be even with his armpits. The floor of the position should slope to the middle and towards the front, where a grenade sump has been dug. All the displaced soil is placed in a parapet around the front and sides of the position.



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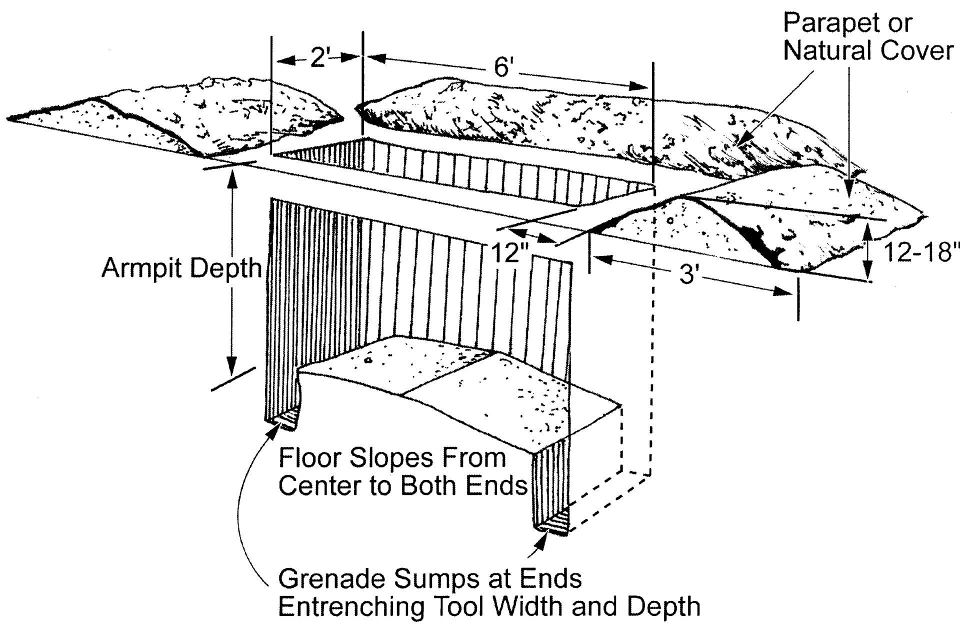
Two-Man Fighting Position

The two-man fighting position (shown below) is preferable to the one-man fighting position, because one Marine can keep watch while the other is working on the position. If one Marine becomes a casualty, the other is still manning the position, so no gap appears in the line. A standard two-man position is 6 feet side-by-side and 2 feet front to back. The floor is angled toward the outside edge and each half of the floor is dug to the individual's armpit that is manning that side. Grenade sumps are dug on each side of the position and the spoil from the hole is used as parapet material. Digging one end or both ends forward toward the frontal cover often modifies the basic position.

Two-Soldier Position (Deliberate)



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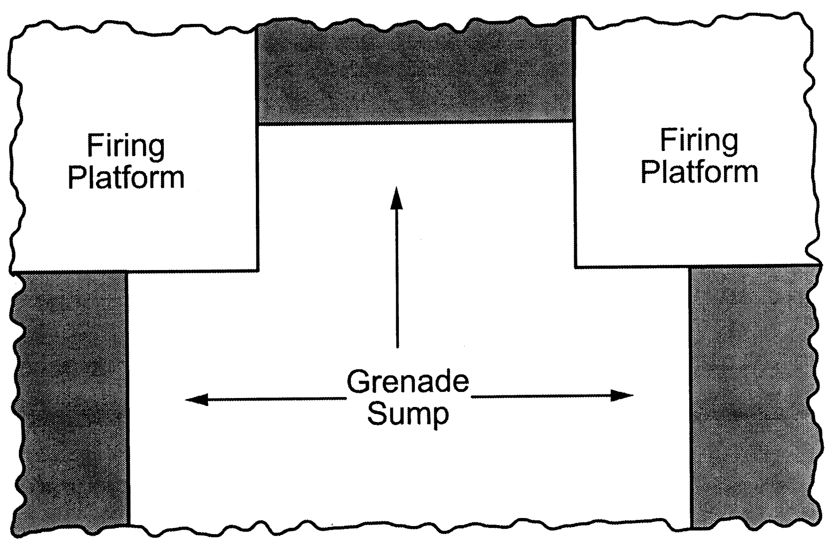
Machinegun Position

A machinegun fighting position is constructed so the gun fires to the front or oblique. The primary sector of fire is usually to the oblique, so that the gun fires across the unit's front. Since the machine gun requires two Marines to operate it, the position is dug so that both Marines have access to the gun at the same time. This is accomplished by leaving two firing platforms, one in each front corner. Reduce the height of the gun by digging the firing platforms down as much as possible while still allowing the gun to operate effectively (traverse across the entire sector of fire). If there is a three Marine crew, the third Marine digs a one-man fighting hole to the flank of the gun and attaches it to the gun position with a crawl trench.

Illustration

The illustration below shows a machinegun position with and without overhead cover.



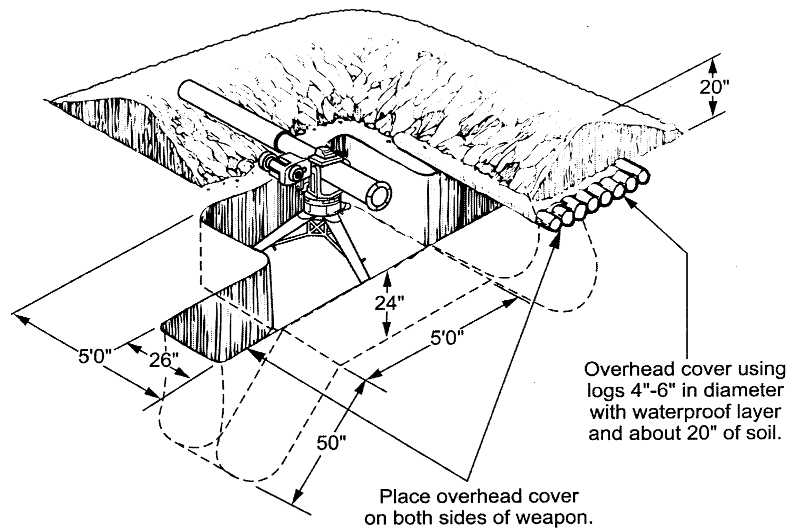
Dismounted TOW Position

A fighting position for a tube-launched, optically tracked, wire-guided weapons system (TOW) must not interfere with the launch or tracking system of the weapon. Back blast area must be taken into account as well. The position is dug to a comfortable kneeling depth, overhead cover (if provided), must not extend into the back blast or deflection area, and should provide cover when not operating the weapon.

Continued on next page

TOW Position with Overhead Cover

The illustration below shows a TOW position with overhead cover.

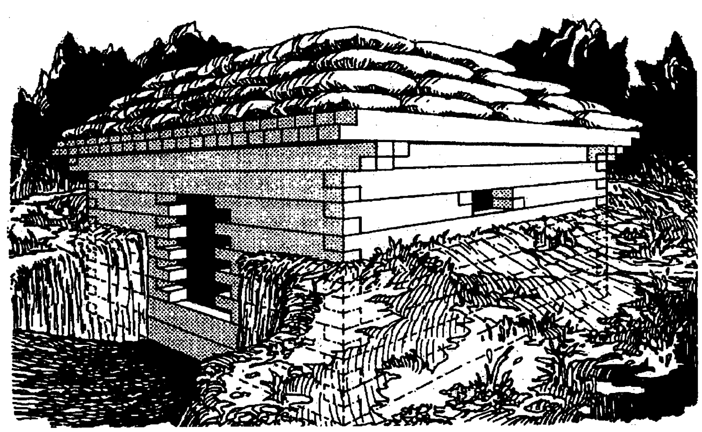


Overhead Cover

Overhead cover is provided for fighting positions by placing logs of more than 6 inches in diameter or 6x6 timbers across the top of the fighting position. The logs are elevated above ground level by laying them on another log. The logs must extend a minimum of 1 foot beyond the edge of the hole. Earth is then placed on top of the logs.

Concrete Log Bunker

The concrete log bunker (shown below) is designed to be a four-man fighting position. It is constructed from precast reinforced concrete logs that weigh approximately 50 pounds per linear foot. They can be cast in lengths up to 10 feet. The logs are held in place by lengths of rebar passed through the precast holes in the logs at various places.



Lesson 3 Exercise

Directions

Complete exercise items 1 through 9 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

The common traits among all types of survivability positions are overhead cover, protection from fragmentation and direct fire weapons, and

a. camouflage.
b. underground protection.
c. protective walls.
d. team support.

Item 2

Survivability positions are built to

a. provide safe, well-ventilated sleeping areas.
b. withstand hits from both indirect and direct fire weapons systems.
c. provide complete protection against all enemy fire and maneuver.
d. protect equipment from being destroyed by enemy combatants.

Item 3

When creating an accurate bill of material, ____ the totals and record it on the materials estimate list.

a. subtract
b. add
c. divide
d. multiply

Item 4

The information required on a bill of materials list comes from the

a. materials estimate list.
b. material data list.
c. material takeoff list.
d. DA Form 2072.

Continued on next page

Item 5

When producing a materials estimate list for a project, what information is recorded in the "Size and Length" column?

a. Length of material
b. Quantity of material
c. Type of material
d. Available material

Item 6

When time permits and an area is to be occupied for an extended period of time, what type of fighting position will be constructed?

a. Hasty
b. Deliberate
c. Hasty with overhead cover
d. Deliberate with overhead cover

Item 7 Through Item 9

Matching: For items 7 through 9, match the fighting position in column 1 with its dimension in column 2.

Column 1	Column 2
Fighting Position	**Dimension**
____7. One-man	a. 6'x2'
____8. Prone	b. 24"x18"
____9. Two-man	c. 2'x3'

Continued on next page

Solutions

The table below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page.

Item Number	Answer	Reference
1	a	2-36
2	b	2-39
3	b	2-43
4	a	2-44
5	a	2-43
6	d	2-45
7	c	2-46
8	b	2-46
9	a	2-47

LESSON 4

LIGHTWEIGHT SCREENING SYSTEM

Introduction

Scope

This lesson describes the process and procedures for assembly and use of the lightweight screening system.

Purpose

The purpose of this lesson is to provide you with the knowledge to successfully inventory, assemble, and construct the lightweight screening system to properly camouflage equipment and positions.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the use of camouflage.
- Identify the components of the lightweight screening system.
- Identify the steps to assemble the lightweight screening system.
- Identify the steps to place lightweight screening system over targets.

In This Lesson

This lesson contains the following topics:

Camouflage

Use

Camouflage is the use of materials and techniques to hide, blend, disguise, or disrupt the appearance of military targets and/or their backgrounds. Camouflage helps to keep the enemy from detecting or identifying friendly troops, equipment, activities, or installations.

Techniques

All camouflage techniques are designed to take advantage of the immediate environment including natural and artificial materials. Proper adherence to techniques aids in conservation of friendly strength for future decisive actions. Part of operational security is protection from attack. Camouflage provides that protection by making personnel and materials difficult to locate.

General Considerations

Camouflage degrades the effectiveness of enemy reconnaissance, surveillance, and target acquisition capabilities. Obscuring tell tale signs of units on the battlefield can defeat skilled observers and sophisticated sensors. Preventing detection impairs enemy efforts to access friendly operational patterns, functions and capabilities. While camouflage enhances friendly survivability by reducing an enemy's ability to detect, identify, and engage friendly elements, it is not restricted to combat operations. Benefits are also gained by denying an enemy the collection of information about friendly forces during peacetime. The deception provided by camouflage helps mask the real intent of primary combat operations and aids in achieving surprise. This deception can delay effective enemy reaction by disguising information about friendly intentions, capabilities, objectives, and locations of vulnerable units and facilities.

Individual Considerations

Each member of the unit must acquire and maintain skills in camouflage techniques. These skills include the ability to

- Analyze and use terrain effectively
- Select an individual site properly
- Hide, blend, disguise, disrupt, and decoy key signatures using natural and artificial materials.

Each Marine is responsible for camouflaging and concealing themselves and their equipment. Practicing good camouflage techniques lessens a Marine's probability of becoming a target. Gaining the individual skills in camouflage will also help the Marine identify enemy positions more easily.

Continued on next page

METT-T

METT-T is the actual memory tool for systematically applying camouflage to each element in METT-T.

- Mission
- Enemy
- Terrain
- Weather
- Troops
- Time available

Mission

The mission is always the first and most important consideration. Camouflage efforts must support and enhance the mission, while not being so elaborate that they hinder a unit's ability to accomplish the mission.

Enemy

An enemy's reconnaissance, surveillance, and target acquisition capabilities often influence the camouflage materials and techniques needed to support a unit's mission. Whenever possible, identification of the enemy's capabilities is important, as it will guide the camouflage mission. The civilians in the area are also a source of information for the enemy, and must be taken into account as an intelligence-gathering source for the enemy.

Terrain and Weather

The battlefield's terrain generally dictates what techniques and materials are necessary. Different terrain types or background environments (urban, mountain, forest, etc.) require specific camouflage techniques.

Troops

Friendly troops must be well trained in camouflage techniques that apply to their mission, unit, and equipment. A change in the environment of the mission often requires additional training on effective techniques. Leaders must also consider the alertness of troops. Careless camouflage efforts are ineffective and may disclose a unit's location, degrade its survivability, and hamper its mission accomplishment. Intelligence analysis should address the relative detectability of friendly equipment and the target signatures that the unit elements normally project.

Continued on next page

Time Available

Time is a critical consideration. Elaborate camouflage may not be practical in all tactical situations. The type and amount of camouflage needed are impacted by the time a unit occupies a given area, is available to employ countermeasures, and to remove and reemploy camouflage during a unit relocation. Units should continue to improve and perfect camouflage measures as time allows.

Components

Capabilities

The Lightweight Camouflage Screen System (LCSS) is a modular system. One module consists of a hexagon screen, a diamond-shaped screen, a repair kit, and a support system. Any number of kits can be joined together to cover a designated target or area. The LCSS protects equipment in four ways:

- Casts patterned shadows that break up the characteristic outlines of a target
- Scatters radar returns (except when radar-transparent nets are used)
- Traps equipment heat and allows it to disperse
- Simulates color and shadow patterns that are commonly found in a particular region

Hexagon Screen

The hexagon screen is a prefabricated camouflage screen in the shape of a hexagon. The hexagon measures 32 feet, 2 inches point-to-point and 27 feet, 9 inches from flat side to flat side.

Diamond-Shaped Screen

The diamond-shaped screen is a prefabricated camouflage screen, which is used to fill in the irregular edges left when hexagon screens are joined. It measures 27 feet, 9 inches by 16 feet, 1 inch.

Repair Kit

The repair kit contains pieces of the prefabricated screen, extra lanyard material, and replacement clips for the lanyards. The lanyards, which are used to attach the screens together, are normally stored in the repair kit.

Support System

The support system comes in its own bag and contains 12 pole sections, 18 stakes, and 6 spreaders. The pole sections may be put together to reach the desired height, and the spreaders attach to the top pole section so they can rest against the screen.

Assembly

Screen

Assembling the screens consists of attaching the screens to create one screen of the size required to cover the designated target/area to be camouflaged. The size of the net is determined by the target to be covered and is obtained by connecting any number of modules together. To assemble the screens, follow the steps below:

Step	Action
1	Connect the individual screens by lanyard. The lanyard is a length nylon rope with the male half of the connectors attached to it.
2	Evenly space the connectors over the length of the rope.
3	Connect the female sections of the connectors, evenly spaced along each edge of the screens.
4	Attach the female connectors from two screens and line up with the female connector from the other screen.
5	Insert the male portion of the connector through both of the female connectors, holding the two screens in place.
6	Insert the male connectors in the same direction, from the outside of the net toward the center, for ease of removal.
7	Pull one end of the lanyard to release all the connections if the male connectors are inserted in the same direction.

Pole

The pole sections are 4-feet long and have one male end and one female end so they can be connected to reach a desired length/height. They are used to hold the spreader in place and support the weight of the assembled modules.

Spreader Attachment

The spreaders are plates with small cleats on the topside (that are used to keep the plate from sliding while supporting the camouflage) and a female receptacle on the bottom for attaching to the poles.

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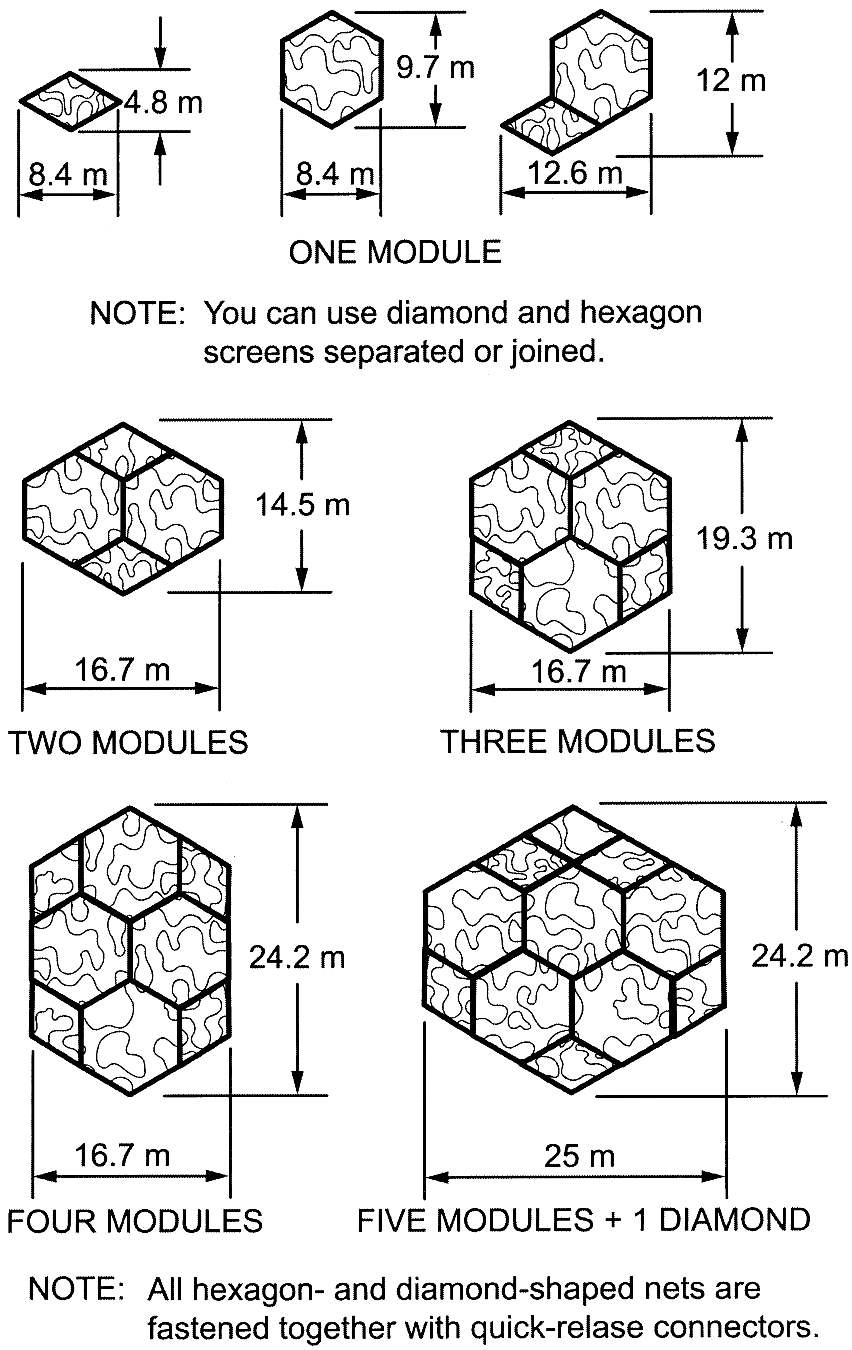
Screening System Layout

The illustration below shows the layout of the screening system.



Erect

Preparation

Once the camouflage screen is connected into the shape and size required, perform an accordion fold of the net. This is done to place the screen over the intended target easier. The fold is performed from both sides so that the net ends up being one long strip 3 to 4 feet wide that can be put into place and unfolded over the target.

Place the Screen Over the Target

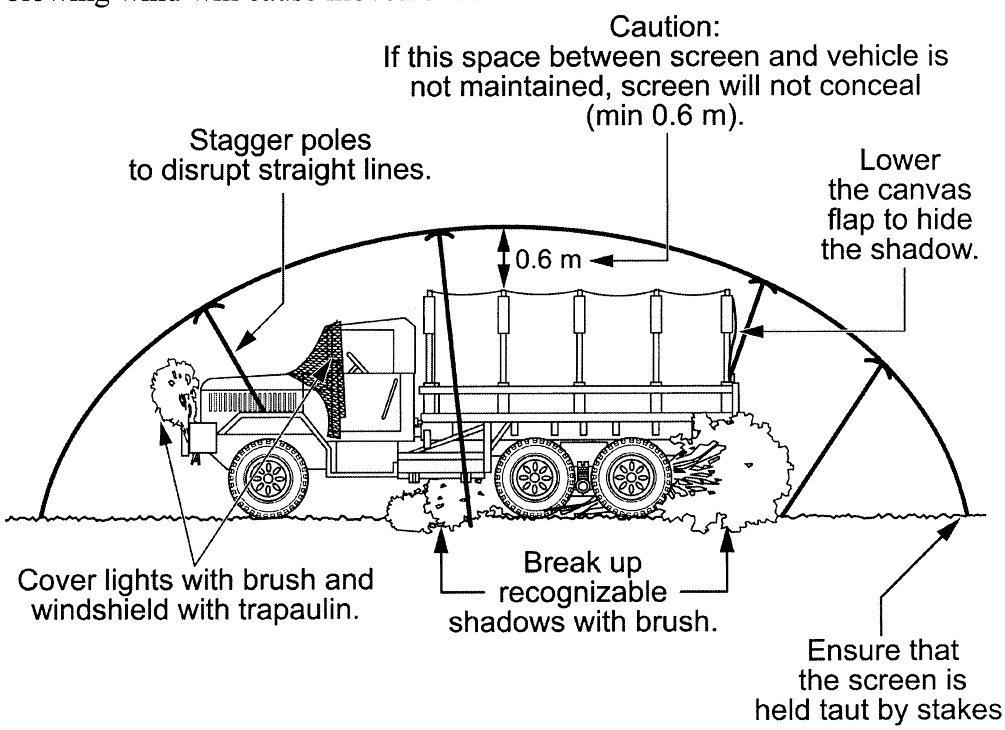
Once the screen has been folded, it is placed over the target with the ends draping down to the ground. The accordion fold is unfolded and the screen is spread out to its full width. The screen is now placed and ready to be erected.

Install the Stakes

The stakes are installed into the ground at the edges of the camouflage screen. Leave enough slack in the screen to allow the poles to raise it above the target.

Place the Poles

The poles are placed in a manner that will help the screen blend into the surrounding area while ensuring that the screen is suspended at least 2 feet from the target. The netting should not have a great deal of slack in it, as blowing wind will cause movement and attract attention to the area.



Lesson Exercise

Directions

Complete exercise items 1 through 4 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

Camouflage is the use of materials and techniques to hide, blend, disguise, or _____ the appearance of military targets and/or their backgrounds.

a. disrupt
b. view
c. identify
d. locate

Item 2

A lightweight camouflage screen system module consists of what four components?

a. Repair kit, screen patch materials, support poles, spreaders
b. Hexagon screen, a diamond-shaped screen, a support system, a repair kit
c. Two hexagon screens, a diamond shaped screen, a support system, and screen patch materials
d. Hexagon screen, support kit, screen patch material, spreaders

Item 3

Assembling the screens consists of attaching the screens to create ___ screen(s) of the size required to cover the designated target/area.

a. one
b. two
c. three
d. four

Continued on next page

Item 4

When constructing the screen, the poles are placed in a manner that will help the screen blend into the surrounding area, while ensuring that the screen is suspended at least ____ foot/feet from the target.

a. 1
b. 2
c. 3
d. 4

Continued on next page

Lesson Exercise, Continued

Solution

The table below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page.

Item number	Answer	Reference Page
1	a	2-54
2	b	2-57
3	a	2-58
4	b	2-60

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STUDY UNIT 3

COUNTERMOBILITY

Overview

Scope

This study unit covers the skills and knowledge for implementing countermobility operations as they pertain to the combat engineer serving with a Marine division.

Purpose

The purpose of this study unit is to provide you with the skills and knowledge necessary to successfully implement, construct, and make recommendations on countermobility issues.

In This Study Unit

This study unit contains the following lessons:

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LESSON 1

OBSTACLES

Introduction

Scope

This lesson describes the process and procedures for making recommendations for the placement of countermobility obstacles.

Purpose

The purpose of this lesson is to provide you with the knowledge to recommend the appropriate obstacle placement to a unit commander based on available assets and engineer capabilities.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the purpose of countermobility obstacles.
- Identify the nine-step planning process for determining the appropriate obstacle for a given situation.
- Identify which obstacle is appropriate for slowing enemy foot troops and vehicles.

In This Lesson

This lesson contains the following topics:

Placement Overview

Introduction

Countermobility is divided into mine warfare (covered in MCI 1374, *Landmine Warfare*) and obstacle development, each with the ultimate goal of delaying, stopping, or channelizing the enemy. As a division engineer, you will be required to install and/or recommend the placement of various obstacles in support of unit missions. You must know which obstacle is best suited to the mission, how it is constructed, and how to effectively place the obstacle. While this is not all-inclusive, it will aid you in performing your mission successfully and more effectively.

Purpose of Counter-mobility Obstacles

Countermobility obstacles are used to reduce the mobility of the enemy while supporting the tactical plan of the unit commander. Reinforcing obstacles support the maneuver commander's plan, and must be covered by observation and fire. They are integrated with observed fires as well as existing obstacles (natural or manmade), and with other reinforcing obstacles. Countermobility obstacles include but are not limited to wire entanglements, log obstacles, abatis, craters, or boobytraps. Obstacles are employed in-depth and can be employed for surprise. These obstacles can be used to channel the enemy, and depending on the method of employment, can slow both foot personnel and vehicle traffic.

Direct Fire Assessment

Marines and construction equipment cannot be exposed to enemy fire while emplacing obstacles. They should be emplaced prior to the start of battle, or on a terrain feature away from a direct fire weapons area in order to reduce the possibility of disruption of the emplacement process by enemy fire. The placement of some obstacles can be time consuming and time must be taken into consideration when determining which obstacles to use.

Continued on next page

Cover by Fire

Develop effective engagement areas to place obstacles where proper placement can restrict and slow enemy maneuver. By slowing enemy movements, we increase the hit probability of friendly direct and indirect fires. The obstacle site is determined by the tactical commander and engineer to offer the best relative advantage, as well as consideration of terrain and effective weapons range. Special attention should be given to locating obstacles that will complement the fires of dragon, tanks, and TOW weapon systems. Since TOWs have a greater maximum effective range than threat tanks, it is advantageous to site part of the tactical obstacle system to capitalize on that advantage.

Indirect Fires

Observed indirect fires are also used in conjunction with obstacles. Observation of the target area and adjustment of fires are essential to take full advantage of the use of indirect fires. Indirect fires serve to protect the obstacle by making it too costly to breach.

Support Other Obstacles

For obstacles to be effective, place them to take maximum advantage of existing obstacles, manmade or natural. Place them so that no gaps exist between obstacles except where the enemy is to be channeled. Obstacles are integrated with each other to ensure that probable bypass routes are closed as well. It does little good to close one avenue of approach if another exists nearby.

Classification of Placement

There are three classifications of obstacles:

- Belt
- Band
- Zone

Belt

A belt is an entanglement one fence in depth.

Band

A band consists of two or more belts in depth, with no interval between them. The belts may be fences of the same type, or the band may be composed of two or more fences of different types.

Continued on next page

Zone

A zone consists of two or more bands or belts in depth, with intervals between them.

Planning

Mission

Obstacle planning can be critical in land warfare, which involves all elements of the combined arms team. Obstacles must support present as well as future operational plans, and be logistically supportable. The mission will always be the primary consideration when planning obstacles. Tailor the obstacle plan to support the mission of the organization and to accomplish the objectives of the command. A defend mission would differ greatly from a delay/offensive mission.

Exploitation

Plan obstacles to exploit the weakness of the enemy. If the enemy has little or no rapid bridging capabilities, a tank ditch would be more effective than a minefield. If the enemy has limited breeching equipment, the more you expose that equipment to fire, the better the chances are of destroying or disabling it.

Terrain and Weather

Terrain and weather play an important role in planning obstacles. With regards to terrain, look for good existing obstacles i.e., fast moving streams, steep grades, pre-existing canals. These are only obstacles if they are within the enemy's avenue of approach. Can those existing obstacles become effective, or become more effective, with reinforcing obstacles tied to them? The existing obstacles must be within range to be effectively covered by fire. Weather may dictate the type of obstacle you can put in. If the ground is frozen, you may not be able to dig. If the ground is saturated with water, you may get your equipment stuck and not be able to dig.

Logistics

Logistics will include available time, equipment, manpower, and materials. The availability of these items will dictate what can or can't be done on the battlefield. By assessing these areas, you can determine what can be done and what additional resources are required to accomplish what is being requested. If the resources have been requested, the length of time for availability is critical information.

Continued on next page

Guidelines

The following guidelines should be enforced:

- Obstacles should support weapons systems and be employed at the maximum effective range of weapons systems.
- Obstacles should not impede friendly maneuvers.
- Obstacles must hinder enemy movement.
- Obstacles are emplaced in as much depth as feasible, taking into account the logistics of placement.

Planning Process

The nine-step planning process below covers everything from analyzing the mission to determining required coordination.

Step	Action
1	**Analyze the mission.** Determine who is going to provide personnel for the mission, what the mission is, where the obstacles are to be installed, and when the operation will start. The estimate, eventual plan, and execution are based on tasks contained in the mission.
2	**Analyze avenues of approach.** This is accomplished through terrain analysis and the evaluation of existing obstacles. The avenues of approach must be analyzed for approach under all conditions, and with varying unit sizes.
3	**Analyze engagement areas, battle positions, and locations of weapon systems.** Use terrain analysis to determine the best areas for friendly weapons placement to engage the enemy. The analysis is the same whether the mission is offensive or defensive in nature. The key factors in determining where to best engage the enemy exist in obstacle areas, fields of fire, and natural cover and concealment.
4	**Determine possible obstacle locations and types.** When engagement areas have been selected, the command and the engineer will determine which reinforcing obstacles will be installed to accomplish the mission. These initial site selections are made without regard to time and materials. This process provides what needs to be done.

Continued on next page

Planning Process, continued

Step	Action
5	**Determine the commander's obstacle priorities.** Having determined what needs to be done, the obstacles can be identified and prioritized to accomplish the mission. Critical obstacles are placed first.
6	**Determine resources.** Available assets are determined for use in construction, guard, and execution of the obstacle plan. The engineer completes their estimate based on available logistics for manpower, materials, etc.
7	**Determine actual work sequence.** When determining the sequence for constructing obstacles, identify those obstacles that can be realistically completed within the allotted time given the constraints of available time, work force, and logistical assets. Identify obstacles that can be constructed during a battle.
8	**Determine task organization.** Decide how to best assign personnel to complete as many obstacles as possible or to complete the most important obstacles.
9	**Determine coordination.** Obstacle planning requires coordination that will likely be above the basic engineer's level. The G-4/S-4 must receive the materials lists as early as possible. Others who need to know where obstacles are being placed are the artillery fire support coordinator, aviation officer, and air liaison officer.

Countermobility Obstacles

Wire

Wire obstacles are used to support the tactical plan in both offensive and defensive operations. Reinforcing obstacles support the maneuver commander's plan, and must be covered by observation and fire. They are integrated with observed fires, existing obstacles (natural or manmade), and other reinforcing obstacles. Wire obstacles are employed in-depth and can be employed for surprise. These obstacles can be used to channel the enemy, and depending on the method of employment, can slow both foot personnel and vehicle traffic.

Log

There are several different types of log obstacles that can be constructed. The advantage of log obstacles is that they take advantage of local material, and can be constructed entirely by hand. They are most effective when there is a lack of bypass in the area that forces the enemy to breech the obstacle. Log hurdles, log cribs, and log posts are some of the available log obstacles. Posts are logs put into the ground at angles to stop enemy armor. Hurdles are made of logs and posts, and log cribs are a combination of logs and earth fill.

Craters and Ditches

The most common application of this is the antitank ditch. The antitank ditch is placed so that the enemy is put within the effective range of friendly forces while at the same time keeping the enemy outside of their best firing range. Ditches disrupt the enemy attack and stop some vehicles completely. The use of ditches will require the enemy to expose their breeching assets to friendly fire, and begin to accordion the follow on forces. This accordion effect will begin to bunch and stall the enemy, exposing their assets to direct and indirect fire.

Continued on next page

Abatis

An abatis is an effective obstacle against vehicular traffic up to and including tanks. It is produced in heavily wooded areas by the use of demolitions to fell trees in the road or trail. The trees should be felled at a 45-degree angle to the road and the tree should remain attached to the stump. This makes the obstacle much more difficult to clear.

Mines

Mines delay, destroy, and channel enemy forces. There are two types of mines:

- Conventional
- Scatterable

Conventional

The conventional method is installing the mines individually by hand, and removing the same way.

Scatterable

The scatterable minefield is delivered via air support or artillery support and is dropped onto a specified location. The emplacement of mines requires permission from higher command, as well as a great deal of coordination with the friendly forces in the area.

Bridge Demolition

Since the use of existing bridges is critical to the mobility of a military force and, in most countries, roads and railways follow the most likely military avenues of approach, the loss of a bridge is an obstacle to enemy maneuver forces. The loss of bridges forces a maneuver element to perform river crossing operations, which is either bridge the gap, ford the river, or perform rafting operations. The only other alternative is to find a bypass that may not be feasible. Performing river crossing operations is time consuming even when the assets are readily available.

Effective Placement

Overview

Placing obstacles cannot be done haphazardly. Effective placement of obstacles is key to any tactical plan. A distinct advantage can be gained both offensively and defensively through the proper placement of obstacles. The obstacle placement must be systematic, coordinated and fully integrated into the tactical plan. The placement should ensure that we could extract the greatest cost from the enemy, in the form of loss of personnel and equipment.

Avenues of Approach

An avenue of approach is an air or ground route of an attacking enemy force that leads to its objective or to key terrain in its path. In most developed countries, there will be roads and or railways that already exist within the avenues of approach. The paths that are preferred are those that allow for speed and are most direct between points. If cover and/or concealment is also available along the route, that is a benefit. Place obstacles on these avenues, and select sites that give advantage to the defender. Place them where they will slow the enemy and allow friendly fire, both direct and indirect, to be most effective while limiting the effectiveness of the enemies' fires.

Tying In

Tying in obstacles with one another or with existing obstacles is the most effective method of placement. Simply put, this is using one obstacle to extend another obstacle either laterally or in depth. When obstacles are not tied together, they become much easier to breech or simple to avoid.

Reinforcing Obstacles

Reinforcing obstacles are obstacles that are specifically constructed, emplaced, or detonated through military effort, and are designed to strengthen existing terrain, to disrupt, fix, turn, or block enemy movement. The use of these obstacles aids a unit in completing obstacle belts with fewer materials through the use of existing obstacles.

Continued on next page

Available Weapons

Place obstacles within effective range of available direct fire weapons. Placing obstacles outside the effective range of our weapons systems defeats our attempts to cause losses to the enemy, which is one of the main purposes of obstacle emplacement. Ideally, place the obstacle within effective range of our weapons but outside the range of enemy weapons. An example of this might be placing antitank obstacles just inside the range of the TOW system, which has a greater effective range than the enemy tank.

Bypass

Identify closest and most likely bypass routes before placing obstacles. If placing obstacles will cause the enemy minimal loss of time due to a convenient bypass, there is no point in placing the obstacle. The bypass must either be made impassable or a different site must be chosen for the obstacle placement. The only other choice is to place obstacles on both the bypass and the main avenue of approach, and cover both with direct and indirect fire. This may not be advisable depending on personnel and equipment. Scatterable mines may be an alternate way to temporarily close a bypass, but this may take permission from a much higher level in the chain of command.

Lesson 1 Exercise

Directions

Complete exercise items 1 through 4 by performing the action required. Check you answers against those listed at the end of this lesson.

Item 1

Countermobility obstacles are used to ______ the mobility of the enemy while supporting the tactical plan of the unit commander.

a. protect
b. support
c. enhance
d. reduce

Item 2

What is the first step in the planning process?

a. Analyze the locations of weapon systems.
b. Determine resources.
c. Determine the location.
d. Analyze the mission.

Item 3

Which obstacle is appropriate for slowing enemy foot troops and vehicles?

a. Rocks
b. Holes
c. Wire
d. Rug

Continued on next page

Solutions

The table below lists the answers to the exercise items. If you have any questions about these items, please refer to the reference page listed for that item.

Item Number	Answer	Reference Page
1	d	3-4
2	d	3-8
3	c	3-10

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LESSON 2

CREATE AN ABATIS

Introduction

Scope

This lesson describes the process and procedures for creating an abatis for use as a countermobility obstacle.

Purpose

The purpose of this lesson is to provide you with the knowledge to create an abatis properly for a unit commander to use it as a countermobility obstacle.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the purpose of an abatis.
- Determine the most effective site for creating an abatis to accomplish the assigned mission.
- Identify the charges needed to drop a tree.
- Calculate the formula used to create an abatis.
- List the steps for creating an abatis in a given situation.

In This Lesson

This lesson contains the following topics:

Abatis Overview

Introduction

As a division engineer, you will be required to install and/or recommend the placement of various obstacles in support of unit missions. You must know how to emplace each obstacle. One such obstacle is the abatis. The abatis is an obstacle created by dropping trees across a road or trail at a 45-degree angle from both sides of the road, creating a crisscross pattern of downed trees. The goal is to leave the tree partially attached to the stump, making removal of the trees more difficult.

