Commercial Explosives

I have included here the essentials of the US Army FM 5-250. Take the time to read this, it is like an undergraduate degree in explosive demolitions. This manual describes the characteristics and proper use of every type of explosive in military use today. The sections on specific demolition operations, such as destroying bridges, contain a wealth of information necessary to the White separatist. This Field Manual is reproduced **without** permission.

FM 5-250

Chapter 1

Military Explosives

Section I. Demolition Materials

1-1. Characteristics. To be suitable for use in military operations, explosives must have certain properties. Military explosives—

- Should be inexpensive to manufacture and capable of being produced from readily available raw materials.

- Must be relatively insensitive to shock or friction, yet be able to positively detonate by easily prepared initiators.

- Must be capable of shattering and must have the potential energy (high energy output per unit volume) adequate for the purpose of demolitions.

- Must be stable enough to retain usefulness for a reasonable time when stored in temperatures between -80 and +165 degrees Fahrenheit.

- Should be composed of high-density materials (weight per unit volume).

- Should be suitable for use underwater or in damp climates.

- Should be minimally toxic when stored, handled, and detonated.

1-2. Selection of Explosives. Select explosives that fit the particular purpose, based on their relative power. Consider all characteristics when selecting an explosive for a particular demolition project.

Table 1-1 contains significant information regarding many of the explosives described below.

1-3. Domestic Explosives.

a. Ammonium Nitrate. Ammonium nitrate is the least sensitive of the military explosives. It requires a booster charge to successfully initiate detonation. Because of its low sensitivity, ammonium nitrate is a component of many composite explosives (combined with a more sensitive explosive). Ammonium nitrate is not suitable for cutting or breaching charges because it has a low detonating velocity. However, because of its excellent cratering affects and low cost, ammonium nitrate is a component of most cratering and ditching charges. Commercial quarrying operations use ammonium nitrate demolitions extensively. Pack ammonium nitrate in an airtight container because it is extremely hydroscopic (absorbs humidity). Ammonium nitrate or composite explosives containing ammonium nitrate are not suitable for underwater use unless packed in waterproof containers or detonated immediately after placement.

b. Pentaerythrite Tetranitrate (PETN). PETN is a highly sensitive and very powerful military explosive. Its explosive potential is comparable to cyclonite (RDX) and nitroglycerin. Boosters, detonating cord, and some blasting caps contain PETN. It is also used in composite explosives with trinitrotoluene (TNT) or with nitrocellulose. A PETN-nitrocellulose composite (Ml 18 sheet explosive) is a demolition charge. The PETN explosive is a good underwater-demolition because it is almost insoluble in water.

1-1

Table 1-1. Characteristics of US demolitions explosives

Name	Applications	Detonation Velocity		RE Factor*	Fume Toxicity	Water Resistance
		M/Sec	Ft/Sec			
Black Powder	Time Fuse	400	1,300	0.55	Dangerous	Poor
Ammonium Nitrate	Cratering Charge	2,700	8,900	0.42	Dangerous	Poor
Amatol 80/20	Bursting Charge	4,900	16,000	1.17	Dangerous	Poor
M1 Dynamite	Demolition Charge	6,100	20,000	0.92	Dangerous	Fair
Detonating Cord	Priming	6,100 to 7,300	20,000 to 24,000	—	Slight	Excellent
TNT	Demolition Charge Composition Explosive	6,900	22,600	1.00	Dangerous	Excellent
Tetrytol 75/25	Demolition Charge	7,000	23,000	1.20	Dangerous	Excellent
Tetryl	Booster Charge Composition Explosive	7,100	23,300	1.25	Dangerous	Excellent
Sheet Explosive M118 and M186	Cutting Charge	7,300	24,000	1.14	Dangerous	Excellent
Pentolite 50/50	Booster Charge Bursting Charge	7,450	24,400	—	Dangerous	Excellent
Nitroglycerin	Commercial Dynamite	7,700	25,200	1.50	Dangerous	Good
Bangalore Torpedo, M1A2	Demolition Charge	7,800	25,600	1.17	Dangerous	Excellent
Shaped Charges M2A3, M2A4, and M3A1	Cutting Charge	7,800	25,600	1.17	Dangerous	Excellent
Composition B	Bursting Charge	7,800	25,600	1.35	Dangerous	Excellent
Composition C4 and M112	Cutting Charge Breaching Charge	8,040	26,400	1.34	Slight	Excellent
Composition A3	Booster Charge Bursting Charge	8,100	26,500	—	Dangerous	Good
PETN	Detonating Cord Blasting Caps Demolition Charges	8,300	27,200	1.66	Slight	Excellent
RDX	Blasting Caps Composition Explosives	8,350	27,400	1.60	Dangerous	Excellent

RDX	Blasting Caps Composition Explosives	8,350	27,400	1.60	Dangerous	Excellent
*TNT equals 1.00						

c. Cyclotrimethlenetrinitramine (RDX). RDX is also a highly sensitive and very powerful military explosive. It forms the base charge in the M6 electric and M7 nonelectric blasting caps.

When RDX is desensitized, it serves as a subbooster, booster, bursting charge, or demolition charge.

The principal use for RDX is in composite explosives, such as Composition A, B, and C explosives. RDX is available commercially under the name cyclonite.

d. Trinitrotoluene. TNT is the most common military explosive. It maybe in composite form, such as a booster, a bursting, or a demolition charge, or in a noncomposite form. Since TNT is a standard explosive, it is used to rate other military explosives.

e. Tetryl. Tetryl is an effective booster charge in its noncomposite form and a bursting or a demolition charge in composite forms. Tetryl is more sensitive and powerful than TNT. However, RDX- and PETN-based explosives, which have increased power and shattering effects, are replacing tetryl and composite explosives containing tetryl.

f. Nitroglycerin. Nitroglycerin is one of the most powerful high explosives. Its explosive potential is comparable to RDX and PETN. Nitroglycerin is the explosive base for commercial dynamites. Nitroglycerine is highly sensitive and extremely temperature-sensitive. Military explosives do not use nitroglycerin because of its sensitivity. Do not use commercial dynamites in combat areas.

g. Black Powder. Black powder is the oldest-known explosive and propellant. It is a composite of potassium or sodium nitrate, charcoal, and sulfur. Time fuses, some igniters, and some detonators contain black powder.

h. Amatol. Amatol is a mixture of ammonium nitrate and TNT. It is a substitute for TNT in bursting charges. Some older bangalore torpedoes use 80-20 amatol (80 percent ammonium nitrate and 20 percent TNT). Because amatol contains ammonium nitrate, it is a hydroscopic compound.

Keep any explosives containing amatol in airtight containers. If properly packaged, amatol remains viable for long periods of time, with no change in sensitivity, power, or stability.

i. Composition A3. Composition A3 is a composite explosive containing 91 percent RDX and 9 percent wax. The purpose of the wax is to coat, desensitize, and bind the RDX particles. Composition A3 is the booster charge in some newer shaped charges and bangalore torpedoes. High-explosive plastic (HEP) projectiles may also contain Composition A3 as a main charge.

j. Composition B. Composition B is a composite explosive containing approximately 60 percent RDX, 39 percent TNT, and 1 percent wax. It is more sensitive than TNT. Because of its shattering power and high rate of detonation, Composition B is the main charge in shaped charges.

k. Composition B4. Composition B4 contains 60 percent RDX, 39.5 percent TNT, and 0.5 percent calcium silicate. Composition B4 is the main charge in newer models of bangalore torpedoes and shaped charges.

l. Composition C4 (C4). C4 is a composite explosive containing 91 percent RDX and 9 percent nonexplosive plasticizers. Burster charges are composed of C4. C4 is effective in temperatures between -70 to+ 170 degrees Fahrenheit; however, C4 loses its plasticity in the colder temperatures.

m. Tetrytol. Tetrytol is a composite explosive containing 75 percent tetryl and 25 percent TNT. It is the explosive component in demolition charges. Booster charges require different mixtures oftetryl and TNT. Tetrytol is more powerful than its individual components, is better at shatteringthan TNT, and is less sensitive than tetryl.

n. Pentolite. Pentolite is a mixture of PETN and TNT. Because of its high power and detonating rate, a mixture of 50-50 pentolite (50 percent PETN and 50 percent TNT) makes an effective booster charge in certain models of shaped charges.

o. Dynamites.

(1) Standard Dynamite. Most dynamites, with the notable exception of military dynamite, contain nitroglycerin plus varying combinations of absorbents, oxidizers, antacids, and freezing-point depressants. Dynamites vary greatly in strength and sensitivity depending on, among other factors, the percentage of nitroglycerin they contain. Dynamites are for general blasting and demolitions, including land clearing,

cratering and ditching, and quarrying.

(2) Military Dynamite. Military dynamite is a composite explosive that contains 75 percent RDX, 15 percent TNT, and 10 percent desensitizers and plasticizers. Military dynamite is not as powerful as commercial dynamite. Military dynamite's equivalent strength is 60 percent of commercial dynamiters. Because military dynamite contains no nitroglycerin, it is more stable and safer to store and handle than commercial dynamite.

1-4. Foreign Explosives.

a. Composition. Foreign countries use a variety of explosives, including TNT, picric acid, amatol, and guncotton. Picric acid is similar to TNT, but it also corrodes metals and thus forms extremely sensitive compounds.

WARNING

Do not use picric acid in rusted or corroded metal containers.

Do not handle picric acid. Notify explosive ordnance disposal (EOD) personnel for disposition.

b. Use. You may use the explosives of allied nations and those captured from the enemy to supplement standard supplies. Only expert demolitionists should use such explosives and then only according to instructions and directives of theater commanders. Captured bombs, propellants, and other devices may be used with US military explosives for larger demolition projects, such as pier, bridge, tunnel, and airfield destruction. Most foreign explosive blocks have cap wells large enough to receive US military blasting caps. Since foreign explosives may differ from US explosives in sensitivity and force, test shots should be made to determine their adequacy before extensive use or mixing with US-type explosives.

Section II. Service Demolition Charges

1-5. Block Demolition Charges. Block demolition charges are prepackaged, high-explosive charges for general demolition operations, such as cutting, breaching, and cratering. They are composed of the high-explosive TNT, tetrytol, Composition-C series, and ammonium nitrate.

Block charges are rectangular inform except for the 40-pound, ammonium-nitrate block demolition charge, military dynamite, and the ¼-pound-TNT block demolition charge, which are all cylindrical in form. The various block charges available are described in the text that follows.

1-6. TNT Block Demolition Charge.

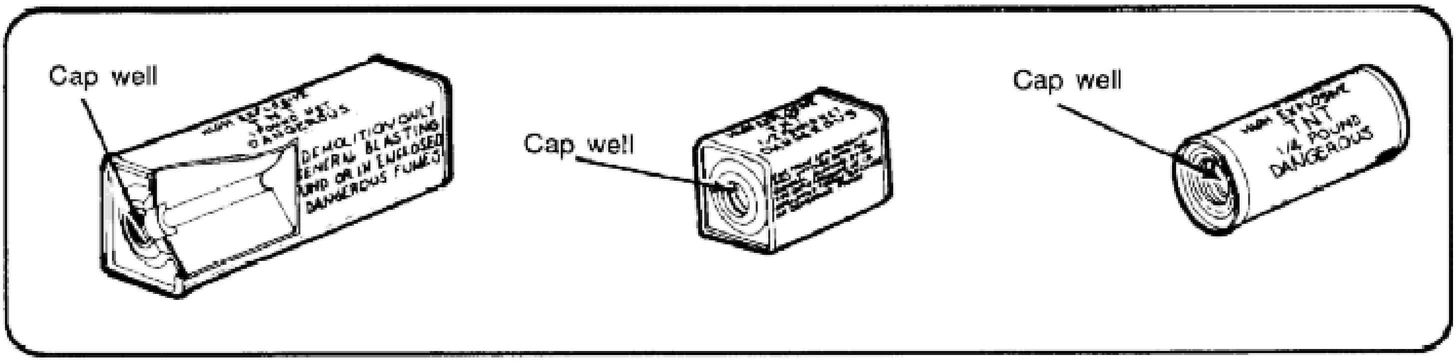


Figure 1-1. TNT block demolition charges

a. Characteristics. TNT block demolitions are available in three sizes (Table 1-2). The ¼-pound block is issued in a cylindrical, waterproof, olive-drab cardboard container. The ½-pound and l-pound blocks are available in similar rectangular containers. All of the three charges have metal ends with a threaded cap well in one end.

b. Use. TNT block demolition charges are effective for all types of demolition work. However, the ¼-pound charge is primarily for training purposes.

c. Advantages. TNT demolition charges have a high detonating velocity. They are stable, relatively insensitive to shock or friction, and water resistant. They also are conveniently sized, shaped, and packaged.

d. Limitations. TNT block demolition charges cannot be molded and are difficult to use on irregularly shaped targets. TNT is not recommended for use in closed spaces because one of the products of explosion is poisonous gases.

1-7. M112 Block Demolition Charge.

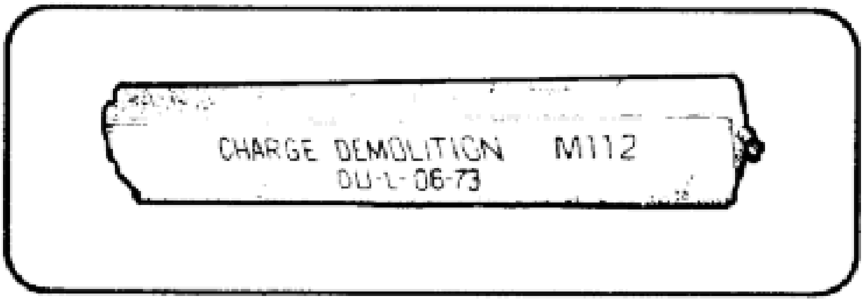


Figure 1-2. M112 block demolition charge

a. Characteristics. The M112 block demolition charge consists of 1.25 pounds of C4 packed in an olive-drab, Mylar-film container with a pressure-sensitive adhesive tape on one surface (Figure1-2). The tape is protected by a peelable paper cover. Table 1-2 (page 1-5) lists additional characteristics of the Ml12 block.

b. Use. The M112 block demolition charge is used primarily for cutting and breaching. Because of its high cutting effect and its ability to be cut and shaped, the M1l2 charge is ideally suited for cutting irregularly shaped targets such as steel. The adhesive backing allows you to place the charge on any relatively flat, clean, dry surface with a temperature that is above the freezing point. The Ml12 charge is the primary block demolition charge presently in use.

WARNING

Composition C4 explosive is poisonous and dangerous if chewed or ingested; its detonation or burning produces poisonous fumes. Cut all plastic explosives with a sharp steel knife on a nonsparking surface.

Do not use shears.

c. Advantages. You can cut to shape the M112 block demolition charge to fit irregularly shaped targets. The color of the wrapper helps camouflage the charge. Molding the charge will decrease its cutting effect.

d. Limitations. The adhesive tape will not adhere to wet, dirty, rusty, or frozen surfaces.

1-8. M118 Block Demolition Charge.

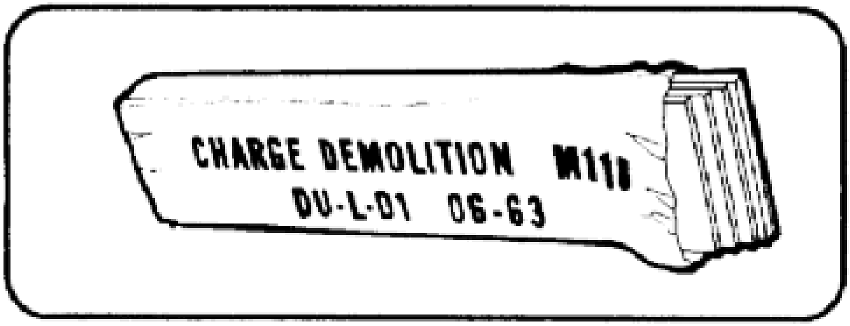


Figure 1-3. M118 block demolition charge

a. Characteristics. The M118 block demolition charge, or sheet explosive, is a block of four ½-pound sheets of flexible explosive packed in a plastic envelope (Figure 1-3). Twenty Ml18 charges and a package of 80 M8 blasting-cap holders are packed in a wooden box. Each sheet of the explosive has a pressure-sensitive adhesive tape attached to one surface. Table 1-2 (page 1 -5) lists additional characteristics for the M118 charge.

b. Use. The Ml18 charges are designed for cutting, especially against steel targets. The sheets of explosive are easily and quickly applied to irregular and curved surfaces and are easily cut to any desired dimension. The Ml18 charge is effective as a small breaching charge but, because of its high cost, it is not suitable as a bulk explosive charge.

c. Advantages. The flexibility and adhesive backing of the sheets allow application to a large variety of targets. You can cut the ½-pound sheets to any desired dimension and apply them in layers to achieve the desired thickness. The Ml18 charge is not affected by water, making it acceptable for underwater demolitions.

d. Limitations. The adhesive tape will not adhere to wet, dirty, rusty, or frozen surfaces.

1-9. M186 Roll Demolition Charge.

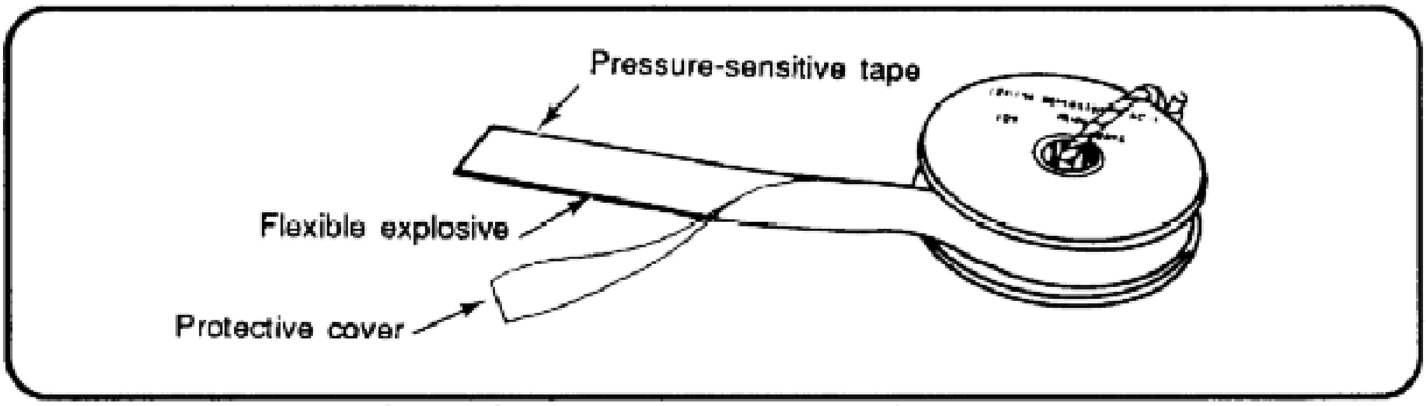


Figure 1-4. Ml86 roll demolition charge

a. Characteristics. The Ml86 roll demolition charge, shown in Figure 1-4, is identical to the Ml18 block demolition charge except that the sheet explosive is in roll form on a 50-foot, plastic spool. Each foot of the roll provides approximately a half pound of explosive. Included with each roll are 15 M8 blasting cap holders and a canvas bag with carrying strap. Table 1-2 (page 1-5) lists additional characteristics for the M186 charge.

b. Use. Use the M186 roll demolition charge in the same manner as the Ml18 block demolition charge. The Ml86 charge is adaptable for demolishing targets that require the use of flexible explosives in lengths longer than 12 inches.

c. Advantages. The Ml86 roll demolition charge has all the advantages of the Ml18 block demolition charge. You can cut the M186 charge to the exact lengths desired.

d. Limitations. The adhesive backing will not adhere to wet, dirty, rusty, or frozen surfaces.

Forty-Pound, Ammonium-Nitrate Block Demolition Charge

a. Characteristics. Figure 1-5 (page 1-8) shows the 40-pound, ammonium-nitrate block demolition charge or cratering charge. It is a watertight, cylindrical metal container with approximately 30 pounds of an ammonium-nitrate-based explosive and 10 pounds of TNT-based explosive booster in the center, next to the priming tunnels. The two priming tunnels are located to the outside of the container, midway between the ends. One tunnel serves as a cap well for priming the charge with an M6 electric or M7 nonelectric military blasting cap. The other tunnel series as a priming path, with the detonating cord passing through the tunnel and knotted at the end.

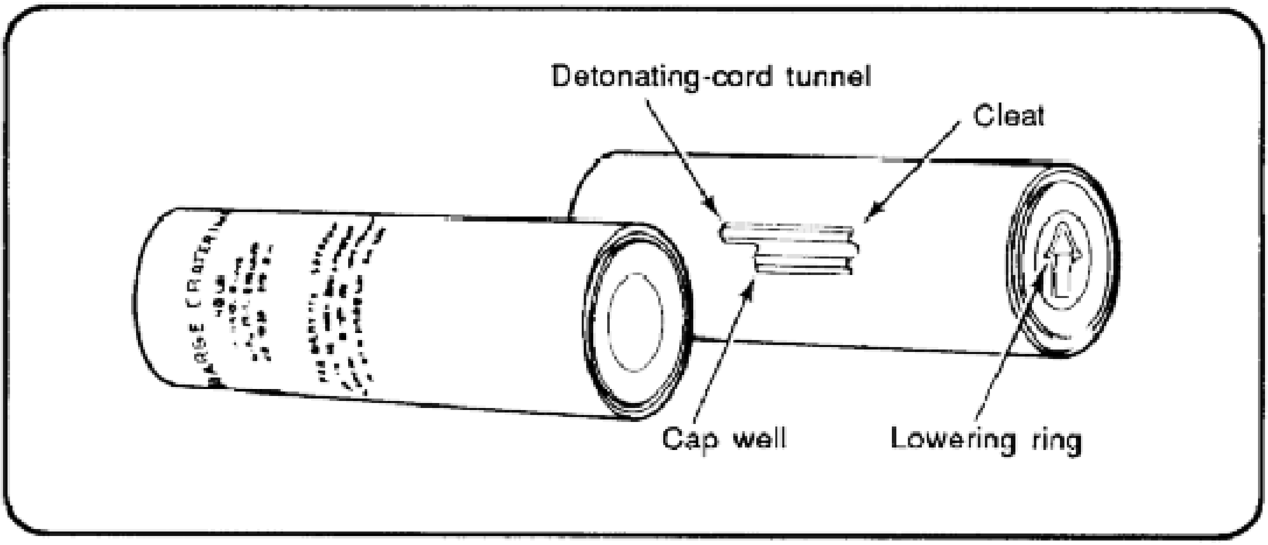


Figure 1-5. Forty-pound, ammonium-nitrate cratering charge

There is a cleat between the tunnels to secure the time blasting fuse, electrical firing wire, or detonating cord. There is a metal ring on the top of the container for lowering the charge into its hole. Table 1-2 (page 1-5) lists additional characteristics for the 40-pound, ammonium-nitrate block demolition charge.

b. Use. This charge is suitable for cratering and ditching operations. Its primary use is as a cratering charge, but it also is effective for destroying buildings, fortifications, and bridge abutments.

c. Advantages. The size and shape of this charge make it ideal for cratering operations. It is inexpensive to produce compared to other explosives.

d. Limitations. Ammonium nitrate is hydroscopic. When wet, it will not detonate. To ensure detonation, use metal containers showing no evidence of water damage. Detonate all charges placed in wet or damp boreholes as soon as possible.

1-11. Ml Military Dynamite.

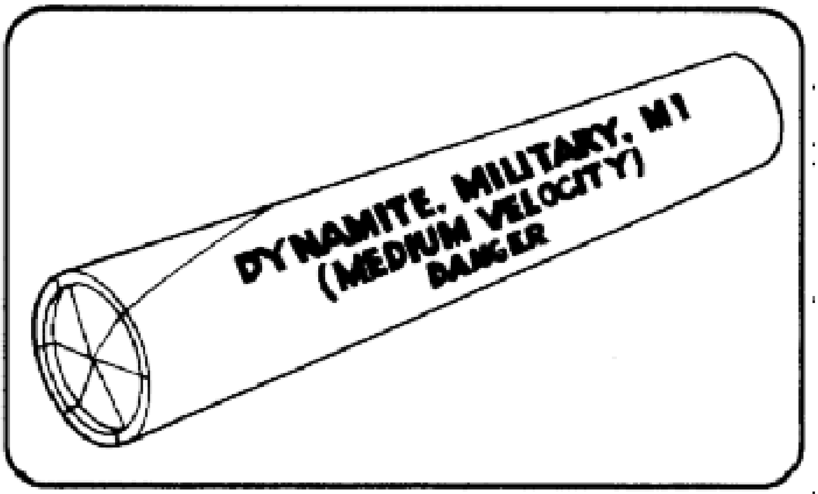


Figure 1-6. M1 military dynamite

a. Characteristics. M1 military dynamite is an RDX-based composite explosive containing no nitroglycerin (Figure 1-6). M 1 dynamite is packaged in ½-pound, paraffin-coated, cylindrical paper cartridges, which have a nominal diameter of 1.25 inches and a nominal length of 8 inches.

Table 1-2 (page 1-5) lists additional characteristics for Ml military dynamite.

b. Use. Ml dynamite's primary uses are military construction, quarrying, ditching, and service demolition work. It is suitable for underwater demolitions.

c. Advantages. Ml dynamite will not freeze or perspire in storage. The Ml dynamite's composition is not hydroscopic. Shipping containers do not require turning during storage. Ml dynamite is safer to store, handle, and transport than 60-percent commercial dynamite. Unless essential, do not use civilian dynamite incombat areas.

d. Limitations. Ml dynamite is reliable underwater only for 24 hours. Because of its low sensitivity, pack sticks of military dynamite well to ensure complete detonation of the charge. Ml dynamite is not efficient as a cutting or breaching charge.

Section III. Special Demolition Charges and Assemblies

1-12. Shaped Demolition Charge. The shaped demolition charge used in military operations is a cylindrical block of high explosive. It has a conical cavity in one end that directs the cone-lining material into a narrow jet to penetrate materials (Figure 1-7). This charge is not effective underwater, since any water in the conical cavity will prevent the high-velocity jet from forming. To obtain maximum effectiveness, place the cavity at the specified standoff distance from the target, and detonate the charge from the exact rear center, using only the priming well provided. Never dual prime a shaped charge.

a. Characteristics.

(1)Fifteen-Pound, M2A4 Shaped Demolition Charge. The M2A4 charge contains a 0.1 l-pound (50 gram) booster of Composition A3 and a 11.5-pound main charge of composition

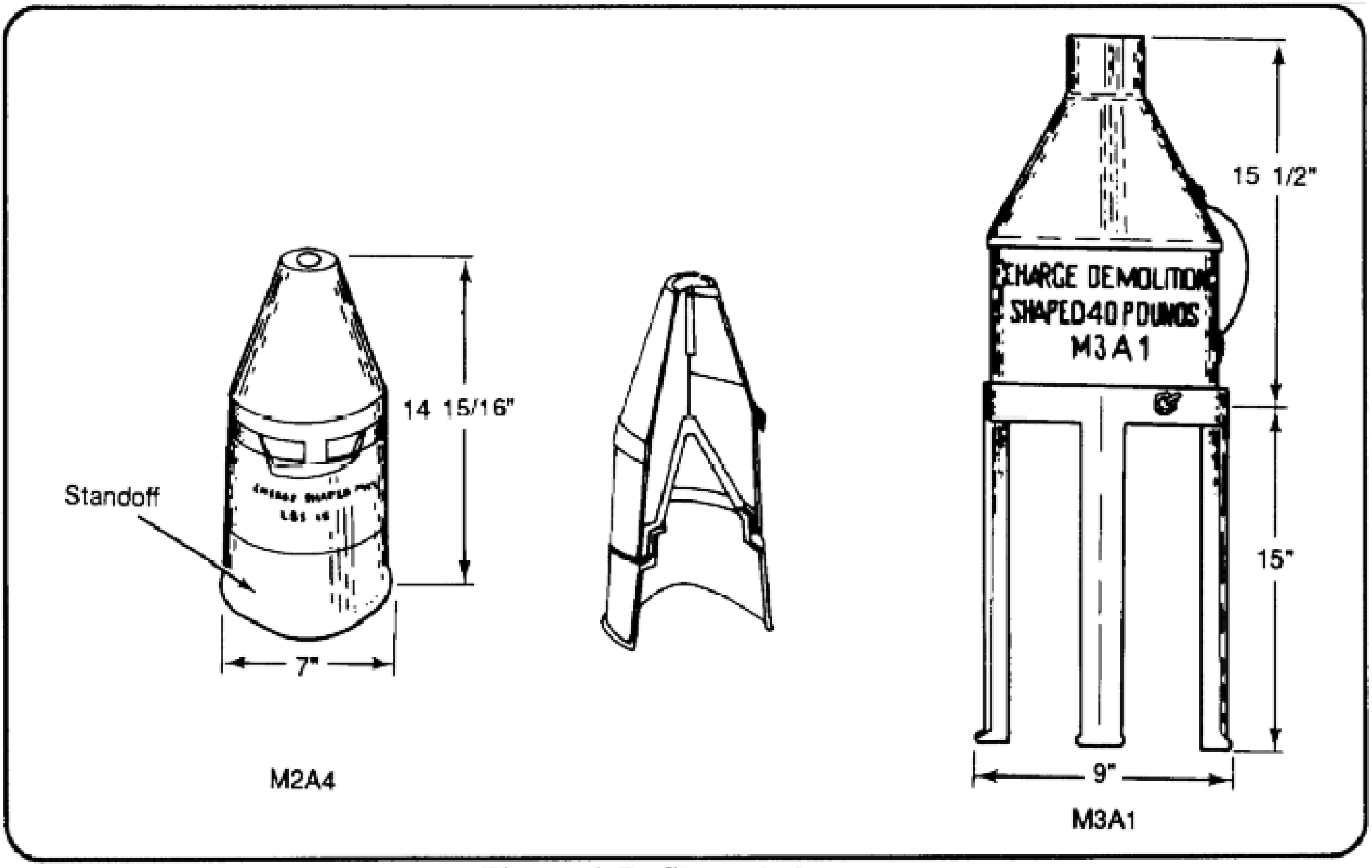


Figure 1-7. Shaped charges

B. It is packaged three charges per wooden box (total weight is 65 pounds). This charge has a moisture-resisting, molded-fiber container. A cylindrical fiber base slips onto the end of the charge to provide a 6-inch standoff distance. The cavity liner is a cone of glass. The charge is 14+5/16 inches high and 7 inches in diameter, including the standoff.

(2) Forty-Pound, M3A1 Shaped Demolition Charge. The M3A1 charge contains a 0.1 l-pound (50 gram) booster of Composition A3 and a 29.5-pound main charge of Composition B. It is packaged one charge per box (total weight is 65 pounds). The charge is in a metal container. The cone liner also is made of metal. A metal tripod provides a 15-inch standoff distance. The charge is 15 ½ inches high and 9 inches in diameter, not including standoff.

b. Use. A shaped demolition charge's primary use is for boring holes in earth, metal, masonry,concrete, and paved and unpaved roads. Its effectiveness depends largely on its shape, composition, and placement. Table 1-3, lists the penetrating capabilities of various materials and the proper standoff distances for these charges.

Table 1-3. Characteristics of boreholes made by shaped charges

Material	Specifications	M2A4 Shaped Charge (15-Pound)*	M3A1 Shaped Charge (40-Pound)**
Armor plate	Penetration Average hole diameter	12.00 in 1.50 in	At least 20.00 in 2.50 in
Reinforced concrete	Maximum wall thickness Penetration depth in thick walls Average hole diameter Minimum hole diameter	36.00 in 30.00 in 2.75 in 2.00 in	60.00 in 60.00 in 3.50 in 2.00 in
Concrete pavement (10-inch with 21-inch rock base course)	Optimum standoff Minimum penetration depth Maximum penetration depth Minimum hole diameter	42.00 in 44.00 in 91.00 in 1.75 in	60.00 in 71.00 in 109.00 in 6.75 in
Concrete pavement (3-inch with 24-inch rock base course)	Optimum standoff Minimum penetration depth Maximum penetration depth Minimum hole diameter	42.00 in 38.00 in 90.00 in 3.75 in	— — — —
Permafrost	Hole depth (30-inch standoff) Hole depth (42-inch standoff) Hole depth (50-inch standoff) Hole diameter (42-inch standoff) Hole diameter (50-inch standoff) Hole diameter (normal standoff)	72.00 in 60.00 in — 1.50 to 6.00 in — 4.00 to 30.00 in	— — 72.00 in — 5.00 to 8.00 in 7.00 to 30.00 in
Ice	Hole depth (42-inch standoff) Hole diameter (42-inch standoff)	7.00 ft 3.50 in	12.00 ft 6.00 in
Soil	Hole depth (30-inch standoff) Hole depth (48-inch standoff) Hole diameter (30-inch standoff) Hole diameter (48-inch standoff)	7.00 ft — 7.00 in —	— 7.00 ft — 14.50 in
Graveled roads	Hole depth (30-inch standoff) Hole depth (48-inch standoff) Hole diameter (30-inch standoff) Hole diameter (48-inch standoff)	7.00 ft — 7.00 in —	— 9.00 ft — 7.00 in

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

c. Special Precautions. To achieve the maximum effectiveness of shaped charges—Center the charge over the target point. Align the axis of the charge with the direction of the desired hole. Use the pedestal to obtain the proper standoff distance.

Suspend the charge at the proper height on pickets or tripods, if the pedestal does not provide the proper standoff distance.

Remove any obstruction in the cavity liner or between the charge and the target.

1-13. M183 Demolition Charge Assembly.

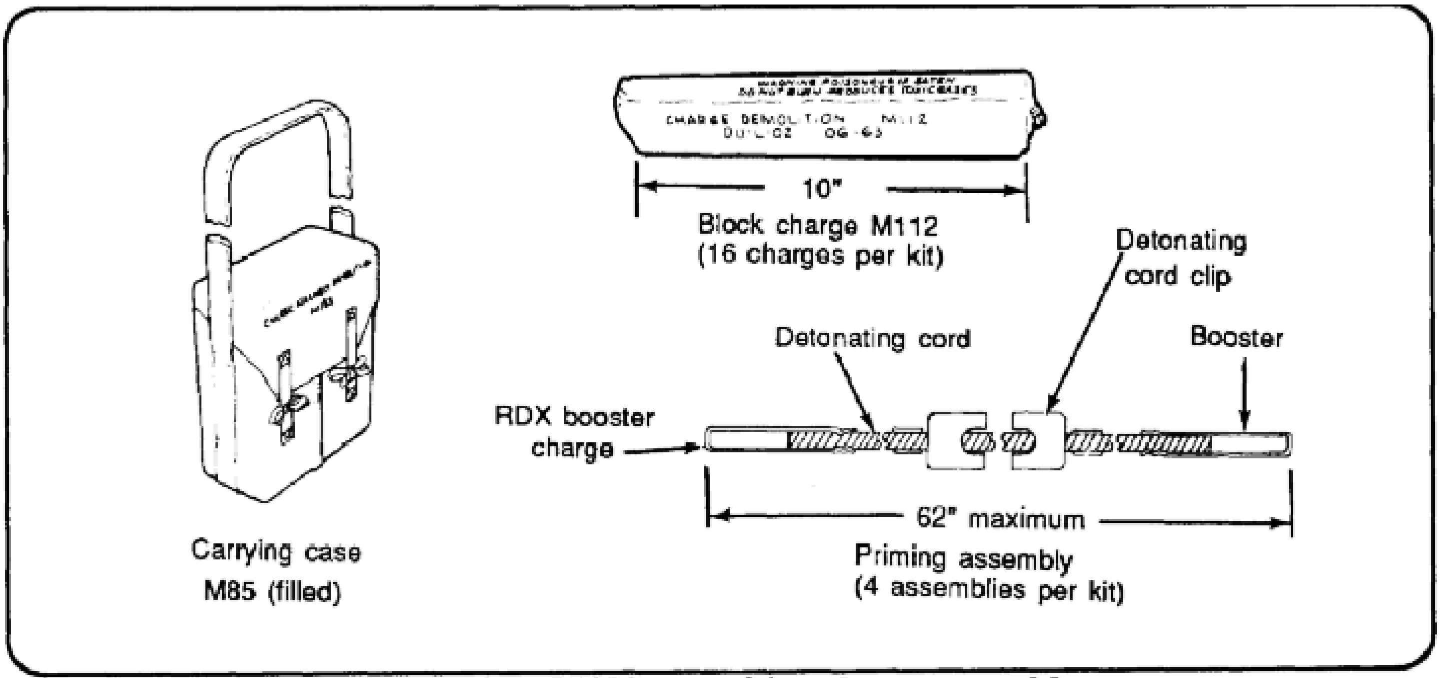


Figure 1-8. M183 demolition charge assembly

a. Characteristics. The Ml83 demolition charge assembly or satchel charge consists of 16 M112 (C4) demolition blocks and 4 priming assemblies. It has a total explosive weight of 20 pounds. The demolition blocks come in two bags, eight blocks per bag. The two bags come in an M85 canvas carrying case. Two M85 cases come in a wooden box 17 1/8 by 11½ by 12½ inches.

Each priming assembly consists of a 5-foot length of detonating cord with an RDX booster crimped to each end and a pair of Ml detonating-cord clips for attaching the priming assembly to a detonating cord ring or line main.

b. Use. The M183 assembly is used primarily forereaching obstacles or demolishing structures when large demolition charges are required (Figure 1-8). The M183 charge also is effective against smaller obstacles, such as small dragon's teeth.

c. Detonation. Detonate the Ml83 demolition charge assembly with a priming assembly and an electric or a nonelectric blasting cap or by using a detonating-cord ring main attached by detonating cord clips.

M1A2 Bangtlore-Torpedo Demolition Kit.

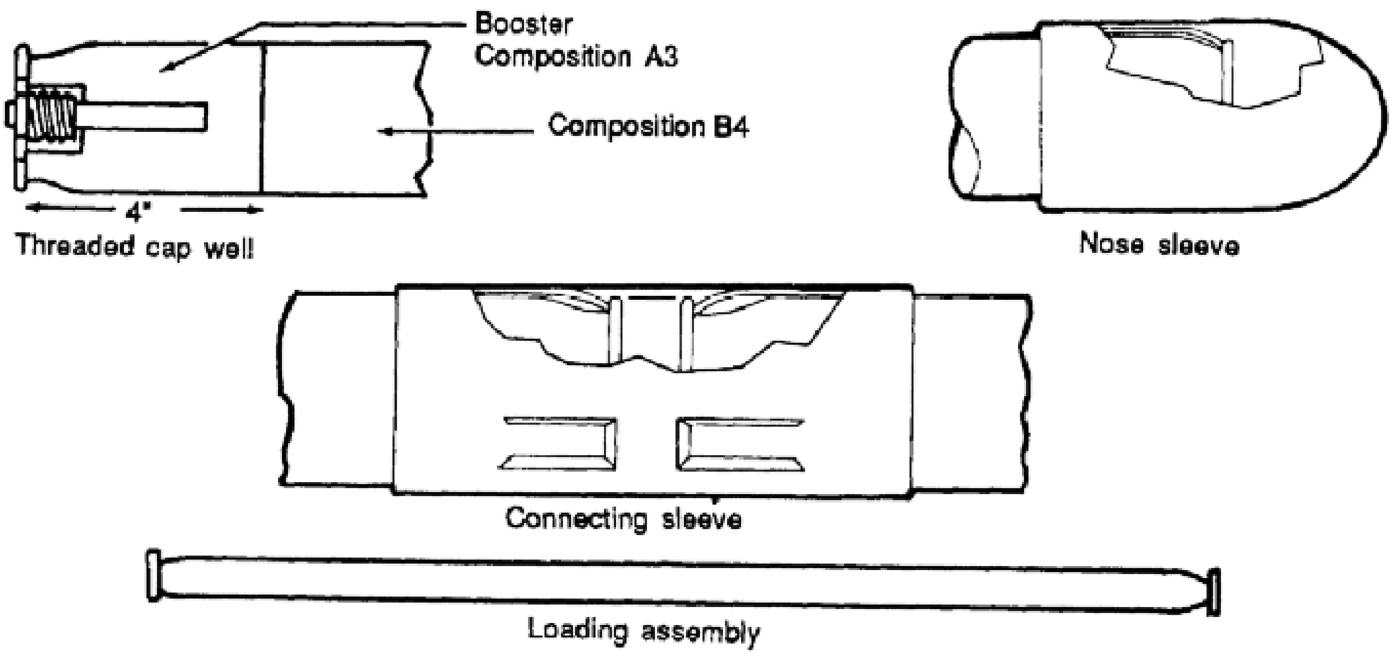


Figure 1-9. M1A2 Bangalore torpedo

a. Characteristics. Each kit consists of 10 loading assemblies, 10 connecting sleeves, and 1 nose sleeve. The loading assemblies, or torpedoes, are steel tubes 5 feet long and 2 1/8 inches in diameter, grooved, and capped at each end (Figure 1-9, page 1-12). The torpedoes have a 4-inch, Composition A3 booster (½ pound each) at both ends of each 5-foot section. The main explosive charge is 10½ pounds of Composition B4. The kit is packaged in a 60¾- by 13¾- by 4 9/16-inch wooden box and weighs 198 pounds.

b. Use. The primary use of the torpedo is clearing paths through wire obstacles and heavy undergrowth. It will clear a 3- to 4-meter-wide path through wire obstacles.

WARNING

The Bangalore torpedo may detonate a live mine when being placed. To prevent detonation of the torpedo during placement, attach the nose sleeve to a fabricated dummy section (approximately the same dimensions as a single Bangalore section) and place the dummy section onto the front end of the torpedo.

c. Assembly. All sections of the torpedo have threaded cap wells at each end. To assemble two or more sections, press a nose sleeve onto one end of one tube, and then connect successive tubes, using the connecting sleeves provided until you have the desired length. The connecting sleeves make rigid joints. The nose sleeve allows the user to push the torpedo through entanglements and across the ground.

d. Detonation. The recommended method to detonate the torpedo is to prime the torpedo with eight wraps of detonating cord and attach two initiation systems for detonation. Another method for priming the Bangalore torpedo is by inserting an electric or a nonelectric blasting cap directly into the cap well. Do not move the torpedo after it has been prepared for detonation. You may wrap the end with detonating cord prior to placing it, but do not attach the blasting caps until the torpedo is in place.

M180 Demolition Kit (Cratering).

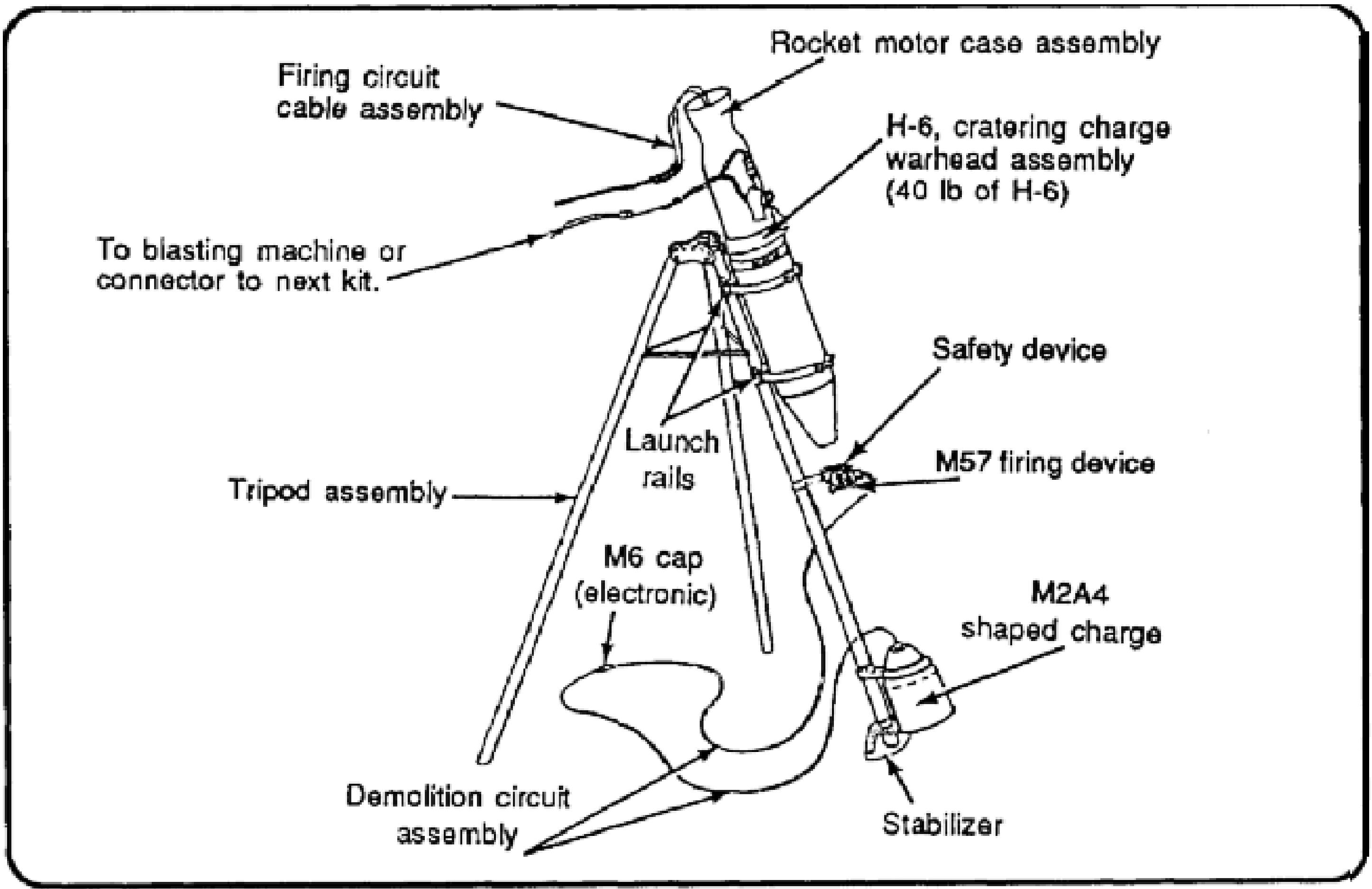


Figure 1-10. M180 demolition kit assembly

a. Characteristics. This kit consists of an M2A4 shaped charge, a modified M57 electrical firing device, a warhead, a rocket motor, a tripod, and a demolition circuit (Figure 1- 10). The shaped charge, firing device, and warhead are permanently attached to the launch leg of the tripod. The rocket motor and the demolition circuit (packed in a wooden subpack) are shipped separately. The kit weighs approximately 165 pounds (74.25 kilograms). TM 9-1375-213-12-1 provides the assembly procedures, operational description, and maintenance instructions for the Ml80 kit.

b. Use. The M180 is designed to produce a large crater in compacted soil or road surfaces, but not in reinforced concrete, arctic tundra, bedrock, or sandy soil. The charge produces a crater in two stages. The shaped charge blows a pilot hole in the surface. Then, the rocket-propelled warhead enters the hole and detonates, enlarging the pilot hole. Up to five kits can be set up close together and fired simultaneously to produce an exceptionally large crater. Up to 15 kits can be widely spaced and freed simultaneously for airfield pocketing.

WARNING

Regardless of the number of kits used, the minimum safe distances for the M180 cratering kit are 1,200 meters for unprotected personnel and 150 meters for personnel under overhead cover.

c. Detonation. When firing the M180, use the M34 50-cap blasting machine.

Section IV. Demolition Accessories

1-16. Time Blasting Fuse. The time blasting fuse transmits a delayed spit of flame to a non-electric blasting cap. The delay allows the soldier to initiate a charge and get to a safe distance before the explosion. There are two types of fuses: the M700 time fuse and safety fuse. Although safety fuse is not often employed, it is still available.

a. M700 Time Fuse. The M700 fuse is a dark green cord, 0.2 inches in diameter, with a

plastic cover (Figure 1-1 1). The M700 bums at an approximate rate of 40 seconds per foot. However, test the burning rate as outlined in Chapter 2 (paragraph 2-lb(l), page 2-2).

Depending on the date of manufacture, the cover may be smooth or have single yellow bands around the outside at 12- or 18-inch intervals and double yellow bands at 60- or 90-inch intervals. These bands accommodate hasty measuring. The outside covering becomes brittle and cracks easily in arctic temperatures. The M700 time fuse is packaged in 50-foot coils, two coils per package, five packages per sealed container, and eight containers (4,000 feet) per wooden box (30 1/8 by 15 1/8 by 14 7/8 inches). The total package weighs 94 pounds.

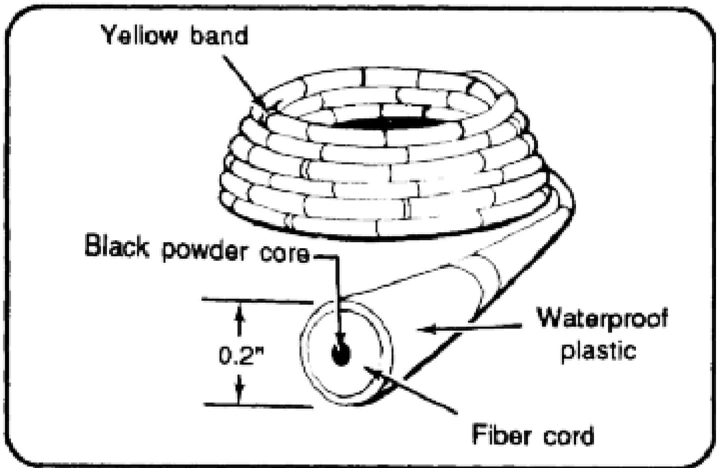


Figure 1-11. M700 time fuse

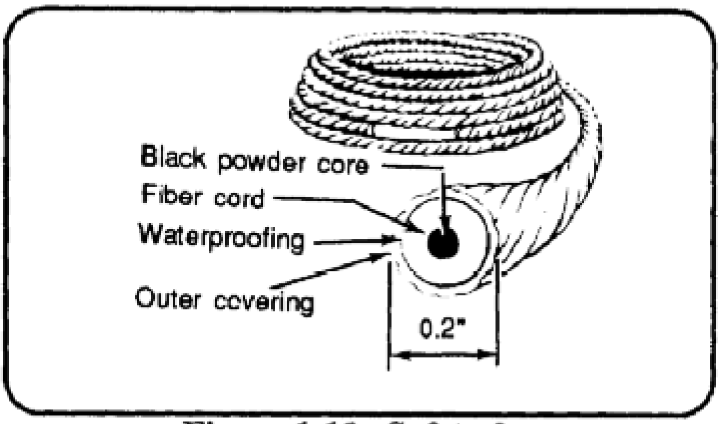


Figure 1-12. Safety fuse

b. Safety Fuse. Safety fuse consists of black powder tightly wrapped with several layers of fiber and waterproofing material. The outside covering becomes brittle and cracks easily in arctic temperatures. The burning rate may vary for the same or different rolls (30 to 45 seconds per foot) under different atmospheric and climatic conditions. This fuse may be any color, but orange is the most common (Figure 1-12). Test each roll in the area where the charge will be placed (paragraph 2-lb(l), page 2-2). Since safety fuse burns significantly faster underwater, test it underwater before preparing an underwater charge.

Safety fuse is packaged in 50-foot coils, two coils per package, and 30 packages (3,000 feet) per wooden box (24¾ by 15¾ by 12 ½ inches). The total package weighs 93.6 pounds.

Detonating Cord.

a. Characteristics. The American, British, Canadian, and Australian (ABCA) Standardization

Program recognizes this Type 1 detonating cord as the standard detonating cord. Detonating cord (Figure 1-13) consists of a core of high explosive (6.4 pounds of PETN per 1,000 feet) wrapped in a reinforced and waterproof olive-drab plastic coating. This detonating cord is approximately 0.2 inches in diameter, weighs approximately 18 pounds per 1,000 feet, and has a breaking strength of 175 pounds. Detonating cord is functional in the same temperature range as plastic explosive, although the cover becomes brittle at lower temperatures. Moisture can penetrate the explosive filling to a maximum distance of 6 inches from any cut or break in the coating. Water-soaked detonating cord will detonate if there is a dry end to allow initiation. For this reason, cut off and discard the first 6 inches of any new or used detonating cord that nonelectric blasting caps are crimped to. Also, leave a 6-inch overhang when making connections or when priming charges.

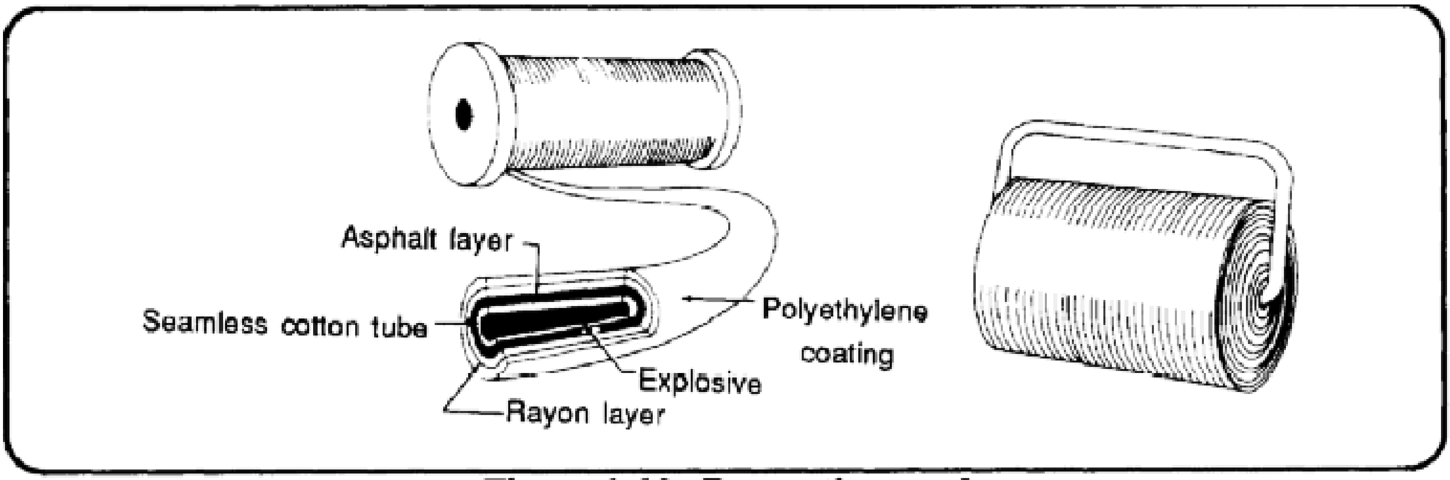


Figure 1-13. Detonating cord

b. Use. Use detonating cord to prime and detonate other explosive charges. When the detonating cord's explosive core is initiated by a blasting cap, the core will transmit the detonation wave to an unlimited number of explosive charges. Chapter 2 explains the use of detonating cord for these purposes.

c. Precautions. Seal the ends of detonating cord with a waterproof sealant when used to fire underwater charges or when charges are left in place several hours before firing. If left for no longer than 24 hours, a 6-inch overlap will protect the remainder of a line from moisture. Avoid kinks or sharp bends in priming, as they may interrupt or change the direction of detonation and cause misfires. Avoid unintended cross-overs of the detonating cord where no explosive connection is intended. To avoid internal cracking do not step on the detonating cord.

