Disclaimer: The material that follows is intended solely to make for a more realistic gaming experience by providing some detail on the use of explosives. The writers and posters take no responsibility for your stupid actions if you decide to try practical application.

Explosives for Millenniums End

Explosives and demolition work seem to occur fairly commonly in Millenniums End and there are not much in the way of rules or guidelines for their use. What follows is a compilation of eight documents posted to the Millennium's End mailing list some years ago. Combined with Ryan Pendergast's explosive damage rules, this should provide adequate information for most gamin situations.

Explosives Pt.1

We start with the basic types of explosives.

Black Powder

Black powder is a low explosive (changing from solid to gaseous state at the relatively low velocity of 400 m/s. Black powder burns to produce 3,000 times it's own volume of gas, and if contained, this will cause an explosion. Uncontained it will simply burn. Black powder is very sensitive to flame and spark, and does not require the use of a blasting cap or detonator. Black powder is used in time fuses, some igniters and detonators, and quite commonly in improvised demolition devices like pipe bombs.

Ammonium Nitrate (AN)

AN is one of the least sensitive explosives, requiring a booster charge for proper detonation. AN prill (pellets) is manufactured for use in agriculture as a fertilizer, making it one of the most produced chemicals in the world. AN prill (94%) can be can be mixed with fuel oil (6%) to form a free flowing, oxygen-balanced explosive mixture called ANFO. Because of it's low price, stability, and ease of use ANFO is a very common explosive in mining, quarrying, and construction. AN is very hygroscopic (water absorbent) and must be stored in air tight containers to insure reliable detonation. AN is used primarily in as a cratering charge, but as Oklahoma City showed, large quantities can be very destructive.

Amatol

Amatol is a mixture of ammonium nitrate (80%) and TNT (20%). It has been used as a substitute for TNT in bursting charges and as a filler for bombs and bangalore torpedoes (older varieties). Because it contains ammonium nitrate, the same precautions should be taken to keep it dry. Because of the TNT in Amatol, a booster charge is not required.

Trinitrotoluene (TNT)

TNT is the most common military explosive and as such, it is used to rate other high explosives (more on this when we get to tables and game effects in later posts). TNT is stable and is insensitive to shock, flame, spark, and heat. It can be melted at 84-degrees C, and in this state can be poured into molds and shaped charges. It is very shock sensitive when in a liquid state. To detonate TNT, a blasting cap or detonator is required.

Pentaerythrite Tetranintrate (PETN)

PETN is highly sensitive and is one of the most powerful military explosives. PETN is almost insoluble in water, making it a common base for underwater demolition charges. PETN is used in boosters, detonating cords, and some blasting caps. It is also used in composite explosives, combining it's high brisance (shattering effect) with the stability of other explosives (see Pentolite and M118).

Cyclonite (RDX)

RDX is highly sensitive and is one of the most powerful military explosives (a little less powerful then PETN). It is used alone as the base charge for most military blasting caps. When it is desensitized (don't know how that is done), it is used as a subbooster, booster, bursting charge, and demolition charge. The principal use of RDX is in composite explosives (see C-4).

Tetryl

Tetryl is used alone as a booster charge and a bursting and demolition charge in some composite explosives. Tetryl is more sensitive and powerful than TNT. However, Tetryl and composite explosives containing Tetryl are being replaced by RDX and PETN-based explosives which have increased power and brisance.

Tetrytol

Tetrytol is a composite explosive of tetryl and TNT (75% tetryl and 25% TNT). It is used boosters and demolition charges. Tetrytol is more powerful and brisant than TNT and less sensitive than tetryl.

Nitroglycerin

Nitroglycerin is one of the most powerful high explosives. It is comparable in force to RDX and PETN. It is used as the explosive base for commercial dynamites. Nitroglycerin is highly sensitive and is affected by extreme temperature. Due to the sensitivity and the difficulty in handling nitroglycerin, it is not used in military explosives.

Composite A3

A3 is a composite explosive containing 91% RDX and 9% wax, which coats the RDX particles, desensitizing them, and acts as a binder. A3 is used as a booster charge in some newer shaped charges and bangalore torpedoes. It is also used as the main charge in high explosive plastic (HEP) projectiles.

Composition B4

B4 is a composite explosive containing 60% RDX, 39.5% TNT, and 0.5% calcium silicate. It is used as the main charge in newer model bangalore torpedoes and shaped charges.

Composition C4

C4 is a composite explosive containing 91% RDX and 9% nonexplosive plasticizers. The primary use of C4 is as a stand-alone explsoive. It is highly brisant and is moldable over a wide range of temperatures (-70 to +170 degrees F). This is the famous "plastic explosive," looks, feels, and acts like putty – a gray-white material you can easily form and shape with your hands, in complete safety. Detonation requires heat and pressure. You can run an electrical charge through it (no bang), hit it with a hammer (no bang), burn it (no bang, but you will get a buzz from short exposure, prolonged exposure can be very harmful), but hit a burning chunk and BANG.

Dynamite

Dynamites are of two types – commercial and military. Their composition and uses differ.

Commercial Dynamite

Commercial dynamites contain nitroglycerin plus varying combinations of absorbents, oxidizers, antacids, and freezing point depressants. Dynamites vary greatly in strength and sensitivity depending upon, among other factors, the percentage of nitroglycerin they contain. Care must be taken in storage to keep the dynamite dry, and prevent the nitroglycerin from settling. Uses include land clearing, cratering and ditching, quarrying, and general demolitions.

Military Dynamite

Military dynamite is a composite explosive that contains 75% RDX, 15% TNT, and 10% desensitizers and plasticizers. Containing no nitroglycerin, military dynamite is more stable and safer to store and handle.

Foreign Explosives

All of my source books are American publications and thus give minimal coverage to foreign explosives. Most western aligned countries will use American or equivalent explosives. Eastern aligned countries use similar explosives, but also include such things as picric acid and guncotton. Picric acid is similar to TNT except that it corrodes metals and thus forms extremely sensitive compounds. I could find next to nothing on guncotton except that it has not been used in America for decades.

Explosives Pt.2

While part one dealt with the different types of explosives, part two will deal with the actual production charges used by the US military and sold to most of their client countries.

TNT Block Demolition Charge

Military TNT is issued in ¼-pound cylinders, and ½-pound and 1-pound blocks. All three charges have cardboard bodies and metal ends with threaded cap wells. The ¼-pound charge is used primarily for training purposes.

M112 Block Demolition Charge

The M112 is one of the most common explosive charges in US service. It consists of 1 ¼-pounds of C4 in a Mylar-film container with pressure-sensitive adhesive tape on one surface. The odd weight can make calculating charges difficult. Like most C4 products, the M112 can be cut and shaped to whatever size and shape desired.

M118 Block Demolition Charge

The M118 block demolition charge, or sheet explosive, is a block of four ½-pound sheets of flexible explosive packed in a plastic envelope. The explosive sheet is usually PETN based and measures ¼”x3”x12”. The M118 is designed as a cutting charge especially against steel targets.