Purpose

An abatis is used to reduce the mobility of the enemy while supporting the tactical plan of the unit commander. They are integrated with observed fires as well as existing obstacles (natural or manmade) and with other reinforcing obstacles. If done properly, the abatis can stall an enemy movement. They are difficult if not impossible to go around, as they are created in heavily wooded environments, which limit travel to the existing roads. The forest itself is a reinforcing obstacle, or the abatis reinforces the forest as a natural obstacle depending on how you choose to look at it. These obstacles can be used to channel the enemy by limiting which roads remain passable and depending on the method of employment, can slow both foot and vehicle traffic.

Support Other Obstacles

For obstacles to be effective, they must be placed to take maximum advantage of existing obstacles, manmade or natural. The abatis does this and can be supplemented with mines and direct fire weapons. The abatis is placed so that no gap exists between the abatis and the forest itself. Obstacles are integrated with each other to ensure that probable bypass routes are closed as well.

Requirements for an Effective Abatis

Site

There are some specific requirements for the selection of an abatis site. The first of these requirements is a road or trail that passes through a heavily wooded area. Plantations aren't as effective since they have rows of trees and the maneuver element can simply pass between the rows and continue on. If the trees are cleared back from the road on both sides to a point that is farther from the road than the tree is tall, an abatis is not an option. The trees must be able to cross the centerline of the road to be blocked when they are dropped at a 45° angle to the road. As with any other obstacle, it should be covered by fire to make it more effective and costly to the enemy.

Explosives

The creation of an abatis is normally completed with the use of explosives. There are two charges needed for each tree to be dropped. The first charge is the kicker charge that is placed near the top of the tree to apply directional force to place the tree where it is needed. The second charge is the charge that cuts 80% to 90% of the base of the tree. The tree is left attached to the stump because it makes clearing the obstacle much more difficult. The calculations for these charges will be discussed later in this lesson.

Time and Equipment

The time will vary based on the size (length) of the abatis. Each tree must be prepared and detonated and the process is done on both sides of the road. The size of the trees will also affect the amount of time required to prepare them. Equipment that will be needed include demolitions, wire/tape, detonating cord, initiation system (electric or non-electric), and climbing equipment (optional).

An Abatis as a Countermobility Obstacle

Abatis

An abatis is an effective obstacle against vehicular traffic up to and including tanks. It is produced in heavily wooded areas by the use of demolitions to make trees fall on or across roads and trails. The trees should be felled at a 45° angle to the road and the tree should remain attached to the stump. By doing this, the obstacle becomes much more difficult to clear. Obstacles are integrated with each other to ensure that probable bypass routes are closed as well. It does little good to close one avenue of approach if another exists nearby.

The 45° Angle

Felling the trees at a 45° angle towards the enemy makes clearing the obstacle much more difficult. The angle makes it nearly impossible for the enemy to push the trees out of the way. If the trees are felled in the opposite direction (away from the enemy), pushing the trees to the side is much simpler. The trees being angled toward the enemy and being overlapped also makes it hard to just pull them out of the way. The more difficult the process of removal, the longer it takes the enemy to complete it. The objective of any obstacle is to slow the enemy, and the 45° helps the abatis to accomplish this.

Stump Remains Attached

The removal of the individual trees is made more difficult by not cutting completely through the tree at the base. Common sense dictates that it is harder to remove a tree that is attached to its stump and root system than it is to remove one that is simply lying on the ground. The ability to leave the tree attached is done through the calculations for the demolitions charges and through the use of a test shot. By having the tree attached, it can't be pushed or pulled out of the way. The enemy has to detach the tree from the stump, which exposes personnel and equipment to friendly fire.

Continued on next page

An Abatis as a Countermobility Obstacle, Continued

Both Sides

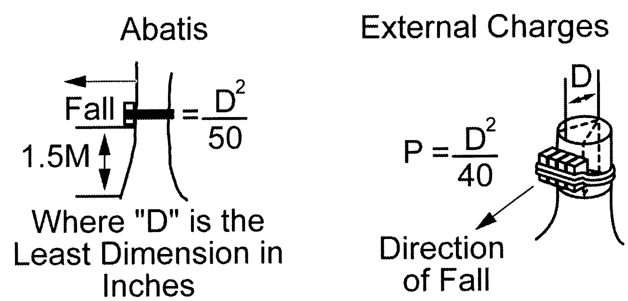
Dropping trees from both sides of the road or trail creates the abatis. Having trees felled from both sides creates more difficulties for the enemy and raises the effectiveness of the obstacle. When the enemy tries to push the trees out of the way, they will end up hitting the tree from the opposite side of the road and defeat the attempt to push them. If the enemy pulls the trees, they will be pulling more than just the one tree, and both trees will still be attached to the stumps on opposite sides of the road.

Demolition Calculations

Formula

The formula for creating an abatis is a fairly simple one. The formula is based on the selected trees to be dropped. The diameter is taken for all of the selected trees. By calculating the explosive required to sever the smallest tree completely, we ensure that the evenly divided explosives will unlikely completely sever any tree. If there are 40 trees to be dropped and the selected trees have diameters ranging from 16 inches to 20 inches, the measurement to be used in the calculations is the smallest i.e., 16. This diameter is then squared (the diameter multiplied by itself) and divided by 50 to get the pounds of explosives required to drop the tree.

The formula looks like this: P (pounds of explosives) = $\frac{D^2}{50}$



Example Problem

Forty trees have been identified and dropped to create an abatis. The trees vary in size from 18 inches to 21 inches in diameter. The following formula is used to get the answer.

40 trees at 18 inches

$\frac{18^2}{50} = \frac{324}{50}$ = 6.48 pounds of TNT, which when rounded to the nearest ½ pound becomes 6.5 pounds per tree.

Answer: 6.5 pounds x 40 trees = 260 pounds of TNT.

Continued on next page

Steps

Follow the steps below to create an abatis.

Step	Action
1	Locate an appropriate site.
2	Determine the direction the enemy will be traveling.
3	Determine the minimum diameter of the trees to be felled.
4	Complete the calculation for the demolition requirements.
5	Place the demolitions in the proper position to fell the tree in the desired direction.
6	Connect/prime the charges.
7	Connect the initiation device (electric or non-electric).
8	Detonate one side.
9	Detonate the opposite side.
10	Cover by fire.

Challenge

You are creating an abatis and there are 26 trees that have been identified for dropping. The trees vary in diameter from 16 inches to 21 inches and average 19.5 inches. The estimated height of the trees is 65 feet. Determine the pounds of explosives for each tree and the total explosives required for the abatis.

Solution

26 trees at 16 inches

16 x 16 = 256

256 divided by 50 = 5.12 pounds of explosives per tree

5.12 rounded to the nearest ½ pound = 5 pounds of TNT per tree

26 trees at 5 pounds each = 130 pounds of TNT

Lesson 2 Exercise

Directions

Complete exercise items 1 through 4 by performing the action required. Check you answers against those listed at the end of this lesson.

Item 1

The purpose of an abatis is to _____ the mobility of the enemy while

a. stop; supporting the tactical plan of the unit commander.
b. reduce; supporting the tactical plan of the unit commander.
c. reduce; providing a friendly avenue of approach.
d. reduce; supporting the fire plan of the regimental commander.

Item 2

The most effective placement for creating an abatis is a road or a(n)

a. trail.
b. tank.
c. armored personnel carrier.
d. wheeled vehicle.

Item 3

There are two charges needed for each tree to be dropped. The _______ charge is placed near the top of the tree to apply directional force to place the tree where it is needed.

a. kicker
b. booster
c. detonating
d. explosive

Item 4

What is the first step when creating an abatis?

a. Connect/prime the charges.
b. Complete calculation for demolition requirement.
c. Locate an appropriate site.
d. Determine the minimum diameter of the trees to be felled.

Continued on next page

Lesson 2 Exercise, Continued

Solutions

The table listed below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page listed for that item.

Item	Answer	Reference Page
1	b	3-18
2	a	3-19
3	a	3-19
4	c	3-23

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LESSON 3

LOG OBSTACLES

Introduction

Scope

This lesson describes the process and procedures for placing and constructing log obstacles for use as countermobility obstacles.

Purpose

The purpose of this lesson is to provide you with the knowledge to construct log obstacles properly for a unit commander to utilize them as countermobility obstacles in the tactical plan.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the purpose of log obstacles.
- Identify the four types of log obstacles used by the Marine Corps.
- Identify the steps for constructing log obstacles.
- Determine the most effective placement of log obstacles.

In This Lesson

This lesson contains the following topics:

Log Obstacle Overview

Introduction

Countermobility is divided into mine warfare and obstacle development, each with the ultimate goal of delaying, stopping, or channelizing the enemy. Log obstacles fall under the obstacle development portion. As a division engineer, you are required to install and/or recommend the placement of log obstacles in support of unit missions. You must know how to emplace each type of log obstacle. Log obstacles are most effective when the enemy is forced to breech them due to a lack of bypass routes. Dropping trees and cutting those trees into logs create the logs for the obstacles. The goal is to create an obstacle that can't be pushed over, driven over, or be easily breeched by the enemy.

Purpose

A log obstacle reduces the mobility of the enemy while supporting the tactical plan of the unit commander. They are integrated with observed fires as well as existing obstacles (natural or manmade) and other reinforcing obstacles. When done properly, log obstacles can stall an enemy movement because they are difficult to breech, as they are heavily dug into the ground and in some cases filled with earth. The log obstacle by itself is not very effective as a maneuver unit can drive around them. With reinforcing, natural, and manmade obstacles used in combination, they are very effective. These obstacles are used to channel the enemy by limiting which roads remain passable and depending on the method of employment, can create choke points and kill zones for enemy equipment.

Support Other Obstacles

For obstacles to be effective, place them to take maximum advantage of existing obstacles, manmade or natural. The log obstacle does this and can be the primary means of blocking travel along a road. Supplemented with mines, direct fire weapons, indirect fire weapons, and reinforcing obstacles, they are integrated with each other to ensure that probable bypass routes are closed as well. It does little good to close one avenue of approach if another exists nearby.

Types

Log Obstacles

There are four types of log obstacles:

- Crib
- Hurdle
- Wall
- Post

Crib

There are two styles of log cribs:

- Rectangular
- Triangular

Both styles are effective roadblocks so as long as there is no readily available bypass in the area. Rectangular and triangular are most effective when the interior is filled with earth. This earth should come from a ditch in front of the obstacle whenever possible. If a ditch cannot be dug in front of the log crib, employ log hurdles to slow enemy vehicles. Both styles take about the same time and equipment to construct.

Rectangular

The rectangular log crib is constructed by building two parallel walls at 60 inches high, 6 feet apart. Diagonal bracing that runs to the bottom of the second wall supports the top of the front wall. There is also diagonal bracing from the top of the second wall down to posts set into ground behind it. Once the walls and bracing are complete, the space between the walls is filled with earth. The two methods for placing the posts are

- Opposing
- Offset

Opposing

Opposing is where the posts are placed directly across from each other, which requires six posts per wall.

Offset

The offset requires five alternating posts. Three posts are placed in front of the wall and two posts are placed behind the wall (centered between the posts in front).

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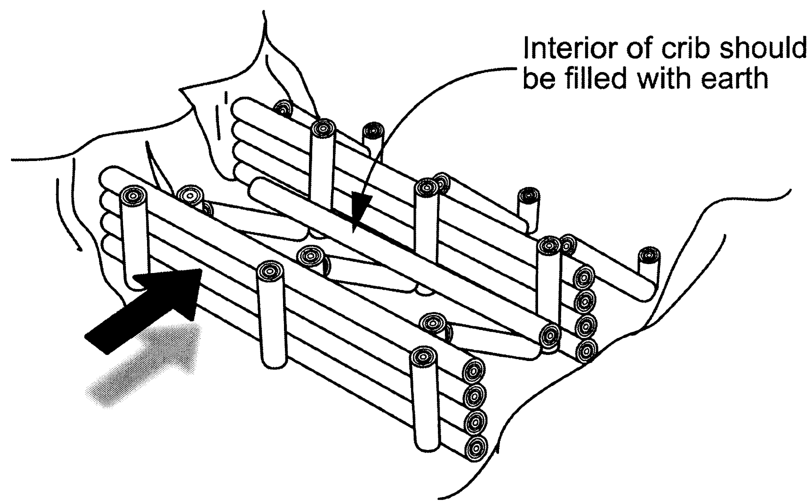
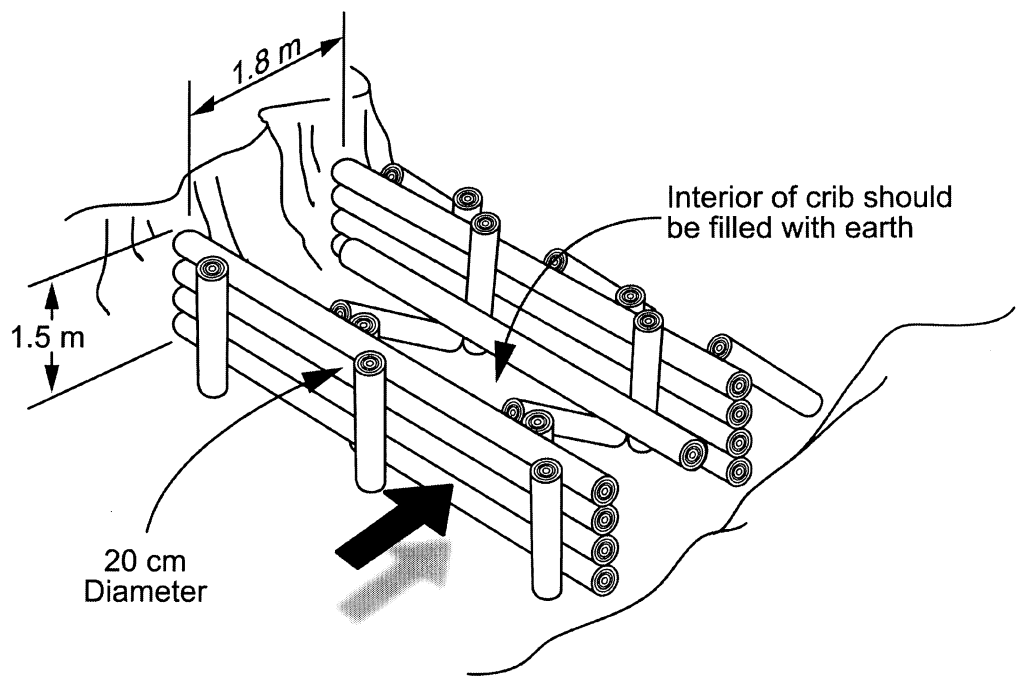
Opposing and Offset Log Cribs

The illustration below shows opposing and offset log cribs:



POST OPPOSING DESIGN



OFFSET POST DESIGN

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Construction Steps

The table below shows the steps to construct a log crib:

Step	Action
1	Gather materials (10-ft posts and 16-foot logs).
2	Lay out first log.
3	Mark holes two paces from each end and one set centered between the end posts.
4	Dig holes 5 feet deep.
5	Install posts into holes.
6	Continue to place logs until a height of 5 feet is reached.
7	Repeat steps 1 through 6 for the second wall (6 feet behind first wall).
8	Install 4-foot anchor posts, 6 feet behind posts of rear wall.
9	Install all diagonal bracing.
10	Wire all logs to the posts.
11	Fill interior with earth.

Triangular

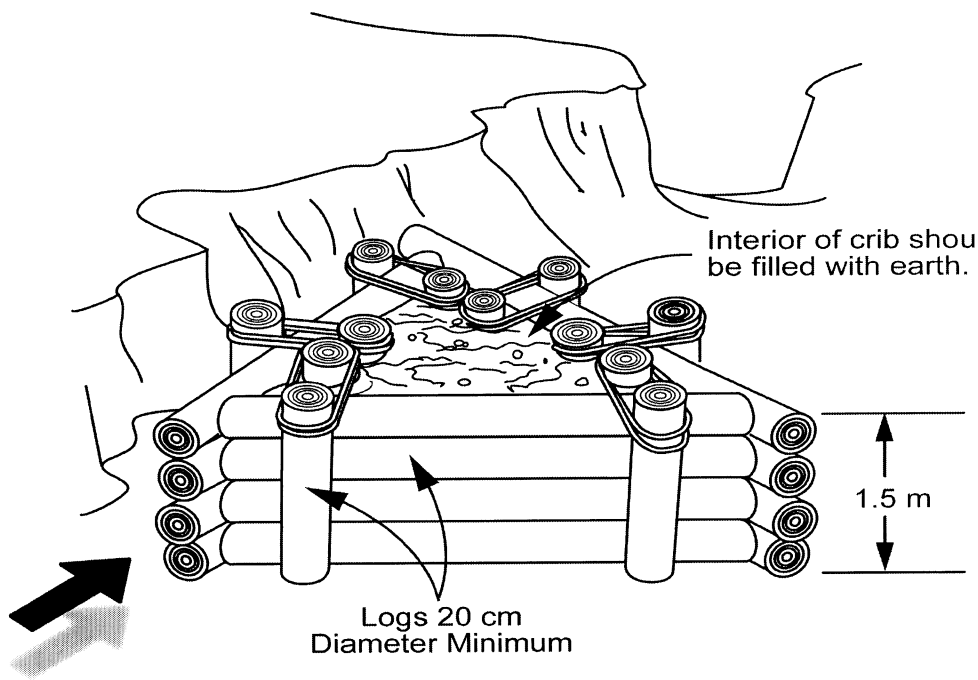
The triangular crib is constructed so that the point of the triangle faces the enemy. Follow the steps below to construct a triangular log crib:

Step	Action
1	Construct the triangular log crib so that the point of the triangle faces the enemy.
2	Construct the log walls in the same manner as the rectangular log crib.
3	Once the walls are built, secure the logs with wire and fill the interior of the crib with earth from a ditch in front of the crib.

Continued on next page

Triangular Log Crib

The wall height, log size, and post dimensions are the same as the rectangular crib. There are four posts per wall and enough logs to reach the 5-foot height for the wall. The illustration below shows a triangular log crib.



Hurdle

The log hurdle will not stop a tank on level ground, but it will slow it down and make it more vulnerable to direct fire weapons. If the obstacle is constructed on an uphill grade, it can stop a tank and force the enemy to breech it. The logs used in the construction of log hurdles are more than 10 inches in diameter. Log hurdles are constructed with single logs or multiple logs tied together. This determination is based on hurdle height and available log diameters. The hurdles are placed as near the top of the hill as possible and can be employed at a 90° angle across the entire width of the road with approximately 24 feet center-to-center spacing, or 8 to 10-foot long hurdles staggered across the width of the road.

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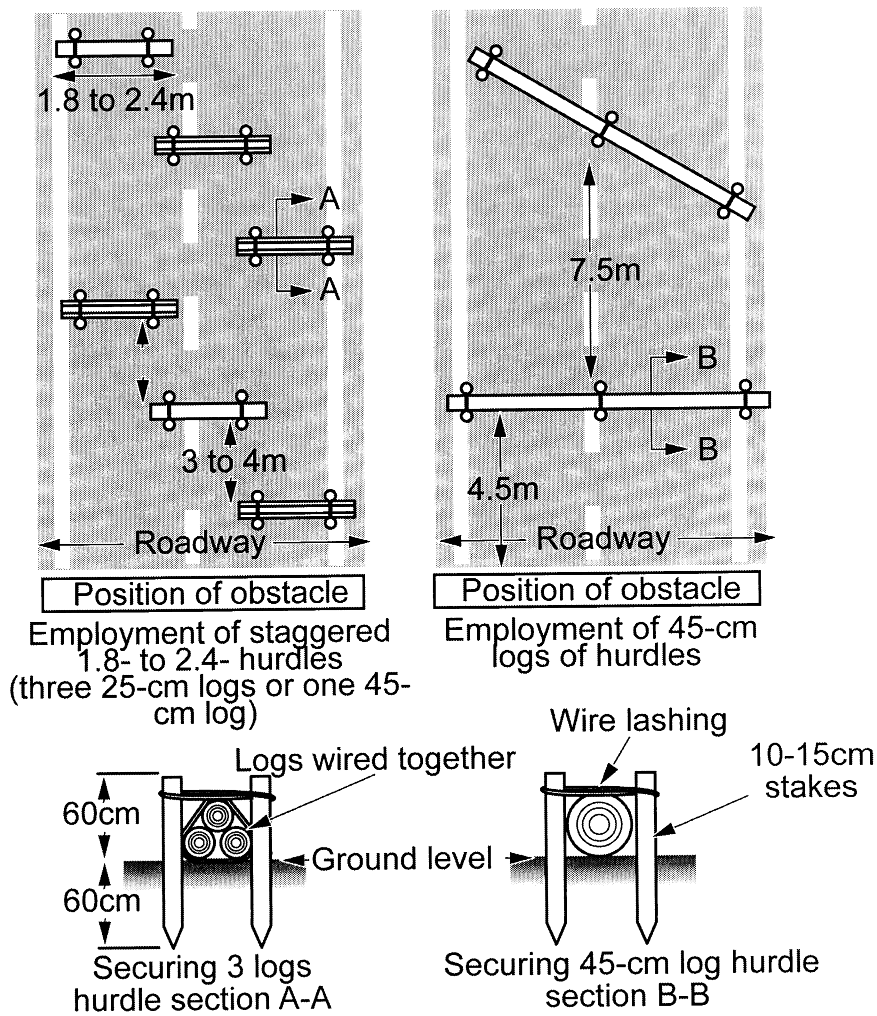
Illustration

The illustration below shows a log hurdle.



Wall

Log walls are not effective against heavy tracked vehicles. They serve well as roadblocks, and are much more effective if hurdles or posts are employed in front of the wall to slow the vehicle speeds. The layout of the log wall is constructed the same way as the log crib. Diagonal bracing may be used, but is not required.

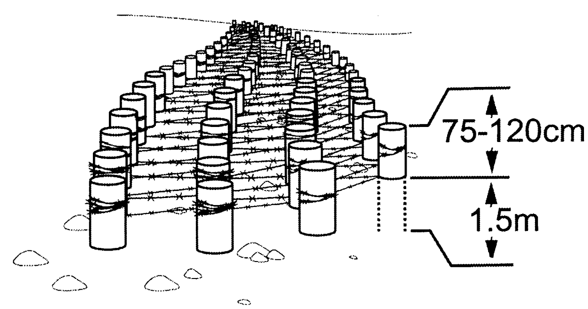
Continued on next page

Post

Log posts are among the best anti-vehicular obstacles because each post presents breaching problems to the attacker. There is no fast, easy way to breech a band of posts. Whenever possible, the attacker will try to bypass this obstacle. It is only effective if bypasses are time consuming or take a great deal of effort on the enemy's part. Log posts are 16-inch diameter hardwood logs.

Construction of a Post

Log posts are buried 5 feet in the ground, either vertically or slightly angled toward the enemy, and protrude from the ground between 30 and 48 inches. The minimum density for posts is 200 posts per 100 meters of front. The spacing is irregular, between 1 to 2 meters. The obstacle is made more effective by weaving barbed wire in zigzag patterns throughout the obstacle band. The illustration below shows log posts.



Placement

Integration

Obstacles are integrated with each other to ensure that probable bypass routes are closed. It does little good to close one avenue of approach if another exists nearby. Log obstacles are more effective when used in bands and when some of the smaller obstacles are used to slow the enemy approach to the larger cribs and walls.

Placement Relative to Each Other

By installing obstacles in bands and providing mutual support, the overall obstacle plan becomes more effective. Log obstacles are only successful when the speed of the enemy is reduced. If heavy-tracked vehicles can maintain enough speed, they can push through a log obstacle. It is also important to remember that part of obstacle placement depends on the weapons that will be supporting the obstacle. Obstacles should always support the defenders' weapons systems and never hinder them. Log obstacles provide opportunities to defenders, where heavy tracked vehicles will expose the belly of the vehicle while traversing over them.

In Depth

Employing obstacles in depth and maximizing the use of existing obstacles affect several key areas:

- Slows down and kills enemy tanks and armored personnel carriers
- Holds the enemy vehicles and personnel in the firing window for direct fire weapons, which maximizes kill opportunities before the enemy is within effective range for employing their weapons
- Gains time for the defenders, while at the same time, disrupting the integrity of enemy formations
- Channelizes the enemy into areas or directions that we want them to go

Drop Standing Timber

Purpose

Standing timber is the source of logs for log obstacles, revetments, survivability positions, and non-standard bridging. Dropping standing timber can be accomplished through mechanical means or demolitions.

Mechanical

While mechanical means covers a wide variety of equipment, for our purposes, it refers to chainsaws and hand tools. When available, heavy equipment is used to fell the trees, but cutting trees into usable logs will still be accomplished through the use of chainsaws (two-man cross-cut saws).

Chainsaw

Dropping standing timber with a chainsaw requires three cuts. The first two cuts are performed to create the directional notch near the base of the tree. The third cut is performed above the notch from the opposite side of the tree that the notch was cut. The third cut should be on a slight downward angle to reduce the possibility that the tree falls in the wrong direction. To drop standing timber, follow the steps below:

Step	Action
1	Identify the tree to be felled.
2	Determine the direction the tree should fall.
3	Ensure the area where the tree is to be felled is clear of personnel and equipment.
4	Cut the notch.
5	Make the final back cut.
6	Let others know when the tree is falling (everyone should be looking at the tree when it falls because trees do not always fall where intended).
7	Limb the tree.
8	Cut the tree into appropriate length logs.

Continued on next page

Illustration

The illustration below shows how to drop standing timber with a chainsaw.

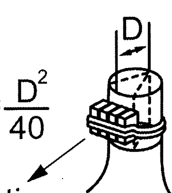
Demolition

The formula and diagram (shown below) for dropping standing timber using explosives is a fairly simple one. The formula is the diameter squared of the tree to be cut, divided by 40 (constant) equals pounds of TNT for the external charge. The diameter is taken for each of the selected trees and the diameter measurement is used for each individual tree. Regardless of the number of trees to be dropped, each tree must be measured and calculated individually.

This is how the formula looks for any given tree:

External Charges

$$P = \frac{D^2}{40}$$



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Drop Standing Timber, Continued

Explosives

Follow the steps below to drop standing timber using explosives:

Step	Action
1	Locate an appropriate tree.
2	Determine the diameter of the tree.
3	Determine the type of charge you intend to use.
4	Complete the calculation for the demolition requirements.
5	Place the demolitions in the proper position to fell the tree.
6	Connect/prime the charges.
7	Connect the initiation device (electric or non-electric).
8	Detonate the explosive.

Lesson 3 Exercise

Directions

Complete exercise items 1 through 4 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

The purpose of log obstacles is to _____ the mobility of the enemy while

a. stop; supporting the tactical plan of the unit commander.
b. reduce; supporting the tactical plan of the unit commander.
c. reduce; providing a friendly avenue of approach.
d. reduce; supporting the fire plan of the regimental commander.

Item 2

What are the four types of log obstacles used in the Marine Corps?

a. Cribs, hurdles, post, and revetment
b. Cribs, hurdles, revetment, and slides
c. Cribs, hurdles, post, and wall
d. Slides, hurdles, post, and revetment

Item 3

When constructing a log crib, dig the holes ___ feet deep using 10-foot posts and 16-foot logs.

a. 4
b. 5
c. 8
d. 10

Item 4

Log obstacles are more effective when used in ______ and when some of the smaller obstacles are used to slow the enemy approach to the larger cribs and walls.

a. bands
b. rows
c. sand
d. hurdles

Continued on next page

Solutions

The table below lists the answers to the exercise items. If you have any questions, refer to the reference page listed for that item.

Item Number	Answer	Reference Page
1	b	3-28
2	c	3-29
3	b	3-31
4	a	3-35

LESSON 4

CRATERS

Introduction

Scope

This lesson describes the process and procedures for creating craters using explosives as countermobility obstacles.

Purpose

The purpose of this lesson is to provide you with the knowledge to create effective craters with explosives for a unit commander to use as countermobility obstacles in their tactical plan.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the three methods of craters.
- Identify the formula for creating relieved face craters.
- Determine the explosive requirements for hasty craters.
- Determine the explosive requirements for deliberate craters.
- Determine the explosive requirements for relieved face craters.

In This Lesson

This lesson contains the following topics:

Background

Introduction

Countermobility is divided into mine warfare and obstacle development, each with the ultimate goal of delaying, stopping, or channelizing the enemy. Craters fall under the obstacle development portion. As a division engineer, you are required to create and recommend the placement of craters in support of unit missions. You must properly calculate and set the explosives for all types of craters. Craters are most effective against vehicles, and when due to a lack of bypass routes, the enemy is forced to breech them. The goal is to create an obstacle that can't be crossed over by tracked vehicles, driven over by wheeled vehicles, or easily breeched by the enemy. To qualify as an antitank obstacle, the resulting crater must force a tank to make a minimum of four attempts to cross the crater before making it across. Those four attempts allow anti-armor weapons time to kill the tank.

Purpose

Craters are used to reduce the mobility of the enemy while supporting the tactical plan of the unit commander. They are integrated with observed fires as well as existing obstacles (natural or manmade) and with other reinforcing obstacles. Done properly, craters can stall an enemy movement. They are difficult to breech, as breeching them requires mechanical assets. The crater by itself is not very effective as a maneuver unit can drive around them. With reinforcing, natural, and manmade obstacles used in combination, they can become very effective. These obstacles can be used to channel the enemy by limiting which roads remain passable, and depending on the method of employment, can create choke points and kill zones against enemy equipment and personnel.

Obstacle Support

For obstacles to be effective, place them to take maximum advantage of existing obstacles, manmade or natural. The crater does this and can be the primary means of blocking travel along a road. The advantage with using craters is the length of a crater is flexible. They can be miles long if they need to be. Time and equipment are usually the deciding factors as to length. When supplemented with mines, direct fire weapons, indirect fire weapons, and reinforcing obstacles, they become very effective obstacles. Obstacles are integrated with each other to ensure that probable bypass routes are closed as well. It does little good to close one avenue of approach if another exists nearby.

Types

Methods

The three methods of craters that are used by the Marine Corps as antitank obstacles are

- Hasty
- Deliberate
- Relieved face

Borehole

In all three methods, the explosives that create the crater are placed in boreholes. A borehole is a hole in the ground with a diameter large enough to accommodate the explosives to be inserted into them. For all craters, they are a minimum of 5-feet deep. Boreholes are created by digging the hole by hand or through the use of shaped charges.

Formulas

There are two formulas for cratering (shown in the table below). The first is used in both hasty and deliberate craters and the second is used for the relieved face crater. The two formulas remain the same and can be used for any cratering situation.

Crater	Formula
Hasty/Deliberate	$N = \frac{L-16}{5} + 1$
Relieved Face	$N = \frac{L-10}{7} + 1$

EXPLANATION

N= Number of boreholes (Round fractional numbers to the next higher whole number.)

L= The desired length of the crater in feet (Measure across the area to be cut and round fractional measurements to the nest higher foot.)

16 (10 for relieved face crater) = Represents the combined blowout on each end of the crater

5 (7 for relieved face crater) = The spacing (in units of feet) between charges

1 = Factor to convert from spaces to boreholes

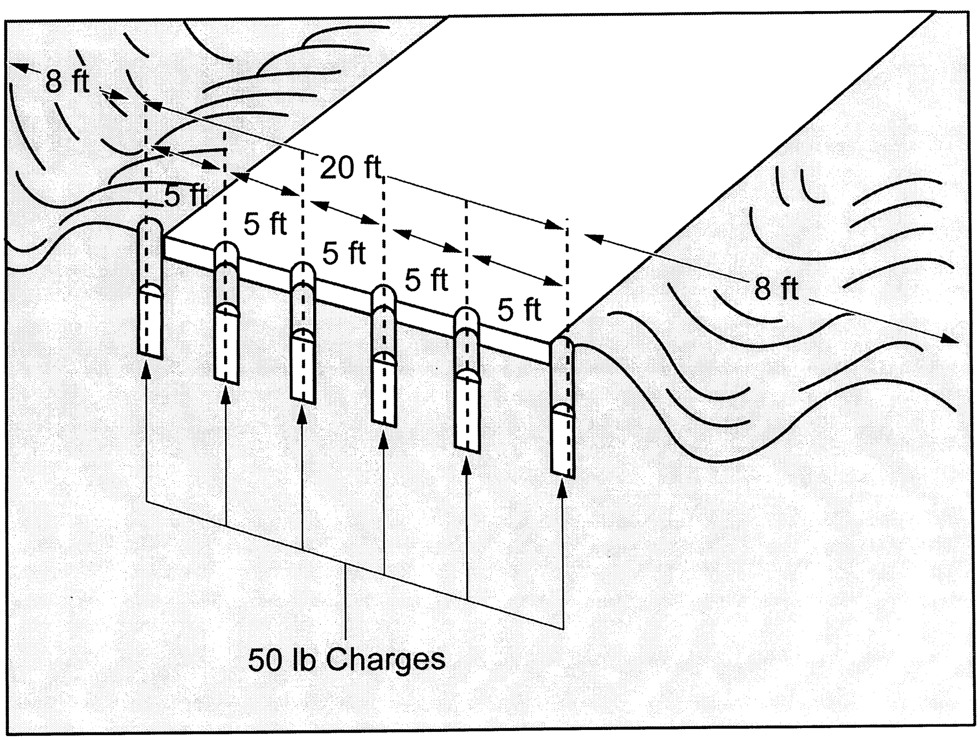
Hasty Craters

Shape and Dimensions

The hasty method takes the least amount of time to construct, based on the number and depth of the boreholes. However, it produces the least effective barrier because of its depth and shape. The hasty crater forms a V-shaped crater about 6 to 7 feet deep and 20 to 25 feet wide that extends about 8 feet beyond the outside boreholes. The sides of the crater have a slope that ranges from 25° to 35°. Modern US tanks require an average of four attempts to breach a hasty crater. To form an effective crater, all boreholes must be a uniform depth. The minimum depth for boreholes is 5 feet. Each borehole must contain a minimum of 50 pounds of explosives.

Procedure

Use the formula, N=L-16, divided by 5 plus 1, to determine the number of boreholes required for the desired crater. Divide by 5 to account for the 5-foot spacing between charges. This means that boreholes are spaced 5 feet on the center starting from the center of the desired crater. Dig or blast boreholes to a uniform depth of 5 feet or deeper. The illustration below shows the layout of a hasty crater.



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Charge Size

The charge size depends on the depth of the boreholes. Boreholes will be loaded with 10 pounds of explosives per 1 foot of depth. When using standard cratering charges, supplement the charges with either TNT or C4 in order to get to the required pounds. A 6-foot hole would require a 40-pound cratering charge and either 20 pounds of TNT or 16 packages of C4 ($1\frac{1}{4}$ pounds per package).

Tamping

All boreholes will be tamped with suitable material. Do not use anything in the tamping material that may cause a misfire, i.e. rocks, rubble, or sharp edged objects.

Firing System

Use a dual firing system on every crater. Initiate either electrically or non-electrically. Dual prime each 40-pound cratering charge.

Challenge

Perform the required calculations for boreholes and required amount of demolitions for a hasty crater based on the following:

The road width is 35 feet, the desired length is 47 feet, and all boreholes will be 7 feet deep. You have 40-pound cratering charges and TNT for use as explosives.

Solution

$N = \frac{47-16}{5} + 1$, which becomes $N = \frac{31}{5} + 1$, which becomes 6.2 + 1

The 6.2 rounds up to 7, so 7 +1 = 8 holes.

Eight holes at 7 feet deep means 8 x 70 (pounds of explosives per hole) = 560 total pounds of explosives. Eight 40-pound cratering charges (one per hole), and 240 pounds of TNT (30 pounds per hole).

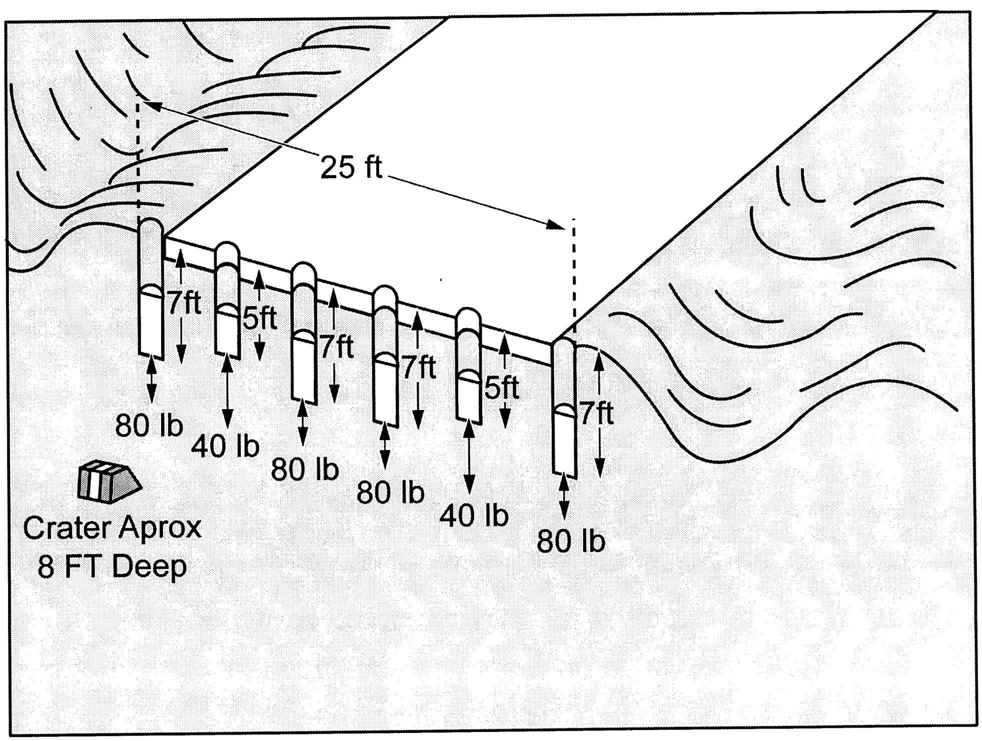
Deliberate Craters

Shape and Dimensions

The deliberate method produces a more effective crater than the hasty method. Modern U.S. tanks require an average of eight attempts to breach a deliberate crater. Placing charges deliberately produces a V-shaped crater, about 7 to 8 feet deep and 25 to 30 feet wide. The sides of the crater have a slope that ranges from 30° to 37°. The crater also extends about 8 feet beyond the end boreholes. This crater requires that boreholes vary in depth, the standard 5-foot hole with some holes being required to be at a depth of 7 feet.

