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FIELD MANUAL

EMPLOYMENT OF ATOMIC DEMOLITION MUNITIONS (ADM)

HEADQUARTERS, DEPARTMENT OF THE ARMY

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CHAPTER 1

INTRODUCTION

1-1. Purpose

This manual provides guidance for commanders and staff officers in the operational and logistical aspects of atomic demolition munitions (ADM) employment. In addition, ADM target analysis techniques and emplacement methods are discussed for engineer personnel and nuclear weapons employment officers.

1-2. Scope and Organization

a. This manual is applicable to ADM employment and emplacement for surface and subsurface (including underwater) bursts.

b. Complete coverage of ADM employment, operational concepts, and target analysis is provided in two separate field manuals:

(1) This manual provides doctrine on unclassified aspects of ADM operations applicable to active nuclear warfare. It contains US Army concepts for ADM employment, and the command and staff actions required to carry out those concepts. Detailed procedures regarding ADM target analysis techniques and methods of emplacement are also presented. This text presents data concerning a family of hypothetical atomic demolition munitions designed specifically for use in unclassified ADM instruction. Illustrative problems in target analysis employ unclassified data extracted from hypothetical effects tables.

(2) Classified information concerning ADM currently within the United States stockpile is presented in FM 101-31-2. It provides tabular data necessary for target analysis and presents information concerning technical procedures which are not a part of this manual because of security clasification. It is designed for use in active nuclear combat.

(3) The presentation of the ADM effects tables in both texts is similar. Differences in data between stockpiled ADM and the family of hypothetical ADM are intentional. Proficiency in the use of hypothetical effects tables, however, insures facility in the use of the actual effects tables.

c. This manual is in consonance with the international agreements listed below. Applicable agreements are listed by type of agreement and number at the beginning of each chapter.

TITLE	NATO STANAG	STANAG CENTO	SEATO SEASTAG
Orders to the Demolition Guard Commander and Demolition Firing Party Commander	2017	2017	2017
Friendly Nuclear Strike Warning to Armed Forces operating on Land	2104	2104	
Target Analysis—Nuclear Weapons	2111		
Employment of Atomic Demolition Munitions (ADM)	2130		

1-3. Changes

Users of this manual are encouraged to recommend changes or provide comments to improve its clarity or accuracy. Comments should be keyed to the specific page, paragraph, and line of the text to which they refer. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to the Commanding Officer, US Army Combat Developments Command, Fort Belvoir, Virginia 22060, to facilitate review and follow-up.

1-4. Concepts of ADM Employment

The doctrine in this manual is based on the following national policy and concepts:

a. The US Army is organized and equipped to fight in nuclear and nonnuclear war and under the threat of nuclear warfare.

b. ADM are employed within the theater of operations in accordance with national policy and when their use is authorized by the theater commander.

c. Once the use of ADM has been authorized, responsibility for ADM employment is normally decentralized to the lowest tactical echelon capable of conducting ADM mission planning, coordination, and execution; for example, a division, an armored cavalry regiment, or a separate brigade.

d. ADM are primarily employed against materiel targets rather than personnel, thus constituting an addition to the present family of military explosives. Their use parallels or complements those of conventional demolitions. Employment of ADM rather than conventional explosives is usually dictated by the resultant savings in time, manpower, and logistical effort.

e. ADM are employed in conformance with tactical requirements to deter the enemy and deny the use of key structures and installations. Lowest possible yields consistent with military and political necessity are employed to prevent civilian casualties, overdestruction of manmade and natural features, or unacceptable radiation hazards.

f. A commander employing ADM coordinates with unit commanders in whose area militarily significant nuclear effects are expected to extend. Lacking concurrence, authorization to employ the demolotion is requested from the commander who exercises military control over both affected areas.

g. ADM, with their nuclear characteristics and consequent massive destructive potential, are subject in large measure to the same command and control procedures as the other members of the nuclear weapons family; i.e., mission planning, security, logistics, troop safety, target analysis, and authority to fire.

h. Special considerations applicable to the employment of ADM by US Army Special Forces are set forth in FM 31-21, Special Forces Operations; and (S) FM 31-21A, Special Forces Operations (U).

CHAPTER 2

ADM CHARACTERISTICS AND EFFECTS

Section I. GENERAL

2-1. Introduction

a. The employment of ADM requires a basic understanding of nuclear effects, particularly those resulting from subsurface bursts; the response of targets to these effects; the distance at which secondary damage or casualties may be expected; the influence of various environmental conditions; and the variability of predicted results.

b. This chapter presents a general qualitative discussion of the nuclear effects of ADM and their military significance; DASA (Defense Atomic Support Agency) EM-1 (formerly TM 23-200) should be consulted for details regarding specific nuclear phenomena.

2-2. Description of Nuclear Detonations

a. Release of Energy. Two types of nuclear reactions produce energy, fission and fusion. The energy released (yield) by either type of reaction is measured in thousands of tons of TNT energy equivalent (kiloton or kt) or in millions of tons of TNT energy equivalent (megaton or mt).

b. Effects Produced. The effects normally associated with any nuclear detonation are blast, thermal radiation, and nuclear radiation. Since ADM are normally detonated on or below the surface, there are two additional effects characteristic of their employment. These are cratering and ground shock.

(1) *Cratering.* Material near the munition is crushed, fractured, and displaced with large quantities being ejected beyond the immediate area of the point of detonation.

(2) *Ground shock.* Mechanical shock effects are produced by a high pressure impulse or wave as it travels outward from the point of detonation (burst point).

c. Effects Categories. For the purpose of evaluating the effectiveness and the hazards associated with ADM employment, it is convenient to group the effects into two categories.

(1) *Primary effects* include cratering, blast, and ground shock. These are the effects used to estimate damage to a target. Cratering is used to destroy massive targets, such as large bridges and dams and to create obstacles by excavating a great volume of material, as in producing craters or landslides. Blast is used to damage extensive surface targets such as depot complexes, port complexes, port facilities, or several separate point targets. Ground shock is effective in the destruction of underground targets such as installations, fortifications, and pipelines. Of the three primary effects, cratering is used most often in ADM employment.

(2) *Bonus and troop safety effects* include thermal radiation, initial nuclear radiation, residual nuclear radiation (fallout), and a high intensity electromagnetic pulse (EMP). These effects are not used in evaluating damage to a target. They are bonus effects when they cause additional damage or casualties to the enemy, and are troop safety effects when they present a hazard to friendly troops. Since ADM are normally employed in areas under friendly control, thermal and nuclear radiation are considered primarily troop safety effects.

d. Control of Effects. Since the bonus and troop safety effects constitute a potential hazard to friendly troops, and could even prevent the employment of ADM in many situations, such as in populated areas, or in areas too close to friendly forces or installations, it is desirable to reduce or eliminate these effects. In addition, in the execution of some missions, it may be desirable to reduce the blast effect to avoid damaging surface structures. Control of these undesirable effects can be accomplished by underground burial of ADM. *This is one of the most important characteristics of ADM employment.* Increasing the depth of burial can effectively reduce undesirable effects. At the same time the primary effect, crater size, is increased (para 6-5). The reduction of troop safety effects will usually allow the tactical commander to cover ADM obstacles with direct fire.

2-3. Damage Criteria and Radius of Damage

a. General. Data pertinent to the military employment of nuclear explosives have been developed through tests. These include—

(1) The magnitude of effects required to cause a particular degree of damage to a given target.

(2) The distance to which any given magnitude of effects extends from a given point of detonation and/or ground zero.

b. Damage Estimation. The prediction of the condition of a target after it has been attacked is termed damage estimation.

c. Degrees of Damage. Damage to materiel targets is classified as severe, moderate, or light. These degrees of damage are described as follows:

(1) *Light damage.* Damage which does not prevent the immediate use of equipment or installations for which it was intended. Some repair by the user may be required to make full use of the equipment or installations.

(2) *Moderate damage.* Damage which prevents the use of equipment or installations until extensive repairs are made.

(3) *Severe damage.* Damage which prevents use of equipment or installations permanently.

d. Criteria. Moderate damage is normally sufficient for most denial targets composed of military equipment or supplies. Severe damage is normally the criterion for hard targets such as field fortifications, dams, or bridges.

e. Radius of Damage. The primary tool used in estimating damage to the target is referred to as the radius of damage (R_D). The radius of damage is the distance from the ground zero (GZ) at which the probability of an individual target element receiving a specified degree of damage is 50 percent. Every nuclear burst produces a radius of damage for each associated target element and a degree of damage. For example, a munition will have one radius of damage for moderate damage to wheeled vehicles, another radius of damage for severe damage to wheeled vehicles, and another for casualties to protected personnel. For purposes of this discussion, all specified target elements within the radius of damage are assumed to receive the desired degree of damage.

2-4. Types of Bursts

Nuclear detonations may occur at any point from deep below the earth's surface to high in the atmosphere. Nuclear bursts may be classified according to the height at which they are detonated; that is, high altitude burst (air defense use), nuclear airburst, nuclear surface burst, nuclear underground (subsurface) burst, and nuclear underwater (subsurface) burst. Types of bursts normally applicable to ADM employment are subsurface and surface bursts. Two types of surface bursts are recognized. The near-surface burst, in which the fireball touches the surface, produces fallout, and has limited employment. The impact or contact surface burst (zero height of burst) is the type generally associated with ADM. The contact burst is defined below and is the type referred to as "surface burst" in this manual. For technical definitions of various heights of burst, see DASA EM-1.

a. Subsurface Burst. This type of burst (less than zero height) is generally used to cause damage to underground targets and to maximize cratering effects. The subsurface burst provides flexibility for the control of both initial and residual nuclear effects. *For example,* at optimum depths of burial for cratering (para 2-22), thermal radiation is eliminated, initial nuclear radiation and blast are greatly curtailed, and downwind distance of zones I, IA, and II for fallout are reduced to approximately 10 to 25 percent of that from a surface burst; moreover, in the case of subsidence craters (surface cave-in), nuclear effects on the surface are virtually eliminated.

b. Surface Burst. This type of burst (zero height) occurs when an ADM is detonated at ground level. It may be used for contact bursts to destroy structural targets such as bridges, canals, and dams, or for creating crater obstacles when burial is not practicable. Whenever fallout is not a limiting factor, the surface burst may be used; however, this is an inefficient use of ADM and requires much larger yields to achieve the same result. Burial is preferred.