M186 Roll Demolition Charge

The M186 is identical to the M118 demolition charge except the sheet explosive is in the form of a 50-foot roll on a plastic spool, rather then in sheet form. There is approximately 1-pound of explosives per two feet of M186. The M186 is most useful when a large quantity of steel needs to be cut, such as when taking out a bridge.

Ammonium Nitrate Block Charge

The An block charge is a watertight cylindrical metal container (7"Dx24"L) with approximately 30-pounds of AN and a 10-pound TNT-based booster charge. The 40-pound AN block charge was designed for cratering and ditching but can also be used in destroying buildings, fortifications, and bridge abutments.

M1 Military Dynamite

This is the military dynamite described in PT.1. M1 military dynamite is packaged in ½-pound paraffin coated, cylindrical paper cartridges which have a nominal diameter of 1 ¼ inches and length of 8 inches.

M183 Demolition Charge Assembly

The M183 or satchel charge consists of sixteen M112 demolition blocks and four priming assemblies for a total explosive weight of 20 pounds. The demolition blocks are packed into two bags, eight blocks per bag, and placed in an M85 canvas carrying case. Each priming assembly consists of a 5-foot length of detonating cord with an RDX booster crimped to each end and a pair of M1 detonating cord clips for attaching the priming assembly to the detonating cord main line. The M183 is used primarily in breaching obstacles or demolition of structures where large demolition charges are required.

M1A2 Bangalore Torpedo Demolition Kit

Each M1A2 kit consists of ten loading assemblies, or torpedoes. The torpedoes are steel tubes 5 feet long and 2 1/8-inches in diameter. The main charge of each torpedo is B4 (10.5 pounds) capped at either end by a booster charge of A3 (1 pound total). Nose cones and connecting sleeves are supplied with each kit, allowing the ten torpedoes to be assembled into one 50-foot tube and slid through an obstacle prior to detonation. Bangalore torpedoes will clear a path 3-to-4 meters wide through barbed-wire entanglements, heavy undergrowth, and bamboo. In minefield clearing, it will explode all A-P mines and most of the A-T mines in a narrow foot path, approximately 1 meter wide. Many of the mines at the sides of the path, however, may be shocked into a sensitive state. Thus extreme care is necessary in any further mine clearing.

Explosive Earth Rod Kit

The earth rod kit is a special explosives kit used to make holes 6 feet deep and several inches in diameter in earth or soft shale for demolitions or construction. The kit comes packed in a large wood case and includes enough material to make 100 holes. The primary component is the propelling charge M12, which is shaped much like a roll of toilet paper. The M12 charge is placed on the ground with a 6 foot rod in the middle, held vertical by a small tripod. When the M12 detonates it propels the rod deep into the ground. The rod is removed and linear demolition charge is lowered into the narrow hole. The linear charge creates a hole 1 ½-inches to 3-inches in diameter (dependent on the firmness of the ground).

Safety Fuse

The safety fuse consists of black powder tightly wrapped with several layers of fiber and waterproofing material. The burning rate may vary for the same or different rolls from 30 to 45 seconds per foot under different atmospheric and climatic conditions. Test each roll prior to using in the area where the charge is to be placed. Take particular precautions if used underwater, as the rate of burn is increased significantly. The outside surface becomes brittle and cracks easily in arctic temperatures. Safety fuse is packaged in 50-foot coils.

M700 Time Fuse

The M700 fuse is a dark green cord 0.2 inches in diameter with a plastic cover. The cover is smooth and has single yellow bands around the outside at 12-inch intervals and double yellow bands at 5-foot intervals for easy measuring. The burning rate is approximately 40 seconds per foot. However, test the burn rate in the same way as the safety fuse. The outside covering becomes brittle in arctic temperatures. M700 is packaged in 50-foot coils.

NOTE: Safety fuse and M700 are fully interchangeable, and I can find nothing that recommends one over another.

Detonating Cord

Detonating cord is a core of RDX or PETN in a textile tube coated with a thin layer of asphalt. On top of this is an outer textile cover finished with a plastic coating. It will transmit a detonating wave from one point to another as a rate between 20,000 and 24,000 feet per second. Detonating cord is often called PrimaCord and is used to prime and detonate other explosive charges. Alone it can also be used to breach light materials like small tree branches and wall board. Ends of the detonating cord should be sealed with a waterproof sealing compound. Avoid kinks or short bends in priming as they may sharply change the direction of detonation and cause a misfire.

Type	Class	Minimum weight of explsoive core per 1,000 ft	Nominal Diameter, inches	Maximum wieght (lb) of finished cord per 1,000 ft	Minimum breaking strength, lb
I	a	5 lb PETN	0.175	14	60
I	b	6 lb PETN	0.216	19	175
I	c	6.4 lb PETN	0.200	18	175
I	d	7 lb PETN	0.200	19	110
I	e	7 lb PETN	0.235	22	190
I	f	12.5 lb PETN	0.245	26	75
I	g	12.5 lb PETN	0.270	33	190
I	h	14.5 lb PETN	0.235	29.5	110
I	j	6.4 lb PETN	0.200	18	150
II	a	7 lb RDX	0.216	19	175
II	b	8.5 lb RDX	0.255	22	190

Blasting Caps

Blasting caps are used for detonating high explosives. There are two types of blasting caps – electric and nonelectric. Military blasting caps (M6 electric and M7 nonelectric) are used to detonate the less sensitive military explosives. There main charges are about double that of the commercial No.8 blasting cap which is used to detonate the more sensitive commercial dynamite and tetryl. Both military and commercial blasting caps are extremely sensitive and may explode unless handled carefully. They should never be stored or transported with other explosives. Electric blasting caps are used when a source of electricity such as a blasting machine or battery, is available. Military electric caps are instantaneous, while commercial can be either instantaneous or with delays ranging from 0.025 to 12 seconds. Each M6 requires one and one-half amperes of electricity to detonate. Nonelectric blasting caps may be initiated by a time or safety fuse, firing device, or detonating cord. Nonelectric blasting caps should not be used underwater, as they are difficult to waterproof.

M51 Blasting Cap Test Set

The test set was developed for continuity testing of electrical firing circuits.. The set is a self-contained unit with a magnetotype impulse generator that generates a very small electrical charge (1/4 amperes) to test the circuit, but without any risk of detonating the explosive charges.

M32/M34 Blasting Machine

Blasting machines are used to detonate electric blasting caps (such as the M6). Unlike the large T-handled plunger boxes of old, these machines are little larger then a stick deodorant and use a squeeze lever to generate the electric charge. Two or three squeezes in rapid succession should fire the charges, but no more then five should be necessary. The M32 is a 10-cap machine, producing an large enough elecrtic charge to fire 10 electric blasting caps connected in series. The M34 differs only in that it is a 50-cap machine, a black band around the base for identification.