Procedure

Use the formula, N =L-16, divided by 5 plus 1, to determine the number of boreholes required for the desired crater. This means that boreholes are spaced 5 feet on center starting from the center of the desired crater. Dig or blast boreholes to depths of 5 and 7 feet, making the end of the boreholes 7 feet, then alternating from 7 to 5 feet, never placing two 5-foot boreholes next to each other. When there is an even number of holes, place two 7-foot boreholes in the middle. The illustration below shows the layout of a deliberate crater with an even number of holes.



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Charge Size

Place 80 pounds of explosive in each 7-foot hole and 40 pounds in each 5-foot hole.

Tamping

All boreholes will be tamped with suitable material. Do not use anything in the tamping material that may cause a misfire, i.e. rocks, rubble, or sharp edged objects.

Firing System

Use a dual firing system on every crater. Initiate either electrically or non-electrically. Dual prime each 40-pound cratering charge.

Challenge

Perform the calculations for the required boreholes and the required amount of demolitions for a deliberate crater, based on the following:

The road width is 38 feet and the desired crater length is 52 feet. You have 40-pound cratering charges and TNT for use as explosives.

Solution

$N = \frac{52-16}{5} + 1$, which becomes $N = \frac{36}{5} + 1$, which becomes 7.2 + 1

The 7.2 rounds up to 8, so 8 +1 = 9 holes.

A total of nine holes mean 5 holes at 7 feet deep and 4 holes at 5 feet deep. 5 x 80 (pounds of explosives per hole) = 400 pounds of explosives for the 7-foot holes and 4 x 40 = 160 pounds of explosives for the 5-foot holes for a total explosive weight of 560 pounds. Fourteen 40-pound cratering charges (two per 7-foot hole and one per 5-foot hole). The only TNT required is for priming purposes and that is one stick per cratering charge.

Relieved Face Craters

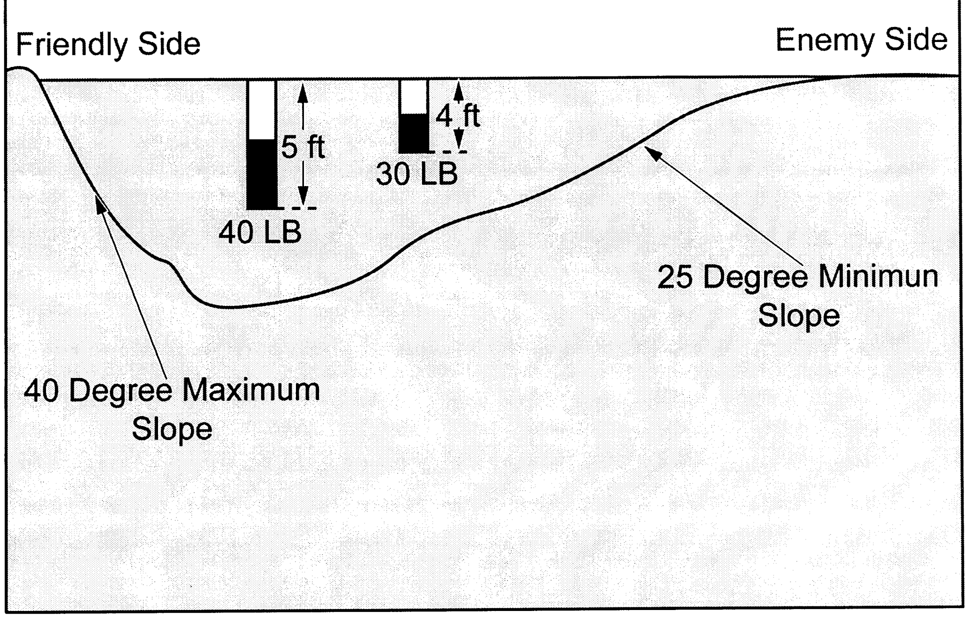
Shape and Dimensions

The relieved face method produces a crater that is more effective than a hasty crater and, depending on the soil, more effective than the deliberate crater. The method produces a trapezoidal-shaped crater about 7 to 8 feet deep and 25 to 30 feet wide with unequal side slopes. The side nearest the enemy slopes is about 25° from the surface to the crater bottom. The opposite (friendly) side slopes from 30° to 40° from the surface to the bottom of the crater. In compact soil, this crater produces greater results than other methods. However, the exact shape and slopes depends on the type of soil.

Procedure

Use the formula, N = L –10 (combined blowout on each end) divided by 7 (distance between holes) plus1, to determine the number of holes for the friendly row. The enemy row is the friendly row minus one. There is spacing between the rows of 8 feet (12 feet for hard surface roads). Stagger the boreholes on the friendly side in relation to the holes on the enemy side. The line closest to the enemy will always contain one less borehole. The boreholes on the friendly side are 5 feet deep and loaded with 40 pounds of explosive. The boreholes on the enemy side are 4 feet deep and loaded with 30 pounds of explosives.

Relieved Face Road Crater



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Charge Size

There are two charge sizes for this crater; 40 pounds per hole for the friendly row and 30 pounds per hole for the enemy row.

Tamping

All boreholes will be tamped with suitable material. Do not use anything in the tamping material that may cause a misfire, i.e. rocks, rubble, or sharp edged objects.

Firing System

Use a dual firing system on every crater. Initiate electrically. Dual prime each 30 and 40-pound cratering charge.

Detonation Delay

There must be a 0.5 to 1.5 second delay in detonation between the two rows of boreholes. Detonate the row on the enemy side first. Then fire the row on the friendly side while the earth from the enemy side detonation is still in the air.

Challenge

Perform the required calculations for boreholes and the required amount of demolitions for a relieved face crater based on the following:

The road width is 42 feet and the desired crater length is 56 feet. You have 40-pound cratering charges and TNT for use as explosives.

Solution

$N = \frac{56-10}{7} + 1$, which becomes $N = \frac{46}{7} + 1$, which becomes 6.5 + 1

The 6.5 rounds up to 7, so 7 +1 = 8 holes in the friendly row. Since the friendly row has 8 boreholes, the enemy row will have 7, totaling 15 boreholes.

Eight holes are 5 feet deep and 7 holes are 4 feet deep. 8 x 40 (pounds of explosives per hole) = 320 pounds of explosives for the friendly row of holes, and 7 x 30 = 210 pounds of explosives for the enemy row of holes, totaling 530 pounds of explosive weight. Eight 40-pound cratering charges (one per friendly hole). The 210 pounds of TNT required is for the enemy row of holes.

Lesson 4 Exercise

Directions

Complete exercise items 1 through 5 by performing the action required. Check your answers against those listed at the end of the lesson.

Item 1

What are the three methods of craters?

a. Relieved face, deliberate, and hostile
b. Hasty, relieved face, and deliberate
c. Relieved face, V-shaped, and hostile
d. V-shaped, relieved face, and deliberate

Item 2

What is the formula for creating relieved face crater?

a. $N = \frac{L-16}{7} + 1$
b. $N = \frac{L-10}{5} + 1$
c. $N = \frac{L-16}{5} + 1$
d. $N = \frac{L-10}{7} + 1$

Item 3

What are the required calculations for boreholes and required amount of demolitions for a hasty crater based on the following information?

The road width is 42 feet and the desired crater length is 56 feet. The boreholes are 6 feet deep. You have 40-pound cratering charges and TNT for use as explosives.

a. Eight 40-pound cratering charges and 160 pounds of TNT
b. Sixteen 40-pound cratering charges and 60 pounds of TNT
c. Eight 40-pound cratering charges and 480 pounds of TNT
d. Six 40-pound cratering charges and 480 pounds of TNT

Continued on next page

Item 4

What are the total explosive requirements for a deliberate crater based on the following information?

The road width is 42 feet and the desired crater length is 45 feet. You have 40-pound cratering charges and TNT for use as explosives.

a. Eleven 40-pound cratering charge
b. Eight 40-pound cratering charge
c. Sixteen 40-pound cratering charge and 90 pounds of TNT
d. Six 40-pound cratering charge and 100 pounds of TNT

Item 5

What are the total explosive requirements for a relieved face crater based on the following information?

The road width is 42 feet and the desired crater length is 66 feet. The boreholes are 6 feet deep. You have 40-pound cratering charges and TNT for use as explosives.

a. Eight 40-pound cratering charges and 140 pounds of TNT
b. Eight 40-pound cratering charges and 240 pounds of TNT
c. Nine 40-pound cratering charges and 140 pounds of TNT
d. Nine 40-pound cratering charges and 240 pounds of TNT

Continued on next page

Solutions

The table below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page.

Item Number	Answer	Reference
1	b	3-43
2	d	3-43
3	a	3-44
4	a	3-46
5	d	3-48

LESSON 5

BOOBYTRAPS

Introduction

Scope

This lesson describes the process and procedures for constructing boobytraps to delay tactics and countermobility obstacles.

Purpose

The purpose of this lesson is to provide you with the knowledge to construct effective boobytraps for a unit commander to utilize them in the tactical plan.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the two types of boobytraps.
- Identify the effects of using boobytraps on the enemy.
- Identify the steps for installing boobytraps.
- Identify various firing devices.
- Determine the three areas that are effective placements for boobytraps in buildings.

In This Lesson

This lesson contains the following topics:

Principles

Definition

A boobytrap is an explosive charge or other device cunningly constructed to activate by an unsuspecting person who disturbs an apparently harmless object or performs a presumably safe act.

Types

There are two types of boobytraps:

- Improvised
- Manufactured

Improvised

Improvised boobytraps are assembled from specially provided material or constructed from material generally used for other purposes.

Manufactured

Manufactured bobbytraps are devices made at a factory for issue to troops. They usually imitate some object or article that has souvenir appeal or that may be used by the target to advantage.

Assembly

An explosive boobytrap consists of a main charge, a firing device, a standard base (not required), and a detonator.

Rules of Thumb

There are three rules of thumb for boobytraps. They must be

- Simple in construction
- Easily disguised
- Deadly

Resources

There are numerous resources for boobytraps, i.e. abandoned explosives and bombs, captured explosives, artillery, and mortars. There is also a universal destruction adapter that will allow for installing a firing device in many of these items.

Tactical Uses

Effects

Making presumably safe acts potentially deadly boobytraps have several effects against the enemy.

- Supplements minefields by increasing their obstacle value
- Adds to the confusion and discomfort of the enemy
- Inflicts casualties to personnel and destroys equipment
- Lowers the morale of enemy combatants while raising stress levels

During a Withdrawal

During a withdrawal, boobytraps may be employed the same way as nuisance mines. There are many locations that are suitable for employing boobytraps. Buildings and other forms of shelter are good locations, as the enemy will likely try to take advantage of available shelter. When there is a commonly used diversion around an existing obstacle, that is a good place for boobytraps. Other locations are along roads and paths and near roadblocks. Bridges and the fords near the bridges are both suitable areas to employ boobytraps.

In the Defense

While in the defense, boobytraps placed in the path of the enemy at strategic locations and in sufficient numbers can slow the enemy's progress. Some advantages exist when boobytraps are used in the defense. Detailed reconnaissance by the enemy becomes very difficult if not impossible. The enemy assault is delayed when they have to disarm mines, and then remove mines. Having boobytraps in place may also serve as an early warning system against attack, when the enemy finds the first one.

Installation

Considerations

All activities involving explosives, including boobytrapping are dangerous. The danger normally comes from mistakes or inattention to detail made by the Marine emplacing them. In the interest of personal safety and effectiveness of the mission, certain procedures must be adhered to.

Common Procedures

The following procedures are common to working with explosives and boobytraps:

- Inspect all components for serviceability before using.
- Ensure components are in good working order prior to use.
- Check all safeties and triggering devices for proper action, rust, or dents.
- Plan a boobytraped plan when being employed. If one is not available, prepare one on arrival to the site so that the material obtained will be required items only.
- Ensure the responsibility is divided into two areas: one Marine does the technical work and the other Marine carries and maintains the supplies.

Boobytrap

The installation for boobytraps is a six-step process.

Step	Action
1	Select a site that will produce the best effect when activated.
2	Lay the charge and protect/conceal it.
3	Anchor the boobytrap securely with nails, wire, rope, or wedges if necessary.
4	Camouflage or conceal, as required.
5	While working toward a safe area, arm the boobytraps systematically.
6	Leave boobytrapped area clean. Carry away all items that might betray the work that has been done such as loose dirt, empty boxes, tape, broken vegetation, and footprints.

Firing Devices

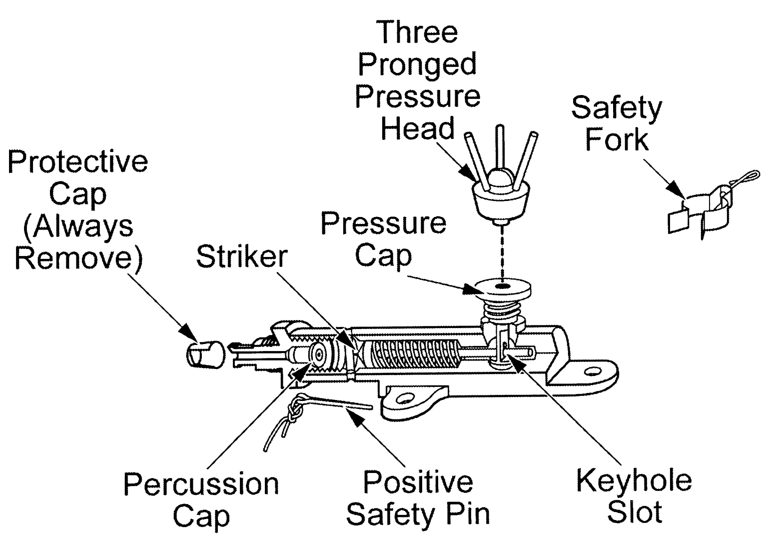
Methods

When dealing with boobytraps, the equipment involved is mainly the firing device. Firing devices come in a variety of styles and have different methods for activation. The different methods are

- Pressure (pressure applied to the trigger mechanism)
- Pull (pressure applied to a wire, pulling a release pin)
- Tension release (a release of pre-applied tension activates the trigger mechanism)
- Pressure release
- Delay
- Multipurpose

M1A1 Pressure

The M1A1 (shown below) is a pressure activated firing device. When pressure is applied directly to the trigger head or transmitted via the three-pronged pressure head, the device is triggered. The required pressure to fire this device is 20 pounds. When applied, the trigger head compresses the striker release pin spring and pushes the release pin inward. The spring-loaded firing pin then fires the prime and standard base. Its accessories include the three-pronged pressure head and an extension rod. There are two safeties, a safety fork and a positive safety pin.



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Arming M1A1

Follow the steps for arming the M1A1 firing device:

Step	Action
1	Remove the protective cap from standard base and mate the base to the firing device. Crimp a non-electric blasting cap to standard base.
2	Install the firing device with coupling to explosive charge.
3	Screw the three-pronged pressure head into the top trigger head (if desired). Use an extension rod when required.
4	Remove the safety fork. Note: If a metallic click is heard, do not remove the positive safety pin. Remove the firing device from the charge.
5	Remove the positive safety pin.
6	Camouflage the mine and firing device, leaving the three-pronged pressure head above ground.

Disarming M1A1

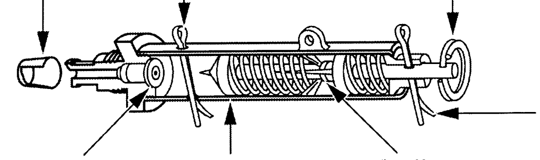
Follow the steps below to disarm the M1A1 firing device:

Step	Action
1	Carefully uncover the explosive charge.
2	Replace the positive safety pin. Replace the safety fork.
3	Disassemble the firing device.

Continued on next page

M1 Pull

The M1 pull firing device (shown below) is a pull-activated device. When a pull of 3 to 5 pounds is applied to a properly anchored trip wire, the tapered end of the release pin is withdrawn from the split head of the striker. This frees the striker to fire the percussion cap and initiate the detonation. The M1 also comes with two safeties, the locking safety and the positive safety.



Arming M1 Pull

Follow the steps below to arm the M1 pull firing device:

Step	Action
1	Remove the protective cap from standard base of firing device. Crimp a non-electric blasting cap to the standard base.
2	Attach the firing device to explosive charge.
3	Remove the locking safety pin. <u>Note</u>: If a metallic click is heard, do not remove the positive safety pin. Remove the firing device from the charge.
4	Remove the positive safety pin.

Disarming M1 Pull

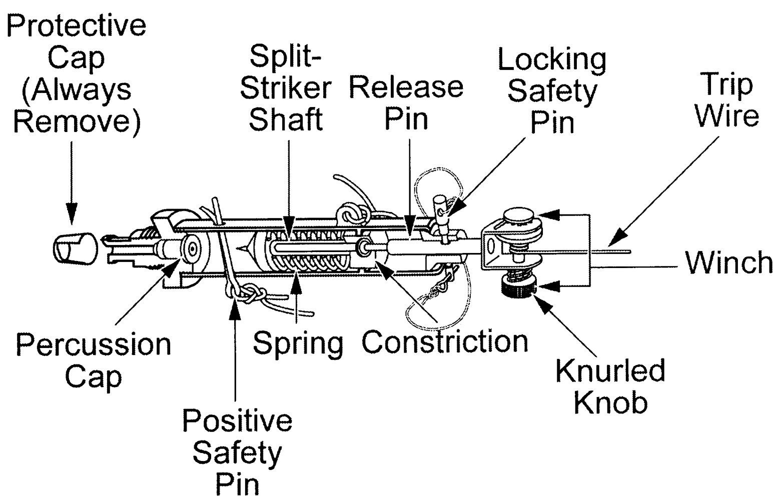
Follow the steps below to disarm an M1 pull firing device:

Step	Action
1	Carefully uncover the explosive charge.
2	Replace the positive safety pin.
3	Cut all loose trip wires.
4	Replace the locking safety pin.
5	Cut all remaining trip wires.

Continued on next page

M3 Pull/Tension-Release

The M3 pull/tension-release firing device (shown below) can be activated in two ways. The first is through 6 to 10 pounds of pull, and the second is through the release of tension from a tension wire. This device has two safeties, the locking safety pin and the positive safety pin.



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Arming M3 Pull/Tension-Release

Follow the steps below to arm the M3 pull/tension-release firing device:

Step	Action
1	Remove the protective cap from the standard base. Crimp a non-electric cap to the standard base.
2	Attach the firing device to the explosive charge.
3	Secure the charge to an object that is anchored well enough to withstand a pull weight of a minimum of 10 pounds.
4	Attach one end of the trip wire to an anchor point and the other end to the winch on the firing device.
5	Using the knurled knob, draw the trip wire taut until the locking pin is pulled into the wide portion of the safety pin hole.
6	Remove the small cotter pin.
7	Remove the locking safety pin.
8	Remove the positive safety pin. Note: If a metallic click is heard, do not remove the positive safety pin. Remove the firing device from the charge.
9	Camouflage the explosive charge.

Disarming M3 Pull/Tension-Release

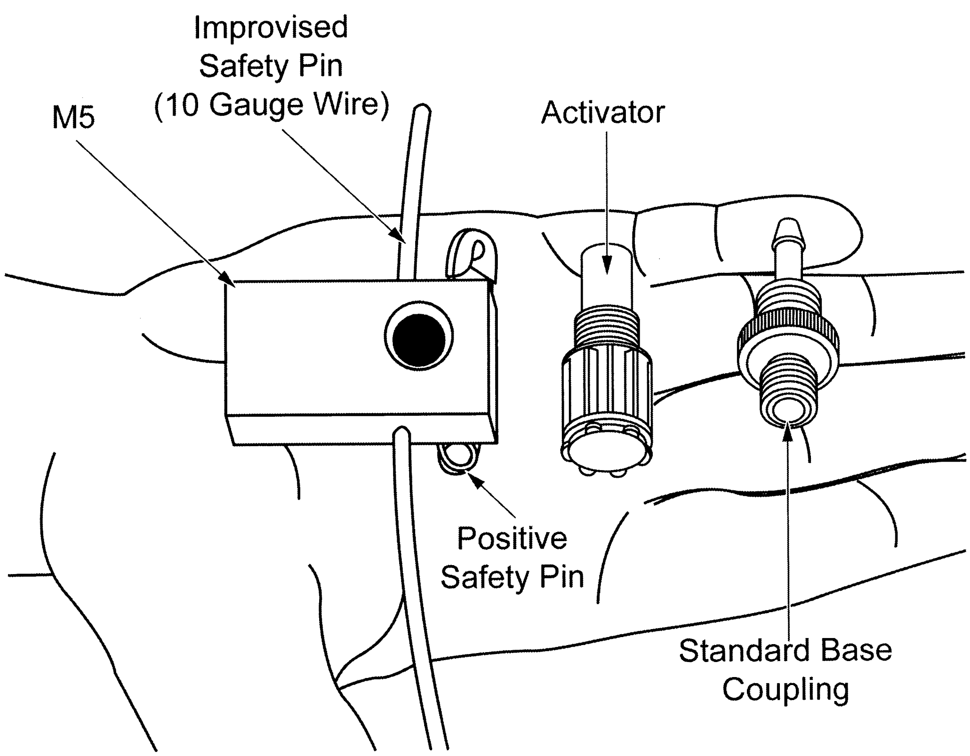
Follow the steps below to disarm the M3 pull/tension-release firing device.

Step	Action
1	Carefully uncover the explosive device.
2	Replace the positive safety pin.
3	Replace the locking safety pin.
4	Check both ends of the tripwire before cutting.

Continued on next page

M5 Pressure Release

The M5 pressure-release firing device (shown below) is activated when the pressure that is keeping the device closed is released. The M5 is also known as the "mouse trap" as the mechanism works similar to a standard mousetrap when sprung. Lifting or removing a restraining weight of at least 5 pounds releases the striker to fire the cap. The M5 comes with one safety, the locking safety pin and a hole with an intermediate or improvised positive safety pin.



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Arming M5 Pressure Release

Follow the steps below to arm the M5 pressure-release firing device:

Step	Action
1	Dig a hole deep enough to bury the explosive device.
2	Remove the protective cap from standard base. Crimp a non-electric cap to the standard base.
3	Using an 8 to 10 gauge wire or nail as a positive safety pin, place the explosive device in the hole leaving enough room to remove the pins. Note: Ensure that the explosive and the firing device are resting on a firm foundation before removing pins.
4	Remove the locking safety pin. Note: If a metallic click is heard, do not remove the positive safety pin. Remove the firing device from the charge.
5	Remove the positive safety pin (interceptor pin).
6	Completely cover the explosive charge, tamping around the explosive.
7	Camouflage the charge.

Disarming M5 Pressure Release

Follow the steps below to disarm the M5 pressure-release firing device:

Step	Action
1	Carefully uncover the explosives and inspect for tampering.
2	Locate and carefully uncover the firing device.
3	Insert a safety pin (8 to 10 gauge wire) into the interceptor hole, then into the safety pin hole.
4	Remove the mine and recover the firing device.

Continued on next page

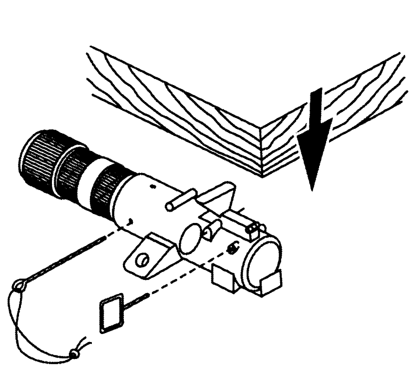
M142 Multipurpose

The M142 multipurpose firing device can be activated through four different arming modes:

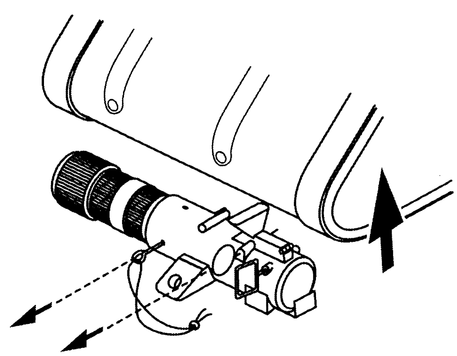
- Pressure
- Pull
- Pressure release
- Tension release

Arming Modes

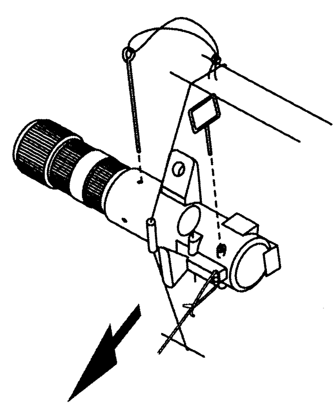
The illustration below shows the different arming modes of the M142.



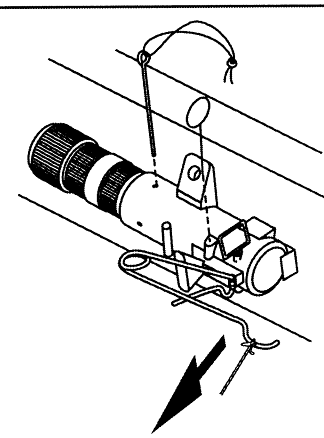
Pressure Mode (25 Lbs)



Pressure Release Mode
2 Or More Lbs



Pull Mode 7 Or More Lbs



Tension Release Mode
2 Or More Lbs

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Pressure Mode

Follow the steps below to arm the M142 firing device in pressure mode:

Step	Action
1	Check the safety pin for ease of removal.
2	Secure the switch in position with nails, screws, or wire.
3	Remove the protective cap from standard base. Crimp a non-electric cap to the standard base.
4	Place a suitable pressure plate on the pressure switch (ensure the plate is not heavy enough to activate the mechanism).
5	Remove the pin with the square head using a wire if necessary.
6	Withdraw the safety pin using a wire if necessary. If the safety pin resists movement, do not withdraw. Recheck the setting.

Pull Mode

Follow the steps below to arm the M142 firing device in pull mode:

Step	Action
1	Check the safety pin for ease of removal.
2	Secure the switch to a fixed object using either nails, screws, or wire.
3	Remove the protective cap from standard base. Crimp a non-electric cap to the standard base.
4	Attach the tripwire to the hole so that it pulls in the direction indicated by the arrow.
5	Remove the pin with the square head.
6	Withdraw the safety pin from a safe distance using a wire if necessary. If the safety pin resists movement, do not withdraw. Recheck the setting.

Continued on next page

Pressure Release Mode

Follow the steps below to arm the M142 firing device in pressure release mode:

Step	Action
1	Check the safety pin for ease of removal.
2	Place the switch in position and secure with either the nails, screws, or wire.
3	Remove the protective cap from the standard base. Crimp a non-electric cap to the standard base.
4	Place an object so that it rests on the pressure switch (requires 2 or more pounds to set, but less than 150 pounds).
5	Remove the pin with the round head, using a wire if necessary.
6	Withdraw the safety pin from a safe distance using a wire if necessary. If the safety pin resists movement, do not withdraw. Recheck the setting. Note: Remove the round head for release.

Tension Release Mode

Follow the steps below to arm the M142 firing device in tension release mode:

Step	Action
1	Check the safety pin for ease of removal.
2	Secure the switch to a fixed object using either the nails, screws, or wire.
3	Remove the protective cap from the standard base. Crimp a non-electric cap to the standard base.
4	Fit the tension release device and loop the end of the wire over the curved neck. Adjust the tension in tripwire until the flat portion of the device is even with the top of the upright arm on the device. Make sure the pull is in the direction shown in the illustration shown previously.
5	Remove the pin with the round head using a wire if necessary.
6	Withdraw the safety pin from a safe distance using a wire if necessary. If the safety pin resists movement, do not withdraw. Recheck the setting. Note: Remove the round head for release.

Continued on next page

Disarming the Four Modes

Follow the steps below to disarm all four modes of the M142:

Step	Action
1	Determine the mode of operation.
2	Determine what fires the charge blasting cap, activator, or time fuse.
3	Proceed based on the following: <table><tr><th>Firer</th><th>Mode</th><th>Steps</th></tr><tr><td>Blasting cap or activator</td><td>Tension release</td><td>4</td></tr><tr><td>Blasting cap or activator</td><td>Pressure, Pull, Pressure release</td><td>6 to 14</td></tr><tr><td>Time Fuse</td><td>All modes</td><td>5 to 14</td></tr></table>
4	Destroy in place or notify Explosive Ordinance Disposal (EOD).
5	Cut the time fuse.
6	Insert the nail, wire, or safety pin through positive safety hole.
7	Insert the round head pin (if not in place).
8	Insert the square head pin (if not in place).
9	Ensure the positive safety pin, round headed pin, and square headed pin are in place before continuing.
10	If disarming on the mine, place mine arming dial to safe.
11	Cut the tripwire or release pressure.
12	Unscrew the coupling base or standard base.
13	Remove the firer from the charge. **WARNING**: Do not remove blasting cap from base.
14	Restore the mechanism to shipping configuration.

Placement

General

The effectiveness of boobytraps is directly related to their placement. If they are placed where the enemy can bypass them or does not encounter them, they are ineffective. The situation and mission will dictate what boobytraps are used and where they are placed. For a mechanized enemy, roads are effective. If the enemy is moving on foot and occupying/clearing buildings, then placement inside the buildings is more appropriate.

Buildings

Boobytrapping buildings is effective since they provide comfort and shelter from the elements for the enemy combatants. The following table explains some of the key areas where boobytraps are most effective.

Placement	Areas
Immediate Surroundings	Out buildings, woodpiles, wells/water points, fences with gates, and walkways are all likely to be high traffic areas and will increase casualty potential.
Entrances	Curiosity prompts soldiers to investigate interesting buildings in their path, sometimes hurriedly. By rushing to be the first to get inside, they make the entrances excellent places to install boobytraps.
Basement Windows	Boobytraps are concealed to prevent detection if the enemy kicks out the pane or door panel. Therefore, windows are boobytrapped at the top or in the floor underneath.
Other Windows	These charges are concealed behind the jam or under the floor, but they must be concealed to be effective.
Structural Framework	Charges are placed where detonation will seriously damage the structural integrity of a building, i.e., load bearing walls, chimneys, beams, and columns.
Interior Furnishings	Vacated buildings provide many opportunities for boobytraps. Anything that can be moved, sat/stepped on, opened, or closed can be boobytrapped. Some of those items include desks, filing cases, cooking utensils, rugs, lamps, and valuables.

Continued on next page

Roads

To effectively boobytrap roads and paths, there cannot be any readily available bypasses in the area. Placing boobytraps on roads, highways, and paths are an effective way to slow down an enemy. The charges are concealed on the enemy side or underground, or placed under heavy obstructions. Some of the charges that may be used include grenades, bounding antipersonnel mines with trip wires, ordinary explosive charges (with expedient projectiles, i.e. nails, gravel, wire, or scrap metal), and anti-vehicular mines.

Dummies

The use of dummy mines or boobytraps is an effective maneuver only if there are real boobytraps mixed in. When a boobytrap is found, the enemy has to treat them as real, even the dummies, until they clear them. This takes just as much time as clearing a real one, making dummies an effective addition to boobytrapping.

Lesson 5 Exercise

Directions

Complete exercise items 1 through 5 by performing the action required. Check your answers against those listed at the end of the lesson.

Item 1

What are the two types of boobytraps?

a. Improved and manufactured
b. Improvised and manufactured
c. Improvised and manipulated
d. Improved and manipulated

Item 2

What effects does the boobytraps have on the enemy?

a. Destruction of the enemy while inflicting hate and discontent and lowering the morale of enemy leaders
b. Confusion and discomfort of the enemy while destroying the morale of enemy combatants and raising stress levels in enemy medical personnel
c. Confusion and discomfort of the enemy medical personnel while inflicting personnel and equipment to lower morale of enemy combatants
d. Confusion and discomfort of the enemy while inflicting casualties to personnel and equipment, lowering the morale of enemy combatants, and raising stress levels

Item 3

What is the first step for installing boobytraps?

a. Select a site that will produce the best effect when activated.
b. Lay the charge and protect/conceal it.
c. Camouflage or conceal, as required.
d. Work toward a safe area and arm the boobytraps systematically.

Item 4

Which of the following is the multipurpose firing device?

a. M5
b. M142
c. M1
d. M3

Continued on next page

Item 5

What three areas are effective placements for boobytraps in buildings?

a. Entrance, windows, and light
b. Entrance, lights, and immediate surroundings
c. Floors, windows, and immediate surroundings
d. Entrance, windows, and immediate surroundings

Continued on next page

Lesson 5 Exercise, Continued

Solutions

The table below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page.

Item Number	Answer	Reference Page
1	b	3-54
2	d	3-55
3	a	3-56
4	b	3-64
5	d	3-68

STUDY UNIT 4

MOBILITY

Overview

Scope

This study unit covers the skills and knowledge for implementing mobility operations as they pertain to the combat engineer serving with a Marine division.

Purpose

The purpose of this study unit is to provide you with the skills and knowledge necessary to successfully implement, construct, and advise superiors on mobility issues.

In This Study Unit

This study unit contains the following lessons:

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LESSON 1

BREACH NONEXPLOSIVE OBSTACLES

Introduction

Scope

This lesson describes the process and procedures for the destruction and reduction on nonexplosive obstacles as it pertains to mobility of maneuver elements.

Purpose

The purpose of this lesson is to provide you with the knowledge to effectively destroy nonexplosive obstacles for a unit commander to execute their tactical plans.

Learning Objectives

At the end of this lesson, you should be able to

- Identify complex obstacles.
- Identify the stages in breaching fundamentals.
- Describe the five areas that make up a breaching organization.
- Identify the four types of breaching operations.
- Identify the ways to breach an antitank ditch nonexplosive obstacle.

Continued on next page

Introduction, Continued

In This Lesson This lesson contains the following topics:

Complex Obstacles

Definition

A complex obstacle is a combination of single explosive and/or nonexplosive obstacles.

Combination

By combining single obstacles to form complex obstacles, the difficulty level for breaching is raised considerably. Complex obstacles are a much more formidable obstacle and can be combined to create a complex obstacle system.

Systems

Complex obstacle systems usually combine the use of mines along with nonexplosive obstacles such as wire and antitank ditches. The result is a belt of obstacles, which can be duplicated in depth to present an even greater obstacle system.

Integration

Where possible, the enemy will integrate these obstacles with natural obstacles like, wet or dry gaps, wooded areas, wetlands, or steep grades. Manmade obstacles will also be integrated, i.e. buildings, canals, or bridges. Integration expands to include the fire plan and supporting arms fire. Prepared fire plans allow for the enemy to concentrate fires on a specific pre-designated area in minutes. These fires can be rapidly adjusted to cover breach sites and will also be designated to cover bypass areas to create kill zones.

Combined Arms

The use of combined arms is critical to the success of breaching. Breaching a complex obstacle system uses all combat support assets available to the ground combat element (GCE). Successful accomplishment will be contingent upon the degree of preparation, planning, and rehearsal accomplished before the operation.

Continued on next page

Terminology

The following terms are unique to breaching operations:

Term	Definition
Breaching Actions	Actions taken on the chance of obstacle contact to include, planning, coordinating, and execution of breaching operations.
Bulling Through	This is not a breach. It is a desperate act taken to extricate oneself from the combined grip of an obstacle and/or decisive engagement. This is a sure sign that something went wrong and it is never a consideration during planning.
Bypass	Alternate route that avoids the obstacle.
Obstacle Reduction	Makes a lane or finds a path through an obstacle that allows friendly forces and equipment to advance through said obstacle.
Proofing	Verifies that a lane is free of mines/booby-traps. Proofing is based on the commanders' acceptable risk and is completed as part of the obstacle reduction process.

Fundamentals

Stages

There are five fundamental stages when breaching nonexplosive obstacles.

- Suppress
- Obscure
- Secure
- Reduce
- Resupply

Suppress

Suppression is the focus of all available fires on enemy personnel, weapons, or equipment to prevent effective fire or observation of fires on friendly forces. Suppressing fires include direct fire weapons, indirect fire weapons electronic countermeasures (ECM), air support, and Naval gunfire. The whole purpose of suppression is to protect the friendly forces that are reducing and maneuvering through the enemy obstacle belts. Effective suppression is the mission-critical task during any opposed breaching operation, and is generally the trigger for the rest of the obstacle reduction process.

Obscure

Obscuration hampers enemy observation and target acquisition and conceals friendly activities and movement. Planning and placing obscurities on or near the enemy blurs their vision. Screening smoke employed between the enemy and the breaching site conceals movement and obstacle breaching activities from the enemy. It also degrades aerial observation. Obscuration must be employed to protect obstacle reduction, passage of assault forces, and deployment of forces in assault formations.

Secure

The force secures the breaching operation site to prevent the enemy from interfering with obstacle reduction and passage of the assault force through the lanes created during the reduction. Security must be effective against outpost and fighting positions near the obstacle and against over-watching units and counterattack forces. Basically, enemy tactical obstacles are secured by force.

Continued on next page

Reduce

Reduction is the creation of lanes through or over the obstacle, which allows the assault force to pass. The number and width of the lanes created varies with the situation and type of breaching operation. Widen the lanes to allow the assault force to cross rapidly and accomplish the mission. Hand over the lanes to follow on forces to be improved as necessary. Reduction cannot be accomplished without the previous areas being accomplished. If there is no reduction, obscuration, or security, the reduction of an obstacle cannot be done.