Section II. ATOMIC DEMOLITION MUNITIONS

2–5. Components

a. The ADM is basically similar to any other member of the nuclear family. The main difference is that it is designed to be detonated in place either on or below ground level, or underwater. Thus the ADM is emplaced and detonated in a manner similar to the emplacement and detonation of the conventional explosive charge.

b. Generally, an ADM is composed of a combination of a warhead and an adaption kit as shown in figure 2–1. The nuclear warhead is developed by the Atomic Energy Commission (AEC), and is similar to those used in other members of the nuclear weapons family. The adaption kit normally consists of the following components:

(1) *Cables*. Connect various components of the firing system to the warhead.

(2) *Timer*. Triggers the firing device when the timer option is used.

(3) *Firing device*. Detonates the warhead when the proper signal is received from either the timer or remote control option.

(4) *Protective case*. Incloses and protects the warhead and other sensitive components; also allows for burial of the ADM underground or for placement underwater.

(5) *Decoder*. Decodes an incoming signal and triggers the firing device if the remote control option is used.

c. The adaption kit may be mated to the warhead in any several configurations as shown on the right of figure 2–1. The warhead is always placed in the protective case. The timer, firing device, and decoder can be separated from the warhead for remote control arming and firing or the applicable components can be mounted inside the protective case and armed from the outside for rapid emplacement and burial.

2–6. Characteristics of ADM

a. *Desirable Characteristics*. From an employment standpoint, the ideal ADM would possess the following characteristics:

(1) Small length and diameter.

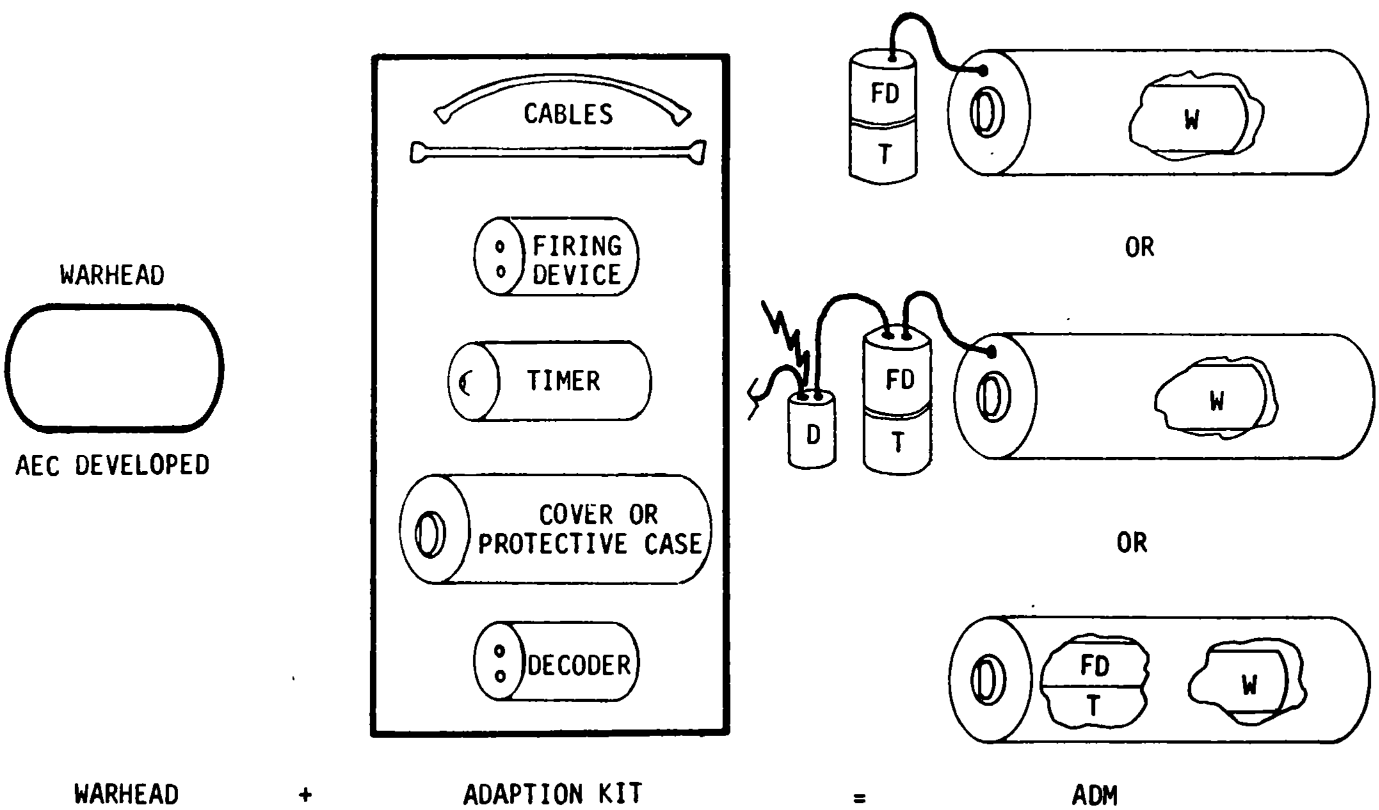


Figure 2–1. Components of an ADM, hypothetical family.

(2) Light weight, man-portable.

(3) Rapid preparation for firing for both the timer and remote options.

(4) Wide range of yield options.

(5) Low fission yields.

(6) Capability for underground burial and underwater placement to at least optimum depth of burial.

b. Constraints. Achievement of the above characteristics is constrained by reasons of economy, safety, control, and current technological capabilities. Factors which influence this are:

(1) Size and weight will increase with larger yields.

(2) Preparation for firing must be consistent with security, control, and safety requirements.

(3) Yield options are limited with any single warhead.

(4) Low yield warheads will be primarily fission.

(5) Practical limitations will be set on burial capabilities.

c. Configuration. An ADM with good employment capabilities can be achieved by a proper balance between the desirable characteristics and the limitations imposed by the constraints. Thus a large yield ADM would have a configuration similar to that shown in figure 2-2, and a smaller yield ADM would appear similar to the one illustrated in figure 2-3.

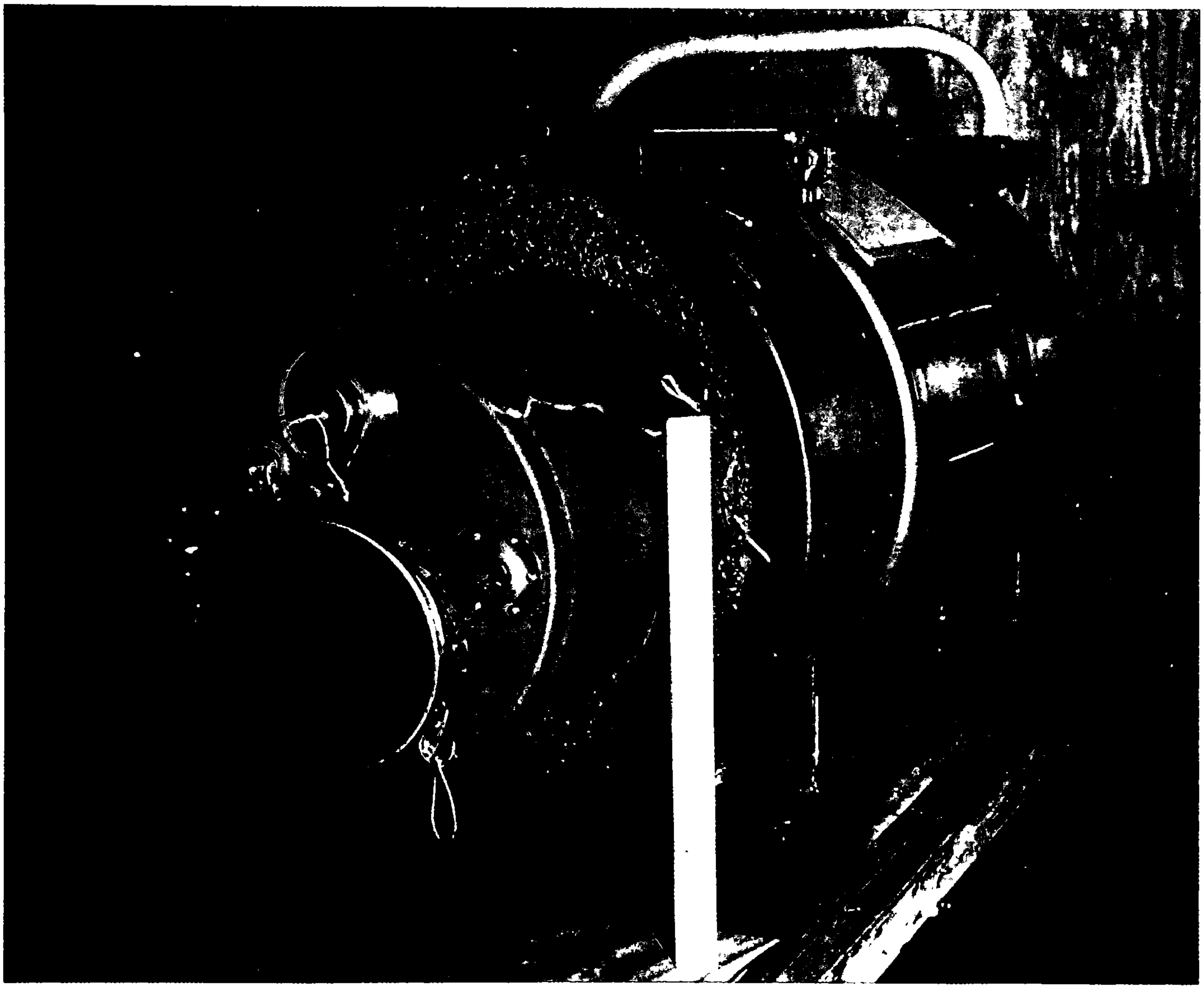


Figure 2-2. Large yield ADM.