Blasting Caps. Blasting caps are for detonating high explosives. There are two types of blasting caps: electric and nonelectric. They are designed for insertion into cap wells and are also the detonating element in certain firing systems and devices. Blasting caps are rated in power, according to the size of their main charge. Commercial blasting caps are normally Number 6 or 8 and are for detonating the more sensitive explosives, such as commercial dynamite and tetryl.

Special military blasting caps (M6 electric and M7 nonelectric) ensure positive detonation of the generally less sensitive military explosives. Their main charge is approximately double that of commercial Number 8 blasting caps. Never carry blasting caps loose or in uniform pockets where they are subject to shock. Separate blasting caps properly. Never store blasting caps with other explosives. Do not carry blasting caps and other explosives in the same truck except in an emergency (paragraph 6-11, page 6-10).

WARNING

Handle military and commercial blasting caps carefully, as both areextremely sensitive and may explode if handled improperly.

Do not tamper with blasting caps. Protect them from shock and extreme heat.

a. Electric Blasting Caps. Use electric blasting caps when a source of electricity, such as a blasting machine or a battery, is available. Both military and commercial caps may be used.

Military caps (Figure 1-14, page 1-6) operate instantaneously. Commercial caps may operate instantaneously or have a delay feature. The delay time of commercial caps for military applications ranges from 1 to 1.53 seconds. Electric caps have lead wires of various lengths. The most common lead length is 12 feet. Electric caps require 1.5 amperes of power to initiate. The standard-issue cap is the M6 special electric blasting cap. TM 43-0001-38 gives additional information on blasting caps.

WARNING Do not remove the short-circuiting shunt until ready to test the cap.

Doing this prevents accidental initiation by static electricity.

If the cap has no shunt, twist the lead's bare ends together with at least three 180-degree turns to provide a shunting action.

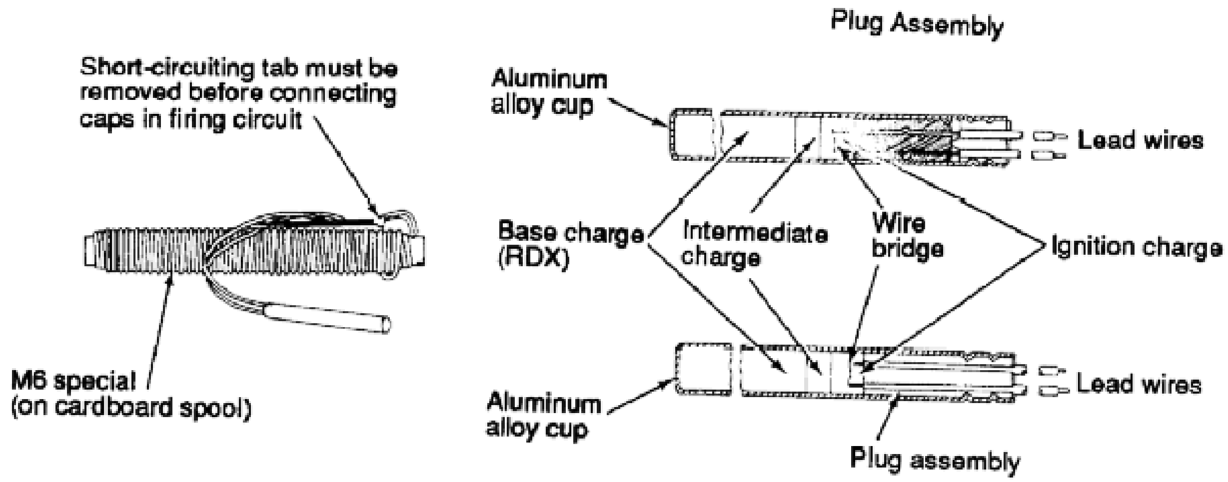


Figure 1-14. Electric blasting caps

b. Non-electric Blasting Caps. Initiate these caps with time-blasting fuse, a firing device, or detonating cord (Figure 1-15). Avoid using non-electric blasting caps to prime underwater charges because the caps are hard to waterproof.

If necessary, waterproof nonelectric blasting caps with a sealing compound. The M7 special nonelectric blasting cap is the standard issue.

The open end of the M7 special nonelectric blasting cap is flared to allow easy insertion of the time fuse. TM 43-0001-38 gives additional information on blasting caps.

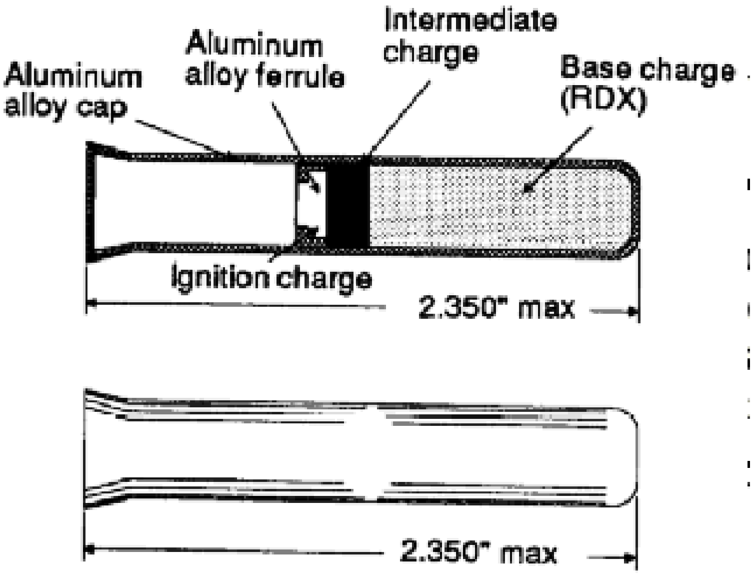


Figure 1-15. Nonelectric blasting cap

MIA4 Priming Adapter. The MIA4 priming adapter is a plastic, hexagonal-shaped device, threaded to fit threaded cap wells. The shoulder inside the threaded end will allow time blasting fuse and detonating cord to pass, but the shoulder is too small to pass a military blasting cap. To accommodate electric blasting caps, the adapter has a lengthwise slot that permits blasting cap lead wires to be quickly and easily installed in the adapter (Figure 1-16).

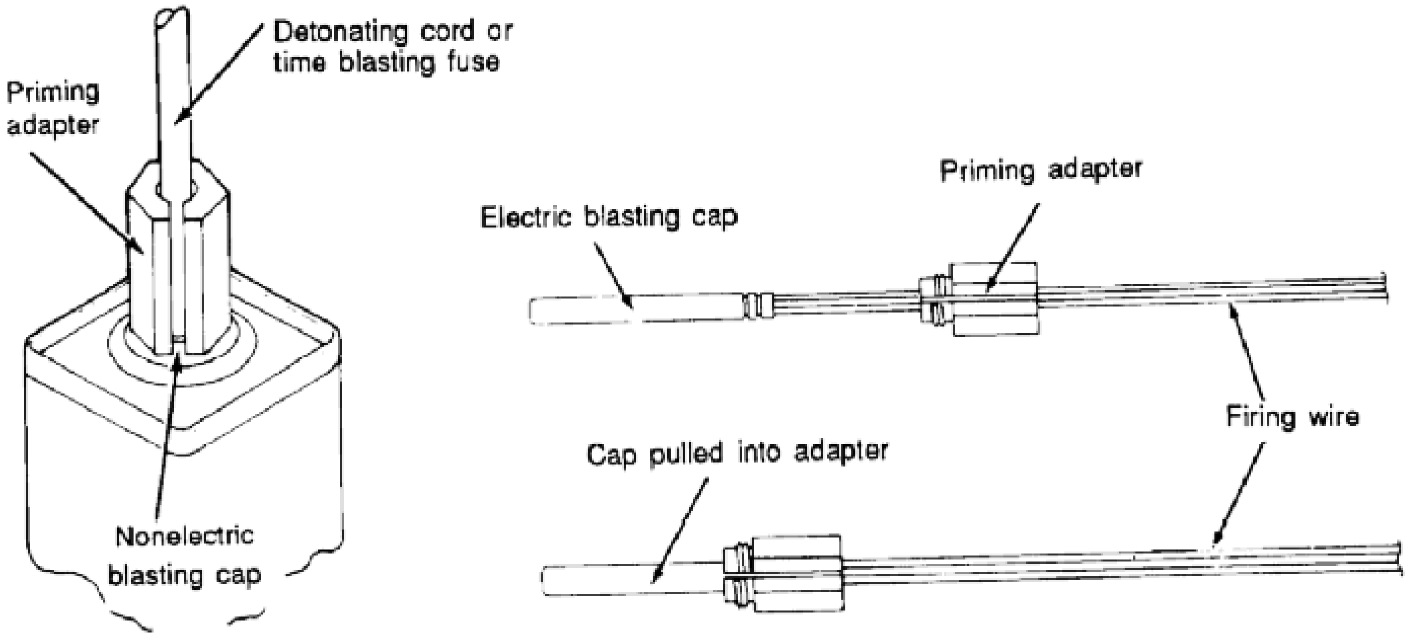


Figure 1-16. M1A4 priming adapter

M8 Blasting Cap Holder. The M8 blasting cap holder is a metal clip designed to attach a blasting cap to a sheet explosive (Figure 1-17). These clips are supplied with Ml18 sheet demolition charges and Ml86 roll demolition charges. The M8 blasting cap holder is also available as a separate-issue item in quantities of 4,000.

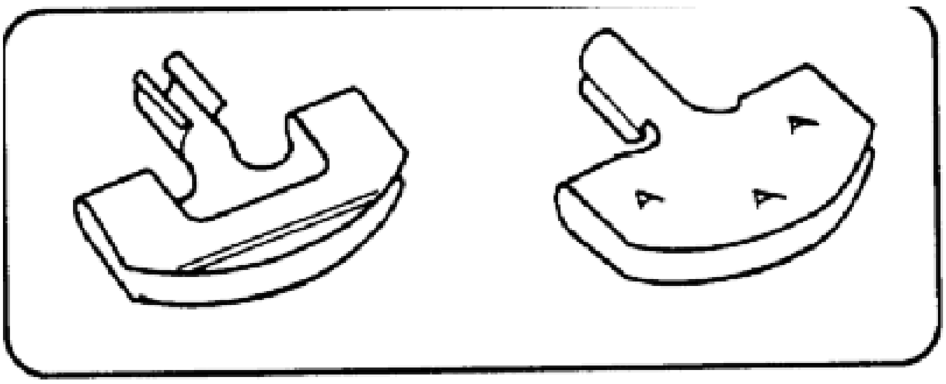
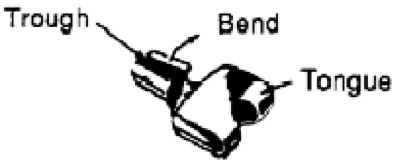
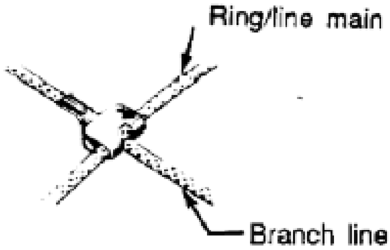


Figure 1-17. M8 blasting cap holder

1-21. Ml Detonating-Cord Clip. The Ml detonating-cord clip is a device for holding two strands of detonating cord together, either parallel or at right angles (Figure 1-18, diagram 1). Using these clips is faster and more efficient than using knots. Knots, if left for extended periods, may loosen and fail to function properly.

a. Branch Lines. Connect a detonating cord branch line by passing it through the trough of the Ml detonating cord clip and through the hole in the tongue of the clip. Next, place the line/ring main into the tongue of the clip so that it crosses over the branch line at a 90-degree angle and ensure the crossover is held secure by the tongue; it may be necessary to bend or form the tongue while doing this.





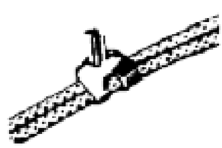


Figure 1-18. M1 detonating-cord clip

b. Splices. Splice the ends of detonating cords by first overlapping them approximately 12 inches. Then secure each loose end to the other cord by using a clip. Finally, bend the tongues of the clips firmly over both strands. Make the connection stronger by bending the trough end of the clip back over the tongue

Ml Adhesive Paste. Ml adhesive paste is a sticky, putty-like substance that is used to attach charges to flat, overhead or vertical surfaces. Adhesive paste is useful for holding charges while tying them in place or, under some conditions, for holding without ties. This paste does not adhere satisfactorily to dirty, dusty, wet, or oily surfaces. Ml adhesive paste becomes useless when softened by water.

Pressure-Sensitive Adhesive Tape.

a. Characteristics. Pressure-sensitive tape is replacing Ml adhesive paste. Pressure sensitive tape has better holding properties and is more easily and quickly applied. This tape is coated on both sides with pressure-sensitive adhesive and requires no solvent or heat to apply. It is available in 2-inch-wide rolls , 72 yards long.

b. Use. This tape is effective for holding charges to dry, clean wood, steel, or concrete.

c. Limitations. This tape does not adhere to dirty, wet, oily, or frozen surfaces.

1-24. Supplementary Adhesive for Demolition Charges.

a. Characteristics. This adhesive is used to hold demolition charges when the target surface is below freezing, wet, or underwater. The adhesive comes in tubes packed in water-resistant, cardboard slide boxes, with wooden applicators

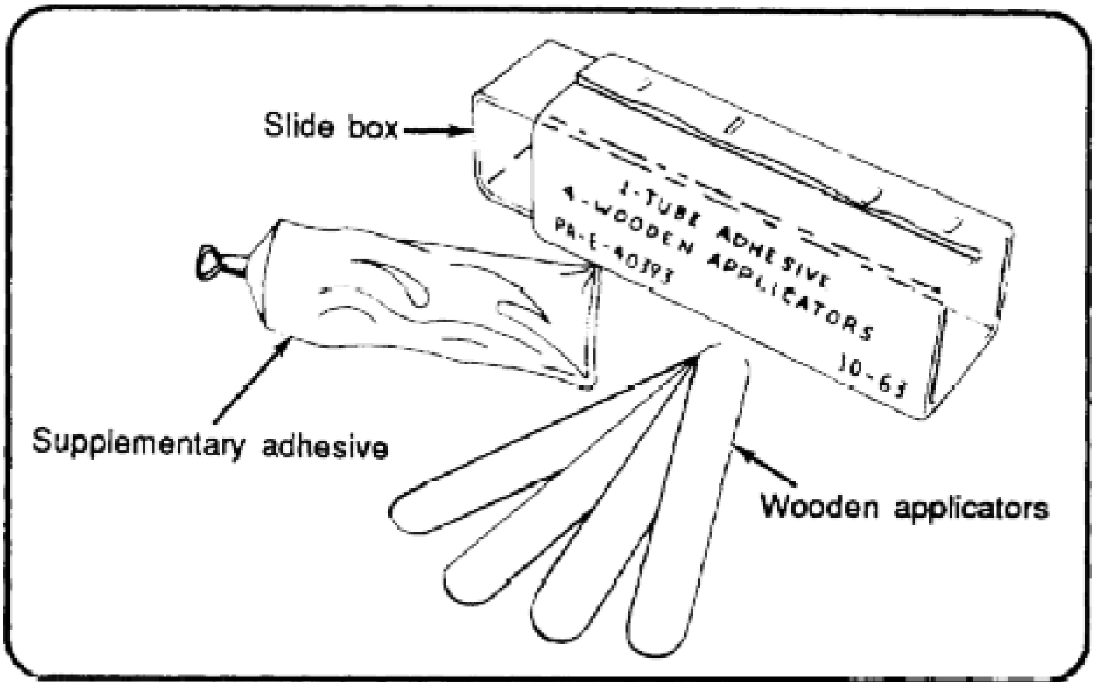


Figure 1-19. Supplementary adhesive

b. Use. Apply the adhesive to the target surface and the demolition block with a wooden applicator and press the two together.

1-25. Waterproof Sealing Compound. This sealant is for waterproofing connections between time blasting fuses or detonating cords and nonelectric blasting caps. The sealing compound will not make a permanent waterproof seal. Since this sealant is not permanent, fire underwater demolitions as soon as possible after placing them.

1-26. M2 Cap Crimper. Use the M2 cap crimper for squeezing the shell of a nonelectric blasting cap around a time blasting fuse, standard coupling base, or detonating cord.

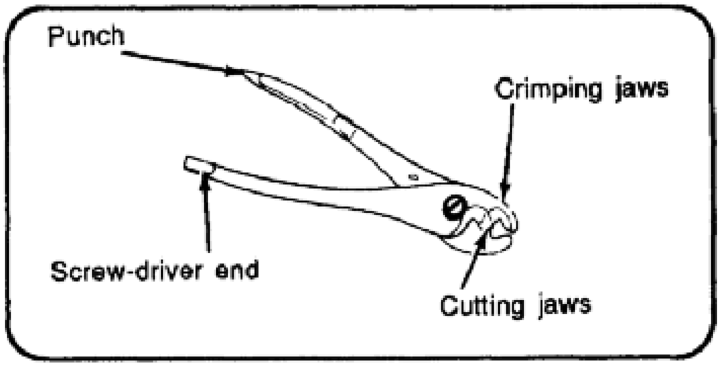


Figure 1-20. M2 cap crimper

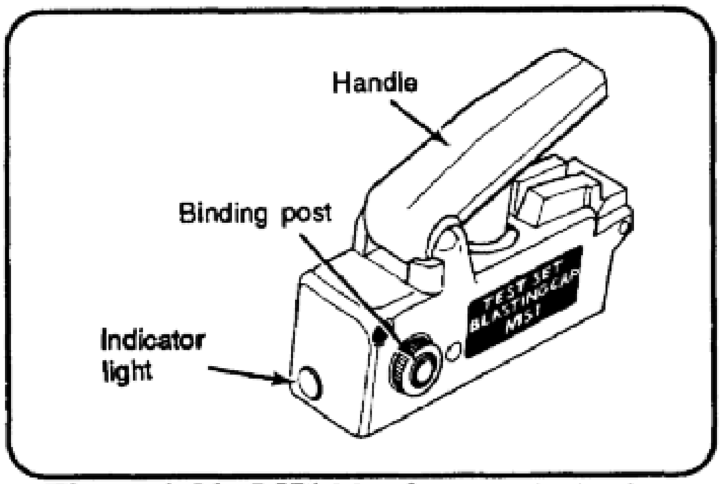


Figure 1-21. M51 blasting-cap test set

Crimp the shell securely enough to keep the fuse, base, or cord from being pulled off, but not so tightly that it interferes with the operation of the initiating device. A stop on the handle helps to limit the amount of crimp applied. The M2 crimper forms a water-resistant groove completely around the blasting cap. Apply a sealing compound to the crimped end of the blasting cap to waterproof it. The rear portion of each jaw is shaped and sharpened for cutting fuses and detonating cords. One leg of the handle is pointed for punching cap wells in explosive materials. The other leg has a screwdriver end. Cap crimpers are made of a soft, nonsparking metal that conducts electricity. Do not use them as pliers because such use damages the crimping surface. Ensure crimp hole is round (not elongated) and the cutting jaws are not jagged. Keep the cutting jaws clean, and use them only for cutting fuses and detonating cords.

M51 Blasting-Cap Test Set.

a. Characteristics. The test set is a self-contained unit with a magneto-type impulse generator, an indicator lamp, a handle to activate the generator, and two binding posts for attaching firing leads.

The test set is waterproof and capable of operation at temperatures as low as -40 degrees Fahrenheit

b. Use. Check the continuity of firing wire, blasting caps, and firing circuits by connecting the leads to the test-set binding posts and then depressing the handle sharply. If there is a continuous (intact) circuit, even one created by a short circuit, the indicator lamp will flash. When the circuit is open, the indicator lamp will not flash.

c. Maintenance. Handle the test set carefully and keep it dry to assure optimum use.

Before using, ensure the test set is operating properly by using the following procedure:

(1) Hold apiece of bare wire or the legs of the M2 crimpers between the binding posts.

(2) Depress the handle sharply while observing the indicator lamp. The indicator lamp should flash.

(3) Remove the bare wire or crimper legs from the binding posts.

(4) Depress the handle sharply while observing the indicator lamp. This time the indicator lamp should not flash.

(5) Perform both tests to ensure the test set is operating properly.

1-28. Blasting Machines. Blasting machines provide the electric impulse needed to initiate electric blasting-cap operations. When operated, the M32 and M34 models use an alternator and a capacitor to energize the circuit.

a. M32 10-Cap Blasting Machine. This small, lightweight blasting machine produces adequate current to initiate 10 electrical caps connected in series using 500 feet of WD-l cable. To operate the machine, use the following procedure:

Figure 1-22. M32 blasting machine

(1) Check the machine for proper operation. Release the blasting machine handle by rotating the retaining ring downward while pushing in on the handle. The handle will automatically spring outward from the body of the machine.

(2) Activate the machine by depressing the handle rapidly three or four times until the neon indicator lamp flashes. The lamp is located between the wire terminal posts and cannot be seen until it flashes, since it is covered by green plastic.

(3) Insert the firing wire leads into the terminals by pushing down on each terminal post and inserting the leads into the metal jaws.

(4) Hold the machine upright (terminals up) in either hand,

so the plunger end of the handle rests in the base of the palm and the fingers grasp the machine's body. Be sure to hold the machine correctly, as the handles are easily broken.

(5) Squeeze the handgrip sharply several times until the charge fires. Normally, no more than three or four strokes are required.

b. M34 50-Cap Blasting Machine. This small, lightweight machine produces adequate current to initiate 50 electrical caps connected in a series. It looks like the M32 blasting machine (Figure 1-22) except for a black band around the base and a steel-reinforced actuating handle.

Test and operate the M34 in the same manner as the M32.

Firing Wire and Reels.

a. Types of Firing Wire. Wire for firing electric charges is available in 200- and 500-foot coils.

The two-conductor AWG Number 18 is a plastic-covered or rubber-covered wire available in 500-foot rolls. This wire is wound on an RL39A reel unit. The single conductor. AWG Number 20 annunciator wire is available in 200-foot coils and is used to make connections between blasting caps and firing wire. The WD- l/TT communication wire will also work, but it requires a greater power source if more than 500 feet are used (blasting machines will not initiate the full-rated number of caps connected with more than 500 feet of WD-l/TT wire).

As a rule of thumb, use 10 less caps than the machine's rating for each additional 1,000 feet of WD-1/TT wire employed.

b. Reel. The RL39A reel, with spool, accommodates 500 feet of wire. The reel has a handle assembly, a crank, an axle, and two carrying straps (Figure 1-23). The fixed end of the wire extends from the spool through a hole in the side of the drum and fastens to two brass thumb-out terminals.

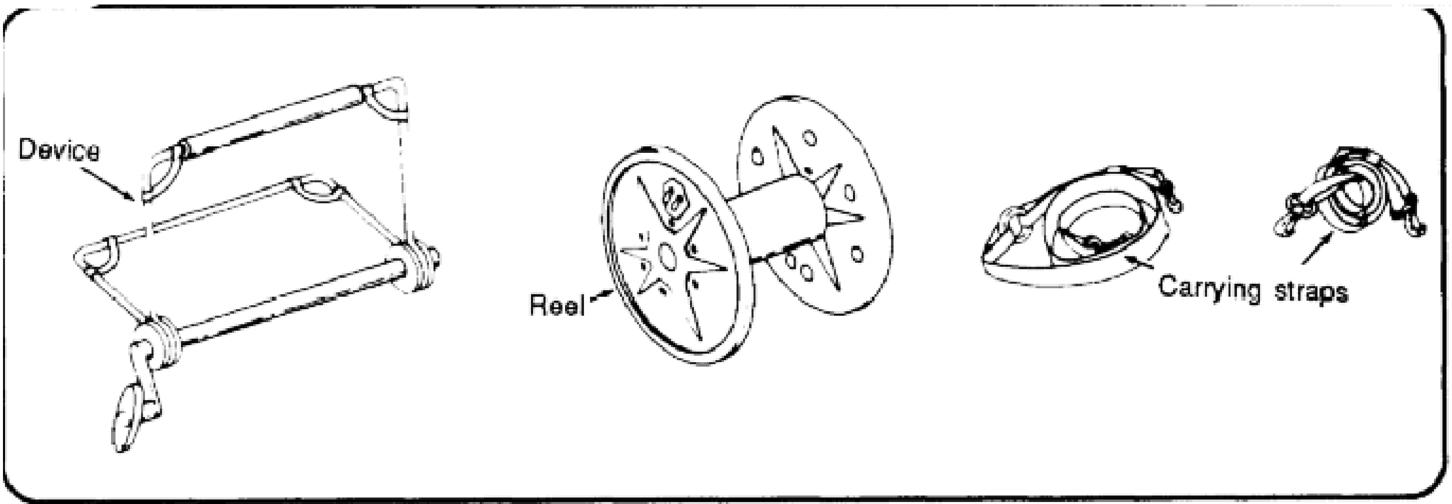


Figure 1-23. Firing-wire reel

The carrying handles are two U-shaped steel rods. A loop at each end encircles a bearing assembly to accommodate the axle. The crank is riveted to one end of the axle, and a cotter pin holds the axle in place on the opposite end.

1-30. Firing Devices and Other Accessory Equipment

a. M60 Weatherproof Fuze Igniter. This device is for igniting timed blasting fuse in all weather conditions, even underwater, if properly waterproofed. Insert the fuse through a rubber sealing grommet and into a split collet. This procedure secures the fuse when the end capon the igniter is tightened. Pulling the pull ring releases the striker assembly, allowing the firing pin to initiate the primer, igniting the fuse. Chapter 2 gives detailed operating instructions for the M60 igniter.

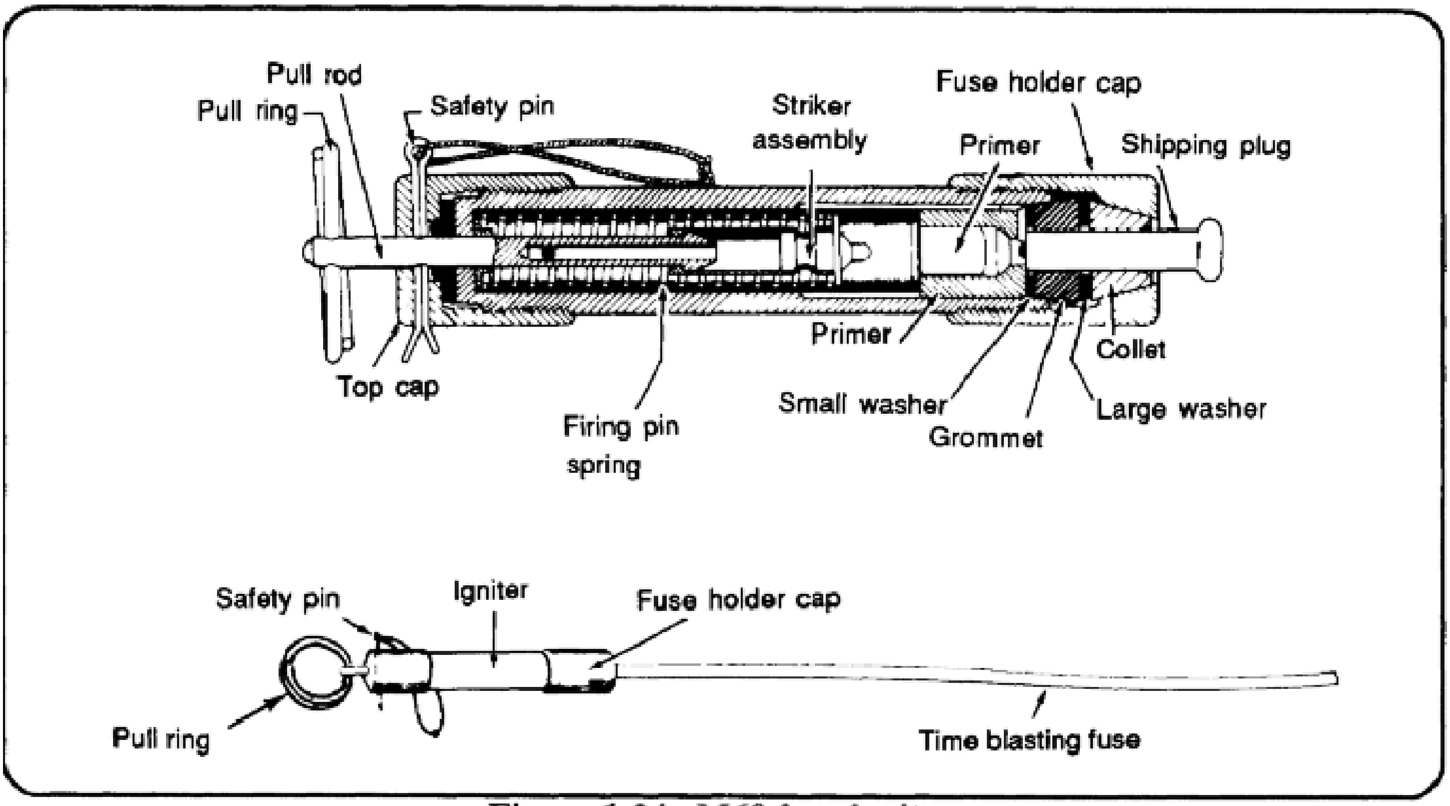


Figure 1-24. M60 fuze igniter

b. Demolition Equipment Set. This set (Electric and Nonelectric Explosive Initiating Demolition Equipment Set) is an assembly of tools necessary for performing demolition operations.

Table 1-4. Demolition equipment set

Quantity	Nomenclature	Quantity	Nomenclature
3	Bag, Demolition Equipment	1	Machine, Blasting, M34
5	Box, Blasting Cap, Plastic, 10-Cap	2	Pliers, Lineman's, w/ Side Cutter, 8-Inch
1	Chest, Demo, Engr Plt, M1931	1	Pliers, Diagonal-Cutting, 6-Inch
4	Crimper, Blasting Cap, M2	4	Reel, Cable
2	Knife, Pocket, w/ Can Opener and Punch	1	Machine, Cable-Reeling, Manual
2	Knife, Pocket, w/ Screwdriver and Wire Scraper	1	Set, Blasting-Cap Test, M51
1	Shears, Metal-Cutting, Manual, 8-Inch		**NOTE**: The individual items listed in this set are available separately.
2	Tape, Measuring, Steel, Millimeters and Inches		
1	Tape, Measuring, Plastic-Coated, 100-Foot		

NEXT

BACK TO COMMERCIAL EXPLOSIVES

Chapter 2

Initiating Sets, Priming, and Firing Systems

Section I. Initiating Sets

WARNING

Refer to the safety procedures in Chapter 6 before undertaking any demolitions mission.

Non-electric Initiation Sets.

a. Components Assembly. A non-electric system uses a non-electric blasting cap as the initiator. The initiation set consists of a fuse igniter (produces flame that lights the time fuse), the time blasting fuse (transmits the flame that fires the blasting cap), and a non-electric blasting cap (provides shock adequate to detonate the explosive) (Figure 2-1). When combined with detonating cord, a single initiation set can fire multiple charges.

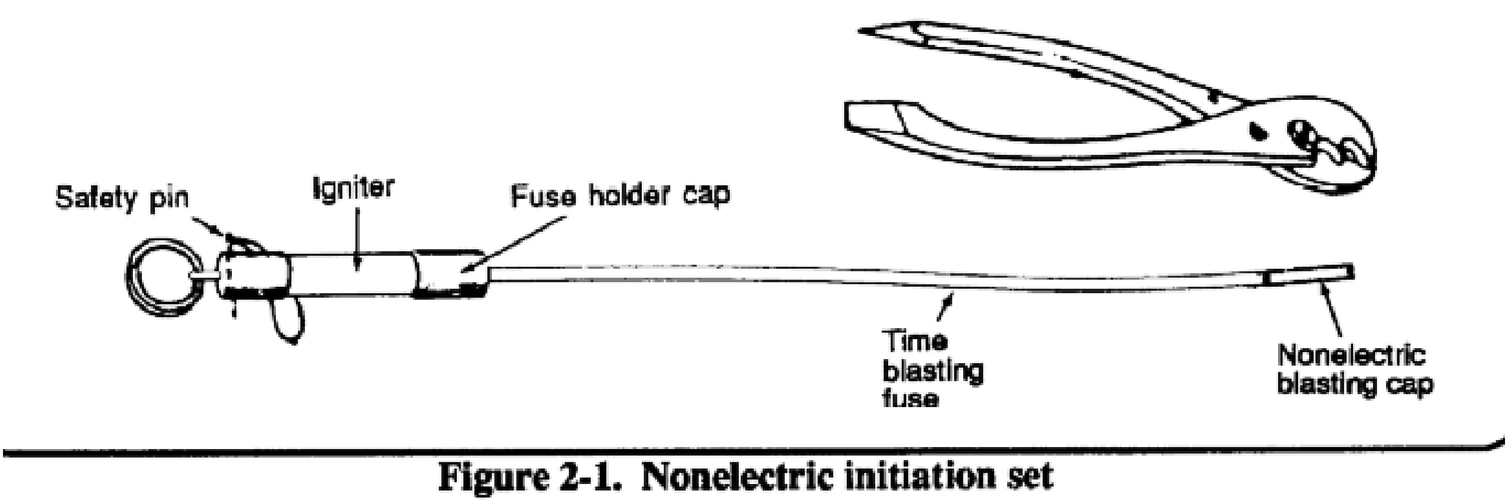


Figure 2-1. Nonelectric initiation set

b. Preparation Sequence. Preparing demolitions for non-electric initiation follows a specified process. This process includes—

Step 1. Checking the time fuse.

Step 2. Preparing the time fuse.

Step 3. Attaching the fuse igniter.

Step 4. Installing the primer adapter.

Step 5. Placing the blasting cap

(1) Checking Time Fuse. Test every coil of fuse, or remnant of a coil, using the burning-rate test prior to use.

One test per day per coil is sufficient.

Never use the first and last 6 inches of a coil because moisture may have penetrated the coil to this length. Using an M2 crimper, cut and discard a 6-inch length from the free end of the fuse

(Figure 2-2). Cut off and use a 3-foot length of the fuse to check the burning rate. Ignite the fuse and note the time it takes for the fuse to burn. Compute the burning rate per foot by dividing the bum time in seconds by the length in feet. If the test bum does not fall within ± 5 seconds of a 40-second-per-foot burn rate, perform another test to verify your results.

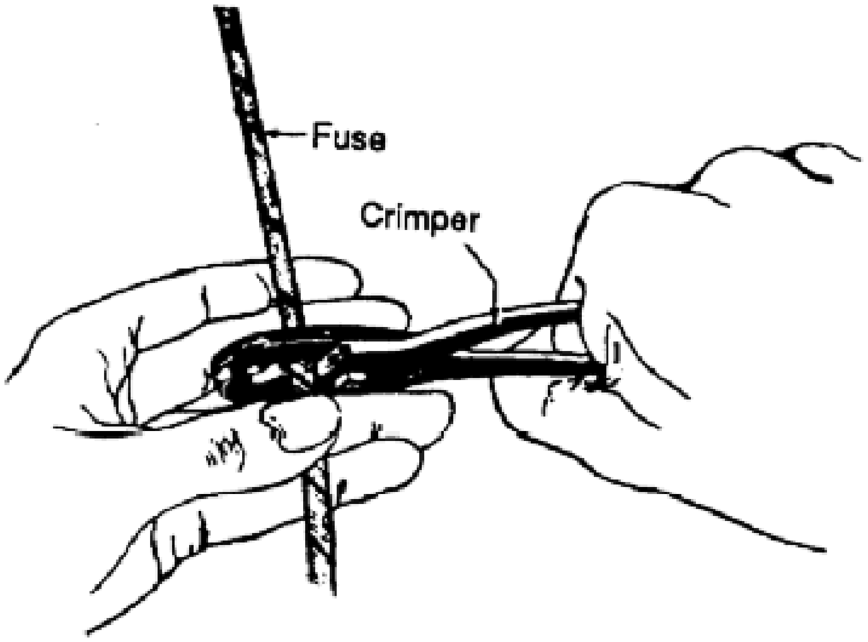


Figure 2-2. Cutting time fuse

WARNING

Test burn a 3-foot length of time blasting fuse to determine the exact rate prior to use.

(2) Preparing Time Fuse. Cut the fuse long enough to allow the person detonating the charge to reach safety (walking at a normal pace) before the explosion. Walk and time this distance prior to cutting the fuse to length. The formula for determining the length of time fuse required is—

Time Required(min) X 60 (sec/min) = Fuse Length (ft)

Burn Rate (sec/ft)

Make your cut squarely across the fuse. Do not cut the fuse too far in advance, since the fuse may absorb moisture into the open ends. Do not allow the time fuse to bend sharply, as you may crack the black powder core, resulting in a misfire.

(3) Attaching Fuse Igniter. To attach an M60 weatherproof fuze igniter, unscrew the fuse holder cap two or three turns, but do not remove the cap. Press the shipping plug into the igniter to release the split collet (Figure 1-24, page 1-22). Rotate and remove the plug from the igniter. Insert the free end of the time fuse as far as possible into the space left by the removed shipping plug.

Sufficiently tighten the holder cap to hold the fuse and weatherproof the joint.

(4) Installing Priming Adapter. If you use a priming adapter to hold a non-electric blasting cap, place the time fuse through the adapter before installing (crimping) the blasting cap onto the fuse.

Ensure the adapter threads are pointing to the end of the time fuse that will receive the blasting cap.

(5) Preparing Blasting Caps.

(a) Inspection. Hold the cap between the thumb and ring finger of one hand, with the forefinger of the same hand on the closed end of the blasting cap. Inspect the blasting cap by looking into the open end. You should see a yellow-colored ignition charge. If dirt or any foreign matter is present, do the following:

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.

If the foreign matter does not dislodge, do not use the cap.

(b) Placing and crimping. Use this procedure for installing blasting caps onto fuse. Using this procedure will allow accurate crimping, even in darkness, because finger placement guides the crimpers to the open end of the blasting cap. Use the following procedures to attach a non-electric blasting cap onto time fuse:

Hold the time blasting fuse vertically with the square-cut end up, and slip the blasting cap gently down over the fuse so the flash charge in the cap touches the fuse.

WARNING

If the charge in the cap is not in contact with the fuse, the fuse may not ignite the cap (misfire). Never force a time fuse into a blasting cap, for example, by twisting or any other method. If the fuse end is flat or too large to enter the blasting cap freely, roll the fuse between the thumb and fingers until it will freely enter the cap. A rough, jagged-cut fuse inserted in a blasting cap can cause a misfire. If the cutting jaws of the M2 crimper are unserviceable, use a sharp knife to cut the fuse. When using a knife to cut fuse squarely, cut the fuse against a solid, non-sparking surface such as wood.

While applying slight pressure with the forefinger on the closed end of the cap, grasp the fuse with the thumb and ring finger. Using the opposite hand, grasp the crimpers. Place the crimping jaws around the cap at a point 1/8 to ¼ inch from the open end. The thumb and ring finger that hold the fuse will be below the crimpers. Rest the second finger of the hand holding the fuse on top of the crimpers to prevent the crimpers from sliding up the cap.

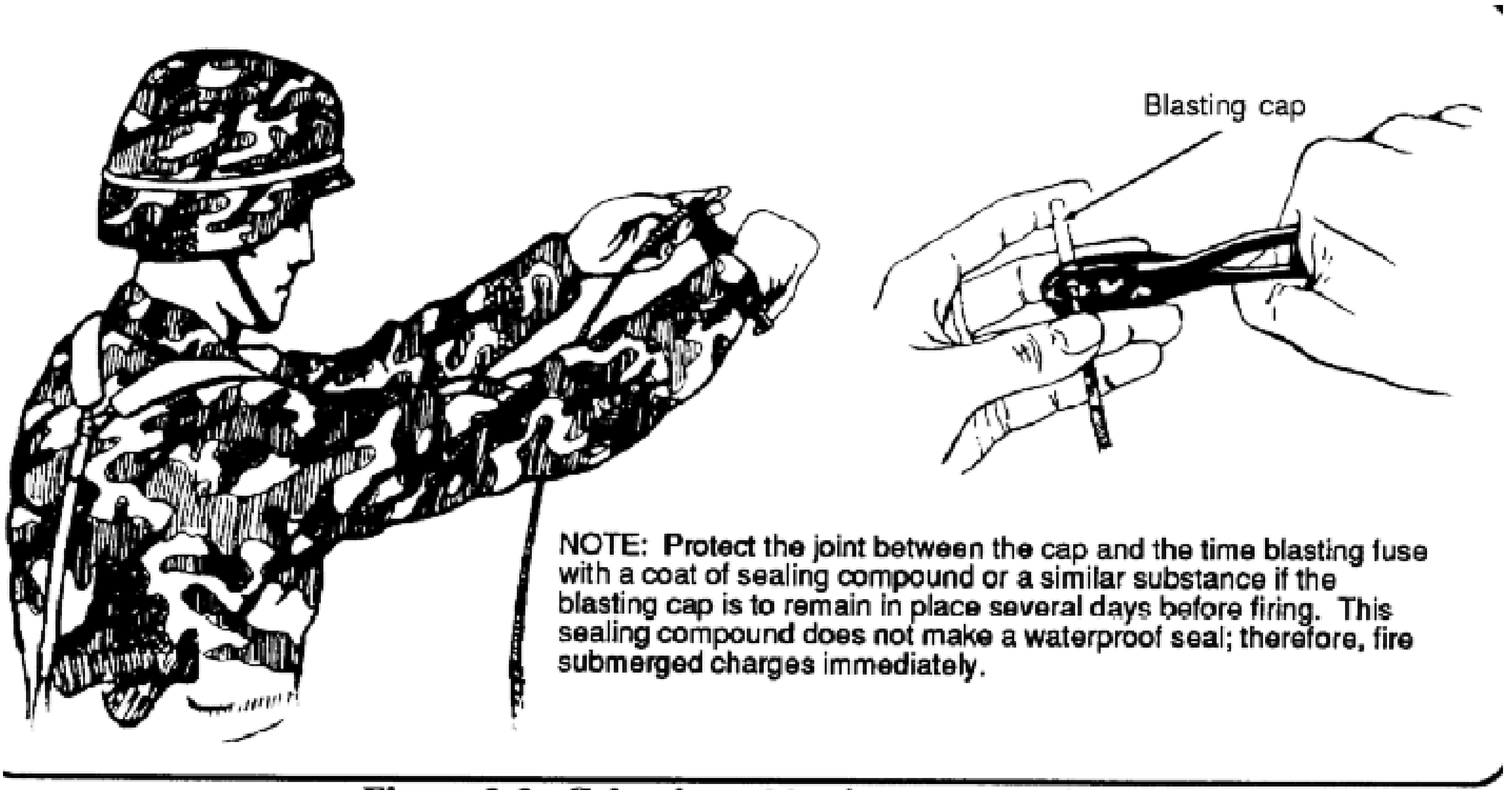


Figure 2-3. Crimping a blasting cap onto fuse

Extend both arms straight out while rotating the hands so that the closed end of the blasting cap is pointing away from the body and from other personnel.

Crimp the blasting cap by firmly squeezing the M2 crimper handles together, maintaining eye contact with the blasting cap. Inspect the crimp after you have finished. Ensure that the fuse and cap are properly joined by gently trying to pull them apart

NOTE: Attach the M60 fuze igniter to the time fuse before crimping a blasting cap to the opposite end. Do not remove the safety pin until you are ready to detonate the charge.

WARNING

Do not crimp too close to the explosive end of the blasting cap; doing this may cause the cap to detonate.

Point the cap out and away from the body during crimping.

NOTE: If the cap is to remain in place several days before firing, protect the joint between the cap and the timed blasting fuse with a coat of sealing compound or similar substance. This sealing compound will not make a waterproof seal; therefore, fire submerged charges immediately.

NOTE: See paragraph 6-8 (page 6-8) for procedures on handling non-electric misfires.

c. Fuse Initiation. To fire the assembly, hold the M60 igniter in one hand and remove the safety pin with the other. Grasp the pull ring and give it a quick, hard pull. In the event of a misfire, reset the M60 by pushing the plunger all the way in, rotate it left and right, and attempt to fire as before.

WARNING

Water can enter through the vent hole in the pull rod when attempting to reset the igniter under water.

This will prevent the fuse igniter from working after resetting.

NOTE: If a fuze igniter is not available, light the time blasting fuse with a match.

Split the fuse at the end (Figure 2-4) and place the head of an unlit match in the powder train. Light the inserted match head with a flaming match, or rub the abrasive on the match box against it. It may be necessary to use two match heads during windy conditions.

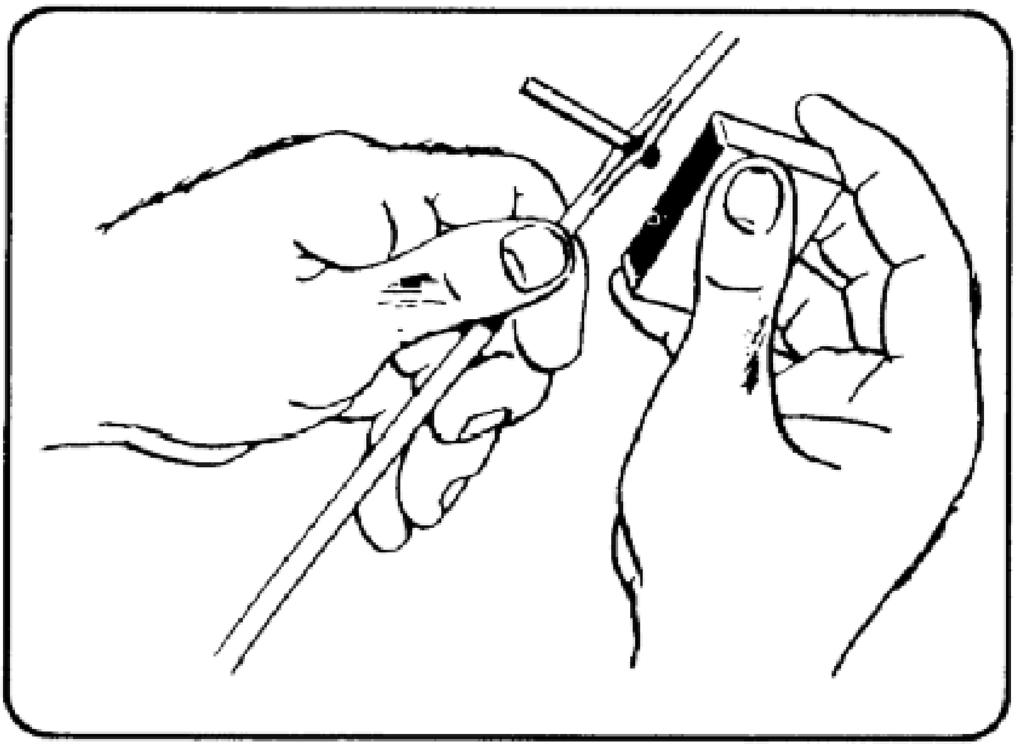


Figure 2-4. Lighting time fuse with a match

Electric Initiation Sets.

a. Preparation Sequence. Use the process below to make an electric initiation set. This process includes—

Testing and maintaining control of the blasting machine.

Testing the M51 blasting-cap test set.

Testing the firing wire on the reel, shunted and unshunted.

Laying out the firing wire completely off the reel.

Retesting the firing wire, shunted and unshunted.

Testing the blasting caps.

Connecting the series circuit.

Connecting the firing wire.

Testing the entire circuit.

Priming the charges.

b. Components Assembly. An electric system uses an electric blasting cap as the explosion initiator. The initiation set consists of an electric blasting cap, the firing wire, and a blasting machine

(Figure 2-5) An electric impulse (usually provided by a blasting machine) travels through the firing wires and blasting cap leads, detonating the blasting cap which initiates the explosion. Radio waves can also detonate electric blasting caps. Therefore, observe the minimum safe distances listed in Chapter 6 (page 6-5) at all times. When combined with detonating cord, a single initiation set can fire multiple charges. TM 9-1375-213-34 provides detailed information about electric blasting equipment.

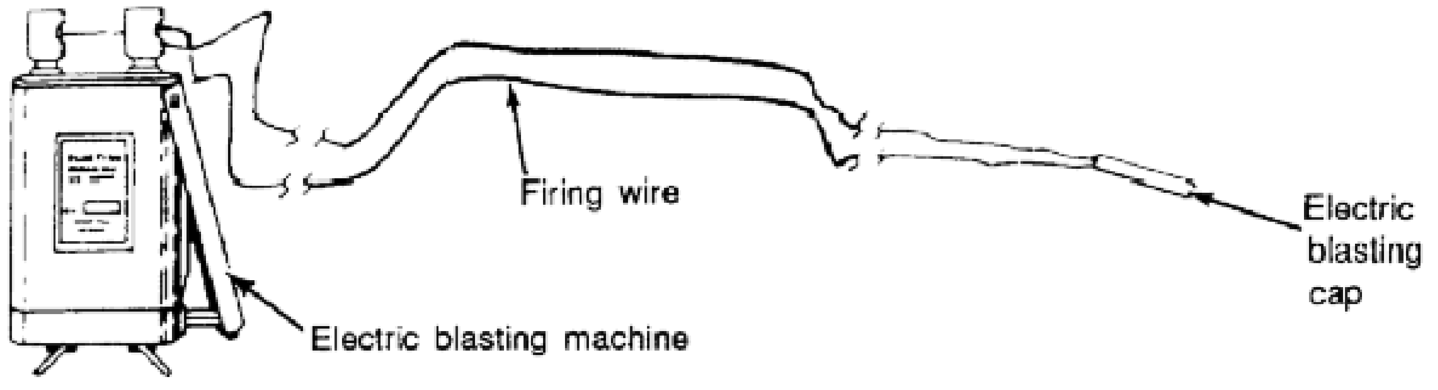


Figure 2-5. Electric initiation set

Always follow the procedure below when preparing an electric initiation set:

(1) Testing and Maintaining Control of Blasting Machine.

(a) Test the blasting machine to ensure it is operating properly (paragraph 1-28, page 1-20).

(b) Control access to all blasting machines. The supervisor is responsible for controlling all blasting machines.

(2) Testing M51 Blasting-Cap Test Set

(a) Check the M51 test set to ensure it is operating properly (paragraph 1-27, page 1-19).

(b) Perform both the open- and short-circuit tests.

(3) Testing Firing Wire on the Reel.

(a) Separate the firing wire leads at both ends and connect the leads at one end to the posts of the MS 1 test set. Squeeze-tie test-set handle. The indicator lamp should NOT flash. If it does, the lamp's flash indicates a short circuit in the firing wire (Figure 2-6).

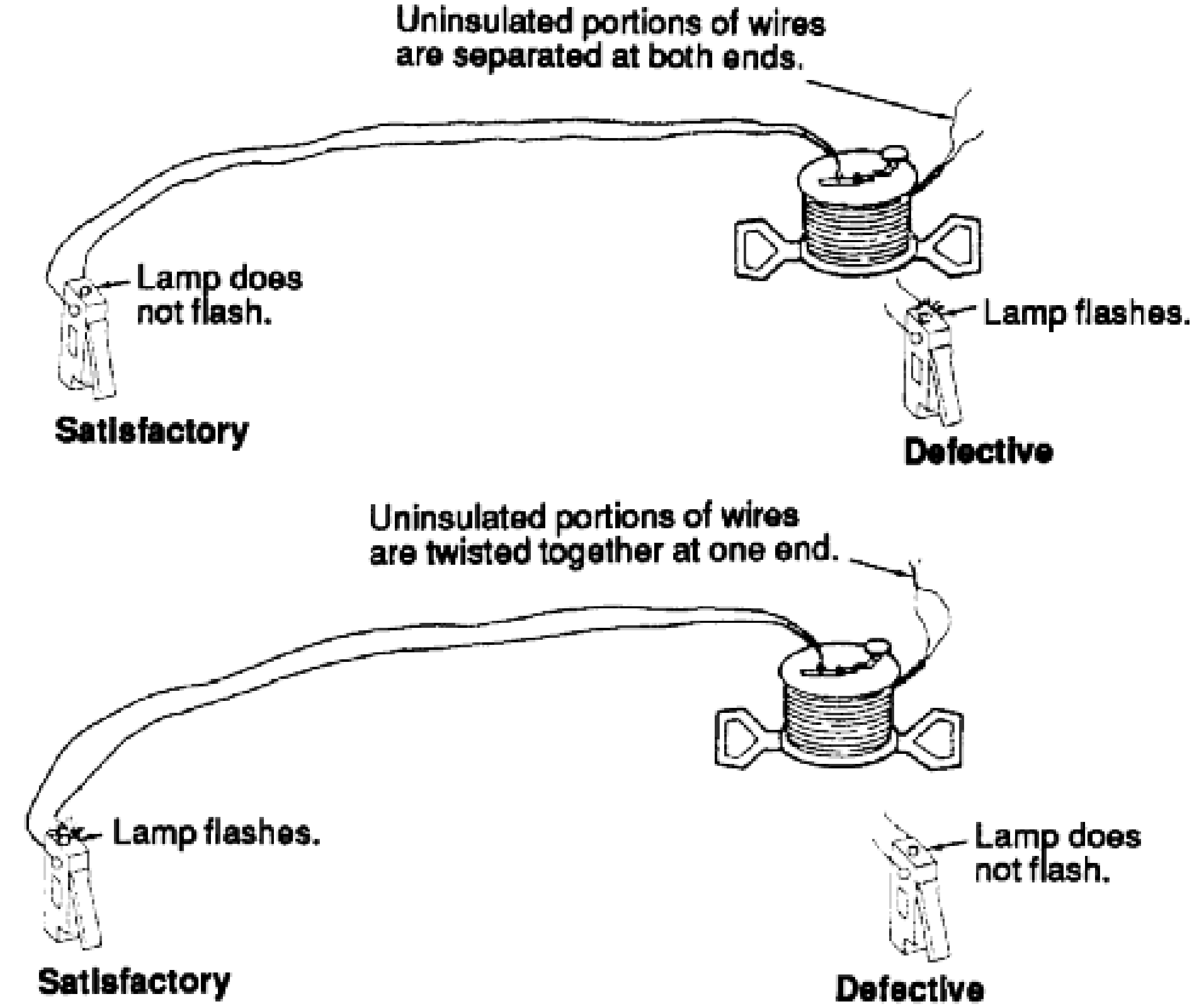


Figure 2-6. Testing firing wire on the reel

(b) Shunt the wires atone end and connect the leads from the other end to the posts of the M51 test set. Squeeze the test-set handle. The indicator lamp should flash. If it does not, the lamp's failure to light indicates a break in the firing wire (Figure 2-6).