M122 Demolition Firing Device

This device is the militaries main radio controlled detonation device consisting of two main components – transmitter and receiver. The M122 is issued in sets of one transmitter and 10 receivers in a form fitted case. The receiver has line of sight range of 2 miles. The receiver generates an electric charge large enough to fire up to 15 attached electric blasting caps. The receiver is not directly attached to the explosives, so it can be recovered and reused.

M10 Universal Explosive Device

The M10 is a small high explosive charge (RDX based) in a metal body with a universal fuse adapter. It is initiated by standard blasting cap. The chief function of the M10 is the conversion of loaded projectiles and bombs to improvised demolition charges and the destruction of abandoned ammunition.

M1 Concussion Detonator

The M1 is a mechanical firing device actuated by the concussion wave of a nearby blast. This allows the near simultaneous firing of several charges with out them being linked by wire or detonating cord. The M1 is crimped directly to a nonelectric blasting cap and placed so that the receiving end faces the primary charge. The effective range of the M1 varies depending on the range (and water depth for underwater use).

M1 Detonating ranges

Weight of initiating charge, pounds	In Water: Depth of Water, ft	In Water: Recommended Range 99% probability of detonation, ft	In Air: Recommended Range 99% probability of detonation, ft
0.5	2	10	--
0.5	4	50	--
0.5	6	80	--
0.5	8	80	--
2.5	2	20	12.5
2.5	4	80	--
2.5	6	90	--
2.5	8	150	--
5	--	--	14.1
10	--	--	18.8
15	--	--	21.5
20	2	20	25.2
20	4	80	--
20	6	180	--
20	8	160	--

M1A2/M2A1 Percussion Detonator

The M1A2 and M2A1 are 5 inch long and ¼ inch diameter metal tubes which are firing assembly and delay charge and are used for short delay detonation (timing and safety fuse typically not being used in under 2 foot lengths for safety reasons). They are crimped directly to a nonelectric blasting cap and differ only in that the M1A2 has a 15-second delay, and the M2A1 has a 8-second delay.

M60 Weatherproof Fuse Igniter

This device is designed to ignite a time (or safety) fuse in all sorts of weather conditions, even underwater if properly waterproofed. When the pull ring is pulled, it releases the striker assembly, allowing the firing pin to drive against the primer, which ignites the fuse.

Explosives Pt.3

In the first two parts we discussed explosives in general and US military explosives in particular. Now it is table time. Time to see the numbers and how one explosive compares to another.

Name	Principal Use	Velocity of Detonation (meters/second)	Relative Effectiveness as a breaching charge	Water Resistance
Black powder	Time fuse	400	0.55	Poor
Ammonium nitrate	Cratering charge	2700	0.42	Poor
Amatol	Bursting charge	4900	1.17	Poor

Military dynamite m1	Demolition charge	6100	0.92	Fair
Straight dynamite 40%	Demolition charge	4600	0.65	Good
(commercial) 50%	Demolition charge	5500	0.79	Good
60%	Demolition charge	5800	0.83	Good
Ammonia dynamite 40%	Demolition charge	2700	0.41	Poor
(commercial) 50%	Demolition charge	3400	0.46	Poor
60%	Demolition charge	3700	0.53	Poor
Gelatin dynamite 40%	Demolition charge	2400	0.42	Good
(commercial) 50%	Demolition charge	2700	0.47	Good
60%	Demolition charge	4900	0.76	Good
Detonating Cord	Priming	6100-7300	--	Excellent
TNT	Demolition charge	6900	1.00	Excellent
Tetrytol	Demolition charge	7000	1.20	Excellent
Tetryl	Booster charge	7100	1.25	Excellent
Pentolite	Bursting charge	7450	--	Excellent
Nitroglycerin	dynamite	7700	1.5	Good
Composite A3	Booster charge	8100	--	Good
Composite B4	Bursting charge	7800	1.35	Excellent
Composite C4	Demolition charge	8040	1.34	Excellent
PETN	Blasting caps, Demolition charges	8300	1.66	Excellent
RDX	Composite explosives	8350	1.60	Excellent
M112	Demolition charge	8040	1.34	Excellent
M118, M186	Cutting charge	7300	1.14	Excellent
M2A1 Bangalore	Clearing charge	7800	1.17	Excellent
TNT Demolition Charge	Demolition charge	6900	1.00	Excellent
AN Demolition Charge	Cratering charge	3400	.42	Good

Relative Effectiveness (RE) factor. Explosives vary in detonating rate or velocity (meters per second), as well as other characteristics, such as density and energy production. These characteristics determine their effectiveness for cutting, breaching, or cratering charges. The amount of explosives used is adjusted by a relative effectiveness factor , which is based upon the shattering effect of the explosive in relation to that of TNT.

NOTES: Finding the velocity and RE factor of most explosives was quite challenging so I was unable to double check most of the numbers with multiple sources. Most of the numbers come from US Army FM 5-25 Demolitions and Explosives so I think they are pretty accurate.

Commercial dynamite is also available in 80% charges, but because of the difficulty in handling these charges FM 5-25 omitted them and I was unable to find another source. (RE would be in the 1-1.2 range)

A3 and Pentolite seem to be unsuitable as breaching charges as FM 5-25 does not assign them a RE value.

Detonating cord contains insufficient explosive per length for use in breaching charges.

Explosives Pt.4

Now that we know the different explosives, it is time to look at putting them to work. First by setting up charges.

Crimping Caps

One of the most dangerous tasks in explosives work is unfortunately also one of the most common, that of crimping blasting caps onto time fuse and detonating cord. Blasting caps are one of the most pressure sensitive explosives and everyone has to be crimped onto a fuse or det cord to be useful. The bottom quarter inch is the only area of the blasting cap where the crimp can be safely applied, otherwise there is a fair risk of detonation. The currently accepted US Army process for crimping blasting caps is as follows;

"After the blasting cap has been seated, grasp the fuse or cord between the thumb and third finger of one hand so that the fingers are touching the open end of the cap. Place the forefinger over the closed end of the cap to hold it firmly against the end of the fuse or cord. Apply slight pressure on the closed end of the cap with the forefinger. Rest the crimpers on top of the thumb and third finger. Place the second finger on top of the crimpers to secure them. If using crimping pliers, fully close the pliers to complete the crimp."

When crimping blasting caps, make sure all other explosives are at least 2 meters away. If crimping onto det cord, make sure the det cord is not linked to other charges. If there is a detonation, you don't want every other charge going off with it.

Electric blasting caps do not requiring crimping as they come with 12 feet of wire already attached. The disadvantage of electrical blasting caps, is the complexity of wiring circuits with multiple charges spread over a wide area. Most of the time an electrical blasting cap will be used to initiate the main line, with all charges being detonated by det cord and nonelectric caps.

What do you do, when you don't have a blasting cap? Six inches of detonating cord equals the explosive power, however, it will not detonate the explosives as reliably as a cap because its power output is not as concentrated.