Figure 2-3. Small yield ADM.

2-7. Hypothetical ADM

a. General. In order to plan for the tactical employment of ADM, commanders and staffs must be familiar with their inherent design characteristics. Features which influence ADM employment and emplacement are: available yields, emplacement dimensions, transportation weight, firing options, subsurface capabilities, and safe separation distance between ADM bursts. Because of security considerations, data pertinent to actual stockpiled ADM are not presented in this manual but are set forth in FM 101-31-2. In this manual, a hypothetical family of ADM is introduced to facilitate unclassified instruction in ADM employment.

b. Physical Data. Table 2-1 lists each ADM of the hypothetical family. For each model it gives the yield, canister length, minimum diameter of emplacement hole, and transportation weight.

c. Firing Options. Each ADM of the hypothetical family is considered to have a remote, on-call firing capability as well as a timer option. When using timer option, the time of detonation may be varied in 10-minute increments from 10 minutes to 1 hour and in 30-minute increments to 12 hours. Accuracy of the timer is assumed to be ±5 minutes per hour of time set on the timer.

d. Subsurface Capability. ADM of the hypothetical family are assumed to have both an underground and underwater capability, using a protective cover. For underground burial, backfill limitation is 10 meters. However, an ADM may be placed much deeper in a partially filled hole if the above backfill limitation is not exceeded. For underwater placement, depth limitation is 30 meters. Special adaption cases are assumed available to permit deeper emplacement in both the underground and underwater modes.

e. Separation Distance. Safe separation distances for ADM are required to insure that an emplaced ADM is not damaged by the detonation of another.

(1) *Separate detonation.* When ADM will not be detonated simultaneously, the safe separation distance for surface emplacement is assumed to be 1,000 meters for all yields; for subsurface emplacement near optimum depth of burial this distance is reduced to 500 meters.

(2) *Simultaneous detonations.* When ADM will be detonated simultaneously, the safe separation distance is assumed to be 500 meters for surface bursts. For any depths of burial greater than 1.5 meters this distance may be reduced to one crater radius.

Table 2-1. Hypothetical ADM Family

Model	Yield (kt)	Cannister length		Emplacement hole diameter		Transportation weight (pounds)
		feet	meters	inches	meters	
ALFA	0.01	3	0.91	15	0.38	100
BRAVO	0.05	3	0.91	15	0.38	100
CHARLIE	0.10	3	0.91	15	0.38	100
DELTA	0.50	5	1.52	30	0.76	500
ECHO	1	5	1.52	30	0.76	500
FOXTROT	5	5	1.52	30	0.76	500
GOLF	15	5	1.52	30	0.76	500

Section III. BLAST AND GROUND SHOCK

2-8. Blast

Blast accompanies all types of bursts except for a completely contained detonation.

a. An airburst detonated over most surfaces produces a greater radius of damage against targets vulnerable to overpressure than would an equivalent-yield surface burst.

b. A surface burst is more effective than an airburst against targets requiring high overpressure to defeat when detonated on surfaces such as desert sand or dry soil.

c. A subsurface burst produces the least blast damage to military targets above ground since the major part of the total energy is used in cratering or is transmitted as ground shock. The deeper the ADM is emplaced, the less blast is produced.

2-9. Damaging Pressures

As the blast wave moves outward in all directions, it exerts two types of damaging pressures on materel targets in its path—

a. Overpressure. This is a squeezing or crushing force which surrounds the object and continues to apply force from all sides until the pressure returns to normal. At any given point away from ground zero, the highest overpressure reached during passage of the blast wave is called the peak overpressure for that point. Targets which are damaged primarily by overpressures are called *diffraction targets.*

b. Dynamic Pressure. As the blast wave moves away from the burst point, it is accompanied by high winds. Dynamie pressure is a measure of the forces associated with these winds. This pressure causes damage by pushing, tumbling, or tearing apart target elements. Targets which are damaged by dynamic pressure are called *drag-type targets.* Most materiel targets are drag-sensitive.

2-10. Ground Target Response to Blast

The blast effect of an ADM is important as a damaging agent against area targets. Most military equipment is drag-sensitive and is damaged primarily by dynamic pressure. Parked aircraft, buildings, and forests are damaged by a combination of overpressure and dynamic pressure, whereas landmines are detonated solely by overpressure.

2-11. Ground Shock

In general, ground shock may be likened to the blast wave phenomenon except that it travels through the earth. Like the blast wave, this shock wave travels outward from the point of detonation. The degree of transmission is dependent upon the soil properties and, in all cases, is attenuated much more rapidly than is blast. As a result the distance to which militarily significant damage to an underground target occurs does not generally extend beyond the plastic zone (para 2-21). Within the region of the rupture and plastic zones, however, sufficient damage to most underground structures occurs to seriously impair the operational capability of personnel and equipment. Weak, shallow-buried structures and some utility pipelines may be damaged by induced ground shock as the blast wave passes over the surface.

Section IV. THERMAL RADIATION

2-12. General

Thermal radiation is the heat and light produced by a nuclear explosion and may extend to great distances dependent on the yield of the munition and the type of burst. Within the atmosphere, thermal radiation exhibits characteristics similar to those of light.

a. Both light and thermal radiation travel at the same velocity.

b. Both travel in straight lines unless scattered or reflected.

c. Both are easily absorbed or attenuated.

2-13. Effect of Depth Burst on Thermal Radiation

a. Approximately 35 percent of the total energy released by a nuclear detonation in free air is emitted from the fireball in the form of ultraviolet, visible, and infrared radiation. The intensity of the thermal radiation received at a given location from a surface nuclear detonation is less than that received from an air burst of the same yield because of attenuation by dust and water vapor in the atmosphere close to the earth's surface. DASA EM-1 provides a procedure for calculating this reduction of intensity.

b. In subsurface bursts, if the fireball is contained underground, practically all thermal radiation released by the detonation is used in the vaporization and melting of the media surrounding the device. Even for shallow depths of burst in which a portion of the fireball extends above the ground surface, the intensity of thermal radiation emitted is considerably less than for a surface burst.

2-14. Military Significance of Thermal Radiation

a. Thermal radiation may constitute either a bonus effect or a hazard with regard to ignition of forest or urban areas.

b. When considering the safety of friendly troops, thermal radiation is an important factor since second degree burns may produce noneffectives.

c. Dazzle (temporary loss of vision) during daylight is usually not an important consideration. However, at night, loss of night vision may reduce combat effectiveness. To minimize the effect of dazzle and the number and severity of retinal burns, troops within the limit of visibility are warned, whenever possible, prior to the detonation.

Section V. NUCLEAR RADIATION

2-15. Initial Radiation

a. Initial nuclear radiation is that nuclear radiation which is emitted by a nuclear detonation *within* the first minute after the burst.

b. Nuclear radiation consists of a flow of subatomic particles; neutrons, alpha and beta particles, and gamma rays. Alpha and beta particles have a short range with little penetration capability; they are of no major significance unless beta emitters come in contact with the skin, or if either alpha or beta emitters are inhaled or ingested. On the other hand, neutrons and gamma rays have a range measured in hundreds or thousands of meters and are highly penetrating. Because of these ranges and penetration properties, only neutrons and gamma rays are considered in evaluating the effects of initial nuclear radiation.

c. Since neutrons and gamma rays interact with other particles in the air, they quickly become scattered in all directions. Adequate protection can be obtained only if the shelter is one which surrounds the individual.

2-16. Residual Radiation

Nuclear radiation emitted after one minute is termed residual radiation and consists primarily of gamma rays and beta particles emitted both from the neutron-induced radioactive soil elements and from the fission fragments in radiological fallout. Hazardous terrain areas from induced radiation are limited to a relatively small area around ground zero. Fallout, however, is characterized by an irregular pattern of hazardous radioactive contamination encompassing ground zero and extending downwind from ground zero, the distance depending upon the yield, wind conditions, and depth of burst. Residual radiation from this fallout contamination may also cause the airspace over the area of operations to be hazardous for limited periods of time while the fallout is being transported downwind and deposited on the ground.

2-17. Effect of Depth of Burst on Nuclear Radiation

With surface and shallow subsurface bursts, both initial and residual nuclear radiation effects are important factors. For deeper subsurface bursts, however, initial radiation is absorbed by surrounding media. In this situation, the radioactive material which escapes to the atmosphere is the only type of radiation hazard that need be considered. Furthermore, the residual radiation hazard area coverage for a specific ADM detonation will depend largely on the depth of burial, selected yield, and the direction and speed of the wind.

2-18. Radiation Measurement

For scientific and technical purposes, nuclear radiation is measured in a variety of units. For practical military use, however, all types of radiation are measured in *rad* which is a unit of measure for *absorbed* doses of radiation. A rad represents 100 ergs of nuclear (or ionizing) radiation absorbed per gram of absorbing material including tissue.

2-19. Military Significance of Nuclear Radiation

a. Induced radiation persists for a period of days; and, in general, decontamination is quite difficult. Consequently, the presence of induced radiation in the immediate vicinity of ADM targets enhances their obstacle value. On the other hand, the relatively small area affected may be easily bypassed if the terrain permits.

b. The large area contamination potential of fallout can introduce a significant operational difficulty or constitute a bonus effect.

c. With minor exceptions nuclear radiation has no destructive effect against materiel targets.

d. The casualty producing potential of nuclear radiation makes it an extremely important troop safety consideration.