Resupply

Breaching operations are logistic intensive in nature. The class V that is used for reducing the obstacles is not reusable once it detonates. If assets go down or are destroyed, replace them or the mission may fail. Class V that needs to be resupplied includes demolitions, line charges, smoke (artillery and mortar), small arms, and standard artillery and mortar rounds. Equipment that is subject to loss includes mine detectors, mine rollers, mine plows, or an ACE. All equipment should be staged for rapid replacement as required during and after a breach.

Organization

Areas

The five areas that make up an organization of a breach are

- Support Force
- Breach Force
- Assault Force
- Follow on Force
- Breaching assets

Support Force

The support force consists of the combat and combat support elements. The support force includes the following units that provide support to the breaching force:

- Artillery
- Mortars
- Direct fire
- ECM
- Close air support

The mission of the support force is to prohibit the enemy from influencing the breaching operation. Winning the direct and indirect fire battles will accomplish this. The reserve breaching and assault assets are included in this force and must be prepared to fulfill the mission.

Breach Force

The breach force is the focus of effort during breaching operations. The primary mission is to maneuver to and make the breaches at selected breach sites. The breach force remains in trace of the assault force until an obstacle is reached. They then move forward and reduce the obstacle. During the reduction of an obstacle, the lanes are made, proofed, marked, and maintained until the assault force is through and the breach force again moves forward or is relieved by follow on forces. This force is made up of engineers, tanks, amphibious assault vehicles (AAVs), and infantry.

Assault Force

The assault force consists of infantry, tanks, AAVs, and engineers. Their primary responsibility is to provide close in securing for the breach force, exploit gaps in the obstacle by maneuvering through the lanes (once created), deploy into attack formation, and defeat the enemy while securing the enemy side of the obstacle.

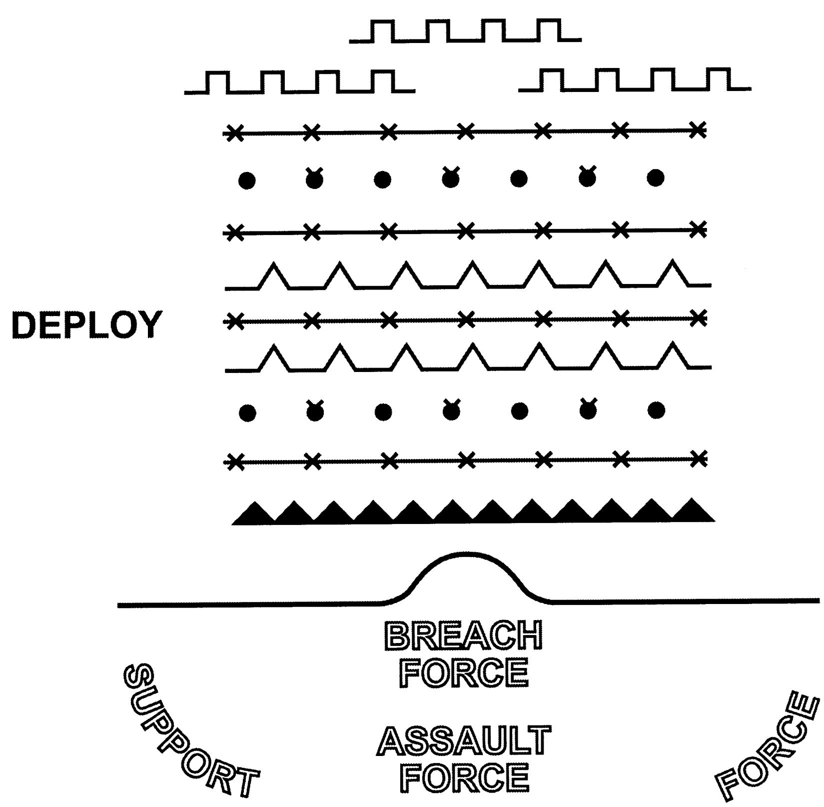
Continued on next page

Follow on Force

The follow on force is responsible for adding more lanes, improving existing lanes, and improving the marking system. This is usually done with a full width mine plow and a D8 bulldozer. They will have additional breaching assets in the event an obstacle was not reduced or they will reduce it to an improved state.

Before the Breach

The illustration below shows the organization before the breach.



Breaching Assets

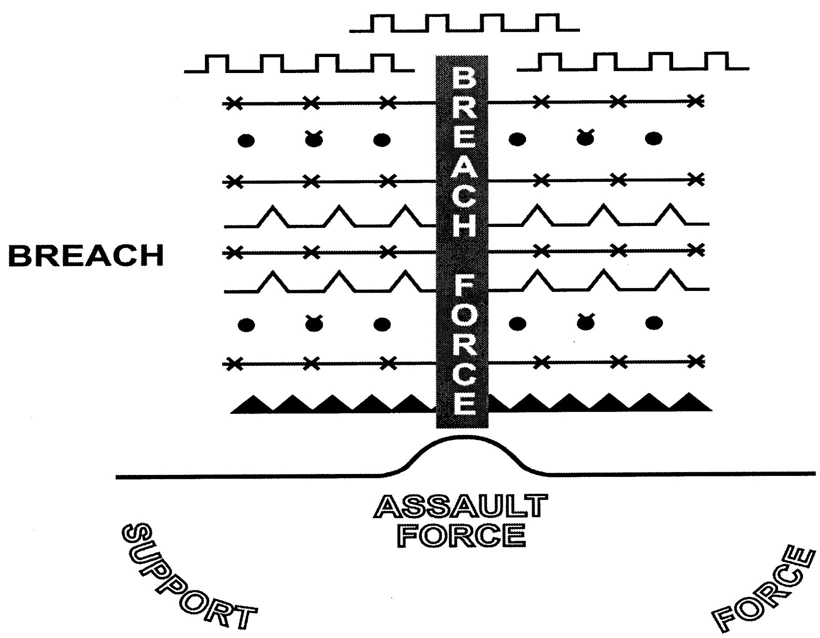
There are breaching assets attached to or owned by all the forces i.e. assault, breach, and support. The specific types and quantities are dependent upon the situation. There should be a minimum of 50 percent redundancy, ideally 75 to 100 percent for all three forces.

Continued on next page

Organization, Continued

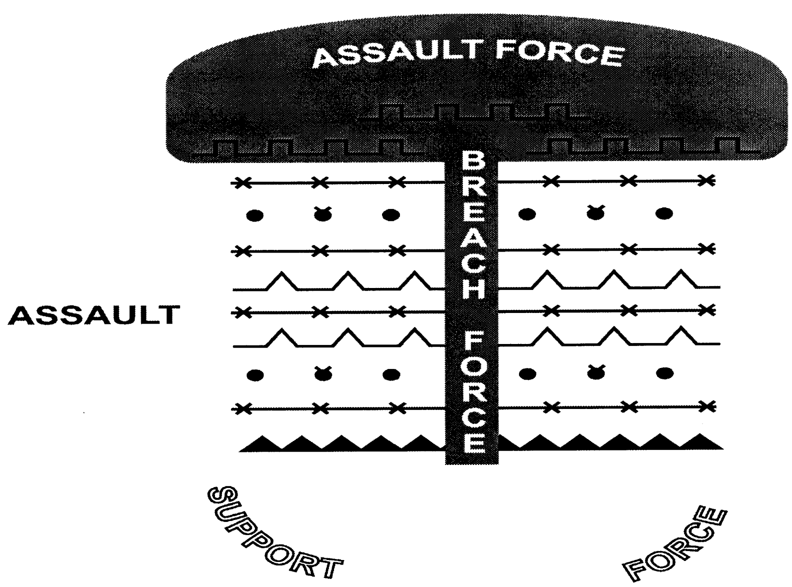
During the Breach

The illustration below shows the organization during the breach.



After the Breach

The illustration below shows the organization after the breach.



Breaching Operations

Types

There are four types of breaching operations:

- Hasty/in-stride
- Deliberate
- Assault
- Covert

Determine Which Breach to Use

Each breaching operation is effective and will complete the mission, but the type that is used is totally mission dependant. The things that will determine which breach is used are

- Time
- Equipment
- Mission
- Personnel
- Class V

Hasty/In-stride

The in-stride brief is conducted without the loss of momentum over simple obstacles. The actual brief itself is conducted on the subordinate level. This does not mean that the breach is not planned out. It must be synchronized with support and follow forces just like any other breach. By the subordinate level conducting the brief, there is no reassignment/realignment of personnel and equipment. These breaches allow us to seize and maintain the initiative through simple, decentralized, independent breaching operation conducted under the responsible commander's command and control.

Deliberate

A deliberate breach is conducted specifically when a unit must cross an obstacle to continue the mission to another objective. It can also be conducted after the failure of an in-stride breach. The reduction of the obstacles normally falls to the engineer-heavy breach force. It masses reduction efforts, attempting a large number of lanes at the same time to overload the enemy defensive fire.

Continued on next page

Assault

An assault breach is conducted when a subordinate unit has been assigned the mission of assaulting an enemy's defense as part of a larger force's action, or when the enemy has had time to prepare protective obstacles around or within its position. Extensive protective obstacles will include combination of wire, antipersonnel mines, antitank mines, fortification, and entrenchments. They will be covered by interlocking fires, small arms fire, and close range anti-armor weapons. This is characterized as the most dangerous and confusing phase of the attack.

Covert

A covert breach is used by dismounted forces during limited visibility, and is executed as silently as possible to achieve surprise and minimize casualties. This breach relies on stealth, which is accomplished through quiet manual reduction techniques and dismounted maneuver. This allows the assault force to bypass an enemy obstacle, or attack at an unexpected place. While suppression is planned for, it remains on order so it can be used if the covert breach is discovered.

Nonexplosive Obstacles

Antitank Ditches

There are a variety of methods to breach an antitank ditch.

- Towed assault bridge
- Armored vehicle launched bridge
- Fascines
- Armored combat earthmover
- Bulldozer

With the exception of the bulldozer, all of these breaching methods can be used in an assault breach.

Towed Assault Bridge

The towed assault bridge (TAB) is a 12-meter long bridge designed to tow or push across manmade ditches or escarpments. The TAB is a class 70 bridge. It effectively breaches ditches from 3 to 10 meters in width with escarpments of up to 5 meters in height. This bridge can be put in place in 30 to 60 seconds. Even if it loses 50 percent of its girders, it will retain its class 70 rating.

Armored Vehicle Launched Bridge

The armored vehicle launched bridge (AVLB) is designed to cross natural gaps or bridges that have been destroyed with a gap of up to 17 meters. This is a scissor type of bridge that can be launched by a two-man crew in under 5 minutes. The AVLB is not designed for crossing tank ditches or any other gap that has escarpments, but it could be used as a last resort. It is a class 60 bridge so tanks with rollers or plows could exceed the limit. During the launch, the AVLB presents a target that is 11-meters high and 4-meters wide.

Fascines

Fascines are large bundles of PVC type pipes that are loosely bound together and designed to be dropped into gaps by a launch vehicle, and they are best used on ditches without escarpments. Fascine materials must have enough width and load-bearing capacity to handle the crossing traffic. Expedient fascines can be constructed in the field, as happened in Operation Desert Storm. The bundles were attached to the sides of the AAV and held in place by a cable. The AAV pulled up to the ditch, turned parallel to it, and the cable was cut dropping the bundle into the ditch. This gives the enemy two flanking shots as the fascines are on both sides of the vehicle. They were effective and much less time consuming during the assault.

Continued on next page

M9 Armored Combat Earthmover (ACE)

The M9 ACE is a highly mobile, armored earth moving system. It is lightly armored (armor protects the operator from small arms, i.e. 7.62mm on the flanks and 12.7mm to the front, when the bowl is full) and has a chemical-biological overpressure system to protect the operator. The M9 ACE can scrape, doze, and haul material. It should primarily be used to construct survivability positions or reduce nonexplosive obstacles. It is also useful in mobility and countermobility efforts in support of mechanized forces. The ACE is capable of removing obstacles such as roadblocks, trees, and rubble while maintaining combat roads and trails. It can be used to breach antitank ditches and berms. It requires approximately 15 minutes to breach an antitank ditch. The ACE is also useful in reducing shallow water non-explosive obstacles.

Wire Obstacles

Wire obstacles are encountered frequently as they are easy to install and maintain. These are obstacles that you will have to breach to get personnel and equipment through, and they often are incorporated into other obstacles like minefields. The most common ways to breach wire are through the use of bangalor torpedo's, Antipersonnel Obstacle Breaching System (APOBS), and the Linear demolition charge.

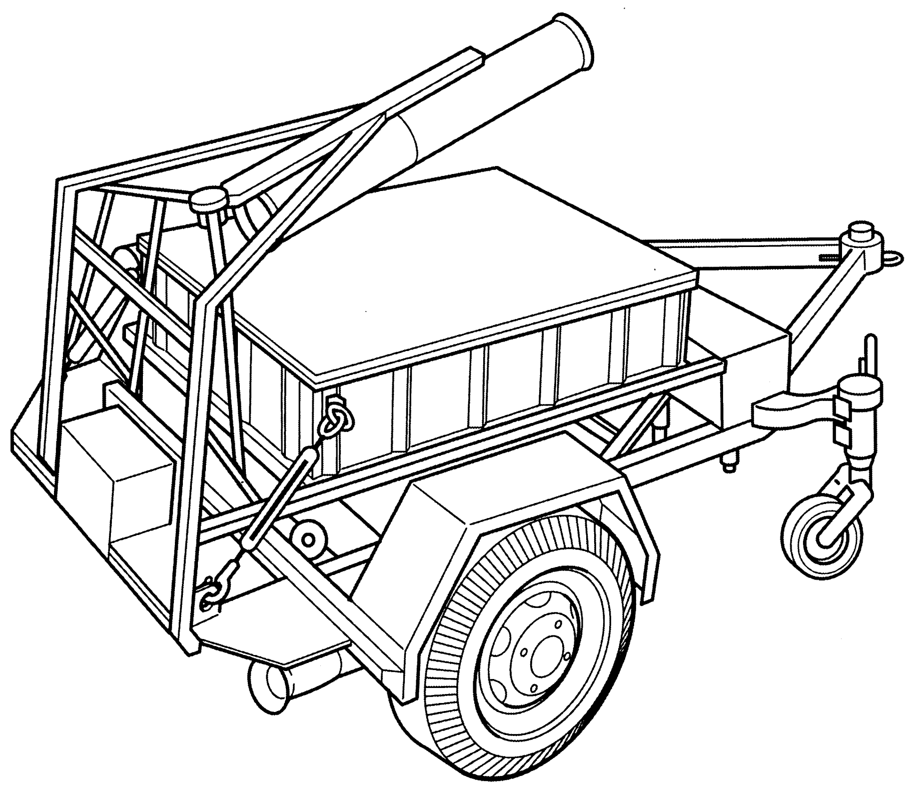
Linear Demolition Charge

The MK1 or MK2 linear demolition charge systems are very effective in breaching wire obstacles. Line charges should be used when wire obstacles are used in conjunction with minefields, in great depth, or the risk of dismounted personnel is too great to use other techniques. Consideration must be given to employing this valuable asset on single/simple wire obstacles.

Continued on next page

Linear Charge on Trailer

The illustration below shows a linear charge on a trailer with the rocket in firing position.



APOBS

The Antipersonnel Obstacle Breaching System (APOBS) was designed for the breaching of antipersonnel mines and wire obstacles by dismounted troops. The APOBS will create a 45 meter long by 3 to 4 meter wide path in wire obstacles, and .6 meters by 45 meters through antipersonnel minefield giving the troops a 25 meter standoff from the obstacle.

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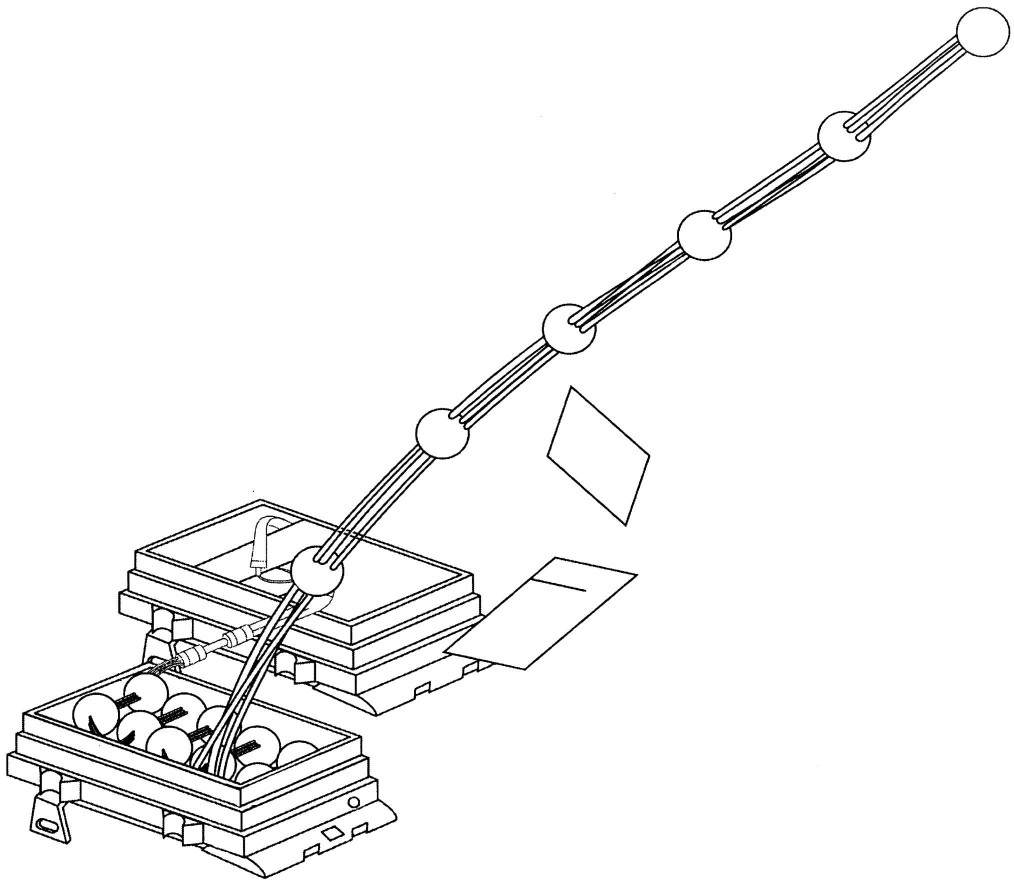
APOBS During Launch

The illustration below shows an APOBS being fired. The inset is a close-up of a grenade.



Bangalore Torpedo

The bangalore torpedo will create a path 3 to 4 meters wide in wire obstacles. Caution must be given when pushing the bangalore through the wire obstacle because there may be booby-traps in the wire so a dummy or inert section should always be utilized as the first section going into the wire. Normally the bangalore torpedo is primed non-electrically since electric firing systems are too complex and time consuming to use in an assault breach. The breach team ensures that all personnel within range have sought cover before the detonation because the bangalore torpedo throws lethal fragments of wire for long distances.

Continued on next page

Timber Obstacles

Heavily wooded areas provide an effective obstacle to vehicular movement. Log obstacles, such as abatis across roads and trails and earth filled cribs, can further decrease mobility.

Earth Filled

Earth filled log cribs can be breached in a number of ways. The 83mm Shoulder Launched Multipurpose Assault Weapon (SMAW) can be used to initiate the breach by firing low at the center of the crib. Then an M9 ACE or D-7 Dozer can usually push the remaining debris from the breached lane. Dismounted troops can manually reduce the log crib through the use of explosives. Forty-pound cratering charges are placed in the center of the crib at 2/3 the depth and tamped. Charges are placed on 8-foot centers along the length of the crib. If under enemy control or fire, log cribs can also be severely damaged by the main gun of the tank.

Abatis

The removal and clearance of log abatis depends on the characteristics of the fallen trees and the total depth of the timber obstacle. An abatis consisting of a few trees or trees of small diameter can generally be forced through with a dozer's pushing effort. When this is not possible, a combination of manual or explosive breaching and mechanical force is recommended. First the fallen trunk of the tree should be separated from its base with saws or explosive charges. The remaining timber is then pushed by an ACE or dozer or winched from the roadway.

Tetrahedrons/ Hedgehogs

These are easily placed and make effective light vehicle barriers. They will force personnel out into the open to breach and expose them to direct fire.

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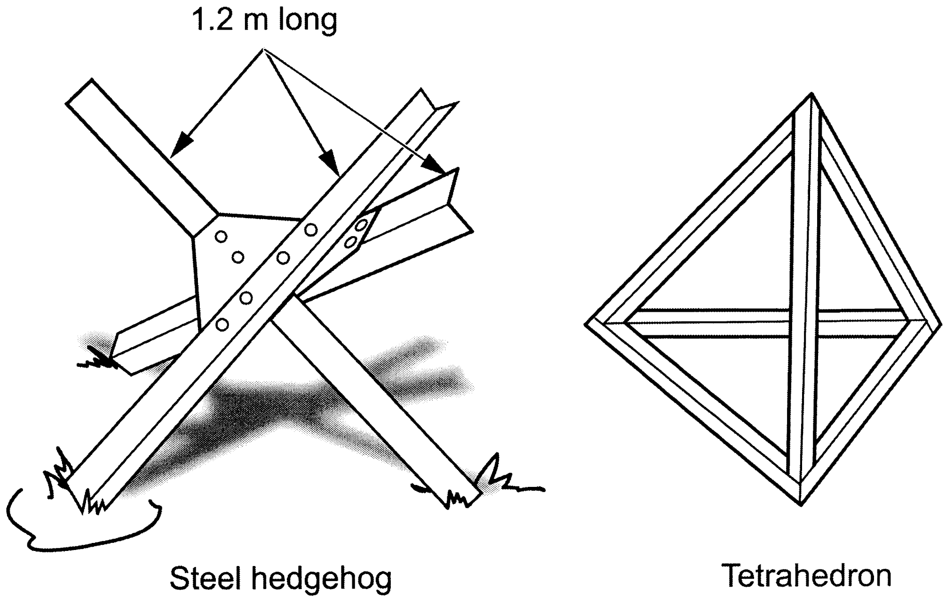
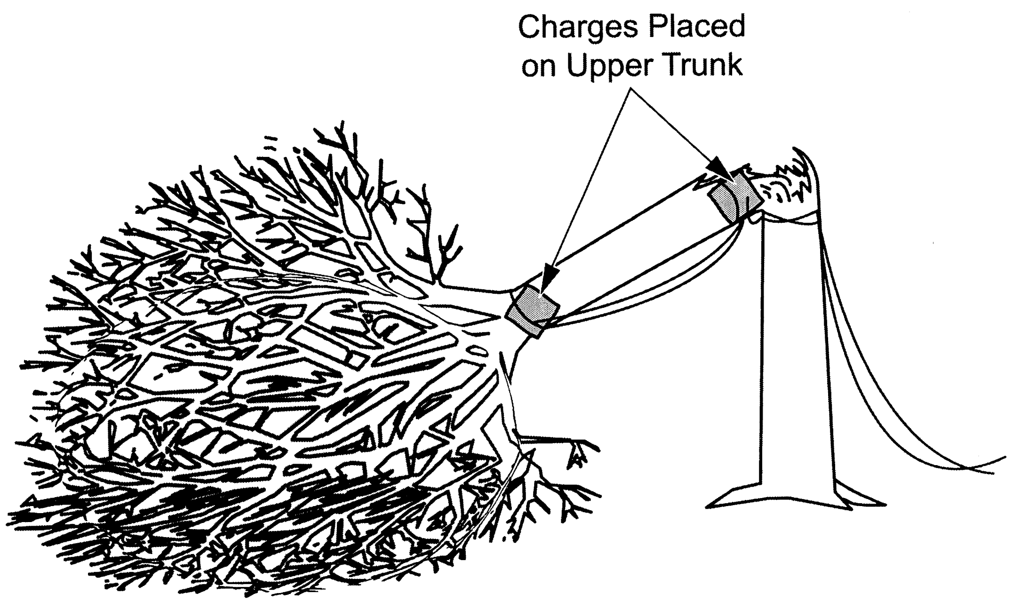
Examples

The illustration below shows a tetrahedron and a hedgehog.



Charge Placement

The illustration below shows the placement of charges to clear a tree in an abatis.



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Log Post

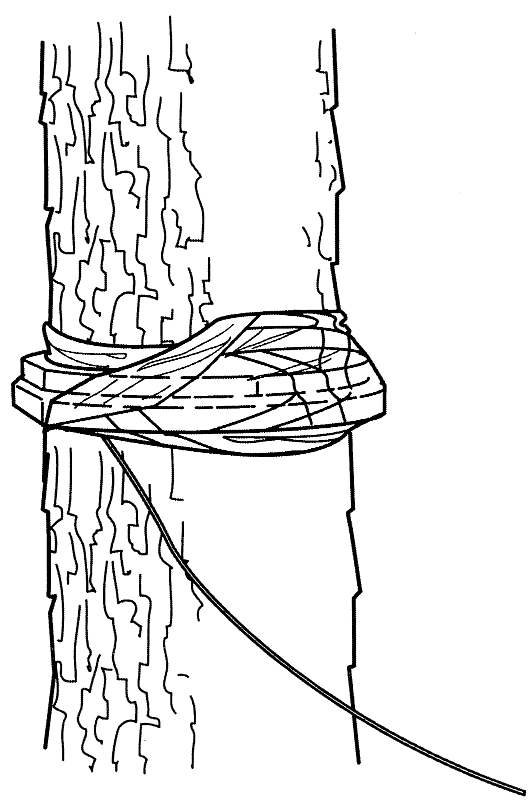
Log post obstacles consisting of small diameter trees or posts can be generally forced through with a mechanical pushing effort. If this is not possible, saws or explosive charges should be used. Charges are placed as close as possible to the surface of the timber and at ground level. The following formula should be used for cutting trees, piles, posts, beams, or other timber with explosives as an untamped external charge:

$$P = \frac{D^2}{40}$$

P = Pounds of TNT required
D = Diameter of round timber, or least dimension of dressed timber, in inches.
40 is a constant

External Charge

The illustration below shows an external charge for use when cutting logs.



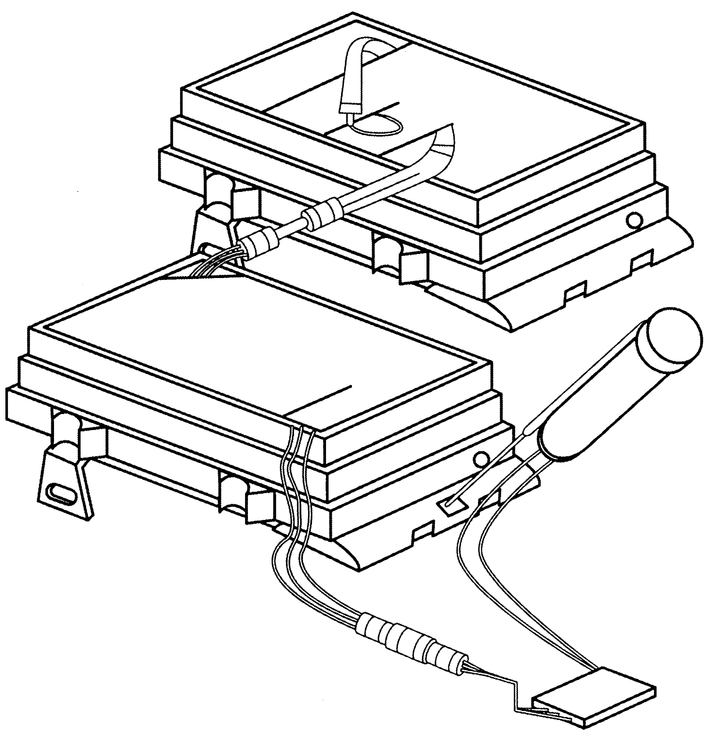
Antipersonnel Obstacle Breaching System

Description

Antipersonnel Obstacle Breaching System (APOBS) is a self-contained, one-shot expendable linear demolition charge system, which can be transported and deployed by a two-person team. APOBS is used by assault elements to breach lanes through encountered wire and anti-personnel mine obstacles. When an obstacle is encountered, a two-man team will advance to a 38-yard (35 meter) standoff position, set, aim, and ignite the mechanical initiator of the rocket motor, then move to a safe position. Deployment and detonation of the line charge is automatic, providing the necessary overpressure and metallic fragmentation to create a safe lane through wire and anti-personnel mine obstacles. The rocket motor will fire within 15 to 22 seconds after ignition of the delay cartridge. The line charge will be deployed and detonated over the obstacle within 8 to 14 seconds after rocket motor lift-off. The APOBS also provides an alternate Command Mode deployment option using the MK19 Mod 0 Electric Squib for rocket motor initiation.

Assembled APOBS

The illustration below shows an assembled APOBS.



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Total Components

APOBS uses a rocket motor to tow the blast and fragmentation line charge over the obstacle. The line charge is 148 feet long (45 meters) and contains 108 individual grenades with a total explosive weight of 51.0 lb (23.1 kg). Rocket initiation is accomplished by a mechanical initiator (delay mode) or by an electric squib initiator (command mode). The mechanical initiator has a single safety pin lock. With the safety pin removed, manual pulling of the firing pin pull ring initiates the delay cartridge and provides time for the firing crew to reach a safe position. A towing bridle is permanently fixed to the rocket motor aft cap, providing mechanical connection to the front fuse assembly. The rocket motor is positioned for firing when inserted onto the launch rod on the front backpack assembly.

Front Backpack Assembly

The front backpack is a durable molded plastic container mounted on a standard backpack frame. It provides a bracket to allow insertion of the rocket motor launch rod. The front backpack dimensions are 27.9 in. x 9.5 in. x 15.5 in. The front backpack is loaded with a 25-meter line charge segment consisting of 60 grenades and detonating cord in overbraid structure to transfer detonation to the grenades, and two quick connectors (one for fuse connection and one for rear line charge connection). The line charge is loaded into the backpack in layers. A thin foam pad is placed over the top layer of grenades. The rocket launch rod, the male connector, and the female connector are placed on top of the thin foam pad. The front backpack assembly weighs approximately 60.2 pounds.

Rear Backpack Assembly

The rear backpack is similar to the front backpack, but has no launch rod bracket. The rear backpack is loaded with a 20-meter line charge segment consisting of 48 grenades, detonating cord in overbraid structure, and two male connectors. The end of the rear line charge segment is secured to frame/backpack connection point by means of a bridle. The dimensions are

- Length - 27.9 in. (70.9 cm)
- Height - 9.5 in. (24.1 cm)
- Width - 15.5 in. (39.4 cm)

The grenades are layered into the backpack. A thin foam pad is also placed over the top layer of grenades. The rear backpack weighs approximately 52.3 pounds. In storage, a blast guard (confinement chamber) is installed on the rear fuse.

Continued on next page

Rocket Motor and Fuse Transport Container

The rocket motor and fuse transport container is a camouflage fabric container with a carrying strap, a molded protective foam insert is provided containing the rocket motor assembly, fuse assembly (with blast guard installed), tow bridle, an electric squib initiator screwed into its blast guard, a field card, and tool kit bag (consisting of two spare connector clips, screwdriver, and two pairs of earplugs for hearing protection). The squib is sealed inside a foil bag. The bags dimensions are

- Length - 18 in. (45.7 cm)
- Height - 4 in. (10.2 cm)
- Width - 6 in. (15.2 cm) with a loaded weight of 11.0 lb (5.0 kg)

Transporting

Divide the APOBS between the two fire team members by either securing the soft pack transport container on rear backpack or using the sling strap to carry it on the shoulder. Each backpack assembly is identified by stencil marking on its top. The launch rod holder located on its front can also identify the front backpack; the rear backpack has no launch rod holder. Before departing the staging area, assure the required flack jacket, helmet, and hearing protection are available. If command mode option has been directed, assure that required ancillary equipment is available and has been inspected per "Before" preventive maintenance checks and services. Follow the steps below to secure soft pack transport container on top of rear backpack.

Step	Action
1	Extend the carrying strap on the soft pack.
2	Equalize pressure in rear backpack.
3	Use only the four side latches to secure the soft pack. Do not open the front or rear latches.
4	Open one side latch and place the carrying strap through the latch opening. Close side latch over the carrying strap and secure. Repeat for the remaining three side latches, one at a time.
5	Buckle carrying strap on the bottom of rear backpack and tighten.
6	Place the soft pack container securing straps through shoulder pad straps and tighten.

Aiming

Aim the rocket by adjusting backpack position until line of sight of rocket motor is aimed toward obstacle. The rocket will swivel on the launch rod. Be sure to aim the rocket, not the backpack.

Lesson 1 Exercise

Directions Complete exercise items 1 through 5 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1 Which of the following would be considered a complex obstacle?

a. A tank ditch
b. A wire obstacle
c. An antitank ditch and wire obstacles
d. Log post

Item 2 What are the stages in breaching fundamentals?

a. Suppress, secure, reduce, resupply, and obliterate
b. Suppress, obscure, secure, reduce, and resupply
c. Suppress, obscure, secure, reduce, and ignite
d. Suppress, secure, reduce, obliterate, and ignite

Item 3 What are the five areas that make up the organization of a breach?

a. Breach force, marking team, support force, follow on force, and breaching assets.
b. Breach force, assault force, support force, follow on force, and breaching assets.
c. Breach force, assault force, marking team, follow on force, and breaching assets.
d. Breach force, assault force, support force, marking team, and breaching assets.

Item 4 What are the four types of breaching operations?

a. Hasty/in-stride, deliberate, amphibious, and covert
b. Hasty/in-stride, dedicated, assault, and covert
c. Hasty/in-stride, deliberate, assault, and converted
d. Hasty/in-stride, deliberate, assault, and covert

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Item 5

One of the methods to breach an antitank ditch is the towed assault bridge method, which is designed to tow or push across manmade ditches or

a. escarpments.
b. pipes.
c. traffic.
d. hills.

Continued on next page

Lesson 1 Exercise, Continued

Solutions

The table below lists the answers to the exercise items. If you have any questions, refer to the reference page listed for that item.

Item Number	Answer	Reference Page
1	c	4-5
2	b	4-7
3	b	4-9
4	d	4-12
5	a	4-14

LESSON 2

M58/M68 LINEAR DEMOLITION CHARGE

Introduction

Scope

This lesson describes the process and procedures for the destruction and reduction on explosive obstacles, with the use of the linear demolition charge as it pertains to mobility of maneuver elements.

Purpose

The purpose of this lesson is to provide you with the knowledge to effectively employ and utilize the linear demolition charge to assist a unit commander in executing their tactical plans.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the major components of the MK2 Mine Clearing System.
- Identify the SL3 components of the linear charge.
- Identify the four areas within the operator's controls and indicators.
- Identify the steps for operating the linear charge.
- Identify the measures to take if a rocket fails to deploy.

In This Lesson

This lesson contains the following topics:

MK2 Mine Clearing System

Description

The MK2 Mine Clearing System is a trailer-mounted, rocket-towed linear demolition charge. It is used to provide a clear path for combat vehicles during minefield-breaching operations.

Components

The major components of the MK2 Mine Clearing System are:

- M58A4 linear demolition charge
- MK22 rocket motor
- MK155 mine clearing launcher
- Trailer chassis

M58A4 Linear Demolition Charge

The M58A4 is capable of clearing a path 16 meters wide and 90 meters long through a minefield. Minefields planted with single-impulse, pressure type, antitank mines, and/or mechanically actuated antipersonnel mines can be cleared with the use of the M58A4 linear charge. The system is designed for towing over rough terrain. The system is deployable in various types of climates. The linear demolition charge M58A4 contains 1750 pounds (5 lbs per foot) of composition C-4. The linear charge is 350 feet long, and consists of a 3/4-inch nylon rope core and two strands of detonating cord passing through the C-4 blocks. The linear demolition charge has three (3) 100-foot sections and one (1) 50-foot section connected together with clamps that act as boosters (PETN FILLED). It is attached to a 205-foot arresting cable.

MK22 Rocket Motor

The MK22, Mod 3 or 4, five-inch rocket motor is designed to tow the linear charge over the target minefield. The rocket motor and linear charge can be remotely initiated.

MK155 Mine Clearing Launcher

The MK155 is a welded framework that holds the packaged linear charge and has a hydraulically elevated launcher rail for the towing rocket. The launcher holds the linear charge and the rocket motor securely during transport to the target minefield. Launcher and trailer are fully reusable and can be reloaded with a new rocket motor and linear charge in 30 minutes.

Trailer Chassis

The trailer chassis is general-purpose 3 1/2 ton trailer, which holds the mine clearing launcher and transports launcher to target minefield.

SL3 Components

Cable Assembly Switch	The cable assembly switch primarily consists of the switch housing and two cables. The cable assembly switch determines power flow to the rocket motor or linear charge through 75 feet of electrical cables. The housing on the electrical cable switch is watertight. The other cable on the cable switch has two electrical leads emerging from it that are used to connect the M34 blasting machine or M51 test set.
M51 Test Set	The M51 Test Set is used to test the circuit on the entire electrical system.
M34 or COTS Blasting Machine	The blasting machine is used to send enough power through the system to propel the rocket and to detonate the main charge.
Lifting Sling	The lifting sling is used to load/unload the linear charge container and launcher.
Protective Nylon Cover	The protective nylon cover is used to cover the linear charge container after the hard cover has been removed.
Turn Buckles and U-bolts	U-bolts secure the launcher to the chassis; turn buckles secure the linear charge container to the trailer chassis.
Instruction Cards	These cards provide minimum instructions required to operate the system.

Operators Controls and Indicators

Area 1

The four areas that make up the operators controls and indicators are

- Hydraulic system
- Safety switch assembly
- Clinometers
- Launcher rail support

Hydraulic System

The hydraulic system is located near the rear of the launcher. It is used to raise and lower the launcher rail. The table below shows the part and function of the hydraulic system.