NOTE: Use at least three 180-degree turns to shunt wires.

(c) Shunt both ends of the firing wire after testing.

(4) Laying Out Firing Wire.

(a) After locating a firing position a safe distance away from the charges (paragraph 6-7, page 6-6), lay out the firing wire between the charges and the firing position. More than one reel of wire may be necessary.

(b) Do not allow vehicles to drive over or personnel to walk on firing wire. Always bury firing wire or lay it flat on the ground.

(c) Keep the firing wire as short as possible. Avoid creating any loops in the wire (lay it in as straight a line as possible). Cut the wire to length. Do not connect it to a blasting machine through the unused portion of wire on the reel.

(5) Retesting Firing Wire.

(a) Perform the open- and short-circuit tests again. The process of unreeling the wire may have separated broken wires not found when the wire was tested on the reel.

(b) Continually guard the firing position from this point on. Do this to ensure that no one tampers with the wires or fires the charges prematurely.

(c) Use hand signals to indicate the test results. Hand signals are necessary because of the distance involved between the charges and the firing position. The man testing the wire also can give these signals directly to the soldier at the opposite end of the wire or, if they cannot see each other, through intermediate positions or over the radio. The tester indicates to his assistant that he wants the far end of the firing wire unshunted by extending both arms straight out at shoulder height.

After unshunting the firing wire, the assistant at the far end of the wire repeats the signal, indicating to the tester that his end is unshunted. When the tester wants the far end of the firing wire shunted, he signals to his assistant by clasping his hands together and extending his arms over his head, elbows bent, forming a diamond shape. After shunting the firing wire, the assistant repeats the signal, indicating to the tester that his wire is shunted.

(d) Shunt both ends of the firing wire after the tests are complete.

(6) Testing Electric Blasting Cap.

(a) Remove the cap from its spool. Place the cap in the palm of your hand, lead wires passing between your thumb and index finger.

(b) Wrap the wire around the palm of your hand twice. Doing this prevents tension on the wires in the cap and prevents the cap from being dropped.

(c) Grasp the wire spool with your free hand and unreel the wire, letting the wire pass between your fingers as you turn the spool. Completely unreel the cap wires from the cardboard spool. Avoid allowing the wires to slip offends of the cardboard spool, since this will cause excessive twists and kinks in the wires and prevent the wires from separating properly.

(d) Place the blasting cap under a sandbag or helmet while extending the wires to their full length.

(e) Test blasting caps away from all other personnel. Keep your back to the blasting cap when testing it.

(f) Remove the short-circuit shunt from the lead wires.

(g) Hold or attach one lead wire to one of the M51's binding posts. Hold or attach the second lead wire to the other binding post and squeeze the test-set handle. The blasting cap is good if the indicator lamp flashes. If the lamp does not flash, the cap is defective; do not use it.

(h) Always keep the cap wires shunted when not testing them.

(7) Connecting a Series Circuit. When two or more blasting caps are required for a demolition operation. you may use one of the series circuits illustrated in Figure 2-7.

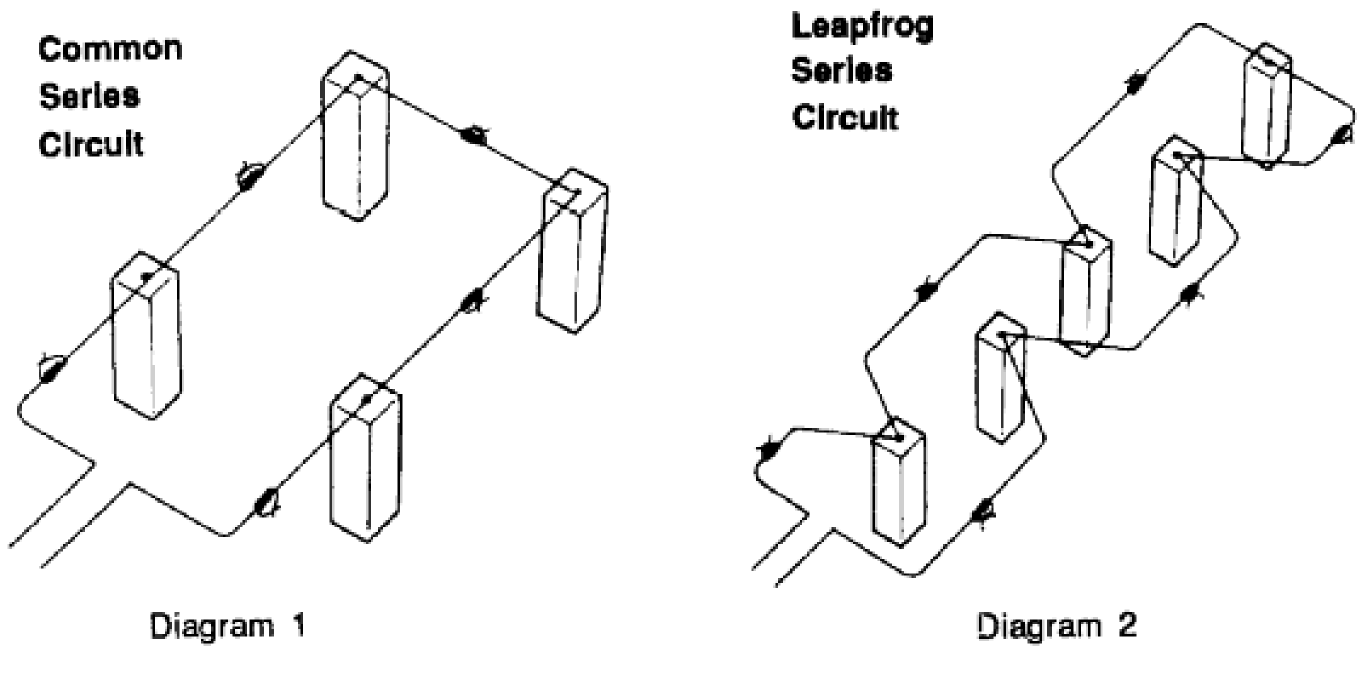


Figure 2-7. Series circuit

Use the following procedure:

(a) Test all blasting caps separately before connecting them in a circuit.

(b) Join blasting cap wires together using the Western Union pigtail splice (Figure 2-8). Protect all joints in the circuit with electrical insulation tape. Do not use the cardboard spool that comes with the blasting cap to insulate these connections.

(c) Test the entire circuit. After the series is completed, connect the two free blasting cap wires to the M51 test set. The indicator lamp should flash to indicate a good circuit. If the lamp does not flash, check your connections and blasting caps again.

(d) After testing the cap circuit, shunt the two free blasting cap wires until you are ready to connect them to the firing wire.

(8) Connecting the Firing Wire.

(a) Connect the free leads of blasting caps to the firing wire before priming the charges or taping a blasting cap to a detonating-cord ring main.

(b) Use a Western Union pigtail splice to connect the firing wire to the blasting cap wires.

(c) Insulate the connections with tape. Never use the cardboard spool that comes with the blasting cap to insulate this connection. The firing wire is likely to break when bent to fit into the spool.

(9) Testing the Entire Firing Circuit. Before priming the charges or connecting blasting caps to ring mains, test the circuit from the firing point. Use the following procedure:

(a) Ensure the blasting caps are under protective sandbags while performing this test.

(b) Connect the ends of the firing wire to the M51 test set. Squeeze the firing handle. The indicator lamp should flash, indicating a proper circuit.

(c) Shunt the ends of the firing wire.

WARNING

Do not prime charges or connect electric blasting caps to detonating cord until all other steps of the preparation sequence have been completed.

(10) Priming the Charges. Prime the charges and return to the firing point. This is the last step prior to actually returning to the firing point and firing the circuit.

WARNING

Prime charges when there is a minimum of personnel on site.

c. Circuit Initiation. At this point the initiation set is complete. Do not connect the blasting machine until all personnel are accounted for and the charge is ready to fire. When all personnel are clear, install the blasting machine and initiate the demolition. Chapter 6 (page 6-9) covers procedures for electric misfires.

d. Splicing Electric Wires.

(1) Preparation. Strip the insulating material from the end of insulated wires before splicing.

Remove approximately 1 ½ inches of insulation from the end of each wire (Figure 2-8, diagram 1).

Also remove any coating on the wire, such as enamel, by carefully scraping the wire with the back of a knife blade or other suitable tool. Do not nick, cut, or weaken the bare wire. Twist multiple-strand wires lightly after scraping.

(2) Method. Use the Western Union pigtail splice (Figure 2-8, page 2-8) to splice two wires.

Splice two pairs of wires in the same way as the two-wire splice (Figure 2-9). Use the following procedure:

(a) Protect the splices from tension damage by tying the ends in an overhand or square knot (tension knot), allowing sufficient length for each splice (Figure 2-8, diagram 2, page 2-8).

(b) Make three wraps with each wire (Figure 2-8, diagram 3, page 2-8).

(c) Twist the ends together with three turns (Figure 2-8, diagram 4, page 2-8).

(d) Flatten the splice, but not so far that the wire crimps itself and breaks (Figure 2-8, diagram 5, page 2-8).

(3) Precautions. A short circuit may occur at a splice if you do not practice some caution. For example, when you splice pairs of wires, stagger the splices and place a tie between them (Figure 2-9, diagram 1). Another method of preventing a short circuit in a splice is using the alternate method (Figure 2-9, diagram 2). In the alternate method, separate the splices rather than stagger them. Insulate the splices from the ground or other conductors by wrapping them with friction tape or other electric insulating tape. Always insulate splices.

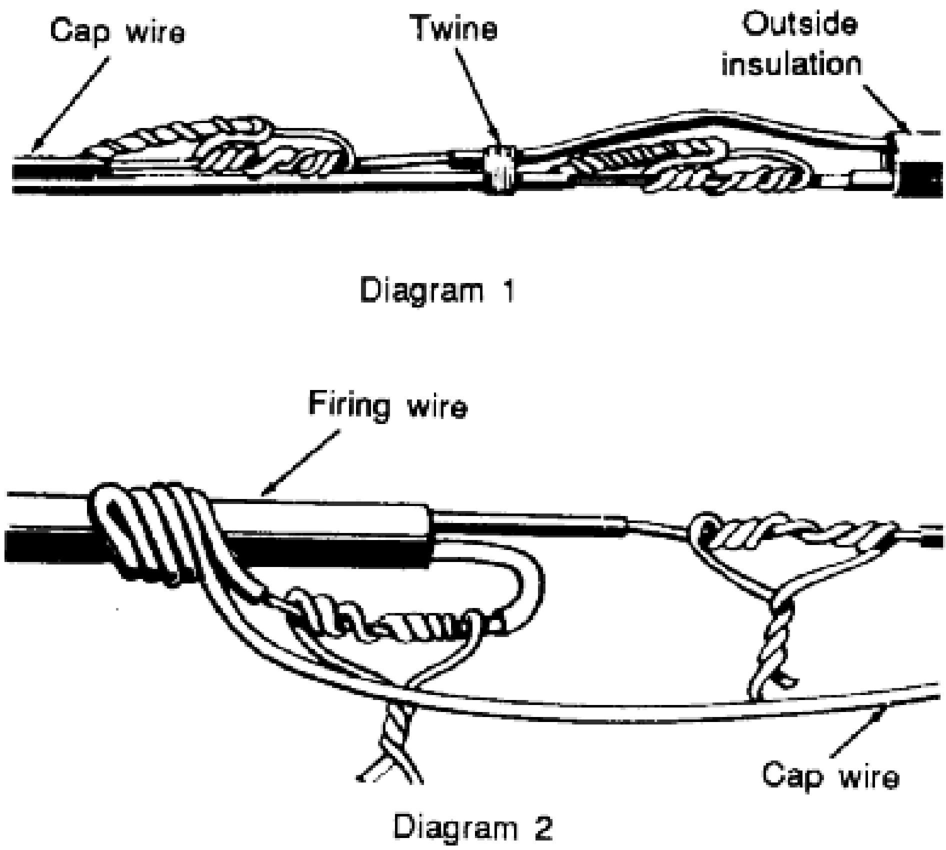


Figure 2-9. Two-wire splice

e. Series Circuits.

(1) Common. Use this circuit to connect two or more electric blasting caps to a single blasting machine (Figure 2-7, diagram 1, page 2-8). Prepare a common series circuit by connecting one blasting cap to another until only two end wires are free. Shunt the two end wires until you are ready to proceed with the next step. Connect the free ends of the cap lead wires to the ends of the firing wire. Use connecting wires (usually annunciator wire) when the distance between blasting caps is greater than the length of the usual cap lead wires.

(2) Leapfrog. The leapfrog method of connecting caps in a series is useful for firing any long line of charges (Figure 2-7, diagram 2, page 2-8). This method is performed by starting at one end of a row of charges and priming alternate charges to the opposite end and then priming the remaining charges on the return leg of the series. This method eliminates the necessity for a long return lead from the far end of the line of charges. Appendix E has additional information on series circuits.

There is seldom a need for this type of circuit, since detonating cord, when combined with a single blasting cap, will fire multiple charges.

Section II. Priming Systems

2-3. Methods. The three methods of priming charges are non-electric, electric, and detonating-cord.

Non-electric and electric priming involves directly inserting blasting caps into the charges. Use the direct-insertion method only when employing shaped charges. Detonating-cord priming is the preferred method for priming all other charges since it involves fewer blasting caps, makes priming and misfire investigation safer, and allows charges to be primed at State of Readiness 1 (safe) when in place on a reserved demolition.

NOTE: You can crimp non-electric blasting caps to detonating cord as well as time fuse. This capability permits simultaneous firing of multiple charges primed with a blasting cap.

2-4. Priming TNT Demolition Blocks.

a. Non-electric. TNT blocks have threaded cap wells. Use priming adapters, if available, to secure non-electric blasting caps and timed blasting fuses to TNT blocks with threaded cap wells (Figure 2-10). When priming adapters are not available, prime TNT blocks with threaded cap wells as follows:

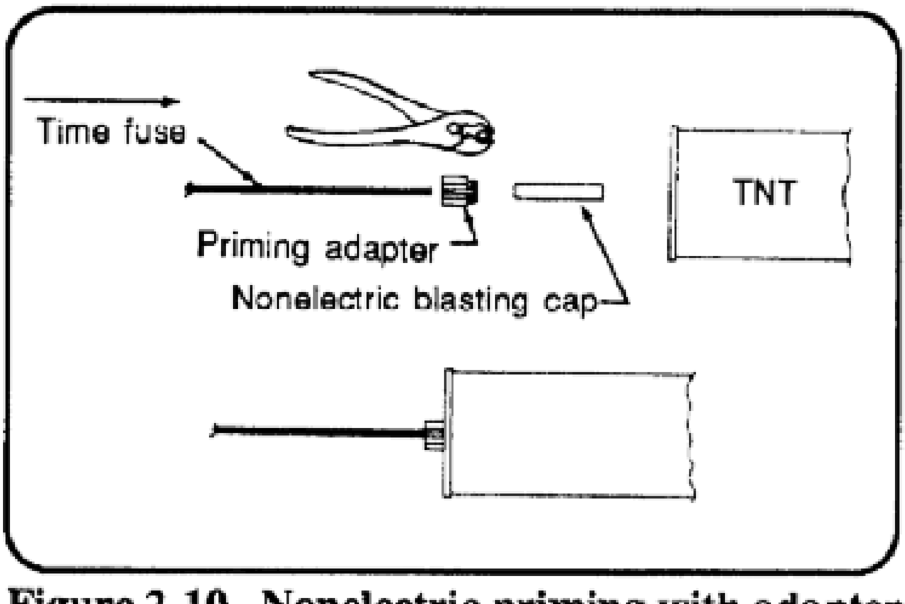
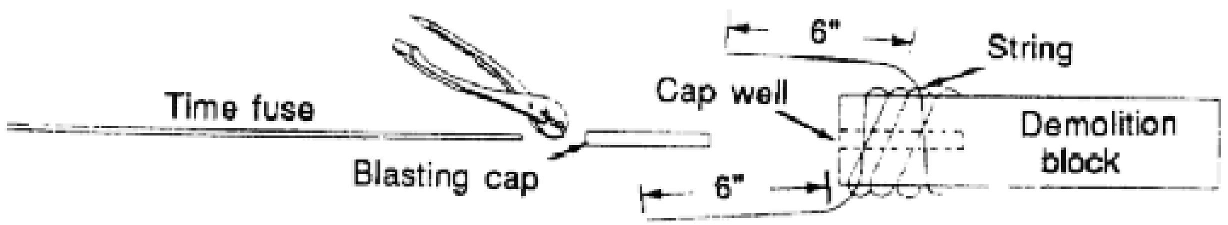


Figure 2-10. Nonelectric priming with adapter

(1) Wrap a string tightly around the block of TNT and tie it securely, leaving approximately 6 inches of loose string on each end (Figure 2-11).

(2) Insert a blasting cap with the fuse attached into the cap well.

(3) Tie the loose ends of the string around the fuse to prevent the blasting cap from being separated from the block. Adhesive tape can also effectively secure blasting caps in charges.



NOTE: Do *not* tie string so tightly that the powder train is broken in the fuse. Electrical or friction tape may be substituted for string if necessary.

Figure 2-11. Nonelectric priming without adapter

b. Electric.

(1) With Priming Adapter. Use the following procedure for priming TNT block, using the priming adapter:

(a) Prepare the electric initiation set before priming.

(b) Pass the lead wires through the slot of the adapter, and pull the cap into place in the adapter (Figure 2-12). Ensure the blasting cap protrudes from the threaded end of the adapter.

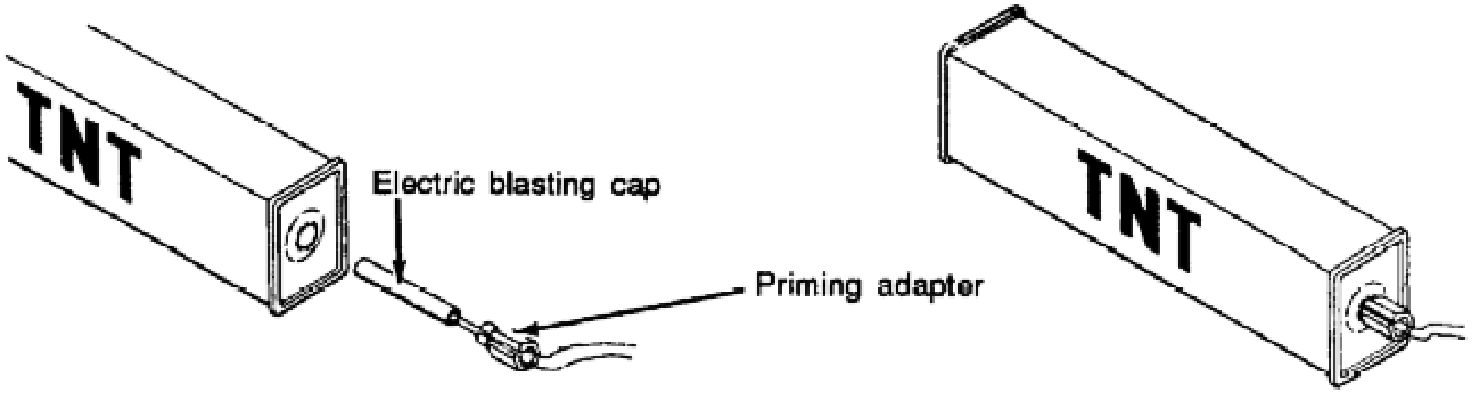


Figure 2-12. Electric priming with adapter

(c) Insert the blasting cap into the threaded cap well of the TNT block and screw the adapter into place.

(2) Without Priming Adapter. If a priming adapter is not available, use the following procedure:

(a) Prepare the electric initiation set before priming.

(b) Insert the electric blasting cap into the cap well. Tie the lead wires around the block, using two half hitches or a girth hitch (Figure 2- 13). Allow some slack in the wires between the blasting cap and the tie to prevent any tension on the blasting-cap lead wires.

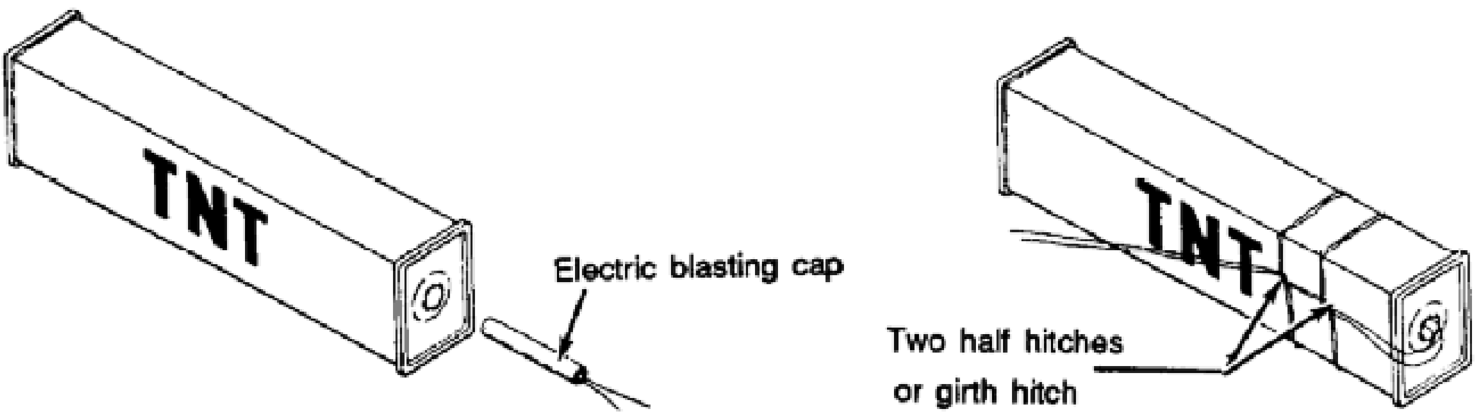


Figure 2-13. Electric priming without adapter

c. Detonating Cord. Use the following methods to prime TNT blocks with detonating cord:

NOTE: A 6-inch length of detonating cord equals the power output of a blasting cap. However, detonating cord will not detonate explosives as reliably as a blasting cap because its power is not as concentrated. Therefore, always use several turns or a knot of detonating cord for priming charges.

(1) Method 1 (Figure 2-14). Lay one end (l-foot length) of detonating cord at an angle across the explosive. Then, wrap the running end around the block three turns, laying the wraps over the standing end. On the fourth wrap, slip the running end under all wraps, parallel to the standing end and draw the wraps tight. Doing this forms a clove hitch with two extra turns.

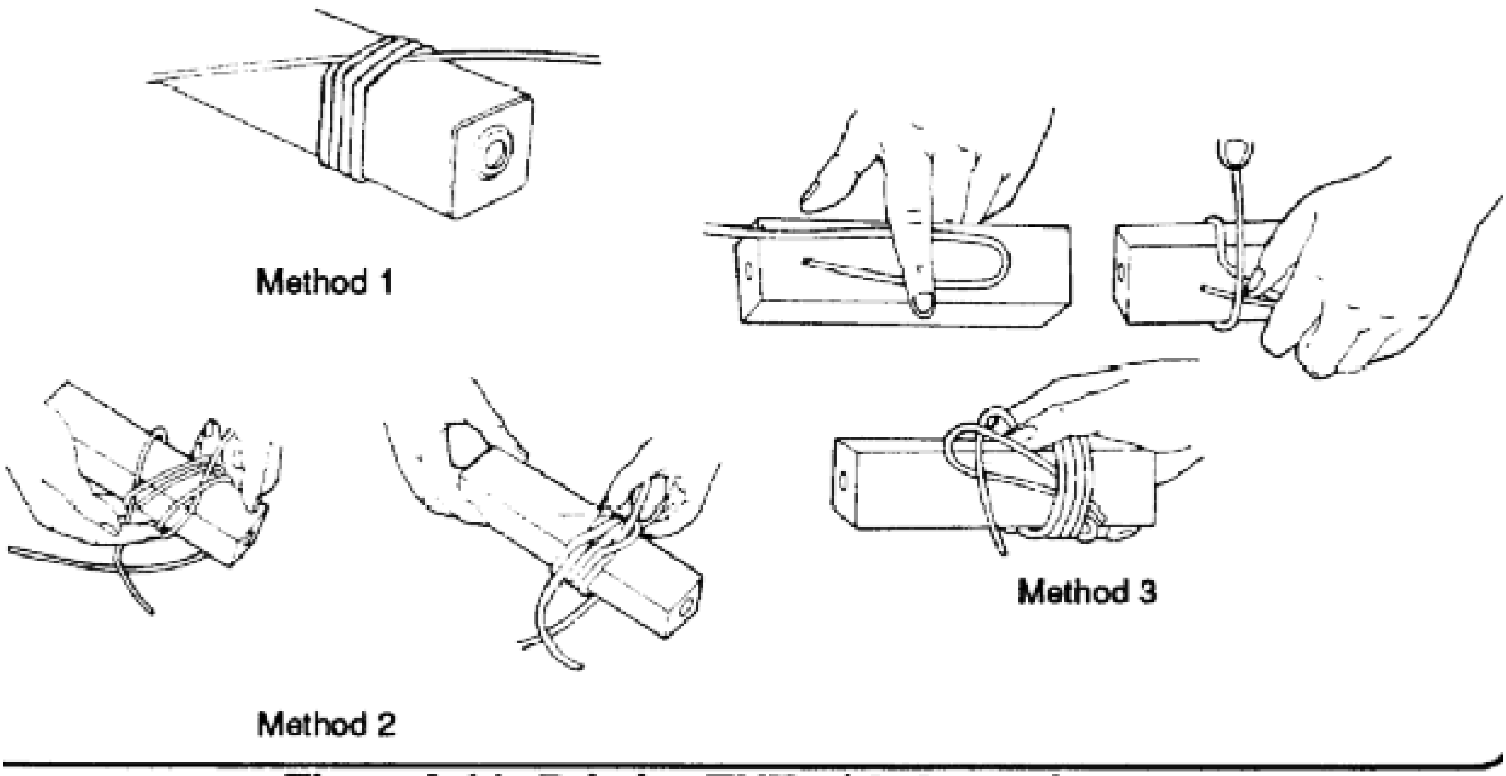


Figure 2-14. Priming TNT with detonating cord

(2) Method 2 (Figure 2-14). Tie the detonating cord around the explosive block with a clove hitch and two extra turns. Fit the cord snugly against the block, and push the loops close together.

(3) Method 3 (Figure 2-14). Place a loop of detonating cordon the explosive, leaving sufficient length on the end to make four turns around the block and loop with the remaining end of the detonating cord. When starting the first wrap, ensure that you immediately cross over the standing end of the loop, working your way to the closed end of the loop. Pass the free end of the detonating cord through the loop and pull it tight. This forms a knot around the outside of the block.

2-5. Priming M112 (C4) Demolition Blocks.

a. Non-electric and Electric. C4 blocks do not have a cap well; therefore, you will have to make one. Use the following procedure:

(1) With the M2 crimpers or other non-sparking tool, make a hole in the end or on the side (at the midpoint) large enough to hold the blasting cap.

(2) Insert the blasting cap into the hole or cut. If the blasting cap does not fit the hole or cut, do not force the cap, make the hole larger.

(3) Anchor the blasting cap in the block by gently squeezing the plastic explosive around the blasting cap.

b. Detonating Cord. To prime plastic explosive with detonating cord, use the following procedure:

(1) Form either a Uli knot, double overhand knot, or triple roll hot as shown in Figure 2-15.

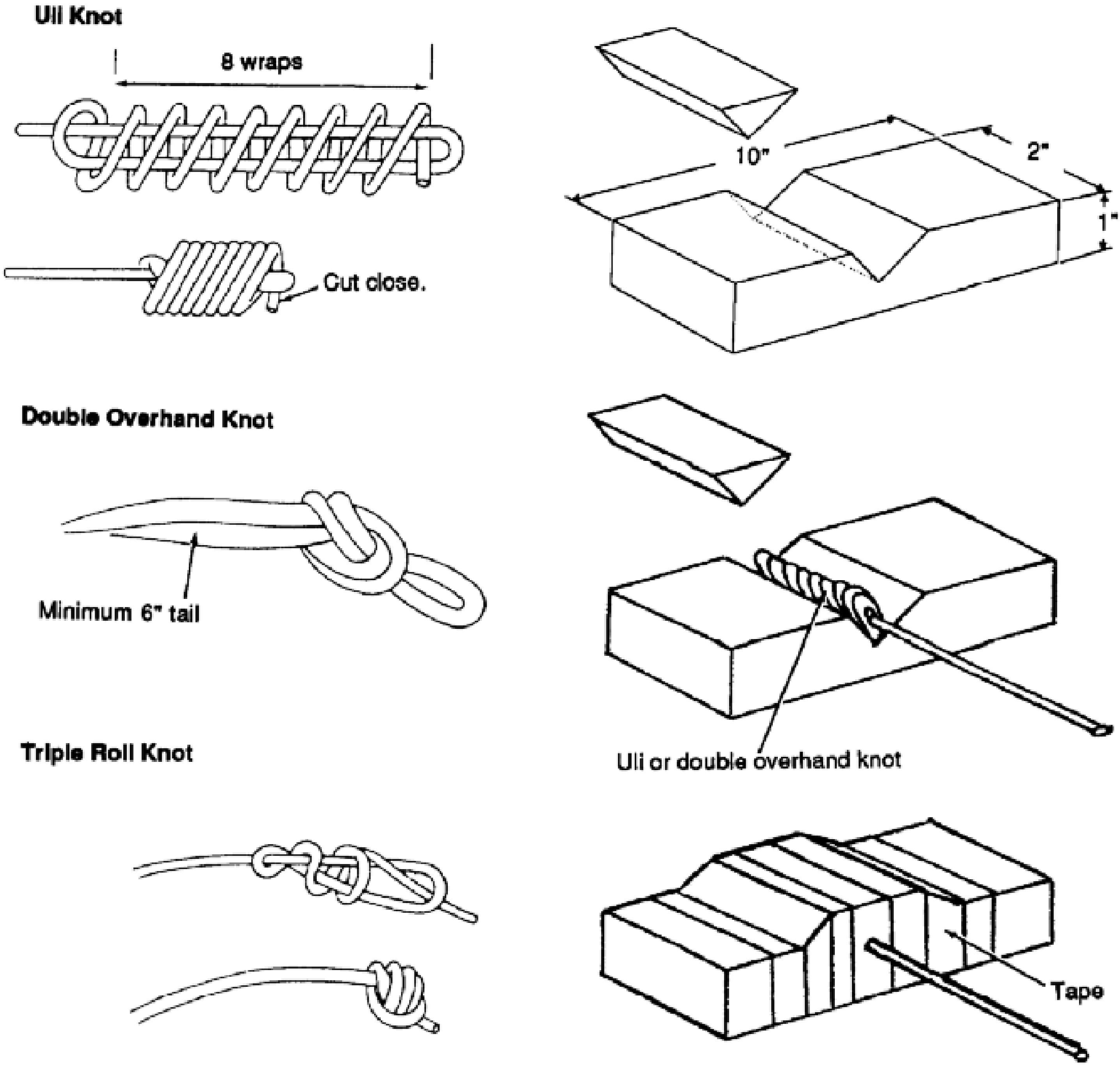


Figure 2-15. Priming plastic explosives with detonating cord

(2) Cut a notch out of the explosive, large enough to insert the knot you formed.

WARNING

Use a sharp knife on a non-sparking surface to cut explosives.

(3) Place the knot in the cut.

(4) Use the explosive you removed from the notch to cover the knot. Ensure there is at least ½ inch of explosive on all sides of the knot.

(5) Strengthen the primed area by wrapping it with tape.

NOTE: It is not recommended that plastic explosives be primed by wrapping them with detonating cord, since insufficient wraps will not properly detonate the explosive charge.

2-6. Priming M118 and M186 Demolition Charges.

a. Non-electric and Electric. Use one of the following methods to prime M118 and M186 demolition charges:

(1) Method 1 (Figure 2-16, page 2- 16). Attach an M8 blasting cap holder to the end or side of the sheet explosive. Insert an electric or a non-electric blasting cap into the holder until the end of the cap presses against the sheet explosive. The M8 blasting cap holder has three slanted, protruding teeth which prevent the clip from withdrawing from the explosive. Two dimpled spring arms firmly hold the blasting cap in the M8 holder.

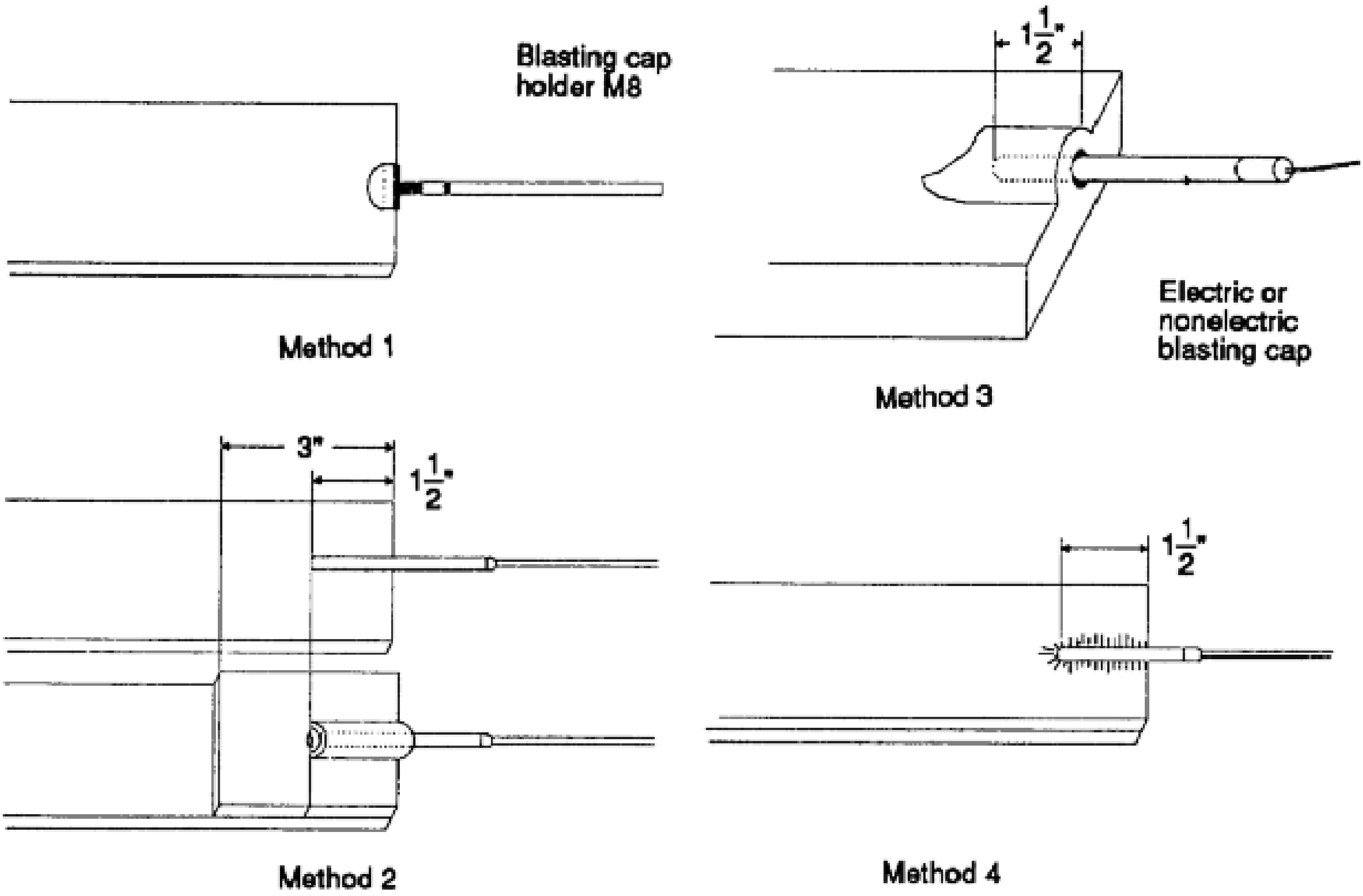


Figure 2-16. Priming sheet explosives

(2) Method 2 (Figure 2-16, page 2-16). Cut a notch in the sheet explosive (approximately 1½ inches long and ¼ inch wide). Insert the blasting cap to the limit of the notch. Secure the blasting cap with a strip of sheet explosive.

(3) Method 3 (Figure 2-16, page 2-16). Place 1½ inches of the blasting capon top of the sheet explosive and secure it with a strip of sheet explosive (at least 3 by 3 inches).

(4) Method 4 (Figure 2-16, page 2- 16). Insert the end of the blasting cap 1½ inches between two sheets of explosive.

b. Detonating Cord. Sheet explosives also can be primed with detonating cord using a Uli knot, double overhand knot, or triple roll knot. Insert the knot between two sheets of explosive or place the knot on top of the sheet explosive and secure it with a small strip of sheet explosive. The knot must be covered on all sides with at least ½ inch of explosive. 2-7. Priming Dynamite. Prime dynamite at either end or side. Choose the method that will prevent damage to the primer during placement.

a. Non-electric. There are three methods for priming dynamite non-electrically:

(1) End-Priming Method (Figure 2-17).

(a) Using the M2 crimpers, make a cap well in the end of the dynamite cartridge.

(b) Insert a fused blasting cap into the cap well.

(c) Tie the cap and fuse securely in the cartridge with a string.

(2) Weatherproof, End-Priming Method (Figure 2-17).

(a) Unfold the wrapping at the folded end of the dynamite cartridge.

(b) Using the M2 crimpers, make a cap well in the exposed dynamite.

(c) Insert a fused blasting cap into the cap well.

(d) Close the wrapping around the fuse and fasten the wrapping securely with a string or tape.

(e) Apply a weatherproof sealing compound to the tie.

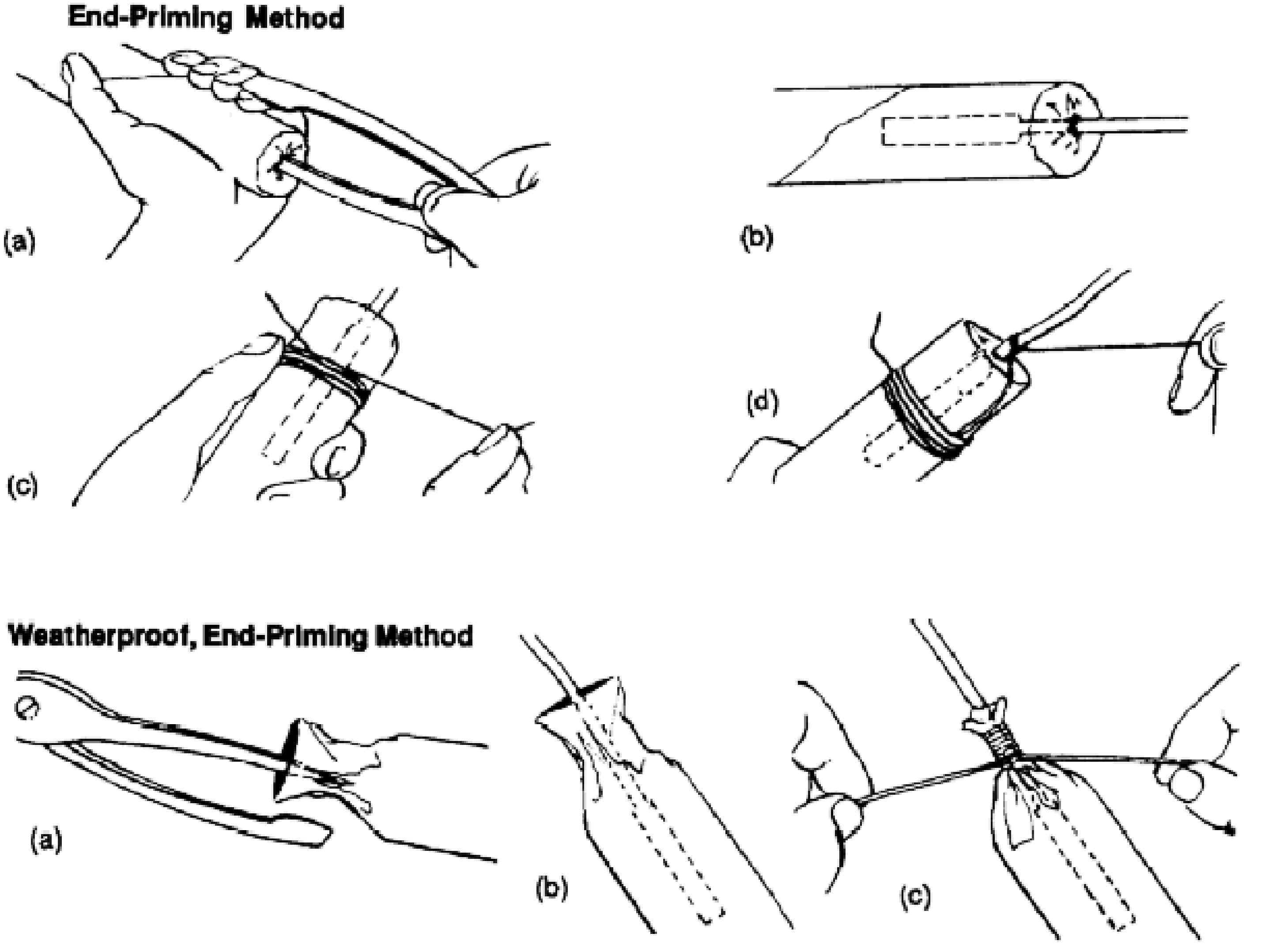


Figure 2-17. Nonelectric end priming of dynamite

(3) Side-Priming Method (Figure 2-18, page 2-18).

(a) Using the M2 crimpers, make a cap well (approximately 1½ inches long) into the side of the cartridge at one end. Slightly slant the cap well so the blasting cap, when inserted, will be nearly parallel to the side of the cartridge and the explosive end of the cap will be at a point nearest the middle of the cartridge.

(b) Insert a fused blasting cap into the cap well.

(c) Tie a string securely around the fuse. Then, wrap the string tightly around the cartridge, making two or three turns before tying it.

(d) Weatherproof the primed cartridge by wrapping a string closely around the cartridge, extending it an inch or so on each side of the hole to cover it completely. Cover the string with a weatherproof sealing compound.

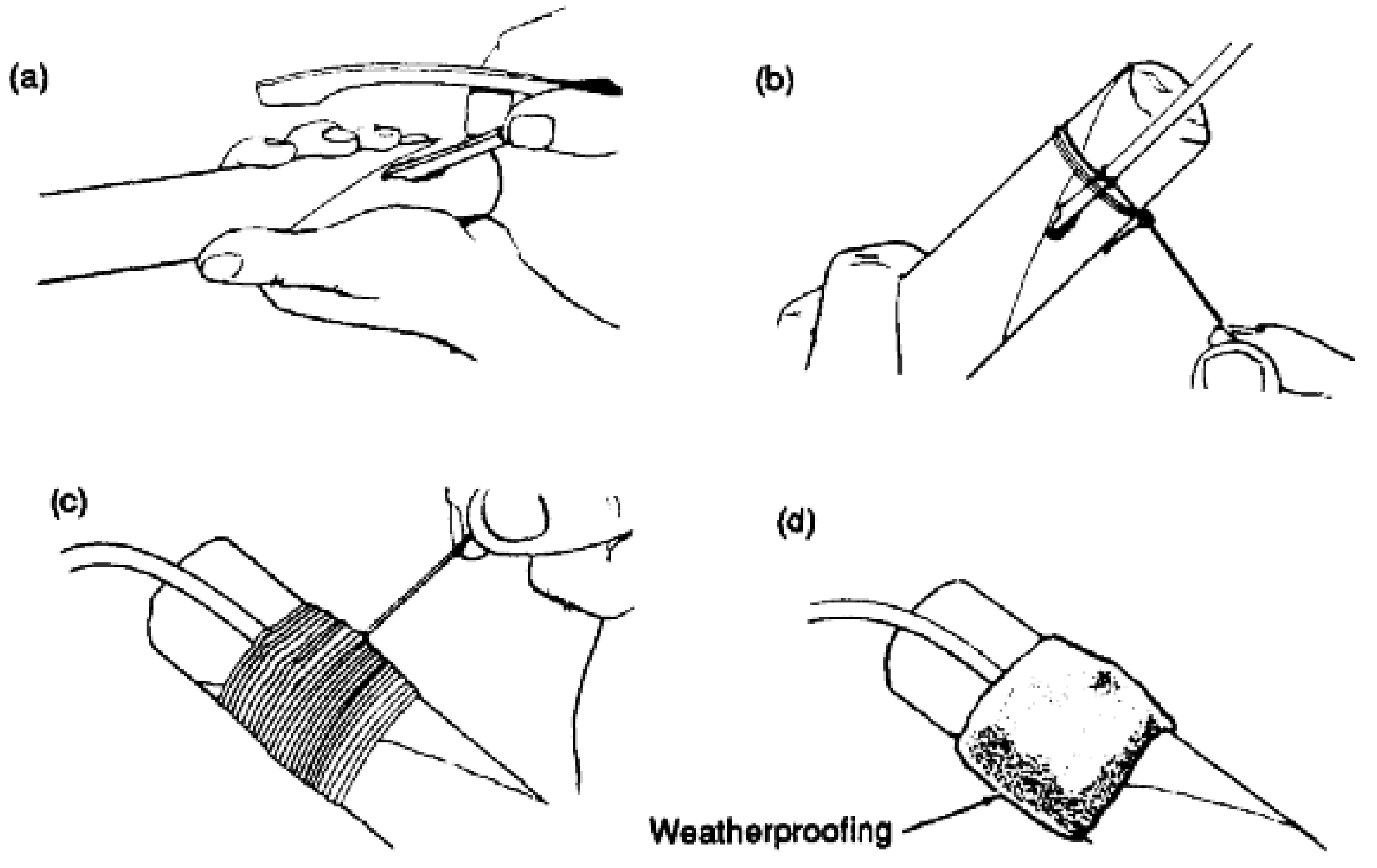


Figure 2-18. Nonelectric side priming of dynamite

b. Electric. Use the following method for priming with electric blasting caps:

(1) End-Priming Method (Figure 2-19).

(a) Using the M2 crimpers, make a cap well in the end of the cartridge.

(b) Using the M2 crimpers, insert an electric blasting cap into the cap well.

(c) Tie the lead wires around the cartridge with two half hitches, a string, or tape.

(2) Side-Riming Method (Figure 2-19).

(a) Using the M2 crimpers, make a cap well (approximately 1½ inches long) into the side of the cartridge at one end. Slightly slant the cap well so the blasting cap, when inserted, will be nearly parallel to the side of the cartridge and the explosive end of the cap will be at a point nearest the middle of the cartridge.

(b) Using the M2 crimpers, insert an electric blasting cap into the cap well.

(c) Tie the lead wire around the cartridge with two half hitches, a string, or tape.

c. Detonating Cord. You also can use detonating cord to prime dynamite. Using the M2 crimpers, start approximately 1 inch from either end of the dynamite charge and punch four equally spaced holes through the dynamite cartridge (Figure 2-20). Make sure to rotate the cartridge 180 degrees after punching each hole to keep the holes parallel. Lace detonating cord through the holes in the same direction the holes were punched. Take care not to pull the loops of the detonating cord too tightly or the dynamite will break. Secure the detonating cord tail by passing it between the detonating cord lace and the dynamite charge.

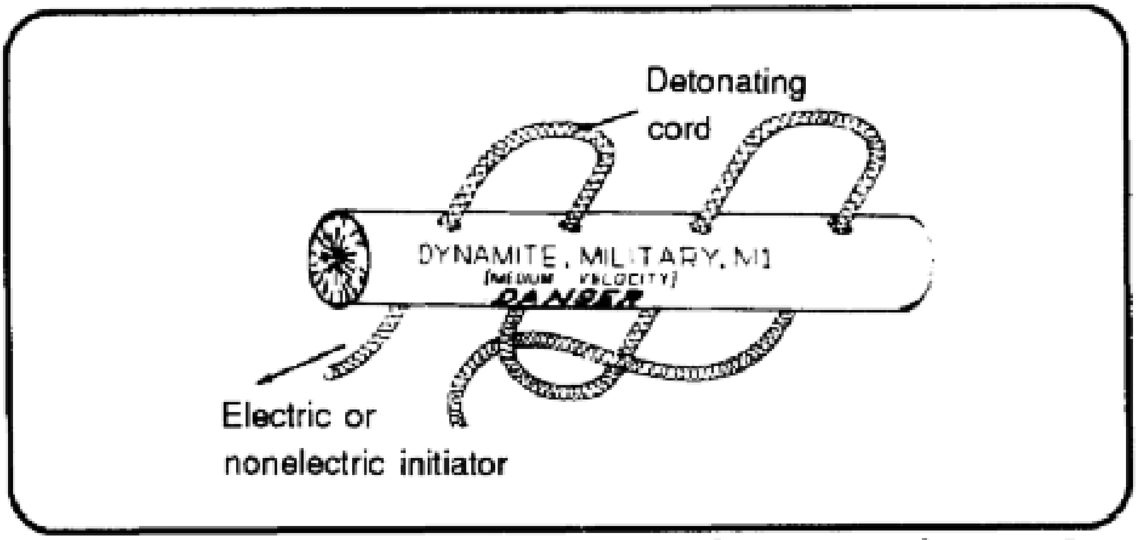
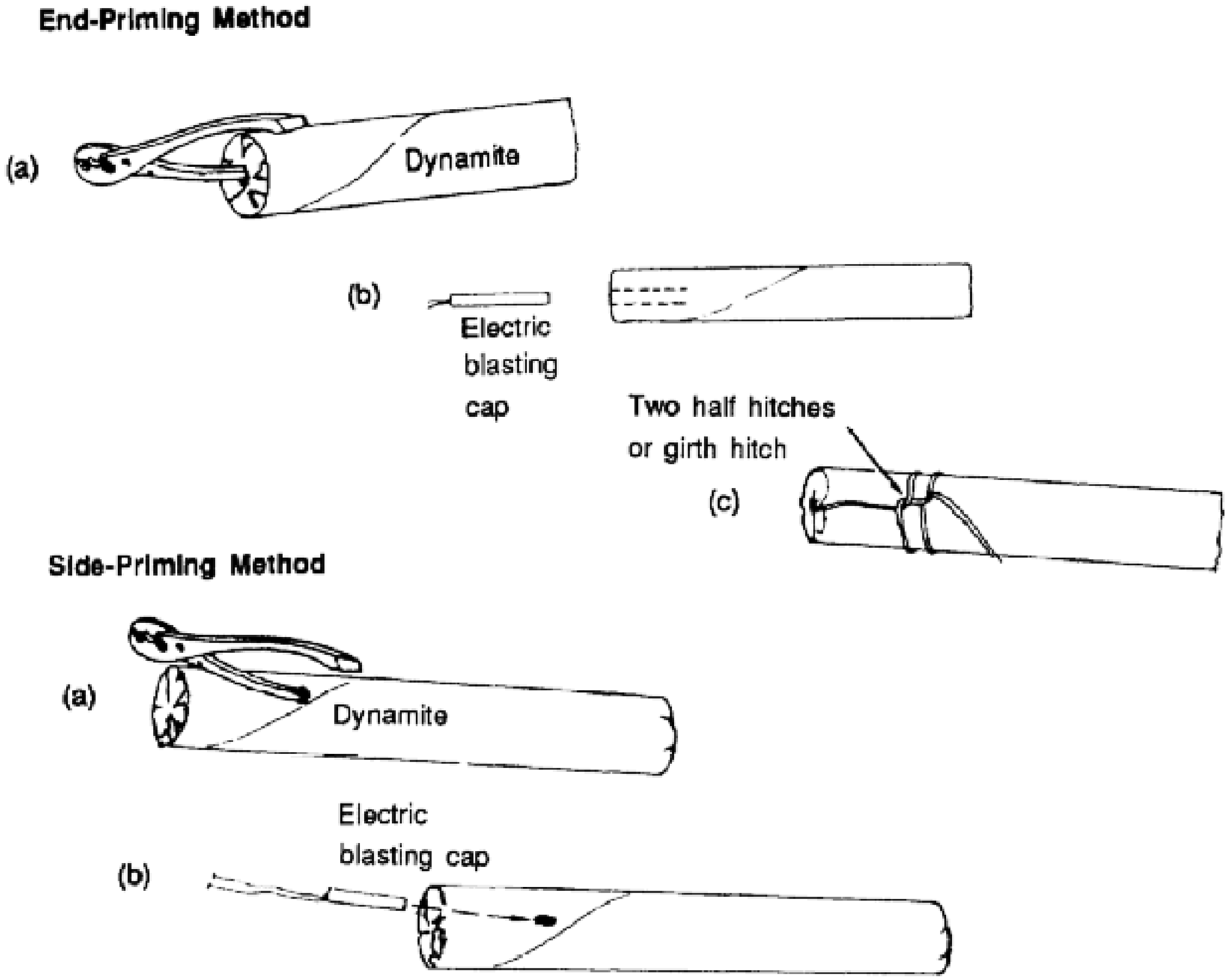


Figure 2-20. Priming dynamite with detonating cord



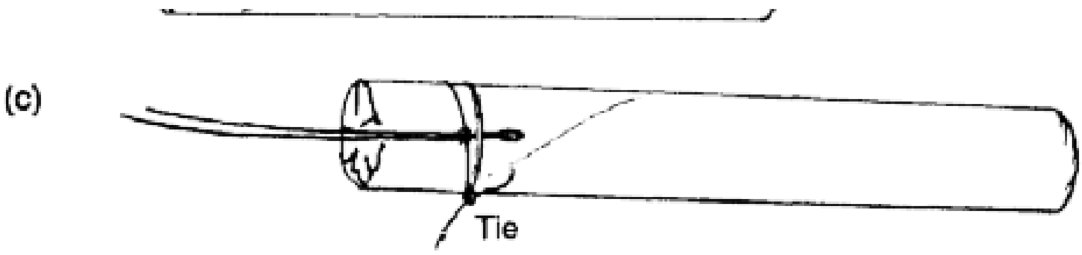


Figure 2-19. Electric priming of dynamite

2-8. Priming 40-Pound, Ammonium-Nitrate Cratering Charges. Because the cratering charge is primarily an underground charge, prime it only with detonating cord. Use dual priming to protect against misfires (Figure 2-21, diagram 2, page 2-20). Use the following procedure:

a. Tie an overhand knot, with a 6-inch overhang, at one end of the length of detonating cord.

b. Pass the opposite end of the detonating cord up through the detonating cord tunnel (Figure 2-21, diagram 1) of the cratering charge.