Section VI. CRATERING

2-20. General

When the ADM is detonated below or on the surface, the material near the munition is crushed, fractured, displaced, and some of it is fused. Great quantities of earth and rock are thrown out of the ground. Some of this material falls back into the resulting crater; most of the remainder falls onto the ground outside the crater although a small portion of the finer particles is carried up in a large dust cloud and is eventually deposited as fallout. The resulting crater is roughly parabolic in cross section (fig 2-4). Its dimensions depend mainly on the yield of the detonation, the depth of burial, and the characteristics of the soil media.

2-21. Crater Definitions

a. Figure 6-2 shows a cross section of a typical nuclear crater depicting pertinent crater dimensions and zones of disturbance.

(1) The *apparent crater* is defined as that portion of the visible crater which is below the preshot ground elevation. The apparent crater is of primary interest when considering military engineering applications involving excavation operations.

(2) The *true crater* is delineated by the boundary (below preshot ground level) between the loose, broken fallback material and the underlying material which has been crushed and fractured but has not experienced significant vertical displacement. The true crater dimensions are of primary interest to the engineer when considering applications involving the demolition of hard targets.

(3) The *lip* of the crater is composed of uplifted and deformed rock or soil with the upper

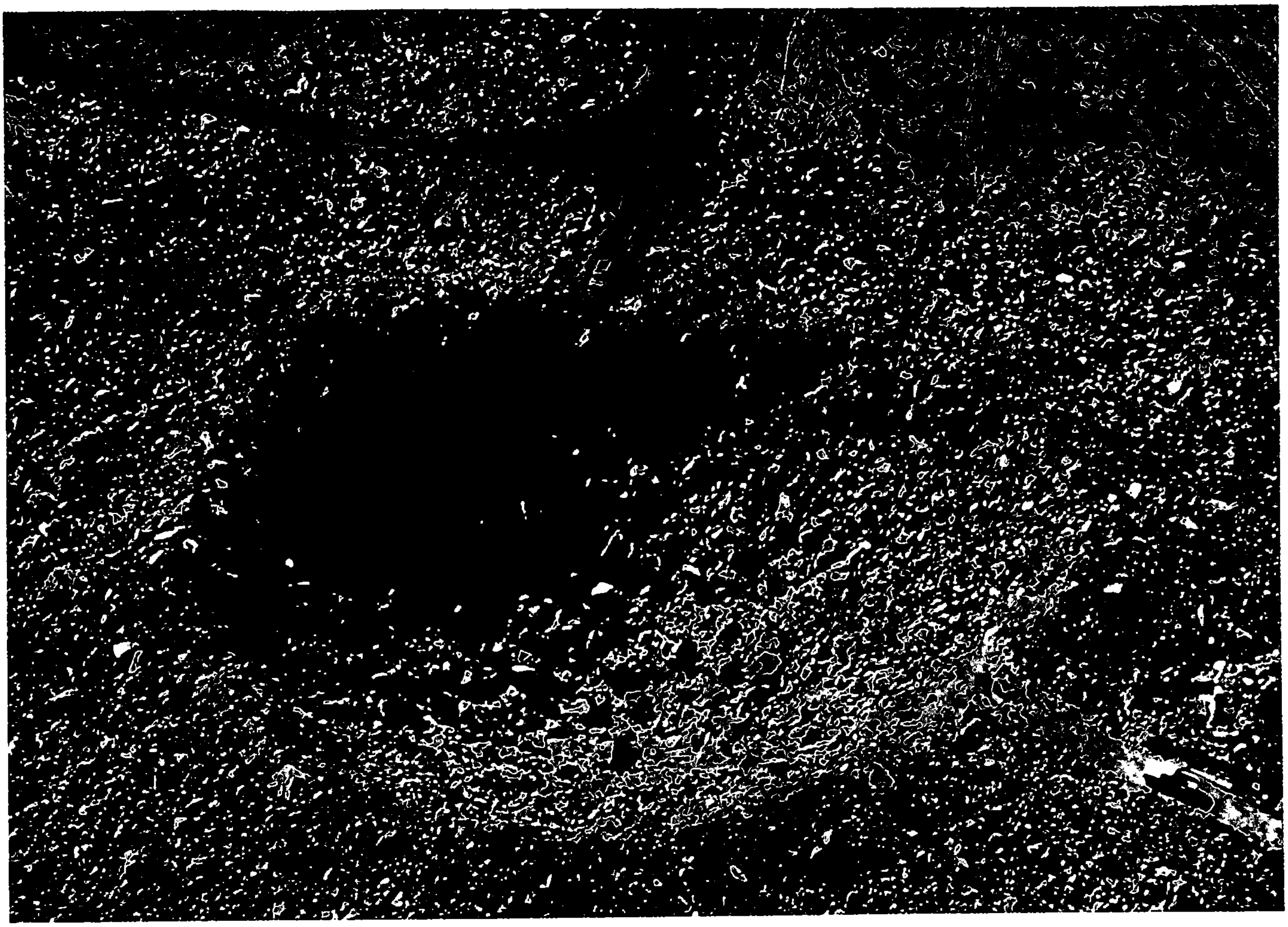


Figure 2-4. Typical nuclear crater.

portion of the lip consisting primarily of material which has been ejected and thrown out of the crater (*ejecta*). The dimension used for the initial obstacle size of the crater is the lip-to-lip distance, D_{AL}.

b. The zones of disturbance resulting from a nuclear cratering detonation in soil or rock are identified as the rupture zone and plastic zone. The undisturbed region beyond the plastic zone is called the elastic zone. The following definitions characterize these various zones.

(1) The *rupture zone* is that zone extending from the true crater boundary in which the stresses created by the detonation cause fracture and crushing of the material. In sand, the rupture zone may be difficult to define or may be nonexistent.

(2) The *plastic zone* is that portion of the cratered medium beyond the rupture zone in which the stresses created by the detonation cause permanent deformation but are not great enough to cause significant fracturing or crushing of the material. The transition from the rupture zone to the plastic zone is gradual. In the plastic zone small permanent displacements occur. These displacements decrease to infinitesimal values as the elastic zone is approached. In sand, it may be difficult to distinguish between rupture and plastic zones, and in hard rock, little or no plastic zone may occur.

(3) The *elastic zone* is that zone extending beyond the plastic zone in which no permanent fissures, cracks, or displacement of material is evident.

c. Subsidence Crater. At very great depths of burial in most media with the exception of hard rock, a crater results from the collapse of overlying material into the cavity formed. A crater created in this manner is referred to as a subsidence crater. Figures 2-5 and 6-4 show typical subsidence craters formed by a nuclear explosive detonated deep below the surface.

Figure 2-5. Typical subsidence crater.

2-22. Effects of Depth of Burial

a. Dimensions. The size and shape of the crater produced varies greatly with the depth of burial of the ADM. As the depth of burial increases, crater dimensions increase to a maximum at some optimum depth, then decrease until a depth of burial is reached where a subsidence crater may be formed. The relationships of depth of burial and crater formation are appropriate for most media. For a given energy yield, however, the maximum crater dimensions differ for various media and occur at different depths of burial.

b. Optimum Depth of Burial. Optimum depth of burial is that which produces, under prevailing conditions, the most favorable combination of crater dimensions for accomplishing the purpose of the intended crater. While the crater diameter will usually be the most significant consideration in optimizing crater dimension, adequate crater depth and side slopes are also important in producing a vehicular obstacle.

CHAPTER 3

COMMAND AND STAFF RESPONSIBILITIES IN ADM EMPLOYMENT

Section I. TACTICAL CONSIDERATIONS OF ADM

3-1. General

There are several important features of ADM that the commander may advantageously employ to support tactical operations. Since ADM are emplaced without delivery error, the most efficient use of nuclear energy is achieved. ADM can accomplish missions which might normally be prohibitive for conventional explosives because of the logistical effort involved. The destruction of massive structures or missions that require moving large quantities of earth, such as blocking defiles or tunnels, are easily within the capability of ADM. The size of the munition makes the time, manpower, and logistical support minor compared to that required for conventional explosives. Moreover, the control of ADM effects by proper preplanning provides the capability for large scale demolition with troop safety distances significantly reduced.

3-2. Offensive Operations

ADM are employed in the offense by the tactical commander as an economy of force measure to rapidly create obstacles which impede or deny enemy movement. ADM may be used to—

a. Contribute to flank and rear security.

b. Impede a counterattack.

c. Assist in enemy entrapment.

3-3. Defensive Operations

a. The obstacles produced by ADM are readily incorporated into defensive barrier systems. ADM also increase the effectiveness of natural and man-made obstacles. In the defense when time, equipment, and manpower are critical, ADM may be employed to:

(1) Block avenues of approach by cratering defiles or creating rubble.

(2) Sever routes of communication by destroying tunnels, bridges, and canal locks, or cratering roads.

(3) Create areas of tree blowdown and forest fires.

(4) Crater areas including frozen bodies of water subject to landings by hostile airmobile units.

(5) Create water barriers by the destruction of dams and reservoirs.

b. As with other man-made obstacles, the obstacles created by ADM should be tied in to natural obstacles to increase barrier effectiveness. They should also be covered by direct and indirect fire.

3-4. Retrograde and Denial Operations

a. The mission of retrograde operations—the trading of space for time—is significantly assisted by the employment of ADM. Obstacles are extensively used, and the availability of nuclear yields in easily transported packages makes ADM well suited for incorporation into the operational plan.

b. ADM can be employed against denial targets considered difficult or impossible to destroy with conventional explosives. These targets may be tactical or strategic. A significant tactical target may have an impact on strategic as well as tactical operations. Such a target might be a large railroad bridge that is included in the theater denial plan to deny the enemy use of the railway system. Since the same bridge affords the enemy a means of breaching a major natural obstacle, it is also included in a barrier plan. A significant strategic target has only a strategic impact. It has no immediate impact on tactical operations. Such a target might be a hydroelectric power plant. Destruction of the plant will have no significant impact on local tactical operations. Normally, tactical targets of interest to a commander in accomplishing his mission are included in the barrier plans of divisions, corps, and field army, unless restricted by specific orders or policies of higher commanders. Responsibility for destruction of these barrier targets flows through command channels. Responsibility for some significant tactical and strategic denial targets requires coordination at all levels of command, since specific targets may be of such overwhelming importance to the theater, theater army, or army group commander's mission, that he is unwilling to delegate authority for their destruction.