Part	Function
Hand Pump	Pressurizes the accumulator or pumps hydraulic fluid to activate the cylinder and raise the rail.
Accumulator	Stores hydraulic pressure needed to raise launcher rail when hydraulic control valve handle is in REMOTE RAISE position.
Pressure Gauge	Indicates accumulator hydraulic pressure.
Hand Pump Release Valve	Allows the hand pump to deliver hydraulic fluid when hand pump is closed. When open, or in the RELEASE position, it causes fluid to flow back into the reservoir, and release pressure.
Hydraulic Control Valve Handle	Directs flow of fluid in manual position, pressure accumulator position and in remote raise position.

Continued on next page

Safety Switch Assembly

The safety switch assembly prevents the rocket motor and linear charge from firing when the launcher rail is not elevated to firing position. The table below shows the part and function of the safety switch assembly.

Part	Function
The safety switch electrical lead connector	Connects to receptacle No. 1 on the linear demolition charge container during operation.
Roller-lever switch	Completes the circuit to the rocket as launcher rail approaches 47 degrees.
Safety switch plug connector	The plug connector for the 75-foot special purpose electrical cable

Clinometers

The clinometers indicate the degree of angle the launcher rail is raised. Launcher must be leveled for the clinometers to be accurate.

Launcher Rail and Support

The launcher rail and support provides a mobile platform for the M58A4 linear charge. The table below shows the part and function of the launcher rail and support.

Part	Function
Front and rear hand knobs	Exerts pressure on the rocket bands to hold the rocket laterally.
Alignment pins	Aligns the rocket on the launcher rail.
Rocket release mechanism	Restrains the rocket on the launcher rail during transport. It is located at the rear of the launching rail.
Detent assemblies	Prevents the launcher rail from lowering when detent assemblies are engaged. When disengaged, detents allow launcher rail to lower.
Ball lock pins	Locks the launcher rail at different elevations when they are in the front lock position, the ball lock pins prevent the launcher rail from raising above 47 degrees.
Launch Position Indicator	A white mark on the launch rail supports, which indicates to the crew that launcher rail, is at desired launch angle. If a vertical white mark appears below the horizontal white mark (T-stripe), the launcher angle is too high for proper deployment of rocket.

Operation

Initial/Pre-Firing Inspection

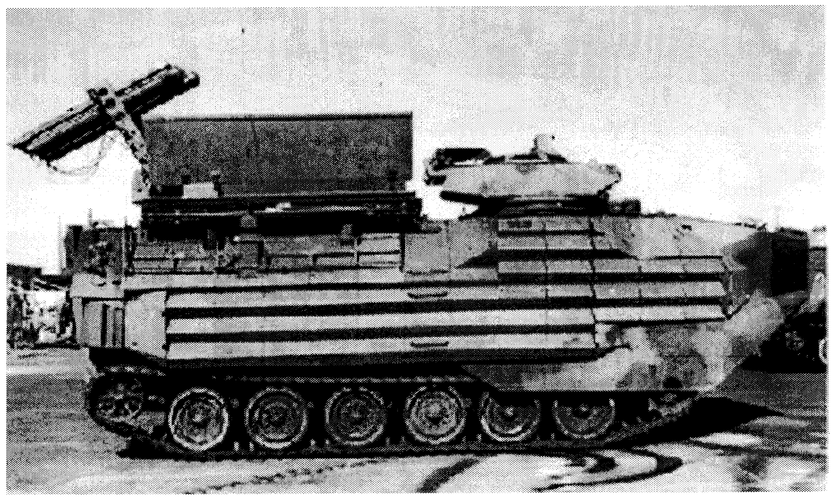
Follow the steps below for the initial/pre-firing inspection.

Step	Action
1	Ensure all components are present and undamaged.
2	Ensure all hydraulic system components are secured to launcher.
3	Check the pump, accumulator, valve, cylinder, and hose for leaks.
4	Check the fluid level in the hand pump by removing the fill plug and dipstick and visually checking the fluid level on the dipstick.
5	Ensure launch rail is in stowed position and accumulator uncharged when fluid level check is performed.
6	Ensure the level is filled to the "FULL" mark on the dipstick with MIL-H-5606 hydraulic fluid and replace the dipstick/fill plug.

Continued on next page

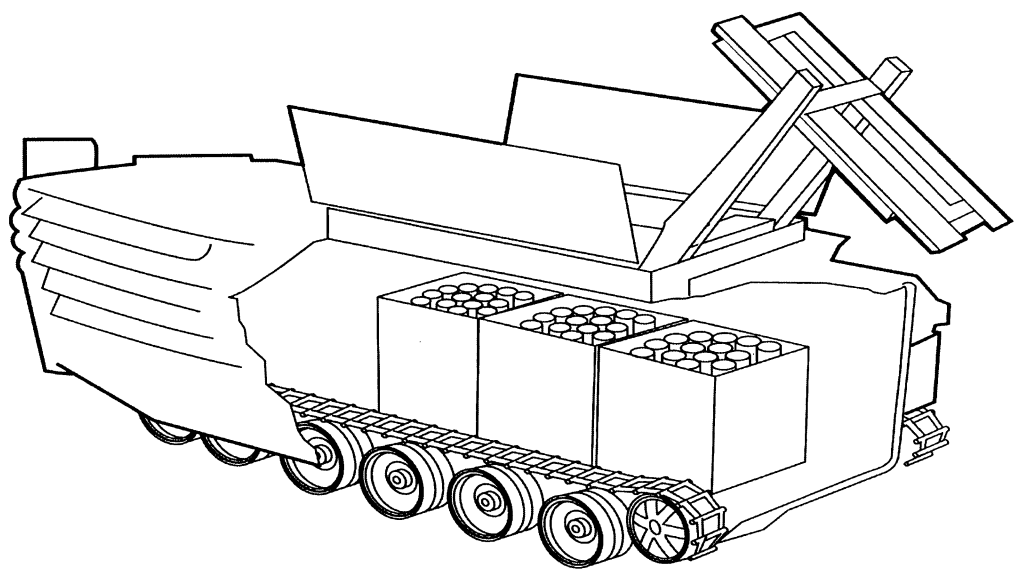
MK 154

The illustration below shows an MK 154.



Cutaway View of MK 154

The illustration below shows three rockets mounted on the MK154 and the interior placement of line charges.



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Operational Check List

The table below shows a checklist for the safe and successful operation of the linear demolition charge.

Step	Action
1	Ensure launcher is placed on level ground.
2	Set detents to "Engaged" (down) position.
3	Set hydraulic control valve handle to "Manuel Raise/Lower" position.
4	Rotate pump valve handle to "Hold" position.
5	Remove ball lock safety pins from "Lock" position. (If pins are hard to move, slowly actuate hand pump while simultaneously attempting to remove pins.)
6	Operate the hand pump handle and raise the launch rail to approximately 60 degrees.
7	Set detents to "Disengaged" (up) position.
8	Rotate pump valve handle to "Release" position and allow the launch rail to return to the down (0 degree) position.
9	Set detents to "Engaged" (down) position.
10	Insert ball-lock safety pins in "Lock" position.
11	Set hydraulic control valve handle to "Pressurize Accumulator" position.
12	Rotate pump valve handle to "Hold" position.
13	Disengage ball-lock pin on hydraulic pressure gauge cover and rotate cover aside.
14	Actuate hand pump handle until the hydraulic pressure gauge indicates 3200 to 3500 PSI.
15	Rotate gauge cover over pressure gauge and install ball-lock pin.
16	Relocate ball-lock safety pins from lock to "Raise" position.
17	Pull lanyard (attached to the hydraulic control valve handle) to move hydraulic control valve handle from Pressurize Accumulator to "Remote Raise" position. Visually monitor clinometers to insure an approximate elevation of 47 degrees is achieved.
18	Set detents to "Disengaged" (up) position.
19	Move hydraulic control valve handle to "Manuel Raise/Lower position.
20	Rotate pump valve handle to "Release" position.
21	Set detents to "Engaged" (down) position when launch rail has lowered to 0 degrees.
22	Relocate ball-lock safety pins from "Raise" to "Lock" position.

Continued on next page

Operation, Continued

Fusing

Remove package fuse from the center of the charge. Remove shock cord assemblies from the center of the charge and store in the storage container (shock cords are used with the hard cover). Follow the steps below to fuse.

Step	Action
1	Remove the fuse from package and inspect: • Check for moisture and corrosion. • Check arming window. It should be green with letter "S" showing. • If window is red and letter "A" is showing, do not use the fuse. • Ensure shear pin is in place.
2	Remove protective cap from the fuse electrical receptacle and check for corrosion.
3	Using two to three Marines, fold back three to four layers of the linear charge as necessary to access arresting cable fuse connector and linear charge fuse connector located on the rear right of container.
4	Place arresting cable fuse connector on linear charge and remove ball-lock pin.
5	Screw on and tighten connector to fuse electrical receptacle. Screw on and tighten arming wire connector to arming pin assembly.
6	Slide the fuse into arresting fuse connector and slide linear charge fuse connector shaft into center hole of the fuse.
7	Mesh the linear charge fuse connector pins with slots in the fuse.
8	Mesh slots of linear charge fuse connector shaft with arresting cable fuse connector key.
9	Insert ball-lock pin into arresting cable fuse connector until it seats in linear charge fuse connector shaft hole.
10	Test the connection by pulling connectors in opposite directions.
11	Remove protective nylon cover from storage container.
12	Position protective nylon cover wear pad at rear center of linear demolition charge container.
13	Attach front and rear shock cord assemblies of protective nylon cover to linear demolition charge contain, leaving flaps open. Do not attach side shock cord assemblies until nylon cover is closed.

Employment

Prepare for Rocket Deployment

Follow the steps below to prepare for rocket deployment.

Step	Action
1	Drive tow vehicle and launcher straight ahead to orient the rocket to fire across the target.
2	Stop 62M from the edge of the minefield. The primary operator will be seated in the T. C. Hatch if AAV is used.
3	Take up slack in lanyard and pull to raise launcher rail.
4	Allow a minimum of 10 seconds for launcher rail elevation.
5	Visually check to ensure rocket is elevated to proper firing angle. **WARNING:** To prevent launch at improper angle, launcher should not be attempted in extremely uneven terrain.
6	Ensure selector switch is in the OFF position.
7	Test the M34 blasting machine, if it is serviceable, attach branch cable to connections on the M34.
8	If the COTS is used, charge until light comes on to ensure COTS is working.

Continued on next page

Rocket Deployment

Follow the steps below to deploy the rocket.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Ensure area is clear and request permission to fire rocket.</td></tr>
<tr><td>2</td><td>Set selector switch to rocket position and repeatedly squeeze the M34 and wait approximately 10 seconds for completion of rocket deployment.</td></tr>
<tr><td>3</td><td>If COTS is used, push and hold charge button until the “fire” light is lit.</td></tr>
<tr><td>4</td><td>Once lit, while still holding charge button down, press and hold fire button until rocket fires.
<table>
<tr><th>If…</th><th>Then…</th></tr>
<tr><td>Rocket fails to deploy</td><td>Repeat previous steps.</td></tr>
<tr><td>Rocket fails to fire after two attempts</td><td>Check blasting machine connection, set selector switch to off and then back to rocket position, attempt to fire.</td></tr>
<tr><td>Rocket fails to deploy again</td><td>Set selector switch to OFF position.</td></tr>
</table>
</td></tr>
<tr><td>5</td><td>Disconnect blasting machine and refer to misfire procedures.</td></tr>
</table>

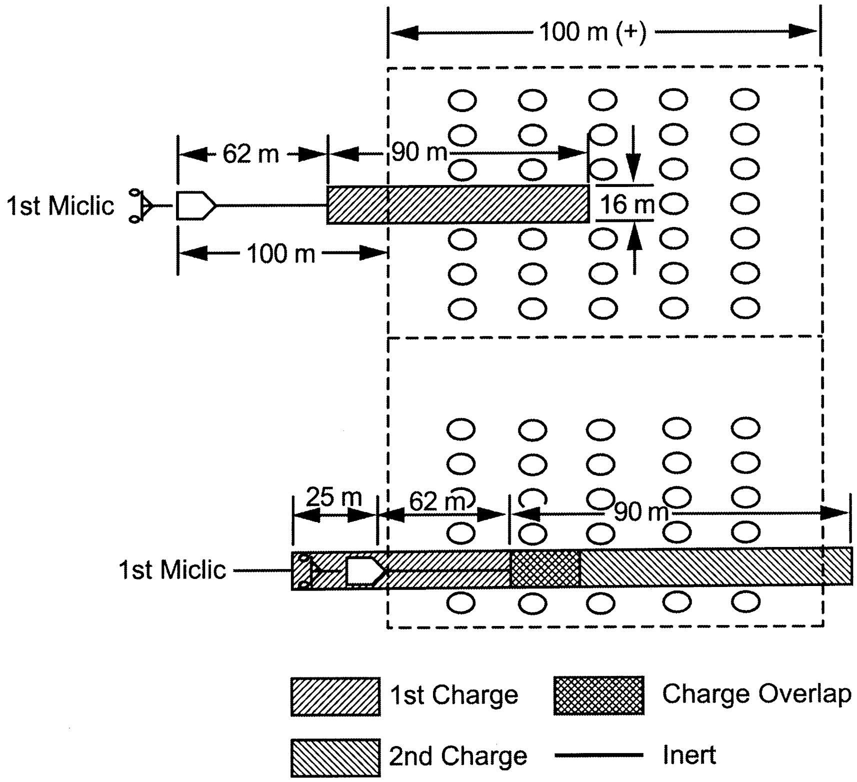
Charge Deployment

Visually verify line charge is properly extended with arresting cable taught.

Continued on next page

Deployment of Linear Charge

The illustration below shows the deployment of the linear charge for the first and when necessary the second charge.



Charge Initiation

Follow the steps below to initiate the charge.

Step	Action
1	Set selector switch to CHARGE position.
2	Operate M34 blasting machine repeatedly to detonate M58A4 line charge.
3	If COTS is used, repeat procedures as stated in step #8 of the previous table for preparing rocket deployment to detonate charge.
4	If linear charge fails to detonate, repeat step.
5	If linear charge fails to detonate after two attempts, check blasting machine connections.
6	Set the selector switch to OFF and back to CHARGE position and repeat firing.

Continued on next page

Misfire

If the linear charge misfires, follow the steps below:

Step	Action
1	Set selector switch to OFF position.
2	Disconnect blasting machine and refer to misfire procedures.
3	Disconnect leads from M34 and set selector switch to OFF position.

Lesson 2 Exercise

Directions

Complete exercise items 1 through 5 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

Which of the following lists the major components of the mine clearing linear system?

a. Linear charge, rocket, mine clearing launcher, and the trailer chassis
b. Linear charge, rocket motor, mine launcher, and the trailer chassis
c. Linear charge, rocket, mine launcher, and the trailer chassis
d. Linear charge, rocket, mine clearing launcher, and the trailer component

Item 2

The cable assembly switch, blasting machine, lift sling, and turn buckles are examples of ______ components.

a. trailer
b. major
c. SL3
d. demolition

Item 3

What are the four areas that make up the operators controls and indicators?

a. Launcher support, clingonometers, hydraulic system, and safety switch assembly
b. Launcher rail with support, clinometers, hydraulic pumps, and safety pins
c. Launcher rail with support, clinometers, hydraulic system, and safety switch assembly
d. Launcher, clinometers, hydraulic system, and safety switch assembly

Item 4

What is the first step to perform when preparing to operate a linear demolition charge?

a. Ensure the rocket is securely fastened.
b. Ensure the launcher is connected to the blasting machine.
c. Ensure the charge is primed properly.
d. Ensure the launcher is placed on level ground.

Continued on next page

Lesson 2 Exercise, Continued

Item 5 If the rocket fails to fire after two attempts, what do you do?

a. Check blasting machine connector and set selector switch to off and then back to rocket position.
b. Set selector switch to OFF position.
c. Attach branch cable to connections on the M34.
d. Set selector switch to CHARGE position.

Continued on next page

Lesson 2 Exercise, Continued

Solutions

The table below lists the answers to the exercise items. If you have any questions, refer to the reference page listed for that item.

Item Number	Answer	Reference Page
1	a	4-28
2	c	4-29
3	c	4-30
4	d	4-34
5	a	4-37

LESSON 3

VERTICAL TAKE-OFF AND LANDING PADS/TACTICAL LANDING ZONES

Introduction

Scope

This lesson describes the process and procedures for the requirements of vertical take-off pads and tactical landing zones.

Purpose

The purpose of this lesson is to provide you with the knowledge to successfully construct vertical take-off pads and landing zones.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the four classifications of airfields in a tactical environment.
- Identify the required placement of stakes for various matting during construction of vertical take-off and landing pads.
- Identify the minimum distance required for landing points in a landing zone.
- Identify the four areas within a forward arming and refueling point (FARP).

In This Lesson

This lesson contains the following topics:

Definitions

Expeditionary Airfield

Expeditionary airfields utilize prefabricated materials such as AM-2 matting with accessories in their construction. The four classifications of an airfield are

- LZ
- Forward Operation Base
- Main Base
- Air Facility

VTOL

Vertical Take-off and Landing (VTOL) is a type of expeditionary airfield, which allows one aircraft to land or take-off. It is constructed with the AM-2 matting surface. The primary user of this facility is the AV-8B HARRIER.

LZ

A landing zone (LZ) is an opened area on the ground used for helicopter operations. Landing zones are designated by a series of code names such as birds, animals, or trees. Landing zones are divided into two areas:

- Landing Sites
- Landing Points

Forward Operating Base

The forward operating base platform is designed to provide flexible AGS to the ACE of the Marine Air-Ground Task Force (MAGTF) in an ever-changing tactical environment. Airfields are further broken down into four classifications.

Main Base

The main base secures the airfield capable of handling all types of aircraft, up to and including theater lift assets. The main base contains maintenance and engineering assets to support anticipated needs. In most cases, they are located near shore and integrated into the MAGTF logistics pipeline. The function will be to support sustained operations ashore.

Air Facility

The air facility is a secure airfield capable of supporting a detachment or squadron of aircraft, and associated assets. Minor repairs, refueling, rearming, and de-arming can be accomplished at the air facility. The air facility has little to no permanent structures. This facility may be an airfield, road segment, matted runway, or a grassy surface.

Continued on next page

Air Site

The air site is a secure location where aircraft are prepositioned to enhance response time. This area must be suitable for a fully armed and fueled aircraft to land, and await a mission. Fuel and ordnance may be stored at this site, but a minimal number of personnel, and little to no logistical support will exist here. Upon completion of a mission from an air site, aircraft would normally return to the air facility or main base. Air sites are limited to receiving and launching previously loaded aircraft.

Air Point

Air points are tactical designations applied to a predetermined geographical location that will support a specific tactical mission. For the purpose of planning, air points are further classified as either a forward arming and refueling point (FARP) or a Lagger Point.

Forward Arming and Refueling Point (FARP)

Provides a location with landing sites for receipt of fuel and arming/dearming, which is necessary for mobile and flexible helicopter operations.

Lagger Point

Lagger points are secure locations designated by aviation units to be utilized for the rendezvous, marshaling or positioning of flights of aircraft between missions, or when waiting for the completion or activation of an assigned mission. Only communication support is required. Lagger points can be isolated, or be adjacent to any of the previously mentioned facilities.

Aircraft Characteristics

Helicopters

The characteristics of the different types of aircraft utilized in the Marine Corps are very important. The size of the aircraft will definitely affect the amount of area to be used and the amount of manpower and equipment to be used for construction of VTOL/LZs. The CH53E-Super Sea Stallion is the largest helicopter with a 79-foot rotor, and the AH-1 Cobra is the smallest with a 44-foot rotor. The table below shows the description and characteristics of the aircraft.

Aircraft	Description	Characteristics
AH-1 Cobra	The AH-1 cobra is a twin engine, two-seat, combat helicopter used for the escorting of other helicopters or as attack and fire support for ground forces	• Rotor 44' • Gross weight 6,073 lbs • Overall length w/rotors turning 53' • Range 357 miles • Speed 219 mph • Height 13'5"
UH-1N Huey	This twin-engine helicopter is sometimes used for emergency resupply mission. It has an internal cargo space of 220 cubic feet and can lift a maximum of 2000 lbs externally. It has a seating capacity of 7 troops plus the pilot or 6 litters and an attendant.	• Rotor 48' • Gross weight 6,600 lbs • Overall length w/rotors turning 58' • Range 316 miles • Speed 135 knots • Front height 13'4"
CH-46E Sea Knight	The CH-46E is a twin turbine powered, tandem rotor helicopter. The primary mission of the CH-46E is to rapidly disperse combat troops, support equipment, and supplies from amphibious assault loading ships and established landing zones.	• 50' each rotor • Gross weight 15,452 lbs • Overall length w/rotors turning 85' • Front height 11'9" • Rear height 16'9" • Range 350 miles • Downwash 100 mph • External cargo weight 5000 lbs • 15 troops or 15 litters w/two medical attendants

Continued on next page

Aircraft Characteristics, Continued

Aircraft	Description	Characteristics
CH-53E Super Sea Stallion	The CH-53E is a single rotary win, rotary rudder, triple turbine engine assault transport helicopter. The helicopter is designed for land and carrier based operations with the primary mission of the movement of supplies and equipment.	• Rotor 79' • Gross weight 36,000 lbs • Overall length w/rotors turning 99' • Internal weight 23,500 lbs • External weight 23,000 lbs • Cruising speed 150 knots • Maximum speed 170 knots • Range with tanks 750 miles (two 650-gallon external tanks) • Range with in-flight refueling is unlimited • Downwash 175 mph • Front height 10'8" • Rear height 9'1/2" • Troop, (combat) 37 (up to 55 with centerline seats installed) or 24 litters w/three medical attendants

Continued on next page

Fixed Wing

There are two fixed wing aircraft in the Marine Corps inventory:

- AV-8B Harrier
- OV22 Osprey

Aircraft	Description	Characteristics
AV-8B Harrier	This is a fixed wing jet capable of vertical take-off and landings. The Harriers primary mission is attack/close air support. This aircraft also serves as a sea-based defense system aboard amphibious assault ships such as LPHs, LHAs, and LHDs.	• Engine is capable of producing 21,500 lbs. of thrust • Wing span 30'3" • Length 42'11" • Height 11'3" • Weight: Empty 12,400 lbs, Maximum loaded 29,000 lbs • Speed: subsonic • Range w/arms 748 miles
V-22 Osprey	The V-22 Osprey is a tilt rotor aircraft. A tilt rotor combines the speed; range and fuel efficiency normally associated with turboprop aircraft with the vertical take-off, landing, and hover capabilities of helicopters. This aircraft represents a major technological breakthrough in aviation that meets long-standing military needs.	• Width with prop rotors turning 84.6' • Length 63' • Weight empty 33,459 lbs • Height 22.1' • Maximum vertical Take-off weight 52,600 lbs • Range with full 24 combat loaded troops 242 nautical mile radius • Speed 241-257 knots

Vertical Take-Off and Landing Pad

Description

Vertical and take-off landing (VTOL) pads are normally the first step in Expeditionary Airfield Operations (EAF), which support the Marine Air Ground Task Force. The construction of a 96 x 96 landing pad is the requirement for supporting one helicopter or one AV-8B aircraft, an additional 150' must be cleared from each side of the pad, especially in heavily forested areas.

Surface

AM-2 matting will be used as the surfacing material for VTOL pads.

AM-2 Matting

The VTOL pad construction will require

- Twenty F-71 pallets containing 18 2 x 12 sheets and 20 locking bars
- Three F-72 pallets containing 18 2 x 6 sheets and 20 locking bars
- One F-28 pallet containing 130 edge clamps, 120 stakes, and 80 locking bars

Time Standard

Mat laying data prepared by the Marine Corps Landing Force Development Center indicates a mat-laying rate of 12,000 square feet/6-hour shift, utilizing two 13-man crews. This equates to 2,000 square feet per hour. AF-71 pallet contains 432 square feet of mat; therefore, a 13-man crew should be able to lay 5 pallets, which is 90 pieces of mat in 1 hour.

Sixteen-Marine Crew

Sixteen Marines maximizes efficiency for mat laying. The breakdown of the crew is as follows:

Crew	Duties
One alignment man	Aligns edges of each row of mat
Two pry bar men	Adjusts mat/inserts locking bars
Six two-man teams	Works with partner, carries and lays mats

Continued on next page

Equipment

Equipment and tools required vary depending on the location and the terrain the pad will be constructed on. At the minimum, the following equipment is required:

- Shovels
- Sledgehammers
- Crowbars
- 2 lbs. hammers
- 100-foot tapes
- Wooden blocks
- Forklifts
- 260 CFM Compressor
- Rakes

Site Selection

Once a site is selected, a soils test is conducted to identify the type of soil the VTOL pad will be constructed over. The soil and sub-base materials should be suitable for use with the AM-2 landing mats. Site preparation may not be required if there is an existing concrete or asphalt surface. Matting may be laid over the hard surface. The sub-base material shall have a bearing capacity relative to a minimum California Bearing Ratio (CBR) rating of four or more. The CBR of various soils can be determined by identifying the characteristics in accordance with a comparable type listed in the Unified Soils Classification Systems (USCS) chart.

Site Clearing

In many cases, there will be clearing work to be accomplished, specifically that of rocks and trees. The use of bulldozers, chainsaws, and military explosives will be quite extensive in a theater of operation with this type of terrain. The terrain in the area to be utilized shall be leveled and rolled to provide a compact matting base. Grading shall provide adequate drainage of surface and rainwater away from the field area. If possible, the soil shall be disturbed a minimum amount in obtaining the prescribed finish to provide a soil of maximum bearing capacity. Any areas under the matting requiring installation of service or drainpipes or other objects shall be back filled and thoroughly tamped.

Continued on next page

Survey

The final grading operation shall be sufficiently leveled so that mats when laid shall not vary more than 1/4" in height over a 12-foot distance. Hand raking may be necessary to accomplish this condition. Once the earthwork is accomplished, the engineer assistants (1361s) perform a survey to establish lines for the first row and left hand edge of the pad.

Pallet Deployment

Deployment of pallets should be such as to keep manual handling of mats and related components to a minimum. Deployment should be consistent with the available equipment, manpower, and conditions under which the installation is undertaken. Pallet deployment may be accomplished by either of the following general methods:

- Rough Terrain Forklift
- On Field Deployment

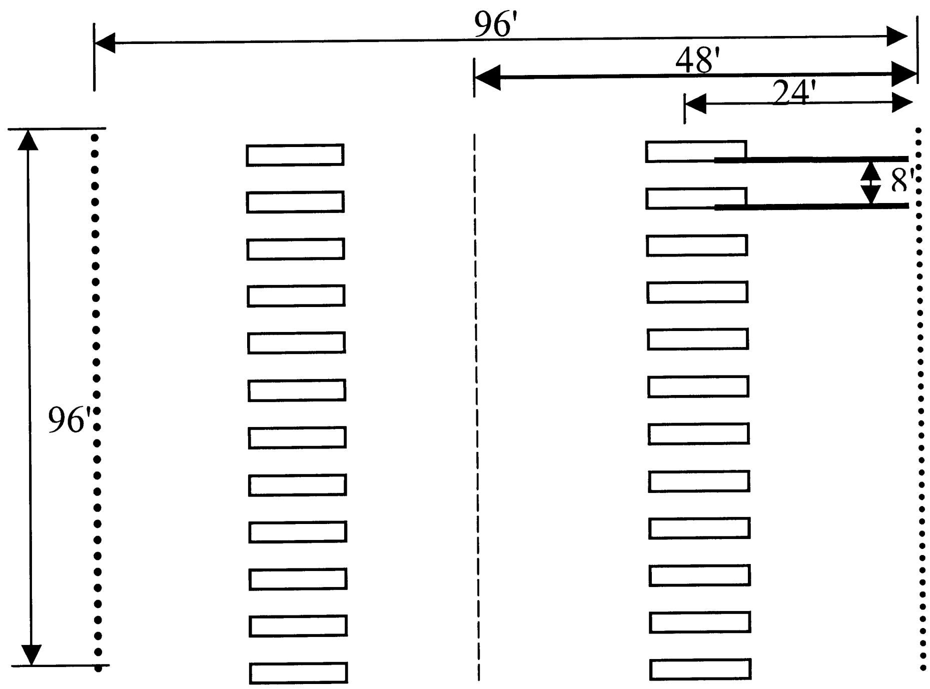
Rough Terrain Forklift

Deployment of pallets by rough terrain forklift is the most desirable method. The forklift delivers the pallet directly to the mat laying crews. Pallets are disassembled while on the forklift and it remains until the pallet load has been installed. This method obviously will require a number of forklifts to continuously supply the crews with pallets. Pallet disassembly is preferably done at the work area rather than at the storage area since loose mats are subject to spillage.

Continued on next page

On Field Deployment

On field deployment will probably be the one performed due to the shortage of forklifts. The pallets will be grouped on the field after major leveling operations have been completed. For a 96-foot wide pad, place the pallets in two rows of 24-foot centerlines at 8-foot intervals. Arrange the appropriate edge clamp and stake pallet components around the edge of the pad for proper anchoring. The illustration below shows the pallet spacing.



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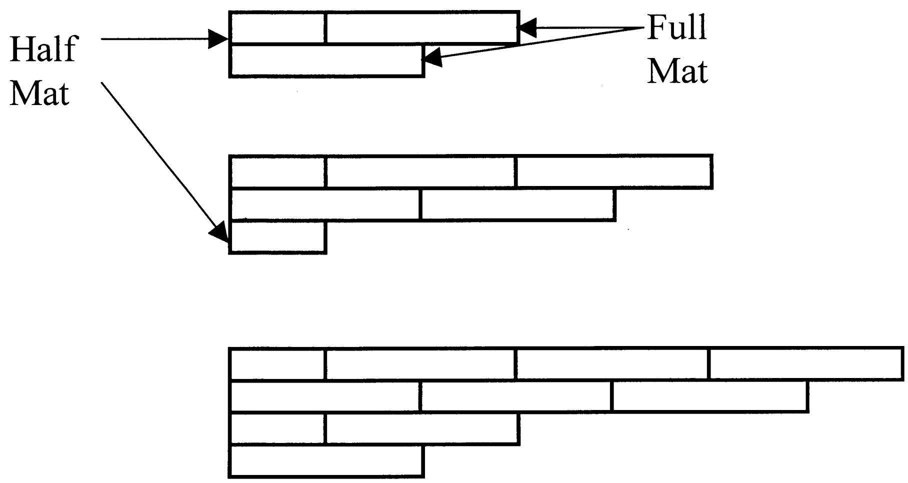
Laying the Mat

The sequence for laying matting is to start at one end and proceed in one direction. The individual mats are laid in brickwork pattern from left to right. Always ensure that the edge of the mat is following the surveyor's line.



Anchoring the Pad

Edge clamps and stake assemblies are used to secure matting on all four sides. The stakes are placed along the outer edges and spaced 12 feet apart. There are four types of edge clamps in the F-28 pallet one for each of the four different edges of mat. With the edge clamps in place, insert the anchor stake through the hole in the edge clamp. Use a sledgehammer or paving breaker to drive the stake into the ground. The edge clamp required for each mat edge is

- 9 - TYPE 1 clamps to anchor the female edge
- 8 - TYPE 2 clamps to anchor the male edge
- 8 - TYPE 3 clamps to anchor the down-turned prongs
- 8 - TYPE 4 clamps to anchor the upturned prongs

Landing Zone Construction

Landing Zone

This type of facility, normally located in the battle area, represents the minimum cleared area at which a helicopter can land to discharge or pick up passengers and/or cargo under conditions existing at the time of use. Geometric requirements are kept to the absolute minimum. A landing zone (LZ) is the ground area used for landing a helicopter-borne force and its supplies. LZs are designated by code names such as birds, animals, or trees. The LZ itself will be broken down internally into two areas:

- Landing sites
- Landing points

Landing Sites

A landing site is a specified area in the LZ where one to four helicopters can land at the same time. The helicopter-borne unit as a tactical control measure to land certain subordinate units in specific locations uses landing sites within the zone. The number of landing sites required for an operation depends upon the mission, terrain, and number of aircraft using the zone. Landing sites are designated by an assigned color such as green, blue, white, and yellow.

Landing Points

A landing point is a specified ground area in the landing site where one helicopter lands or picks up a load. A two-digit number designates the landing points within a landing site.

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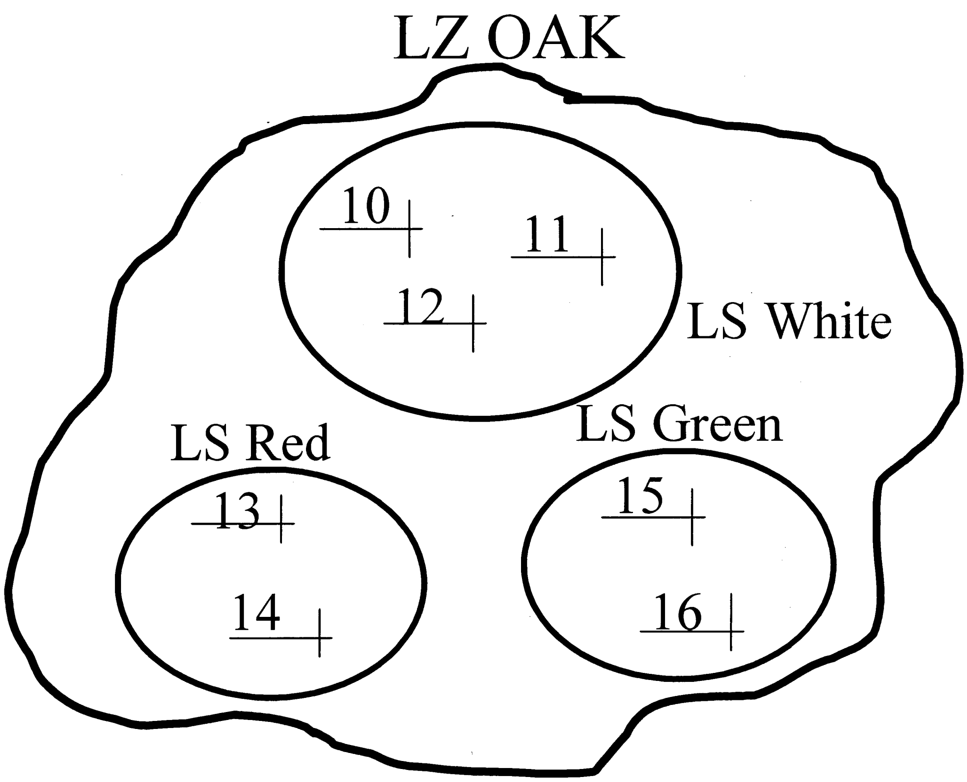
Typical Landing Zone

The illustration below shows a landing zone.



Landing Zone Selection

The supported or receiving unit commander, in coordination with the aviation unit liaison officer, if available, selects the location of the tactical landing zone. The aviation liaison officer or aircraft pilot makes the final decision concerning the minimum requirements or the suitability of the zones. There are several factors that should be considered in the selection of a landing zone such as security and concealment and convenience.

Security and Concealment

In a tactical situation, LZs should be shielded from enemy observation by masking terrain or in wooded areas. Artificial camouflage measures should also be utilized to conceal the LZ.

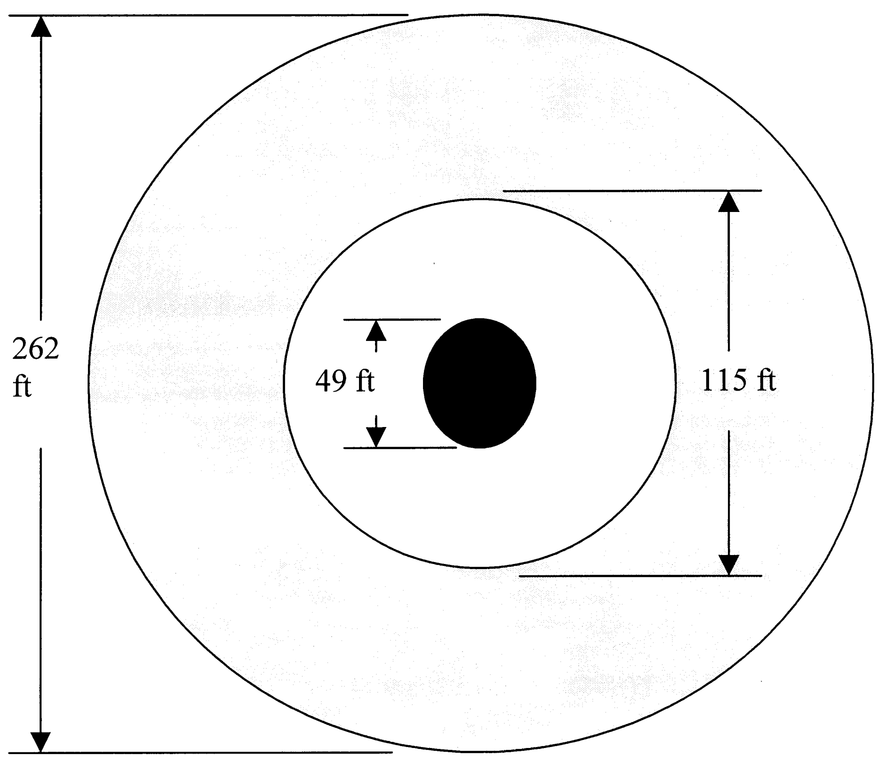
Continued on next page

Convenience

Landing sites that are used primarily for supply or resupply should be located near storage or supply points to reduce ground movement of cargo after it is delivered.

Size

The appropriate LZ size is determined by the type and number of helicopters as well as by the obstructions around the site. The area required for each landing point can be determined by comparing the helicopter size to the "bulls-eye" chart. This is the minimum size required for each landing point. To provide maneuvering space between helicopters, the distance between landing points should be 2 to 4 times the rotor diameter of the largest aircraft utilizing the landing point. This distance is measured from the center of each point. The height of the surrounding obstructions also affects the distance separating the landing points. Below is a "bulls-eye" chart for UH1 and AH-1 helicopters.