Ammonium nitrate is hydroscopic. When wet, ammonium nitrate is ineffective. WARNING

Therefore, inspect the metal container for damage or rust. Do not use damaged or rusty charges.

c. When dual priming a single 40-pound cratering charge, use a minimum of one pound of explosive.

Prime a block of TNT or package of C4 with detonating cord (paragraphs 2-4c, page 2-13, and 2-5b, page 2-14, respectively) and tape this charge to the center of the cratering charge (Figure 2-21, diagram 2). The detonating cord branch lines must be long enough to reach the detonating-cord ring mains after the cratering charge is in the ground. Twelve-foot branch lines should be adequate.

When placing two cratering charges in the same borehole, prime only the detonating cord tunnels of each charge. In this manner, the borehole is dual-primed and extra explosives are not required, as shown in Figure 2-21, diagram 3.

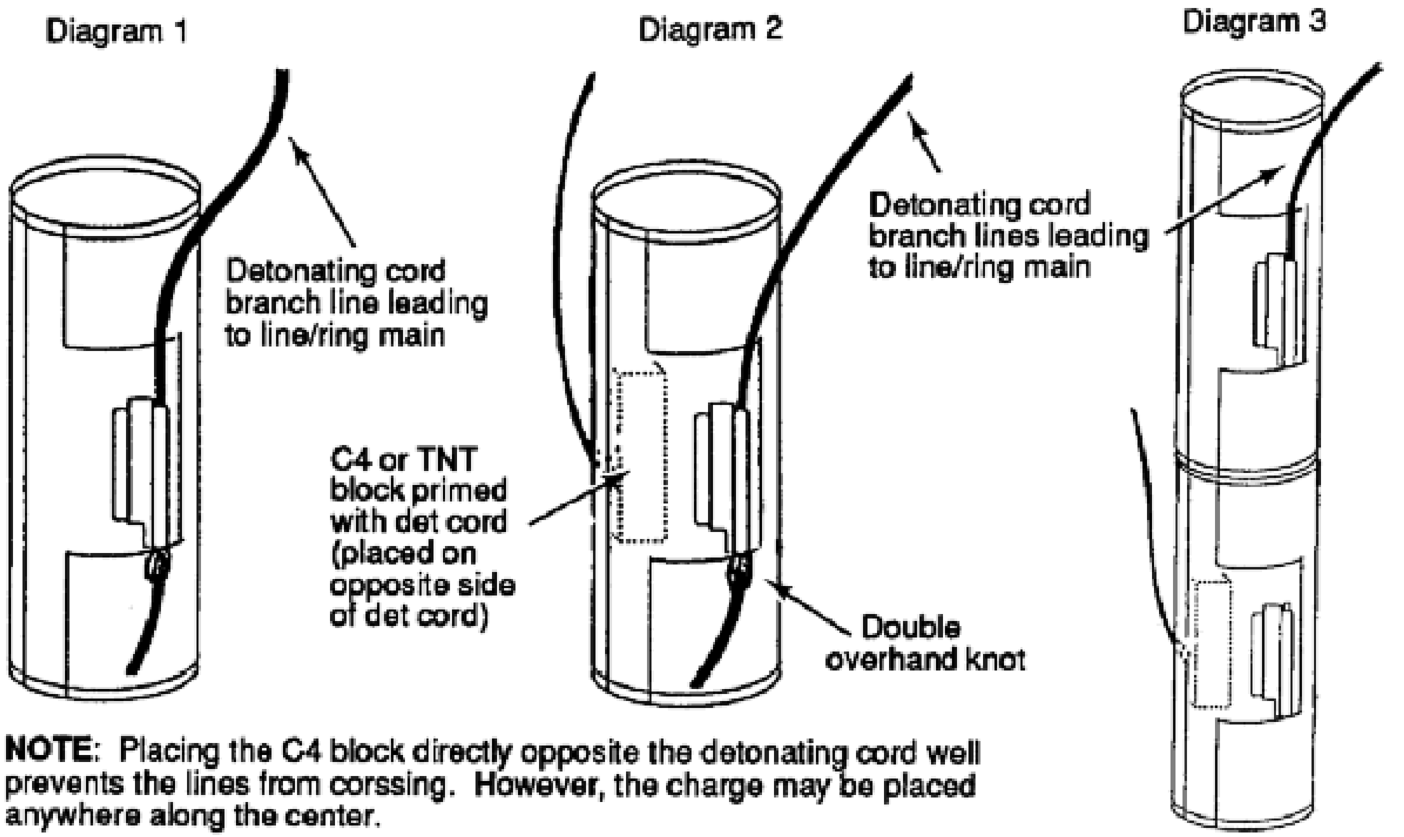


Figure 2-21. Priming ammonium-nitrate cratering charge

2-9. Priming M2A4 and M3A1 Shaped Charges. The M2A4 and M3A1 are primed only with electric or non-electric blasting caps. These charges have a threaded cap well at the top of the cone.

Prime them with a blasting cap as shown in Figure 2-22. Use a piece of string, cloth, or tape to hold the cap if a priming adapter is not available. Simultaneously detonate multiple shaped charges to create a line of boreholes for cratering charges by connecting each charge into a detonating-cord ring or line main. Use the following procedure for priming shaped charges:

a. Crimp a non-electric blasting cap to a branch line.

b. Connect the branch line to the ring main.

c. Insert the blasting cap into the blasting cap well of the shaped charge.

d. When detonating multiple shaped charges, make all branch-line connections before priming any shaped charges.

WARNING

Do not dual prime shaped charges. Prime them only with a blasting cap in the blasting cap well.

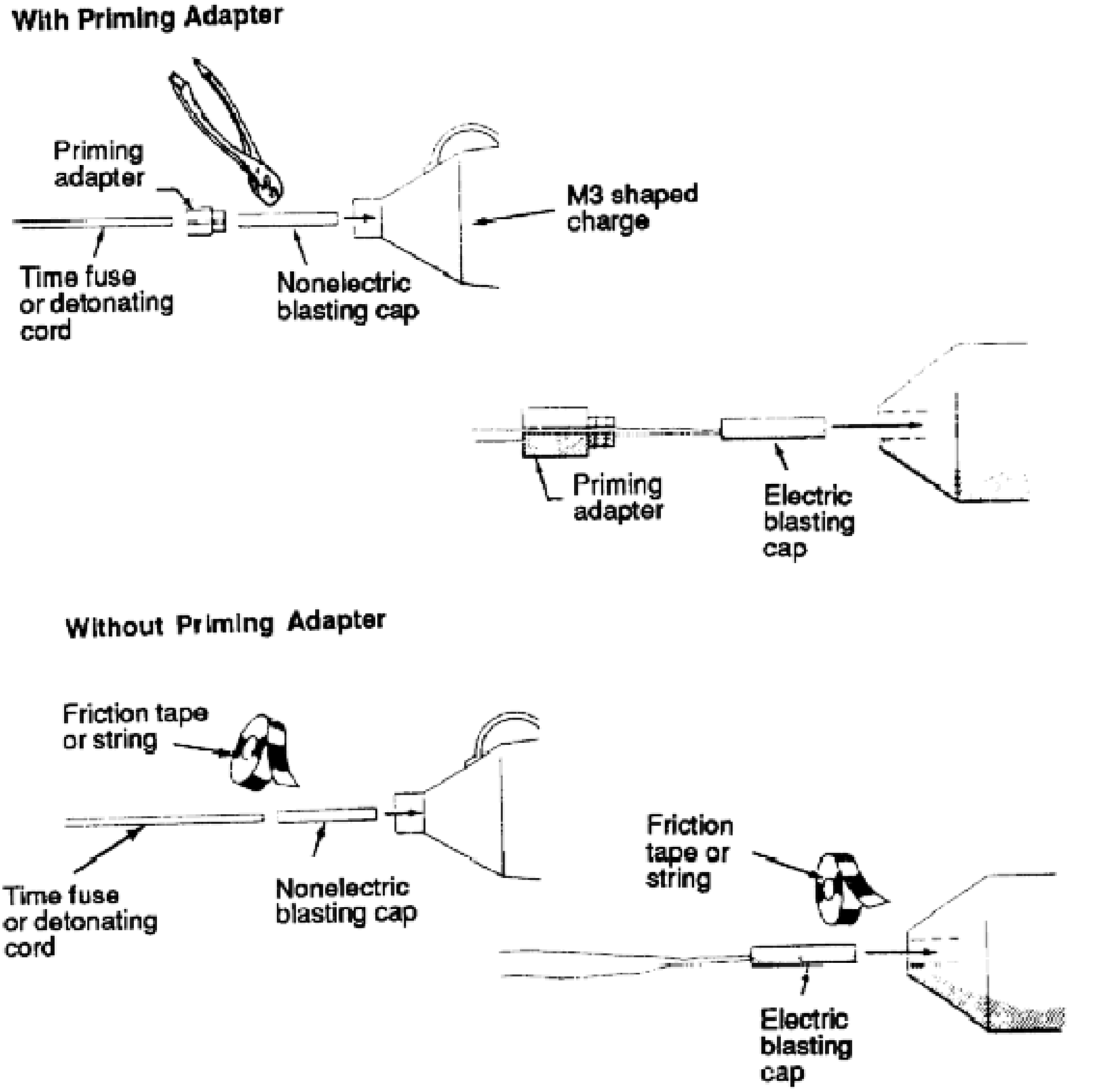


Figure 2-22. Priming shaped charges

2-10. Priming the Bangalore Torpedo.

a. Non-electric. Insert the blasting cap of a non-electric initiation set directly into the cap well of a torpedo section. If a priming adapter is not available, use tape or string to hold the blasting cap in place (Figure 2-23, diagram 1, page 2-22).

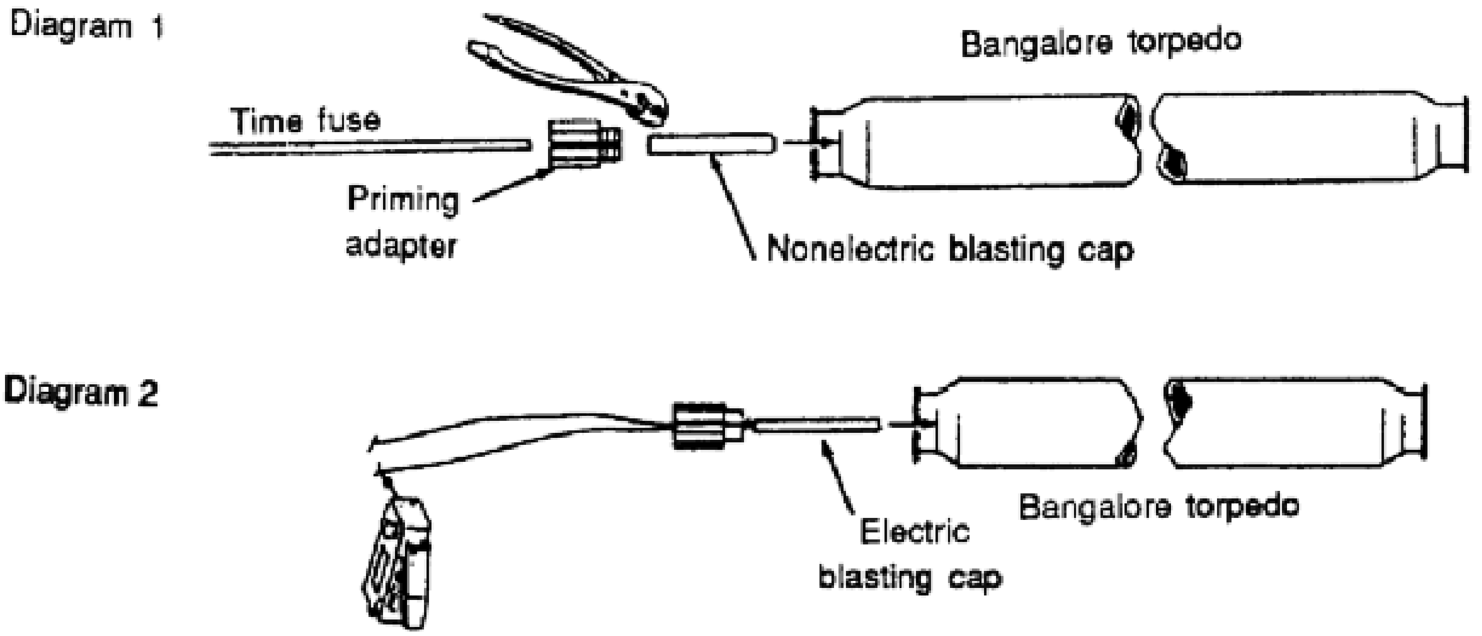


Figure 2-23. Priming a Bangalore torpedo with a blasting cap

b. Electric. Insert the blasting cap of an electric initiation set into the cap well of a torpedo section. If a priming adapter is not available, hold the cap in place by taping or tying (with two half hitches) the lead wires to the end of the torpedo. Allow some slack in the wires between the blasting cap and the tie to prevent tension on the blasting cap leads.

c. Detonating Cord. Prime the torpedo by wrapping detonating cord eight times around the end of the section, just below the bevel (Figure 2-24). After pulling the knot tight, insert the short end of the detonating cord into the cap well and secure it with tape. Never use the short end (tail) of the detonating cord to initiate the torpedo. Initiation must come from the running end of the detonating cord.

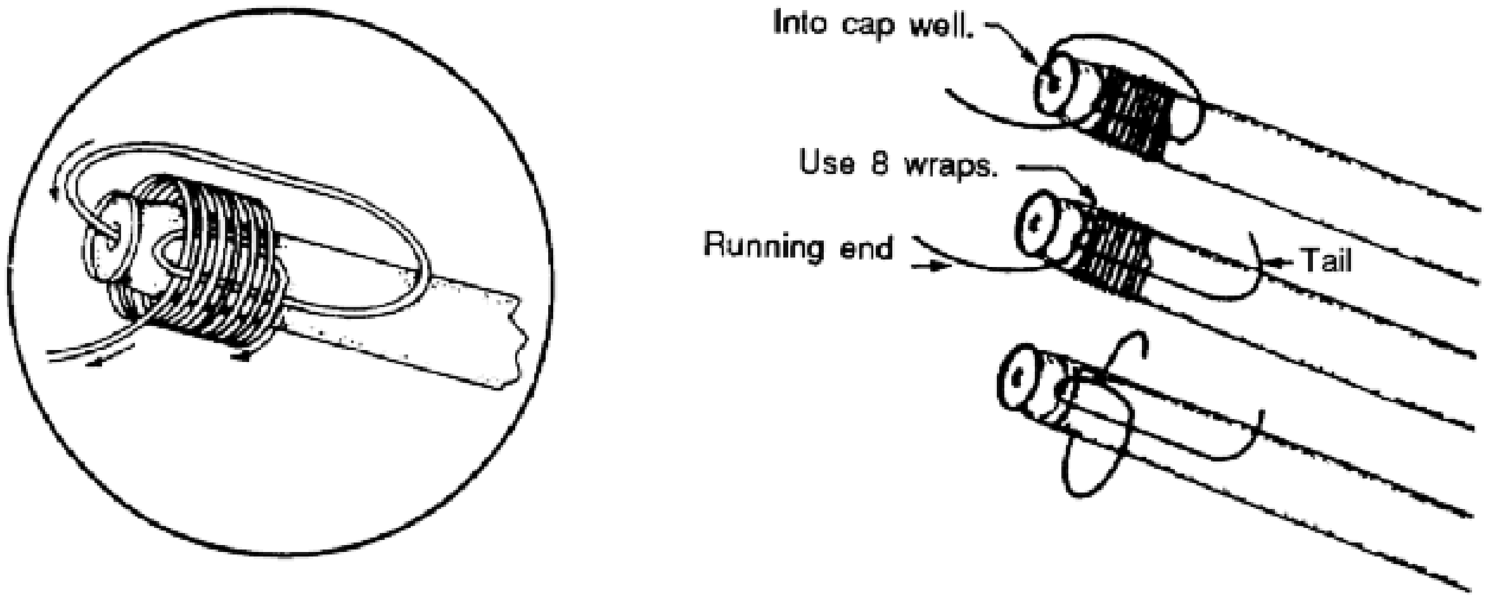


Figure 2-24. Priming a Bangalore torpedo with detonating cord

WARNING

Do not use more than or less than eight wraps to prime the Bangalore torpedo.

Too many wraps will extend the detonating cord past the booster charge housing, possibly causing the torpedo to be cut without detonating. Too few wraps may cause the torpedo to only be crimped, without detonating.

Section III. Firing Systems

2-11. Types of Firing Systems. There are two types of firing systems: single and dual. Chapter 5 covers the tactical applications for these systems.

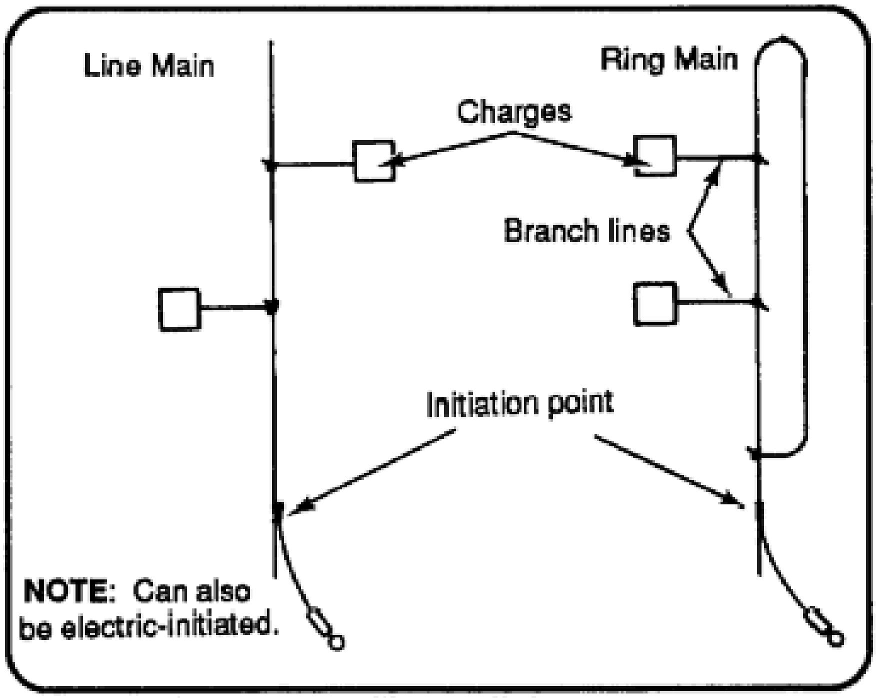


Figure 2-25. Single-firing system (single-initiated, single-fired, single-primed)

a. Single. Figure 2-25 shows a single-firing system Each charge is singly primed with a branch line. The branch line is tied to the line main or ring main. (Tying to the ring main is preferred but construction of a ring main may not be possible because of the amount of detonating cord. The ring main decreases the chances of a misfire should a break or cut occur anywhere within the ring main.) The electric, non-electric, or combination initiation systems are then taped onto the firing system. When using a combination initiation system, the electric initiation system is always the primary means of initiation. When using dual, non-electric initiation systems, the shorter time fuse is the primary initiation system

(Figure 2-26).

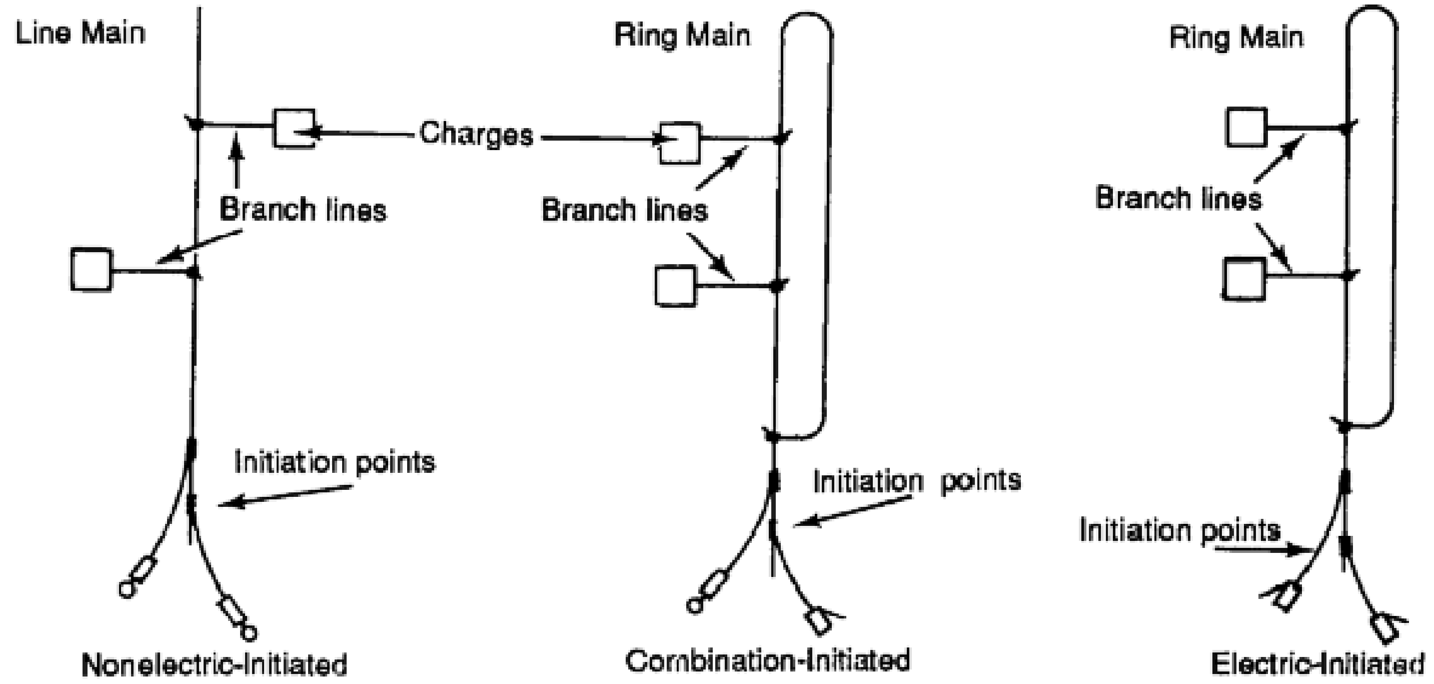


Figure 2-26. Single-firing system (dual-initiated, singled-fired, single-primed)

b. Dual. Figure 2-27 (page 2-24) shows a dual-firing system. Each charge is dual-primed with two branch lines (Figure 2-28, page 2-24). One branch line is tied to one firing system, and the other branch line is tied to an independent firing system. Line mains or ring mains may be used; however, they should not be mixed. To help prevent misfires, use detonating-cord crossovers.

Crossovers are used to tie both firing systems together at the ends. The initiation systems are taped in the primary initiation system goes to one firing system, the secondary goes to the other.

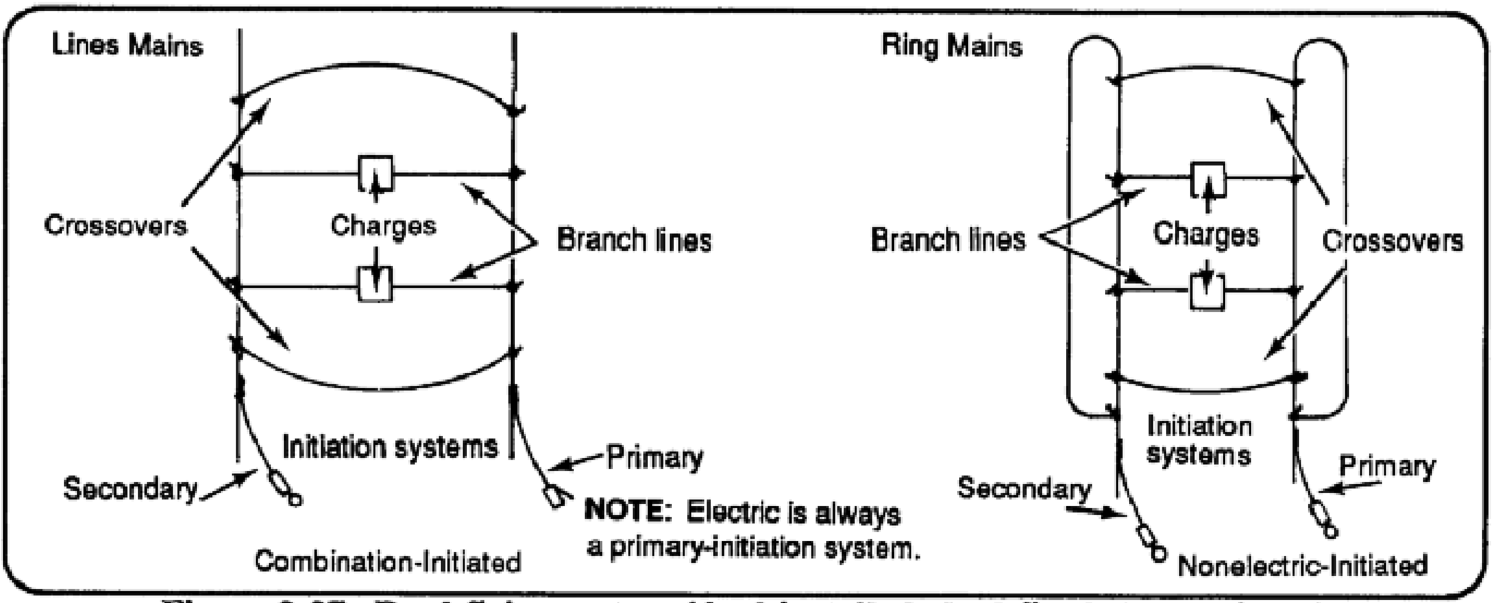


Figure 2-27. Dual-firing system (dual-installed, dual-fired, dual-primed)

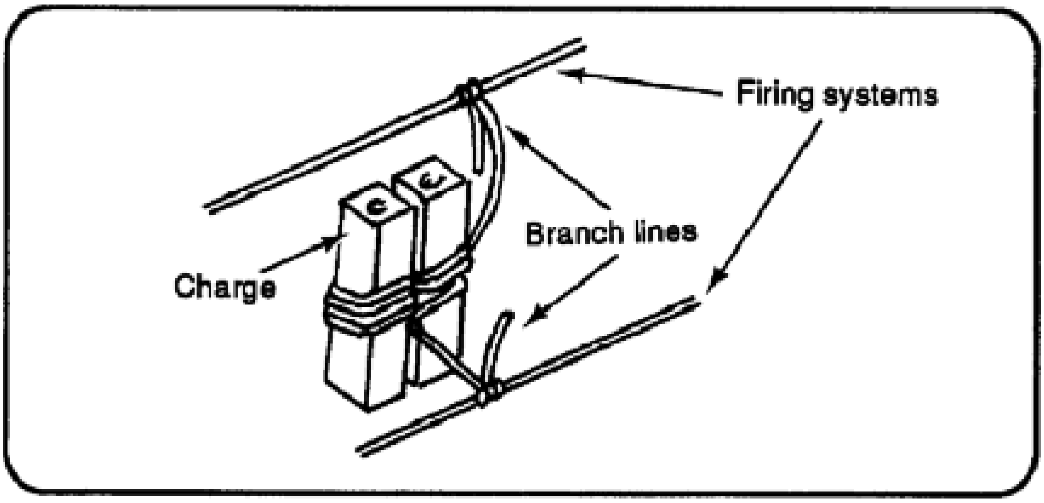


Figure 2-28. Dual-primed charge

Figure 2-29 shows a dual-firing system using horizontal and vertical ring mains. The complexity simultaneous detonation. These will be referred to as horizontal and vertical lines or ring mains.

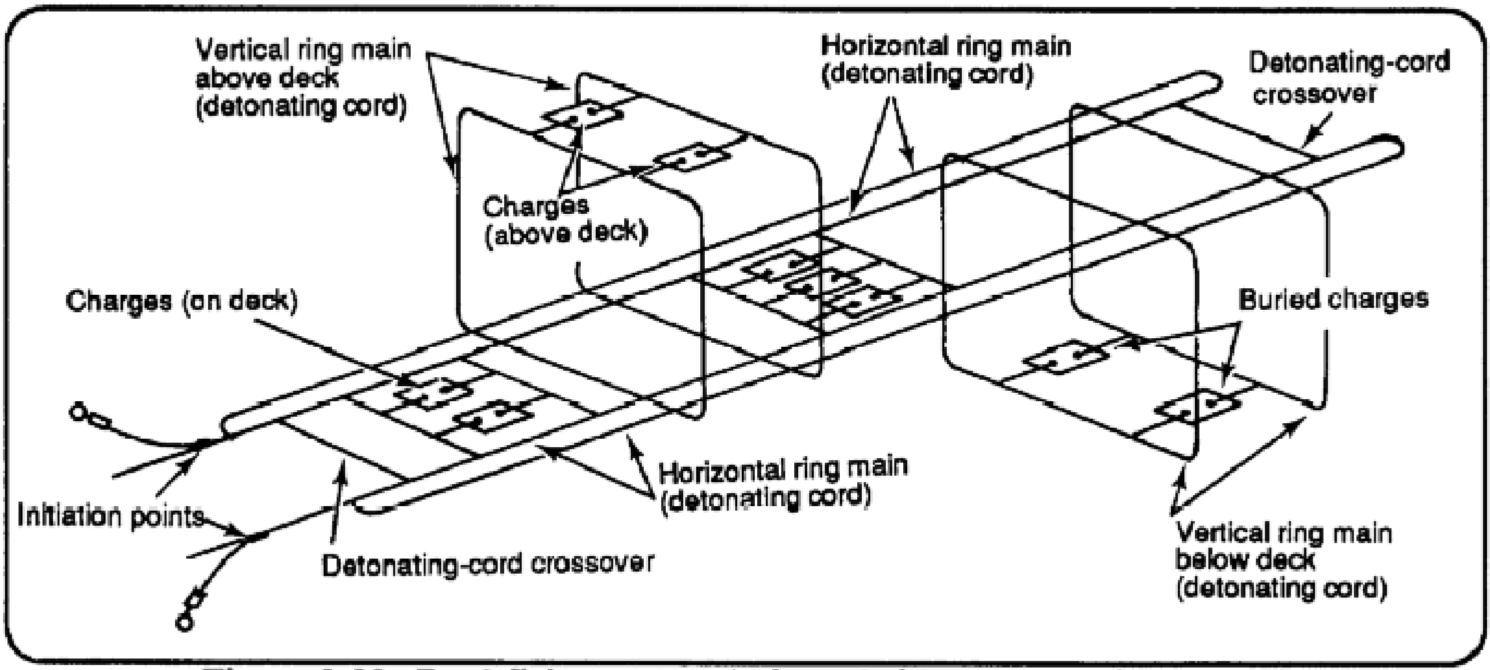


Figure 2-29. Dual-firing system (using a bridge as a possible target)

of a target or obstacle may necessitate using multiple line mains or ring mains for 2-12. Detonating Cord. A firing system uses detonating cord to transmit a shock wave from the initiation set to the explosive charge. Detonating cord is versatile and easy to install. It is useful for underwater, underground, and above-ground blasting because the blasting cap of the initiation set may remain above water or above ground and does not have to be inserted directly into the charge. Detonating-cord firing systems combined with detonating-cord priming are the safest and most efficient ways to conduct military demolition missions. Initiate detonating cord only with non-electric or electric initiation sets.

2-13. Attaching the Blasting Cap. Attach the blasting cap, electric or non-electric, to the detonating cord with tape. You can use string, cloth, or fine wire if tape is not available. Tape the cap securely to a point 6 inches from the end of the detonating cord to overcome moisture contamination. The tape must not conceal either end of the cap. Taping in this way allows you to inspect the cap in case it misfires. No more than 1/8 inch of the cap needs to be left exposed for inspection (Figure 2-30).

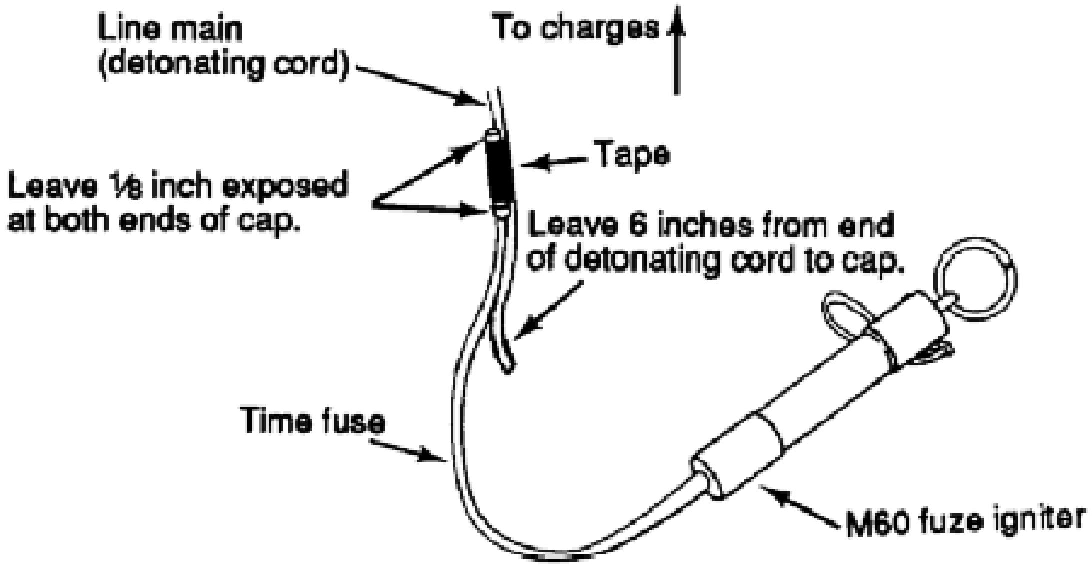


Figure 2-30. Attaching blasting cap to detonating cord

2-14. Detonating-Cord Connections. Use square knots or detonating-cord clips to splice the ends of detonating cord (Figure 2-31). Square knots may be placed in water or in the ground, but the cord must be detonated from a dry end or above ground. Allow 6-inch tails on square knots to prevent misfires from moisture contamination. Paragraph 1-21 (page 1-17) describes the process for connecting detonating cord with detonating-cord clips.

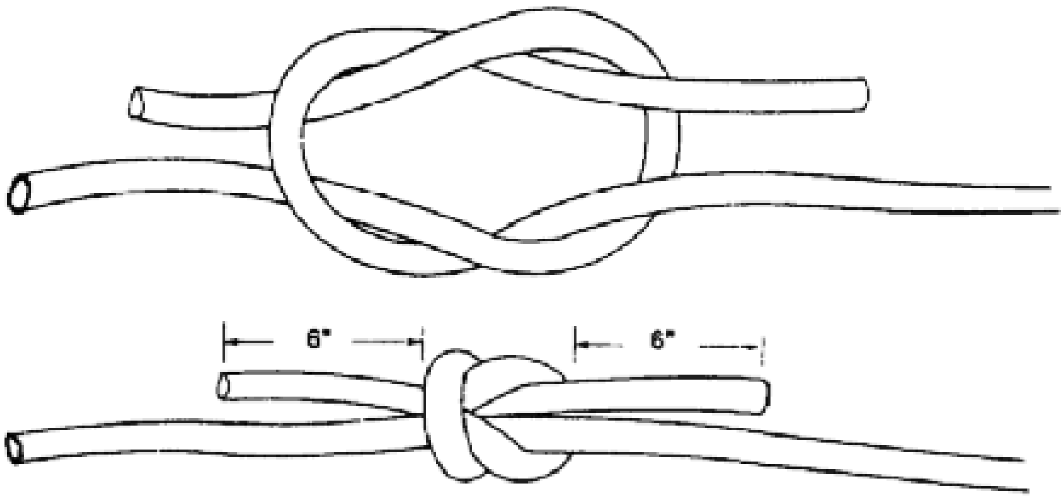


Figure 2-31. Square-knot connections

a. Branch Line. A branch line is nothing more than a length of detonating cord. Attach branch lines to a detonating-cord ring or line main to fire multiple charges. Combining the branch line with an initiation set allows you to fire a single branch line. If possible, branch lines should not be longer than 12 feet from the charge to the ring or line main. A longer branch line is too susceptible to damage that may isolate the charge. Fasten a branch line to a main line with a detonating-cord clip

(Figure 1-18, page 1-17) or a girth hitch with an extra turn (Figure 2-32). The connections of branch lines and ring or line mains should intersect at right (90-degree) angles. If these connections are not at right angles, the branch line may be blown off the line main without complete detonation. To prevent moisture contamination and ensure positive detonation, leave at least 6 inches of the running end of the branch line beyond the tie. It does not matter which side of the knot your 6-inch overhang is on at the connection of the ring or line main.

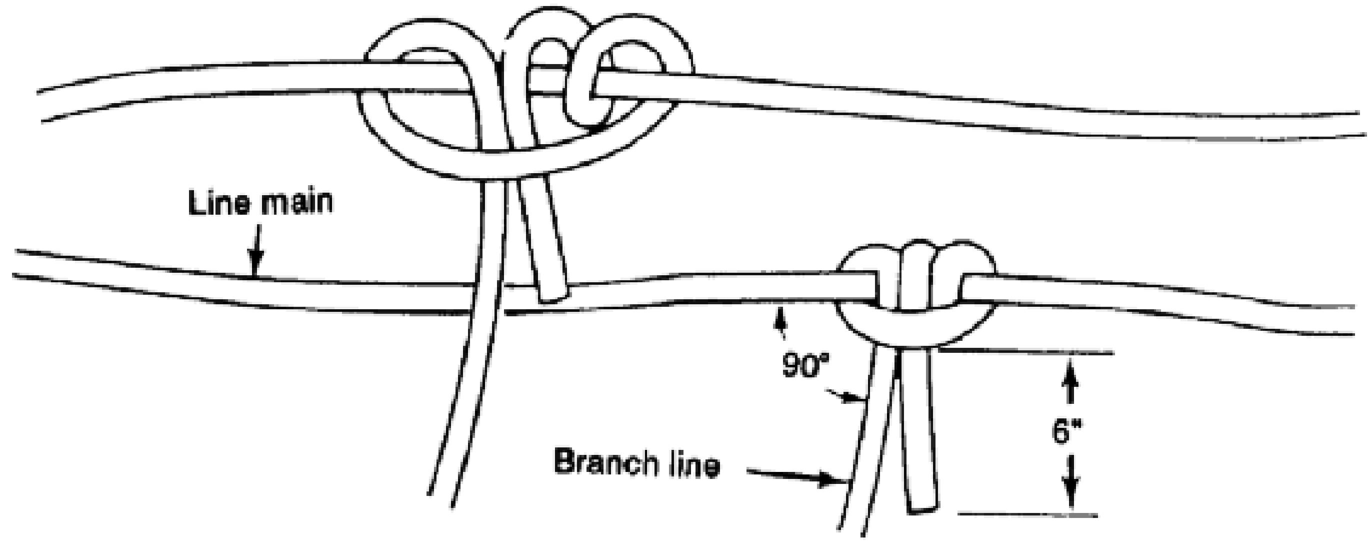


Figure 2-32. Girth hitch with an extra turn

b. Ring Main. Ring mains are preferred over line mains because the detonating wave approaches the branch lines from two directions. The charges will detonate even when them is a break in the ring main. A ring main will detonate an almost unlimited number of charges.

Branch-line connections at the ring main should be at right angles. Kinks in the lines should not be sharp. You can connect any number of branch lines to the ring main; however, never connect a branch line (at the point) where the ring main is spliced. When making branch-line connections, avoid crossing lines. If a line crossing is necessary, provide at least 1 foot of clearance between the detonating cords. Otherwise, the cords will cut each other and destroy the firing system.

(1) Method 1. Make a ring main by bringing the line main back in the form of a loop and attaching it to itself with a girth hitch with an extra turn (Figure 2-33, diagram 1).

(2) Method 2. Make a ring main by making a U-shape with

the detonating cord, and then attaching a detonating-cord crossover at the open end of the U. Use girth hitches with extra turns when attaching the crossover (Figure 2-33, diagram 2). An advantage of the U-shaped ring main is that it provides two points of attachment for initiation sets.

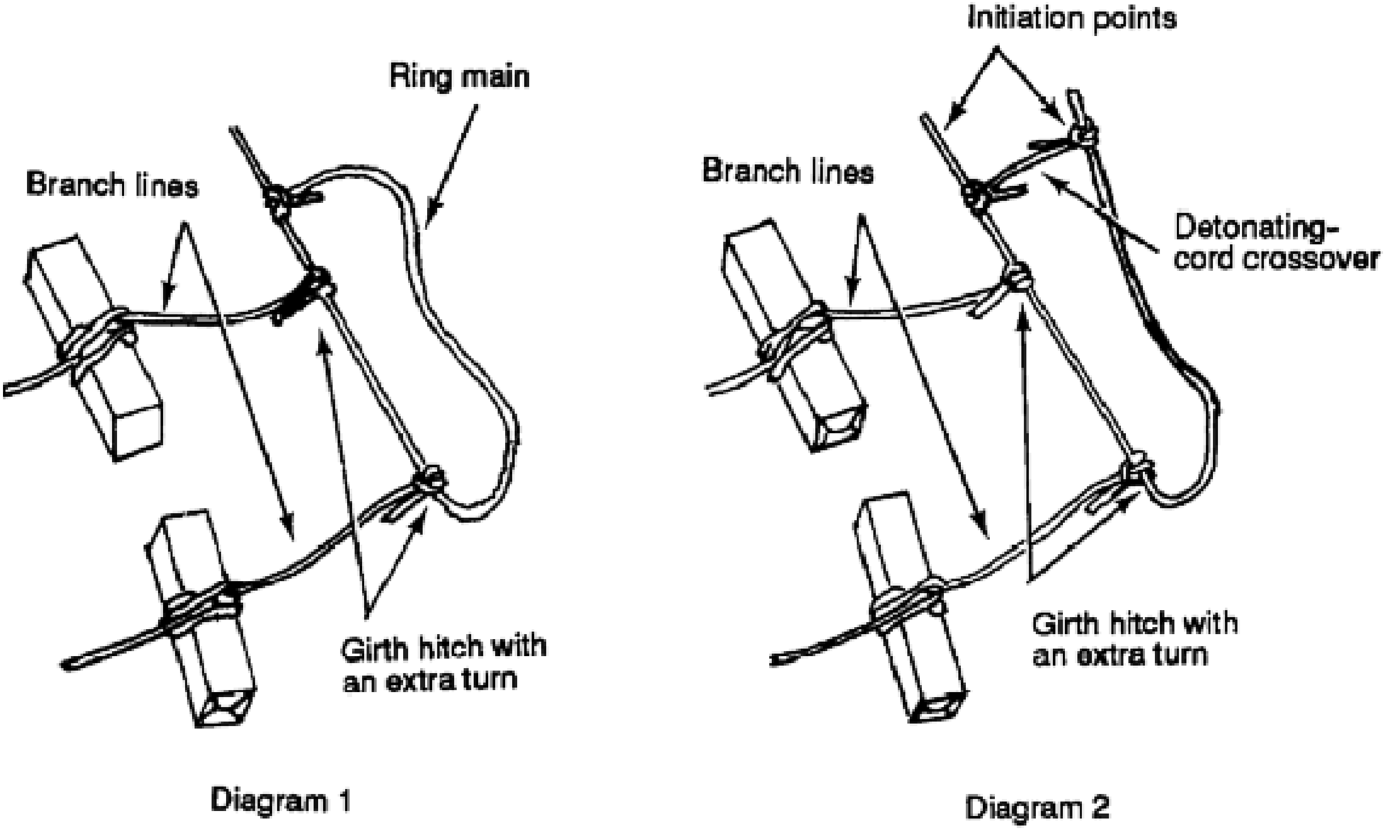


Figure 2-33. Ring mains

c. Line Main. A line main will fire multiple charges (Figure 2-34), but if a break in the line occurs, the detonating wave will stop at the break. When the risk of having a line main cut is unacceptable, use a ring main. Use line mains only when speed is essential and a risk of failure is acceptable. You can connect any number of branch lines to a line main. However, connect only one branch line at any one point unless you use a junction box (Figure 2-35, page 2-28).

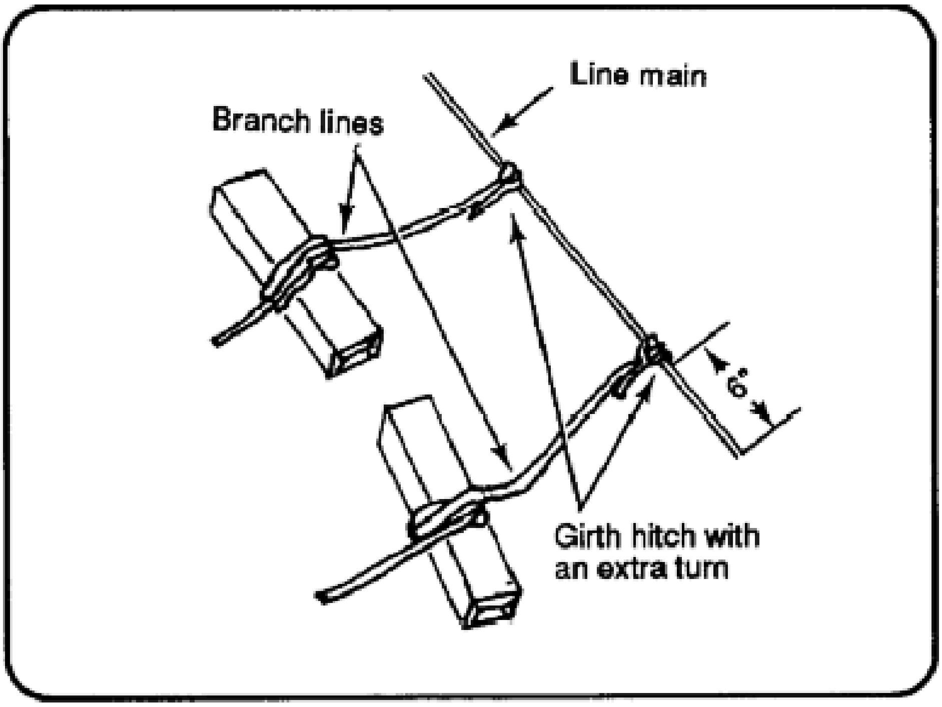


Figure 2-34. Line main with branch lines

2-15. Initiating Lines and Mains.

a. Line Main and Branch Line. Whenever possible, dual initiate a line main or a branch line (Figure 2-36, page 2-28). Place the blasting cap that will detonate first closest to the end of the detonating cord (for example, the electric cap of a combination of initiation sets). Doing this will ensure the integrity of the backup system when the first cap detonates and fails to initiate the line main. Do not try to get both caps to detonate at the same time. This is virtually impossible to do with time fuse. Stagger the detonations a minimum of 10 seconds.

b. Ring Main. Initiate ring mains as shown in Figures 2-33. The blasting caps are still connected as shown in Figure 2-36 (page 2-28), but by having one on each side of the ring main, the chances of both caps becoming isolated from the ring are greatly reduced.

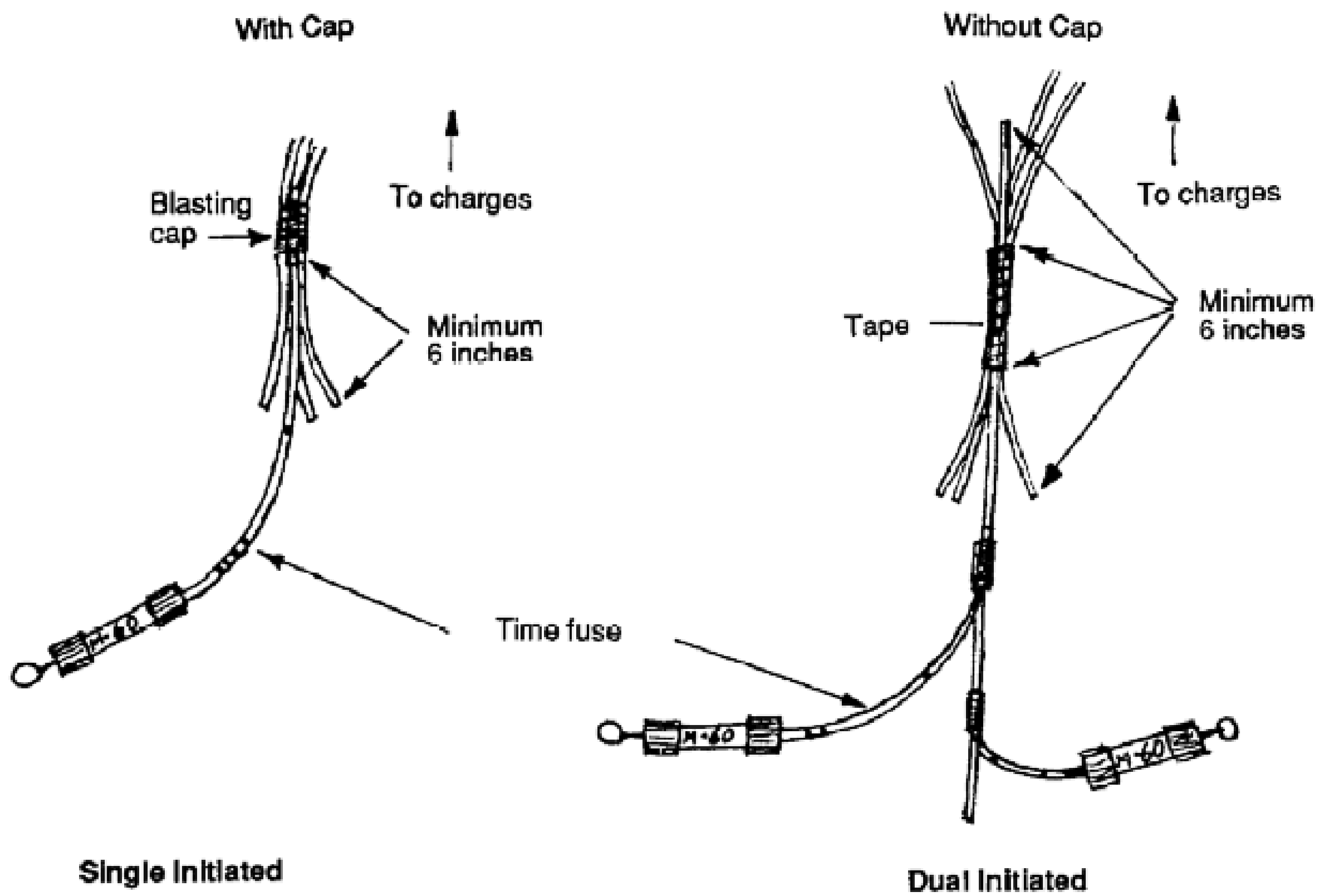


Figure 2-35. Junction box

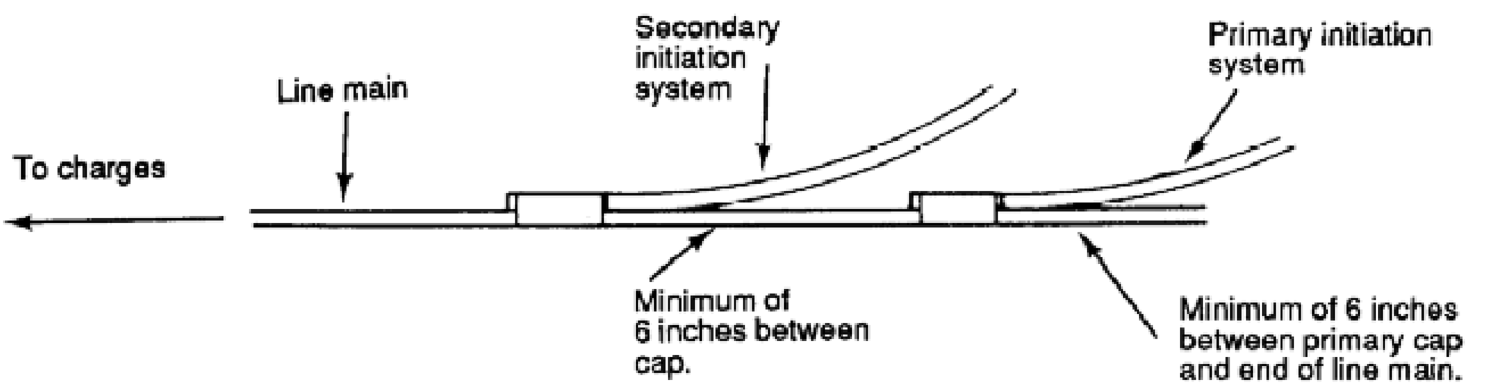


Figure 2-36. Attaching blasting caps to a line main

WARNING

When using time or safety fuse, uncoil it and lay it out in a straight line.

Place the time fuse so that the fuse will not curl up and prematurely detonate the blasting cap crimped to it.

NEXT

BACK TO COMMERCIAL EXPLOSIVES

Chapter 3

Calculation and Placement of Charges

Section I. Demolition

3-1. Principles. The amount and placement of explosives are key factors in military demolition projects. Formulas are available to help the engineer calculate the required amount of explosives.

Demolition principles and critical-factor analysis also guide the soldier in working with explosive charges. The available formulas for demolition calculations are based on the following factors:

a. Effects of Detonation. When an explosive detonates, it violently changes into highly compressed gas. The explosive type, density, confinement, and dimensions determine the rate at which the charge changes to a gaseous state. The resulting pressure then forms a compressive shock wave that shatters and displaces objects in its path. A high-explosive charge detonated in direct contact with a solid object produces three detectable destructive affects:

(1) Deformation. The charge’s shock wave deforms the surface of the object directly under the charge. When the charge is placed on a concrete surface, it causes a compressive shock wave that crumbles the concrete in the immediate vicinity of the charge, forming a crater. When

placed on a steel surface, the charge causes an indentation or depression about the size of the contact area of the charge.

(2) Spall. The charge's shock wave chips away at the surface of the object directly under the charge. This action is known as spalling. If the charge is large enough, it will span the opposite side of the object. Because of the difference in density between the target and the air, the charge's compressive shock wave reflects as a tensile shock wave from the free surface, if the target has a free surface on the side opposite the charge. This action causes spalling of the target-free surface.

The crater and spans may meet to forma hole through the wall in concrete demolitions. On a steel plate, the charge may create one span in the shape of the explosive charge, throwing the spall from the plate.

