UNITED STATES MARINE CORPS
Infantry Training Battalion
School of Infantry
Camp Lejeune, NC 28542-0161

AM1501
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STUDENT OUTLINE

INTRODUCTION TO URBAN MOBILITY

LEARNING OBJECTIVES FOR THIS LESSON

a. **TERMINAL LEARNING OBJECTIVE**.

(1) Given a target and specific breaching charge, determine the appropriate standoff distance in accordance with the Guidebook for Assault Entry Techniques, Volume I and II. (51TR.02.15)

b. **ENABLING LEARNING OBJECTIVES**.

(1) Given different types, amounts, and configurations of explosives used in assault breaching, compute the Net Explosive Weight (NEW) in accordance with the Guidebook for Assault Entry Techniques, Volume I and II. (51TR.02.15c)

(2) Given a list of choices, identify breaching hazards in accordance with the Guidebook for Assault Entry Techniques, Volume I and II. (51TR.02.16a)

STUDENT INFORMATION

OVERVIEW: The purpose of this lesson is to introduce you to Urban Mobility. This instruction applies directly to all other Urban Mobility lessons.

CLASS PREPARATION: Read this outline prior to class.

OUTLINE

1. PURPOSE OF BREACHING. Breaching is the method by which an assault team gains access to a hostile stronghold. Personnel assigned to the duty of breaching are known as "Breachers." The primary goal of the Breacher is to provide the assault force with rapid, positive and dynamic access to an objective through any obstruction (wall, door, roof, window, etc.). An assault force, during a breach, uses speed, surprise and violence of action to accomplish the mission. Without a successful breach to provide access to the objective, there is no assault and no assault results in a failure of the mission. A Breacher's knowledge of mechanical and explosive breaching, combined with the ability to penetrate any target encountered, substantiates the Breacher as an important asset of the assault force.

2. NET EXPLOSIVE WEIGHT.

a. **Definition.** Net Explosive Weight (N.E.W.) is the total amount of explosive material in a given charge expressed in a pounds of TNT equivalent.

(1) **N.E.W. Formula.**

(a) Every breaching charge is designed and constructed to defeat a specific target. These charges may be modified as necessary to ensure penetration on any given target. By calculating the N.E.W. for every charge, we will be able to determine the safest location for assault teams that will still allow rapid entry into the structure.

(b) There are 7000 grains in a pound; thus the 7000 grains are used to convert grains to pounds. All calculations are figured to hundredths (two decimal places) of a pound.

(2) **NEW = 7000 / W.**

(a) NEW is the net explosive weight in pounds equivalent to that of TNT.

(b) W is the weight, in grains, of **all** explosives in the charge converted to TNT equivalent.

(2) Example: You are given 96" of 50gr/ft detonation cord, and two blasting caps. The first step is to convert inches to feet. Simply divide 96" by 12" to achieve 8'. Next, multiply 8' by 50gr/ft detonation cord to achieve 400 grains. Since the blasting caps need to be converted to grams, multiply 13.5 grains by the number of blasting caps provided, to achieve 27

grams. Next, take the 400 grains of 50-grain detonation cord and multiply that number by the relative effectiveness factor (REF) of detonation cord that is 1.66 grains to achieve 43.2 grains. Next, take the relative effectiveness factor (REF) of a blasting cap (1.60) and multiply it by 27 grams to achieve 43.2 grains. Lastly, add all of the grains together (707.2 grains) and divide that number by 7000 grains to achieve .10 lbs of TNT equivalent.

3. STANDOFF DISTANCES. Net explosive weights calculations are used to determine the placement of the assault team, as well as the safe blast and fragmentation distances. Standoff distances are what allow the assault team to get as close to the target as possible with and without shielding from the blast. Standoff distances will also avoid damage to your equipment and prevent unnecessary injuries or casualties to the team. To determine your standoff distances take the achieved net explosive weight and apply it to the formula for calculating various safe-blast and safe-fragmentation distances form the point of the detonation.

(1) **D = K x W (cubed root)**.

(a) D is the distance in feet that a given pounds per square inch (PSI) value or safe-blast or safe-fragmentation will be found form the point of detonation.

(b) K or K-factor is the constant value taken from the table below. It is a conversion factor that has been calculated for various pressures expressed in PSI. To select a factor, determine how much pressure the team should withstand then select the K-factor across from that number. The level of pressure normally authorized for breaching is 3.4 PSI because the most susceptible damage is to the eardrums. Because you will wear hearing protection, 4 PSI has been set for the appropriate pressure level, which actually increases the level that can be withstood.

(c) W = the total weight of the explosives involved expressed as the equivalent of TNT.