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Approaches And Departures

It is not desirable to establish LZs that require the helicopter to take off straight up and down since this decreases their allowable payload. In other words, once the load is well clear of the ground, the helicopter will require less power if it can take-off with some forward airspeed. To allow for this, landing sites should be clear of high obstructions (30 feet or higher) for at least 150 feet from the landing site. If the landing site is located where it is likely to be sheltered from the prevailing winds, the cleared area should extend to 300 feet. This increased area allows the helicopter to gain forward speed so that it can begin climbing without using all of its power. The rule that must be maintained is the 10:1 ratio rule. This means that for every one foot of obstruction height, there must be ten feet of distance from the center of the landing point. This ratio should be maintained for a distance of 1500 feet.

Determining Obstruction Height

One field method for determining an obstructions height is known as the "Triangulation" or "Off Set" method. Follow the steps below to perform the triangulation method.

Step	Action
1	Have one Marine stand at the center/base of the obstruction, for instance at the base of a tree.
2	Holding a straight object such as a pen at arms length, position yourself so that the tip of the pen is at the highest point of the obstruction and the bottom of the pen is at the Marines feet.
3	Turn the pen at a 90-degree angle left or right. The base of the pen should still be at the Marines feet.
4	Have the Marine face 90 degrees to his/her left or right. Instruct the Marine to walk forward until his/her feet are at the tip of the pen and halt.
5	Mark the spot where the Marine stopped and measure the distance to the base of the tree. This distance is equal to the height of the obstruction.

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Other Considerations

Other considerations include wind direction, slope, and surface conditions.

Wind Direction

Since helicopters can take-off and hover with less power when they are headed into the wind, landing sites should be set up to allow for a 12 o'clock wind direction into the helicopter. Otherwise, adequate space should be provided at each landing point to maneuver the aircraft into the wind.

Slope

Although helicopters can touchdown hover (one or two wheels are placed on the ground, but not all of the wheels) on any sloping ground which also provides the necessary rotor clearance on the uphill side, landing sites should be kept as level as possible. When selecting the landing site, the ground slope must be no more than 15 degrees. Helicopters cannot safely land on a slope of more than 15 degrees.

Surface Conditions

Dry, barren areas should be avoided because they create dust clouds when the helicopter lands which can blind both the aircrew and the ground crew. In addition, the debris from the dust clouds could damage the helicopter engines. In general, areas of hard surface or grass make the best natural landing areas.

Landing Site Preparation

Each landing point must be level and firm enough to keep a fully loaded aircraft's landing gear from sinking into the ground. The ground is firm enough for UH-1 helicopters if it can support a 1 ¼-ton truck. If the ground can support a 5-ton truck, CH-46 and CH-53 helicopters can land without risk of sinking.

The use of the trafficability test set provides an accurate means of determining the soils carrying capacity. The entire landing point must be cleared of any loose material and debris to prevent it from being blown into the ground crew or rotor blades, or drawn into the helicopter engines. All trees, brush, stumps, or other obstacles that could cause damage to the rotor blades or the underside of the aircraft must be cleared around the landing points. If trees must be cut, stumps in the immediate vicinity of the landing points must not exceed 10" in height on level ground. All holes should be filled in or marked. It may be necessary to prepare the ground with some form of soil stabilizer or other material such as matting to reduce the amount of dust that is raised by the helicopter rotor wash. Hard-packed sod makes the best natural landing area.

Forward Arming and Refueling Point

Description

Forward arming and refueling point (FARP) is normally a temporary facility, transitory in nature, and established for a specific duration and mission. The ultimate objective of the FARP is to minimize the response time and reduce the turn around time of aircraft in support of sustained operations. Ideally, the FARP will be located 10 to 15 miles from the Forward Edge of the Battle Area (FEBA). This positioning is far enough to the rear to prevent enemy artillery fire from targeting the FARP, yet allows for quick turn around time for aircraft and logistical transportation supporting the operation. Concealment of operation from enemy observation plays a large role in selection of the site. The user unit, based upon analysis of the METT-TSL, will make the final decision on the actual location of the FARP.

Construction Considerations

When construction of a FARP has been deemed necessary, consider the following.

Consideration	Description
Spacing Between Aircraft	The space between refueling points must be great enough to the largest aircraft expected to utilize the facility. Normally, all types of helicopters refuel at the FARP. Therefore, the standard layout should accommodate aircraft in size up to the CH-53E.
Wind Direction	The FARP should be laid out so that aircraft can land, refuel and take off into the wind.
Vapor Collection	Fuel vapors are heavier than air and will pool in a depression or hollow. If the ground slopes, arrange the FARP with the equipment on the higher ground.
Drainage	Ensure that the area drains away from the FARP equipment, and refueling points in the event of a fuel spill or sudden rainfall.
Foreign Object Debris (FOD)	Ensure the area is clear of any loose debris or FOD producing material.
Obstacles	The criteria for landing zone construction will apply in the take off and landing zones. Further, ensure there are no protrusions or depressions exceeding 10 inches.
Ground slope	Landing points within the FARP should not exceed 5 degrees.
Soil	Utilize areas that provide minimum soil disturbance.
Access Roads	When possible, use areas that maximize available access roads. Roads should be capable of supporting a 5,000-gallon refueling truck (max load) if trucks will be replenishing fuel stores.

Continued on next page

Layout

The FARP is broken down into four specific areas:

- Arming/de-arming
- Pre-refueling
- Refueling
- Post refueling

The distances between the specific areas within the FARP should be great enough to avoid conflicts of airspace. The following are some recommended spacing, and layout designs.

Area	Description
Arming/de-arming	Area in which aircraft will be de-armed prior to refueling.
Pre-refueling	Area where aircraft will position themselves when all refueling points are full. This area should be within the visual range of the FARP, and be large enough to contain a division of aircraft. The use of this area will prevent aircraft from having to orbit the FARP. The size of the refueling area will be limited by the logistical capability of the supporting unit.
Refueling	Area where the actual refueling of aircraft will take place. The size of the refueling area will be limited by the logistical capability of the supporting unit.
Post-refueling	Area for aircraft to stage themselves after they have refueled and are waiting for their wingmen to join.

Lesson 3 Exercise

Directions

Complete exercise items 1 through 4 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

Which one is a classification of an airfield in a tactical environment?

a. Landing zone
b. Air station
c. Auxiliary field
d. Main base

Item 2

The required placement of stakes for various matting during construction of VTOL pads is along the outer edges every ___ feet.

a. 4
b. 8
c. 12
d. 16

Item 3

To provide maneuvering space between helicopters, the distance between landing points should be ____________ times the rotor diameter of the largest aircraft utilizing the landing point.

a. 2 to 4
b. 3 to 5
c. 5 to 7
d. 6 to 8

Continued on next page

Item 4

What are the four areas within a FARP site?

a. Arming/de-arming, reloading, refueling, and post refueling
b. Arming/de-arming, pre-refueling, refueling, and post refueling
c. Re-arming, pre-refueling, refueling, and post refueling
d. Re-arming, reloading, refueling, and post refueling

Continued on next page

Lesson 3 Exercise, Continued

Solutions

The table below lists the answers to the exercise items. If you have any questions, refer to the reference page listed for that item.

Item Number	Answer	Reference Page
1	d	3-44
2	c	3-53
3	a	3-56
4	b	3-60

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LESSON 4

MK-153 SHOULDER-LAUNCHED MULTIPURPOSE ASSAULT WEAPON

Introduction

Scope

This lesson describes the process and procedures for familiarization and operation of the MK-153 Shoulder-Launched Multipurpose Assault Weapon (SMAW).

Purpose

The purpose of this lesson is to provide you with the knowledge to successfully employ the MK-153 SMAW.

Learning Objectives

At the end of this lesson, you should be able to

- Identify the MK-153 SMAW.
- Identify the maximum effective range of the MK-153 SMAW.
- Identify the immediate action for the MK-153 SMAW.
- State the four types of rockets available for use in the MK-153 SMAW.

In This Lesson

This lesson contains the following topics:

Characteristics

General

The MK-153 SMAW (shown below) is a shoulder fired, multipurpose assault weapon used for short-range bunkers and armored vehicle engagement. It is a reusable 83.5mm smoothbore, recoilless rocket launcher, equipped with a 9mm spotting rifle. It can fire multiple types of 83mm rockets for different missions.

The SMAW has two modes of operation:

- Spotting
- Launch

Spotting

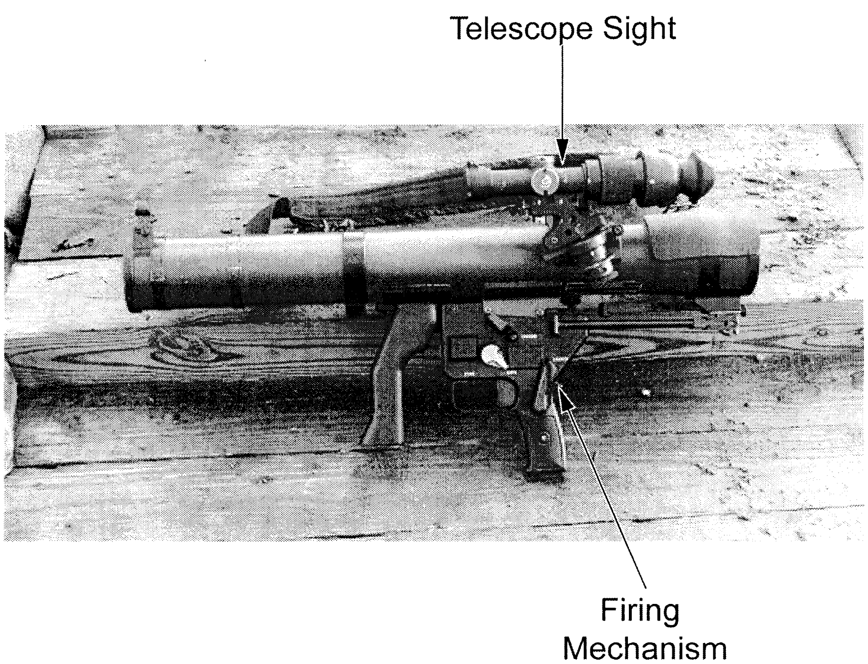
In the spotting mode, the gunner fires the spotting rounds.

Launch

In the launch mode, the gunner has launch capabilities for the rocket.

MK-153 SMAW

The illustration below shows the MK-153 SMAW.



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Specifications

There are several areas of the SMAW with their own specifications:

- Launcher
- Spotting rifle
- Telescopic sight
- Rockets
- Effective Range

The SMAW has an operating range from -40° F to 140° F. The table below shows the areas of SMAW and their specifications.

Area	Specifications
Launcher	Length: 760mm (29.92 inches) Weight: 7.69kg (16.92 lbs.)
Spotting rifle	Length: 694mm (27.3 inches) Weight: 1.7kg (3.74 lbs.) Caliber: 9mm (0.354 inches)
Telescopic sight	Length: 200 cm (7.9 inches) Weight: 0.9 kg (1.99 lbs.) Magnification: 3.8x Field of View: 6 degrees
Rockets	Dual Mode Rocket: 29.01 lbs HEAA Rocket: 29.16 lbs Novel Explosive Rocket: 30.8 lbs
Effective Range	Open Sights: 17meters (min.) to 250 meters (max.) With HEAA Rocket: 17meters (min.) to 500meters (max.)

Nomenclature

Launch Tube

The launch tube is a smooth bore fiberglass tube with a 83.5mm internal diameter. For structural support, protective metal rings have been placed on each end of the launch tube. A cheek pad has also been attached to the launch tube to provide facial support when using the open sights.

Front Open Sight

The front open sight is mounted on the protective metal ring. It consists of a post protected by a metal guard. It is adjustable by armory personnel using a special tool.

Rear Open Sight

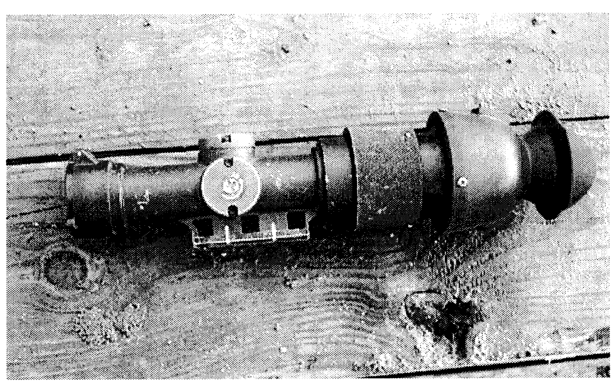
The rear open sight consists of a metal "U" shaped notch through which the front post is aligned with the target. It is not adjustable.

Bipod

The bipod has two folding legs that are mounted to the rear-reinforcing ring on the underside of the shoulder rest mount. These legs fold along the underside of the launch tube, rotate rearward, and spread to a 60-degree angle locking position to support the center of gravity of the loaded weapon. The gunner uses the bipod only when firing from the prone position.

Telescopic Sight

The telescopic sight (shown below) is a 3.8 power sight with a 6-degree field of view, which is used for day and low light operation. The eye-guard can be turned to fit the gunner's face. An armorer does vertical and horizontal adjustments. The sight base has two holes in it for mounting on the sight mount. The aft hole is used when firing the SMAW with a gas mask.



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Sight Mount

The sight mount is designed to accommodate either the telescopic sight or the AN/PVS-17 night vision sight. The sight mount is attached to the left side of the launcher and positions the sights during their use. The mount is equipped with an outer drum and an inner drum for setting the correct super elevation on the sight. For each rocket, the range indicator has two marks:

- White for normal/hot temperature above 32 degrees F (0 degrees C)
- Blue for cold temperatures (32 degrees F and below)

The sight mount is also designed to accommodate the trajectory of up to four ballistically different rockets, if they are fielded. The outer drum, which selects the type of warhead, is spring-loaded and has locking detents so it will not be inadvertently turned during range selection. The inner drum, which selects the range to the target is gear driven, which allows it to be turned in either direction.

Spotting Rifle

The spotting rifle is attached to the right side of the launch tube by two mounting rings, which permits it to be bore-sighted to the launch tube and help it withstand rough handling. The spotting rifle has the following description:

- Semiautomatic, closed bolt, magazine fed weapon which fires a 9mm tracer round that is ballistically matched to travel the same trajectory as the rocket.
- The magazine holds six rounds and locks in place like a magazine for an M16.
- The magazine release lever located on the left side of the magazine well releases it.
- Equipped with a cocking lever to initially cock the firing pin and help clear or chamber rounds.
- A loaded magazine stored inside the forward end cap of an encased rocket to ensure its availability.
- Field stripped by the gunner for cleaning.

The SMAW is always laid on the spotting rifle unless the telescopic sight is removed.

Continued on next page

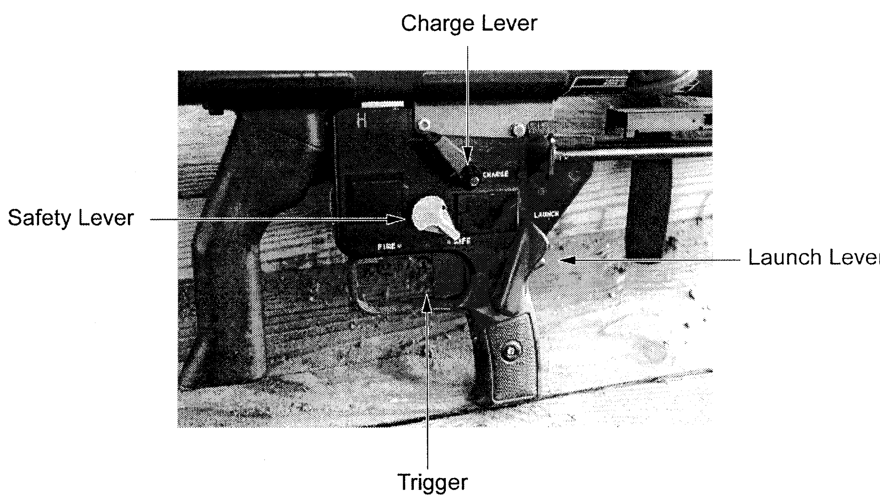
Shoulder Rest

The shoulder rest is mounted on the underside of the launch tube as part of the rear protective metal ring. It is a retractable shoulder rest consisting of a folding square metal bracket with two rubber pads which opens at a 90-degree angle when pulled rearward. When retracted, it folds into a channel flush with the underside of the launcher.

Firing Mechanism

The firing mechanism is mounted on the underside of the launch tube and is operated by the right hand. It contains the rocket firing mechanism and mechanical firing interface for the spotting rifle. The firing mechanism contains one trigger and three control levers:

- Safety
- Charge
- Launch



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Nomenclature, Continued

Control Levers The following table shows the trigger and control lever and function of each firing mechanism.

Lever	Function
Safety	A two-position lever located above and just forward of the trigger. It is marked **SAFE** and **FIRE**. In the **SAFE** position, it mechanically locks the trigger preventing the firing of either the spotting rifle or the rocket. In the **FIRE** position, it releases the trigger for normal operation.
Charge	A two-position lever located near the top center of the firing mechanism. It is marked only for the charged position. When the spotting rifle is cocked and the lever is placed in the **CHARGE** position, it remains there until the rocket is launched. Once charged, the **CHARGING LEVER** is locked into place by a mechanical sear. It cannot be returned to its "at rest" position by hand. When the charging lever is at the "at rest" position, either the spotting rifle or the rocket can be fired.
Launch	A spring-loaded lever marked only for the launch position. It is operated by the gunner's thumb. When the **LAUNCH LEVER** is depressed and the trigger is squeezed, an electrical firing impulse is sent to the rocket.
Trigger	Located above and in front of the handgrip. Depending on the position of the three control levers, the **TRIGGER** will either be locked, set to fire the spotting rifle, or set to launch the rocket.

Carrying Strap The carrying strap is an adjustable strap that is attached to both the forward and rear spotting rifle attachment rings. The strap permits the gunner to carry the SMAW.

Reticle The reticle is a mark such as a cross or a system of lines lying in the image plane of a viewing apparatus. It may be used singly as a reference mark on certain types of monocular instruments. It could be in the form of a cross, broken "T," a dot, or a series of cross lines in a scope. In the case of the telescopic sight, the reticle is a set of crosshairs with evenly spaced reference lines on the crosshairs.

Employment

Minimum Engagement Ranges

Targets may be engaged at shorter ranges than these but only if the gunner fires from a protective position. Other personnel on or close to the firing line should also be in a defilade position. The minimum target engagement is 17 meters.

Ammunition	Brick/Cement/Sandbags	Steel/ Metal
Tactical Rocket	Combat – 50 meters Training – 100 meters	Combat – 80 meters Training – 150 meters
Tracer Cartridge	Combat – 50 meters Training – 50 meters	Combat – 50 meters Training – 50 meters

Firing Site Selection

There are three areas to be considered when choosing a site from which to fire a SMAW:

- Back blast
- Field of fire
- Open area

Back Blast

The back blast is to ensure friendly troops are clear of the back blast area. The back blast area of the SMAW extends 90 meters to the rear of the launcher and is broken down into two sections. The danger area extends 30 meters to the rear of the launcher at an angle of 60 degrees. No personnel should be allowed in this area because severe injury will be sustained. The caution area extends 60 meters beyond the danger area. No personnel should be allowed in this area because of possible injury from flying debris. Hearing protection is mandatory for all personnel within 100 meters of either side of the weapon system. During training, the gunner is allowed to fire only five (5) rockets per day (with single hearing protection) because the sound pressure causes hearing loss.

Continued on next page

Field of Fire

The field of fire (down range) should be clear of obstructions such as trees, heavy brush, or power lines. These obstructions may deflect the rocket, damage fins, or cause premature detonation of the warhead.

Open Area

The open area should be clear of obstructions and loose objects for at least 30 meters. Solid obstructions can deflect shock waves and loose objects back toward the gunner. It is not recommended that the SMAW be fired from inside any enclosure. The blast, concussion, noise, toxic fumes, and fire would be dangerous to the gunner and anyone else inside the enclosure. Furthermore, the structure could structurally fail, resulting in injury to personnel.

Clear a MK-153 SMAW

Before loading and after unloading the weapon, always clear the SMAW to ensure that there is no ordinance in the weapon and that it is a complete safe weapon. This includes clearing both the launch tube and the spotting rifle.

MK-153 Spotting Rifle and Launcher

Follow the steps below to load the spotting rifle and launcher:

Step	Action
1	Clear the MK-153 SMAW spotting rifle and launch tube.
2	Assume a load position with the launcher across lap and the firing mechanism up ensuring the weapon is on safe.
3	Grasp the rocket with one hand and remove the end cap with the other hand.
4	Remove the magazine from the end cap.
5	Insert the rocket into the launcher, rotating clockwise until it is locked into place.
6	Insert the magazine into the magazine well and ensure it is properly seated.
7	Place the launcher into shoulder.

Continued on next page

Prepare to Fire

The following table provides the steps for preparing to fire the MK-153 SMAW:

Step	Action
1	Assume a firing position.
2	Acquire a target using the telescopic sight or open sight.
3	Estimate range to target.
4	Set the estimated range on the inner selector drum.
5	Ensure the temperature on the outer selector drum is set.
6	Pull the cocking handle to the rear and release.
7	Place the charging lever to the CHARGE position.
8	Place the weapon in the "fire" position.

Unloading

To unload the SMAW, ensure the muzzle is pointed down range and follow the steps below:

Step	Action
1	Place the weapon on SAFE, remove the magazine, and pull the cocking lever to the rear to inspect the chamber, sound off "clear."
2	Push in on the shoulder rest. Remove the encased rocket from the launcher by rotating it counterclockwise.
3	Reinstall the forward end cap on the encased rocket if not fired or dispose expended encasement if fired.

Firing Positions

There are four firing positions used for the MK-153 SMAW:

- Sitting
- Kneeling
- Standing
- Prone

Note: Each of the four firing positions can be used. Always check the back blast area to be sure it is clear of all personnel.

Continued on next page

Sitting

In the sitting position, the gunner will face the target. Sit with your legs crossed, lean slightly forward, and rest your elbows inside the knees to avoid bone-to-bone contact. This is the same as the sitting position you assume on the rifle range while firing the M16A2.

Kneeling

In the kneeling position, the gunner will face the target. Point the left leg and foot at the target (ensure the position you are in offers a maximum amount of stability) and place the fleshy part of the left arm (triceps) above the elbow on the left knee, eliminating bone-to-bone contact.

Standing

In the standing position, the gunner will face the target. Place the SMAW on your right shoulder (ensuring the shoulder rest is fully seated in your shoulder), spread your legs at a comfortable distance, and with the left hand, grasp the front pistol grip while the right hand grasp the firing mechanism grip. Press the elbows against your side for added stability. Aiming is done with the whole body. Ensure your body is square to the target.

Prone

The prone position differs from the rifle position because of the back blast. The gunner will face the target. Extend the bipod legs and lay down at an angle as close to 90 degrees to the launcher as possible (this keeps you clear of the back blast area). Keep your back straight with your right leg directly on line running through the right shoulder. Flatten your feet so that both heels are on the ground with your left leg moved out to a comfortable position.

Continued on next page

Engage Target

Follow the steps below to engage the target:

Step	Action
1	Select a firing site clear of obstructions and with a clear back blast area and assume a firing position.
2	Ensure the drum is set to HE.
3	Acquire a target using the telescopic sight or open sight.
4	Estimate range to target and set the estimated range on the inner drum.
5	Place weapon on “fire” position.
6	Fire spotting round at the target by squeezing the trigger without depressing the launch lever.
7	Observe tracer impact in relation to the sight reticule and adjust aiming point on target by moving weapon.
8	Repeat steps 6 and 7 until spotting rounds impact center mass of target.
9	Clear the back blast area by physically observing the area behind launcher and sounding off “Back blast area all secure, rocket.”
10	Depress the launch lever and squeeze the trigger to fire the rocket.
11	Place weapon on “safe” position.
12	Remove magazine by depressing the magazine release and pulling downwards on the magazine.
13	Pull the cocking handle to the rear and observe the chamber for brass and live ammunition.
14	Release the cocking handle.
15	Rotate the rocket encasement by pulling it to the rear and observe the inner portion of the launch tube for serviceability.

Sighting the Target

There are two types of sights used with the SMAW:

- Telescopic
- Open

When using either the telescopic or open sights, the first step the gunner should do is identify the target, then estimate range.

Continued on next page

Telescopic Sight

Once the gunner has estimated the range to the target with the telescopic sight, follow the steps below:

Step	Action
1	Set the estimated range on the inner drum. The outer drum is also used for determining the temperature and the type of round that you will use. The white indicator is used for temperatures above 32°F degrees F and the blue is used for temperatures below 32°F degrees. Assume a firing position.
2	Assume a firing position.
2	Aim by placing the cross hairs center and at the base of the target. Do not aim for doors or windows.
3	Fire the first spotting round and observe the impact. If there is no impact point, or a large error is observed, re-estimate the range to the target.
4	Fire the first spotting round and observe the impact. If there is no impact point, or a large error is observed, re-estimate the range to the target.
5	Adjust the impact by observing the tracer point of impact on the target in relation to the sight reticle. This point of impact on the sight reticle is now the adjusted aim point.
6	Adjust the subsequent shots by moving the reticle point (where the round impacted) to your desired impact point. Squeeze the trigger and continue holding the aim point until the tracer strikes the target. Observe the second tracer point of impact on the target in relation to the sight reticle. Repeat these steps until desired target impact point is observed. Six spotting rounds are contained in the magazine for impacting on the target.
7	Once the spotting rounds are impacting on the target, fire the rocket and observe the impact.

Continued on next page

Open Sights

The open sights are provided in case the telescopic sight becomes lost or damaged. Since this sight does not have range adjustment features, the gunner must remember that it is bore-sighted at 250 meters. The only time the gunner will hold the sights at center mass is when the target is actually 250 meters away. If the gunner is closer than 250 meters, the gunner will aim below or short of the target. If the target is further away than 250 meters, the gunner will aim above or over the target. Again, you have six (6) spotting rounds to get on target with. The principle of the open sight is the same as a pistol sight. When aiming, apply marksmanship principles of sight alignment and sight picture. Once your spotting rounds are on target, launch the rocket.

Immediate Action

Description

Sometimes, throughout the course of combat or training, your weapon may fail to function properly. It is important that you clear the malfunction so that you can continue the mission. The SMAW is two weapons combined to make one weapon. Both weapons are fired using the same firing mechanism and the same sights. However, both weapons have separate misfire procedures.

Spotting Rifle

There are several types of malfunction for the spotting rifle. The spotting rifle may fail to fire, extract, feed, and/or chamber a spotting round. All of these malfunctions should be cleared in the same manner. The steps below are for the spotting rifle:

Step	Action
1	Tap the magazine with the palm of the right hand.
2	Pull the cocking handles to the rear, and ensure a round is ejected.
3	Observe the chamber for brass and ammunition.
4	Release the cocking handle, chambering a new round.
5	Attempt to fire the spotting rifle again.

Continued on next page

Launcher

For misfires while using the rocket, follow the steps below:

Step	Action
1	Wait 15 seconds to ensure the rocket does not launch.
2	Release the launch lever and trigger and place the weapon on SAFE.
3	Charge the weapon.
4	Place weapon on FIRE and attempt to fire again.
5	Wait 15 seconds, if the weapon fails to fire again.
6	Release the launch lever and trigger, and place the weapon on SAFE.
7	Assume a kneeling position.
8	Rotate the SMAW upside down and place on the left knee.
9	Remove the rocket by turning the rocket counter clockwise and pulling it to the rear.
10	Rotate the rocket 180 degrees, replace the rocket into the SMAW, and rotate clockwise until seated.
11	Place weapon on FIRE and attempt to fire.
12	Wait 15 seconds, if the weapon fails to fire again.
13	Release the charging lever and trigger, and place the weapon on SAFE.
14	Remove the magazine by reaching around with your right hand and hitting the magazine release.
15	Pull the cocking lever to the rear to inspect and make sure the round extracts.
16	The A-gunner will visually inspect the chamber and if its clear, he will sound off "clear," the gunner will also visually inspect the chamber and if its clear he will then sound off "all clear."
17	Assume a kneeling position.
18	Remove the rocket by rotating counter clockwise.
19	Replace the forward end cap and place the rocket on the ground pointed down range.
20	Obtain a replacement rocket and attempt to fire.
21	If rocket fails to fire, obtain a replacement SMAW and attempt to fire.

Ammunition

Multiple Ammunitions

The SMAW is unique in that it fires two types of ammunition:

- 9mm spotting rounds
- 83mm rockets

Spotting Rounds

The spotting round consists of a 9mm tracer round crimped into a standard NATO 7.62 cartridge. The propellant is contained within a primed Winchester Hornet case inserted into the rear of the 7.62mm case. The tracer is visible out to approximately 500 meters.

Rockets

The rocket comes encased in a fiberglass launch container. The rocket motor is ignited electrically when the LAUNCH lever and the trigger are depressed. The forward end cap of the encased rocket has a copper band in it to shunt the electrical contacts of the rocket motor. A magazine of six rounds is located within the forward end cap. There are four types of rockets used with the SMAW:

- Practice MK 4 MOD 0
- Dual Mode MK 3 MOD 0
- HEAA
- Novel Explosive (NE)

Practice MK 4 MOD 0

The MK 4 MOD 0 has the same characteristics as the dual mode, except that it has an inert aluminum cased warhead. There are no explosives located inside of this warhead and it is used for training purposes only.

Continued on next page

Dual Mode MK 3 MOD 0

The dual mode MK 3 MOD 0 is designed to neutralize bunkers and urban targets. The rocket consists of

- A fast burning propellant motor propulsion system
- A fuse with safety and arming characteristics
- Aluminum cased high explosive warhead packed in a disposable fiberglass container
- 2.4 pounds of aluminized composition A-3 in the warhead
- Equipped with a dual mode fuse that allows it to determine whether a hard or soft target was hit. If a hard target was hit, the warhead will detonate upon impact. If a soft target was hit, the warhead will bury itself into the target prior to detonation.
- Maximum effective range of 250 meters and a maximum range of 400 meters
- Muzzle velocity of 220 meters per second and the warhead will become armed 6 to10 meters beyond the launch tube

HEAA

The high explosive anti-armor warhead (HEAA) is designed to provide a lethal penetration for armored targets. The outside case of the warhead is stainless steel, which houses a copper liner and explosive charge of a sedimentation cast octal. The HEAA has an optimum range of 500 meters and a maximum effective range of 500 meters. The HEAA has a muzzle velocity of 208 meters per second and is armed 10-17 meters beyond the launch tube.

Novel Explosive

The novel explosive is the newest rocket in the inventory for the SMAW. It is 1.7 pounds heavier than the MK-3 MOD 0 rocket and designed to provide enhanced-blast lethality to defeat personnel in structures. Ideally, the penetrating warhead would be fired into a building by either penetrating the side or through an opening, and then detonating. The detonation produces pressure and heat sufficient to neutralize personnel in a two-story structure. The novel explosive warhead has a peak pressure at detonation and an impulse (sustained pressure) for a period of time as a result of the reverberating explosive material and the re-ignition of the explosive from superheated aluminum particles with the oxygen in the air.

Lesson 4 Exercise

Directions

Complete items 1 through 4 by performing the action required. Check your answers against those listed at the end of this lesson.

Item 1

The MK-153 SMAW is a shoulder fired, multipurpose assault weapon used for ________ bunkers and armored vehicles engagement.

a. short-range
b. long-range
c. large
d. small

Item 2

What is the maximum effective range of the SMAW when using open sights?

a. 50 meters
b. 150 meters
c. 250 meters
d. 500 meters

Item 3

What is the first step of immediate action when a rocket misfires?

a. Wait 15 seconds to ensure the rocket doesn't launch.
b. Place weapon on FIRE and attempt to fire again.
c. Rotate the SMAW upside down and place on the left knee.
d. Pull the cocking handles to the rear and ensure a round is ejected.

Item 4

The four types of rockets for the MK153 SMAW are Practice MK _____ MOD 0, Dual Mode MK 3 MOD 0, HEAA, and Novel Explosive.

a. 4
b. 12
c. 20
d. 25

Continued on next page

Answers

The table listed below lists the answers to the exercise items. If you have any questions about these items, refer to the reference page listed for that item.

Item Number	Answer	Reference
1	a	4-66
2	c	4-78
3	a	4-80
4	a	4-81

Appendix A

Metric Conversion Chart

This appendix complies with current Army directives which state that the metric system will be incorporated into all new publications. Table A-1 is a conversion chart.

Table A-1. Metric conversion chart

US Units	Multiplied By	Metric Units
Acres	0.4947	Hectares
Cubic feet	0.0283	Cubic meters
Cubic inches	16.3872	Cubic centimeters
Cubic inches	0.0164	Liters
Cubic yards	0.7646	Cubic meters
Feet	0.3048	Meters
Feet per second	18.288	Meters per minute
Gallons	3.7854	Liters
Inches	2.54	Centimeters
Inches	0.0254	Meters
Inches	25.4001	Millimeters
Miles	1.6093	Kilometers
Square feet	0.0929	Square meters
Square inches	6.4516	Square centimeters
Square miles	2.590	Square kilometers
Square yards	0.8361	Square meters
Yards	0.914	Meters
Metric Units	**Multiplied By**	**US Units**
Centimeters	0.3937	Inches
Cubic centimeters	0.0610	Cubic inches
Cubic meters	35.3144	Cubic feet
Cubic meters	1.3079	Cubic yards
Kilometers	0.62137	Miles
Meters	3.2808	Feet
Meters	39.37	Inches
Meters	1.0936	Yards
Millimeters	0.03937	Inches
Square centimeters	0.155	Square inches
Square kilometers	0.3861	Square miles
Square meters	1.1960	Square yards
Square meters	10.764	Square feet

Appendix B

Bridge Classification

Bridge and vehicle classification allows vehicle operators to avoid bridge failure due to overloading. Vehicle operators may drive across without restrictions if their vehicles' class numbers are less than or equal to the bridge class number. This appendix provides a quick method of estimating bridge capacity in the field.

BRIDGE SIGNS

All classified vehicles and bridges in the theater of operations require classification signs. Bridge signs are circular with a yellow background and black inscriptions. Sign diameters are a minimum of 16 inches for one-lane bridges and 20 inches for two-lane bridges. A two-lane bridge classification sign has two numbers, side by side, on its sign (see Figure B-1). The number on the left is the bridge classification when both lanes are in service simultaneously. The number on the right indicates the classification if the bridge is carrying one-way traffic and the vehicles proceed along the centerline of the bridge. For bridges with separate classifications for wheeled and tracked vehicles (dual classification), use a special circular sign that indicates both classifications (see Figure B-1, right side). Classify bridges greater than class 50 as dual-class bridges. Use a separate rectangular sign, if necessary, to show bridge width limitations.

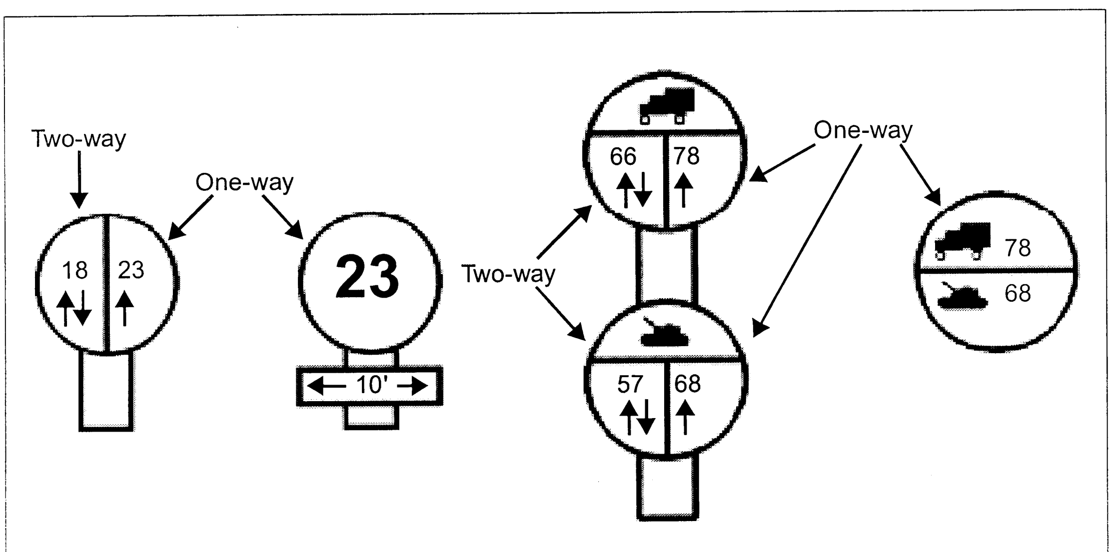


Figure B-1. Bridge classification signs

WIDTH AND HEIGHT RESTRICTIONS

Table B-1 lists width restrictions for bridges. If a one-lane bridge does not meet width requirements, post a rectangular warning sign under the classification sign showing the actual clear width. For a two-lane bridge, downgrade the two-way classification to the highest class for which it does qualify (one-way class is not affected). If the minimum overhead clearance is less than 4.3 meters, post a sign with the limited clearance.

Table B-1. Minimum roadway widths

Roadway Width (Meters)	Bridge Classification	
	One-Way	Two-Way
2.75 to 3.34	12	0
3.35 to 3.99	30	0
4 to 4.49	60	0
4.5 to 4.99	100	0
5 to 5.4	150	0
5.5 to 7.2	150	30
7.3 to 8.1	150	60
8.2 to 9.7	150	100
9.8+	150	150
NOTE: The minimum overhead clearance for all classes is 4.5 m.		

CLASSIFICATION PROCEDURES

Tables B-2 through B-9 and Figures B-2 through B-16, pages B-2 through B-26, are used to determine the bridge classification of various bridges.