3-5. Response Time

The time necessary to analyze the target, secure the emplacement site, deliver and prepare the ADM for firing, emplace the munition, and warn friendly units significantly affects the manner in which ADM are employed. As a basis for general tactical planning, two hours is assumed to be the average time for a reasonably well-trained ADM team operating in daylight under favorable conditions to prepare and emplace a hypothetical ADM with remote options on the surface or in a previously prepared position. If only timer option is used, planning time may be reduced to one hour. Blackout operations, enemy interference, elaborate emplacement techniques, or severe weather conditions may considerably extend this period. Moreover, transportation time to pick up the ADM at a special ammunition supply point (SASP) and to deliver it to the emplacement site must be taken into account. Obviously, each target presents varied circumstances which affect response time and require individual consideration prior to ADM employment. Response time may be materially reduced by thorough training, preplanning, prechambering emplacement positions, and the establishment of effective ADM standing operating procedures (SOP).

Section II. COMMAND AND STAFF PROCEDURES

3-6. General

Planning for the employment of ADM involves the same command and staff procedures normal to planning any tactical operation. The command, intelligence, operational, and logistical procedures are carried out concurrently rather than sequentially. ADM missions are implemented by plans and orders formulated under the guidance of the tactical commander during staff planning.

3-7. Allocation of ADM

a. Because of the combat potential afforded by ADM and their limited number, the commander carefully controls the supply, expenditure, and resupply of this type munition. ADM fall into the category of special ammunition, which is ammunition specially designated by the Department of the Army because of unique requirements in control, handling, and security.

b. An allocation of ADM is a specified number of complete ADM that a commander may plan to expend during a specified period of time or during a specified phase of an operation. Allocation of ADM does not include authority for their expenditure. The authority to expend ADM may be granted concurrent with their allocations or at a later date. Additional authority is required for actual dispersal of allocated ADM to locations desired by the commander to support his plans. A commander cannot authorize the expenditure of an ADM unless he has been specifically authorized to do so; or unless he is disposing of the munition in compliance with emergency denial operating procedures. Procedures for disposition of excess ADM are found in FM 9-6.

c. The duration of the allocation periods generally is dictated by the commander's concept of the operation. He allocates ADM for the period during which he can visualize the operation. He retains ADM in reserve for those periods that he cannot visualize, i.e., for employment against targets of opportunity and for use during later phases of the allocation period. The duration of an allocation period differs at each echelon of command. The field army commander may be allocated ADM for a longer period than the corps commander and the corps commander for a longer period than the division commander.

d. Reserve maneuver forces receive only a planning allocation until committed; at this time, they may be assigned a portion of the reserve allocation.

e. A commander who allocates ADM to a subordinate command may withdraw or change that allocation as required. Reduction in an allocation is made only when absolutely essential and with as much prior notification as possible.

3-8. Command Guidance

a. The magnitude and nature of nuclear effects have a profound influence on ground operations. Therefore, command guidance to the staff before commencement of planning is essential. If there is little time for staff planning, this guidance may consist of an immediate decision by the commander to employ ADM. When more time is available, the guidance may include specific courses of action for staff consideration during the development of staff estimates.

b. In developing his initial staff planning guidance, the commander considers the requirements of all the general staff. In addition, he provides guidance for the staff engineer, the artillery commander, the chemical officer, and other concerned staff officers. The commander provides additional guidance as required throughout all planning phases up until the time the ADM mission is executed.

c. It is essential that commanders and staff officers generally understand the capabilities and limitations of ADM, the combat service support requirements involved, and the procedures for employing these munitions. These officers receive technical advice from nuclear weapons employment officers (NWEO) and engineers on matters relating to the use of ADM.

d. Initial staff planning guidance normally falls into the following categories: type of targets, allocation to subordinate units, desired ADM reserve, and acceptable degree of risk for civilian populations in the area. The commander's initial staff planning guidance for ADM employment varies in content with the echelon of command. Damage criteria and troop safety considerations are matters of standing operating procedures (SOP). Command guidance in these respects is appropriate only when departure from SOP is desired. Based on the SOP, the nuclear weapons employment officer and engineer determine the extent and nature of the damage desired and recommend the ADM best suited for that task. Similarly, the commander designates, whenever possible, negligible risk for his own and adjacent forces. The staff, without further direction, takes this into account in their operational planning. If greater than negligible risk must be taken or if friendly troops must be warned, the nuclear weapons employment officer includes this information as part of his recommendations. Creation of obstacles to friendly movement and similar undesirable effects are also matters of SOP not normally requiring specific guidance to the staff and nuclear weapons employment officers.

3-9. Staff Responsibilities

a. In planning the employment of ADM, certain specific responsibilities are allocated to the general and special staff. Coordination within the staff is continuous, and areas which tend to overlap are handled jointly or by specific command assignment.

b. The intelligence officer keeps the commander, subordinate units, and other staff sections abreast of potential ADM targets including their description and location. He also makes available timely information concerning weather, terrain, and significant enemy activities.

c. The operations officer has primary staff responsibility for the planning of ADM missions. He is responsible for the preparation of the atomic demolition plan, and he utilizes the advice and assistance of the engineer in carrying out this responsibility. The operations officer:

(1) Integrates the use of ADM with the scheme of maneuver.

(2) Disseminates warning information to appropriate higher, lower, and adjacent headquarters.

(3) Recommends the allocation of munitions to include the prescribed nuclear load and prescribed nuclear stockage.

(4) Evaluates potential ADM targets recommended by the intelligence officer and engineer.

(5) Requests detailed analyses of selected targets from engineer and fire support elements and incorporates the results of these analyses into the courses of action under consideration.

(6) Reviews and secures approval for the atomic demolition plan and ADM standing operating procedures.

(7) Assures integration of planned supporting fires with the atomic demolition plan when required.

d. The logistics officer considers the supply and distribution capability of the unit and, based on this information, advises the commander, the operations officer, and the staff engineer on the logistical feasibility of each course of action under consideration. He has primary staff responsibility for transportation, storage, maintenance, and distribution of ADM prior to their employment.

e. The artillery officer participates in ADM target evaluation in coordination with the operations officer and the engineer. The atomic demolition plan is incorporated into the fire support plan.

f. The chemical officer advises the commander and staff on fallout prediction, radiological survey, monitoring, and decontamination. He may also be designated to disseminate friendly troop warning messages through CBRE nuclear, biological, and chemical reporting channels.

g. The civil-military operations officer is informed of ADM targeting which will affect the civilian population and vital civilian facilities. He advises the commander and staff of any consequences which may adversely affect the accomplishment of the overall mission or constitute a violation of the commander's legal and moral responsibilities to the civilian population. He recommends warning or other measures as appropriate.

h. The surgeon advises the commander and his staff of effects on personnel from blast, thermal radiation, and initial and residual nuclear radiation.

3-10. Engineer Staff Officer

a. The Army, corps, or division staff engineer participates in preliminary conferences in which methods of carrying out the commander's plan are discussed. Targets and delivery means are considered and the engineer, when appropriate, presents recommendations for retention or elimination of specific nuclear targets. The engineer is particularly concerned with the effects of nuclear employment on terrain, such as cratering, tree blowdown, and radiological contamination; and the influence of these effects on the overall tactical plan and engineering requirements. He may assist in the evaluation of likely targets and propose employment of atomic demolition munitions.

b. When the commander decides to employ atomic demolition munitions, the engineer recommends the executing unit to control the mission. At corps level, the mission is normally assigned to the division responsible for the area in which the demolition sites are located. The mission may be accomplished by the division within its own capability; however, if the number of demolition targets warrant, the corps engineer recommends attachment of additional ADM teams. If the demolition site is not in a division area, but rather one of a smaller, independent unit, the corps engineer recommends the control arrangements appropriate to the circumstances and designates the emplacing and firing units. The executing unit may be a major tactical organization such as an armored cavalry regiment, a separate brigade, or an engineer combat group. In situations which require direct control of the demolition by the commander, the engineer may recommend the formation of a demolition task force and designate the engineer elements of the task force. Unless the mission has been assigned to a unit which has an ADM capability, the engineer is also responsible for providing ADM teams and additional engineer support. The capability of the engineers to support multiple ADM operations is primarily dependent upon the number of available ADM teams. Specifically, the engineer staff officer has special staff responsibility for the employment of barriers and the erection and reduction of obstacles. Therefore, he is the officer who prepares the atomic demolition plan under the supervision of the operations officer and through whom all matters concerning ADM are coordinated.

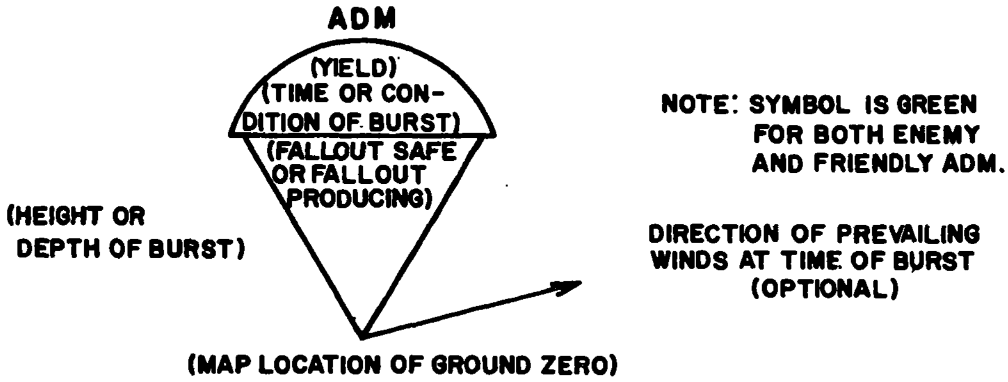
c. Commanders of engineer combat units, operating closely with other combat elements to form combined arms teams, function in the capacity of staff engineer for the supported unit. Under these circumstances, the engineer commander advises on engineering aspects of ADM employment, selects suitable ADM targets, and recommends the task organization to conduct ADM missions. The engineer commander coordinates ADM employment with other staff members of the combat maneuver unit to which he is attached or in direct support and maintains close liaison with higher engineer echelons and ADM teams.