0.99	1.00	**0.45**	0.77	**0.02**	0.27
0.98	0.99	**0.43**	0.75	**0.01**	0.22
0.95	0.98	**0.40**	0.74		
0.93	0.98	**0.38**	0.72		
0.90	0.97	**0.35**	0.70		
0.88	0.96	**0.33**	0.69		
0.85	0.95	**0.30**	0.67		
0.83	0.94	**0.28**	0.65		
0.80	0.93	**0.25**	0.63		
0.78	0.92	**0.20**	0.58		
0.75	0.91	**0.18**	0.56		
0.73	0.90	**0.15**	0.53		
0.70	0.89	**0.10**	0.46		
0.68	0.88	**0.09**	0.45		
0.60	0.84	**0.08**	0.43		
0.58	0.83	**0.07**	0.41		
0.55	0.82	**0.06**	0.39		
0.53	0.81	**0.05**	0.37		
0.50	0.79	**0.04**	0.34		
0.48	0.78	**0.03**	0.31		

Expolsion Effect		**K Factor**
Hazardous Fragmentation		500.01
	psi	
	0.07	300.02
	0.10	250
	0.50	75
	1	45
	2	30
	3	20
Blast Overpressure (psi)	**4**	18
	5	15
	6	14
	7	13
	8	12
	9	11
	10	10
	15	8
	20	7
	30	6
	40	5
	60	4
	100	3.5
	200	3

(2) **Using the formula**:

(a) Blast overpressure is based on the total amount of explosives involved, therefore if two are more charges are expected to be detonated at the same time, each is converted to TNT equivalent and the results are added together. All calculations are based on the combined weight.

(b) Fragmentation travel is based on a single charge. If two or more charges are supposed to be detonated at the same time, apply the distance formula to the charge with highest fragmentation potential or the highest explosive weight. The calculated safe-fragmentation distance should be regarded as a minimum value. Greater distances may be estimated to provide an extra margin of safety.

(c) Use the formula in the following manner:

1. Determine the N.E.W. involved, ensuring that answer in TNT equivalent.
2. Fine the cube root of the amount of N.E.W. (This can be found on the chart that is provided.)
3. Find the K-factor for the PIS value, either 18 for safe blast distance or 300 for safe fragmentation distance.

4. Multiply the K-factor by the cube root value for the N.E.W.
5. The distance is provided in feet and be used a radius in which anticipated blast overpressures and potential fragmentation hazards will be present.

(d) Example: Taking the N.E.W. from the previous example (.10 lbs of TNT equivalent), and incorporate it with the formula. Take the K-factor (18) and multiply and by it the cubed root of .10 lbs of TNT equivalent (.46415888336128), to achieve 8.354869900503002. Refer to the chart provided to determine the distance with shielding and without shielding. Use the K-factor (300) for the safe fragmentation distance.

*** Remember *** these calculations are for personnel who are unprotected in the open. The distance is provided in feet and can be used as the radius in which anticipated blast overpressure and potential fragmentation hazards will be present.

4. BREACHING HAZARDS. When an explosive is detonated, the explosive material is instantaneously converted into a rapidly expanding mass of gases. The explosive detonation will result in four fundamental effects (Blast pressure, Fragmentation, Thermal and Chemical), which can create great damage to the assault team, and in the area surrounding the explosion.

(a) **Blast Pressure Wave**: The first fundamental effect is a blast pressure. Detonation creates very hot, expanding gases, formed in approximately 1/10,000 of a second. These gases expand outwards at velocities up to 19,067 fps, exerting pressures of approximately 700 tons PSI, compressing atmosphere surrounding the point of detonation. This mass of expanding has rolls outward in a circular pattern from the point of detonation like a giant tidal wave, smashing and shattering any object in its path. The father the pressure wave travels from the point of detonation the less power it possesses until it dwindles to nothing. The blast pressure wave has two distinct phases, which exert two different types of pressures, the positive pressure phase and the negative pressure phase. In addition to blast pressure has distinct characteristics that are important to the breacher.

(1) **Positive Pressure Phase**: When the blast pressure wave is formed at the instant of detonation, the pressures

actually compress the surrounding atmosphere. The compressed layer of air becomes visible in some cases as a white, rapidly expanding circle. Known as the shock front, the layer of compressed air is the leading edge of the positive pressure wave. The shock front is only a fraction of an inch thick and is that part of the atmosphere that is being compressed before it is set in motion to become part of the positive pressure wave. It is this shock front and the positive pressure that it contains that causes damage. As the shock front, followed by the positive pressure wave, moves outward, it applies a sudden shattering hammering blow to any object in its path.

a. Example: Thus if it should strike an object such as a brick wall, the shock front would deliver a massive blow to the wall followed instantly by the strong winds of the positive pressure wave itself. The shock front shatters the wall and the positive pressure wave gives it a sudden and violent push that may cause all or part of the wall to topple in a directional way from the point of detonation.

b. The positive pressure phase lasts only a short duration. After striking the wall, the positive pressure phase wave continues to move outward until its power is dissipated over the distance traveled.