Main Line

The main line, is a detonating cord line that links all of the explosive charges. The main line is initiated by a blasting cap, either electric from a blasting machine or nonelectric from time fuse. Individual explosive charges are linked to the main line by branch lines which are tied into the main line by special clips or by a girth hitch with extra turn. When only a couple of charges are on the firing circuit, it is not uncommon for the last charge to be primed straight from the main line. If more then four charges are linked to the main line, it is wise to use a Ring Main, in which case all charges should be primed from branch lines.

A ring main is a main line that after branching from the last charge, loops back around and links to itself before the first charge. The ring main makes the detonation of all charges more positive because the detonating wave approaches the branch lines from both directions. Care must be taken to make sure the detonating cord does not cross over itself, one foot of clearance in all directions being a good distance.

Dual Priming

The risk of a bullet, fragment or unforeseen circumstance severing the main line is such that it is always advisable to dual prime. Dual priming requires two duplicate main lines complete with independent initiation systems, main and branch lines. Thus each charge is primed twice from different systems. This process greatly increases the material necessary for demolition but almost eliminates the chances of full or partial failure of detonation. Charges that utilize blasting cap wells, such as military dynamite and Ammonium Nitrate Demolition Charges, are only able to be directly primed by one blasting cap, thus for dual priming a 1-pound explosive charge with the second blasting cap is attached to the side of the main charge. Dual priming can be electric or nonelectric, or a combination of both. If both systems are nonelectric, the fuses should be as close to the same length as possible. The expense and weight of the extra blasting caps and detonating cord, may make you opt against dual priming, but the first time you have a misfire or the main line is cut, you will be very glad you did

Misfires

In the rare event that you have followed all the proper steps in setting up the demolition circuit and there is a misfire, these are the steps to follow.

Nonelectric misfire: Initiate the second firing system if dual priming was used. Wait 30 minutes (if possible) to insure the misfire is not the result of a defective powder train in the fuse (as a minimum safety measure, wait twice as long as the time fuse was supposed to burn). If the charges are not tamped, do not move or disturb; lay a primed 1-pound charge at the side of the misfired charge and fire. If the charge has no more than a foot of tamping, place a primed 2-pound charge on top of the tamping and fire. If tamped more than a foot, remove the material with a nonmetallic tool until less than a foot of tamping remains, prime with a 2-pound charge and fire.

Electric misfire: Attempt to fire the charge with a different blasting machine or operator. Initiate the second firing system if dual priming was used. Wait 30 minutes (if possible) to insure the charge is not burning. Disconnect the blasting machine and insure the firing wires are shunted. Have the personnel who placed the charges recheck all the circuit connections. Reattach the blasting machine and fire.

Note: With electric blasting caps, where there is no detonating cord to insure positive detonation, it is possible for the blasting cap to only partially fire. Called a ‘fizzle’, this partial detonation is rarely enough to detonate the main charge, but can generate enough energy to cause the charge to burn. Most military explosives will not detonate when burning, but they do become very sensitive to pressure, thus picking up a C4 charge, to investigate a misfire, that is burning internally could cause detonation.

Premature Detonation

Nonelectric: Premature detonations are very rare with nonelectric firing systems. Outside of operator stupidity the typical cause is time fuse with an irregular burn rate. As long as the fuse is tested prior to use, this should not be much of a concern.

Electric: Electric blasting caps can be prematurely detonated by induced current from radio-frequency signals caused by operating radios, radar, microwave or television transmitters. Portable transmitters (like personal radios) should never be within 50 meters of electric blasting caps. For higher power transmitters use the following table to determine minimum safe distance.

Peak transmitter power Watts	Minimum safe distance Meters
0 - 30	30
30 - 50	50
50 - 100	110
100 - 250	160
250 - 500	230
500 - 1000	305
1000 - 3000	480
3000 - 5000	610
5000 - 20000	915
20000 - 50000	1530
50000 - 100000	3050

What are the chances, the blasting cap will prematurely detonate if you are within the minimum safe distance? I could find no numbers, so the formula I use is guesswork. For every 10% within the minimum safe distance there is a 1% chance per power bracket of premature detonation (ie. A 30 watt transmitter has a 1% chance per 10% of safe range, a 50000 watt transmitter has an 11% chance per 10% of range). In other words, if you have been assigned to destroy a large transmitter, don't use an electric firing system, the results could be explosive. (Sorry for the bad joke, it is late.)

Explosives Pt.5

We have looked at the different explosives, and now it is time to figure out how much explosives we will need to blowup a particular object.

TIMBER-CUTTING CHARGES

Type of explosives used: Use dynamite or plastic explosives for tampered internal charges in boreholes. The cartridge size of dynamite and ability to mold plastic explosives make them convenient to emplace . Use a block explosive (TNT, tetrytol, and C4)for untamped external charges because they are easily tied or fastened tot he target. Use plastic explosives or sheet explosives for untamped external ring charges because they are easily fastened to and molded around the target.

Formula for tampered internal charge.
P = 0.004 x D x D
P = pounds of TNT required per tree
D = diameter of tree or least dimension of dressed timber, in inches.
Example: For a 15-inch tree, P = 0.004 x 15 x 15 = 0.90 or 1 pound of TNT

Internal Charge placement: Place the charge in a borehole parallel to the greatest dimension of cross section, and tightly tamp it with moist earth. If the charge is too large for one borehole, make two boreholes side by side in dimensional timber. On round timber, make two boreholes at approximately right angles to each other, but do not intersect. Tamp both boreholes and firefire the charges simultaneously.

Formula for untamped external charges.
$P = 0.025 \times D \times D$
P = pounds of TNT required per tree
D = diameter of tree or least dimension of dressed timber, in inches.
Example: For a 30-inch tree, $P = 0.025 \times 30 \times 30 = 22.50$ or 23 pounds TNT

Concentrated external charge placement: To be most destructive, concentrated charges should be rectangular, 1 or 2 inches thick, and about twice as wide as they are high. Place charges as close as possible to the surface of the timber (it is often useful to notch the tree to form a flat surface which also holds the explosives in place.) If the tree is not round and the direction of fall is of no concern, place the explosive on the widest face so that the cut will be through the least thickness. The tree will fall towards the side where the explosive is placed, unless influenced by lean or wind.

Ring Charge Placement: The ring charge is a band of explosives completely circling the tree. The explosives band should be as wide as possible, at least ½ inch thick for small diameter trees and 1 inch thick for medium- and large-diameter trees up to 30 inches in diameter (above 30 inches in diameter use either a concentrated external charge or internal charge). Use this technique when the direction of fall is not a consideration, but the elimination of stumps is important.

Formula for Abatis charges
$P = 0.002 \times D \times D$
P = pounds of TNT required per tree
D = diameter of tree or least dimension of dressed timber, in inches.

Placement of Abatis charges: Charges for making fallen-tree obstacles are placed as a concentrated external charge in the same way as for timber cutting except that they are placed approximately 5 feet above ground. The tree will fall toward the side where the explosive is placed unless influenced by lean or wind. (Trees for Abatis charges should be at least 24 inches in diameter and the charged should be placed so that they fall at a 45-degree angle towards the enemy.)