3-11. Estimate of the Situation

An estimate of the situation is a logical and orderly examination of all factors affecting the accomplishment of the mission. As a result of the estimate, the commander decides the proper method of engaging each demolition target. Factors affecting the decision to employ ADM are included in the following discussion:

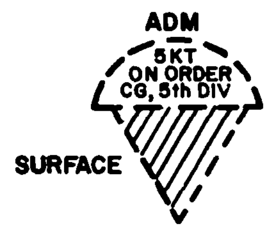
a. Target evaluation is the process of examining a target to determine its importance and to establish its priority. It encompasses an analysis of the tactical mission and an evaluation of target intelligence to include terrain and meteorological conditions.

b. Once targets have been evaluated and given a priority for destruction or denial, the commander compares the advantages of employing ADM to those of conventional demolitions. Most potential targets can be destroyed by employing ADM. However, targets are not considered suitable for ADM if conventional explosives can readily achieve the desired degree of destruction. The

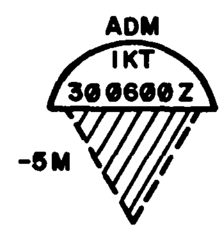


DESCRIPTION **EXAMPLES**

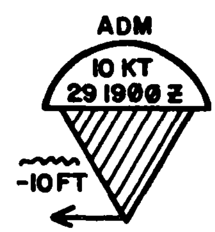
1. Proposed surface burst ADM (dotted lines), 5 KT, fallout producing (shaded stem), to be detonated on order of the Commanding General, 5th Division.



2. Emplaced but not detonated ADM (dotted stem), 1 KT, minus 5 meters underground, fallout producing, to be executed on the 30th of the month at Ø6ØØZ hours.



3. Executed ADM (solid lines), 10 KT, minus 10 feet underwater (below wave line), fallout producing, easterly prevailing wind, detonated on the 29th of the month at 19ØØZ hours.



4. Executed enemy ADM (double head), approximately 0.5 KT (brackets), fallout safe (no shading in stem), minus 200 meters underground, detonated on the 28th of the month at 14ØØZ hours.

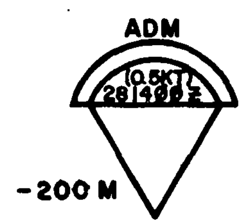


Figure 3–1. ADM map symbols.

general characteristics which denote a suitable ADM target are massiveness and extensiveness (table 3-1). The commander may choose to use ADM against less suitable targets when such use will save a significant amount of time, manpower, and materiel.

c. There are many other considerations which influence the decision to employ ADM against a target. For *example:*

(1) The availability of ADM is included in the estimate.

(2) The time available to employ ADM influences the decision.

(3) The ability of the enemy to interfere with ADM missions is also evaluated.

(4) The results of target analysis affect the estimate of the situation.

d. Before target demolition, circumstances may alter the commander's decision and cause modification or cancellation of a specific ADM mission. Such circumstances include adverse meteorological conditions, malfunction of the ADM, or an enemy threat to capture or destroy the munition. As a result, one or more of the following actions, which may necessitate return to the emplacement site, may be required: a change in detonation times, repair, recovery, or denial of the munition. It is, therefore, important that the commander be continually informed about changes in the tactical situation affecting ADM targets.

Table 3-1. Typically Suitable ADM Targets.

Massive
1. Earth fills
2. Valley defiles
3. Canal locks
4. Bridges
5. Dams
6. Tunnels
7. Underground facilities
8. Airfield runways
Extensive
1. Railroad marshaling yards
2. Sea and river ports
3. Utilities systems
4. Industrial complexes
5. High-speed, high-volume avenues of approach (superhighways)

3-12. Atomic Demolition Plan

a. The atomic demolition plan represents the commander's decision for the selective employment of ADM. The operations officer has general responsiblity for the atomic demolition plan in close coordination with the staff engineer and fire support element. When approved by the commander, the atomic demolition plan may be announced verbally; transmitted electrically; or published as an appendix to the barrier plan annex, an appendix to the engineer annex, or an appendix to the fire support annex. When published as an appendix to the barrier plan annex, the atomic demolition plan need only be referenced in the engineer and fire support annexes. The atomic demolition plan contains the information necessary for subordinate units to prepare their supporting plans.

b. The atomic demolition plan normally is prepared in detail for preplanned targets only. An atomic demolition plan contains as a minimum:

(1) Target locations and descriptions.

(2) Target designation number or code word.

(3) Model and yield of ADM, locations of ground zero, emplacement configurations, and depths of burst.

(4) Units to be designated task responsibility for each ADM mission.

(5) Firing options.

(6) Times of emplacement and final arming, if applicable.

(7) Times or conditions for execution of each target, if applicable.

(8) Designation of the source of authority to arm and fire each ADM.

(9) Designation of the source of authority to change or cancel each mission or to institute emergency ADM evacuation or destruction.

c. The atomic demolition plan may be partially prepared and transmitted in overlay form utilizing the ADM map symbols illustrated in figure 3-1.

3-13. ADM Standing Operating Procedures (SOP)

a. To insure effective ADM employment, combat maneuver battalions and above prepare a portion of the unit SOP for implementation upon assignment of an ADM mission. In general, items to be standardized as matters of SOP include task organization for ADM missions, staff coordination and responsibilities, transportation, communications, command and control, safety, security procedures, and unit training. Each unit SOP is closely coordinated with the ADM procedures of higher headquarters and supporting engineers.

b. Engineer combat units maintain a detailed ADM SOP at the group, battalion, and company level. This SOP incorporates existing directives, circulars, memorandums, bulletins, and SOP items of higher command echelons and standardizes ADM operations within the unit and in its coordination with supporting and supported units. Appendix D contains a guide for the preparation of an engineer battalion ADM SOP.

Section III. CONDUCT OF ADM MISSIONS

3–14. Types of ADM Targets

Selection of ADM targets are usually based on intelligence reports and engineer demolition reconnaissance. The tactical commander considers the recommendations of his staff, especially the engineer and the nuclear weapons employment officer, before authorizing the employment of ADM or requesting support from the ADM allocation of a higher echelon. In accordance with the tactical situation, ADM targets are categorized in two types:

a. Targets of opportunity are unscheduled targers located during the course of tactical operations and whose success often rests on the speed of execution. Targets of this nature are more prevalent during fluid tactical operations, and their acquisition is often made at lower echelons of command with no specific ADM allocation. However, ADM are best suited to preplanned missions, and their use on targets of opportunity will be the exception rather than the rule.

b. Preplanned targets are targets which have previously been evaluated and scheduled and whose execution is based on some contingency of the operational plan or action of the enemy. In many instances, emplacement positions have been prepared, targets assigned a priority of execution, subordinate units alerted of their respective roles, and written orders prepared to facilitate rapid implementation.

3–15. Targets of Opportunity

a. The destructive nature of ADM necessitates strict command and control as well as close coordination between engineer, fire control, and CBR staff agencies. For targets of opportunity, a commander requiring ADM support for which he has no allocation requests support from the next higher command (fig 3–2). Simultaneously and through separate channels of communication, engineer, fire support, and CBR elements of concerned headquarters are alerted. ADM requests contain detailed tactical justification to permit evaluation and analysis of the mission. As a minimum, a request for ADM support contains the target description and location, the results desired, and the desired time of burst. The request may contain additional information such as limiting requirements, acceptable risk to friendly troops, or location and degree of protection of nearest friendly troops and civilians. If the target has been analyzed by the requesting unit, the request may specify the desired ADM and yield. (See sample ADM request format, app D.)

b. The commander, who has an ADM allocation and in whose area significant nuclear effects will be contained, approves or disapproves the request. In some cases, he may submit a request to higher echelons for ADM more suitable for the target than those among his own allocation.

c. Early notification to ADM emplacement, security, and transportation units reduces delays in target execution. Advance information (warning orders) which provides time to pick up and prepare the munition for firing is desirable. Occasionally, this information is given to ADM emplacement units prior to the time a decision is made to actually implement the mission.

d. Upon approval or disapproval of an ADM request, the requesting unit is notified. A commander who disapproves a request provides the reason for the disapproval, whenever possible.