(3) Radial Cracks. If the charge is large enough, the expanding gases can create a pressure load on the object that will cause cracking and therefore displace the material. This effect is known as radial cracking. When placed on concrete walls, the charge may crack the surface into a large number of chunks and project them away from the center of the explosion. When placed on steel plates, the charge may bend the steel away from the center of the explosion.

b. Significance of Charge Dimensions. The force of an explosion depends on the quantity and power of the explosive. The destructive effect depends on the direction in which the explosive force is directed. To transmit the greatest shock, the charge must have the optimal relationship of contact area and thickness to target volume and density. If you spread a calculated charge too thinly, you will not have provided enough space for the shock wave to reach full velocity before striking the target. In improperly configured explosives (too thin or wrong strength), the shock wave tends to travel in a parallel rather than a perpendicular direction to the surface. As a result, the volume of the target will be too much for the resulting shockwave. Additionally, a thick charge with too small a contact area will transmit a shock wave over too small a target area, with much lateral loss of energy.

c. Significance of Charge Placement. The destructive effect of an explosive charge also depends on the location of the charge in relation to the target size, shape, and configuration. For the most destructive effect, detonate an explosive of the proper size and shape for the size, shape, and configuration of the target. Any significant air or water gap between the target and explosive will lessen the force of the shock wave. Cut explosives (such as sheet or plastic explosives) to fit odd-shaped targets. Whenever possible, place explosive charges to act through the smallest part of the target. Use internal charges to achieve maximum destruction with minimum explosives expense.

Tamping external charges increases their destructive effect.

3-2. Types of Charges.

a. Internal Charges. Place internal charges in boreholes in the target. Confine the charges with tightly packed sand, wet clay, or other material (stemming). Stemming is the process of packing material on top of an internal borehole or crater charge. Fill and tamp stemming material against the explosive to fill the borehole to the surface. In drill holes, tamp the explosive as it is loaded into the hole. Tamp stemming material only with nonsparking equipment.

b. External Charges. Place external charges on the surface of the target. Cover and tamp the charges with tightly packed sand, clay, or other dense material. Stemming material may be loose or in sandbags. To be most effective, make the thickness of the tamping material at least equal to the breaching radius. Tamp small breaching charges on horizontal surfaces with several inches of wet clay or mud.

3-3. Charge Calculations. Determine the amount of explosives required for any demolition project by calculation, based on the following critical factors:

a. Type and Strength of Materials in Targets. A target may be timber, steel, or other material.

Concrete may be reinforced with steel, thereby increasing the concrete's strength.

b. Size, Shape, and Configuration of Target. These characteristics all influence the required type and amount of explosives. For example, large or odd-shaped targets, such as concrete piers and steel beams, are more economically demolished with multiple charges than with a single charge.

c. Desired Demolition Effect. Consider the extent of the demolition project and the other desired effects, such as the direction trees will fall when constructing an abatis.

d. Type of Explosive. The characteristics of each type of explosive determine its application for demolition purposes. Tables 1-1 and 1-2 (pages 1-2 and 1-5) list these characteristics.

e. Size and Placement of Charge. When using external charges without considering placement techniques, use a flat, square charge with a thickness-to-width ratio of 1:3. In general, charges of less than 5 pounds should be at least 1 inch thick. Charges from 5 to 40 pounds should be 2 inches thick. Charges of 40 pounds or more should be 4 inches thick. Fasten charges to the target using wire, adhesive compound, tape, or string. Prop charges against targets with wooden or metal frames made of scrap or other available materials or place the charges in boreholes.

f. Method of Tamping. If you do not completely seal or confine the charge or if you do not ensure the material surrounding the explosive is balanced on all sides, the explosive's force will escape through the weakest spot. To keep as much explosive force as possible on the target, pack material around the charge to fill any empty space. This material is called tamping material and the process is called tamping. Sandbags and earth are examples of common tamping materials.

Always tamp charges with a nonsparking instrument.

g. Direction of Initiation. The direction in which the shockwave travels through the explosive charge will affect the rate of energy transmitted to the target. If the shock wave travels parallel to the surface of the target (Figure 3-1, diagram 1), the shock wave will transmit less energy over a period of time than if the direction of detonation is perpendicular to the target. For best results, initiate the charge in the center of the face opposite the face in contact with the target.

3-4. Charge Selection and Calculation.

a. Selection. Explosive selection for successful demolition operations is a balance between the critical factors listed above and the practical aspects: target type; the amount and types of explosives, materials (such as sandbags), equipment, and personnel available; and the amount of time available to accomplish the mission.

b. Calculation. Use the following procedure to determine the weight (P) of the explosive required for a demolition task, in pounds of TNT. If you use an explosive other than TNT, adjust P accordingly by dividing P for TNT by the relative effectiveness (RE) factor of the explosive you plan to use (Table 1-1, page 1-2). Use the following six-step, problem-solving format for all charge

calculations:

(1) Determine the critical dimensions of the target.

(2) Calculate the weight of a single charge of TNT to two decimal places by using the appropriate demolition formula (do not round). If your calculations are for TNT, skip to Step 4.

(3) Divide the quantity of explosive by the RE factor (carry the calculations to two decimal places, and do not round). If you are using TNT, skip this step.

(4) Determine the number of packages of explosive for a single charge by dividing the individual charge weight by the standard package weight of the chosen explosive. Round this result to the next-higher, whole package. Use volumes instead of weights for special purpose charges (ribbon, diamond, saddle, and similar charges).

(5) Determine the number of charges for the target.

(6) Determine the total quantity of explosives required to destroy the target by multiplying the number of charges

(Step 5) by the number of packages required per charge (Step 4).

Section II. Normal Cutting Charges

3-6. Steel-Cutting Charges.

WARNING

Steel-cutting charges produce metal fragments.

Proper precautions should be taken to protect personnel. Refer to Table 6-3, page 6-7.

a. Target Factors. The following target factors are critical in steel-structure demolitions, more so than with other materials:

(1) Target Configuration. The configuration of the steel in the structure determines the type and amount of charge necessary for successful demolition. Examples of structured steel are I-beams, wide-flange beams, channels, angle sections, structural tees, and steel plates used in building or bridge construction. Example A-3 (page A-3) shows how to calculate steel-cutting charges for wide-flange beams and girders.

(2) Target Materials. In addition to its configuration, steel also has varied composition:

High-carbon steel. Metal-working dies and rolls are normally composed of high-carbon steel and are very dense.

Alloy steel. Gears, shafts, tools, and plowshares are usually composed of alloy steel. Chains and cables are often made from alloy steel; however, some chains and cables are composed of high-carbon steel. Alloy steel is not as dense as high-carbon steel.

Cast iron. Some steel components (such as railroad rails and pipes) are composed of cast iron. Cast iron is very brittle and easily broken.

Nickel-molybdenum steel. This type of steel cannot be cut easily by conventional steel-cutting charges. The jet from a shaped charge will penetrate it, but cutting requires multiple charges or linear-shaped charges. Nickel-molybdenum steel shafts can be cut with a diamond charge. However, the saddle charge will not cut nickel-molybdenum shafts. Therefore, use some method other than explosives to cut nickel-molybdenum steel, such as thermite or acetylene or electrical cutting tools.

b. Explosives Factors. In steel-cutting charges, the type, placement, and size of the explosive are important. Confining or tamping the charge is rarely practical or possible. The following factors are important when selecting steel-cutting charges:

(1) Type. Select steel-cutting charges that operate with a cutting effect. Percussive charges are not very effective for steel cutting. Plastic explosive (C4) and sheet explosive

(Ml 18) are best. These explosives have very effective cutting power and are easily cut and shaped to fit tightly into the grooves and angles of the target. These explosives are particularly effective when demolishing structural steel, chains, and steel cables.

(2) Placement (Figure 3-7). To achieve the most effective initiation and results, ensure that—

The charge is continuous over the complete line of the proposed cut.

There is close contact between the charge and the target.

The width of the charge's cross section is between one and three times its thickness. Do not use charges more than 6 inches thick because you can achieve better results by increasing the width rather than the thickness.

Long charges are primed every 4 to 5 feet. If butting C4 packages end to end along the line of the cut, prime every fourth package.

The direction of initiation is perpendicular to the target (Figure 3-1).

Figure 3-7. Placement of charges on steel members

(3) Size. The size of the charge is dictated by the target steel's type and size and the type of charge selected. Use either C4 or TNT block explosives for cutting steel. C4 works best. Each steel configuration requires a unique charge size.

(a) Block charge. Generally, the following formula will give you the size of charge necessary for cutting I-beams, built-up girders, steel plates, columns, and other structural steel sections. (When calculating cutting charges for steel beams, the area for the top flange, web, and bottom flange must be calculated separately.) Built-up beams also have rivet heads and angles or welds joining the flanges to the web. You must add the thickness of one rivet head and the angle iron to the flange thickness when determining the thickness of a built-up beam's flange. Use the thinnest point of the web as the web thickness, ignoring rivet-head and angle-iron thickness. Cut the lattice of lattice-girder webs diagonally by placing a charge on each lattice along the line of the cut. Use tables 3-2 and 3-3 (page 3-10) to determine the correct amount of C4 necessary for cutting steel sections. Use the following formula to determine the required charge size (Table 3-3, page 3-10, is based on this formula):

$$P = (\frac{3}{8})A \quad or \quad P = 0.375A$$

where–

P = TM required, in pounds.

A = cross-sectional area of the steel member, in square inches.

Table 3-2. Hasty steel-cutting chart for TNT

Average Thickness of Section (in)	Pounds of explosive* for rectangular steel sections of given dimensions — Height of section (in)																
	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24
¼	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.7	1.9	2.1	2.3
⅜	0.3	0.5	0.6	0.7	0.9	1.1	1.2	1.3	1.4	1.6	1.7	2.0	2.3	2.6	2.8	3.1	3.4
½	0.4	0.6	0.8	1.0	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.7	3.0	3.4	3.8	4.2	4.5
⅝	0.5	0.7	1.0	1.2	1.4	1.7	1.9	2.2	2.4	2.7	2.9	3.3	3.8	4.3	4.7	5.2	5.7
¾	0.6	0.9	1.2	1.4	1.7	2.0	2.3	2.6	2.8	3.1	3.4	4.0	4.5	5.1	5.7	6.3	6.8
⅞	0.7	1.0	1.4	1.7	2.0	2.4	2.7	3.0	3.3	3.7	4.0	4.6	5.3	6.0	6.6	7.3	7.9
1	0.8	1.2	1.5	1.9	2.3	2.7	3.0	3.4	3.8	4.2	4.5	5.3	6.0	6.8	7.5	8.3	9.0

*TNT

Table 3-3. Hasty steel-cutting chart for C4

Section Thickness (Inches)	Weight of Composition C4 Required for Rectangular Steel Sections (Height or Width, in Inches)													
	2	3	4	5	6	8	10	12	14	16	18	20	22	24
1/4	0.2	0.3	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.8
3/8	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.5	1.8	2.0	2.1	2.4	2.6
1/2	0.3	0.5	0.6	0.8	0.9	1.2	1.5	1.8	2.1	2.3	2.6	2.9	3.2	3.4
5/8	0.4	0.6	0.8	0.9	1.1	1.5	1.8	2.2	2.5	2.9	3.2	3.5	3.9	4.3
3/4	0.5	0.7	0.9	1.1	1.3	1.8	2.1	2.6	3.0	3.4	3.8	4.3	4.7	5.1
7/8	0.6	0.8	1.1	1.3	1.5	2.1	2.5	3.0	3.5	4	4.5	5.0	5.5	5.9
1	0.6	0.9	1.2	1.5	1.8	2.3	2.9	3.4	4.0	4.5	5.1	5.6	6.2	6.8

NOTE: Round UP to the nearest 1/10 pound when calculating charge sizes.

To use this table:

1. Measure each rectangular section of the total member separately.
2. Find the approparite charge size for the rectangular section from the table. If the section dimension is not listed in the table, use the next-larger dimension.
3. Add the individual charges for each section to obtain the total charge weight.

(b) High-carbon or alloy steel. Use the following formula to determine the required charge for cutting high-carbon or alloy steel:

$$P = D^2$$

where–

P = TNT required, in pounds.

D = diameter or thickness of section to be cut, in inches.

(c) Steel bars, rods, chains, and cables (up to 2 inches). The size of these materials makes proper charge placement difficult. For example, Figure 3-8 shows charge placement on a chain. If the explosive is long enough to bridge both sides of the link or is large enough to fit snugly between the two links, use one charge. If the explosive is not large enough to bridge both sides, use two charges. Use the following amount of explosive:

For materials up to 1 inch in diameter or thickness, use 1 pound of explosive.

For materials between 1 and 2 inches in diameter or thickness, use 2 pounds of explosive.

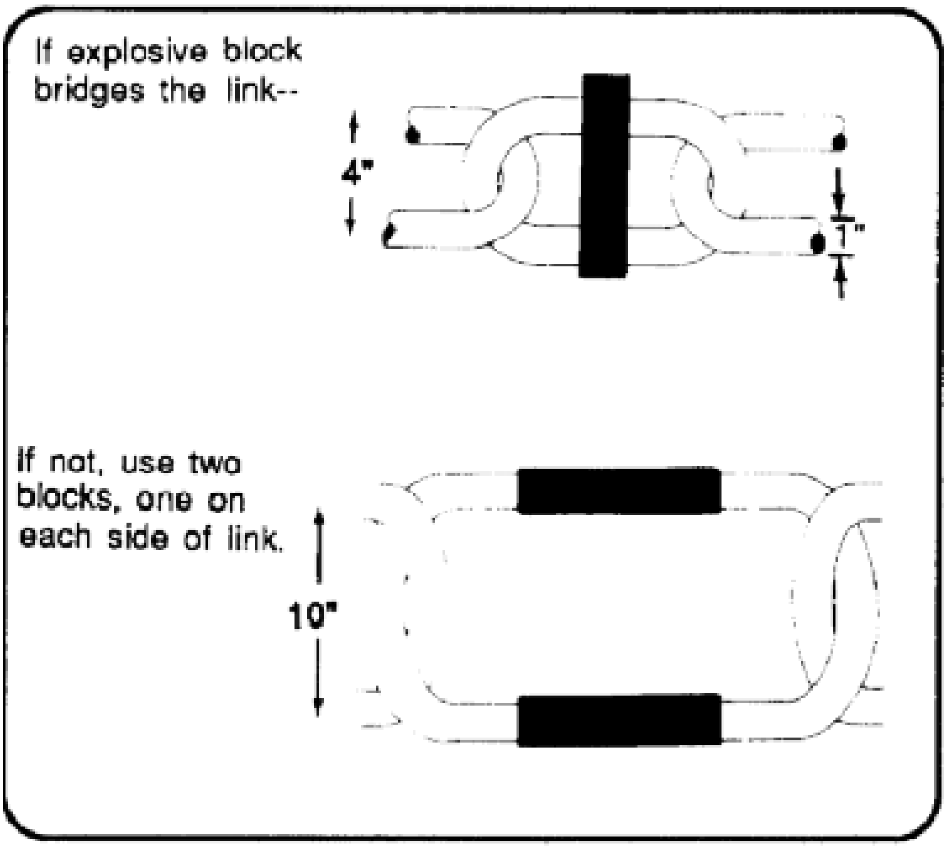


Figure 3-8. Charge placement on chains

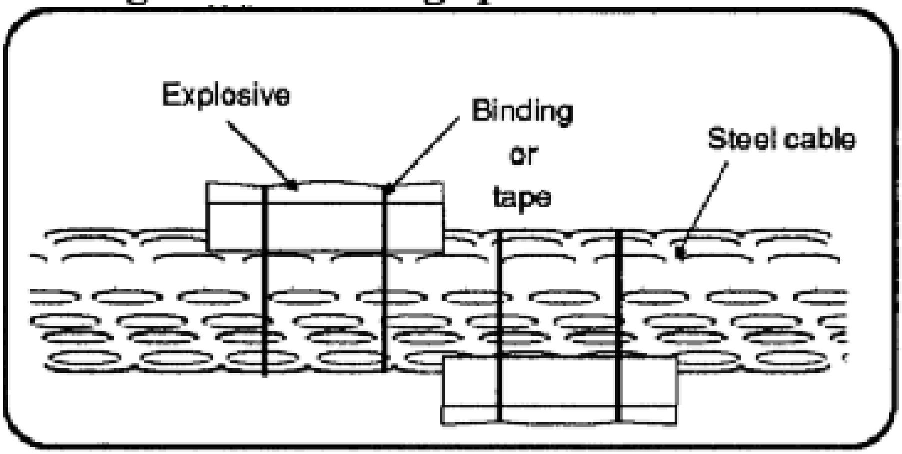


Figure 3-9. Charge placement on steel

(d) Steel bars, rods, chains, and cables (over 2 inches). When the target diameter or thickness is 2 inches or greater, use equation 3-4.

When the thickness or diameter is 3 inches or greater, place half of the charge on each side of, the target and stagger the placement to produce the maximum shearing effect (Figure 3-9).

(e) Railroad rails. The height of the railroad rail is the critical dimension for determining the amount of explosive required.

For rails 5 inches or more in height, crossovers, and switches, use 1 pound of C4 or TNT. For rails less than 5 inches high, use 1/2 pound of C4 or TNT (Figure 3-10, page 3-12). Railroad frogs require 2 pounds of C4 or TNT. Place the charges at vulnerable points, such as frogs, curves, switches, and crossovers, if possible. Place the charges at alternate rail splices for a distance of 500 feet.

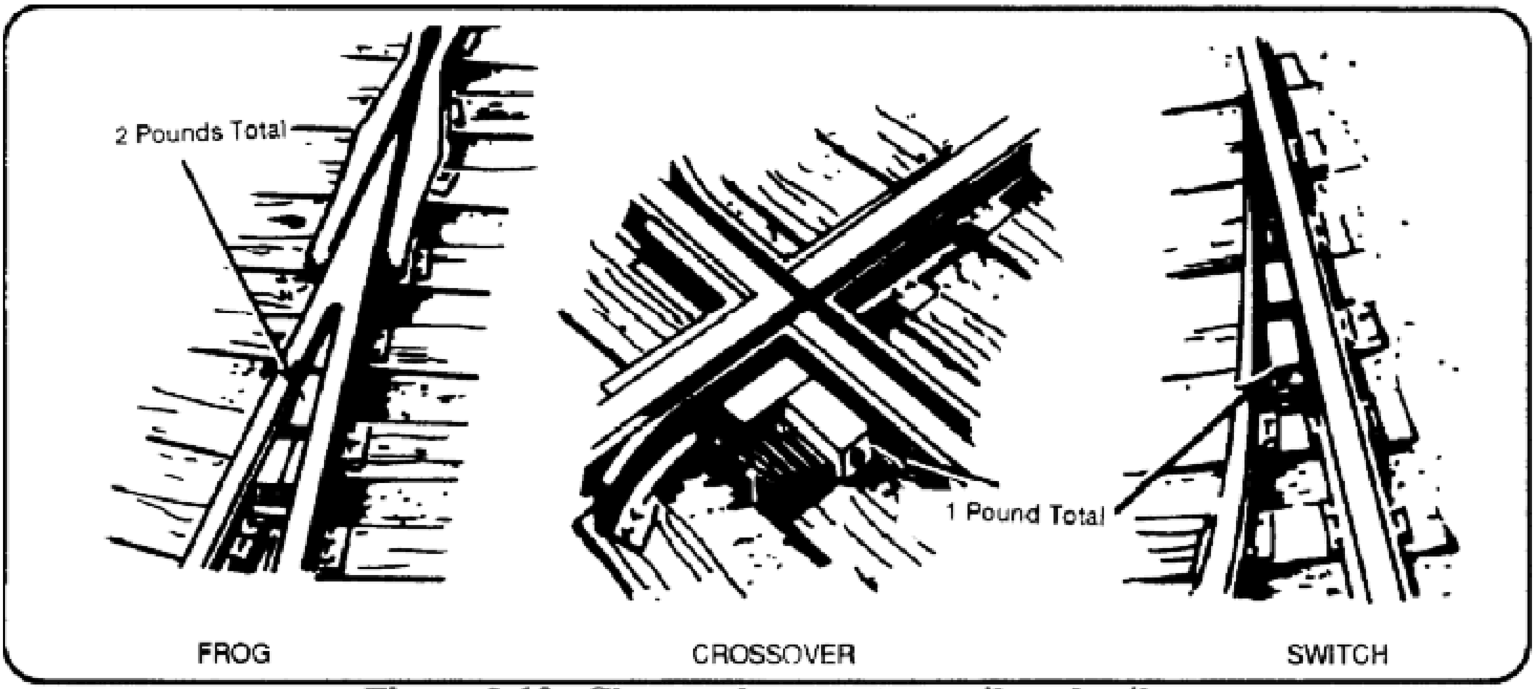


Figure 3-10. Charge placement on railroad rails

Section III. Special Cutting Charges

3-7. Purpose. When time and circumstances permit, you can use the special cutting charges (ribbon, saddle, and diamond charges) instead of conventional cutting charges. These charges may require extra time to prepare, since they require exact and careful target measurement to achieve optimal effect. With practice, an engineer can become proficient at calculating, preparing, and placing these charges in less time than required for traditional charges. Special cutting charges use considerably less explosive than conventional charges. Use plastic-explosive (M112) or sheet-explosive (Ml18 or Ml86) charges as special charges. C4 requires considerable cutting, shaping, and molding, which may reduce its density and, therefore, its effectiveness. Sheet explosive is more suitable than C4, since sheet explosive is more flexible and requires less cutting.

Use of these charges requires considerable training and practice. The charges are thin and require blasting caps crimped to a detonating-cord branch line for initiation. (A detonating-cord knot will work but is difficult to place and can ruin the advantage of the special charge shape).

3-8. Ribbon Charges. Use these charges to cut flat, steel targets up to 3 inches thick (Figure 3- 11).

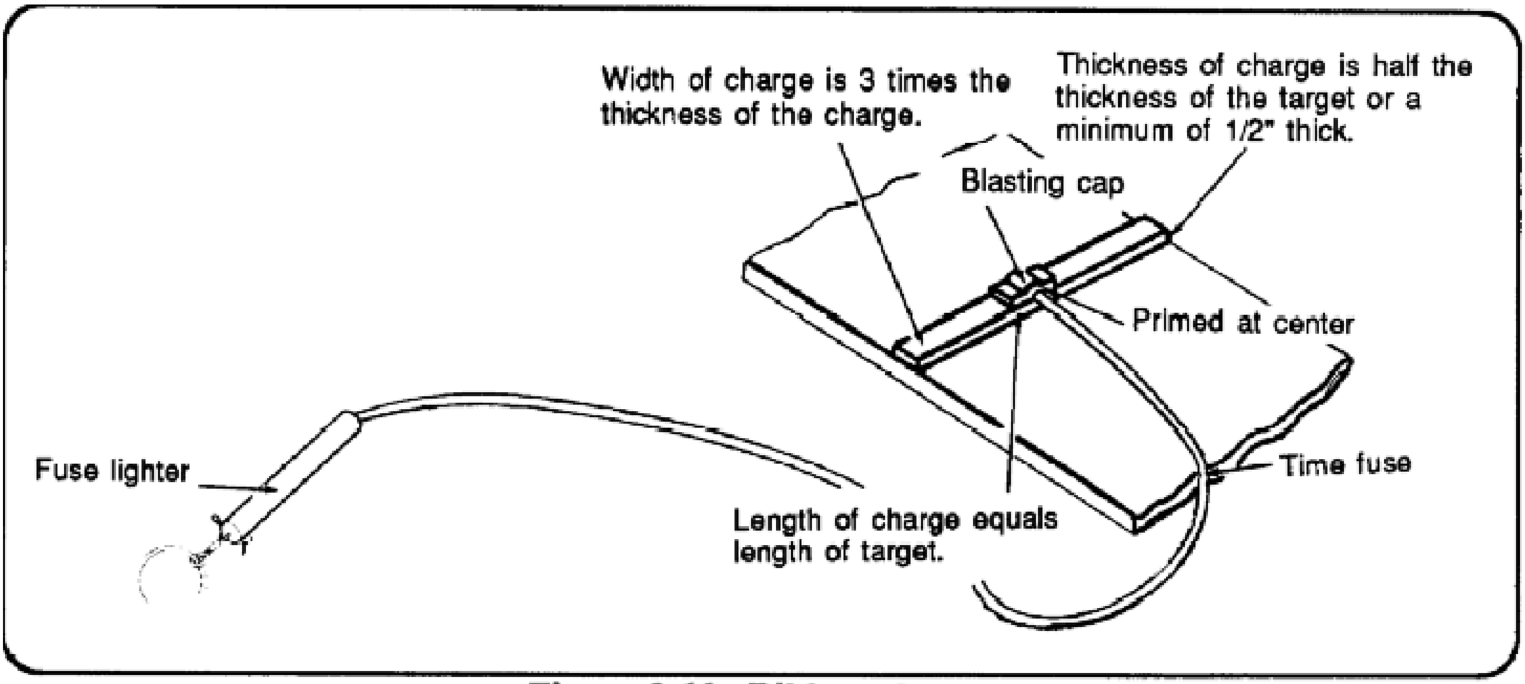


Figure 3-11. Ribbon charge

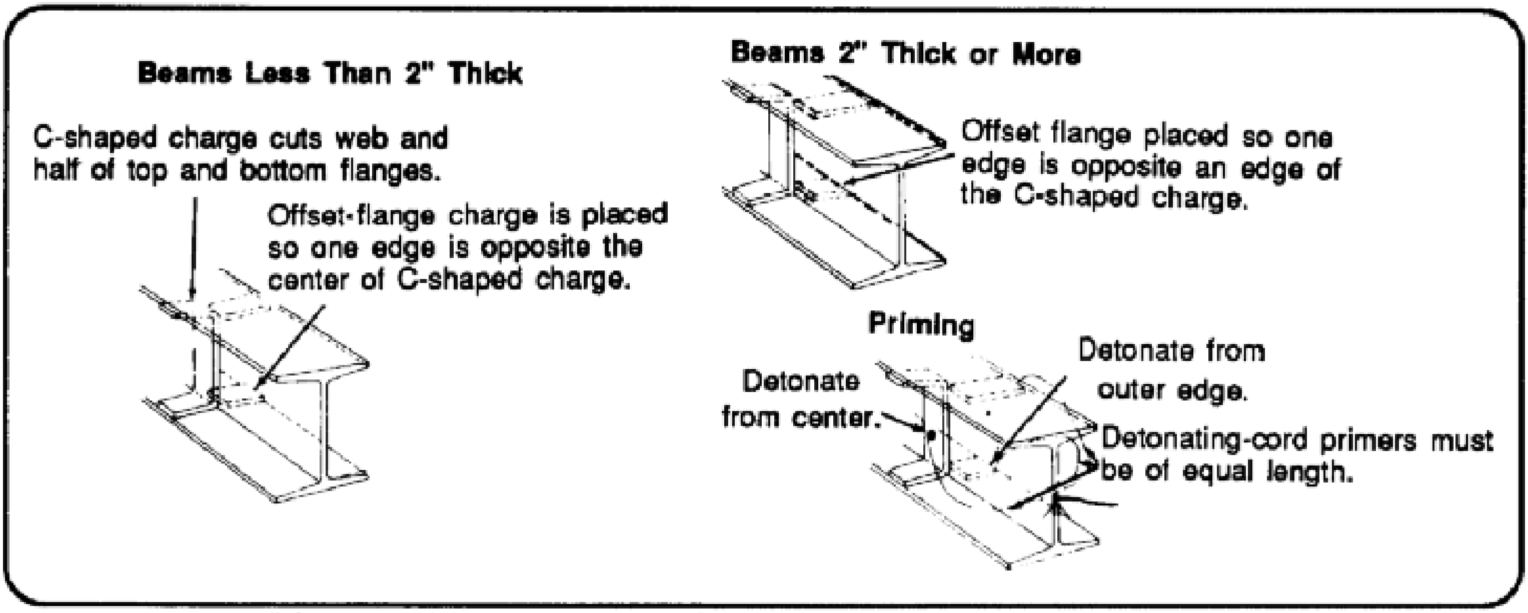


Figure 3-12. Placement of ribbon charge on structural steel

Make the charge thickness one-half the target thickness but never less than 1/2 inch. Make the charge width three times the charge thickness and the length of the charge equal to the length of the desired cut. Detonate the ribbon charge from the center or from either end. When using the ribbon charge to cut structural steel sections, place the charge as shown in Figure 3-12. The detonating-cord branch lines must be the same length and must connect in a junction box (Figure 2-35, page 2-27). Example A-5 (page A-5) shows how to calculate steel-cutting charges for steel plates. The formula for the ribbon charge is as follows:

a. Charge Thickness. The charge thickness equals one half the target's thickness; however, it will never be less than 1/2 inch.

b. Charge Width. The charge width is three times charge thickness.

c. Charge Length. The charge length equals the length of the desired cut.

3-9. Saddle Charge. This steel-cutting method uses the destructive effect of the cross fracture formed in the steel by the base of the saddle charge (end opposite the point of initiation). Use this charge on mild steel bars, whether round, square, or rectangularly shaped, up to 8 square inches or 8 inches in diameter (Figure 3-13, page 3-14). Make the charge a uniform l-inch thick. Example A-7 (page A-7) shows how to calculate steel-cutting charges for steel bars, Determine the dimensions of the saddle charge as follows:

a. Dimensions.

(1) Thickness. Make the charge 1 inch thick (standard thickness of Ml 12 block explosive).

(2) Base Width. Make the base width equal to one-half the

target circumference or perimeter.

(3) Long-Axis Length. Make the long-axis length equal to the target circumference or perimeter.

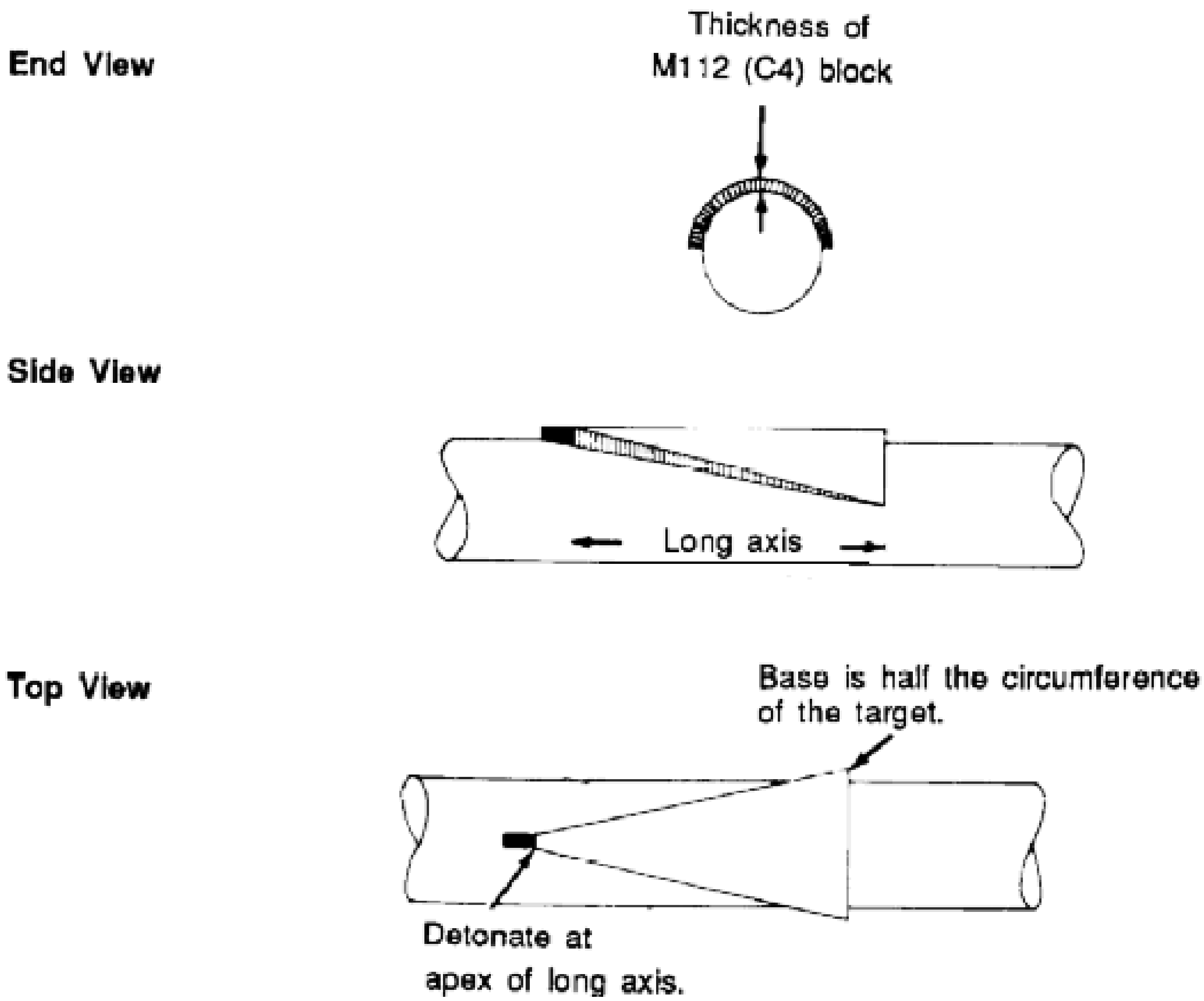


Figure 3-13. Saddle charge

b. Detonation. Detonate the saddle charge by placing a blasting cap at the apex of the long axis.

c. Placement. The long axis of the saddle charge should be parallel with the long axis of the target. Cut the charge to the correct shape and dimensions and then place it around the target. Ensure the charge maintains close contact with the target by taping the charge to the target.

3-10. Diamond Charge. This technique, the stress-wave method, employs the destructive effect of two colliding shock waves. The simultaneous detonation of the charge from opposite ends (Figure 3-14) produces the shock waves. Use the diamond charge on high-carbon or alloy steel bars up to 8 inches in diameter or having cross-sectional areas of 8 square inches or less. Example A-8 (page A-7) shows how to calculate steel-cutting charges for high-carbon steel.

a. Dimensions.

(1) Thickness. Make the charge 1 inch thick (standard thickness of Ml12 block explosive).

(2) Long-Axis Length. Make the long-axis length equal to the target circumference or perimeter.

(3) Short-Axis Length. Make the short-axis length equal to one-half the target circumference or perimeter.

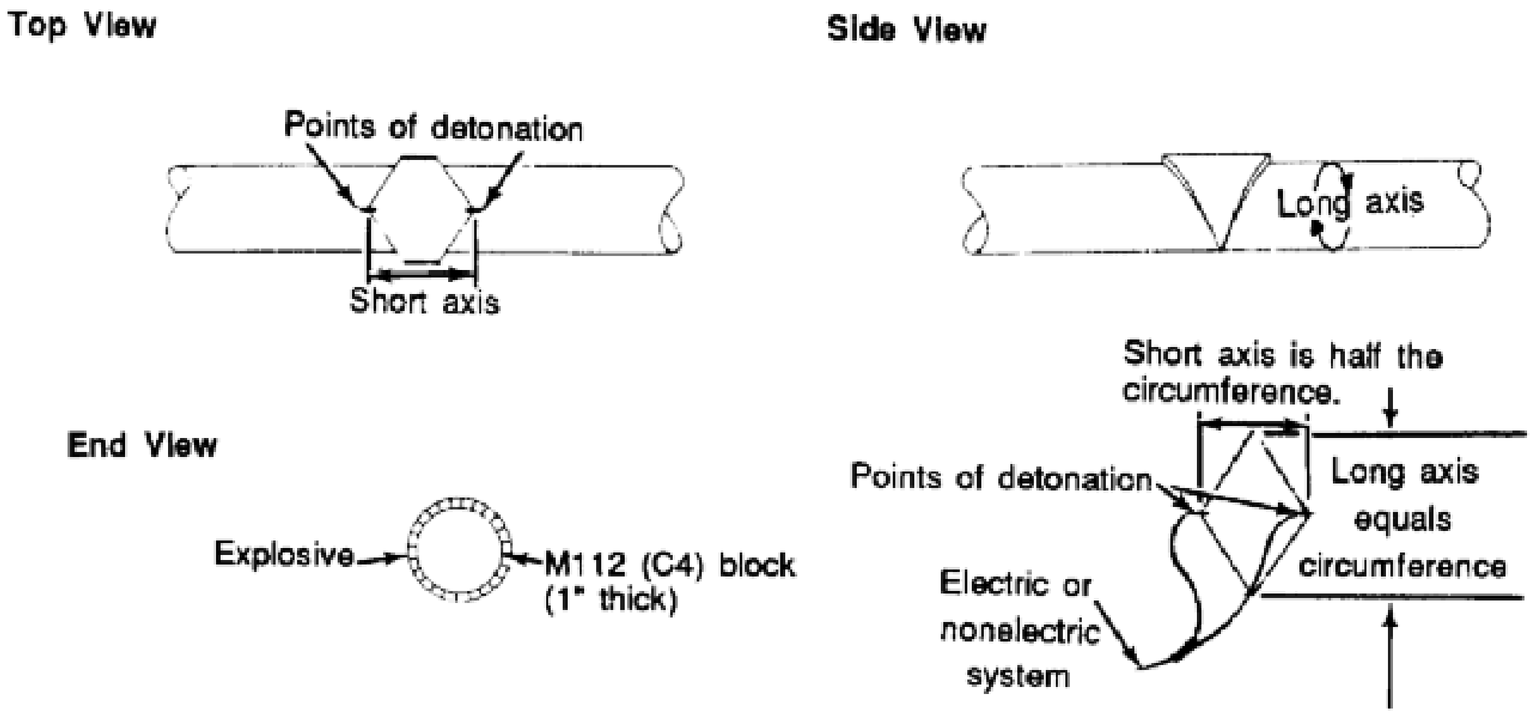


Figure 3-14. Diamond charge

b. Placement. Place the explosive completely around the target so that the ends of the long axes touch. You may have to slightly increase the charge dimensions to do this. To ensure adequate contact with the target, tape the charge to the target.

c. Priming. Prime the diamond charge (Figure 3-14) with two detonating cord branch lines using one of the following methods:

Detonating cord knots (Figure 2-15, page 2- 14).

Two electric blasting caps in a series circuit (Figure 2-7, page 2-8).

Two nonelectric blasting caps (Figure 2-35, page 2-27).

NOTE: When using detonating cord knots or nonelectric blasting caps, the branch lines must be the same length.

Section IV. Breaching Charges

3-11. Critical Factors. Use breaching charges to destroy bridge piers, bridge abutments, and permanent field fortifications. The size, shape, placement, and tamping or confinement of breaching charges are critical to success. The size and confinement of the explosive are the most critical factors because the targets are usually very strong and bulky. The intent of breaching charges is to produce and transmit sufficient energy to the target to make a crater and create spalling. Breaching charges placed against reinforced concrete will not cut metal reinforcing bars. Remove or cut the reinforcement with a steel-cutting charge after the concrete is breached.

3-12. Computation.

a. Formula. Determine the size of the charge required to breach concrete, masonry, rock, or similar material by using the following formula:

$$P = R^3KC$$

where—

P = TNT required, in pounds.

R = breaching radius, in feet.

K = material factor, which reflects the strength, hardness, and mass of the material to be demolished, (Table 3-4).

Table 3-4. Material factor (*K*) for breaching charges

Material	Breaching Radius (*R*)	*K*
Earth	All values	0.07
Poor masonry, Shale, Hardpan, Good timber, Earth construction	Less than 1.5 m (5 ft) 1.5 m (5 ft) or more	0.32 0.29
Good masonry, Concrete block, Rock	0.3 m (1 ft) or less Over 0.3 m (1 ft) to less than 0.9 m (3 ft) 0.9 m (3 ft) to less than 1.5 m (5 ft) 1.5 m (5 ft) to less than 2.1 m (7 ft) 2.1 m (7 ft) or more	0.88 0.48 0.40 0.32 0.27
Dense concrete, First-class masonry	0.3 m (1 ft) or less Over 0.3 m (1 ft) to less than 0.9 m (3 ft) 0.9 m (3 ft) to less than 1.5 m (5 ft) 1.5 m (5 ft) to less than 2.1 m (7 ft) 2.1 m (7 ft) or more	1.14 0.62 0.52 0.41 0.35
Reinforced concrete (Factor does not consider cutting concrete)	0.3 m (1 ft) or less Over 0.3 m (1 ft) to less than 0.9 m (3 ft) 0.9 m (3 ft) to less than 1.5 m (5 f)t 1.5 m (5 ft) to less than 2.1 m (7 ft) 2.1 m (7 ft) or more	1.76 0.96 0.80 0.63 0.54

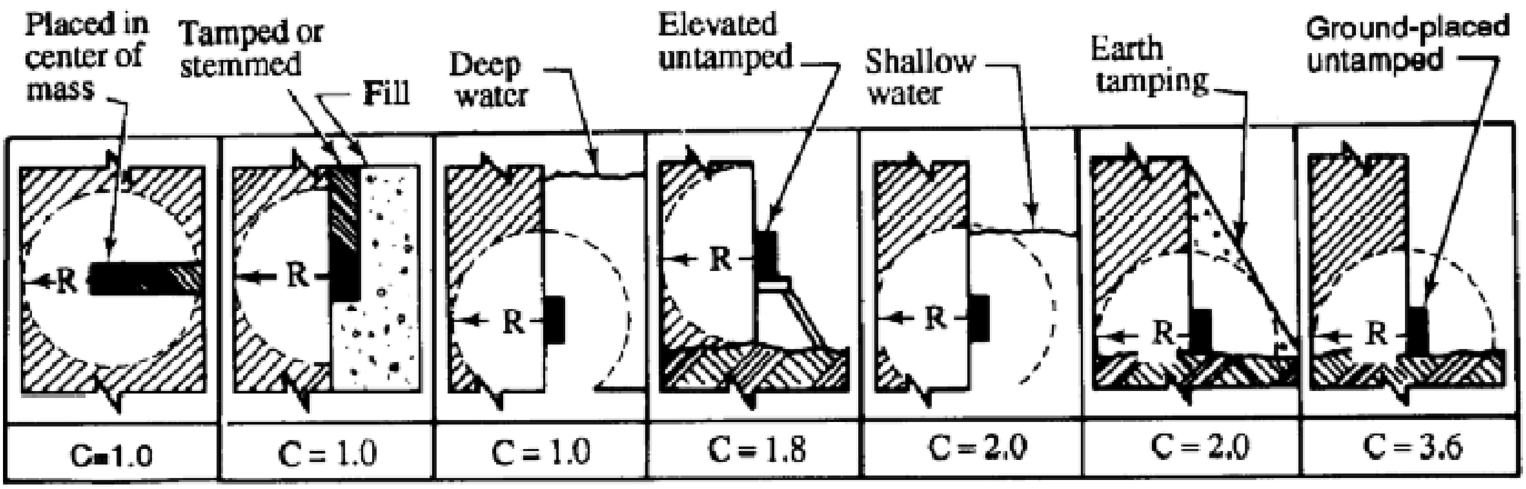


Figure 3-15. Tamping factor (*C*) for breaching charges

C = tamping factor, which depends on the location and tamping of the charge (Figure 3-15).

b. Breaching Radius (R). The breaching radius for external charges is equal to the thickness of the target being breached. For internal charges placed in the center of the target's mass, the breaching radius is one half the thickness of the target. If the charge is placed at less than half the mass thickness, the breaching radius is the longer of the distances from the center of the charge to the outside surfaces of the target. For example, when breaching a 4-foot wall with an internal charge placed 1 foot into the wall, the breaching radius is 3 feet (the longest distance from the center of the explosive to an outside target surface). If placed at the center of the wall's mass, the explosive's breaching radius is 2 feet (one-half the thickness of the target). The breaching radius is 4 feet for an external charge on this wall. Round values of R to the next-higher ¼-foot distance for internal charges and to the next-higher ½-foot distance for external charges.

c. Material Factor (K). K represents the strength and hardness of the target material. Table 3-4 gives values for K for various types and thicknesses of material. When you are unable to positively identify the target material, assume the target consists of the strongest type of material in the general group. Always assume concrete is reinforced and masonry is first-class unless you know the exact condition and construction of the target materials.

d. Tamping Factor (C). C depends on the charge location and materials used for tamping.

Figure 3-15 illustrates methods for placing charges and gives the values of C for both tamped and untamped charges. When selecting a value for C from Figure 3-15, do not consider a charge tamped with a solid material (such as sand or earth) as fully tamped unless you cover the charge to a depth equal to or greater than the breaching radius.

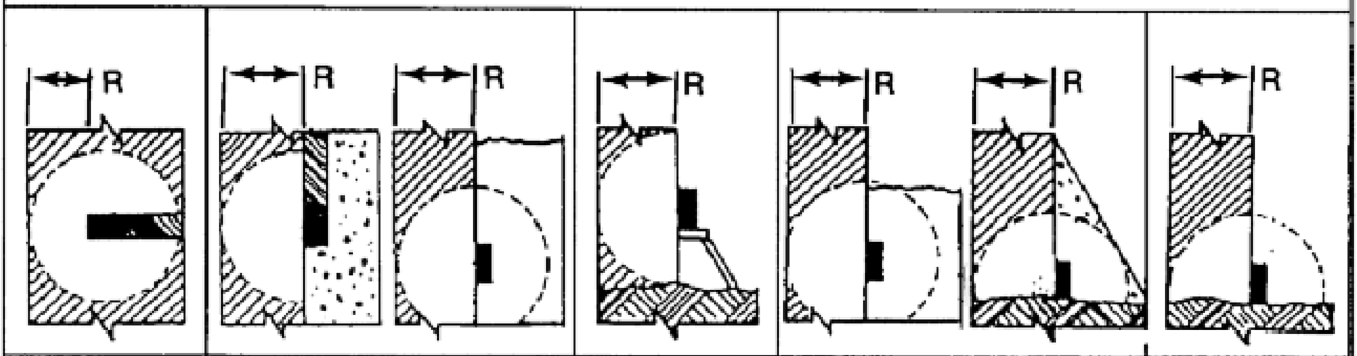
3-13. Breaching Reinforced Concrete. Table 3-5 (page 3-18) gives the number of C4 packages required for breaching reinforced-concrete targets. Example A-9 (page A-8) shows how to calculate the breaching charge for a reinforced-concrete pier. The amounts of C4 in the table are based on equation 3-6. To use the table, do the following:

a. Measure the concrete thickness.

b. Decide how the charge will be placed against the target. Compare the method of placement with the diagrams at the top of the Table 3-5 (page 3-18). If in doubt about which column to use, always use the column that lists the greatest amount of explosive.

c. Using the column directly under the chosen placement method, select the amount of explosive required, based on target thickness. For example, 200 packages of C4 are required to breach a 7-foot reinforced-concrete wall with an untamped charge placed 7 feet above ground.

Table 3-5. Breaching charges for reinforced concrete



Concrete Thickness (Feet)	Placement Methods				
	C = 1.0	C = 1.0	C = 1.8	C = 2.0	C = 3.6
	Packages of M112 (Composition C4)				
2.0	1	5	9	10	17
2.5	2	9	17	18	33
3.0	2	13	24	26	47
3.5	4	21	37	41	74
4.0	5	31	56	62	111
4.5	7	44	79	88	157
5.0	9	48	85	95	170
5.5	12	63	113	126	226
6.0	13	82	147	163	293
6.5	17	104	186	207	372
7.0	21	111	200	222	399
7.5	26	137	245	273	490
8.0	31	166	298	331	595

NOTE: The results of all calculations for this table have been rounded UP to the next whole package.

3-14. Breaching Other Materials. You can also use Table 3-5 to determine the amount of C4 required for other materials by multiplying the value from the table by the proper conversion factor from Table 3-6. Use the following procedure:

a. Determine the type of material in the target. If in doubt, assume the material to be the strongest type from the same category.

b. Determine from Table 3-5 the amount of explosive required if the object were made of reinforced concrete.

c. Find the appropriate conversion factor from Table 3-6.

d. Multiply the number of packages of explosive required (from Table 3-5) by the conversion factor (from Table 3-6).

Table 3-6. Conversion factors for material other than reinforced concrete

Material	Conversion Factor
Earth	0.1
Ordinary masonry Hardpan Shale Ordinary concrete Rock Good timber Earth construction	0.5
Dense concrete First-class masonry	0.7

3-15. Number and Placement of Charges.

a. Number of Charges. Use the following formula for determining the number of charges required for demolishing piers, slabs, or walls:

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

where–

N = number of charges. (If N is less than 1.25, use one charge; if N is 1.25 but less than 2.5, use two charges; if N is equal to or greater than 2.5, round to the nearest whole number and use that many charges.)

W = pier, slab, or wall width, in feet.

R = breaching radius, in feet.

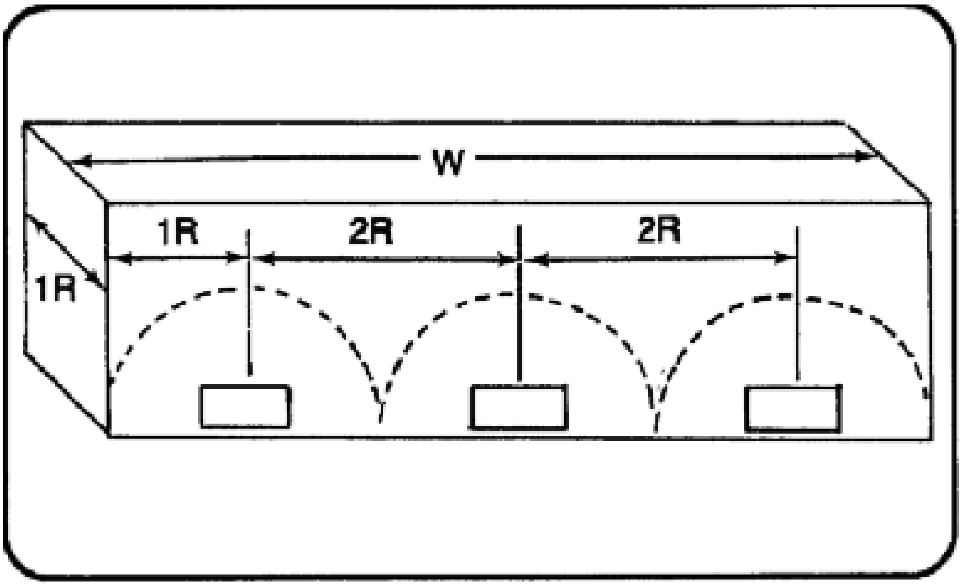


Figure 3-16. Charge placement

The first charge is placed R distance in from one side of the target. The remainder

of the charges are spaced at a distance of 2R apart (Figure 3-16).

b. Placement.

(1) Limitations. Piers and walls offer limited locations for placing explosives.

Unless a demolition chamber is available, place the charge (or charges) against one face of the target. Placing a charge above ground level is more effective than placing one directly on the ground. When the demolition requires several charges to destroy a pier, slab, or wall and you plan to use elevated charges, distribute the charges equally, no less than one breaching radius high from the base of the target.

Doing this takes maximum advantage of the shock wave. If possible, place breaching charges so that there is a free reflection surface on the opposite side of the target. This free reflection surface allows spalling to occur. If time permits, tamp all charges thoroughly with soil or filled sandbags.

The tamped area must be equal to or greater than the breaching radius. For piers, slabs, or walls partially submerged in water, place charges equal to or greater than the breaching radius below the water line, if possible (Figure 3-15, page 3-16).

(2) Configuration. For maximum effectiveness, place the explosive charge in the shape of a flat square. The charge width should be approximately three times the charge thickness. The thickness of the charge depends on the amount of explosive required (Table 3-7).

Table 3-7. Breaching charge thickness*

Charge Weight (Pounds)	Charge Thickness (Inches)
Less than 5	1
5 to less than 40	2
40 to less than 300	4
300 or more	8
*Approximate values	

3-16. Counterforce Charge.

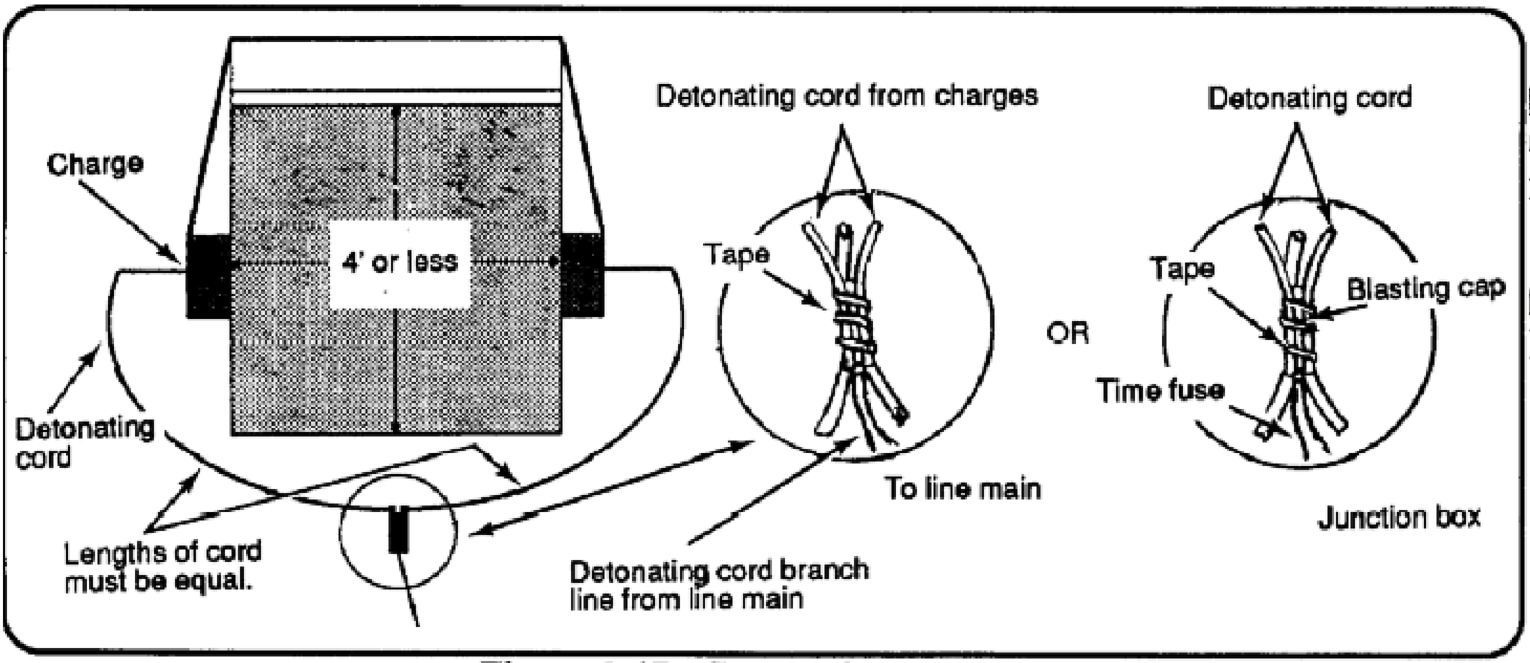


Figure 3-17. Counterforce charge

a. Use. This special breaching technique is effective against rectangular masonry or concrete columns 4 feet thick or less. It is not effective against walls, piers, or long obstacles. The obstacle also must have at least three free faces or be freestanding. If constructed of plastic explosives (C4) and properly placed and detonated, counterforce charges produce excellent results with a relatively small amount of explosive. Their effectiveness results from the simultaneous detonation of two charges placed directly opposite each other and as near the center of the target as possible (Figure 3-17).

b. Calculation. The thickness or diameter of the target determines the amount of plastic explosive required. The amount of plastic explosive equals 1½ times the thickness of the target, in feet (1 ½ pounds of explosive per feet). Round fractional measurements to the next higher half foot before multiplying. For example, a concrete target measuring 3 feet 9 inches thick requires 6 pounds of plastic explosive (1.5 lb/foot x 4 feet).

c. Placement. Split the charge in half. Place the two halves directly opposite each other on the target. This method requires accessibility to both sides of the target so the charges will fit flush against their respective target sides.

d. Priming. Prime both charges on the face farthest from the target. Join the ends of the detonating-cord branch lines in a junction box (Figure 3- 17). The length of the branch lines from both charges must be equal to ensure simultaneous detonation.