NOTE: Wood varies considerably in strength. In military deployments, a series of test shots are made to judge the strength of local wood. This is impractical in most Blackeagle operations, so some research into local trees before deployment would be advisable. For softer woods subtract 10-20% of charge size, for hard woods increase the charge size by 10-20%.

STEEL-CUTTING CHARGES

Explosives used: select steel-cutting charges for their cutting effect and adaptability to placement. Plastic explosives and sheet explosives are best because they have great cutting power, and can be easily molded into the grooves and angles of the target. TNT, on the other hand, is adequate, generally available, and cast into blocks that can be readily assembled and fixed, but not molded to the target.

Formulas for block explosive charges:

A) Compute charges to cut I-beams, built-up girders, steel plates, columns, and other structural steel sections using the following formula.

P = 0.375 x A
P = pound of TNT required per cut
A = cross-section area, in square inches, of steel member to be cut

B) The following formula is recommended for the computation of block cutting charges for high-carbon and alloy steel, such as that found in machinery.

P = D x D
P = pounds of TNT per cut
D = diameter or thickness, in inches, of section to be cut.

C) Use the following formula for round steel bars, such as concrete reinforcing rods, where the size makes charge placement difficult or impossible, and for chains, cables, and steel rods with a diameter of less than 2 inches (for round steel greater than 2 inches, use formula A).

P = D
P = pounds of TNT per cut
D = diameter, in inches, of section to be cut.

Formulas for Plastic and Sheet Explosives:

Note: Plastic and sheet explosives can be fitted to the target with little or no air gaps, and use calculation formulas that are based on the best charge configuration and shape, and not actual weight. To find the weight of the charge, first calculate the charge dimensions using the following formulas and then compare with M118 dimensions to find the weight.

1) Use the following formula for ribbon charges. If properly calculated and placed, the ribbon charge cuts steel with less explosives than standard charges. It is effective on noncircular steel targets up to 3 inches thick.

Charge thickness = ½ times steel thickness (minimum ½ inches of explosives)
Charge width = 3 times the charge thickness
Charge length = length of desired cut.

Note: Place the blasting cap in the middle of the ribbon charge

2) Use the following formula for saddle charges, to cut mild steel bars. This steel-cutting method uses the destructive effect of the end split or cross fracture formed in the steel at the end of the charge, opposite the end where detonation was started. Use this technique on round, square, or rectangular mild steel bars up to 8 inches square or 8 inches in diameter. This method uses a charge cut in the shape of a triangle which lays across the target, thus the name, saddle charge.

Thickness of charge = 1 inch (the thickness of a M112 C4 block)
Base of charge = ½ circumference (or perimeter) of the target.
Long axis of charge = circumference (or perimeter) of target.
Note: The long axis of the charge is laid along the target, and place the blasting cap at the apex of the long axis.

3) Use the following formula for diamond-shaped charge, to cut hard steel bars. The stress-wave method is a steel-cutting technique that employs the destructive effect of two colliding shock waves. The shock waves are created from an explosive charge simultaneously detonated at opposite ends. Use this technique on high-carbon steel and steel-alloy bars up to 8 inches in diameter or square in cross-section. As the name implies, this charge is diamond shaped.

Thickness of charge = 1 inch (the thickness of a m112 C4 block)
Long axis of charge = circumference (or perimeter) of target
Short axis of charge = ½ the circumference (or perimeter) of target
Note: Wrap the explosives completely around the target so the ends of the long axis touch. Blasting caps are placed at both ends of the short access and must be detonated simultaneously.

Explosives Pt.6

BREACHING CHARGES

Type of explosives used: TNT is the most commonly used breaching explosive because of it's low cost and availability, but any explosive that lists a RE factor may be used. The size and confinement of the explosives are more important because of the strength and bulk of the material to be breached. The metal bars in reinforced concrete will not be cut by breaching charges, so if it is necessary to remove them, cutting charges will have to be used after the breaching charge. For maximum effectiveness, place the explosives in the size of a flat square. The thickness of the charge depends on the amount of explosives.

< 5 pounds – 1 inch
5 to < 40 pounds – 2 inches
40 to < 300 pounds – 4 inches
300 pound or more – 8 inches

Calculation formula
P = R x R x R x M x T
P = pounds of TNT required
R = breaching radius (in feet)
M = Material Factor
T = tamping factor

Breaching Radius: The breaching radius is the distance from the charge to the edge of the object to be breached.

Material factor: The following table gives values for various types and thickness of material. if the type of material is questionable, always assume it is the stronger. Always assume masonry is first-class unless stated otherwise.

Material	R	M
Earth	All values	0.07
Poor masonry, shale, hardpan, good timber and earth	< 5 feet	0.32
	5 feet or more	0.29
Good masonry, concrete block, rock	< 1 foot	0.88
	1 to < 3 feet	0.48
	3 to < 5 feet	0.40
	5 to < 7 feet	0.32
	7 feet or more	0.27
Dense concrete, first-class masonry	< 1 foot	1.14
	1 to < 3 feet	0.62
	3 to <5 feet	0.52
	5 to <7 feet	0.41
	7 feet or more	0.35
Reinforced Concrete	< 1 foot	1.76
	1 to < 3 feet	0.96
	3 to < 5 feet	0.80
	5 to < 7 feet	0.63
	7 feet or more	0.54

Tamping factor: the following table gives tamping factor (T) for various charge placements and tamping levels. The charge should not be considered tamped unless a solid material (sand or dirt) is used, and of a thickness greater than the breaching radius.

Tamping and placement	C	Explanation
Center mass	1.0	The charge is placed equal distance from the sides of the target, and more then one breaching distance from top or base.
Full Tamped	1.0	The charge is placed against to target more than one breaching distance from the base, and tamped in all direction by more than one breaching distance.
Deep water	1.0	The charge is placed against the target more than one breaching distance from the base and underwater more than one breaching distance above the charge.
Elevated untamped	1.8	The charge is placed against the target more than one breaching distance, and untamped (or tamped less than one breaching distance).
Shallow water	2.0	The charge is placed against the target more than one breaching distance and underwater less than one breaching distance.
Base tamped	2.0	The charge is placed at the base of the target and fully tamped.
Base untamped	2.8	The charge is placed at the base of the target and untamped (or tamped less than one breaching radius).

Note: If the charge is not placed in direct contact with the target, the effects are greatly reduced (how much I cannot say for sure, but I use a 66% reduction in effectiveness, or three time the charge to do the same thing if not in direct contact.)

Number of Charges: The number of charges required to demolish a pier, slab, or wall is calculated from the following formula.
N = W / 2R
N = number of charges
W = width of pier, slab, or wall (in feet)
R= breaching radius (in feet)

If the N < 1.25, use one charge; 1.25 to < 2.5, use two charges; if 2.5 or more, round to the nearest whole number. The first charge is placed R distance from one side of the target, with the remainder of charges placed at a distance of 2R apart.