(2) **Negative Pressure Phase**: As the shock front moves outward it pushes the surrounding air away from the point of detonation. This outward compressing and pushing of air forms a partial vacuum at the point of detonation. When the shock front and positive pressure has dissipated the broad partial vacuum causes to compress and displace atmosphere to reverse its movement and rush inward to fill the void. This reverse movement of air is known as the negative pressure or suction phase. This displacement of air rushing back toward the point of detonation has mass, power, and though not moving with the same intensity as the positive pressure wave, it still has great velocity. This inward rush of displaced air will strike and move objects in its path. Using the previous example, when it strikes the brick wall, it causes additional portions of the already shattered and violently battered wall to topple in direction towards the point of detonation.

(3) Pressure phase comparison: **Blast waves, like sound waves will bounce off solid objects.**

a. A charge placed in a large diameter pipe will maintain its strength for a greater distance. This is due to the reflection of the blast wave reinforcing itself.

b. Blast waves can also bounce off natural barriers, i.e., hills, low clouds, etc.

(4) Shielding of the pressure wave: Because the wave will bounce, a person can shield himself from the blast. Tests have shown that a person behind a shield will feel approximately half of the shock waves pressure.

(b) **Fragmentation**: Any item in close proximity to the charge may be hurled outward at the velocity of a bullet. These fragments may be toxic (lead, etc.) and hot. A hot fragment may ignite any fuel it encounters. The blast will also cause a cloud of debris that will make visibility difficult.

(c) **Thermal**: An explosion creates a flame mass at the point of detonation. A low explosive flame will last longer than a high explosive. The explosion may cause structural fires. The bright light of the flame may cause problems to an entry team wearing night vision devices.

(d) **Chemical Asphyxiation**: The chemicals used in explosives may create a toxic gas when ignited. Construction materials may also create this cloud when they are breached with explosives.

5. TYPES OF BLAST PRESSURE.

1. In addition to having phases, the blast effect creates various types of pressure phenomenon. Some of these pressures can cause major problems for the Breacher and the assault team. Because of this the Breacher needs to understand blast and the pressures generated. The blast pressures created must be taken into account when ensuring suitable protection for the assault team.

(a) **Dynamic Pressure**. Dynamic pressure is the transitional pressure exerted on an object by the blast. This is in effect the pressure felt and damage caused by the impact of the shock front with the object. A person standing in the open, in the line of travel of a blast shock wave, will be exposed to dynamic pressure.

(b) **Incidental Pressure**. Incidental pressure is felt behind a barrier. Measured at 90 degrees from direction of travel and is approximately half of dynamic pressure. Incident pressure is equal to one half the dynamic pressure.

(c) **Reflective Pressure**. Reflective pressure is a rapid build up of a pressure that occurs when a shock front strikes any surface in the line of travel. When this occurs, there is a rapid amplification of pressure as a result of the piling up and reflection of the wave off the surface. Rapid build-up of force when a shock wave strikes a surface. A pressure wave striking a surface will bounce at twice its original strength.

(d) **Residual Pressure**. Residual pressure is the amount of overpressure built up in a space as a result of detonation. Essentially it is the sum of all pressures felt in a confined space.

6. HAZARDS FROM THE FUNDAMENTAL EFFECTS OF AN EXPLOSION.

(a) The fundamental effects of an explosion create other hazards that must be considered by the Breacher when determining his method of breaching.

1. **Structural Fires**. Generally, the structural fires originate not from the detonation of the explosive, rather, from broken and shorted electrical circuits, or ruptured natural gas/fuel lines.

2. **Structural Damage**. Explosive breaching inflicts a degree of structural damage upon the target by design. To ensure team safety, Breachers must be aware of building construction methods and take target characteristics into consideration during the planning process. In many cases, structural damage from blast pressure will cause false ceilings, lights, wallboard, etc., to fall or become dislodged.

3. **Reduced Visibility**. Visibility is hindered in three ways will create problems for the breacher and the assault team.

    a. During low-light conditions, personnel will experience a loss of night vision due to the bright flash or fireball at the instant of detonation.

b. Smoke created from detonation can make finding the entry hole difficult and within the target can make identification very difficult.

c. Debris such as fiberglass and drywall dust floating in the air will mix with this smoke obscure vision within the target.

7. **TYPES OF BLAST INJURIES**. Knowing what effects an explosion will have on personnel will assist the breacher in planning what explosive techniques to use for an assault and how to minimize injuries to the team. The blast injuries are broken down into the following categories:

a. **Overpressure**. Overpressure in direct relation to the explosion and the separation distance of personnel from the blast.