Section V. Cratering and Ditching Charges

3-17. Factors.

a. Sizes. To be effective obstacles, road craters must be too wide for track vehicles to span and too deep and steep-sided for any vehicle to pass through. Blasted road craters will not stop modern tanks indefinitely. A tank, making repeated attempts to traverse the crater, will pull soil loose from the slopes of the crater, filling the bottom and reducing both the crater's depth and angle of slope.

Road craters are effective antitank obstacles if a tank requires three or more passes to traverse the

crater, thereby providing enough time for antitank weapons to stop the tank. Road craters should

be large enough to tie into natural or constructed obstacles at each end. Improve the effectiveness of blasted road craters by placing log hurdles on either side, digging the face of the hurdle vertically on the friendly side, mining the site with antitank and antipersonnel mines, filling the crater with water, or by using other means to further delay enemy armor. Cut road craters across the desired gap at a 45-degree angle from the direction of approach. This angled cut will increase the tank's tendency to slip sideways and ride off its track. To achieve sufficient obstacle depth, place craters in multiple or single rows, enhancing some other obstacle, such as a bridge demolition. When creating more than one row of craters, space them far enough apart so that a single armored vehicle launch bridge (AVLB) will not span them.

b. Explosives. All military explosives can create antitank craters. When available, use the 40-pound, ammonium-nitrate cratering charge (Figure 1-5, page 1-8) for blasting craters.

c. Charge Confinement. Place cratering charges in boreholes and tamp them.

3-18. Breaching Hard-Surfaced Pavements. Breach hard-surfaced pavements so that holes can be dug for the cratering charges. This can be done by exploding tamped charges on the pavement surface. Use a l-pound charge of explosive for each 2 inches of pavement thickness. Tamp the charges twice as deep as the pavement thickness. Shaped charges also are effective for breaching hard-surfaced pavements. A shaped charge will readily blast a small-diameter borehole through the pavement and into the subgrade. Blasting the boreholes with shaped charges will speed up the cratering task by first, eliminating the need to breach the pavement with explosive charges and then digging the hole for the cratering charge. Do not breach concrete at an expansion joint because the concrete will shatter irregularly. Table 1-3 (page 1-10) lists hole depths and optimum standoff distances when using the 15- or 40-pound shaped charges against various types of material, Shaped charges do not always produce open boreholes capable of accepting a 7-inch diameter cratering charge. You may need to remove some earth or widen narrow areas to accommodate the cratering charge. Widen deep, narrow boreholes by knocking material from the constricted areas with a pole or rod or by breaking off the shattered concrete on the surface with a pick or crowbar.

3-19. Hasty Crater. This method takes the least amount of time to construct, based upon the number and depth of the boreholes. However, it produces the least effective barrier because of its depth and shape (Figure 3-18).

The hasty method forms a V-shaped crater about 6 to 7 feet deep and 20 to 25 feet wide, extending approximately 8 feet beyond each end borehole. The sides of the crater slope 25 to 35 degrees. Modern US tanks require an average of four attempts to breach a hasty crater. To form a crater that is effective against tanks, boreholes must be at least 5 feet deep with at least 50 pounds of explosive in each hole. Use the following procedure to create a road crater:

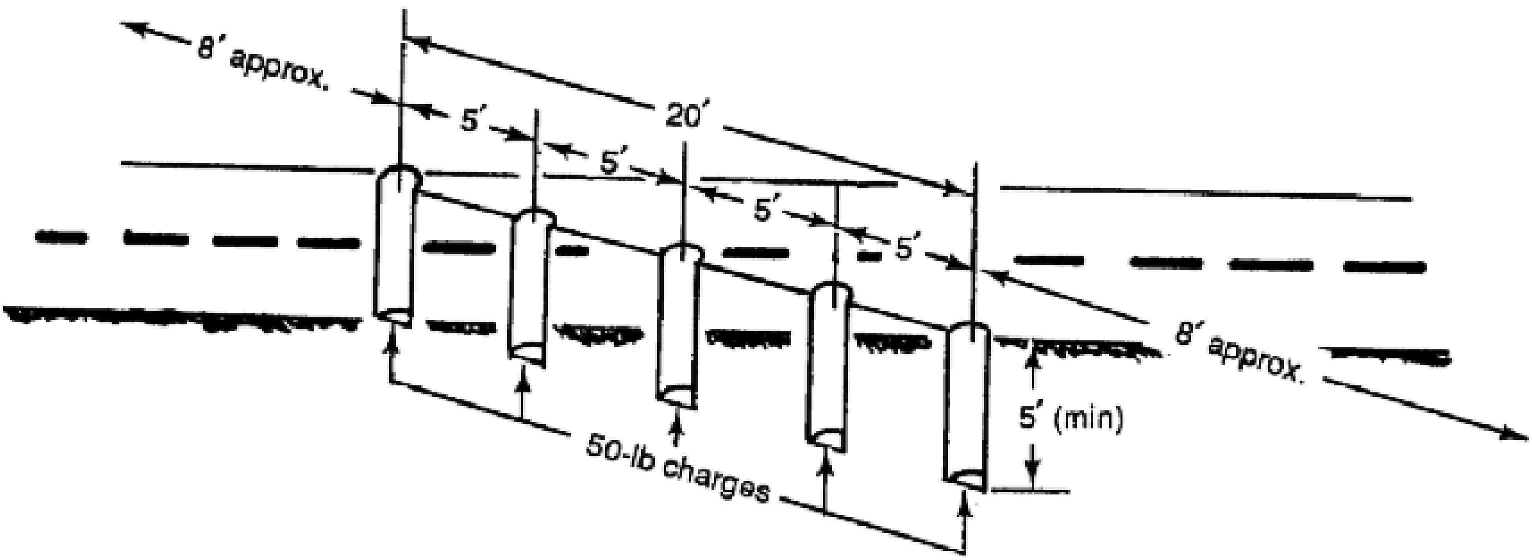


Figure 3-18. Placing charges for a hasty crater

a. Boreholes. Dig all boreholes to the same depth (5 feet or deeper recommended). Space the boreholes at 5-foot intervals, center to center, across the road. Use the following formula to compute the number of boreholes:

$$N = \frac{L - 16}{5} + 1$$

where–

N = number of boreholes; round fractional numbers to next higher whole number.

L = length of the crater, in feet. (Measure across the area to be cut. Round fractional measurements to the next higher foot).

16 = combined blowout of 8 feet each side.

5 =5-foot spacing.

1 = factor to convert from spaces to holes.

b. Charge Size. Load the boreholes with 10 pounds of explosive per foot of borehole depth.

When using standard cratering charges, supplement each charge with additional explosives to obtain the required amount. For example, a 6-foot hole would require one 40-pound cratering charge and

20 pounds of TNT or C4.

c. Firing System. Use dual firing systems when time and explosives permit (Figures 2-27, page 2-24). Initiate with either electric or nonelectric caps. Dual prime the 40-pound cratering charge as shown in Figure 2-21 (page 2-20).

d. Tamping. Tamp all boreholes with suitable materials.

3-20. Deliberate Crater. Figure 3-19 illustrates a method that produces a more effective crater than the hasty method.

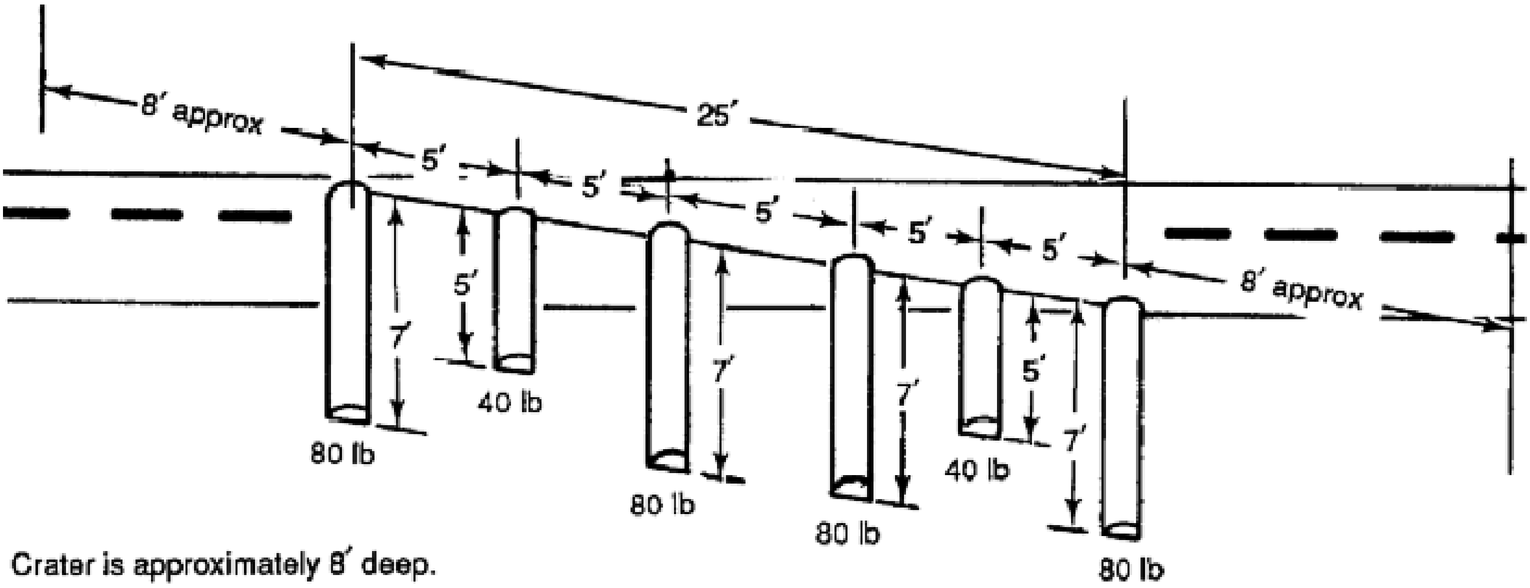


Figure 3-19. Placing charges for a deliberate crater

Modem US tanks require an average of eight attempts to breach a deliberate crater. Placing charges deliberately produces a V-shaped crater, approximately 7 to 8 feet deep and 25 to 30 feet wide, with side slopes of 30 to 37 degrees. The crater extends approximately 8 feet beyond the end boreholes. Example A-11 (page A-9) shows how to calculate a cratering charge.

a. Determine the number of boreholes required, using the same formula as for a hasty crater.

When there is an even number of holes (Figure 3-20, page 3-24), place two adjacent 7-foot boreholes in the middle.

b. Dig or blast the boreholes 5 feet apart, center to center, in a line across the area to be cut.

Make the end boreholes 7 feet deep and the other boreholes alternately 5 and 7 feet deep. Never place two 5-foot holes next to each other.

c. Place 80 pounds of explosive in the 7-foot holes and 40 pounds of explosive in the 5-foot holes.

d. Use dual firing systems (Figure 2-27, page 2-24). Initiate with either electric or nonelectric caps. Dual prime the 40-pound cratering charge as shown in Figure 2-21 (page 2-20).

e. Tamp all charges with suitable materials.

3-21. Relieved-Face Crater. The method shown in Figure 3-20 (page 3-24) produces a crater that is a more effective obstacle to modern tanks than the standard V-shaped crater. This technique produces a trapezoidal-shaped crater about 7 to 8 feet deep and 25 to 30 feet wide with unequal side slopes. In compact soil, such as clay, the relieved-face cratering method will create an obstacle such as the one illustrated in Figure 3-20 (page 3-24). The side nearest the enemy slopes approximately 25 degrees from road surface to crater bottom. The opposite (friendly) side slopes approximately 30 to 40 degrees from road surface to crater bottom. However, the exact shape of the crater depends on the type of soil. Use the following procedure to create a relieved-face crater:

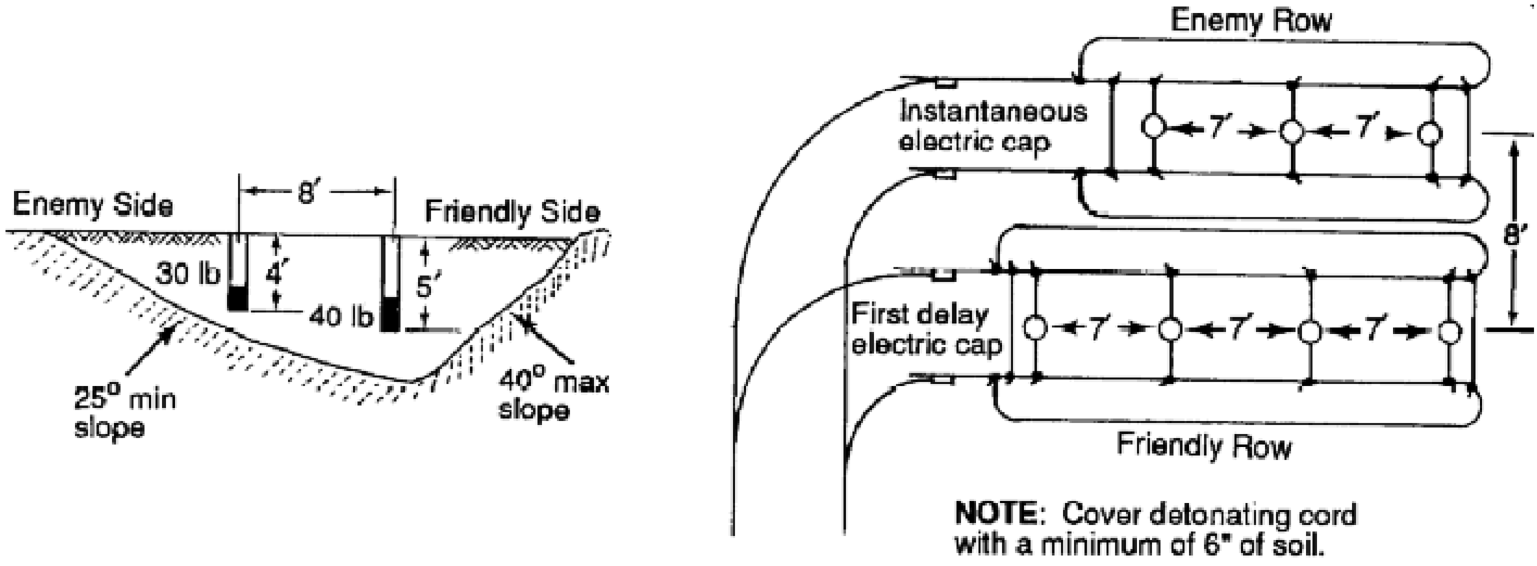


Figure 3-20. Relieved-face crater

a. On dirt or gravel-surfaced roads, drill two lines of boreholes 8 feet apart, spacing them at 7-foot centers. On hard-surfaced roads, drill the two lines of boreholes 12 feet apart. Use the following formula to compute the number of boreholes for the friendly-side row:

$$N = \frac{L - 10}{7} + 1$$

where—

N = number of boreholes; round fractional numbers to the next higher whole number.

L = crater length, in feet. (Measure across the area to be cut. Round fractional measurements to the next higher foot.)

10 = combined blowout of 5 feet each side.

7 = spacing of holes.

1 = factor to convert spaces to holes.

b. Stagger the boreholes in the row on the enemy side in relation to the holes in the row on the friendly side (Figure 3-20). The line closest to the enemy will always contain one less borehole than the friendly line.

c. Make the boreholes on the friendly side 5 feet deep, and load them with 40 pounds of explosive. Make the boreholes on the enemy side 4 feet deep, and load them with 30 pounds of explosive.

d. Use a dual firing system for each line of boreholes. Prime any 40-pound cratering charge as shown in Figure 2-21 (page 2-20).

e. Tamp all holes with suitable material.

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 frost. Then fire the friendly-side row while the earth from the enemy-side detonation is still in the air. Use standard delay caps. If the firings cannot be staggered, fire both rows simultaneously. However, the crater produced by a simultaneous detonation will not have the same depth and trapezoidal shape as a relieved-face crater.

3-22. Misfire Prevention. The shock and blast of the first row of charges may affect the delayed detonation of the friendly-side charges. To prevent misfires of the friendly-side charges, protect its detonating-cord lines by covering them with approximately 6 inches of earth.

3-23. Creating Craters in Permafrost and Ice.

a. Blasting in Permafrost. Permafrost can be as hard as solid rock. Therefore, you must adapt the procedures for blasting or cratering to accommodate permafrost conditions. In permafrost, blasting requires approximately twice as many boreholes and larger charges than for cratering operations in moderate climates. Blasted, frozen soil breaks into clods 12 to 18 inches thick and 6 to 8 inches in diameter. Because normal charges have insufficient force to blow these clods clear of the boreholes, the span falls back into the crater when the blast subsides.

(1) Boreholes. Before conducting extensive blasting, perform a test on the soil in the area to determine the number of boreholes needed. Dig the boreholes with standard drilling equipment, steam-point drilling equipment, or shaped charges. Standard drilling equipment has one serious defect—the air holes in the drill bits freeze. There is no known method to prevent this freezing.

Steam-point drilling is effective for drilling boreholes in sand, silt, or clay, but not in gravel. Place the charges immediately after withdrawing the steam point; otherwise, the area around the borehole thaws and collapses. Shaped charges also are effective for producing boreholes, especially when forming craters. Table 1-3 (page 1-10) lists borehole sizes made by shaped charges in permafrost and ice.

(2) Explosives. If available, use low-velocity explosives, such as ammonium nitrate, for blasting holes in arctic climates. The displacing quality of low-velocity explosives will more effectively clear large boulders from the crater. If only high-velocity explosives are available, tamp the charges with water and let them freeze before detonating. Unless thoroughly tamped, high-velocity explosives tend to blow out of the boreholes.

b. Blasting in Ice. Access holes in ice are required for obtaining water and determining the capacity of the ice for bearing aircraft and vehicles. To accommodate rapid forward movements, you must be capable of quickly determining ice capacities. Blasting operations provide this ability.

(1) Boreholes. Make small-diameter access holes using shaped charges. The M2A4 charge will penetrate ice as thick as 7 feet; the M3A1 charge will penetrate over 12 feet of ice (Table 1-3, page 1-10). The M3A1 can penetrate deeper, but it has only been tested on ice approximately 12 feet thick. If placed at the normal standoff distance, the charge forms a large crater at the surface, requiring you to do considerable probing to find

the actual borehole. Use a standoff distance of 42 inches or more with the M2A4 shaped charge to avoid excessive crater formation. The M2A4 creates an average borehole diameter of 3 ½ inches. An M3A1 borehole has an average diameter of 6 inches. In late winter, ice grows weaker and changes color from blue to white. Although the structure and strength of ice vary, the crater effect is similar, regardless of the standoff distance.

(2)

Craters. Make surface craters with ammonium-nitrate cratering charges or demolition blocks.

For the best results, place the charges on the surface of cleared ice and tamp them with snow. When determining charge size, keep in mind that ice has a tendency to shatter more readily than soil, and this tendency will decrease the charge's size.

c. Making Vehicle Obstacles. Create a vehicle obstacle in ice by first making two or more rows of boreholes. Space the boreholes 9 feet apart and stagger them in relation to the holes in the other rows. Suspend Ml12 charges about 2 feet below the bottom surface of the ice with cords tied to sticks, bridging the sticks over the top of the holes. The size of the charge depends on the thickness and condition of the ice. Use test shots to find the optimum amount. This type of obstacle can retard or halt enemy vehicles for approximately 24 hours at temperatures near -24 degrees

Fahrenheit.

3-24. Craters as Culverts. Destroying a culvert not more than 15 feet deep may also produce an effective crater. Prime the charges for simultaneous detonation, and thoroughly tamp all charges with sandbags. Destroy culverts that are no deeper than 5 feet by placing explosive charges in the same way as for hasty road craters. Space the boreholes at 5-foot intervals in the fill above and alongside the culvert. In each hole place 10 pounds of explosives per foot of depth 3-25. Craters as Antitank Ditches. Excavate antitank ditches by either the hasty or deliberate cratering method (paragraphs 3-19 and 3-20, pages 3-22 and 3-23).

3-26. Ditching Methods. Explosives can create ditches rapidly. Slope ditches at a rate of 2 to 4 feet of depth per 100 feet of run. Place ditches in areas where natural erosion will aid in producing the correct grade. If you cannot place a ditch in an area aided by erosion, make the ditch deeper, increasing the depth as the length increases. Use the following methods for creating ditches:

a. Single Line. The single-line method (Figure 3-21) is the most common ditching method.

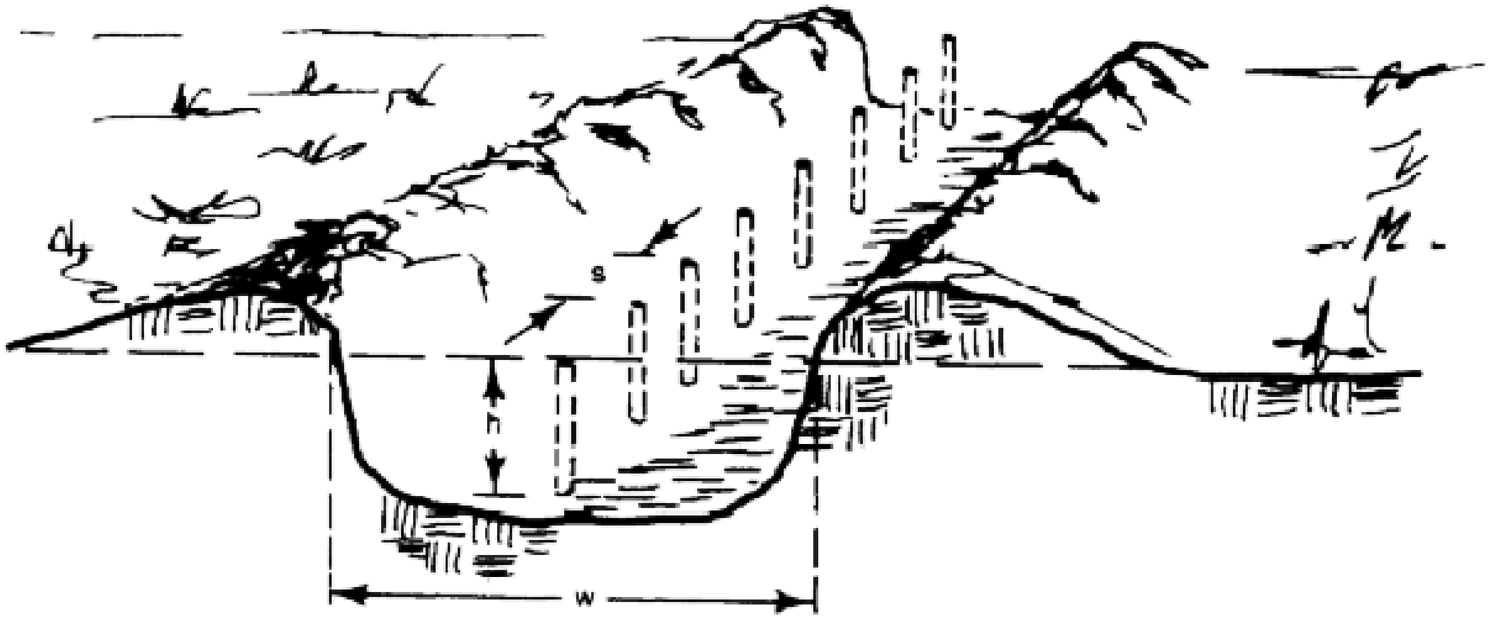


Figure 3-21. Single-line method of ditching

Table 3-8. Single-line ditching explosives data

Serial	Required Ditch Depth (*d*)	Required Width Top of Ditch (*w*) (Feet)	Charges per Hole (Pounds)	Borehole Depth (*h*) (Feet)	Borehole Spacing (*s*) (Feet)
a	b	c	d	e	f
1	2.5	5.0	0.5	1.5	1.5
2	3.0	7.0	1.0	2.0	2.0
3	4.0	9.0	2.0	3.0	3.0
4	6.0	12.0	5.0	5.0	4.0
5	10.0	16.0	10.0	8.0	5.0

Detonate a single row of charges along the centerline of the proposed ditch, leaving any further widening for subsequent lines of charges. Table 3-8 gives charge configurations for the single-line method.

b. Cross Section. When it is necessary to blast the full width of the ditch in one operation, use the cross-section method (Figure 3-22). Table 3-9 gives charge configurations for the cross-section method. Place an extra charge midway between lines of charges.

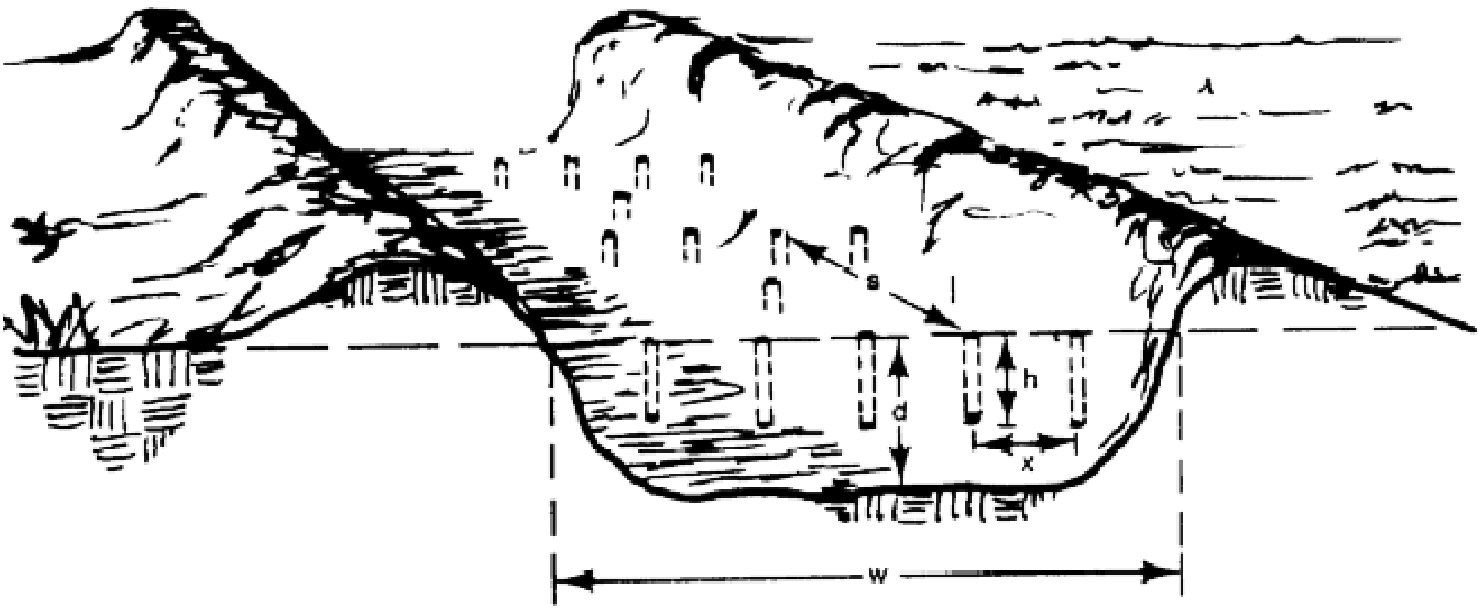


Figure 3-22. Cross-section method of ditching

Table 3-9. Cross-section ditching explosives data

Serial	Required Depth (*d*)	Required Width (*w*) in Feet — Number of Boreholes in Each Cross Section					Charge per Hole (Pounds)	Borehole Depth (*h*) (Feet)	Borehole Spacing (*s*) (Feet)	Row Spacing (x) (Feet)
		3	5	7	9	11				
a	b	c	d	e	f	g	h	i	j	k
1	2.5	7.5	11.0	13.0	16.0	18.0	0.5	1.5	1.3	2.5
2	3.0	10.0	13.0	16.0	19.0	22.0	1.0	2.0	1.5	3.0
3	4.0	14.0	19.0	24.0	29.0	34.0	2.0	3.0	2.5	4.5
4	6.0	20.0	28.0	36.0	44.0	52.0	5.0	5.0	4.0	6.0
5	10.0	26.0	33.0	46.0	56.0	65.0	10.0	7.0	5.0	8.0

Section VII. Special Applications

3-31. Survivability Positions. In many circumstances, the use of explosives can reduce digging time and effort. Use explosives only in soil that would normally be excavated by pick and shovel. Explosives are not recommended for excavations less than 2 feet deep. Use small charges buried and spaced just enough to loosen the soil, limiting the dispersion of soil to as small an area as possible. Do not attempt to form a crater doing this spreads soil over a large area, affecting concealment and weakening the sides of the finished position. Explosives can create individual fighting positions and larger crew-served, gun, or vehicle positions. Using explosives in this manner requires some advance preparation. In the case of an individual fighting position, the preparation time may exceed time required to prepare the position by traditional methods.

a. Depth. Place charges 1 foot shallower than the required depth, to a maximum of 4 feet. If the required depth is greater than 5 feet, dig the position in two stages, dividing the required depth in half for each stage. Make the boreholes with an earth auger, wrecking bar, picket driver, or other expedient device.

b. Spacing. For rectangular excavations, dig the boreholes in staggered lines. For circular excavations, dig the boreholes in staggered, concentric rings. The spacing between boreholes in each line or ring and between lines or rings should be between 1 and 1.5 times the borehole depth.

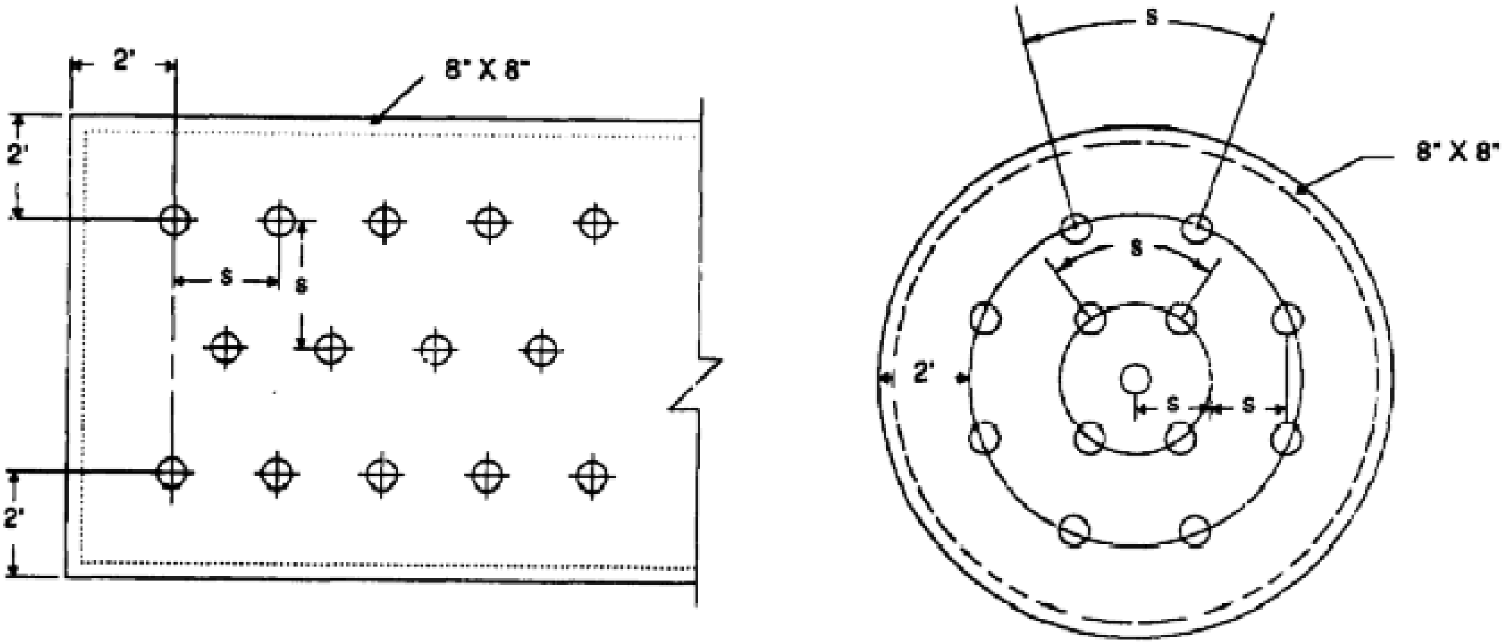


Figure 3-25. Borehole layouts

Ensure all charges are at least 2 feet inside the proposed perimeter of the excavation. Also, dig an 8-by 8-inch channel around the outer perimeter of the proposed excavation, with the outer edge of the channel forming the outer edge of the finished excavation. Figure 3-25 shows layouts for rectangular and circular excavations.

c. Charge Size. Use ¼-pound charges of plastic explosive to dig foxholes. For large excavations, use charges between ½ and 1 ½ pounds, depending on spacing and soil characteristics.

A test shot is usually necessary to determine the correct charge size.

d. Concealment. Reduce explosion noise and spoil scatter by leaving any sod in place and covering the site with a blasting mat. Improvise blasting mats by tying tires together with natural or synthetic rope (steel-wire rope is unacceptable) or by using a heavy tarpaulin.

3-32. Equipment Destruction.

WARNING

Steel-cutting charges produce metal fragments.

Proper precautions should be taken to protect personnel.

Refer to Table 6-3, page 6-7.

a. Guns. Destroy gun barrels with explosives or their own ammunition. Also be sure to remove or destroy the small components, such as sights and other mechanisms.

(1) Explosive Method.

(a) To prepare a gun for demolition, first block the barrel just above the breach. For small-caliber guns that use combined projectile-propellant munitions, solidly tamp the first meter of the bore with earth. For heavier guns that use projectiles separate from propellants, simply load a projectile and aim the tube to minimize damage should the round be ejected.

(b) Charge Size. Table 3-11 (page 3-32) details the charge size required for standard barrel sizes. If necessary, determine the required charge size using the following formula:

$$P = \frac{D^2}{636}$$

where–

P = quantity of explosive (any high explosive), in pounds.

D = bore size of the barrel, in millimeters.

(c) Placement. Pack the explosive, preferably C4, into the breach, immediately behind the tamping. Place the plastic explosive in close contact with the chamber. Close the breach block as far as possible, leaving only enough space for the detonating cord to pass without being bent or broken. If time permits, place 15-pound charges on the drive wheels of tracked guns and on the wheels and axles of towed guns. Connect the branch lines in a junction box or use a ring main.

Simultaneously detonate all charges.

Table 3-11. Gun-destruction charge sizes

Serial	Barrel Size (Millimeters)	Charge Size (Pounds)
a	b	c
1	76	10
2	105	18
3	120	23
4	155	38
5	203	66

Note: Determine appropriate charge sizes for barrel sizes not listed by comparing them to known barrel sizes. For example, you would use the explosive weight in Serial 3 for a 112-mm barrel (23 pounds); Serial 4 for a 152-mm barrel (38 pounds).

(2) Improvised Method. When block explosives are not available, destroy a gun with its own ammunition. Insert and seat one round in the muzzle end and a second charge, complete with ropellant charge (if required), in the breach end of the tube. Fire the gun from a safe distance, using the gun's own mechanism. Use a long lanyard and ensure the firing party is under cover before firing the gun.

b. Vehicles. To destroy friendly vehicles, refer to the applicable TM. Use the following priorities when destroying vehicle components:

Priority 1. Carburetor, distributor, fuel pump or injectors, and fuel tanks and lines.

Priority 2. Engine block and cooling system.

Priority 3. Tires, tracks, and suspension system.

Priority 4. Mechanical or hydraulic systems (where applicable).

Priority 5. Differentials and transfer case.

Priority 6. Frame.

(1) Armored Fighting Vehicles (AFVs). Destroy AFVs beyond repair by detonating a 25-pound charge inside the hull. The charge may be a bulk 25-pound charge or a number of smaller charges, placed on the driving, turret, and gun controls. To increase the amount of damage to the AFV, ensure the ammunition within the AFV detonates simultaneously with the other charges, and ensure all hatches, weapons slits, and other openings are sealed. If it is not possible to enter the AFV, place the charges under the gun mantle, against the turret ring, and on the final drive (Figure 3-26).

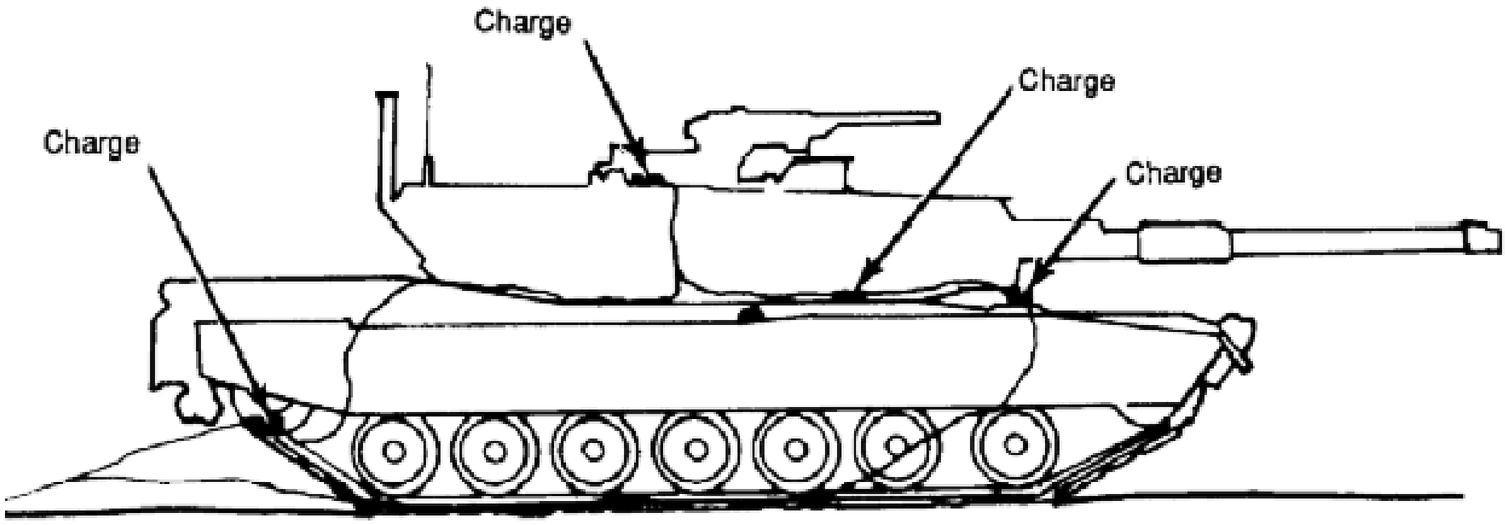


Figure 3-26. Placing charges on the AFV

If explosives are not available, destroy the AFV by using antitank weapons or fire, or destroy the main gun with its own ammunition.

(2) Wheeled Vehicles.

(a) Explosives method. Destroy wheeled vehicles beyond repair by wrecking the vital parts with a sledgehammer or explosives. If high explosives are available, use 2-pound charges to destroy the cylinder head, axles, and frame.

(b) Improvised method. Drain the engine oil and coolant and run the engine at full throttle until it seizes. Finish the destruction by burning the vehicle (ignite the fuel in the tank).

NEXT

BACK TO COMMERCIAL EXPLOSIVES

Chapter 4

Bridge Demolition

Section I. Requirement

4-1. Purpose of Bridge Demolition. The purpose of bridge demolitions is to create gaps in bridges by attacking key components of the bridge. This makes gaps large enough to make repair uneconomical and to force the enemy to construct other bridges on other sites. The minimum gap required must exceed the enemy's assault bridging capability by 5 meters. For planning purposes, use 25 meters as the minimum gap size, but 35 meters is better. The gap may be less than 25 meters if enemy forces must depend on the demolished bridge components to bear their assault bridging and there is insufficient bearing capacity in the remains to carry the loads.

4-2. Degree of Destruction. The complete demolition of a bridge usually involves the destruction of all the components (spans, piers, and abutments). Complete demolition may be justified when the terrain forces the enemy to reconstruct a bridge on the same site. However, complete destruction is not normally required to meet the tactical objective. Select the method of attack that achieves the tactical goal, with a minimum expenditure of resources.

4-3. Debris. Debris may cause enemy forces serious delays if it obstructs the gap (Figure 4-l). Debris also provides excellent concealment for mines and booby traps. Whenever possible, demolish bridges in such a way that the resulting debris hinders reconstruction.

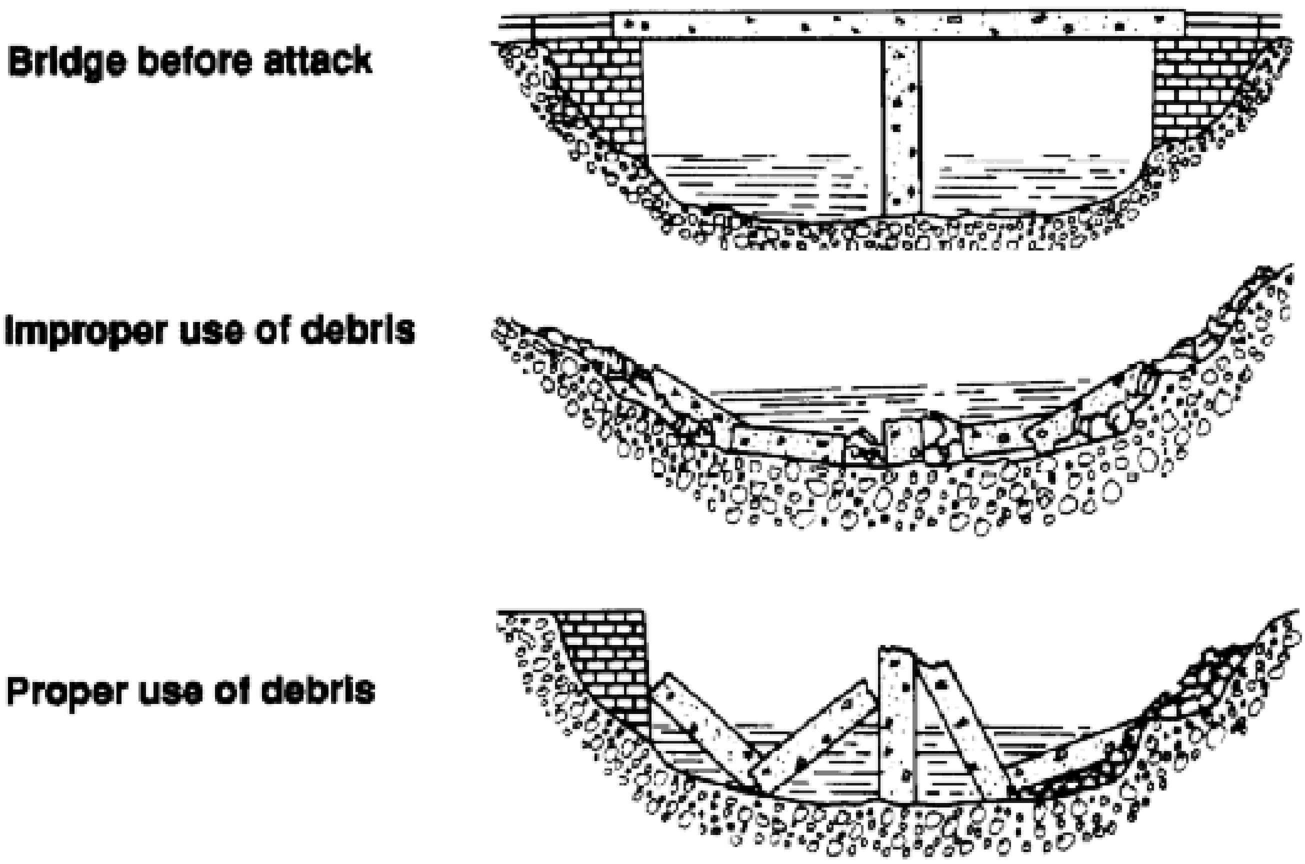


Figure 4-1. Use of debris

Section II. Considerations

4-4. Bridge Categories. The first step in any efficient bridge demolition is to categorize the bridge correctly. The term categorization has been adopted to avoid confusion with classification, which is concerned with the load-carrying capacity of bridges. The correct categorization of bridges, coupled with an elementary knowledge of bridge design, allows you to select a suitable attack method. All bridges fit into one of three categories:

a. Simply Supported. In simply supported bridges, the ends of each span rest on the supports; there are no intermediate supports. The free-bearing conditions shown in Figure 4-2 represent any bearing that allows some horizontal movement (for example, roller bearings, sliding bearings, and rubber bearing pads).

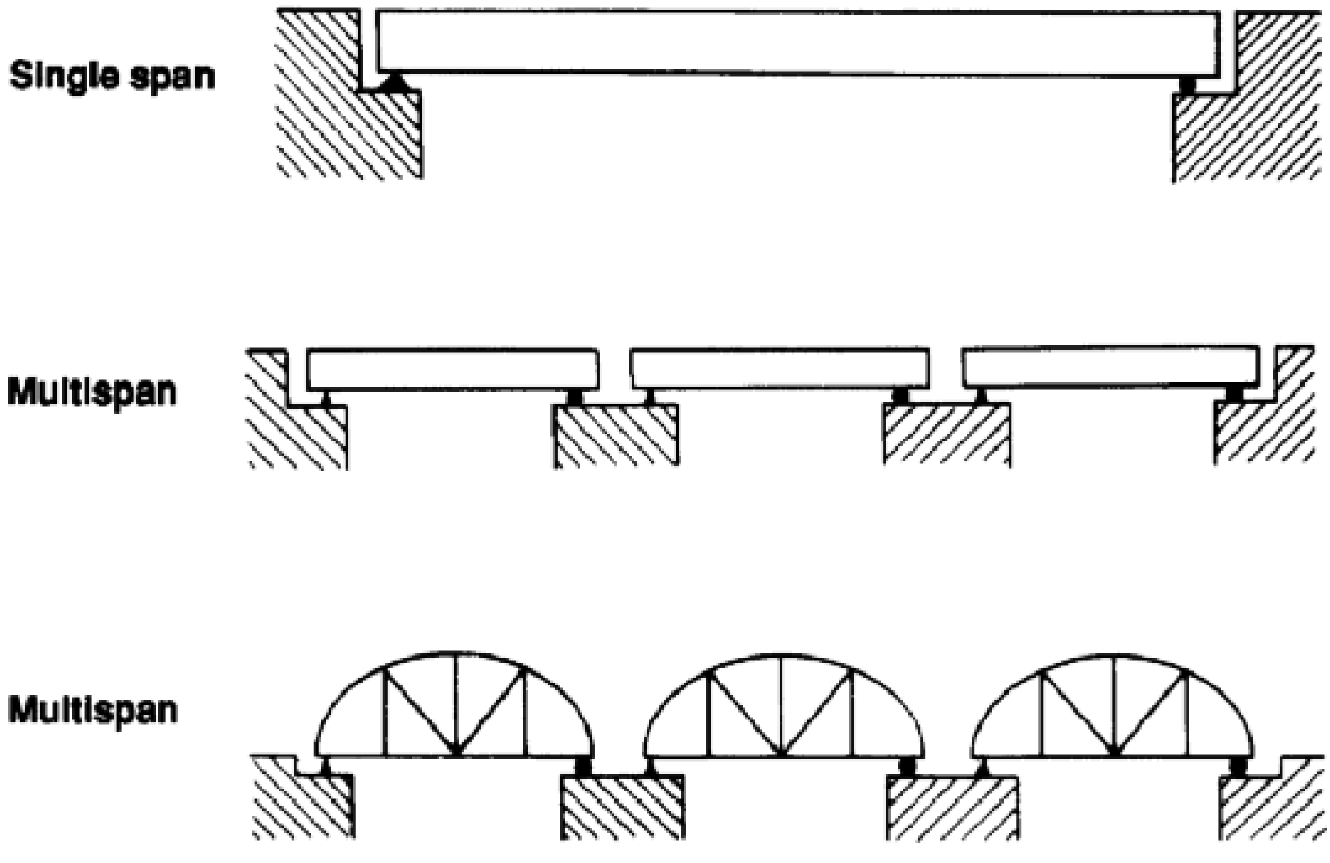


Figure 4-2. Simply supported bridges

b. Miscellaneous. Miscellaneous bridges form a small proportion of bridge structures. The theoretical principles governing these bridges determine the appropriate methods of attack. Examples of bridges in this category are suspension, lift, and cable-stayed bridges.

c. Continuous. If a bridge does not fit the miscellaneous category and is not simply supported, categorize it as a continuous bridge. Hence, continuous has a wider meaning than multispan, continuous-beam bridges, as is normally implied.

4-5. Stages of Destruction. When designing a bridge demolition, the first priority is to create a gap. Accomplishing this may require one or two attacks. Further actions that improve the obstacle may follow, if the situation permits.

a. Minimum Conditions. There are two minimum conditions for successful bridge demolition:

You must design a proper collapse mechanism.

You must ensure the attacked span will be free to move far enough, under its own weight, to create the desired obstacle.

(1) Condition 1. Under normal conditions, a bridge is a stable structure. In bridge demolitions, the goal is to destroy the appropriate parts of a bridge so that it becomes unstable and collapses under its own weight. In other words, you form a collapse mechanism. This may involve either cutting completely through all structural members or creating points of weakness in certain parts of the bridge. Figure 4-3 shows an improper collapse mechanism and the hinges that have not been formed. At times, making bridges unstable by attacking their piers

rather than their superstructures is easier, but it is still possible for bridges not to collapse, even though they lost the support provided by one or more of their piers. To avoid this type of demolition failure, place the charges on the structural members of the superstructure, immediately above the piers being attacked.

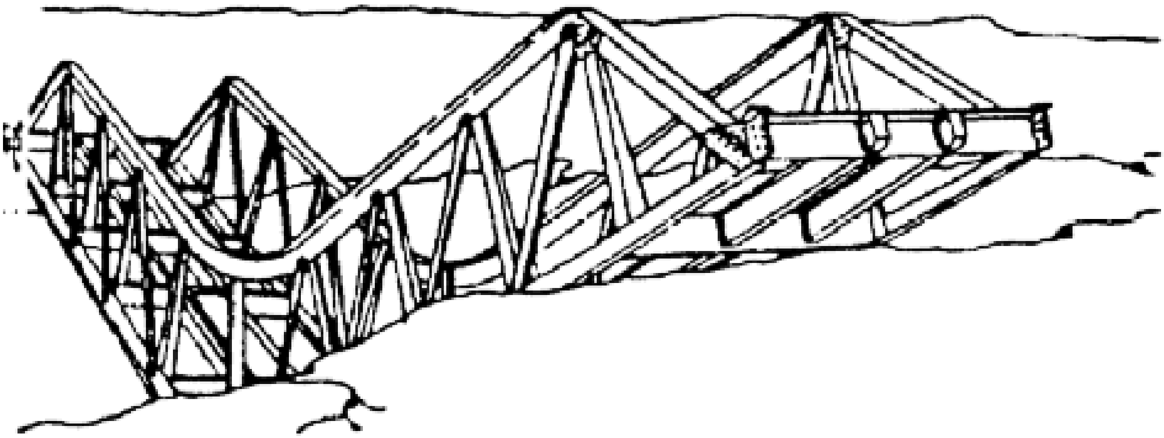


Figure 4-3. Improper collapse mechanism and hinges

(2) Condition 2. Figure 4-4 shows a bridge demolition where the collapse mechanism has formed, but where, because the bridge span has jammed before moving far enough, it has failed to form the desired obstacle. To complete the demolition in this example, you need to remove only a small portion of the abutment to allow the span to swing down freely.

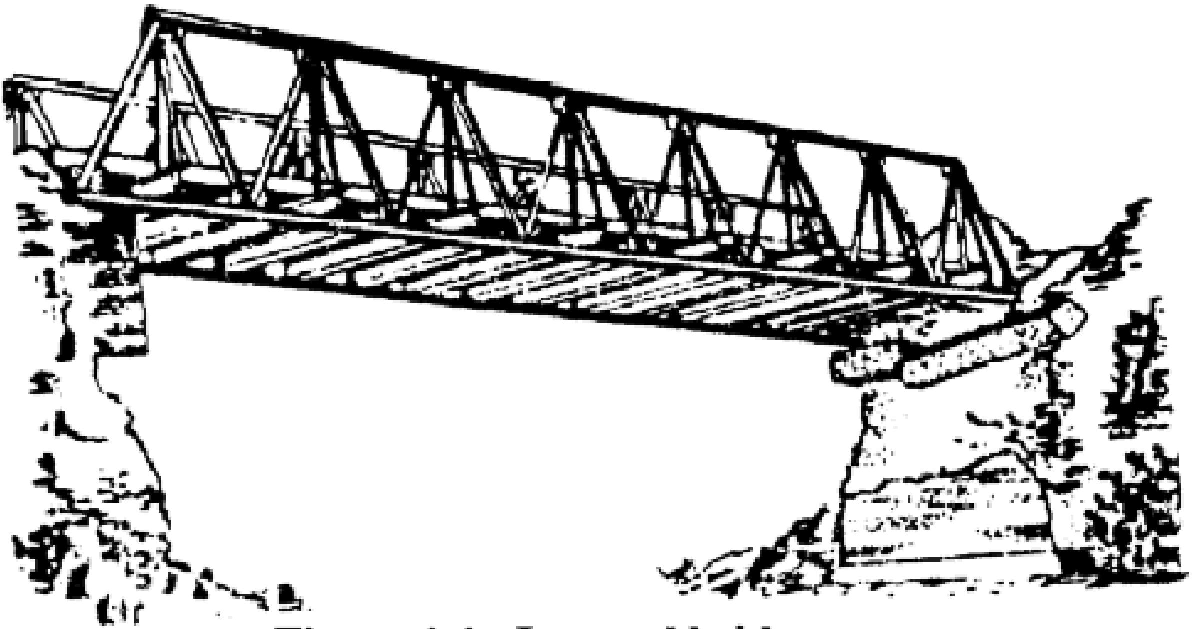


Figure 4-4. Jammed bridge span

b. Types of Collapse Mechanism. Figures 4-5 through 4-7 illustrate the three basic collapse mechanisms.