3–16. Preplanned Targets

Normally, preplanned, *tactical demolition targets* are planned and exeucted on order of corps and lower commanders. *Strategic* demolitions, on the other hand, may be planned and executed on order of field army or higher command echelons. If a demolition target has both strategic and tactical implications, preparation and execution of the target is usually delegated to the tactical commander responsible for the area in which the target is located. Some targets may be so important to the success of the operation, however, that the commander authorizing ADM employment may retain target execution for his own order. Such demolition targets are termed *reserved demolitions* (FM 31–10) and may include targets planned as part of preliminary operations as well

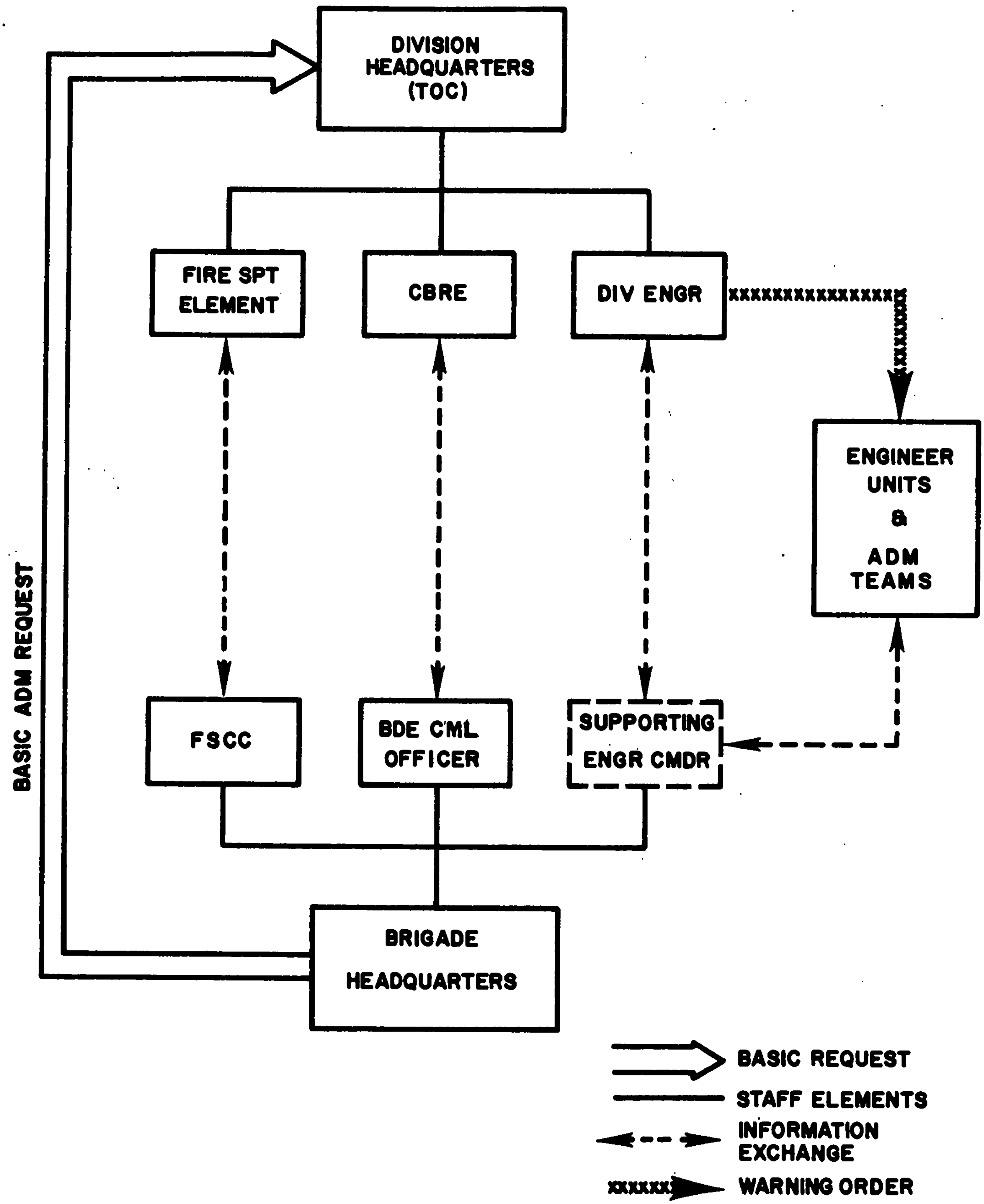


Figure 3–2. Typical ADM request from brigade to division.

as those to be destroyed in the face of an advancing enemy. For reserved demolitions, the commander in control of target execution establishes direct communications with the commanders concerned or dispatches a liaison agent or staff officer to the target site to receive and transmit the execution order. Under such circumstances, the liaison agent insures that destruction is accomplished at the proper time through coordination with responsible commanders in the target area. Regardless of the method of execution, the key personnel required to execute the mission will generally be as follows:

a. The releasing commander has overall responsibility for the mission, authorizes the ADM to be employed from his own nuclear allocation or requests an additional allocation from higher command echelons, and orders or delegates target execution. The releasing commander may utilize his own headquarters or designate a subordinate executing unit to conduct the ADM mission.

b. The executing commander is responsible for the conduct of all assigned ADM missions within his operational area.

c. The mission officer is the direct representative of the executing commander and is responsible for his specific assigned ADM target. He may be the demolition guard commander.

d. The demolition guard commander is normally a subordinate officer of the executing unit commander and is responsible for providing physical and local security for the ADM. He may be the mission officer.

e. The demolition firing party commander is the senior engineer of the ADM firing party attached to the demolition guard for the mission. He is responsible for the emplacement and detonation of the munition.

3-17. Releasing Commander

a. The releasing commander normally is the commander of a division or larger organization. He is appointed by higher headquarters and is empowered to authorize ADM expenditure subject to the restraints imposed by higher authority. The releasing commander exercises approval authority over all subordinate ADM plans and targets within his operational area. The releasing commander is also designated the "Authorized Commander" in the Orders to the Demolition Guard Commander (STANAG 2017) illustrated in appendix D. He designates his own headquarters or a subordinate unit as the executing headquarters for each ADM mission. A combat maneuver brigade, a task force, or any other major unit tactically responsible for the taget area may act as an executing unit. In areas not under the control of a subordinate tactical commander, the releasing commander may designate an engineer group or battalion commander as the executing commander.

b. The releasing commander provides the executing unit with the resources needed to accomplish the mission. He provides instructions, as required, to coordinate all elements engaged in the mission and insures that adequate control procedures are initiated. If authority to detonate the ADM is retained by the releasing commander, reliable channels of communication must be established whereby the order to detonate the ADM may be quickly and securely transmitted.

3-18. Executing Commander

a. The executing commander is responsible for ADM targets within his operational area and the execution of such targets in accordance with the orders of the releasing commander. The executing commander informs the releasing commander of any ADM mission beyond his capability and, if appropriate, recommends alternate courses of action. Details of the mission not specified by the releasing commander, such as fire support coordination, are the responsibility of the executing unit. The executing commander appoints a mission officer for each of his assigned ADM targets. In addition he usually designates the organization (the demolition guard) to provide physical and local security for the mission and prepares the orders to the demolition guard commander and the commander of the demolition firing party (STANAG 2017). Communications are provided to insure adequate control of the mission.

b. The executing unit has the added responsibility of warning friendly units and civilians in the target area. Such responsibility encompasses control of traffic and refugee flow; and, if warranted, military and civilian evacuation of danger areas. Lastly, the executing commander provides the releasing commander with changes in the state of ADM readiness, munition expenditures, and tactical damage evaluation reports.

3-19. Mission Officer

a. The mission officer is responsible to the executing commander for the direction and control of

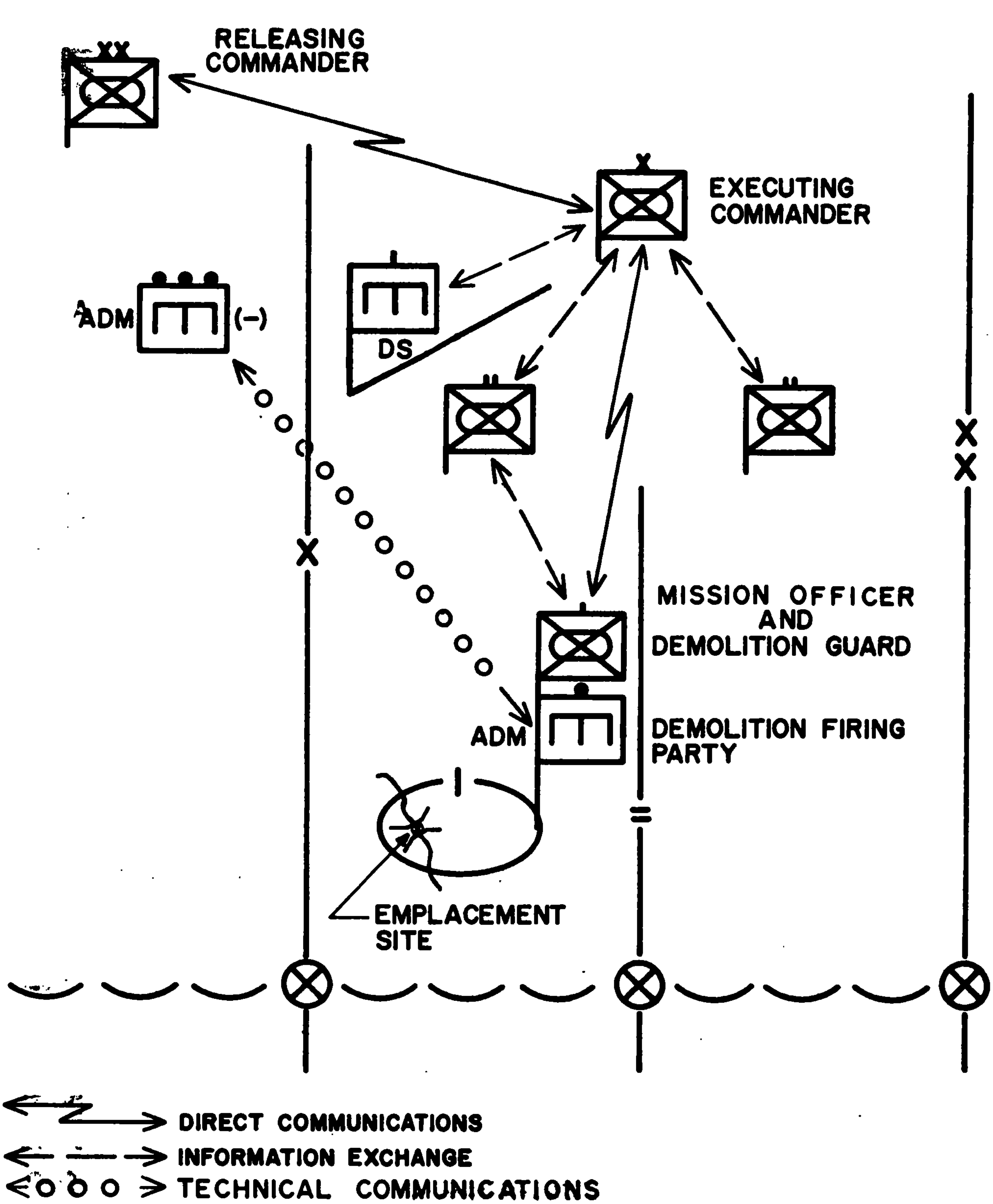


Figure 3-3. Typical communications for an ADM target.

the ADM mission as provided by competent mission orders. He relays the orders of the executing headquarters to the demolition firing party commander. One order (the ADM firing order) is prepared by the executing unit in conjunction with the orders to the demolition guard for each target and contains the necessary instructions for target demolition. The written ADM demolition order follows a format which parallels, although it does not duplicate, the conventional demolition firing order standardized by STANAG 2017 (app D).

b. After the munition is armed, the mission officer and the demolition firing party commander remain at the command site. Depending on the urgency of the target, the order for target demolition may follow normal command channels or may be established directly with the releasing commander and/or the executing headquarters (fig 3–3).

c. The mission officer is responsible for keeping the executing headquarters informed of the tactical situation at the target site and the state of readiness of the ADM. After detonation, a tactical damage evaluation report is rendered based on target damage reported by the mission officer. In the event of a misfire or partial destruction of the target, the mission officer immediately initiates steps to complete target destruction by other means within his capabilities.

d. When the mission officer is also designated the demolition guard commander he assumes the duties and responsibilities of that position.