Table B-2. Notations

Variable	Definition
b	stringer width, in inches
b_d	concrete slab width, in feet
b_e	effective slab width, in feet
b_{e1}	effective slab width for one-lane traffic, in feet
b_{e2}	effective slab width for two-lane traffic, in feet
b_R	curb-to-curb roadway width, in feet
d	stringer depth, in inches
d_f	depth of fill, in inches
d_i	interior stringer depth ($d - 2t_f$), in inches
f_{bDL}	allowable bearing stress of the stringer, in ksi
L	span length, in feet
L_c	maximum brace spacing, in feet
L_m	maximum span length, in feet
m	moment capacity per stringer, in kip-feet

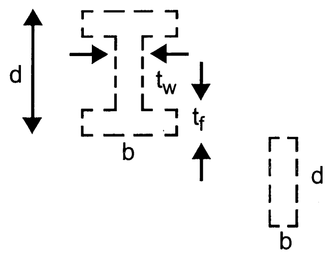
Table B-2. Notations (continued)

Variable	Definition
m_{DL}	dead-load moment per stringer, in kip-feet
M_{DL}	dead-load moment for entire span, in kip-feet
m_{LL}	live-load moment per stringer, in kip-feet
M_{LL}	live-load moment per lane, in kip-feet
M_{LL1}	live-load moment for one-lane traffic, in kip-feet
M_{LL2}	live-load moment for two-lane traffic, in kip-feet
N_b	number of braces
N_L	number of lanes
N_S	total number of stringers in the span
N_1	effective number of stringers for one-lane traffic
N_2	effective number of stringers for two-lane traffic
PLC	provisional load class
R	rise of arch, in feet
S	section modulus, in cubic inches
S_b	actual brace spacing, in feet
S_c	section modulus of the composite section, in cubic inches
S_s	center-to-center stringer spacing, in feet
t_c	crown thickness, in inches
t_d	average deck thickness, in inches
t_{eff}	effective deck thickness, in inches
t_f	flange thickness, in inches
t_{pl}	plate thickness, in inches
t_w	web thickness, in inches
t_x	thickness factor
T_1	one-lane, tracked-vehicle classification
T_2	two-lane, tracked-vehicle classification
v	shear capacity per stringer, in kips
v_{DL}	dead-load shear per stringer, in kips
V_{DL}	estimated dead-load shear of span, in kips
v_{LL}	live-load shear per stringer, in kips
V_{LL}	live-load shear per lane, in kips
W_s	stringer weight, in lbs/ft
W_1	one-lane, wheeled-vehicle classification
W_2	two-lane, wheeled-vehicle classification
X_{pl}	plate thickness factor
%lam	percent of lamination

Map Sheet Grid
Recon Officer/NCO Unit Date

BRIDGE DIMENSIONS

L _____ ft
b_R _____ ft
N_L _____ (2 if $b_R \geq 18$ ft)
N_S _____
S_S _____ ft
N_b _____
S_b _____ ft
Deck: Single-layer, multilayer, or laminated
t_d _____ in
%lam _____



STRINGER DIMENSIONS

Timber: b _____ in
d _____ in
Steel: Type _________
(Table B-4)
d _____ in
b _____ in
t_w _____ in
t_f _____ in

PROCEDURE

1. m _____ (Table B-3 or B-4)
2. M_{DL} _____ (Table B-5)
3. m_{DL} _____ (M_{DL} / N_s)
4. m_{LL} _____
   a. Timber: m - m_{DL}
   b. Steel: (m - m_{DL}) / 1.15
5. L_m _____ (Table B-3 or B-4)
6. Adjust m_{LL} if L > L_m: m_{LL} (L_m / L)
7. N_1 _____ (5 / S_s) + 1
8. N_2 _____ $0.375N_s$; calculate only if $b_R \geq 18$ ft
9. M_{LL1}_____ (N_1) m_{LL}
10. M_{LL2}_____ (smaller of N_1 or N_2) m_{LL}
11. Moment classification (Figures B-13 and B-14)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
12. v _____ (Table B-3 or B-4)
13. V_{DL} _____ (Table B-5)
14. v_{DL} _____ (V_{DL} / N_s)
15. v_{LL} _____ (v - v_{DL})
16. V_{LL} _____
    a. Timber:
    (16/3) (v_{LL}) ([N_1 or N_2] / [N_1 or N_2] + 1)
    b. Steel: (2v_{LL} / 1.15)
17. Shear classification (Figures B-15 and B-16)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
18. Width classification (Table B-2)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
19. Deck classification (Figure B-8)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
    a. Single-layer: $t_{eff} = t_d$
    b. Multilayer: $t_{eff} = t_d$ - 2 in
    c. Laminated: $t_{eff} = t_d$ (%lam)
20. $N_{b(reqd)}$ _____
    a. Timber: 3 required if $d \geq 2_b$
    b. Steel: (L / L_c) + 1 (L_c in Table B-4)
    Add braces if $N_b < N_{b(reqd)}$
21. Final classification

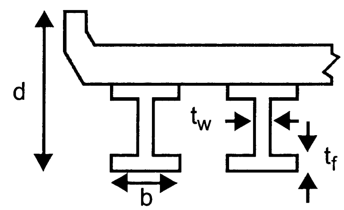
	T_1	T_2	W_1	W_2
Moment (Step 11)				
Shear (Step 17)				
Width (Step 18)				
Deck (Step 19)				
Final (lowest number)				

Figure B-2. Timber- or steel-trestle bridge with timber deck

Map Sheet Grid
Recon Officer/NCO Unit Date

BRIDGE DIMENSIONS

L _____ ft
b_R _____ ft
N_L _____ (2 if $b_R \geq 18$ ft)
N_S _____
S_S _____ ft
t_d _____ in (do not include wearing surface)



STRINGER DIMENSIONS

Type _______ (Table B-4)
b _____ in
d _____ in
t_w _____ in

PROCEDURE

1. m _____ (Table B-4)
2. W_s _____ (Table B-4)
3. m_{DL} _____ $0.00013L^2 (W_s + (t_d) S_s)$
4. m_{LL} _____ $(m - m_{DL}) / 1.15$
5. L_m _____ (Table B-4)
6. Adjust m_{LL} if $L > L_m$: $m_{LL} (L_m / L)$
7. N_1 _____ $(5 / S_s) + 1$
8. N_2 _____ $0.375N_s$; calculate only if $b_R \geq 18$ ft
9. M_{LL1}_____ $(N_1)\ m_{LL}$
10. M_{LL2}_____ (smaller of N_1 or N_2) m_{LL}
11. Moment classification (Figures B-13 and B-14)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
12. Width classification (Table B-2)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
13. Deck classification (Figure B-8)
    T_1 _____ T_2 _____ W_1 _____ W_2 _____
    a. $t_d < 5$ in: Class 40
    b. $t_d \geq 5$ in: Class 150
14. Final classification

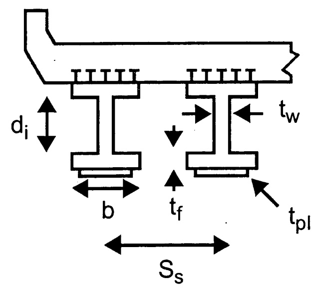
	T_1	T_2	W_1	W_2
Moment (Step 11)				
Width (Step 12)				
Deck (Step 13)				
Final (lowest number)				

Figure B-3. Steel-stringer bridge with concrete deck (noncomposite construction)

Map Sheet Grid
Recon Officer/NCO Unit Date

BRIDGE DIMENSIONS

L _____ ft
b_R _____ ft
N_L _____ (2 if $b_R \geq 18$ ft)
N_S _____
S_S _____ ft
t_d _____ in (do not include wearing surface)
S_c _____ (Table B-8)



STRINGER DIMENSIONS

Type _______ (Table B-4)
b _____ in
d _____ in ($d = d_i + 2t_f$)
t_w _____ in
t_f _____ in
S _____ in^3
t_{pl} _____ in
W_s _____ (steel type)

PROCEDURE

1. m_{DL} _____ $0.00013L^2 (W_s + (t_d) S_s)$
2. f_{bDL} _____ $12m_{DL} / [(S)(x_{PL})]$
   a. No plate: $x_{PL} = 1.00$
   b. $t_{pl} = 0.5t_f$: $x_{PL} = 1.25$
   c. $t_{pl} = t_f$: $x_{PL} = 1.50$
3. m_{LL} _____ $[(29 - f_{bDL})(S_c)(x_{PL})(t_x)] / 13.8$ (t_x from Table B-9)
4. N_1 _____ $(5 / S_s) + 1$
5. N_2 _____ $0.375N_s$; calculate only if $b_R \geq 18$ ft
6. M_{LL1}_____ $(N_1)\, m_{LL}$
7. M_{LL2}_____ (smaller of N_1 or N_2) m_{LL}
8. Moment classification (Figures B-13 and B-14)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____
9. Width classification (Table B-2)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____
10. Deck classification (Figure B-8)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____
   a. $t_d < 5$ in: Class 40
   b. $t_d \geq 5$ in: Class 150

11. Final classification

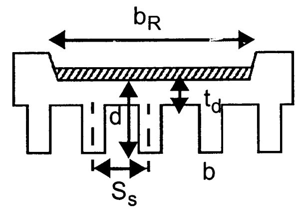
	T_1	T_2	W_1	W_2
Moment (Step 8)				
Width (Step 9)				
Deck (Step 10)				
Final (lowest number)				

Figure B-4. Concrete steel-stringer bridge (composite construction)

Map Sheet Grid
Recon Officer/NCO Unit Date

BRIDGE DIMENSIONS

L _____ ft
b_R _____ ft
t_d _____ in
S_S _____ ft
N_S _____



STRINGER DIMENSIONS

d _____ in
b _____ in

PROCEDURE

1. m _____ $0.0116 (S_s) (d^2)$
2. m_{DL} _____ $0.00013L^2 (b_d + (t_d) S_s)$
3. m_{LL} _____ $(m - m_{DL}) / 1.15$
4. N_1 _____ $(5 / S_s) + 1$
5. N_2 _____ $0.375N_s$; calculate only if $b_R \geq 18$ ft
6. M_{LL1}_____ $(N_1)\ m_{LL}$
7. M_{LL2}_____ (smaller of N_1 or N_2) m_{LL}
8. Moment classification (Figures B-13 and B-14)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____
9. Width classification (Table B-2)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____
10. Final classification

	T_1	T_2	W_1	W_2
Moment (Step 8)				
Width (Step 9)				
Final (lowest number)				

Figure B-5. Concrete T-beam bridge with asphalt wearing surface

Map Sheet | Grid
Recon Officer/NCO | Unit | Date

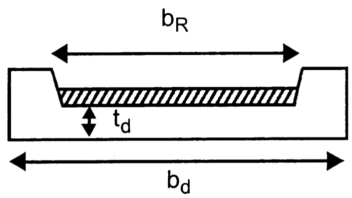
BRIDGE DIMENSIONS

L _____ ft

b_d _____ ft

b_R _____ ft

t_d _____ in (do not include wearing surface)



PROCEDURE

1. m_{LL} _____ (Figure B-10)
2. b_e _____
   a. One-lane:
      $b_{e1} = L / [0.75 + (L / b_d)]$
   b. Two-lane:
      $b_{e2} = L / [0.25 + (2L / b_d)]$
   (Calculate b_{e2} only if $b_R \geq 18$ ft)
3. M_{LL1}_____ (b_{e1}) m_{LL}
4. M_{LL2}_____ (b_{e2}) m_{LL}
5. Moment classification (Figures B-13 and B-14)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____
6. Width classification (Table B-2)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____

7. Final classification

	T_1	T_2	W_1	W_2
Moment (Step 5)				
Width (Step 6)				
Final (lowest number)				

Figure B-6. Concrete-slab bridge with asphalt wearing surface

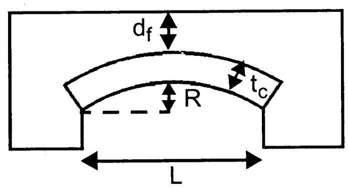
Map Sheet
Recon Officer/NCO

Grid
Unit

Date

BRIDGE DIMENSIONS

L _____ ft
t_c _____ ft
d_f _____ ft
b_R _____ ft
R _____ ft



PROCEDURE

1. PLC _____ (Figure B-11)
2. Arch factors:
   a. Span-to-rise ratio (SR = L / R) _____
   b. Profile factors (Table B-6) _____
   c. Material factors (Table B-7) _____
   d. Joint factors (Table B-7) _____
   e. Deformations (Table B-7) _____
   f. Crack factors (Table B-7) _____
   g. Abutment size factors (Table B-7) ____
   h. Abutment fault factors (Table B-7) ____
3. Classification of arch factors:
   T_1 _____ (PLC x product of factors 2b through 2h)
   T_2 _____ ($0.9T_1$)
   W_1 _____ (Figure B-12)
   W_2 _____ (Figure B-12)
4. Width classification (Table B-2)
   T_1 _____ T_2 _____ W_1 _____ W_2 _____

5. Final classification

	T_1	T_2	W_1	W_2
Factors (Step 3)				
Width (Step 4)				
Final (lowest number)				

Figure B-7. Masonry-arch bridge

Table B-3. Properties of timber stringers

Rectangular Stringers			
Nominal Size (b x d, in)[1]	m (kip-ft)[2]	v (kips)[3]	L_m (ft)[4]
4 x 6	4.80	2.40	7.14
4 x 8	8.53	3.20	9.50
4 x 10	13.33	4.00	11.90
4 x 12	19.20	4.80	14.30
6 x 8	12.80	4.80	9.50
6 x 10	20.00	6.00	11.90
6 x 12	28.80	7.20	14.30
6 x 14	39.20	8.40	16.70
6 x 16	51.20	9.60	19.10
6 x 18	64.80	10.80	21.50
8 x 8	17.07	6.40	9.50
8 x 10	26.70	8.00	11.90
8 x 12	38.40	9.60	14.30
8 x 14	52.30	11.20	16.70
8 x 16	68.30	12.80	19.10
8 x 18	86.40	14.40	21.50
8 x 20	106.70	16.40	23.80
8 x 22	129.10	17.60	26.20
8 x 24	153.60	19.20	28.60
10 x 10	33.30	10.00	11.90
10 x 12	48.00	12.00	14.30
10 x 14	65.30	14.00	16.70
10 x 16	85.30	16.00	19.10
10 x 18	108.00	18.00	21.50
10 x 20	133.30	20.00	23.80
10 x 22	161.30	22.00	26.20
10 x 24	192.00	24.00	28.60
12 x 12	57.60	14.40	14.30
12 x 14	78.40	16.80	16.70
12 x 16	102.40	19.20	19.10
12 x 18	129.60	21.60	21.50
12 x 20	160.00	24.00	23.80
12 x 22	193.60	26.40	26.20
12 x 24	230.00	28.80	28.60
14 x 14	91.50	19.60	16.70
14 x 16	119.50	22.40	19.10
14 x 18	151.20	25.20	21.50
14 x 20	186.70	28.00	23.80
14 x 22	226.00	30.80	26.20
14 x 24	269.00	33.60	28.60

Rectangular Stringers			
Nominal Size (b x d, in)[1]	m (kip-ft)[2]	v (kips)[3]	L_m (ft)[4]
16 x 16	136.50	25.60	19.10
16 x 18	172.80	28.80	21.50
16 x 20	213.00	32.00	23.80
16 x 22	258.00	35.20	26.20
16 x 24	307.00	38.40	28.60
18 x 18	194.40	32.40	21.50
18 x 20	240.00	36.00	23.80
18 x 22	290.00	39.60	26.20
18 x 24	346.00	43.20	28.60
Round Stringers (Nominal Size is Diameter)			
8	10.05	5.70	9.50
9	14.31	7.20	10.70
10	19.63	8.80	11.90
11	26.10	10.60	13.10
12	33.90	12.70	14.30
13	43.10	15.00	15.50
14	53.90	17.40	16.70
15	67.50	20.20	17.80
16	80.40	22.60	19.10
17	98.20	26.00	20.20
18	114.50	28.60	21.50
19	137.10	32.40	22.60
20	157.10	35.40	23.80
21	185.20	39.60	24.90
22	209.00	42.70	26.20
23	243.00	47.60	27.30
24	271.00	50.80	28.60
25	312.00	56.20	29.70
26	351.00	60.80	30.90
27	393.00	65.60	32.10
28	439.00	70.50	33.30
29	487.00	75.60	34.50
30	540.00	81.00	35.70
31	595.00	86.40	36.80
32	655.00	92.10	38.00
33	718.00	98.00	39.20
34	786.00	104.00	40.40
35	857.00	110.20	41.60
36	933.00	116.60	42.80

[1] If $d > 2b$, bracing is required at the midspan and at both ends.

[2] Moment capacity for rectangular stringers not listed is $bd^2/30$. Moment capacity for round stringers not listed is $0.02d^3$.

[3] Shear capacity for rectangular stringers not listed is $bd/10$. Shear capacity for round stringers not listed is $0.09d^2$.

[4] Maximum span length for stringers not listed is $1.19d$.

Table B-4. Properties of steel stringers (F_y = 36 ksi, f_b = 27 ksi, f_v = 16.5 ksi)

Nominal Size	d (in)	b (in)	T_f (in)	t_w (in)	m (kip-ft)	v (kips)	L_m (ft)	L_c (ft)
W39x211	39.250	11.750	1.438	0.75	1,770	450	100	12.4
W37x206	36.750	11.750	1.438	0.75	1,656	425	95	12.4
W36x300	36.750	16.625	1.688	0.94	2,486	520	94	17.6
W36x194	36.500	12.125	1.250	0.81	1,492	431	93	12.8
W36x182	36.375	12.125	1.187	0.75	1,397	406	93	12.8
W36x170	36.125	12.000	1.125	1.06	1,302	381	92	12.7
W36x160	36.000	12.000	1.000	1.06	1,217	365	92	12.7
W36x230	35.875	16.500	1.250	0.75	1,879	421	91	17.4
W36x150	35.875	12.000	0.937	0.62	1,131	350	91	12.7
W36x201	35.375	11.750	1.438	0.75	1,545	402	90	12.4
W33x196	33.375	11.750	1.438	0.75	1,433	377	85	12.4
W33x220	33.250	15.750	1.250	0.81	1,661	392	85	16.6
W33x141	33.250	11.500	0.937	0.62	1,005	313	85	12.1
W33x130	33.125	11.500	0.875	0.56	911	300	85	12.1
W33x200	33.000	15.575	1.125	0.56	1,506	362	84	16.6
W31x180	31.500	11.750	1.312	0.75	1,327	327	80	12.4
W30x124	30.125	10.500	0.937	0.68	797	273	77	11.1
W30x116	30.000	10.500	0.875	0.62	738	263	76	11.1
W30x108	29.875	10.500	0.750	0.56	672	255	76	11.1
W30x175	29.500	11.750	1.312	0.56	1,156	304	75	12.4
W27x171	27.500	11.750	1.312	0.68	1,059	282	70	12.4
W27x102	27.125	10.000	0.812	0.68	599	217	69	10.6
W27x94	26.875	10.000	0.750	0.50	546	205	68	10.6
W26X157	25.500	11.750	1.250	0.50	915	237	65	12.4
W24x94	24.250	9.000	0.875	0.62	497	191	62	9.5
W24x84	24.125	9.000	0.750	0.50	442	174	61	9.5
W24x100	24.000	12.000	0.750	0.50	560	173	61	12.7
S24x120	24.000	8.000	1.125	0.50	564	286	61	8.4
S24x106	24.000	7.875	1.125	1.18	527	224	61	8.3
S24x80	24.000	7.000	0.875	0.62	391	183	61	7.4
W24x76	23.875	9.000	0.687	0.50	394	163	61	9.5
W24x153	23.625	11.750	0.250	0.43	828	217	60	12.4
S24x134	23.625	8.500	1.250	0.62	634	283	60	9.0
S22x75	22.000	7.000	0.812	0.81	308	168	56	7.4
W21x139	21.625	11.750	1.187	0.50	699	198	55	12.4
S21x112	21.625	7.875	1.187	0.62	495	238	55	8.3
W21x73	21.250	8.250	0.750	0.75	338	148	54	8.7
W21x68	21.125	8.250	0.687	0.50	315	140	54	8.7
W21x62	21.000	8.250	0.625	0.43	284	130	53	8.7

Table B-4. Properties of steel stringers (continued)
(F_y = 36 ksi, f_b = 27 ksi, f_v = 16.5 ksi)

Nominal Size	d (in)	b (in)	T_f (in)	t_w (in)	m (kip-ft)	v (kips)	L_m (ft)	L_c (ft)
S20x85	20.000	7.125	0.937	0.37	337	195	51	7.5
S20x65	20.000	6.500	0.812	0.68	245	132	51	6.9
W20x134	19.625	11.750	1.187	0.43	621	177	50	12.4
W18x60	18.250	7.500	0.687	0.62	243	115	46	7.9
S18x86	18.250	7.000	1.000	0.43	326	184	46	7.4
W18x55	18.125	7.500	0.625	0.37	220	108	46	7.9
S18x80	18.000	8.000	0.937	0.50	292	133	46	8.4
W18x50	18.000	7.500	0.562	0.37	200	99	46	7.9
S18x55	18.000	6.000	0.687	0.50	199	126	46	6.3
S18x122	17.750	11.750	1.062	0.56	648	145	45	12.4
S18x62	17.750	6.875	0.750	0.37	238	100	45	7.3
S18x77	17.750	6.625	0.937	0.62	281	163	45	7.0
W16x112	16.750	11.750	1.000	0.56	450	136	42	12.4
S16x70	16.750	6.500	0.937	0.62	238	146	42	6.9
W16x50	16.250	7.125	0.625	0.37	181	94	41	7.5
W16x45	16.125	7.000	0.562	0.37	163	85	41	7.4
W16x64	16.000	8.500	0.687	0.43	234	106	40	9.0
W16x40	16.000	7.000	0.500	0.31	145	75	40	7.4
S16x50	16.000	6.000	0.687	0.43	155	105	40	6.3
W16x36	15.875	7.000	0.437	0.31	127	74	40	7.4
W16x110	15.750	11.750	1.000	0.56	345	127	40	12.4
S16x62	15.750	6.125	0.875	0.56	200	129	40	6.5
S16x45	15.750	5.375	0.625	0.43	150	104	40	5.7
W15x103	15.000	11.750	0.937	0.56	369	121	38	12.4
S15x56	15.000	5.875	0.812	0.50	173	110	38	6.2
S15x43	15.000	5.500	0.625	0.43	132	93	38	5.8
W14x101	14.250	11.750	0.937	0.56	344	114	36	12.4
S14x40	14.250	5.375	0.375	0.37	119	83	36	5.7
S14x51	14.125	5.625	0.750	0.50	150	104	36	5.9
S14x70	14.000	8.000	0.937	0.43	204	87	35	8.4
S14x57	14.000	6.000	0.875	0.50	153	101	35	6.3
W14x34	14.000	6.750	0.437	0.31	121	78	35	7.1
W14x30	13.875	6.750	0.375	0.25	109	61	35	7.1
W14x92	13.375	11.750	0.875	0.50	297	96	34	12.4
S14x46	13.375	5.375	0.687	0.50	126	99	34	5.7
S13x35	13.000	5.000	0.625	0.37	85	72	33	5.3
S13x41	12.625	5.125	0.687	0.37	108	104	32	5.4
W12x36	12.250	6.625	0.565	0.31	103	56	31	7.0
S12x65	12.000	8.000	0.937	0.43	182	73	30	8.4
W12x27	12.000	6.500	0.375	0.25	76	44	30	6.9

Table B-4. Properties of steel stringers (continued)
(F_y = 36 ksi, f_b = 27 ksi, f_v = 16.5 ksi)

Nominal Size	d (in)	b (in)	T_f (in)	t_w (in)	m (kip-ft)	v (kips)	L_m (ft)	L_c (ft)
S12x50	12.000	5.500	0.687	0.68	113	120	30	5.8
S12x32	12.000	5.000	0.562	0.37	81	62	30	5.3
S12x34	11.250	4.750	0.625	0.43	81	72	28	5.0
W11x76	11.000	11.000	0.812	0.50	202	67	28	11.6
S10x29	10.625	4.750	0.562	0.31	67	48	27	5.0
W10x25	10.125	5.750	0.437	0.25	59	38	25	6.1
S10x40	10.000	6.000	0.687	0.37	92	53	25	6.3
S10x35	10.000	5.000	0.500	0.62	65	88	25	5.3
S10x25	10.000	4.625	0.500	0.31	55	46	25	4.9
W10x21	9.875	5.750	0.312	0.25	48	36	25	6.1
W10x59	9.250	9.500	0.687	0.43	132	56	25	10.0
S9x25	9.500	4.500	0.500	0.31	51	43	24	4.8
S9x50	9.000	7.000	0.812	0.37	103	45	23	7.4
S8x35	8.000	6.000	0.625	0.31	65	34	20	6.3
S8x28	8.000	5.000	0.562	0.31	49	35	20	5.3
W8x31	8.000	8.000	0.437	0.31	61	33	20	8.4
W8x44	7.875	7.875	0.625	0.75	81	40	20	8.3
W7x35	7.125	7.125	0.562	0.37	58	37	18	7.5
W6x31	6.250	6.250	0.562	0.37	45	31	16	6.6

Table B-5. Dead-load moment and shear

L (ft)	Timber Stringer/Timber Deck				Steel Stringer/Timber Deck			
	One-Lane		Two-Lane		One-Lane		Two-Lane	
	M_{DL} (kip-ft)	V_{DL} (kips)	M_{DL} (kip-ft)	V_{DL} (kips)	M_{DL} (kip-ft)	V_{DL} (kips)	M_{DL} (kip-ft)	V_{DL} (kips)
70					649.26	37.10	1,133.13	64.75
65					538.68	33.15	937.42	57.69
60					441.00	29.40	765.00	51.00
55					355.44	25.85	614.45	44.69
50					281.25	22.50	484.38	38.75
45					217.69	19.35	373.36	33.19
40					164.00	16.40	280.00	28.00
38					145.12	15.28	247.85	26.03
36					127.66	14.18	217.08	24.12
34					111.55	13.12	189.30	22.27
32					96.77	12.10	163.84	20.48
30	91.13	12.15	160.88	21.45	83.25	11.10	140.63	18.75
28	76.24	10.89	134.06	19.15	70.95	10.14	119.56	17.08
26	63.04	9.70	110.36	16.98	59.83	9.20	100.56	15.47
24	51.41	8.57	89.57	14.93	49.82	8.30	83.52	13.92
22	41.26	7.50	71.51	13.00	40.90	7.44	68.37	12.43
20	32.50	6.50	56.00	11.20	33.00	6.60	55.00	11.00
18	25.03	5.56	42.85	9.52	26.10	5.80	43.34	9.63
16	18.75	4.89	31.87	7.97	20.10	5.02	33.28	8.32
14	13.57	3.88	22.88	6.54	14.99	4.28	24.75	7.07
12	9.40	3.13	15.70	5.23	10.73	3.58	17.64	5.88
10	6.13	2.45	10.13	4.05	7.25	2.90	11.88	4.75
9	4.80	2.13	7.89	3.51				
8	3.66	1.83	5.98	2.99				

Table B-6. Profile factors

Serial No	Span-to-Rise Ratio	Factor	Remarks
1	Up to 4	1.0	For a given load, a flat arch of steeper profile (although it has a very large rise) may fail due to the crown's action as a smaller, flatter arch.
2	Over 4	See Figure B-9	

Table B-7. Arch factors

Material Factors

Serial No.	Type of Material	Factor
1	Granite, white stone, or built-in course masonry	1.50
2	Concrete or blue engineering bricks	1.20
3	Good limestone masonry and building bricks	1.00
4	Poor masonry or any kind of brickwork	0.70 - 0.50

Joint Factors

Serial No.	Type of Joint	Factor
1	Thin joints, 1/10 inch or less in width	1.25
2	Normal joints, width to 1/4 inch, pointed mortar	1.00
3	Normal joints, mortar unpointed	0.90
4	Joint over 1/4 inch, irregular good mortar	0.80
5	Joint over 1/4 inch, mortar with voids deeper than 1/10 of the ring thickness	0.70
6	Joints 1/2 inch or more, poor mortar	0.50

Deformations

Serial No.	Condition	Adjustment	Note
1	The rise over the affected portion is always positive.	Discard profile factor already calculated and apply span-to-rise ratio of affected portion to whole arch.	Arch ring deformation may be due to partial failure of the ring (usually accompanied by a sag in the parapet) or movement at the abutment.
2	Distortion produces a flat section of profile.	Maximum MLC = 12.	
3	A portion of the ring is sagging.	Maximum MLC = 5 only if fill at crown > 18 inches.	

Abutment Size Factors

Serial No.	Type of Abutment	Factor	Note
1	Both abutments satisfactory	1.00	An abutment may be regarded as inadequate to resist the full thrust of the arch if— • The bridge is on a narrow embankment, particularly if the approaches slope steeply up to the bridge. • The bridge is on an embanked curve. • The abutment walls are very short and suggest little solid fill behind the arch.
2	One abutment unsatisfactory	0.95	
3	Both abutments unsatisfactory	0.90	
4	Both abutments massive but a clay fill suspected	0.70	
5	Arch carried on one abutment and one pier	0.90	
6	Arch carried on two piers	0.80	

Table B-7. Arch factors (continued)

Abutment Fault Factors		
Serial No.	**Type of Fault**	**Factor**
1	Inward movement of one abutment	0.75 - 0.50
2	Outward spread of abutments	1.00 - 0.50
3	Vertical settlement of one abutment	0.90 - 0.50

Crack Factors			
Serial No.	**Type of Crack**	**Factor**	**Note**
1	Longitudinal cracks within 2 feet of the edge of the arch; if wider than 1/4 inch and longer than 1/10 of the span, in bridges. • Wider than 20 feet between parapets. • Narrower than 20 feet between parapets.	 1.00 0.90 - 0.70	Due to an outward force on the spandrel walls caused by a lateral spread of the fill.
2	Longitudinal cracks in middle third of the ridge with— • One small crack under 1/8 inch wide and shorter than 1/10 of the span. • Three or more small cracks as above. • One large crack wider than 1/4 inch and longer than 1/10 of the span.	 1.00 0.50 0.50	Due to varying amount of subsiding along the length of the abutment; large cracks are danger signs which indicate that the arch ring has broken up into narrower independent rings.
3	Lateral and diagonal cracks less than 1/8 inch wide and shorter than 1/10 of the arch width	1.00	Lateral cracks, usually found near the quarter points, are due to permanent deformation of the arch, which may be caused by partial collapse of the arch or by abutment movement. Diagonal cracks, usually starting near the sides of the arch at the springing and spreading toward the center of the arch at the crown, are probably due to subsiding at the sides of the abutment.
4	Lateral and diagonal cracks wider than 1/4 inch and longer than 1/10 of the arch width: Restrict load class to 12 or to the calculated class using all other applicable factors, whichever is less.		
5	Cracks between the arch ring and spandrel or parapet wall greater than 1/10 of the span due to fill spread	0.90	Cracks indicate that the bridge is in a dangerous condition due to spreading of the fill pushing the wall outward or movement of a flexible ring away from a stiff fill, so that the two act independently. The latter type of failure often produces cracks in the spandrel wall near the quarter points.
6	Cracks between the arch ring and spandrel or parapet wall due to a dropped ring: Reclassify from the nomograph, taking the crown thickness as that of the ring alone.		

Table B-8. Section moduli for composite steel stringers

Nominal Size	d (in)	b (in)	S_c (cu in) t_d = 3"	S_c (cu in) t_d = 4"	S_c (cu in) t_d = 5"	S_c (cu in) t_d = 6"	S_c (cu in) t_d = 8"
W36x300	36.750	16.625	1,105	1,264	1,323	1,380	1,489
W36x230	35.875	16.500	835	972	1,018	1,061	1,145
W36x194	36.500	12.125	663	805	847	887	961
W36x182	36.375	12.125	621	757	796	833	902
W36x170	36.125	12.000	579	709	745	779	844
W36x160	36.000	12.000	541	667	701	733	794
W36x150	35.875	12.000	502	624	656	686	744
W33x220	33.875	15.750	740	868	910	951	1,031
W33x200	33.625	15.750	669	789	828	865	938
W33x141	33.250	11.500	446	555	585	612	666
W33x130	33.125	11.500	404	509	536	561	612
W30x172	30.500	15.000	528	630	663	694	757
W30x124	30.125	10.500	354	449	474	497	546
W30x116	30.000	10.500	327	419	442	464	511
W30x108	29.875	10.500	299	387	409	429	473
W27x161	27.625	14.000	455	537	566	595	655
W27x102	27.125	10.000	267	342	362	381	423
W27x94	26.875	10.000	243	315	333	350	390
W27x84	26.750	10.000	213	279	295	311	347
W24x94	24.250	9.125	222	288	306	323	364
W24x84	24.125	9.000	196	258	274	290	326
W24x76	23.875	9.000	176	233	247	262	295
W21x73	21.250	8.250	151	203	216	231	263
W21x68	21.125	8.250	140	189	202	216	246
W21x62	21.000	8.250	127	172	184	197	224
W18x60	18.250	7.500	108	149	160	173	201
W18x55	18.125	7.500	98	137	147	159	184
W18x50	18.000	7.500	89	124	134	145	168