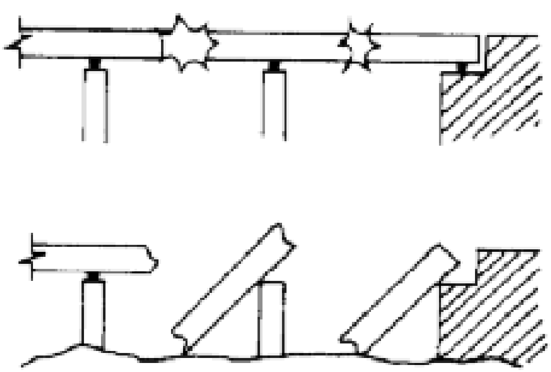


Figure 4-5. See-saw collapse mechanism

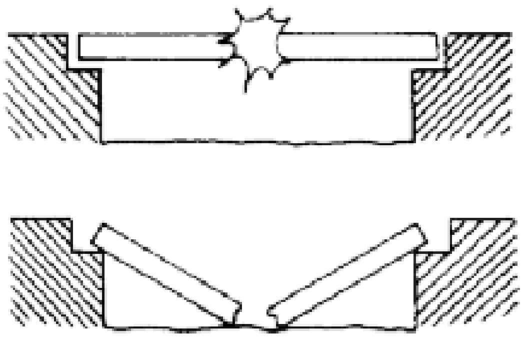


Figure 4-6. Beam collapse mechanism

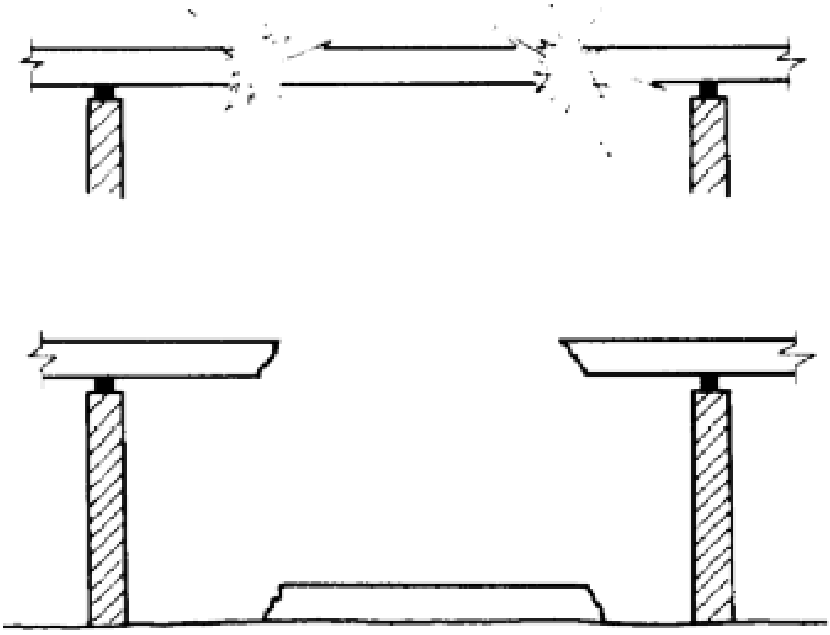


Figure 4-7. Member without support collapse mechanism

c. Unsuccessful Bridge Demolitions.

Two possible reasons for unsuccessful bridge demolitions are—

(1) No-Collapse Mechanism. The formation of cantilevers (Figure 4-8) is a typical example of a no-collapse mechanism being formed. The likelihood of this occurring is high when attacking continuous bridges.

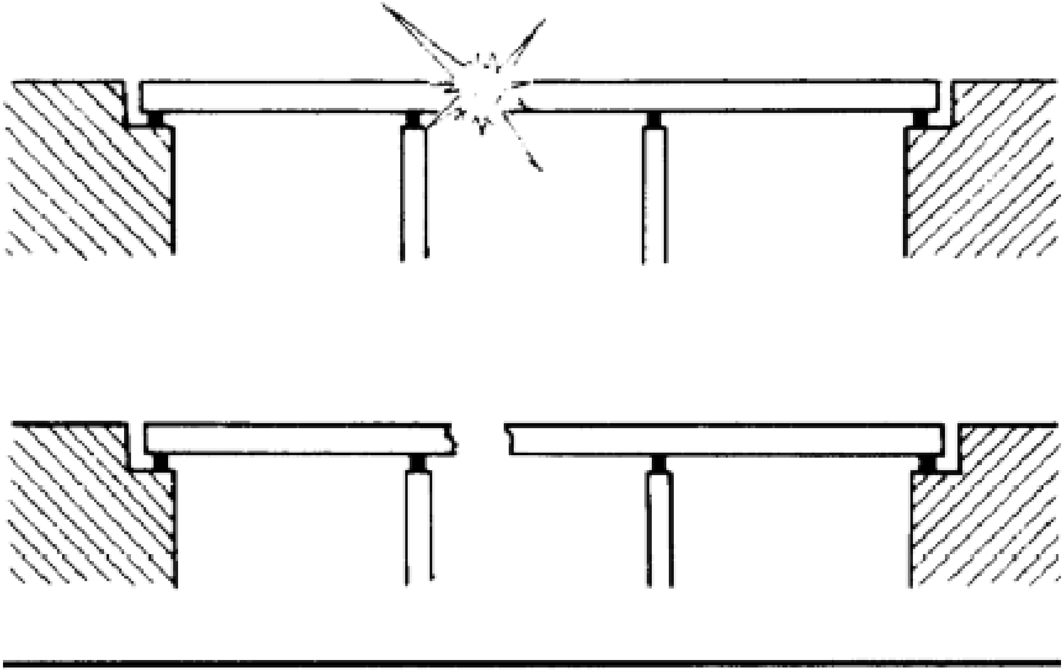


Figure 4-8. Cantilever effect

(2) Jamming. The span, once moved by the collapse mechanism, jams before moving far enough to create the desired obstacle. The most likely causes of jamming are the formation of a three-pin arch or a cranked beam (Figure 4-9). When attacking bridge spans, always consider the possibility of jamming during bottom and top attacks.

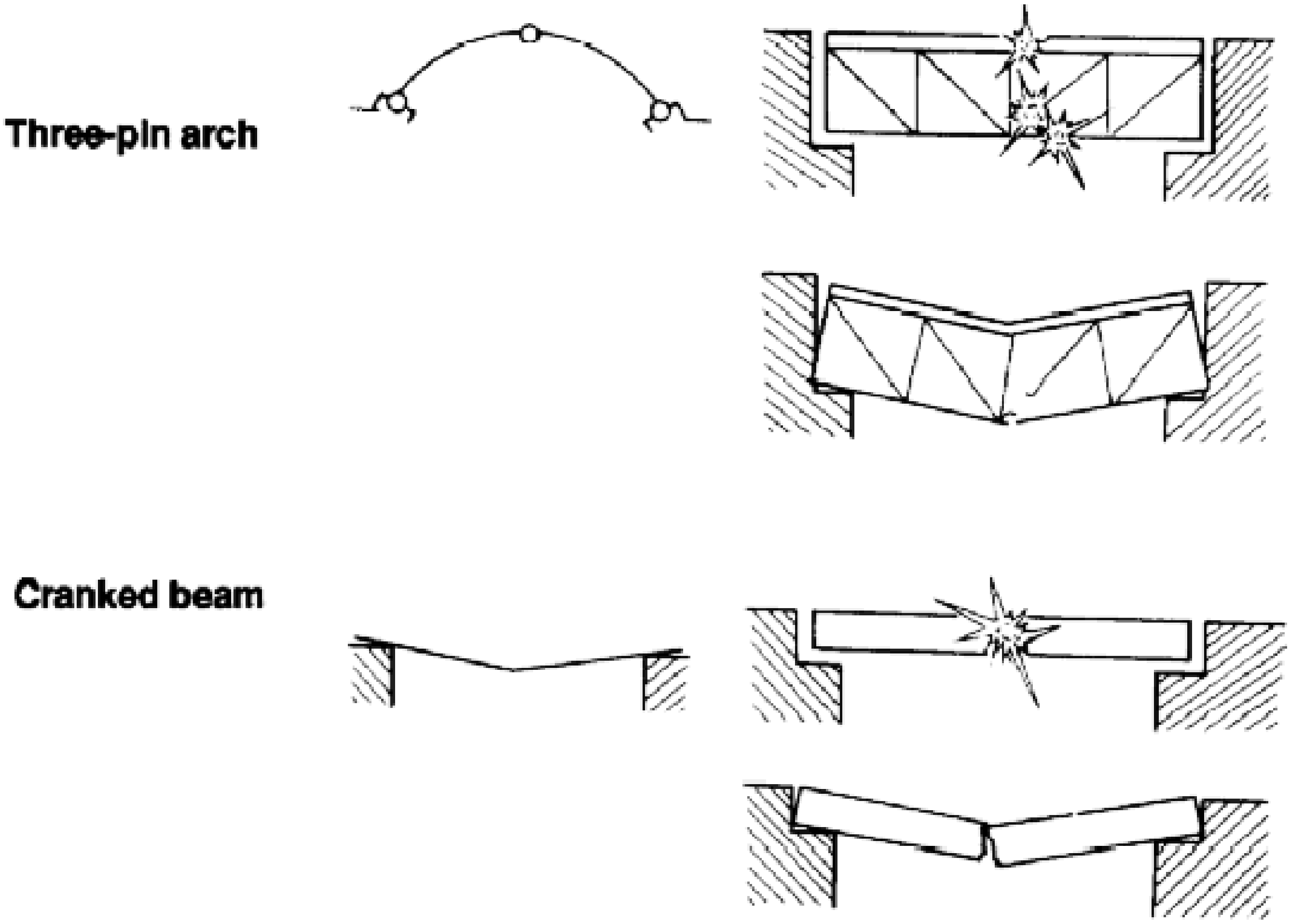


Figure 4-9. Causes of jamming

4-6. Bottom Attack. In the bottom attack, the hinge forms at the top. As the span falls, the cut ends at the bottom move outward. The span may form a three-pin arch and fail to fall completely if the distance the cut ends must move is greater than the total end clearance between the span ends and the pier or abutment faces (Figure 4-10). If a three-pin arch situation is likely, do not attempt a bottom attack.

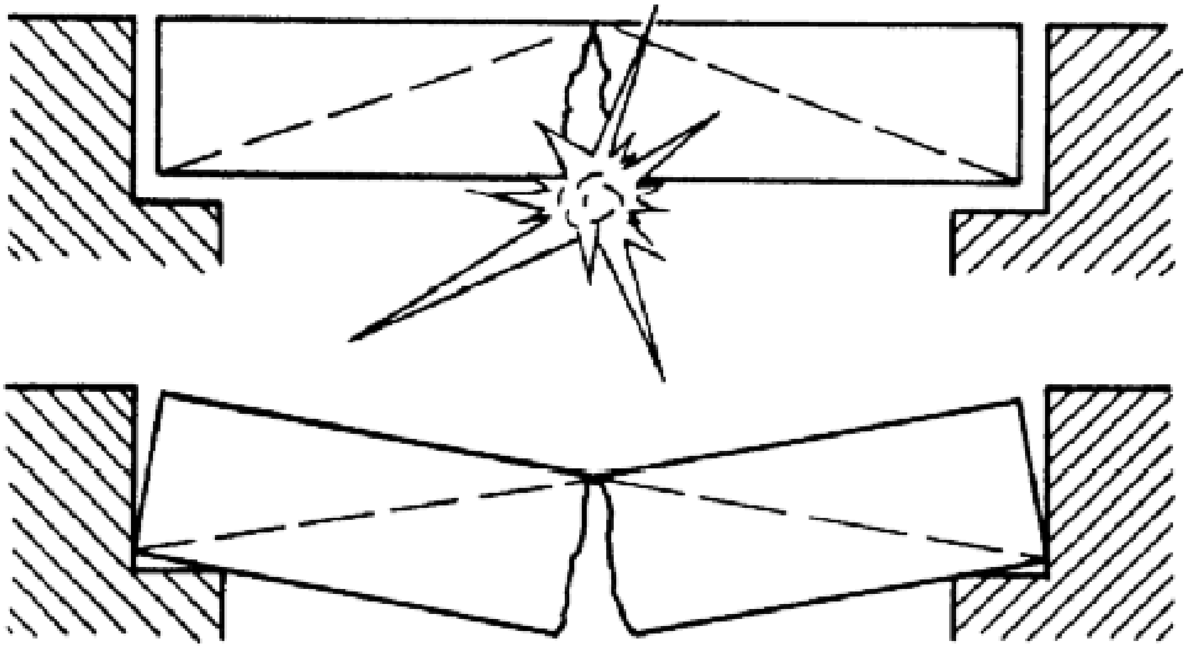


Figure 4-10. Three-pin arch effect

4-7. Top Attack. In a top attack, the hinge forms at the bottom. As the span falls, the cut ends at the top move inward. Some bridges may jam along the faces of the cut before the ends of the span have fallen off the abutments, forming a cranked beam (Figure 4-11).

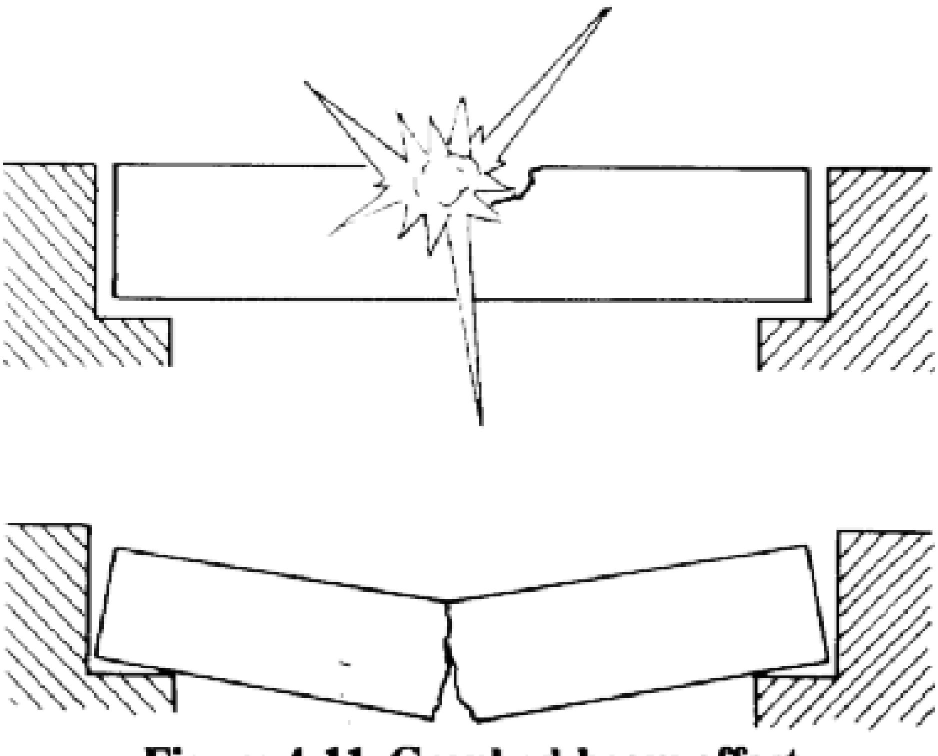


Figure 4-11. Cranked-beam effect

Ensure the length of span removed (LC) at the top is sufficient to prevent the formation of a cranked beam.

4-8. Efficient Demolition Methods.

To ensure that a demolition achieves collapse with reasonable economy, consider the factors required to achieve an efficient demolition. The best balance between these factors will depend on the particular demolition under consideration. An efficient demolition should—

a. Achieve the desired effect.

b. Use the minimum amount of resources (time, manpower, and explosives).

c. Observe the proper priorities. The demolition reconnaissance report must clearly state the priorities and separately list the requirements for Priority 1 actions and Priority 2 improvements (priorities are explained below). If a sufficient gap will result by attacking bridge spans, do not perform the Priority 2 improvements unless the report specifies complete destruction or an excessively long gap. If the total gap spanned by a bridge is too small to defeat enemy assault bridging, consider the site an unsuitable obstacle unless the gap can be increased. Your engineer effort may be better applied elsewhere. Alternatively, to improve an obstacle, it may be necessary to increase the gap by demolishing the abutments and building craters on the immediate approaches. In this case, you should also attack nearby bypass sites (place mines and craters).

(1) Priority One. Create the desired obstacle. The minimum gap required is 5 meters greater than the enemy's assault bridging capability. Ideally, accomplish the demolition with the first attempt. However, many reinforced- or prestressed-concrete bridges may require two-stage attacks. Attacking the friendly side of spans will permit economical reconstruction of the bridge at a later date, if necessary.

(2) Priority Two. Make improvements to the gap. Perform this activity only when it is specified on the demolition reconnaissance report. When no reconnaissance report has been issued and time permits, perform improvements in the sequence specified below. Deviate from this sequence only under exceptional circumstances or when directed to do so by the responsible commander. The standard sequence of demolition is to-

(a) Destroy and mine the blown abutment

(b) Lay mines in likely bypasses.

(c) Blast craters and lay mines in likely approaches.

(d) Destroy the piers.

4-9. Concrete-Stripping Charges.

a. Description. Concrete-stripping charges are bulk, surface-placed charges designed for removing concrete from reinforced-concrete beams and slabs and exposing the steel reinforcement.

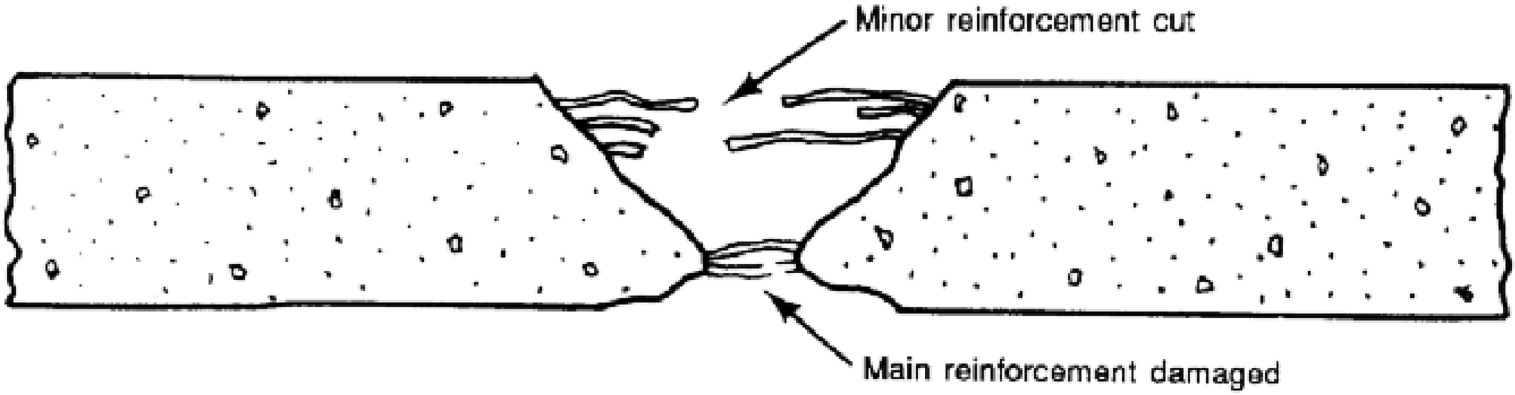


Figure 4-12. Effect of concrete charge

Although these charges cause some damage to the reinforcing steel, you will not be able to predict the extent of this damage. These charges are effective against reinforced-concrete beams and slabs up to 2 meters thick. Figure 4-12 shows the effect of the concrete-stripping charge. Using the proper charge size for the thickness of the target will— —

Remove all concrete from above the main reinforcing steel.

Remove all concrete from below the main reinforcing steel (spalling).

Damage the main reinforcing steel to some extent.

Destroy the minor reinforcing steel near the surface under the charge.

b. Charge Calculations (Simply Supported Bridges). For all simply supported concrete bridges, removing all concrete over a specified LC will cause collapse. For beam-and-slab bridge spans (T-beam and I-beam bridges), determine the charge sizes for the beams and slab separately.

Example A-12 (page A-10) shows how to calculate beam-and-slab bridge charges. Use the following procedure for determining charge sizes for simply supported spans:

(1) Calculate the mass of the charge required:

$P = 3.3(3.3\ h + 0.5)^3$ where—

P = required charge size, in pounds per meter of bridge width.

h = beam or slab plus roadway depth, in meters (minimum is 0.3 meters and maximum is 2 meters).

(2) Calculate the width of the required ditch. The charge will produce a ditch across the width of the bridge. To determine the width of this ditch, use the following formula:

Wd = 2 h + 0.3 (4-2)

where-Wd = ditch width, in meters.

h = overall roadway and beam or slab depth, in meters.

(3) Compare the required Wd with the required LC, and take the appropriate action:

If LC is equal to or less than Wd, use one row of charges as specified by P.

If LC is greater than Wd, but less than twice Wd, increase the size of charge by 10 percent.

If LC is twice Wd, double the charge and place them in two lines, side by side.

(4) Place charges in a continuous line across the full width of the bridge at the point of attack.

The shape of the end cross section of the charge should be such that the width is between one and three times the height.

(5) Tamp the charges, if required. No tamping is required for the concrete stripping charge as calculated, but if tamping with two filled sandbags per pound of explosive is used, reduce the calculated mass of charge by one third. The width of ditch formed will remain the same as for the original mass of charge.

Section III. Bridge Attacks

4-10. Guidelines (Continuous and Simply Supported Bridges). There are a number of factors that will assist you inadequately differentiating simply supported bridges from continuous bridges.

Figure 4-13 and the subparagraphs below describe these factors.

a. Continuity. In simply supported bridges, the entire superstructure is composed of a span or multiple spans supported at each end. The main structural members (individual spans) meet end to end, and each intermediate pair of ends is supported by a pier. The single ends are supported by the abutments. In continuous bridges, the main structural members are formed into one piece and do not have breaks over the piers, if any are present.

b. Construction Depth. In multispan, simply supported bridges, the construction depth of the span may decrease at the piers. In continuous bridges, construction depth frequently increases at the piers.

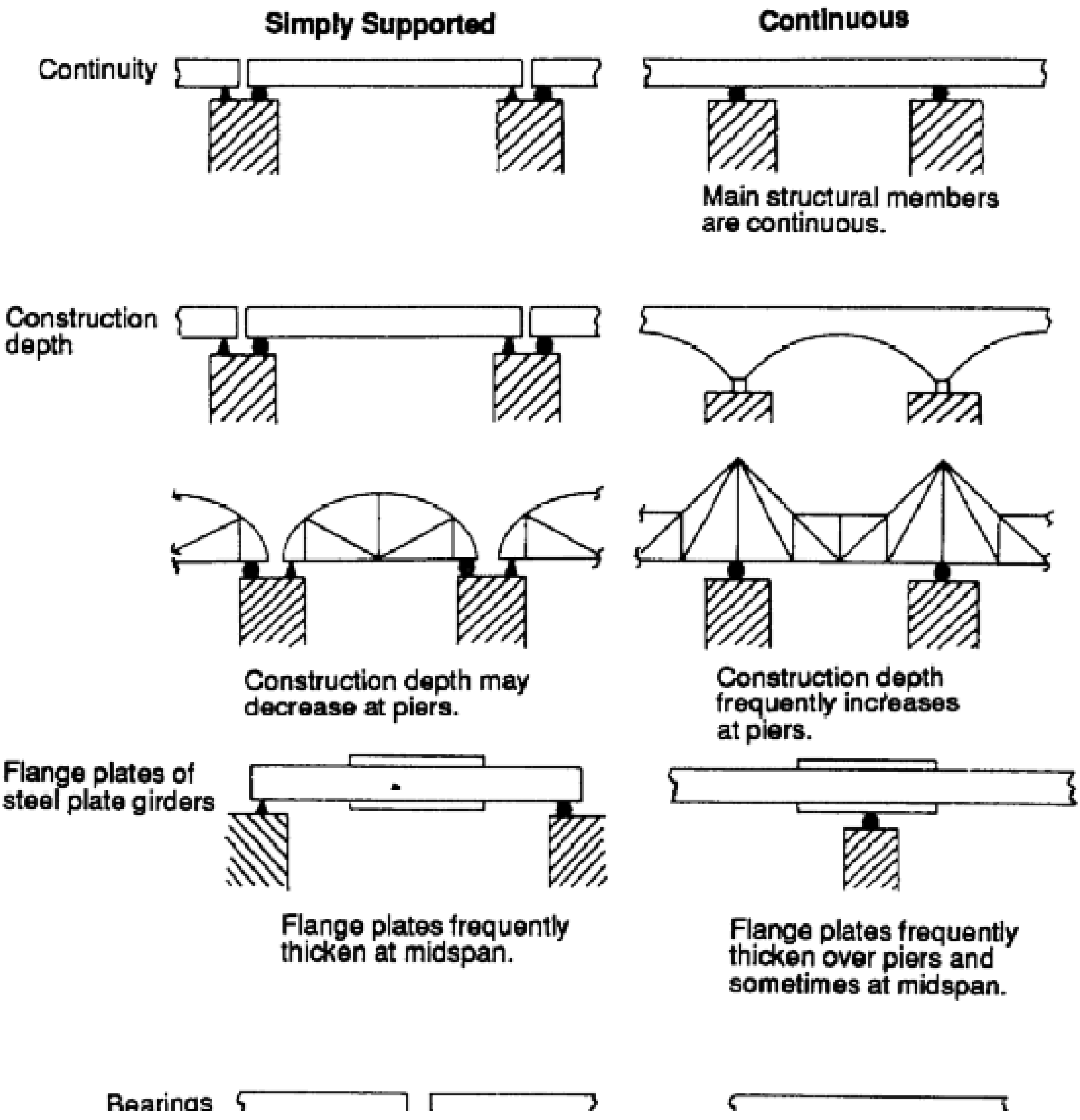
c. Flange Thickness (Steel-Girder Bridges). In simply supported, steel-girder bridges, the thickness of the flange frequently increases at midspan. In continuous bridges, the size of the flange frequently increases over the piers.

d. Bearing. Multispan, simply supported bridges require two lines of bearing at the piers; continuous bridges require only one.

e. Category Selection.

The external appearance of a bridge can sometimes be deceptive.Whenever possible, consultconstruction drawings to ascertain the correct bridge category. If drawings are not available and there is any uncertainty about the category to which the bridge belongs, assume the bridge is of continuous construction. Since more explosive is necessary to demolish a continuous bridge, assuming a continuous construction will provide more than enough explosive to demolish a bridge of unknown construction.

f. Reconnaissance Procedures. To correctly use the tables in Appendix H, decide whether the bridge is in the simply supported, continuous, or miscellaneous category, and follow the procedures outlined in the appropriate paragraph.



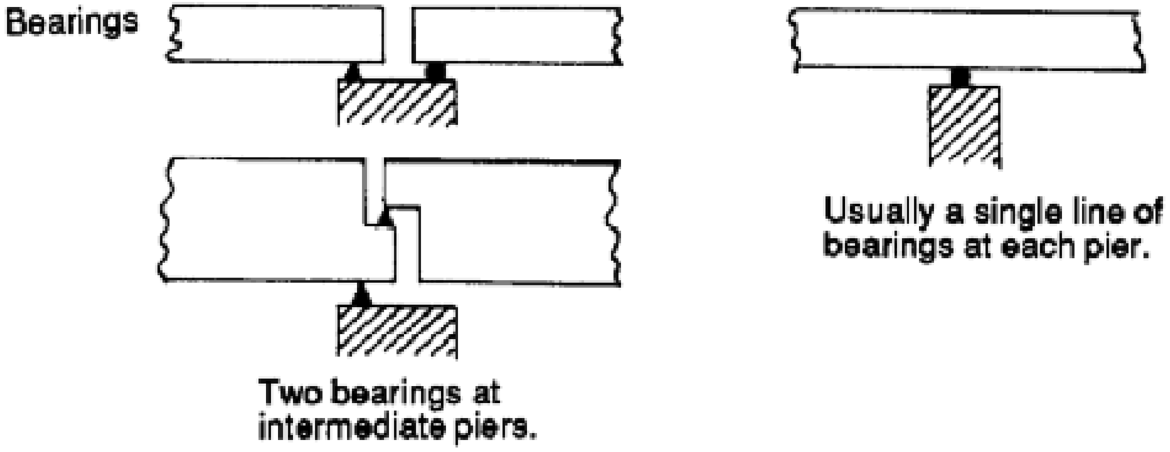


Figure 4-13. Span differences

4-11. Simply Supported Bridges.

a. Categorization. There are four main subcategories: steel beam, steel truss, concrete beam and slab, and bowstring.

The first three are further subdivided into deck bridges, which carry their loads on top of the main structural members. When dealing with deck bridges, note the locations of bearing (supporting the top or bottom chord or flange), as this will influence the possibility of jamming.

(1) Steel-Beam Bridges. Stell-beam bridges may be constructed of normal steel-beam, plate-girder, or box-girder spans. Figure 4-15 shows typical cross sections of these spans.

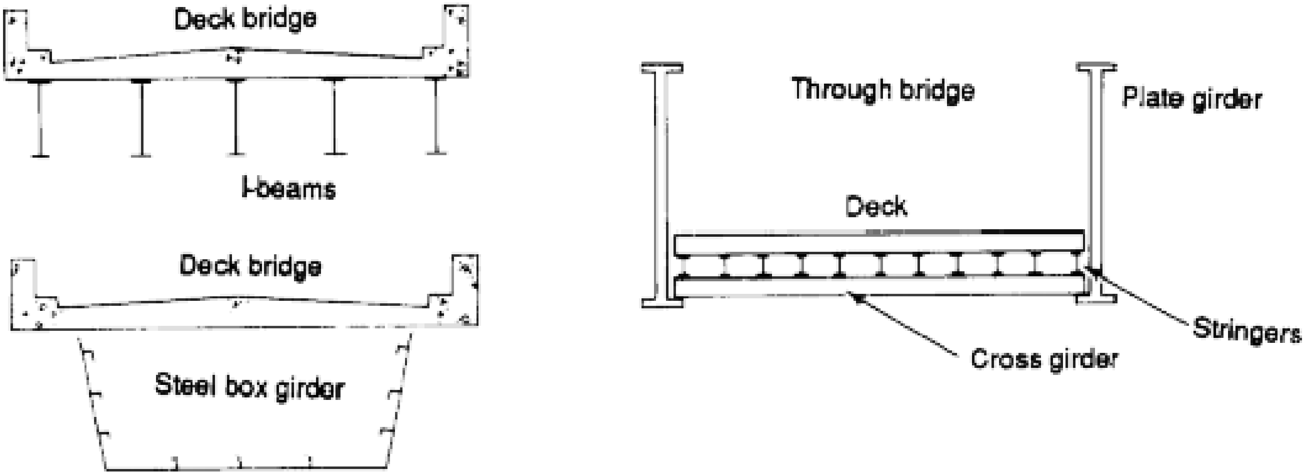


Figure 4-15. Typical cross sections ot steel-beam bridges

(2) Steel-Truss Bridges. Figure 4-16 shows the side elevations for three normal steel-truss spans. Note that all truss bridges have diagonal members in the trusses.

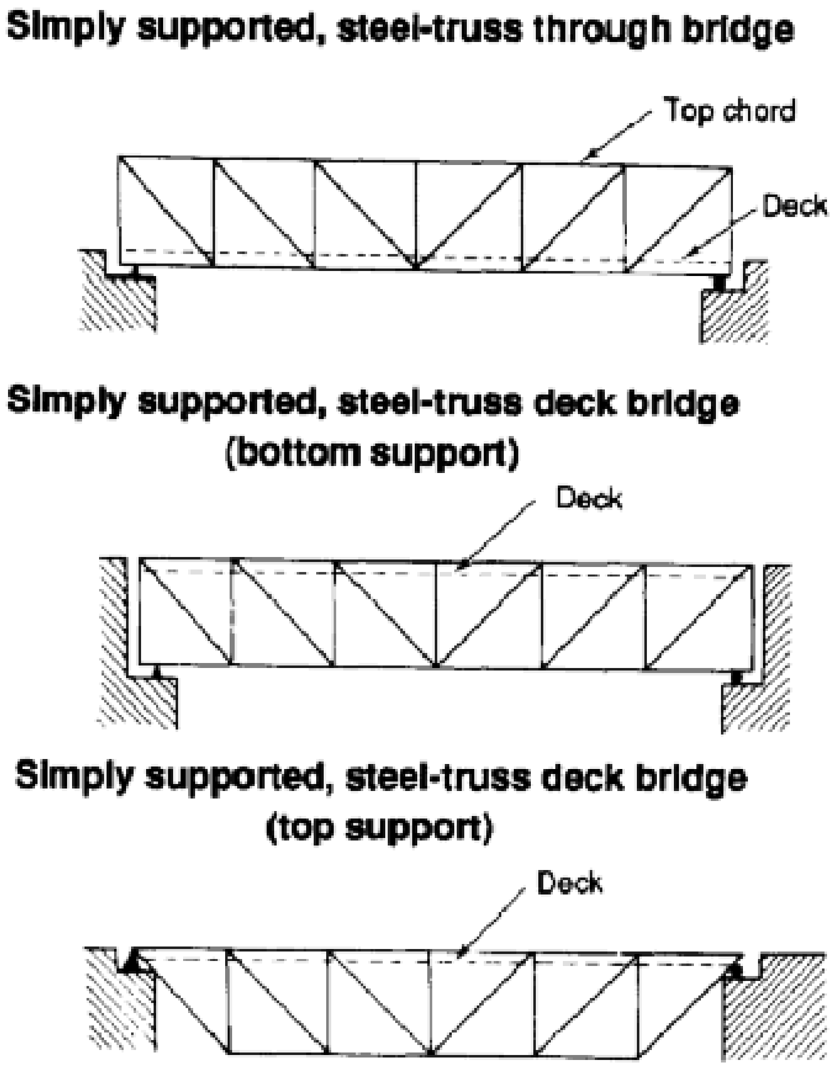


Figure 4-16. Side elevation of steel-truss bridges

(3) Concrete-Beam-and-Slab

Bridges. For categorization purposes, you will not need to distinguish between reinforced- and

prestressed-concrete bridges, as the methods of attack are the same for both. Figure 4-17 shows midspan cross-sectional views of these types of bridges. At midspan, the majority of steel reinforcing rods or tendons are located in the bottom portion of the superstructure. The attack methods detailed in Appendix H take this reinforcing condition into account.

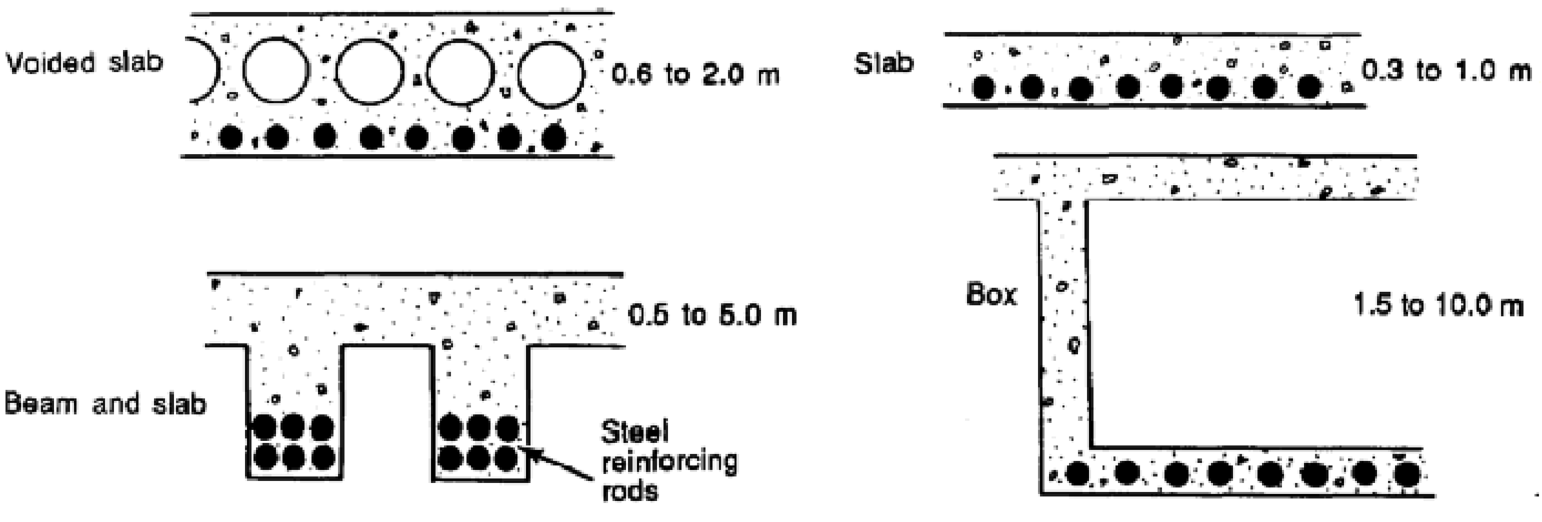


Figure 4-17. Midspan, cross-sectional views of typical concrete bridges

(4) Bowstring Bridges. Note the following about bowstring bridges:

(a) Features. Figure 4-18 (page 4-12) shows the features of a normal bowstring bridge. Recognize that—

The bow is in compression.

The bow may be a steel beam, box girder, concrete beam, or steel truss.

The bow's depth (thickness) is larger than or equal to the depth of the deck support members.

The deck acts as a tie and resists the outward force applied by the bow.

The deck is designed as a weak beam supported by the hangers.

There is no diagonal bracing between the hangers.

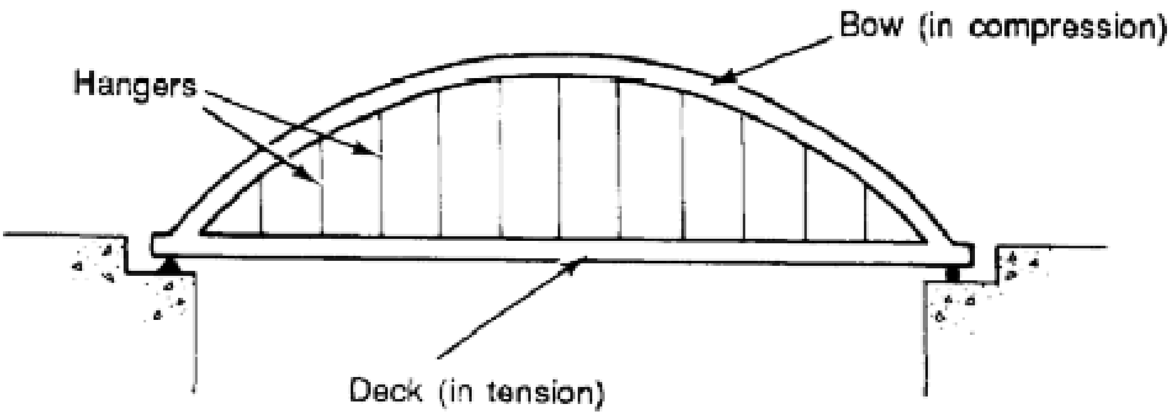


Figure 4-18. Normal bowstring bridge

(b) Uses. Occasionally the bow and hangers are used to reinforce a steel-beam or-truss bridge.

Categorize this type of bridge as a bowstring reinforced-beam or -truss bridge. In this type of bridge, the depth (thickness) of the bow will always be less than the depth of the deck support members.

(c) Pseudo-bowstring bridges. The bridge illustrated in

Figure 4-20 is not a bowstring, but an arch bridge. Categorize this type of bridge as an arch bridge because the outward forces of-the arch (pseudo bow) are restrained primarily by the abutments, not the deck.

b. Reconnaissance. For simply supported bridges, use the following reconnaissance procedure:

(1) Categorize the bridge.

(2) Measure the bridge

(Figure 4-21):

(a) Length (L). Measure the length of the span to be attacked, in meters.

NOTE: This distance is not the clear gap, but the length of the longitudinal members that support the deck from end to end.

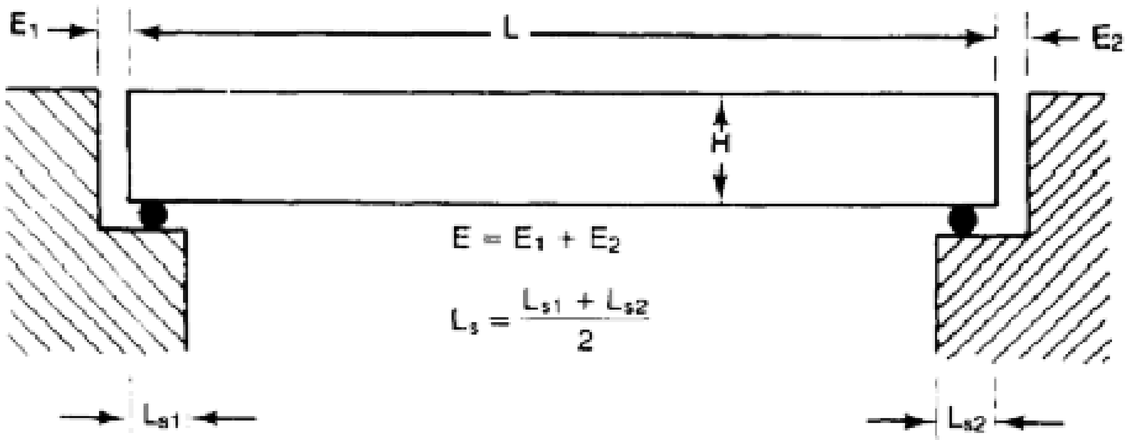


Figure 4-21. Measurements of simply supported spans

(b) Depth (H). Measure the depth of the beam, truss, or bow, in meters (include the deck with the beam or truss measurement).

(c) Total end clearance (E). Total the amount of end clearance at both ends of the span, in meters.

(d) Average length of the bearing supports (LS). Measure the average length of the bearing supports from the ends of the spans to the faces of the abutments or piers, in meters.

(3) Determine the attack method.

(4) Determine the critical dimensions of the span required for charge calculations.

c. Attack. Two considerations apply when attacking a simply supported span:

(1) Point of Attack. Attack simply supported bridges at or near midspan, because—

Bending moments are maximum at midspan.

The likelihood of jamming during collapse is reduced if the bridge is attacked at midspan.

(2) Line of Attack. Make the line of attack parallel to the lines of the abutments (Figure 4-22). Doing this reduces the risk that the two parts of the span will slew in opposite directions and jam. Do not employ any technique that induces twist in the bridge. If the line of attack involves cutting across transverse beams, reposition the line of attack to cut between the transverse beams.

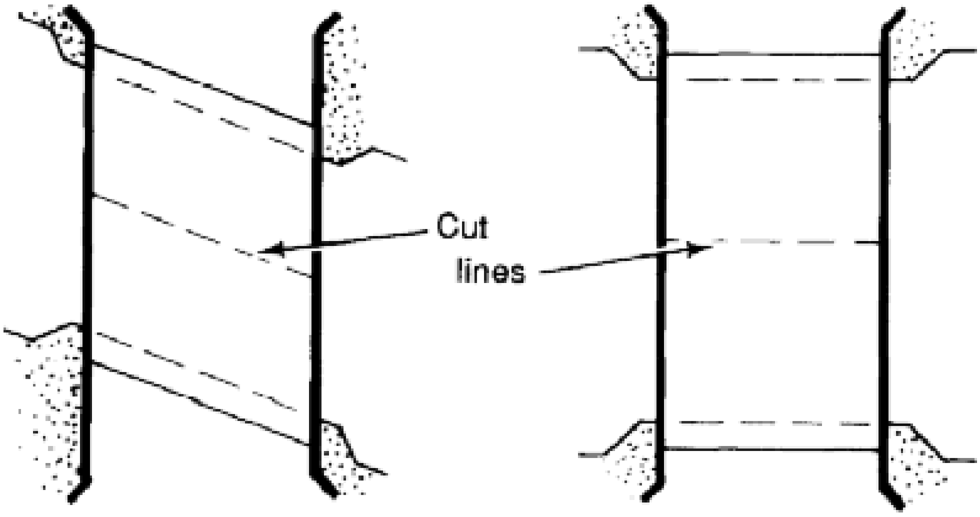


Figure 4-22. Line of attack

d. Attack Methods. Table H-3 (page H-3) lists in recommended order, attack methods likely to produce the most economical demolition, by bridge category. Within each category are variations to accommodate differences in construction materials, span configurations, load capacities (road, rail, or both), and gap and abutment conditions. The three recommended ways of attacking simply supported spans are bottom, top, and angled attacks. In all cases, ensure jamming cannot occur during collapse.

(1) Bottom Attack. Use the bottom attack whenever possible, as it leaves the roadway open and enables you to use the bridge, even when the demolitions are at a ready-to-fire state (State 2).

Reinforced and prestressed (tension) beams are very vulnerable to bottom attack, as the steel cables and reinforcing bars run along the bottom portion of the beam and are thus covered by less concrete.

The major disadvantages of the bottom attack are the increased amount of time and effort necessary for placing and inspecting the charges. Because it is generally impracticable to place sufficient explosive below a reinforced or prestressed slab to guarantee a cut deeper than 0.15 meters, used the top or angled attacks listed in Table H-3 (page H-3) for these types of bridges. When Table H-3 (page H-3) lists a bottom attack, determine the required end clearance (ER) from Table H-1 (page H-1) to prevent jamming. If the total end clearance (E) is greater than ER, jamming will not occur.

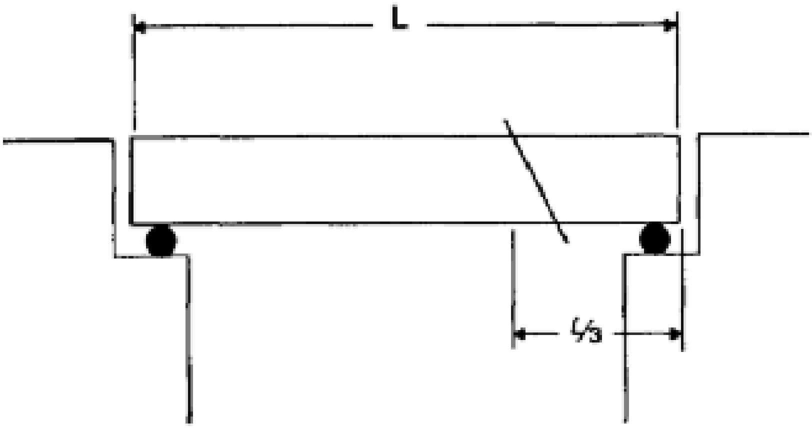
If E is less than ER, use a top or angled attack or destroy one abutment at the places where jamming would occur. Example A-13 (page A-12), explains the method for bottom attack calculations.

(2) Top Attack. When Table H-3 (page H-3) lists a top attack, LC must be removed from the top of the bridge to prevent jamming. Determine LC from Table H-2 (page H-2). Remove LC in a V-shaped section along the full depth of the target. For reinforced-concrete bridges, use a concrete-stripping charge (paragraph 4-9, page 4-7) to remove LC from the top of the bridge. This action, by itself, should cause collapse. There is no requirement to cut steel reinforcing rods.

Example A-14 (page A-13) shows the method for top attack calculations.

(3) Angled Attack. For angled attacks, cut all members (span, hand-rails, service pipes, and so forth) of the bridge. Make the angle of attack approximately 70 degrees to the horizontal to prevent jamming. The location of the charge should be between the midspan point and a point L/3 from the end (Figure 4-23).

Although an angled attack is effective on any type of bridge, it is essential when the bridge must be kept open to traffic, or when there is ample time to prepare demolitions.



Cut between L/3 span and midspan

Figure 4-23. Location of angled charge

4-12. Continuous Bridges.

a. Categorization. Figure 4-24 is a categorization chart for continuous bridges. Use this chart like the chart for simply supported bridges. There are six main subcategories: cantilever, cantilever and suspended span, beam or truss, portal, arch, and masonry arch. The first five categories differentiate between steel and concrete construction, as each material has a different attack method.

If a continuous bridge is of composite construction (for example, steel beams supporting a reinforced-concrete deck), the material that comprises the main, longitudinal load-bearing members will determine the attack method.

(1) Cantilever Bridges. A cantilever bridge has a midspan shear joint.

Note that the full lengths of the anchor spans may be built into the abutments, making the cantilever difficult to identify.

(2) Cantilever and Suspended-Span Bridges. If a cantilever bridge incorporates a suspended span (Figure 4-26, page 4-16) that is at least 5 meters longer than the enemy assault bridging capability, attack this section of the bridge; attacking this section requires less preparation. Because suspended spans are simply supported, use the attack method described for simply supported bridges (Table H-3, page H-3).

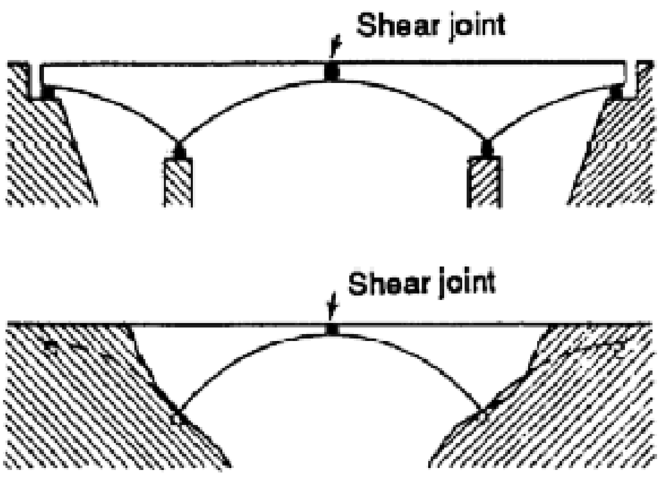


Figure 4-25. Cantilever bridges

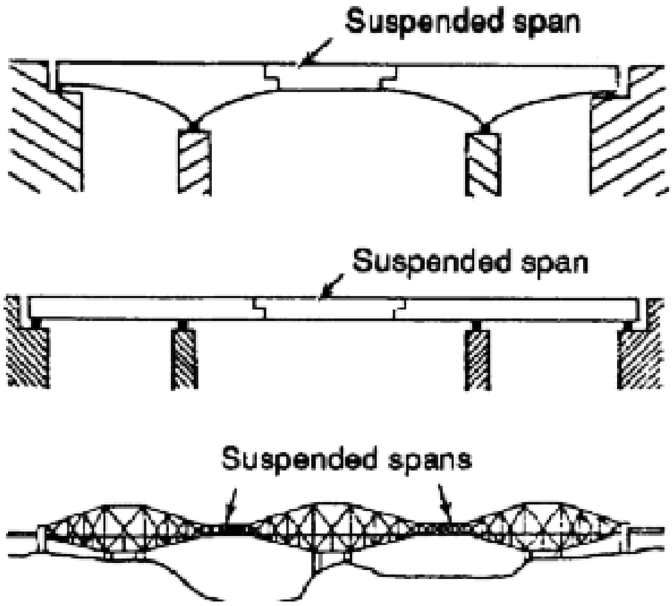


Figure 4-26. Cantilever and suspended span bridges

(3) Beam or Truss Bridges. For beam or truss bridges differentiate between those bridges with spans of similar lengths and those with short side spans because this affects the attack method. A short side span is one that is less than three quarters of the length of the next adjacent span.

(4) Portal Bridges. For portal bridges (Figure 4-30), differentiate between those with fixed footings and those with pinned footings, as this affects the attack method. If you cannot determine the type of footing, assume fixed footings. Portal bridges, as opposed to arch bridges, lack a smooth curve between the bearing point of the span and the span itself.

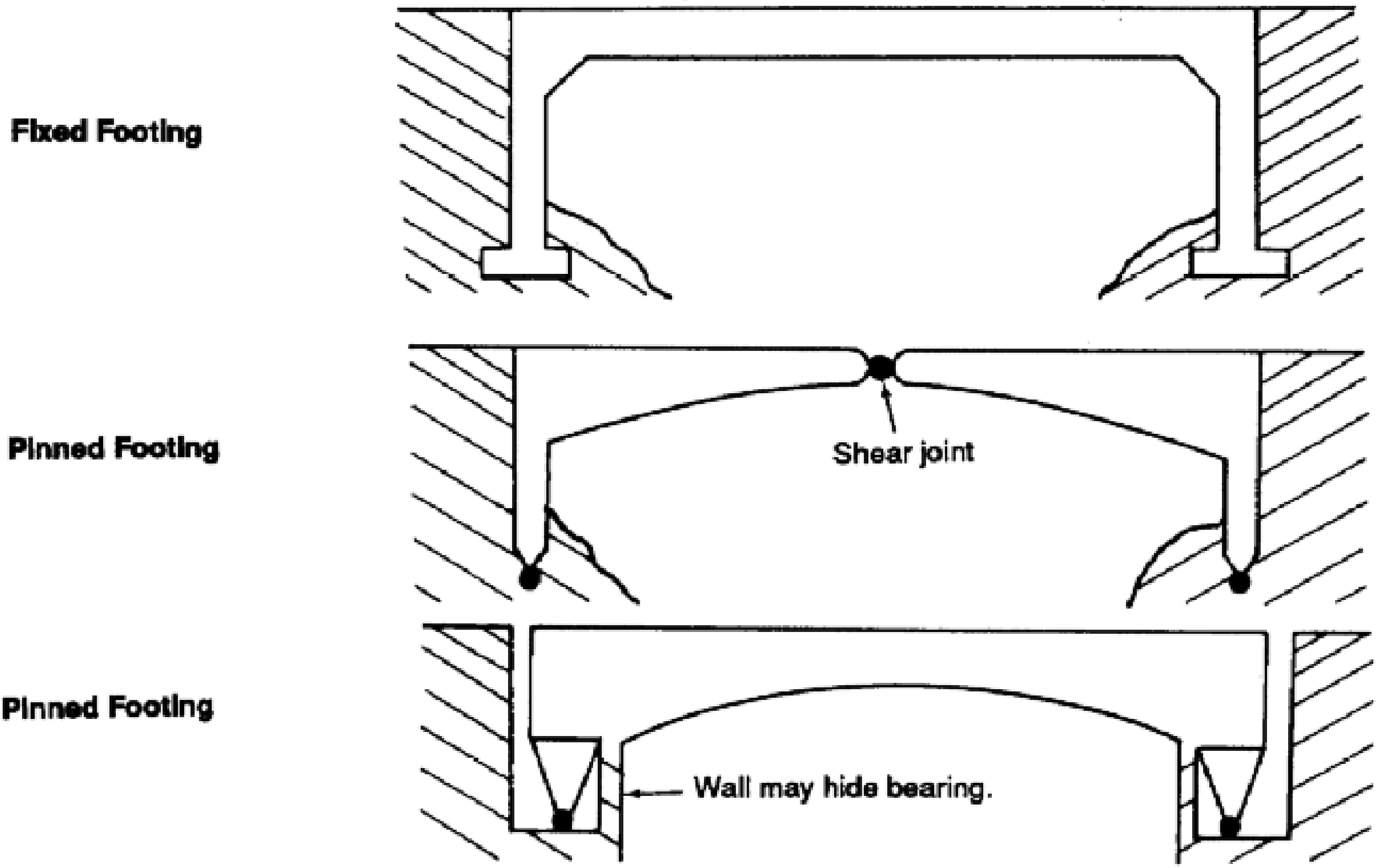


Figure 4-30. Typical portal bridges

(5) Arch Bridges. In arch bridges determine whether the bridge has an open or solid spandrel and fixed or pinned footings. Again, when in doubt, assume fixed footings.