Counterforce charge: This special breaching technique is effective against comparatively small cubical or columnar concrete and masonry objects 4 feet or less in thickness and width. The target must have at least three faces free or be freestanding. If constructed of plastic explosives, properly placed and detonated, counterforce charges produce excellent results with a relatively small charge. The effectiveness results from the simultaneous detonation of two charges placed directly oppsite each other and as near to the center of the target as possible.

Charge calculation: The counterforce charge requires 1 ½ pounds of plastic explosive per foot of thickness of the target. Round fractions to the next highest ½ foot before calculating the charge.

Preparation and placement of the charges: Divide the amount of plastic explosives in half and make two equal charges. Place the two charges directly opposite each other.

Priming: The simultaneous detonation of both charges is required for best results. For electrical detonation, use electrical blasting caps wired in series to the same circuit. For nonelectric detonation, crimp nonelectric blasting caps to equal lengths of detonating cord. Prime both charges at the center rear point. Bring the free ends of the detonation cord together, and attach to detonation means (main detonating cord line or blasting cap linked to detonator).

Explosives Pt.7

For the most part, the use of cratering charges will be beyond the scope of most Millennium's End games. The large quantity of equipment, explosives, and time to prepare cratering charges would tax the capabilities of most ME cells.

CRATERING CHARGES

Selection of Explosives: All military explosives can be used for cratering charges, but the 40-pound Ammonium Nitrate Demolition Charge is the primary choice. Low velocity explosives are preferred over high velocity explosives for their greater ability of displacing soil and material.

Preparing boreholes: Boreholes are typically prepared by one of three methods; post hole augur, Explosive Earth Rod Kit (covered in Pt.2), or shaped charge. Hard-surfaced pavement must be breached before use of post hole augur or Earth Rod Kit. Use a 1-pound charge of explosive per 2 inches of pavement thickness, tamped with material twice as thick as the pavement.

M2A4 Shaped Demolition Charge: The fifteen pound M2A4 uses a booster of A3 and main charge of B4 for total of 11-1/2 pounds of explosives. The cone liner is made of glass. For maximum effectiveness, the M2A4 must be separated from the target, this 'standoff' distance allows the cone liner to be formed into to a narrow jet for maximum penetration. The standard standoff for the M2A4 is 7 inches, but consult the table below for variation based on the material to be breached.

M3A1 Shaped Demolition Charge: The forty pound M2A4 uses a booster of A3 and main charge of B4 for total of 27-1/2 pounds of explosives. The cone liner is made of metal. For maximum effectiveness, the M2A4 must be separated from the target, this 'standoff' distance allows the cone liner to be formed into to a narrow jet for maximum penetration. The standard standoff for the M2A4 is 15 inches, but consult the table below for variation based on the material to be breached.

Material	Specifications	M2A4	M3A1
Armor Plate	Penetration	12 in	20+ in
	Average diameter of hole	1 ½ in	2 ½ in
Reinforced concrete	Maximum wall thickness that can be perforated	36 in	60 in
	Depth of penetration on thick walls	30 in	60 in
	Average diameter of hole	2 ¾ in	3 ½ in
	Minimum diameter of hole	2 in	2 in
10-in concrete pavement with 21-in rock base course	Optimum standoff	42 in	60 in
	Minimum depth of penetration	44 in	71 in
	Maximum depth of penetration	91 in	109 in
	Minimum diameter of hole	1 ¾ in	6 ¾ in
3-in concrete pavement with 24-in rock base course	Optimum standoff	42 in	--
	Minimum depth of penetration	38 in	--
	Maximum depth of penetration	90 in	--
	Minimum diameter of hole	3 ¾ in	--
Permafrost	Depth of hole with normal standoff	4 in	7 in
	Diameter of hole with normal standoff	30 in	30 in
	Depth of hole with 30-in standoff	72 in	--
	Diameter of hole with 30-in standoff	1 ½ - 6 in	--
	Depth of hole with 50-in standoff	--	72 in
	Diameter of hole with 50-inch standoff	--	5 - 8 in
Ice	Depth of hole with 42-in standoff	7 ft	12+ ft
	Diameter of hole with 42-in standoff	3 ½ in	6 in
Soil	Depth of hole with 30-in standoff	7 ft	--
	Diameter of hole with 30-in standoff	7 in	--
	Depth of hole with 48-in standoff	--	7 ft
	Diameter of hole with 48-in standoff	--	14 ½ in
Graveled road	Depth of hole with 30-in standoff	7 ft	--
	Diameter of hole with 30in standoff	7 in	--
	Depth of hole with 60-in standoff	--	9 ft
	Diameter of hole with 60-in standoff	--	7 in

Note: Several hazards arise when creating boreholes with shaped charges. First is the fact that the boreholes can become very hot from the shaped charge, possibly prematurely detonating charges placed within. Secondly is that toxic fumes from the shaped charge can be trapped in the borehole, posing a risk to personnel placing the main charge. A fifteen to twenty minute wait will allow the borehole to cool and the fumes to escape. The process can be expedited with compressed air.

M180 Cratering Demolition Kit: This kit consists of a M2A4 shaped charge, a modified M57 electric firing device, a warhead (40 pounds of B4), a rocket motor, a tripod assembly, and a demolition circuit. The shaped charge, firing device, and warhead are permanently attached to the launch leg of the tripod. For safety reasons the rocket motor and demolition circuit are packaged separately and connected to the other components at the time of use. The kit weighs approximately 165 pounds. When fired the rocket motor propels the warhead down the firing leg, activating the M57 which fires the M2A4 shaped charge. The rocket motor drives the warhead down the borehole created by the M2A4 and detonates at the bottom. This will create a crater 6-8 feet deep, and 15-20 feet in diameter. Because of speed and ease of emplacement, the M180 is commonly used in the war on drugs for runway denial. Multiple M180s can be fired together to produce an exceptionally large crater.

Hasty road crater

This method takes the least amount of time for construction, based on the number and depth of boreholes, and requires the least explosives, but produces the least effective barrier because of its depth and shape. The method described forms a V-shaped crater approximately 6-7 feet deep and 20 feet wide, extending approximately 8 feet beyond each end borehole. The sides have slopes 25 to 35 degrees.

* Dig all boreholes to the same depth (recommended at least 5 feet), Space the holes 5 feet apart center to center across the road.
* Load the boreholes with 10 pounds of explosives per foot of depth (a single 40 pound AN charge in a 5 foot borehole will produce a satisfactory crater).
* Connect all charges to fire simultaneously. Use a dual firing system (covered in Pt.7).
* Tamp all boreholes with appropriate material (tamping is critical in cratering charges, otherwise all of the explosive energy goes out the borehole and you don't get a crater.)