Table B-9. Deck thickness factors for allowable live-load moment

t_d (in)	t_x	t_d (in)	t_x
4	1.00	8	1.20
5	1.05	9	1.25
6	1.10	10	1.30
7	1.15		

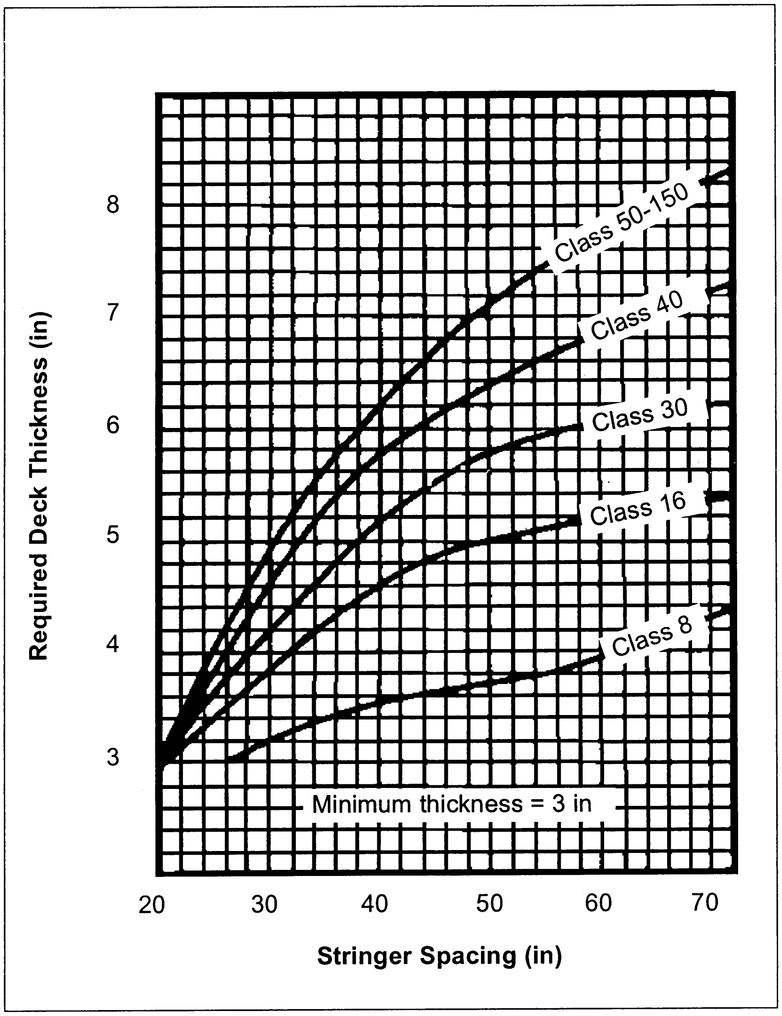


Figure B-8. Timber-deck classification

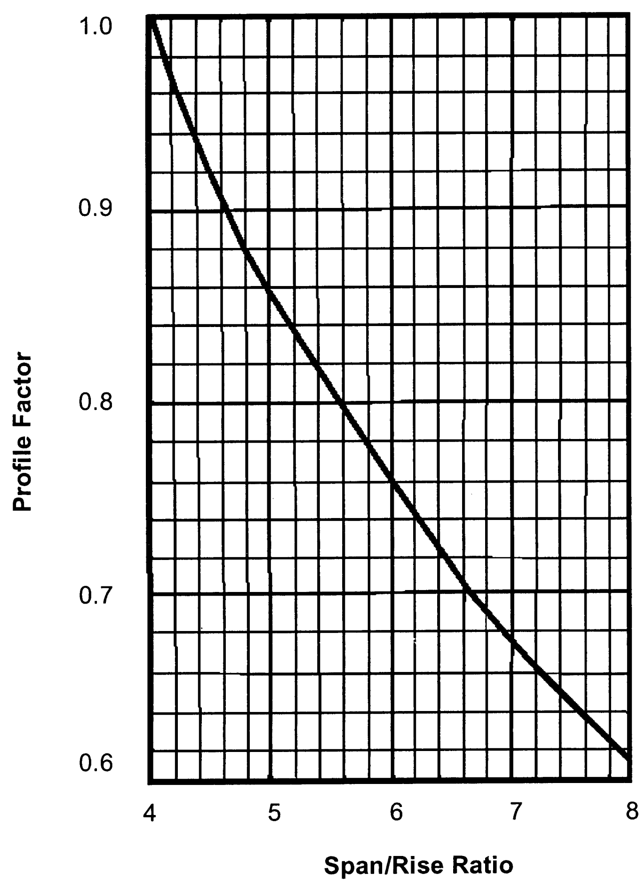


Figure B-9. Profile factors for arch bridges

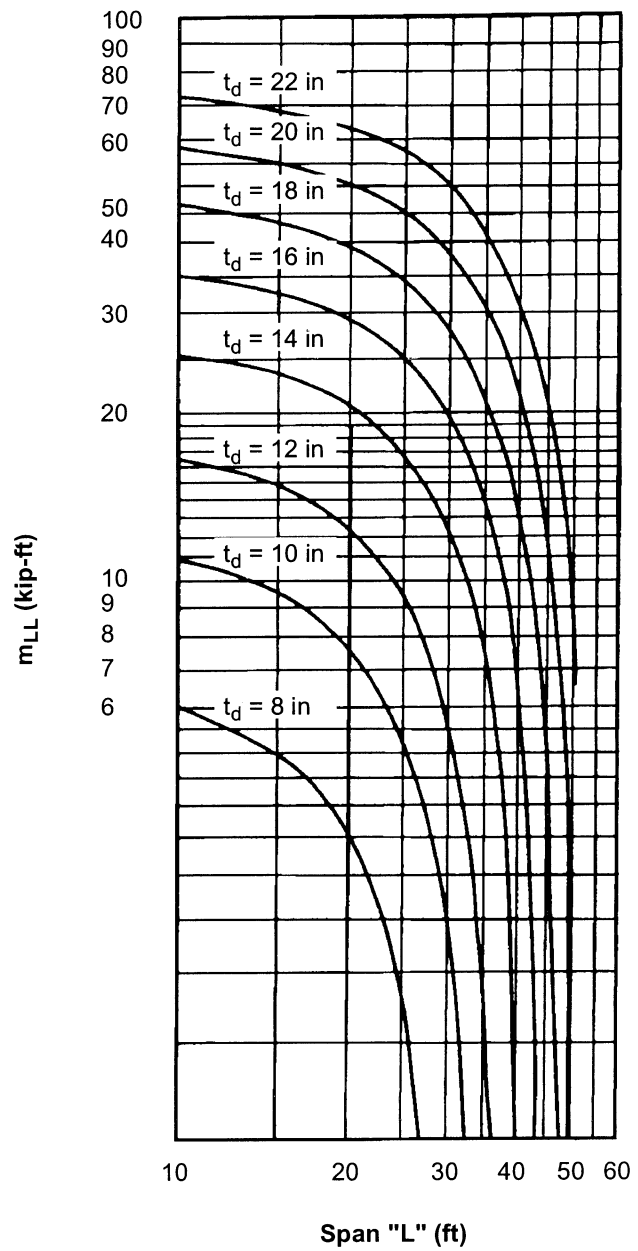


Figure B-10. Live-load moment for a 12-inch reinforced concrete strip

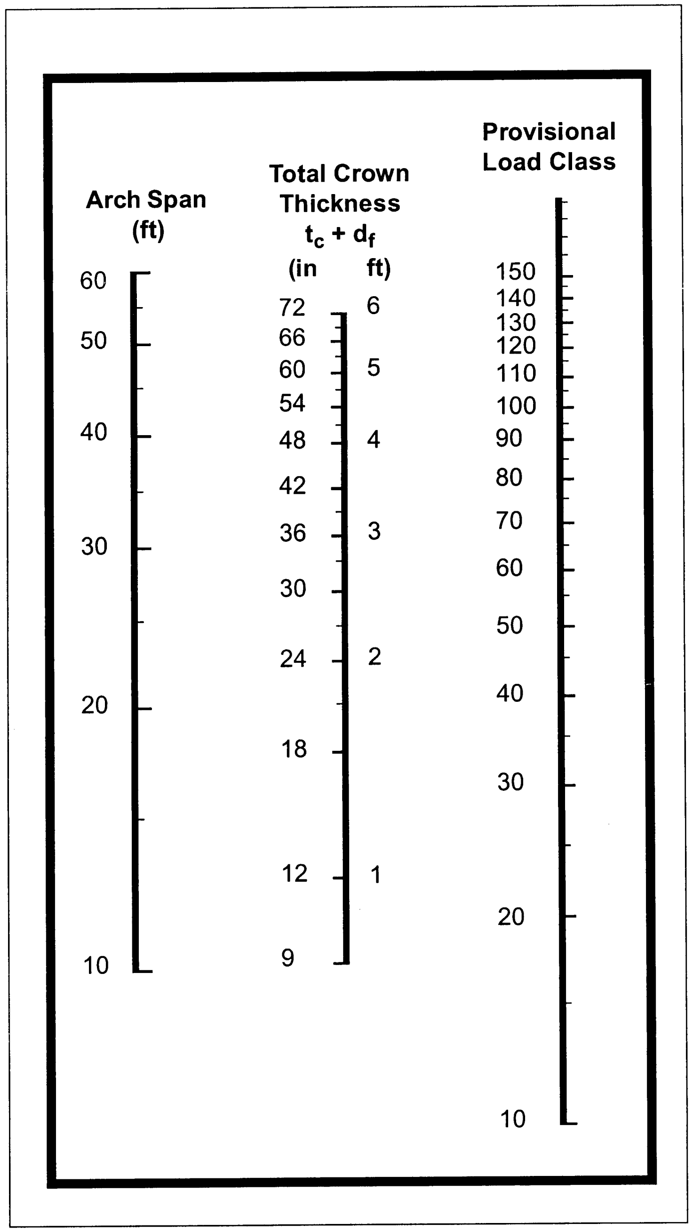


Figure B-11. Masonry arch PLC

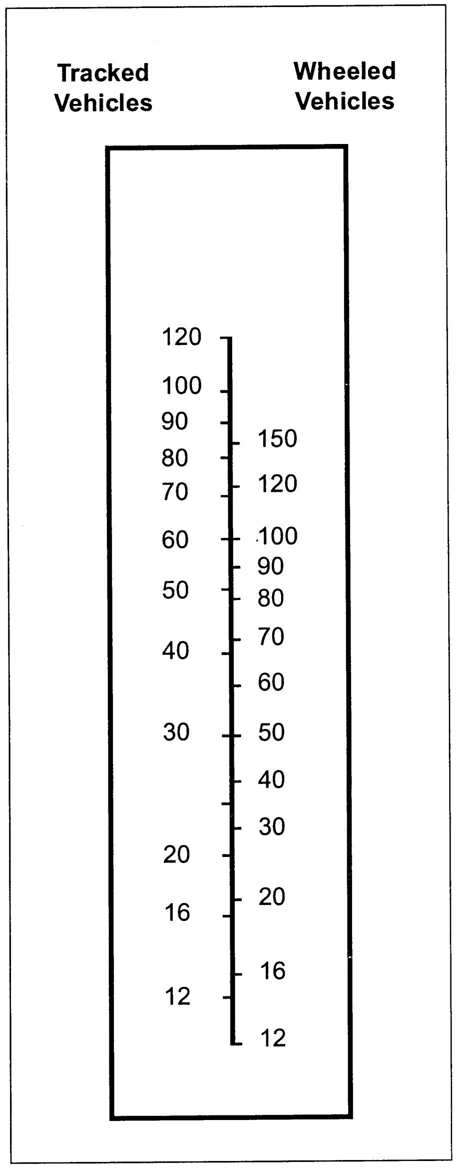


Figure B-12. Bridge class

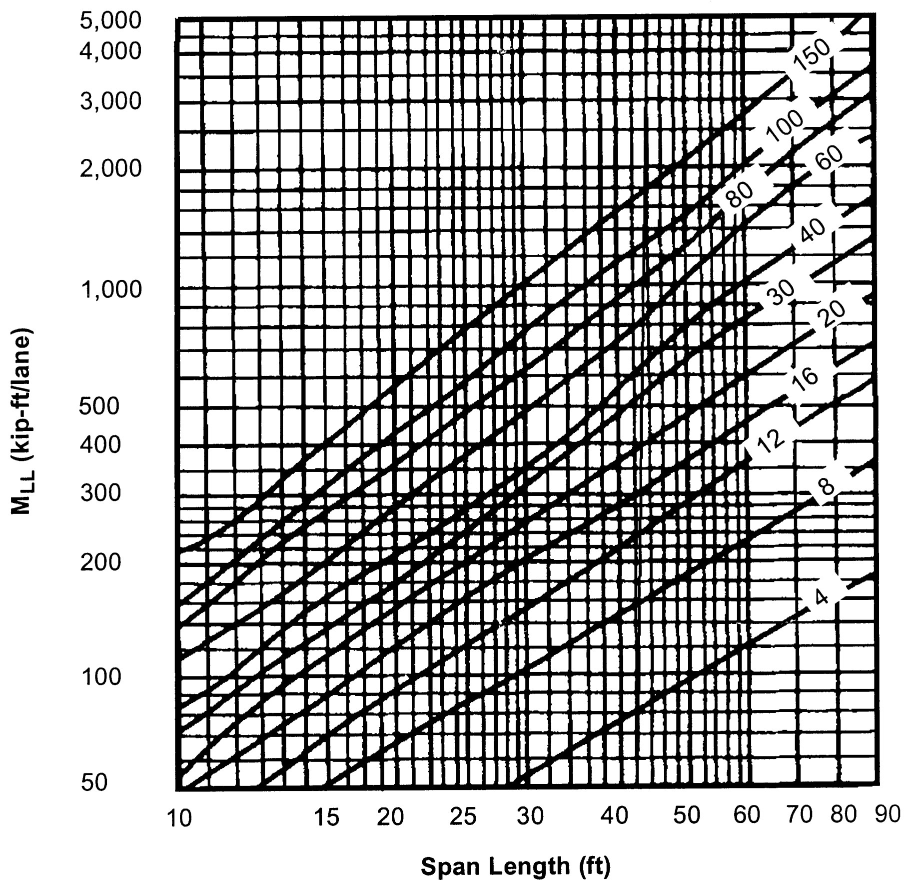


Figure B-13. Live-load moment for wheeled vehicles

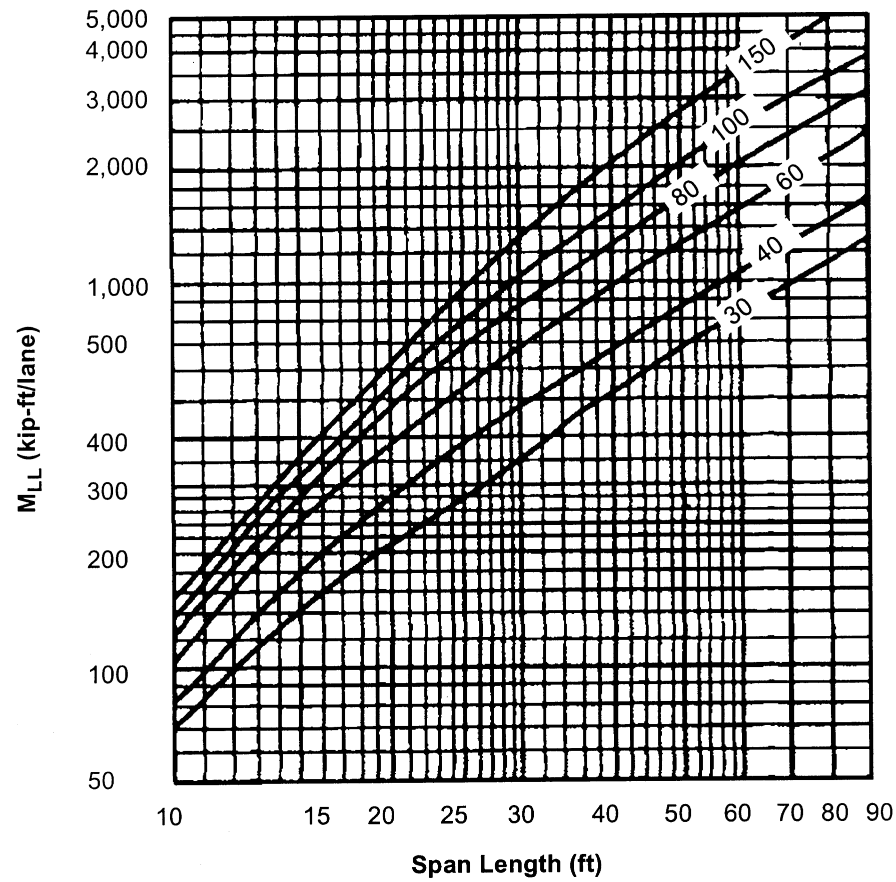


Figure B-14. Live-load moment for tracked vehicles

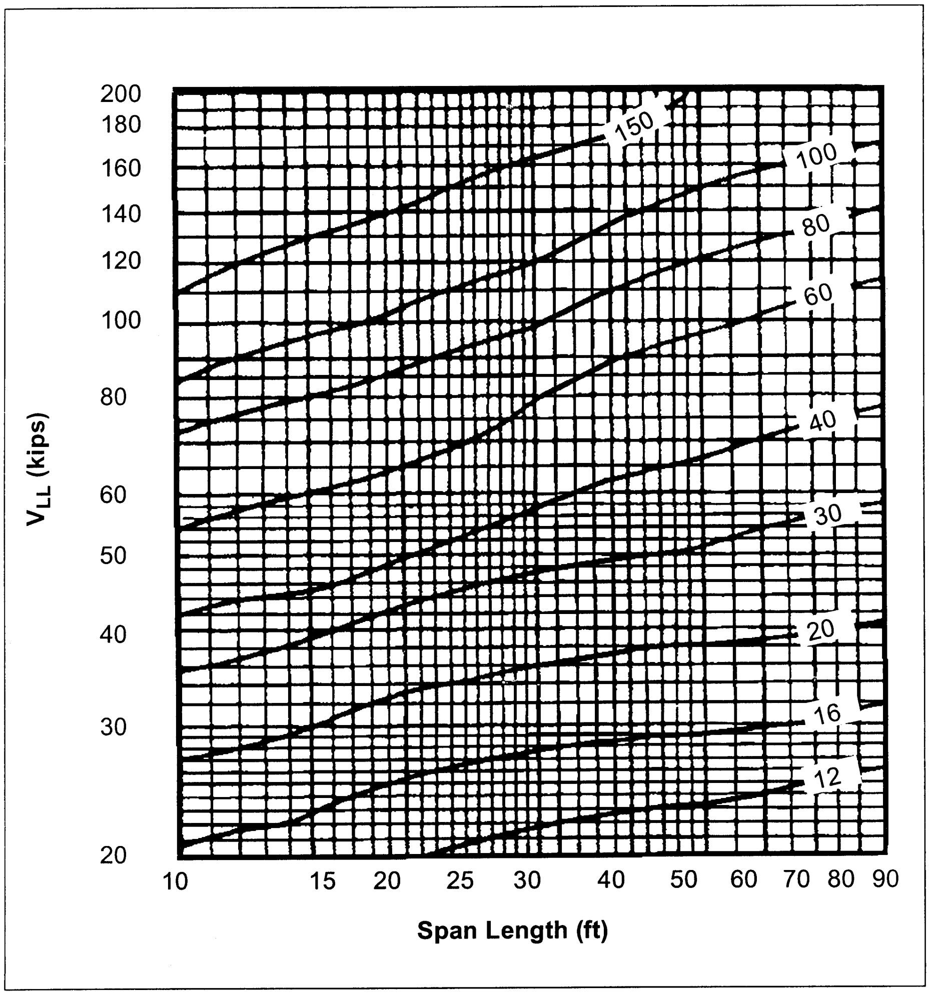


Figure B-15. Live-load shear for wheeled vehicles

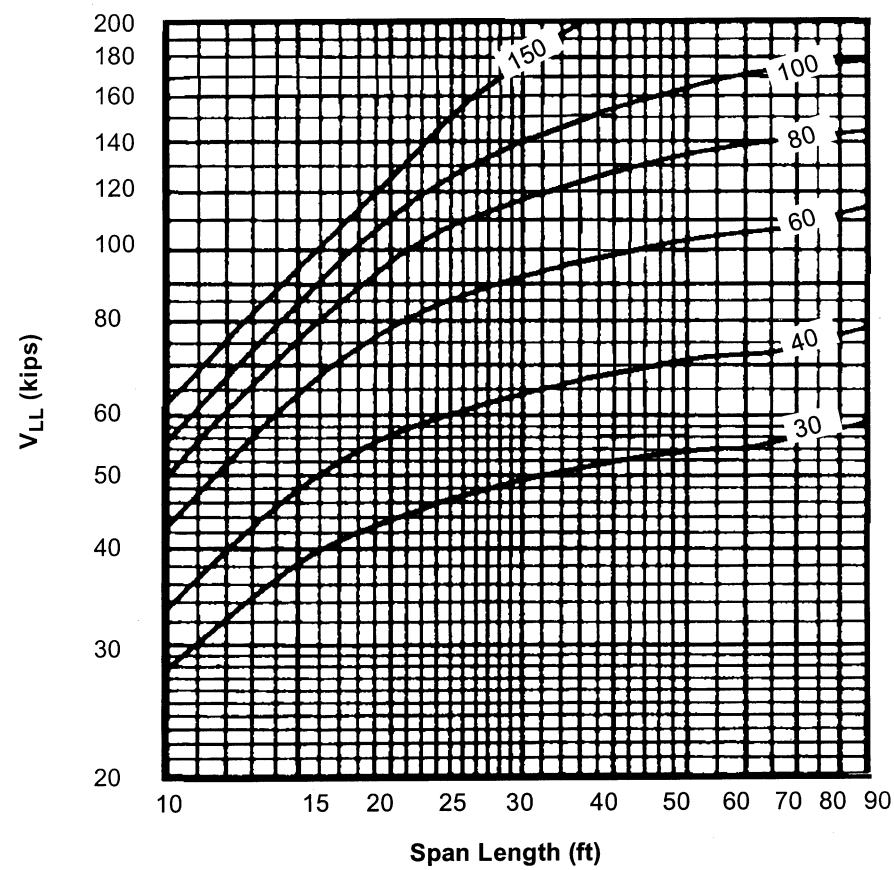


Figure B-16. Live-load shear for tracked vehicles

BASIC ENGINEER: COMBAT OPERATIONS

REVIEW LESSON EXAMINATION

Review Lesson

Introduction

The purpose of the review lesson examination is to prepare you for your final examination. We recommend that you try to complete your review lesson examination without referring to the text, but for those items (questions) you are unsure of, restudy the text. When you finish your review lesson and are satisfied with your responses, check your responses against the answers provided at the end of this review lesson examination.

Directions

Select ONE answer that BEST completes the statement or that answers the item. For multiple choice items, circle your response. For matching items, place the letter of your response in the space provided.

Item 1

The three components of a bridge are substructure, superstructure and

a. foundation.
b. truss.
c. approach.
d. header.

Item 2

The components in a building structure are foundation, exterior walls, interior walls, roof, and

a. footer.
b. header.
c. joists.
d. door.

Continued on next page

Item 3

A bypass is an alternate

a. route, which will allow you to reach your objective in an acceptable amount of time.
b. route around an obstacle, which allows the foot mobile Marines to continue the attack
c. An alternate path to an enemy position allowing for an unobserved approach
d. attack route that approaches the enemy from the flank

Item 4

The record used to provide all information required in relation to the target is called

a. Identification Record.
b. Demolition Reconnaissance Record.
c. Building Record.
d. GTA.

Item 5

The two goals in bridge demolition are to disable the bridge by creating a gap large enough to make repairs uneconomical and

a. force the enemy to reroute or rebuild by destroying the bridge completely.
b. enable the enemy to cross the water.
c. make the enemy give up.
d. force the enemy to make other plans.

Item 6

The difference between a cross sectional sketch and an area sketch is the area sketch _______ while the cross sectional sketch is

a. shows the surrounding area of the target/the target from which most calculations are made.
b. is of a specific point or area of the target/of a specific point of the target.
c. is of great detail/generally an overview or rough sketch of a target.
d. is only required when a building is the target/always required regardless of the target.

Continued on next page

Item 7

What is the proper warning to give prior to detonation of an explosive charge?

a. Heads up
b. Stand by
c. Fire in the hole
d. Commence firing

Item 8

Noise, blast pressure missiles, and incendiary are ______ detonation.

a. types of demolition
b. purpose of demolition
c. characteristics of explosive
d. hazards of explosive

Item 9

What is the most common fatal injury caused by the blast wave?

a. Blast pressure
b. Blast concussion
c. Blast lung
d. Blast contusions

Item 10

Pounds of explosives are the only information required for computing minimum safe distances for _______ laid charges.

a. surface
b. external
c. concrete
d. TNT

Continued on next page

Item 11 Convert 25 pounds of TNT into pounds of dynamite.

a. 27.17 or 28
b. 25
c. 22.17 or 23
d. 29

Item 12 What is the net explosive weight for a span that has eight stringers and each stringer requires 14 pounds of TNT to cut?

a. 112 pounds
b. 114 pounds
c. 150 pounds
d. 151 pounds

Item 13 A container, projectiles, buffer materials, a charge, and an initiator are the components for what expedient charge?

a. Flame Fougasse
b. Bangalore Torpedo
c. Shaped charge
d. Claymore

Item 14 The purpose of the expedient ________ is to concentrate the energy of the explosion released on a small area.

a. claymore
b. platter charge
c. shaped charge
d. grape shot

Continued on next page

Item 15

A 55-gallon drum of thickened fuel, a kicker charge, trip flare, a detonating cord, and blasting cap are the components of an expedient __________ charge.

a. flame fougasse
b. shaped
c. platter
d. bangalore torpedo

Item 16

Four U-shaped pickets, C-4, detonating cord, tape or wire, and a firing system are the components of an expedient

a. flame fougasse.
b. shaped.
c. platter.
d. bangalore torpedo.

Item 17

Initiating the detonation of an explosive charge at a designated time is the purpose of a

a. priming system.
b. demo team leader.
c. blasting cap.
d. M60 fuse igniter.

Item 18

What are the three components in an electrical initiation set?

a. Time fuse, firing wire, and electric blasting cap
b. Electric blasting cap, firing wire, and a blasting machine
c. Electric blasting cap, firing wire, and a M60 fuse igniter
d. Electric blasting cap, M60 fuse igniter, and a blasting machine

Continued on next page

Item 19 To prepare a(n) ______ series circuit, connect one blasting cap lead wire from the first cap to one lead wire of the second cap until only two ends are free.

a. common
b. leapfrog
c. complete
d. electrical

Item 20 The ________ series circuit is laid by starting at one end of a row of charges and primed every other charge (i.e. odd number charges) to the end of the row.

a. common
b. leapfrog
c. complete
d. electrical

Item 21 An ignition source, blasting cap, and time fuse make up the components of a(n) ____________ system.

a. electric firing
b. nonelectric firing
c. command detonated
d. MDI

Item 22 An M81, shock tube, and a blasting cap are the components of a(n)___ system.

a. electric firing
b. nonelectric firing
c. command detonated
d. MDI

Continued on next page

Item 23 The proper method for setting up a shaped charge is to use the appropriate _____ for the charge.

a. standoff
b. tamping
c. detonation
d. jet

Item 24 The effect the shaped charge has on the penetration of its target is the

a. size.
b. depth.
c. density.
d. length.

Item 25 When the explosive is detonated, the metal liner is compressed and squeezed forward, forming a jet whose tip may travel as fast as ___ kilometers a second.

a. 10
b. 15
c. 30
d. 40

Item 26 The shaped charges must be primed _______ for the jet to form correctly.

a. in the top in an exposed area
b. in the exact center opposite the cone
c. in the exact center of the cone
d. from the side closest to the target

Continued on next page

Item 27

The purpose of wire entanglements is to

a. support each other and provide firing lanes.
b. stop enemy tanks.
c. stop the enemy approach.
d. support the tactical plan in both offensive and defensive operations.

Item 28

Belt, band, and zone represent the three __________of obstacle employment.

a. classifications
b. footers
c. charges
d. explosives

Item 29

The three basic methods for wire entanglements are

a. tactical, protective, and supplementary.
b. concertina, Razor wire, and barbed wire.
c. belt, band, and zone.
d. supporting, defensive, and tangle foot.

Item 30

Physical components common to any wire obstacle installation are wire material, picket material, and

a. stake drivers.
b. personnel.
c. stakes.
d. tape.

Item 31

During stage one of the installation process, Team 1 is responsible for

a. laying enemy row.
b. laying out front row long pickets at five-pace intervals.
c. attaching the barbed wire.
d. laying the top row and attach to the barbed wire.

Continued on next page

Item 32	Corrugated metal, timber, plywood, doors, and brushes are all examples of suitable ______ material. a. building b. revetment c. reinforcing d. compaction
Item 33	The components of a revetment are anchoring system, horizontally laid material, and a. slope ratio. b. uprights. c. earthworks. d. runners.
Item 34	How is timber and dimensional lumbar revetment laid? a. Vertically b. Horizontally c. Upright d. Under the soil
Item 35	The holding power of a deadman is affected by frontal bearing area, mean depth, slope ratio/angle of pull, deadman material, and a. soil compaction. b. cable length. c. soil condition. d. cable size.

Continued on next page

Item 36

Overhead cover, protection from fragmentation and direct fire weapons, and camouflage are all common traits of

a. all types of survivability positions.
b. underground protection.
c. protective walls.
d. revetted enclosures.

Item 37

_________________ are built to withstand hits from both indirect and direct fire weapons and weapons systems.

a. Overhead cover
b. Camouflage
c. Hasty positions
d. Survivability positions

Item 38

The information from the materials estimate list is used to complete the

a. bill of materials.
b. material data list.
c. material takeoff list.
d. DA Form 2072.

Item 39

To produce a material estimate list, calculate the length of material of the same dimension in the _______ column.

a. quantity
b. board feet
c. size and length
d. waste allowance

Continued on next page

Item 40 What are the two types of fighting positions?

a. Covered and uncovered
b. Revetted and covered
c. Revetted and deliberate
d. Hasty and deliberate

Item 41 A standard two-man position is ________ feet side-by-side and ______ feet front to back.

a. 2/2
b. 2/8
c. 6/2
d. 6/4

Item 42 __________ is the use of materials and techniques to hide, blend, disguise, or disrupt the appearance of military targets and/or their backgrounds.

a. Cover
b. Camouflage
c. Parapets
d. Spoil

Item 43 A hexagon screen, a diamond-shaped screen, a repair kit, and a support system are all components of

a. the lightweight camouflage screen system.
b. camouflage multipurpose kit.
c. lightweight multipurpose camouflage kit.
d. vehicle screening system.

Continued on next page

Item 44

What is the first step in the assembly of the lightweight screening system?

a. Insert lanyards in the same direction.
b. Place the diamond shaped screen first.
c. Connect the individual screens by using lanyards.
d. Connect both diamond shaped screens.

Item 45

Once the screen is assembled and folded (accordion style), the next step in erecting the screen is

a. driving the stakes.
b. placing the poles.
c. tightening the screen.
d. unfolding the screen.

Item 46

The purpose of countermobility obstacles is to delay, stop, or _________ the enemy.

a. confuse
b. demoralize
c. kill
d. channelize

Item 47

Analyze the mission and analyze avenues of approach are the first two steps in the obstacle ___________ process.

a. construction
b. planning
c. breaching
d. removal

Continued on next page

Item 48 Which of the following obstacles are the most effective at slowing or stopping both personnel and vehicle traffic?

a. Abatis
b. Four strand cattle fence
c. Wire
d. Log cribs

Item 49 An abatis is used to _____ the mobility of the enemy while supporting the tactical plan of the unit commander.

a. enhance
b. stop
c. reduce
d. control

Item 50 The most effective site for creating an abatis is to have a road or trail that passes through a heavily wooded area and that the trees

a. are not more than 28-inches in diameter.
b. can cross the centerline of the road to be blocked when they are dropped at a 45° angle to the road.
c. should all be felled at the same time in order to create the desired pattern in the road.
d. can be felled toward the friendly side of the obstacle.

Item 51 What is the calculation for felling a 22-inch diameter tree for use in an abatis using the P (pounds of explosives) = $\frac{D^2}{50}$ formula?

a. 9.68 or 9.5 pounds
b. 9.68 or 10 pounds
c. 8.98 or 9 pounds
d. 8.98 or 8.5 pounds

Continued on next page

Item 52

What are the total pounds of TNT required to create an abatis, when there are 20 trees to be felled with diameters ranging between 17 and 23 inches?

a. 5.5 pounds per tree for 110 total pounds
b. 6 pounds per tree for 120 total pounds
c. 10.5 pounds per tree for 210 total pounds
d. 11 pounds per tree for 220 total pounds

Item 53

After locating an appropriate location for an abatis, the next step is to

a. determine the trees height.
b. measure the tree diameters.
c. measure the length of the obstacle.
d. determine the direction the enemy will be traveling.

Item 54

Log obstacles are intended to reduce the mobility of the enemy while supporting the _____ plan of the unit commander.

a. obstacle
b. command
c. appropriate
d. tactical

Item 55

The four types of log obstacles are crib, posts, _________, and wall.

a. tetrahedron
b. square
c. hurdle
d. pier

Item 56

When constructing a log crib, how deep are the holes?

a. 12 inches
b. 5 feet
c. 20 feet
d. 25 feet

Continued on next page

Item 57

Install obstacles in _____ and provide mutual support for the overall obstacle plan to be effective.

a. parts
b. rows
c. bands
d. sections

Item 58

What are the three methods of craters used by the Marine Corps?

a. Deliberate, hostile, and relieved face
b. Relieved face, decisive, and hasty
c. Hasty, relief, and deliberate
d. Hasty, deliberate, and relieved face

Item 59

Which of the following formulas is the correct formula for creating a hasty crater?

a. $N = \frac{L-16}{7} + 1$
b. $N = \frac{L-10}{5} + 1$
c. $N = \frac{L-16}{5} + 1$
d. $N = \frac{L-10}{7} + 1$

Continued on next page

Item 60

Determine the total explosive requirements for a hasty crater based on the following information:

The road width is 29 feet; the desired crater length is 38 feet. The boreholes are 6-feet deep. You have at your disposal 40-pound cratering charges and TNT for use as explosives.

a. (6) 40-pound cratering charges and 120 pounds of TNT
b. (5) 40-pound cratering charges and 60 pounds of TNT
c. (8) 40-pound cratering charges and 120 pounds of TNT
d. (6) 40-pound cratering charges and 60 pounds of TNT

Item 61

Determine the total explosive requirements for a deliberate crater based on the following information:

The road width is 39 feet; the desired crater length is 46 feet. The boreholes are 6-feet deep. You have at your disposal 40-pound cratering charges and TNT for use as explosives.

a. (9) 40-pound cratering charges and 160 pounds of TNT
b. (14) 40-pound cratering charges and 0 pounds of TNT
c. (9) 40-pound cratering charges and 0 pounds of TNT
d. (14) 40-pound cratering charges and 90 pounds of TNT

Item 62

Determine the total explosive requirements for a relieved face crater based on the following information:

The road width is 41 feet; the desired crater length is 45 feet. The boreholes are 6-feet deep. You have at your disposal; 40-pound cratering charges and TNT for use as explosives.

a. (5) 40-pound cratering charges and 160 pounds of TNT
b. (9) 40-pound cratering charges and 120 pounds of TNT
c. (5) 40-pound cratering charges and 120 pounds of TNT
d. (9) 40-pound cratering charges and 480 pounds of TNT

Continued on next page

Item 63

The two types of boobytraps are manufactured and

a. Claymore mines.
b. land mines.
c. improved.
d. improvised.

Item 64

The intended effects boobytraps have against the enemy include supplement minefields by increasing their obstacle value, add to the confusion and discomfort of the enemy, ____________, and lower the morale of enemy combatants while raising stress levels.

a. inflict casualties to personnel and destroy equipment
b. kill enemy medical personnel
c. destroy enemy buildings
d. decentralize enemy command

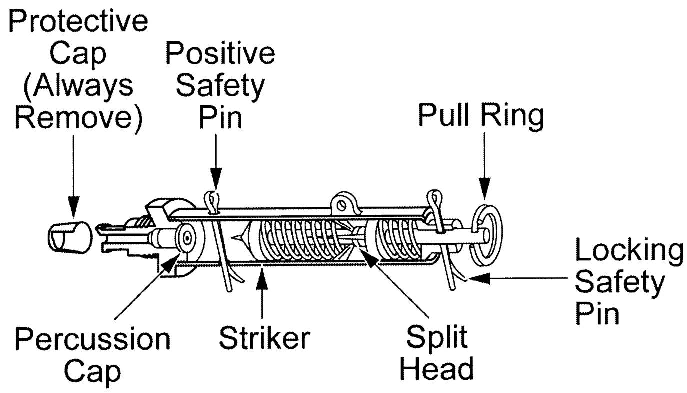
Item 65

What is the first step in installing the boobytrap?

a. Conceal the explosive.
b. Select a site that will produce the best effect when activated.
c. Reconnoiter where the enemy patrols travel.
d. Select a hidden site, off the beaten trail.

Continued on next page

Item 66 What is the name of the following firing device?



a. M3 pull
b. M3 pull/tension release
c. M5 Pull
d. M1 Pull

Item 67 The most effective placement for boobytraps are

a. under porches.
b. on sidewalks.
c. inside buildings.
d. on rooftops.

Item 68 A _____ is a combination of single explosive and /or nonexplosive obstacles.

a. complex obstacle
b. anti-vehicular obstacle
c. multipurpose obstacle
d. check point

Continued on next page

Item 69

The five fundamental stages when breaching nonexplosive obstacles are suppress, obscure, secure, reduce, and

a. reconnoiter.
b. resupply.
c. reload.
d. reconstruct.

Item 70

The five areas that make up a breeching organization are support force, breach force, assault force, _______ and breaching assets.

a. initiating
b. occupation
c. follow on force
d. supply force

Item 71

The four types of breaching operations are hasty/in-stride, deliberate, ________, and covert.

a. initiating
b. follow on
c. mechanized
d. assault

Item 72

What is one of the ways to breach an antitank ditch?

a. Artillery
b. Deliberate
c. Machinegun
d. Bulldozer

Continued on next page

Item 73 The four major components of the MK2 Mine Clearing System are the M58A4 linear demolition charge, MK22 rocket motor, _________, and trailer chassis.

a. MK12 Mine clearing equipment
b. MK155 Mine clearing launcher
c. MK240 Mine detonation equipment
d. MK 125 Mine clearing launcher

Item 74 What is the first step in operating the linear charge?

a. Ensure locking pins are in the lock position.
b. Ensure the safety is off.
c. Ensure the launcher is on level ground.
d. Ensure the launcher is set at 19° from horizontal.

Item 75 The SL-3 component for a linear charge includes cable assembly switch, _________, M34 or COTS blasting machine, lifting sling, protective nylon cover, turn buckles and U-bolts, and instruction cards.

a. M16 test set
b. M16 instruction kit
c. M51 test set
d. M51 instruction kit

Item 76 Hydraulic system, safety switch assembly, clinometers, and launcher rail and support make up the four areas within the

a. operator's controls and indicators.
b. operator's control files.
c. operation of the line charge.
d. operation of the indicator switches.

Continued on next page

Item 77

To deploy the rocket, set the selector switch to rocket position and repeatedly squeeze the M34 and wait approximately ____ seconds for completion.

a. 10
b. 20
c. 30
d. 40

Item 78

The four classifications of airfields in a tactical environment are landing zones (LZ), forward operating base, ___________, and air facility.

a. air station
b. rapid rearm/refuel point
c. main base
d. VTOL

Item 79

The required placement of stakes along the outer edge for various matting during construction of VTOL and landing zones is every ___ feet.

a. 21
b. 8
c. 12
d. 16

Item 80

The minimum distance required for landing points in a landing zone is ___ the rotor diameter of the largest aircraft.

a. 2 to 3 times
b. 2 to 4 times
c. 3 to 6 times
d. 5 to 7 times

Continued on next page

Item 81 The required areas for a forward arming and refueling point are, arming/de-arming, _________, refueling area, and post refueling area.

a. post arming area
b. pre-refueling area
c. pre-rearming/de-arming area
d. wash pits

Item 82 The ______________ is a shoulder fired, multipurpose, assault weapon used for short-range bunkers and armored vehicle engagement

a. MK- 134 SMAW
b. MK-153 SMAW
c. M19-SMAW
d. AT4-SMAW

Item 83 Using open sights, the maximum effective range of the SMAW is _____ meters.

a. 150
b. 250
c. 400
d. 550

Item 84 What immediate action do you take if a rocket misfires with the SMAW?

a. Wait 15 seconds to ensure the rocket does not launch.
b. Immediately remove and replace the rocket.
c. Remove the weapon from your shoulder and place it on the ground.
d. Wait 30 minutes to ensure the rocket does not "cook off."

Continued on next page

Item 85 The practice MK 4 MOD 0, Dual Mode MK 3 MOD 0, HEAA, and the ___________ are the four types of rocket available for use in the SMAW.

a. depleted uranium
b. multipurpose
c. anti-personnel
d. novel explosive

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Answers

The table below provides the answers to the exercise items. If you have any questions, refer to the reference page listed for each item.

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4	b	1-16
5	a	1-20
6	a	1-31/1-32
7	c	1-41
8	d	1-46
9	c	1-48
10	a	1-49
11	a	1-57
12	a	1-58
13	d	1-63
14	c	1-65
15	a	1-67
16	d	1-69
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19	a	1-79
20	b	1-80
21	b	1-81
22	d	1-87
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43	a	2-57
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45	d	2-60
46	d	3-4
47	b	3-8
48	c	3-10
49	c	3-18
50	b	3-19
51	a	3-22
52	b	3-22
53	d	3-23
54	d	3-28
55	c	3-29
56	b	3-31
57	c	3-35
58	d	3-43
59	c	3-44
60	a	3-45
61	b	3-47
62	c	3-49
63	d	3-54
64	a	3-55
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Answer, continued

Item Number	Answer	Reference Page
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74	c	4-34
75	c	4-29
76	a	4-30
77	a	4-37
78	c	4-44
79	c	4-53
80	b	4-56
81	b	4-60
82	b	4-66
83	b	4-78
84	a	4-80
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