(6) Masonry Arch Bridges. Identify masonry arch bridges by their segmental arch ring. However, it is easy to mistake a reinforced-concrete bridge for a masonry-arch bridge because many reinforced-concrete bridges have masonry faces. Always check the underside of the arch. The underside is rarely faced on reinforced-concrete bridges.

b. Reconnaissance. For continuous bridges, use the following reconnaissance procedure:

(1) Categorize the bridge.

(2) Measure the bridge

(Figure 4-33):

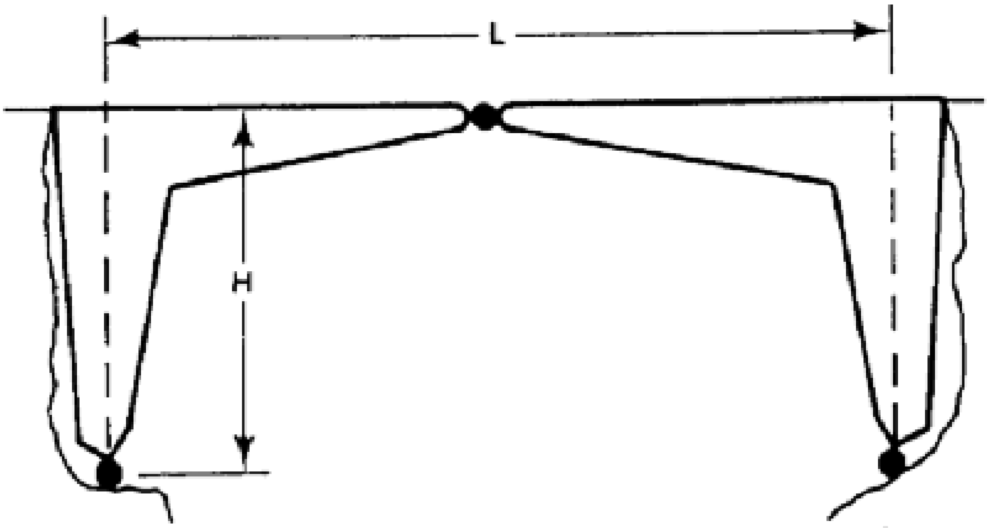


Figure 4-33. Measurements of continuous bridges

(a) Length (L).

Measure the span you plan to attack, in meters (between centerlines of the bearings).

(b) Rise (H). For arch and portal bridges, measure the rise, in meters (from the springing or bottom of the support leg to the deck or top of the arch, whichever is greater).

(c) Determine the attack method from Appendix H.

(d) Determine the critical dimensions necessary for charge calculations.

c. Bridge Attacks. As with simply supported spans, two considerations apply when attacking continuous spans: the point of attack and line of attack. No common point-of-attack rule exists for all categories of continuous bridges, but the line-of-attack rule applies to all continuous bridges.

That is, the line of attack must be parallel to the lines of the abutments, and twisting must not occur during the demolition. If the recommended line of attack involves cutting across transverse beams, reposition the line to cut between adjacent transverse beams. Table H-4 (page H-7) lists attack methods for continuous spans.

(1) Steel Bridges. When attacking continuous-span steel bridges, use the see-saw or unsupported-member collapse mechanism. Both mechanisms produce complete cuts through the span. Providing you can properly place charges, you may be able to demolish these bridges with a single-stage attack. However, on particularly deep superstructures (concrete decks on steel beams), charges designed to sever the deck may not cut through all of the reinforcing steel. Therefore, during reconnaissance, always plan for the possibility of a two-stage attack on deep, composite superstructures. Make angle cuts at about 70 degrees to the horizontal to prevent jamming during collapse.

(2) Concrete Bridges. Continuous concrete bridges are the most difficult to demolish and hence are poor choices for reserved demolitions. Even when construction drawings are available and there is ample time for preparation,

single-stage attacks are rarely successful. Consider using a bottom attack for this bridge type.

(3) Arch and Portal Bridges. For arch bridges and portal bridges with pinned footings, collapse can be guaranteed only be removing a specified minimum span length. Determine this minimum length by using Table 4-1 and the L and H values determined by reconnaissance.

Table 4-1. Minimum L_C values for arch and pinned-footing bridge attacks

$\frac{H}{L}$	0.040	0.060	0.080	0.100	0.120	0.140	0.160	0.180	0.200
$\frac{L_c}{L}$	0.003	0.007	0.013	0.020	0.030	0.040	0.053	0.067	0.083
$\frac{H}{L}$	0.220	0.240	0.260	0.280	0.300	0.320	0.340	0.360	
$\frac{L_c}{L}$	0.100	0.130	0.150	0.170	0.200	0.230	0.270	0.300	

NOTES:

1. The values in this table are based on the following formula:

$$\frac{L_c}{L} = 1 - [1 - 4(\frac{H}{L})^2]^{1/2}$$

2. If the result of $\frac{H}{L}$ is not on the chart exactly as calculated, round UP to the next higher value on the chart. For example, if $\frac{H}{L} = 0.089$, use the column headed 0.10 to determine $\frac{L_c}{L}$. In this case, $\frac{L_c}{L} = 0.02$. Multiply the $\frac{L_c}{L}$ value by L to get L_C. For example, $0.02 \times L = L_C$.

4-13. Miscellaneous Bridges.

a. Suspension-Span Bridges. Suspension-span bridges usually span very large gaps. These bridges have two distinguishing characteristics: roadways carried by flexible members (usually wire cable) and long spans.

(1) Components. The components of suspended-span

bridges are cables, towers, trusses or girders, and anchors. Suspension-bridge cables are usually multiwire-steel members that pass over the tower tops and terminate at anchors on each bank. The cables are the load-carrying members.

(The Golden Gate bridge has 127,000 miles of wire cable of this type.) The towers support the cables. Towers may be steel, concrete, masonry, or a combination of these materials. The trusses or girders do not support the load directly; they only provide stiffening. Anchors hold the ends of the cables in place and may be as large as 10,000 cubic feet.

(2) Demolishing Methods.

(a) Major bridges. Anchors for major suspension bridges are usually too massive to be demolished. The cables are usually too thick to be effectively cut with explosives. The most economical demolition method is to drop the approach span or a roadway section by cutting the suspenders of the main or load-bearing cables. The enemy's repair and tactical bridging capabilities determine the length of the target section. When reinforced-concrete towers are present, it may be feasible to breach the concrete and cut the steel of the towers.

(b) Minor bridges. The two vulnerable points on minor suspension bridges are towers and cables. Use the following methods:

Towers. Destroy towers by placing tower charges slightly above the level of the roadway. Cut a section out of each side of each tower. Place the charges so that they force the ends of the cut sections to move in opposite directions, twisting the tower. Doing this will prevent the end of a single cut from remaining intact. Demolition chambers, provided in some of the newer bridges, make blasting easier, quicker, and more effective.

Cables. Destroy the cables by placing charges as close as possible to anchor points, such as the top of towers. Cables are difficult to cut because of the air space between the individual wires in the cable. Ensure the charge extends no more than one half the cable's circumference. These charges are usually bulky, exposed, and difficult to place. Shaped charges are very effective for cable cutting.

b. Movable Bridges. These bridges have one or more spans that open to provide increased clearance for waterway traffic. The three basic types of movable bridges are swing-span, bascule, and vertical-lift. The characteristics of these bridges are described in the next paragraphs.

(1) Swing-Span Bridges.

(a) Characteristics. A swing span is a continuous span capable of rotating on a central pier. The arms of a swing-span bridge may not be of equal length. If the arms are not of equal length, weights are added to balance them. Rollers that run on a circular track on top of the central pier carry the span's weight. The swing span is independent from any other span in the bridge. Identify a swing-span bridge by its wide, central pier. This central pier is much wider than the one under a continuous-span bridge that accommodates the rollers and turning mechanism (Figure 4-35).

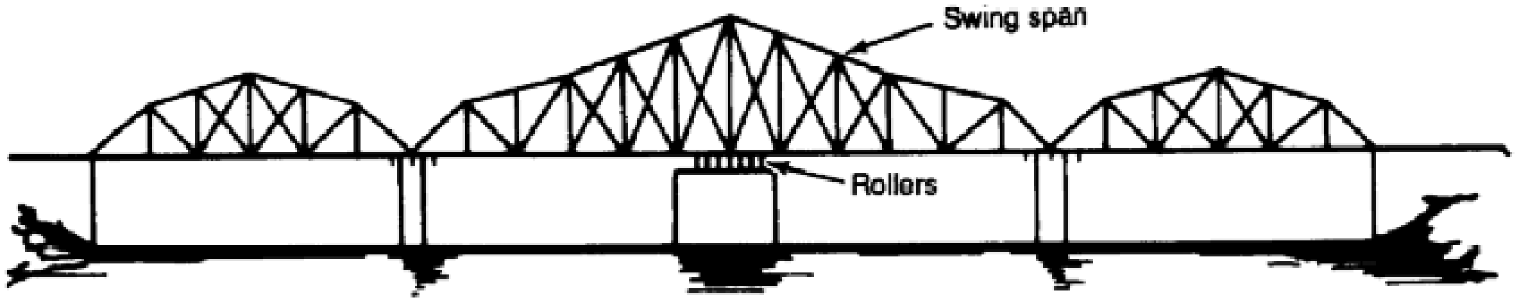


Figure 4-35. Swing-span truss bridge

(b) Demolition methods. Because swing-span bridges are continuous bridges, use an attack method from the continuous bridge section in Appendix H. For partial demolition, open the swing span and damage the turning mechanism.

(2) Bascule Bridges.

(a) Characteristics. Bascule bridges are more commonly known as drawbridges. These bridges usually have two leaves that fold upward (Figure 4-36), but some bascule bridges may have only one leaf (Figure 4-37). The movable leaves in bascule bridges appear in three general forms: counterweights below the road level (most modem), counterweights above the road level (older type), and no counterweights (lifted by cable or rope; oldest type; usually timber).

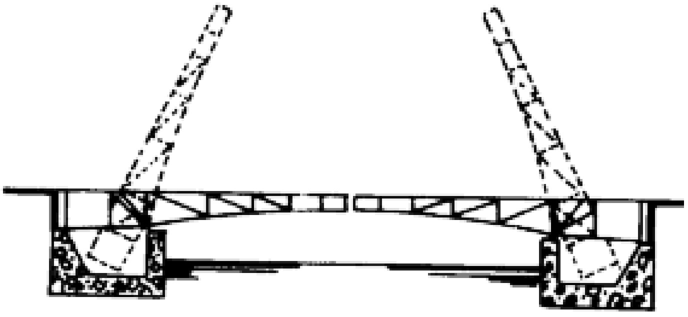


Figure 4-36. Double-leaf bascule bridge

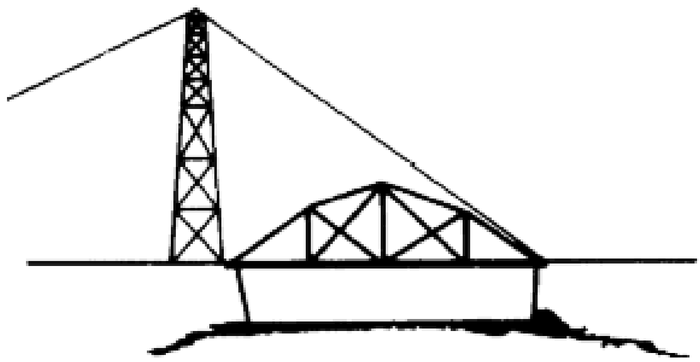


Figure 4-37. Single-leaf bascule bridge

(b) Demolition methods. Demolish the cantilever arms with an attack method appropriate for simply supported bridges. For partial demolition, open the bridge and jam or destroy the lifting mechanism.

(3) Vertical-Lift Bridges.

(a) Characteristics. These bridges have simply supported, movable spans that can be raised vertically in a horizontal position. The span is supported on cables that pass over rollers and connect to large, movable counterweights.

(b) Demolition methods. Demolish the movable span with an attack method appropriate for simply supported bridges. Another method is to raise the bridge and cut the lift cables on one end of the movable span. The movable span will either wedge between the supporting towers or fall free and severely damage the other tower.

(4) Floating Bridges. Floating bridges consist of a

continuous metal or wood roadway supported by floats or pontoons

(a) Pneumatic floats. Pneumatic floats are airtight compartments of rubberized fabric inflated with air. For hasty attack of these bridges, cut the anchor cables and bridle lines with axes and the steel cables with explosives. Also, puncture the floats with small-arms or machine-gun fire. Using weapons to destroy the floats requires a considerable volume of fire because each float has a large number of watertight compartments. Another method is to make a clean cut through the float, using detonating cord stretched snugly across the surface of the pontoon compartments.

One strand of cord is enough to cut most fabrics, but two strands may be necessary for heavier materials. Also, place one turn of a branch-line cord around each inflation valve. This will prevent the raft from being reinflated if it is repaired. Do not use main-line cords to cut valves because the blast wave may fail to continue past any sharp turn in the cord.

b) Rigid pontoons. Rigid pontoons are made of various materials: wood, plastic, or metal. To destroy these bridges, place a ½-pound charge on the upstream end of each pontoon at water level.

Detonate all charges simultaneously. If the current is rapid, cut the anchor cables so that the bridge will be carried downstream. Another method is to cut the bridge into rafts. Place ½-pound charges at each end of each pontoon and detonate them simultaneously. To destroy metal treadways on floating bridges, use the steel-cutting formula (paragraph 3-6, page 3-8). The placement and size of the charges depend on bridge type. Typically, placing cutting charges at every other joint in the treadway will damage the bridge beyond use.

(5) Bailey Bridges. To destroy these bridges, place l-pound charges between the channels of the upper and lower chords. Use ½-pound charges for cutting diagonals and l-pound charges for cutting sway bracing (Figure 4-40).

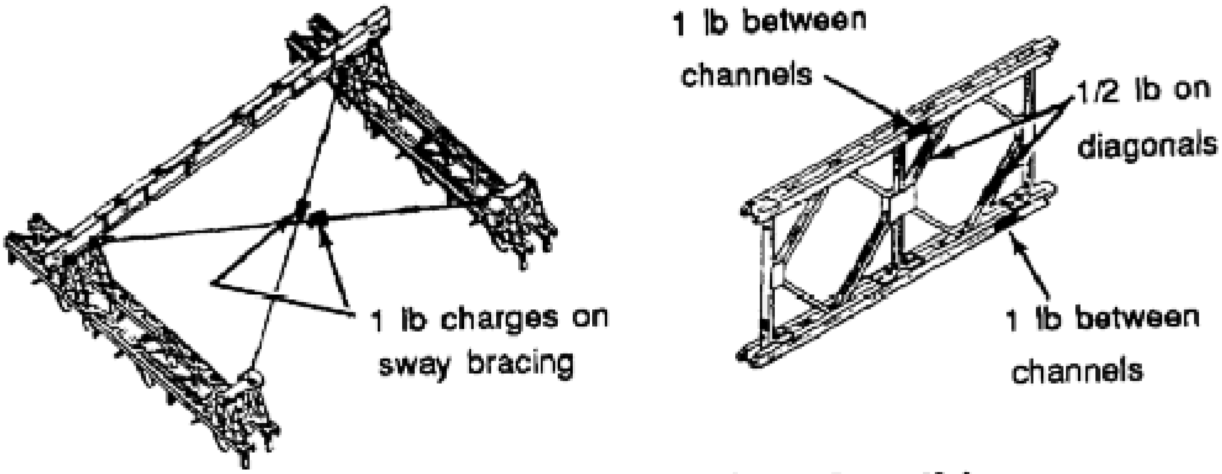


Figure 4-40. Bailey bridge demolition

(a) In-place demolitions. Cut the bridge in several sections by attacking the panels on each side, including the sway bracing. The angle of attack should be 10 degrees to the horizontal to prevent jamming. In double-story or triple-story bridges, increase the charges on the chords at the story-junction line. For further destruction, place charges on the transoms and stringers.

(b) In-storage or-stockpile demolition. When abandoning bridges in storage, do not leave any component the enemy can use as a unit or for improvised construction. Do this by destroying the essential components that the enemy cannot easily replace or manufacture. Panel sections fulfill the role of essential components. To render the panel useless, remove or distort the female lug in the lower tension chord. Destroy all panels before destroying other components.

Section III. Abutments and Intermediate Supports

4-14. Abutments. To demolish abutments, place charges in the fill behind the abutment. This method uses less explosive than external breaching charges and also conceals the charges from the enemy. The disadvantage is the difficulty in placing the charges. When speed is required, do not place charges behind abutments if you know the fill contains large rocks.

a. Abutments (5 Feet Thick or Less). Demolish these abutments by placing a line of 40-pound cratering charges, on 5-foot centers, in boreholes 5 feet deep, located 5 feet behind the face of the abutment (triple-nickel-forty method). Place the first hole 5 feet from either end of the abutment and continue this spacing until a distance of 5 feet or less remains between the last borehole and the other end of the abutment (Figure 4-41). If the bridge approach is steep, place the breaching charges against the rear of the abutment. Determine the number of 40-pound cratering charges as follows:

$$N = \frac{W}{5} - 1$$

where—

N = number of charges; round UP to next higher whole number.

W = abutment width, in feet.

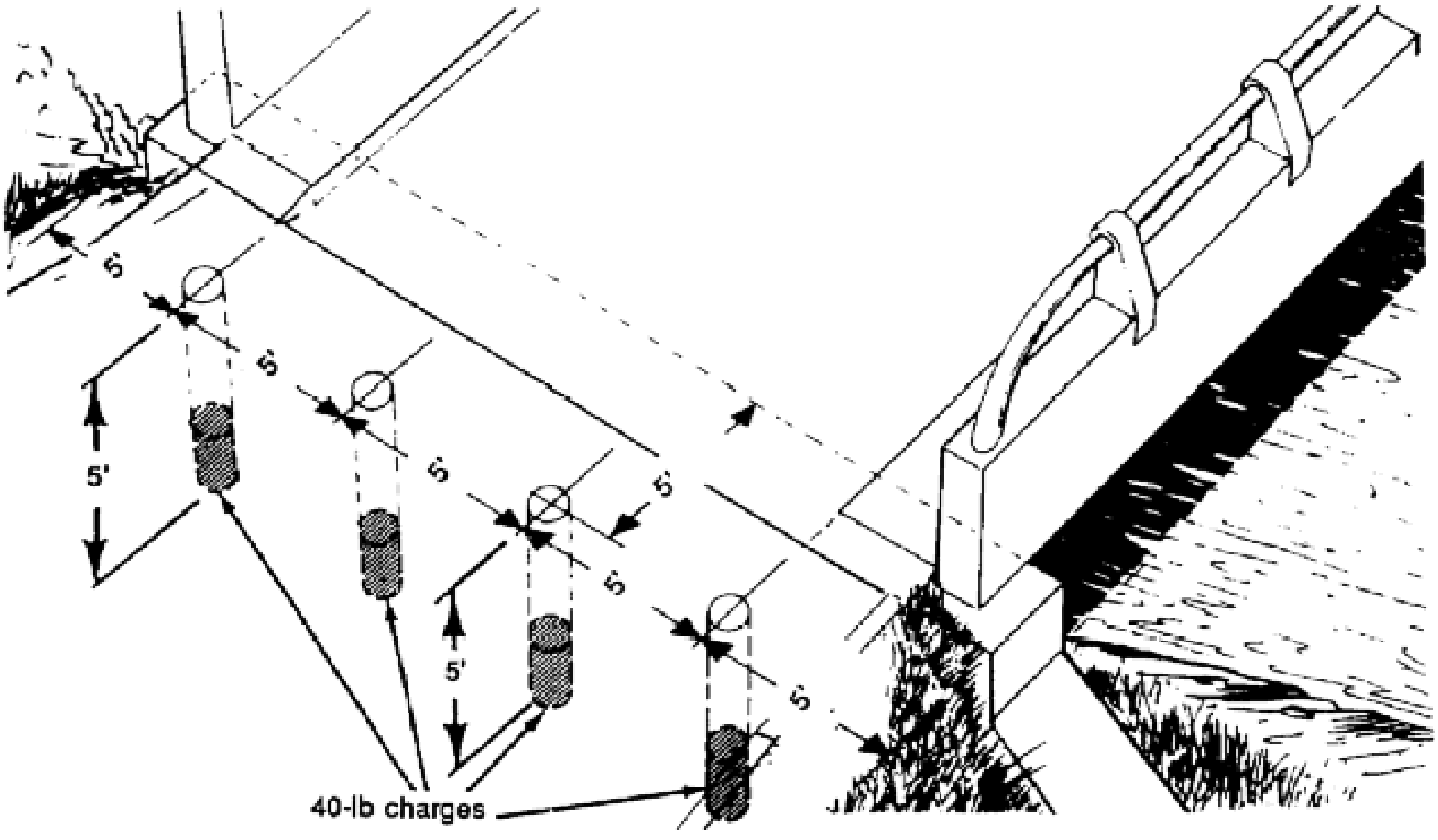
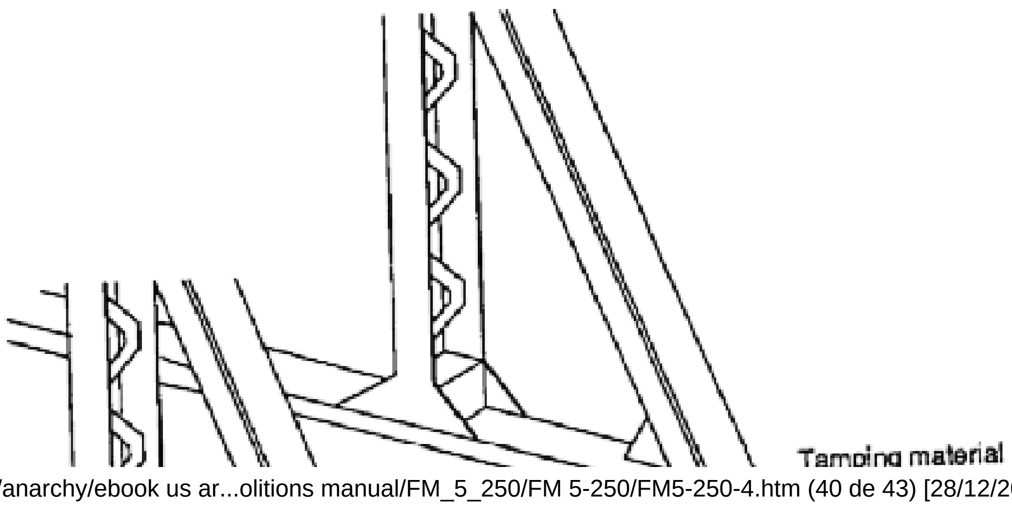


Figure 4-41. Abutment destruction (5 feet thick or less)



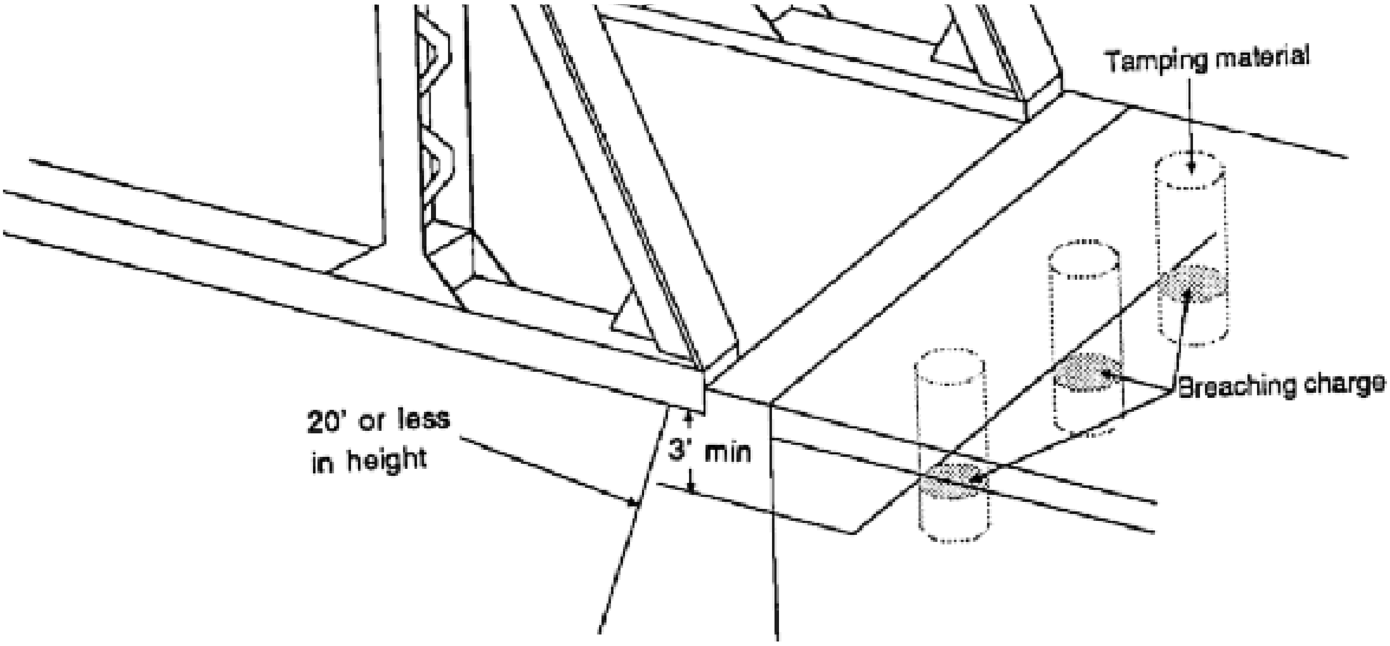


Figure 4-42. Abutment destruction (over 5 feet thick)

b. Abutments (0ver 5 Feet Thick). Destroy these abutments with breaching charges in contact with the back of the abutment. Calculate the amount of each charge using the breaching formula in equation 3-6 (page 3-16). Use the abutment thickness as the breaching radius. Determine the number of charges and their spacing using equation 3-7 (page 3-19). Place charges at least three feet below the bridge seat (where the bridge superstructure sits on the abutment) (Figure 4-42).

c. Abutments (Over 20 Feet High). Demolish these abutments by placing a row of breaching charges at the base of the abutment on the gap side, in addition to the charges specified in paragraphs 4-14a or 4-14b above. Fire all charges simultaneously. This method tends to overturn and completely destroy the abutment.

d. Wing Walls. If the wing walls can support a rebuilt or temporary bridge, destroy the wing walls by placing charges behind them in the same manner as for abutments (Figures 4-41 and 4-42).

4-15. Intermediate Supports. Demolish concrete and masonry piers with internal or external charges (Figure 4-43).

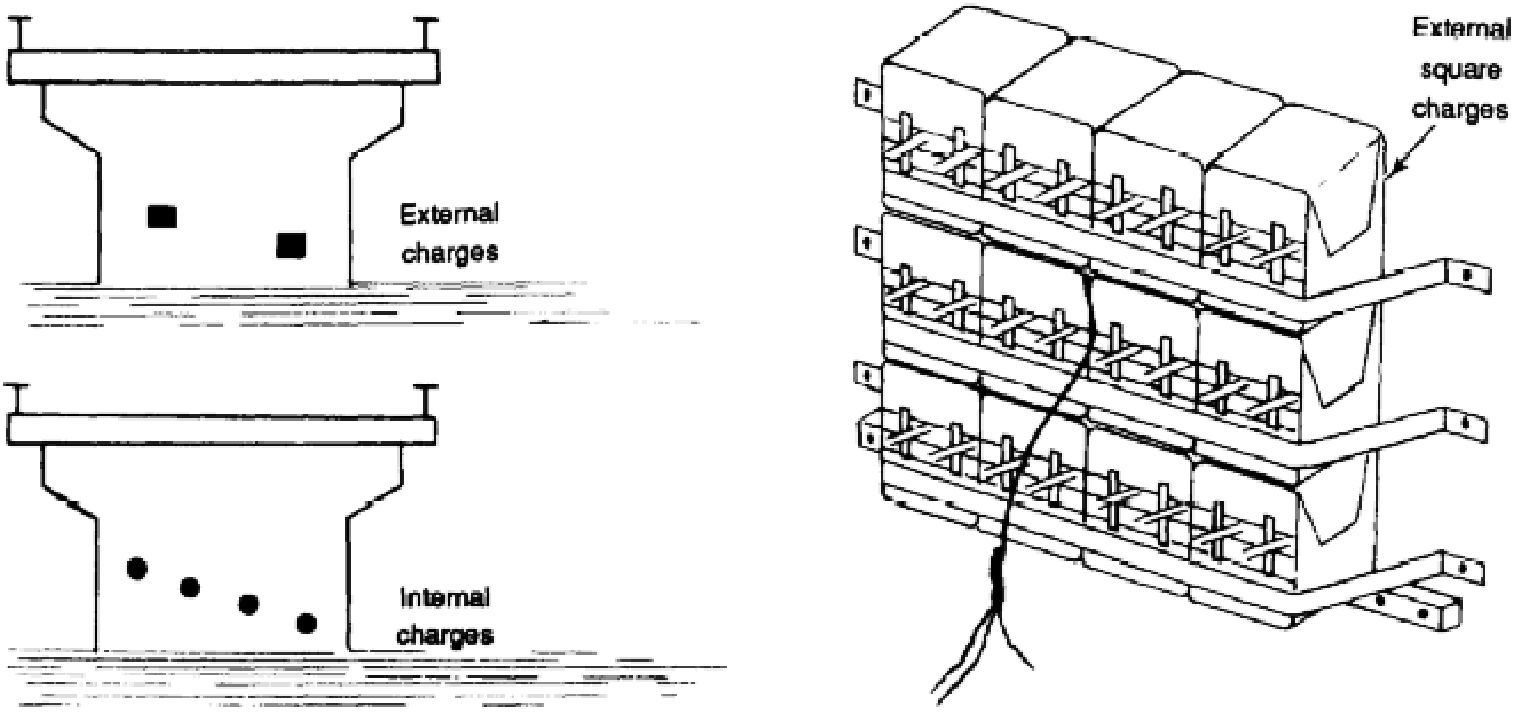


Figure 4-43. Placing charges on intermediate supports

a. Internal Charges. These charges require less explosive than do external charges. However, unless the support has built-in demolition chambers, this method requires an excessive amount of equipment and preparation time. Use equation 3-6 (page 3-16) to determine the amount of each charge. Ml12 (C4) is ideal for internal charges. Thoroughly tamp all charges of this type with nonsparking tools (blunt, wooden tamping sticks or similar tools). If the support has demolition chambers, place the charges in boreholes created with shaped charges or drilled with pneumatic or hand tools. A 2-inch-diameter borehole holds approximately 2 pounds of explosive per foot of depth. The steel reinforcing bars, however, make drilling in heavily reinforced concrete impractical.

b. External Charges. Place these charges at the base of the pier or higher, and do not space the charges by more than twice the breaching radius. Stagger the charges to leave a jagged surface to hinder future use. Thoroughly tamp all external charges with earth and sandbags, if time, size, shape, and location of the target permit.

NEXT

BACK TO COMMERCIAL EXPLOSIVES

Chapter 6

Demolition Safety

Section I. General Safety

6-1. Considerations.

Do not attempt to conduct a demolitions mission if you are unsure of 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 demolitions mission.

Take your time when working with explosives; make your actions deliberate.

Always post guards to prevent access inside the danger radius.

Always maintain control of the blasting machine or initiation source.

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 all personnel and equipment are accounted for prior to detonating a charge.

Ensure you give warnings before initiating demolitions; give the warning "Free in the hole!" three times.

Always guard firing points.

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 or damaged explosives.

Do not dismantle or alter the contents of any explosive material.

Avoid mixing live and inert (dummy) explosives.

WARNING

Do not use blasting caps underground.

Use detonating cord to prime underground charges.

6-2. Explosive Materials.

a. Blasting Caps. Both military and commercial blasting caps 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 and often more sensitive than their commercial counterparts. When using commercial blasting caps to detonate military explosives, ensure they are powerful enough to detonate the explosives, thus, avoiding misfires. Because power requirements for caps from different manufacturers vary, never mix caps from different manufacturers; mixing caps could result in rnisfires. When installing caps in explosives, never force them into an explosive or a cap well; use an appropriate tool for making or enlarging the cap well.

Ensure 1/8 to 1/4 inch of the cap is clearly visible at both ends when taping onto detonation cord. Do not connect blasting-cap initiation sets to ring or line mains or charges when nonessential personnel are on site. Never leave blasting caps unattended before or after attaching them to the charges or firing system.

(1) 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 blasting caps with explosives.

Never carry loose blasting caps in your pocket or place loose blasting 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.

Never insert anything but time fuse or detonation cord into a nonelectric blasting cap.

Do not twist time fuse or detonating cord while attempting to insert into a blasting cap.

Never attempt to crimp a blasting cap installed in an explosive. If the blasting cap has come loose from the time fuse or detonating cord, remove the blasting cap from the charge, recrimp the cap, and then 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.

When using nonelectric caps to dual prime demolitions, cut the fuse to allow an interval of not less than 10 seconds between firings.

(2) Electric.

Do not remove the short-circuiting shunt unless 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-degree turns) to provide a proper shunt.

Use proper grounding procedures when static electricity is present, see paragraph 6-5b (page 6-4).

When transporting electric blasting caps near vehicles (including aircraft) equipped with a transmitter, protect the blasting caps by placing them in a metal can with a snug-fitting cover (½ inch or more of cover overlap). Do not remove blasting 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 blasting caps near power lines, temporarily cut the power to the lines during blasting operations.

Always use at least the minimum current required to fire electric blasting caps.

Always check circuit continuity of electric blasting caps before use.

Cover connections between blasting cap leads and firing wires with insulating tape, not the cardboard spool.

Remove firing wire loops and, if practical, bury blasting wires.

b. Time Fuse and Detonating Cord.

(1) Time Fuse.

Always conduct a test burn of at least three feet for each roll of time fuse. If you do not use the fuse within 24 hours of the test burn, perform another test burn before using the fuse.

Use M2 crimpers to cut time fuse. If serviceable M2 crimpers are not available, use a sharp knife to cut fuse. Be sure to cut the fuse end squarely. Make the cut on a nonsparking surface, such as wood. A rough or jagged-cut fuse can cause a misfire.

Avoid cutting the fuse until you are ready to insert it into the igniter and blasting cap.

To avoid problems from moisture infiltration, never use the first or last 6 inches of time fuse from a new or partial roll.

Avoid sharp bends, loops, and kinks in time fuse. Avoid stepping on the fuse. Any of these conditions or actions can break the powder train and result in a misfire.

(2) Detonating Cord.

Do not carry or hold detonating cord by placing it around your neck.

To avoid problems from moisture infiltration, never use the first or last 6 inches of detonating cord from a new or partial roll.

Avoid sharp bends, loops, and kinks in detonating cord. Avoid stepping on the cord.

Any of these conditions or actions can change the path of detonation or cause the cord to cut itself.

c. Plastic and Sheet Explosives.

Always cut plastic and sheet explosives with a sharp knife on a nonsparking surface.

Never use shears.

Avoid handling explosives with your bare skin as much as possible.

d. Picric Acid. Picric acid degrades with time. Do not use picric acid if its container is rusted or corroded. A rusty or corroded container indicates the explosive is unstable.

WARNING

Do not handle picric acid. Notify EOD for disposition.

e. Commercial Explosives. Commercial dynamite is sensitive to shock and friction and is not recommended for use in combat areas. Do not use old, commercial dynamite because it is extremely sensitive and very unstable. Follow the procedures in TM 9-1300-206 or the manufacturer’s recommendations to destroy aged commercial dynamite. When commercial dynamite freezes, it becomes covered with crystals and is very unstable. Do not use frozen dynamite. Commercial dynamite containing nitroglycerin requires special handling and storage. Rotate commercial dynamite in storage to prevent the nitroglycerin from settling to the bottom of the explosive.

6-3. Boreholes. Do not leave any void spaces in boreholes, especially in quarrying operations. A secondary explosion can result from a borehole with voids between loaded explosives. After the first blast, it may take up to 15 minutes for such an explosion to occur. Tamp all voids with appropriate material. When using springing charges to dig boreholes, allow at least 2 hours for boreholes to cool between placing and firing successive springing charges, or cool the boreholes with water or compressed air to save time.

6-4. Toxicity. Most military explosives are poisonous if ingested and will produce lethal gases if detonated in confined areas such as tunnels, caves, bunkers, and buildings. Allow sufficient time for blast fumes, dust, and mists to clear before inspecting or occupying a blasting area. TNT is extremely poisonous; avoid using TNT to blast in enclosed areas. Avoid touching sensitive areas of your body, such as around the face and groin, when working with explosives. Wash your hands after working with explosives, especially before consuming food.

6-5. Natural and Physical Properties.

a. Lightning. Lightning is a hazard to both electric and nonelectric blasting charges. A lightning strike or nearby miss is almost certain to initiate either type of system. If lightning strikes occur, even far away from the blasting site, electrical firing circuits could be initiated by high, local earth currents and shock waves resulting from the strikes. These effects are increased when lightning strikes occur near conducting elements, such as fences, railroads, bridges, streams, underground cables or conduits, and in or near buildings. The only safe procedure is to suspend all blasting activities during electrical storms or when an electrical storm is imminent.

b. Static Electricity. Though rare, electric blasting caps can possibly be initiated by static electricity. If possible, avoid using electric blasting caps if static electricity is a problem. Exercise extreme caution when working with explosives in cold, dry climates or when wearing clothing and equipment that produce static electricity, such as clothing made of nylon or wool. Before handling an electric blasting cap, always remove the static electricity from your body by touching the earth or a grounded object. It may be necessary to perform this grounding procedure often in an area where static electricity is a constant problem.

c. Induced Currents. Radio signals can induce a current in electric blasting caps and prematurely detonate them. Table 6-1 lists the minimum safe distances from transmitters for safe electrical blasting. This table applies to operating radio, radar, microwave, and television transmitting equipment. Keep mobile transmitters and portable transmitters at least 50 meters from any electric blasting cap or electrical firing system. Do not use electric blasting caps within 155 meters of energized power transmission lines.

d. Blast Effects. Personnel in close proximity to explosions may experience permanent hearing loss or other injury from the pressure wave caused by an explosion. Hearing protection should be worn during all blasting operations. Personnel observing minimum safe distances for bare charges (see Table 6-1 and Army Regulation (AR) 385-63) generally will not be affected by blast effects. Refer to AR 385-63, Chapter 18, for additional information on blast effect.

Table 6-1. Safe distances for blasting near radio frequency energy

Average or Peak Transmitter Power (Watts*)	Minimum Safe Distance (Meters)
0 to 29	30
30 to 49	50
50 to 99	110
100 to 249	160
250 to 499	230
500 to 999	305
1,000 to 2,999	480
3,000 to 4,999	610
5,000 to 19,999	915
20,000 to 49,999	1,530
50,000 to 100,000	3,050

*When the transmission is a pulsed- or pulsed, continuous-wave type and its pulse width are less than 10 microseconds, the left-hand column indicates average power. For all other transmitters, including those with pulse widths greater than 10 microseconds, the left-hand column indicates peak power.

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

6-6. Underwater Operations.

a. Explosives. Explosives are subject to erosion by water. Unprotected explosives will deteriorate rapidly, reducing their effectiveness. Ensure all exposed explosives are adequately protected when used in water, especially running water.

b. Nonelectric Caps. Nonelectric caps depend on combustion to work properly. Any moisture inside a nonelectric cap may cause a misfire. Because nonelectric blasting caps are difficult to waterproof, aviod using them to prime underwater charges or charges placed in wet boreholes.

c. Time Fuse. Time fuse depends on combustion to burn properly. Time fuse burns significantly faster underwater due to water pressure. Waterproof sealing compounds will not make

a permanent waterproof seal between the fuse and a nonelectric blasting cap. Place the fuse underwater at the last possible moment before firing.

NOTE: If the mission requires using time fuse underwater, then do the test burn underwater.

d. Detonating Cord. Seal the ends of detonating cord with a waterproof sealing compound when using detonating cord for initiating underwater charges or charges that will remain in place several hours before firing. Leaving a 6-inch overhang in detonating cord normally will protect the remaining line from moisture for 24 hours.

e. M60 Fuze Igniter. The M60 depends on combustion to work properly. Water can penetrate the fuze igniter through the vent hole located in the pull rod. Therefore, if the igniter fails to fire on the initial attempt, it probably will fail on any subsequent attempt after reset. Always use a backup initiation set for underwater demolitions.

6-7. Safe Distances. The following criteria give distances at which personnel in the open are relatively safe from missiles created by bare charges placed on the ground, regardless of the type or condition of the soil (AR 385-63). Table 6-2 lists safe distances for selected charge weights. The following general rules apply:

Charges of Less than 27 Pounds. The minimum missile hazard distance is 300 meters.

Charges of More than 27 Pounds But Less Than 500 Pounds. Use the distances in Table 6-2.

Charges More than 500 Pounds. Use the following formulas:

$$Safe\ Distance\ (meters) = 100\sqrt[3]{Pounds\ of\ Explosive}$$

$$Safe\ Distance\ (feet) = 300\sqrt[3]{Pounds\ of\ Explosive}$$

Missile-Proof Shelters. A missile-proof shelter can be as close as 100 meters from the detonation site provided it is strong enough to withstand the heaviest possible missile resulting from the demolition.

Charges Fixed to Targets. When charges are fixed to targets and not simply placed on the ground, use the safe distances specified in Tables 6-2 or 6-3, whichever is farthest.

Table 6-2. Safe distances for personnel (near bare charges)

Explosive Weight (Pounds)	Safe Distance		Explosive Weight (Pounds)	Safe Distance	
	Feet	Meters		Feet	Meters
27 or less	985	300	175	1,838	560
30	1,021	311	200	1,920	585
35	1,073	327	225	1,999	609
40	1,123	342	250	2.067	630
45	1,168	356	275	2,136	651
50	1,211	369	300	2,199	670
60	1,287	392	325	2,258	688
70	1,355	413	350	2,313	705
80	1,415	431	375	2,369	722
90	1,474	449	400	2,418	737
100	1,526	465	425	2,461	750
125	1,641	500	500	2,625	800
150	1,752	534			

Table 6-3. Safe distances for personnel (charges on target)

Serial	Charge Type	Target	Charge Size	Radius of Danger Area (m)	Remarks
a	b	c	d	e	f
1	Blasting caps Primers Detonating cord (in the open)	—	—	20	For service personnel under supervision. Applicable to all serials.
2	Cutting	a. Trees	Any	300	
		b. Concrete columns and beams	Any	500	—
		c. Metal girders and plates, guns, and so forth	Any	1,000	Fragments may fly up to 1,000 meters in all directions.
3	Concussion	Buildings and AFV	Any	1,000	If personnel are wearing helmets, you may reduce the safe distance to 500 meters. Consider the strong blast effect when considering buildings as potential blast shelters.
4	Cratering	Roads and airfields	a.. Up to 2 kg	100	
			b. Up to 30 kg	300	
			c. Over 30 kg	500	
5	Mines	Piers Abutments Retaining walls	Any	500	
6	Borehole	Rock Masonry Concrete Brick	Any	300	
7	Breaching	Reinforced-concrete beams and slabs Mass-concrete walls and obstacles	Any	1,000	If personnel are wearing helmets, you may reduce the safe distance to 500 meters. Consider the strong blast effect when considering buildings as potential blast shelters.
8	Shaped	Concrete Steel	Any	1,000	When these charges are fired into the ground vertically, you may reduce the safe distance to 300 meters.
9	Bangalore Torpedo	Wire obstacles	—	a. All right angles to axis, 1,000 meters	
			—	b. In the line of the axis, 200 meters for standing personnel and 100 meters for prone personnel	
10	M180	Roads and airfields	1-15 kits	1,200	Fragments may fly up to 1,000 meters in all directions.

NOTES:
1. The air clearance required is the ground safety distance plus 500 meters above the explosive area.
2. The ship clearance required is the same distance as for the ground safety distance.

Note that these distances depend on the target configuration, not quantity of explosive.

Section II. Misfire Procedures

6-8. Nonelectric Misfires.

a. Causes.

Moisture in the time fuse, detonating cord, or explosives.

Time fuse not seated completely in blasting cap or in fuse igniter.

Breaks in time fuse or detonating cord.

Jagged or uneven ends on time fuse.

Blasting caps not seated securely in cap well or explosive.

Loose or improper detonating-cord installation.

Debris in the blasting cap.

Commercial blasting caps were not strong enough to detonate military explosives.

b. Prevention. You can minimize nonelectric misfires by taking the following precautions:

Prepare and place all primers properly.

Load all charges carefully.

Detonate charges with the proper techniques.

Use dual-initiation systems and, if possible, dual firing systems.

Use detonating cord for underground demolitions. Do not bury caps!

Perform tamping operations with care to avoid damaging prepared charges.

Avoid crimping blasting caps onto time fuse in the rain; seek a covered area out of the rain.

Ensure you completely seat time fuse when installing it into a blasting cap or fuse igniter.

c. Clearing Procedure.

The soldier who placed the charges should investigate and correct any problems with the demolition.

After attempting to fire the demolition, delay investigating any detonation problem for at least 30 minutes plus the time remaining on the secondary. Tactical conditions may require investigation prior to the 30-minute limit.

For above-ground misfires of charges primed with blasting caps, place a primed, l-pound charge next to the misfired charge and detonate the new charge. Each misfired charge or charge separated from the firing circuit that contains a blasting cap requires a 1-pound charge for detonation. Do not touch scattered charges that contain blasting caps; destroy there in place. For charges primed with detonating cord, use the procedures in paragraph 6-10 (page 6-10).

For a nonelectric cap that has detonated but failed to initiate a detonating-cord branch line, line main, or ring main, attach a new cap to the detonating cord, and then move to a safe place.

For buried charges, remove the tamping to within one foot of the misfired charge.

Constantly check depth while digging to avoid striking the charge. When within 1 foot of the misfired charge, place a primed, 2-pound charge on top of the original charge and detonate the new charge. If digging over the original charge is impractical, dig a new borehole of the same depth beside the original hole, l-foot away. Place a primed, 2-pound charge in the new hole and detonate the new charge.

6-9. Electric Misfires.

a. Causes.

Inoperable or weak blasting machine or power source.

Improper operation of blasting machine or power source.

Defective or damaged connections. (Short circuits, breaks in the circuit, or too much resistance in the electrical wiring are common conditions resulting in misfires.)

Faulty blasting caps.

Blasting caps made by different manufacturers in the same circuit.

Power source inadequate for the number of blasting caps in the circuit (too many caps, too small a blasting machine).

b. Prevention. Assign one individual the responsibility for all the electrical wiring in a demolition circuit. This individual should do the following:

Perform all splicing.

Install all blasting caps in the firing circuit. Do not bury caps!

Make all of the connections between blasting cap wires, connecting wires, and firing wires.

Inspect system for short circuits.

Avoid grounding out the system.

Ensure the number of blasting caps in any circuit does not exceed the rated capacity of the power source.

c. Clearing Procedure. Use the following procedures to clear electric misfires:

Make another attempt to fire.

Use the secondary firing system, when present.

Check the wire connections, blasting machine, or power-source terminals.

Disconnect the blasting machine or power source and test the blasting circuit. Check the continuity of the firing wire with a circuit tester.

Use another blasting machine or power source and attempt to fire the demolition again, or change operators.

When employing only one electrical initiation system, disconnect the blasting machine, shunt the wires, and investigate immediately. When employing more than one electrical initiation system, wait 30 minutes before inspecting. Tactical conditions may require investigation prior to the 30-minute limit.

Inspect the entire circuit for wire breaks or short circuits.

If you suspect an electric blasting cap is the problem, do not attempt to remove or handle it. Place a primed, 1-pound charge next to the misfired charge and detonate the new charge.

6-10. Detonating-Cord Misfires.

a. Detonating Cord. If detonating cord fails to function properly, take the following action:

Attach a new blasting cap to the remaining detonating cord, taking care to fasten it properly, and detonate the new blasting cap.

Treat branch lines in the same manner as noted above.

b. Detonating-Cord Priming. If the detonating cord leading to the charge detonates but fails to explode the charge, take the following action:

Do not investigate until the charges have stopped burning. Wait 30 minutes if the charge is underground.

Reprime and attempt to detonate the charge.

Scattered charges that do not contain blasting caps may be collected and detonated together.

For underground charges, dig to within one foot of the charge; place a primed, 2-pound charge on top or to the side of the charge; and detonate the new charge.

Section III. Transportation and Storage Safety

6-11. Transportation.

a. Regulations. Both military and commercial carriers are subject to regulations when transporting military explosives and other dangerous military materials within the United States.

AR 55-355 covers the transportation of explosives. When transporting explosives outside the United States, follow the regulations from the host countries as well. TM 9-1300-206 contains minimum safety requirements for handling and transporting military explosives and ammunition.

All explosives transport personnel must learn the local procedures and safety requirements.

b. Safety Procedures. The commander should assign a primary and assistant operator to each vehicle transporting explosives on public highways, roads, or streets. Whenever transporting explosives locally, operators must observe the following safety rules:

(1) Vehicles.

Ensure vehicles are in good condition. Inspect all vehicles intended for hauling explosives before loading any explosives. Pay particular attention to protecting against any short circuits in the electrical system.

When using vehicles with steel or partial-steel bodies, install fire-resistant and nonsparking cushioning to separate the explosives from the metal truck components.

Do not load vehicles beyond their rated capacities when transporting explosives.

Cover open-body vehicles hauling explosives with a fire-resistant tarpaulin.

Mark all vehicles transporting explosives with reflective placards indicating the type of explosives carried (TM 9-1300-206, Chapter 6).

Use demolition transports for explosives only. Do not carry metal tools, carbides, oils, matches, firearms, electric storage batteries, flammable substances, acids, or oxidizing or corrosive compounds in the bed or body of any vehicle transporting explosives.

Equip vehicles transporting explosives with not less than two Class 1-BC fire extinguishers for on-post shipments. Place the extinguishers at strategic points, ready for immediate use.

Keep vehicles away from congested areas. Consider congestion when parking.

Operate vehicles transporting explosives with extreme cam. Do not drive at a speed greater than 35 miles per hour. Make full stops at approaches to all railroad crossings and main highways. This does not apply to convoys or crossings protected by guards or highway workers (flaggers).

Keep flames at least 50 feet from vehicles or storage points containing explosives.

(2) Cargo (Explosives).

Never leave explosives unattended.

Never mix live and inert (dummy) explosives.

Secure the load of explosives in the transport to prevent shifting during transport.

Transport blasting caps separately from other explosives. Do not transport blasting caps or other initiators in the same vehicles carrying explosives. If both blasting caps and explosives must be carried in the same vehicle, separate blasting caps from the other explosives by carrying the caps in a closed metal container in the cab of the transport.

No persons other than the primary and the assistant operators will ride on or in a truck transporting explosives. Do not refuel a vehicle while carrying explosives except in an emergency.

(3) Fire. If fire breaks out in a vehicle transporting explosives, take the following actions:

Try to stop the vehicle away from any populated areas.

Stop traffic from both directions. Warn vehicle drivers and passengers and occupants of nearby buildings to keep at least 2,000 feet away from the fire. Inform police, fire fighters, and other emergency-response personnel that the cargo is explosives.

If the fire involves only the engine, cab, chassis, or tires, make an effort to extinguish the fire with fire extinguishers, sand, dirt, or water. If the fire spreads to the body of the transport or the cargo, stop fighting the fire and evacuate to a distance of at least 2,000 feet.

Do not attempt to extinguish burning explosives without expert advice and assistance.

6-12. Storage Safety.

a. Magazines. There are two types of magazines: permanent and temporary. Although permanent magazines are preferred, temporary or emergency magazines are frequently required when permanent construction is not possible. Field Manual (FM) 9-6 and TM 9-1300-206 give details on magazine storage of explosives. Consider the following when constructing magazines:

(1) Permanent.

(a) Placement. Consider acceptability of magazine locations based on safety requirements, accessibility, dryness, and drainage. Safety and accessibility are the most important. An ideal location is a hilly area where the height of the ground above the magazine provides a natural wall or barrier to buildings, centers of communication, and other magazines in the area. Hillside bunkers are not desirable because adequate ventilation and drainage are often difficult to achieve. Clear brush and tall grass from the site to lessen the danger of fire.

(b) Lightning protection. All magazines must have a grounded, overhead lightning-rod system.

Connect all metal parts (doors, ventilator, window sashes, reinforcing steel, and so forth) to buried conduits of copperplate or graphite rods in several places.

(c) Barricades. Install barricades around magazines; that is, there must be a substantial obstacle between magazines and inhabited buildings. For certain explosives, effective natural or artificial barricades reduce the required safe distance between magazines and railways and highways by one half. The use of barricades permits the storage of larger quantities of explosives in any given area.

Although barricades help protect magazines against explosives and bomb or shell fragments, they do not safeguard against pressure damage. TM 9-1300-206 gives more specific guidance on barricades.

(d) Security. Place guards at all magazines to prevent unauthorized personnel from gaining access to magazine facilities.

(2) Temporary.

(a) Placement. When permanent magazine construction is not possible, create temporary magazines by placing explosives on pallets to accommodate ventilation. Store the pallets in a well-drained bunker. Excavate the bunker in a dry area and revet the bunker with timber to prevent collapse. Alternatives are an isolated building or a light, wooden-frame house with a wedge-type roof covered with corrugated iron or tent canvas.

(b) Identification. Mark field-expedient storage facilities on all four sides with signs (TM 9-1300-206).

b. Temporary Storage. When necessary, store limited supplies of explosives in covered ammunition shelters. Ensure the temporary facilities are separated adequately to prevent fire or explosion from being transmitted between shelters. Piles of temporarily stored explosives should contain no more than 500 pounds each and be spaced no closer than 140 feet. Pile explosive components separately. Keep explosives, caps, and other demolition materials stored in training areas in covered ammunition shelters and under guard at all times. Local safety standing operating procedures (SOPS) and TM 9-1300-206, Chapter 4, are guides for temporary storage operations.

BACK TO COMMERCIAL EXPLOSIVES