Deliberate Road Crater

This method requires more time and explosives, but produces a more effective crater than the hasty method. The crater produced is V-shaped, approximately 7-8 feet deep, 25-30 feet wide, with sides sloping 30-37 degrees. The crater extends 8 feet beyond the end holes. Boreholes are 5 feet apart, center-to-center, in a line across the area to be cut. The end holes are 7 feet deep, and the others are alternately 5 feet and 7 feet deep. Do not place two 5 foot holes next to each other, double 7 foot holes to offset, placing the adjacent 7 foot holes close to the middle of the line. Place 80 pounds of explosives in 7 foot holes and 40 pounds of explosives in the 5 foot holes. Connect for simultaneous firing and tamp appropriately.

Note: For the most effective road crater, make the line of the crater at a 45 degree angle to direction of movement.

Ditching charges
Use this method of demolition for creating ditches to move water or as initial excavations for preparing a defense. Military dynamite works good for this type of demolition, because individual charges are quite small, and dynamite creates a more vertically directed ditch. The rule of thumb for ditching in average soil is to use 1 pound of explosives per cubic yard of earth to be removed. Charges are placed 18-24 inches apart in two parallel lines 24 inches apart, each charge approximately 30 inches deep. This should create a ditch approximately 4 feet wide and 3 feet deep. A second series of charges is placed in the base of the ditch 3 feet deep, 2 feet apart, and 18 inches between the two lines of charges. After the second firing the ditch should be 4 feet wide and 5-7 feet deep.

Explosives Pt.8

Everything we have discussed before, leads up to this, taking out the target. This is the area where analysis of the particular target and desired level of destruction play a major role. Every target is going to be different, requiring different amounts of explosives and placed differently to accomplish the same objective. Thus the manuals give only basic guidelines, and even then they are far to lengthy to be covered here (FM 5-25 devotes 28 pages to just the basics of bridge demolition alone). I have tried to cover the key points for a variety of targets, but unfortunately much of this work is left to the GM.

Level of Destruction

How much damage has to be done to the target to accomplish the mission goals? Does the client want the target turned into scrap or only unusable by the enemy for a short period of time? This is a critical consideration affecting how much explosives and how many charges are necessary (or if explosives are even necessary.)

Partial Destruction: Partial destruction renders the target unusable until repaired/replaced. When replacement is necessary, a significant portion of the original object are usable in the construction of the replacement.

Complete Destruction: Damage to the target is so extreme that no components can be used in the construction of the replacement.

Bridges

Bridges are hard to classify because they come in such a variety and are usually built on site to the needs of the location. Some general principles follow;

A) Give tension members priority because they are harder to repair than compression members. Tension members almost always require steel riveting or welding, while compression members can sometimes be replaced by cribbing.

B) Long steel members that require cutting in only one place to demolish the bridge should be further damaged to prevent their ready salvage by cutting or splicing (for complete destruction only).

C) If travel routes (roadways or canals) pass under the bridge, plan the demolitions so that any temporary piers that might be erected to repair the bridge will be located where they will block traffic.

D) If the distance from the base terrain to the bridge is great enough, the weight of the bridge can be used to assist in its destruction, reducing the amount of explosives needed.

E) If the bridge is to be cut at only one end, it should be the end opposite the enemy territory, requiring the enemy to cross the obstacle to repair the bridge.

Simple-Span Fixed Bridge: A simple-span fixed bridge is supported only at either end. It is perhaps the most common type of fixed bridge.

Partial Destruction - is difficult because any demolition will effect the entire span and may result in more than the desired damage to the abutments. If the base terrain is close enough, cut both trusses at one end. The bridge should come to a rest at an incline with the uncut end still on its abutment.

Complete Destruction - 1) Cut both trusses in the middle. This should buckle the trusses at both ends and damage the abutments. 2) If the bridge rests relatively close to a fast moving waterway, cut the upstream truss at both ends. The water beating against the dropped section will twist the remaining truss from the abutment and pound the bridge to pieces.

Continuous-Span Fixed Bridge: These bridges are basically the same as above except the are supported by one or more intermediate piers.

Partial Destruction - Cut the bridge midway between one abutment and the nearest pier. This will drop this small section, but should leave the remainder of the bridge intact for future use.

Complete destruction - Cut the span on each side of all the intermediate piers. The cuts should be at unequal distances from the pier so the sections will be unbalanced and fall, usually damaging the supporting piers in the process.

Swing Bridges: A continuous span that can be rotated on its central pier to provides clear passage for waterborne traffic.

Partial Destruction - The easiest method is to open the bridge and disable the rotating mechanism. This can be accomplished with little or no explosives and leaves the bridges in relatively good shape for future repair.

Complete Destruction - Complete destruction can be accomplished as discussed under Continuous-Span Fixed Bridge. Additional explosives should be used to destroy the rotating mechanism.

Bascule Bridge: The bascule bridge is more commonly referred to as a drawbridge. There are one or two arms that will fold upward out of the way of waterborne traffic. The bridge arms are usually balanced by couter weights (either above or below the bridge surface).

Partial Destruction - This can be accomplished by cutting the moveable arm (usually at the mid point) or by opening the bridge and disabling the operating mechanism.

Complete Destruction - This is accomplished by cutting the moveable arms (single arm bascule bridges should be cut in more than one location) and destroying the operating system.

Virtical Lift bridges: This type of bridge is characterized by a simple span that is raised between two towers, out of the path of water traffic.

Partial Destruction - The lift span is often quite delicate making partial destruction challenging. If continuous spans lead to the lift span, it is usually easier to cut one of these for partial destruction. If not, cutting the vertical lift span in the middle will prevent traffic but rarely damages the lifting mechanism.

Complete Destruction - 1) Cutting the counter weight cables will prevent the lift span from being raised, and the falling counter weights usually destroy the towers and the access leading to the lift span. 2) Raise the lift span and cut it at one end, the dropping span should take out one of the towers. 3) With the lift span down, cut the two support towers. With the counter weights near the top, the towers will crash down and if cut correctly take out the lift span and one access route.

Pneumatic Float Bridge: This is characterized by a rigid roadway supported by rubberized fabric made into airtight compartments and inflated with air.

Partial Destruction - Cut the anchor cables and bridle lines (either with explosives or axes). This will separate the bridge into sections and cause it to float away from the anchorage.

Complete Destruction - Because of the large number of watertight compartments in each float, it can require large volumes of smallarms fire to sink them. An easier way is with one turn of detonating cord around each float, which should be from a branch line.

Rigid Pontoon Bridge: Rigid pontoons are made from various materials such as wood, plastic and metal and are usually open.

Partial Destruction - The same as for Pneumatic Float Bridges.

Complete Destruction - Place a ½-pound charge on the upstream end of the bottom of each pontoon and detonate simultaneously. If the current is fast enough, it will often overturn the bridge before sinking it.

Roadways

Partial destruction can be accomplished by cratering charges, dropping overpasses or trees onto the roadway, or collapsing abutments. Trees are the least effective, but also require substantially less explosives then the other methods.

Complete destruction of roadways is all but impossible, since almost any damage can be repaired. The best that can be hoped for is that the enemy deems the damage to widespread and serious to justify repairs.