(1) Head.

a) Ears: Ear injury is the most likely overpressure related injury to the head. Eardrums rupture from overpressure as low as 3.4 PSI. Within an enclosed area of 1000 cubic feet a charge of just over .10 lbs of TNT Equivalent, will cause eardrum damage.

(2) Torso. The threshold for lung damage is 40 PSI, which is the equivalent to standing unshielded, five feet away from a 1-pound charge of TNT detonating in the open.

(3) Extremities. Extremities will release at a PSI of 220, which is the equivalent to standing unshielded, closer than three feet from 1-pound charge of TNT detonating in the open.

b. **Fragmentation**. The injury potential of fragmentation is dependent upon shape, speed of impact, size, and impact location.

(1) Head and Neck. Among the very sensitive areas are the brain and the brain stem. The eye is particularly vulnerable to fragmentation injury as its threshold for perforation can be as much as two times lower than that for skin.

(2) Chest and Abdomen. Sensitive areas in the abdomen include the solid organs, spinal cord, major blood vessels, and gastro-intestinal tract.

(3) Extremities. Minor to extreme injuries can result in amputations.

c. **Impact**. Though not well understood, impact injuries can be fatal and play a major role in the survivability of an individual exposed to an explosion. There are two types of impact injuries; acceleration and deceleration.

(1) Acceleration. Acceleration injuries can be induced two ways. The first is the blunt trauma received when a body part is impacted by a projectile or fragment. The second is a blast induced body acceleration caused by the collision of the blast pressure wave on the victim's body.

(2) Deceleration. Deceleration injury occurs when an accelerated victim impacts a rigid surface following an explosion.

d. **Heat**. Burn injuries from explosive charges can be divided into two categories, those caused by flash of detonation or fireball and those caused by a longer duration contact burn.

8. PROTECTIVE MEASURES.

a. Safe Blast Distance Calculations. When a known quantity of explosive is detonated, the extent of its effects can be predicted using an established formula. The severity and type of damage to structures and personnel at given distances from the detonation can then be calculated. Like wise, necessary safety distance for Breachers to avoid injuries can be determined. Blast overpressure and fragmentation normally retaliate equally away from the point of detonation. The blast pressure and fragmentation velocity decrease as the distance from the point of detonation increases. A plot of specific PSI values and the safe-blast or safe-fragmentation distances would result in circles/rings around the point of detonation. The size of the rings is in proportion to the amount of explosive detonated.

1. The general guidelines and distance tables for demolition safety requirements are contained in:

    a. NAVSEA OP 5 Volume 1, Ammunition and Explosives Ashore

    b. NAVSEA SWO060-AA-MMA-010, Demolition Materials.

    c. Urban Mobility Advanced Course Guidebook

b. Fragmentation Distance. When in the vicinity of the detonation of high explosive, the resulting fragmentation/missile hazard must be reduced to an acceptable level. As you will notice, the safe fragmentation distance far exceeds the safe pressure distance for any given charge. Since the safe fragmentation distance won't allow an expedient entry it is the responsibility of the breacher to recommend measures to protect the team from missile hazards. The following guidelines are provided for planning considerations.

c. Charge Placement. Place charges so that the fragmentation and missiles will be thrown away from personnel or structures that should not be damaged. Also, the charge can be placed such that the doorframe, or other solid structure protects the team from fragmentation and acts as a reflector for the blast. Do not place unnecessary items on the top of charges.

d. Explosives. Always use the least amount of explosives necessary to perform the mission. Consider the use of explosives that produce the least amount of fragmentation when possible. Attempting to use explosives that do not produce fragmentation may not be acceptable in all situations. FLSC is much more efficient than either sheet explosive or ECT. More efficient explosives allow the breacher to use considerably less to do the same amount of work. The large decrease in explosive weight overcomes the disadvantage of fragmentation. As discussed earlier, the hardest hazard for Breachers to overcome is blast overpressure.

e. Fragmentation Adapters. Fragmentation adapters are devices or materials that shield the breacher from the fragmentation effect. These adapters do not always stop all fragmentation, but do tend to reduce the effect significantly.

f. Distance and Proper Positioning. This is the single-most important factor in reducing hazards to personnel. Each person can and must do his part to ensure personal safety and the safety of those around him. The following rules apply for maintaining distance and proper positioning:

(a) Limit the number of personnel to the absolute minimum needed in the immediate vicinity of the detonation.

(b) Take full advantage of any available cover during detonation. If no cover is available, use the breacher blanket. The breacher blanket has been designed to provide a protective barrier for Breachers. It provides protection from both fragmentation and related explosive effects.

g. Protective Equipment. Wear ALL appropriate personal protective equipment (fire retardant assault suit, hood, and gloves, goggles, elbow and knee pads, ear protection, body armor, helmet, etc.) when conducting explosive breaching operations.