Railroads

The destruction of railroads with explosives should be done at vulnerable points such as curves, switches, frogs, and crossovers. These areas can be destroyed with small amounts of explosives (typically only 1-2 pounds) and is called *spot method*. Destroying straight sections is best accomplished by placing 1-pound charges on both tracks at 30-yard intervals, staggered from one side to the other. This allows a 150-meter section of track to be destroyed with only 20-pounds of explosives. To increase the destruction, cratering charges can be used to destroy the track bed.

Railway and Highway Tunnels

This is really beyond the scope of ME cells. Hasty demolition requires huge quantities of explosives, often 10,000 pounds or more. Even with prepared demolition chambers, it takes about 3000 pounds of explosives to destroy a tunnel. The best option for ME cells is to use cratering charges at the tunnel portals to create slides. ADMs are also effective at destroying tunnels, but hopefull no ME GM would allow their use.

Airfields

It is seldom possible to destroy an airfield completely because fo the great amount of explosives and time required. Instead the different components of the airfield should be prioritized as to mission requirements and dealt with individually. Runways and taxiways can be neutralized with cratering charges. Fuel and munitions stockpiles can be easily destroyed with incendiaries and small explosive charges. Buildings, communications, vehicles, and aircraft are covered below.

Aircraft & Helicopters

One charge large enough to turn an aircraft into scrap is an inefficient use of explosives. More efficient use of explosives can be made by using smaller charges to destroy critical components. 4-pound charges will destroy crankshafts, rotor hubs, and jet turbines. 1-pound charges will destroy instrument panels and electronics, control surfaces, engine components, and rupture fuel tanks.

Vehicles

Passenger cars con be completely destroyed by placing a 5-pound charge on the bottom of the engine close to the passenger compartment. A 1-pound charge placed under the driver's seat, electronically primed, and tied into the ignition system is a common form of assassination.

Larger vehicles can be destroyed by 4-pound charges on the axles and drive train. The engine can be destroyed by draining the oil and introducing sand or aluminum powder while the engine is running. At full throttle this takes very little time.

Armored vehicles by their very nature are difficult to destroy from the outside. Shaped charges placed over critical components is the easiest way. Small charges (5-pounds) can be used to jam the turret, destroy tires or break the track, and crack weapon barrels. If access to the inside is possible the engine can be destroyed as above, fuel tanks ruptured, instruments and electronics destroyed. Weapons can be destroyed with explosives and/or incendiaries.

Storage Tanks

Tanks filled with fuel or other combustibles are easiest to destroy with incendiaries. Tanks filled with nonflammables or empty tanks are best destroyed with charges against their bases or around outflow pipes. Full storage tanks can also be destroyed by an internal charge calculated on the basis of 1 pound of explosives per 100 cubic feet of capacity. The storage medium acts as taming and amplifies the shock wave. (Ever put an M80 in a gallon paint can? Same thing.)

Pipelines

Destroying pipelines is rarely efficient because of the ease of repair. If deemed to be necessary, the charges should be placed at junctions, valves, or corners. Destroying the pipe at underground or elevated locations increases the difficulty of repairs, If possible, pipes should be destroyed while under pressure. The pressure of the transported medium, combined with the explosive energy wave often ruptures the pipe well outside the explosive radius.

Communications

Destroying telephone lines rarely has a long term effect, but in the short term it can be very disruptive. If at all possible cuts should be made over natural obstacles such as rivers and recesses to increase the difficulty in repairing. Poles should be cut with external tree cutting charges and then burned. The telephone wire should be cut into small pieces to prevent it from being used in repairs. Telephone wires can also be damaged or destroyed by burning.

Transmitter towers can be dropped by cutting the support wires and using cutting charges at the base. If possible the tower should be dropped onto the transmitter building, transmitter power source or anything else that needs to be destroyed and will further damage the tower. Large towers should be cut into several pieces to prevent components from being used to make a smaller temporary tower. Remember that electric detonators should not be used near transmitters.

Transmitters and switchboards can be destroyed by manual means or small explosive charges. Power generators can be destroyed like engines (see vehicles) or with explosives.

Buildings

This is not the subtle implosion seen in civilian demolitions, where minimal collateral damage is the prime concern. The goal is to drop the building as quickly and efficiently as possible.

Masonry or concrete buildings: Destroy masonry or concrete buildings by placing breaching charges on the inside and at the base of external charges.

Wood or thin-walled buildings: Destroy wooden-frame or thin-walled buildings by fire. Another method is to close all doors and windows and explode on the ground floor a concentrated charge (dust initiator) equal to ¼ pound to 1-pound per cubic yard of volume.

Dust initiator: This device consists of an explosive charge (powdered TNT or C3; C4 will not properly mix with the explosives), an incendiary mix (two parts aluminum powder or magnesium powder to three parts of ferric oxide), and a suitable finely-divided organic material (dust) or a volatile fuel such as gasoline called a surround. A 1-pound charge (1/2 explosives, ½ incendiary mix), will effectively detonate up to 40-pounds of surround. At detonation, the surround is distributed throughout the air within the target and ignited by the incendiary material.

Steel-framed buildings: Destroy buildings with steel frames by first breaching the concrete or masonry where necessary to expose the vital steel members and then cutting them with explosive charges. Another method is the exposure of the building interior to extreme heat (1000 degrees Fahrenheit for 10 minutes); this will cause failure of the structural steel members.

Concrete-beam and Curtain-wall buildings: Destroy concrete-beam and curtain-wall buildings (constructed in such a way that the load is carried by reinforced-concrete beams and columns) by placing breaching charges inside the building at the base of the exterior wall and at the base of all intermediate columns on the ground floor.

Dams

Small earthen dams can be destroyed by placing cratering charges on the internal surface below the water line. The water not only acts as tamping for the charge, but also causes further damage when it rushes in to fill the void created by the detonation. Larger concrete dams are nearly impossible to destroy with conventional explosives (ADMs and specialized air delivered munitions will do the job). Outflow gates and hydroelectric components of the dam can be disabled with explosives, though the size usually requires large quantities.

Electric Power installations

Care should be taken so that the destruction does not exceed tactical demands. Destroy by cutting the windings of generators and motors, by placing and detonating a 2-pound charge inside the casings, or by pouring gasoline on the generators and lighting them. Short out generators by using metal powders or shavings. Break the shafts of motors and generators. Burst boilers with cutting charges.

Wells

Eliminating the water supply of an area can be one of the most efficient ways of causing a force to leave an area. Wells in soft soil are damaged beyond repair by charges that cut the lining. Destroy wells in rock and hard soil with little or no lining by exploding breaching charges 6 to 12 feet from the edge of the well and deep enough to secure good tamping. If time does not permit such preparation, explode a large charge halfway down and against the side of the well.

Bunkers

Bunkers aboveground, semi-buried, or underground are best destroyed by breaching the ceiling or cutting the structural members that support the roof. Walls are usually to thick and reinforced to efficiently breach.