3–20. Demolition Guard Commander

a. Upon designation as demolition guard by the exeucting unit commander and attachment of an ADM capability, the demolition guard commander is rsponsible for providing physical and local security for the ADM. The composition and size of the demolition guard varies in accordance with the tactical situation.

b. Engineer support is required to accomplish the ADM mission. At the very minimum for hasty demolition, such support is composed only of an engineer ADM firing party. For more deliberate demolitions, additional engineers and equipment to assist in emplacement are necessary. The ADM firing party is attached to the demolition guard for the duration of the mission. Attachment facilitates command and control and insures that clear-cut command lines for detonation of the ADM are established. Other engineers engaged in support of the mission, such as emplacement site preparation, need not be attached; they perform their tasks in direct support of the demolition guard, provided adequate coordination of effort is maintained.

c. The demolition guard commander is responsible for the physical security of the ADM, local security of the emplacement and command sites, and the evacuation of the demolition guard and firing party prior to detonation. Upon occupation of the area, outposts are established to provide all-around security; and observation and listening posts are organized to give early warning of an enemy advance. Liaison is accomplished with adjacent units, and the security of the ADM emplacement and command sites is coordinated with existing defenses in the area. The demolition guard insures that the routes of evacuation and areas designated to provide protection from the effects of ADM are disseminated to all members of the demolition guard, demolition firing party, and friendly units through which withdrawal is contemplated.

d. When the demolition guard commander is also designated the mission officer he assumes the duties and responsibilities of that position.

3–21. Demolition Firing Party Commander

a. The demolition firing party is the element responsible for the technical aspects of the ADM mission. Its members are drawn from the appropriate engineer ADM unit.

b. The demolition firing party commander normally will be an engineer ADM squad leader. He is directly responsible to the mission officer for the proper execution of the mission in accordance with the Atomic Demolition Munition Firing Order. In addition, he furnishes the mission officer with technical advice on permissive action link (PAL) procedures, transportation requirements, prefire test procedures, firing procedures, safing procedures, factors affecting reliability of the munition, emergency denial, and technical requirements for the emplacement site and command site.

Section IV. WARNING, LOGISTICAL, SECURITY AND SAFETY PROCEDURES

3-22. Warning of Friendly ADM Detonations

a. Advance warning of ADM detonations is required to insure that friendly forces and civilians are not subjected to casualty-producing nuclear effects. When an ADM is preplanned, usually there is adequate time to alert personnel in areas where significant effects may be received. On the other hand, when ADM are employed against targets of opportunity, a standing operating procedure is required which permits rapid notification of personnel who could be affected by the detonation. The difficulty of warning all personnel can be appreciated if the various concurrent activities in the combat zone are visualized. Messengers, wire crews, litterbearers, aid men, and engineer work parties move about frequently in the performance of their duties and often are not in the immediate vicinity of troops units when warning of impending nuclear employment is issued. Effects that are completely tolerable to troops in tanks or foxholes can cause considerable casualties among those in the open in the same area.

(1) Notification concerning friendly nuclear employment is a time-consuming process unless procedures are carefully established and rehearsed. On the other hand, dissemination of warning earlier than necessary may permit the enemy to learn of the operational plan.

(2) When there is insufficient time to warn personnel within the limits of visibility, only those who may receive tactically significant nuclear effects are warned. Warning of units not requiring the information may cause them to assume a protective posture that interferes with the accomplishment of their mission. Generally, there is no requirement to warn subordinate units when target analysis indicates that there is no more than a negligibile risk to unwarned, exposed troops. Dazzle to ground troops need only be considered in night operations.

(3) Aircraft, particularly Army aircraft, can be damaged by low blast overpressures. Likewise, dazzle is more significant to personnel operating aircraft than to personnel on the ground. Because aircraft can move rapidly from an area of negligible risk to an area where damaging nuclear effects or dazzle may be encountered, all aircraft within the area of operations are given advance warning during both day and night operations.

(*a*) Army aircraft are warned through the appropriate air traffic control facility or through the unit command net.

(*b*) Navy and Air Force aircraft are warned through Navy and Air Force channels. At corps and division level, the notification of planned nuclear employment is transmitted to other services through the Navy or Air Force liaison officer; at field army level, this notification is accomplished through the tactical air control center (TACC).

(*c*) Warnings to aircraft in Marine Corps operating areas will be initiated by the fire support coordination center (FSCC) which passes the warning to the Tactical Air Commander usually via the TACC and/or the direct air support center (DASC) and/or the supporting arms coordination center (SACC).

b. Nuclear employment warning messages are disseminated as rapidly as possible utilizing tactical voice security equipment wherever practicable. In those cases where voice security equipment is not available, utilization of authorized operations codes and adherence to established communications security procedures are required. Conflicts between speed of dissemination and communications security are resolved in favor of speed. In such cases, the amount of information to be encoded is kept to a minimum. Message items DELTA and FOXTROT (app H) will not be sent in the clear unless insufficient time remains for the enemy to react. In all circumstances, the authentication procedures contained in unit signal operation instructions (SOI) will be adhered to.

c. Nuclear warning messages are given a precedence of FLASH.

d. The zones of warning, protection requirements for personnel located in any of the warning zones, and the content of a nuclear warning message (STRIKWARN) are prescribed by STANAG 2104 which is reproduced in appendix H.

e. All available communication means are used to rapidly disseminate nuclear warnings.

f. A fragmentary warning order may be issued while an ADM mission is being processed to alert units that are in an area where they may receive nuclear effects.

g. Procedure for friendly nuclear detonation warning.

(2) Warning responsibilities.

(*a*) Responsibility for issuing the initial warning rests with the executing commander.

(*b*) Releasing commanders will insure that detonation affecting the safety of adjacent and other commands are coordinated with those commands in sufficient time to permit dissemination of warning to friendly personnel and the taking of protective measures. Conflicts must be submitted to the next higher commander for decision.

(2) The executing commander should inform:

(*a*) The releasing commander.

(*b*) Subordinate headquarters whose units are likely to be affected by the detonation.

(*c*) Adjacent headquarters whose units are likely to be affected by the detonation.

(*d*) His next higher headquarters, when units not under the releasing commander are likely to be affected by the detonation.

(3) Each headquarters receiving a nuclear warning message will warn subordinate elements of the safety measures they should take in light of their proximity to the desired ground zero.

(4) Unit SOP should require that STRIKWARN messages be acknowledged and there should be common understanding as to the meaning of the acknowledgment; e.g., all platoon-size units in the affected area have been warned.

3–23. Distribution of Atomic Demolition Munitions

a. Commanders and staff officers continuously evaluate the capabilities and limitations of logistical systems to support nuclear employment. Because of the destructive nature and limited availability of nuclear munitions, distribution is an operational as well as a logistical problem.

b. The nuclear munition logistical system is designed to operate in different tactical situations, forms of warfare, and operational environments. Commanders and staff officers concerned with planning and controlling special ammunition support activities consider the following requirements:

(1) Continuous nuclear logistical support of tactical operations.

(2) Simplificty and uniformity in procedures.

(3) Minimum handling of nuclear ammunition.

(4) Security of classified or critical material and installations.

c. The specific quantity of nuclear weapons to be carried by a delivery unit is termed the prescribed nuclear load (PNL). The specific quantity of nuclear weapons, nuclear weapon components, and warhead test equipment to be stocked in special ammunition supply points (SASP) or other logistical installations is termed prescribed nuclear stockage (PNS).

d. A commander controls the distribution of ADM by—

(1) Determining the number of ADM which organic or attached units under his control will carry as part of their PNL.

(2) Designating any ADM from his own allocation or the allocation of a higher commander which he desires to have carried in the PNL of a unit that is under the control of a subordinate commander. This PNL may contain ADM to support the allocation of the subordinate commander as well as those to be delivered to support the allocation of the higher or adjacent echelon.

(3) Coordinating the stockage of ADM as part of the PNS of a special ammunition installation not under his control; directing the ADM stockage in special ammunition installations under his control.

e. The positioning of ADM for security and operational purposes may result in a commander having more ADM carried by his emplacement units than he is authorized to fire. He may also have fewer ADM within his command than he has been allocated. In the latter case, procedures are established by which the additional ADM can be quickly obtained when required.

f. When the availability of ADM permits, consideration is given to placing them in all engineer emplacement units. ADM may be so dispersed before allocations are announced. In some cases, this procedure permits greater responsiveness once unit allocations are announced.

g. Replenishment of PNL and PNS is accomplished by directed issue, automatic issue, or a combination of both. Because of the limited supply and the movement of ADM to meet the changing tactical situation, directed issue is most practical. If a relatively large number of ADM of a specific type and yield is available, a commander may direct that engineer units under his control replenish their PNL automatically as expenditures occur. The method of replenishment should be covered in the SOP.

h. Distribution of ADM is affected by:

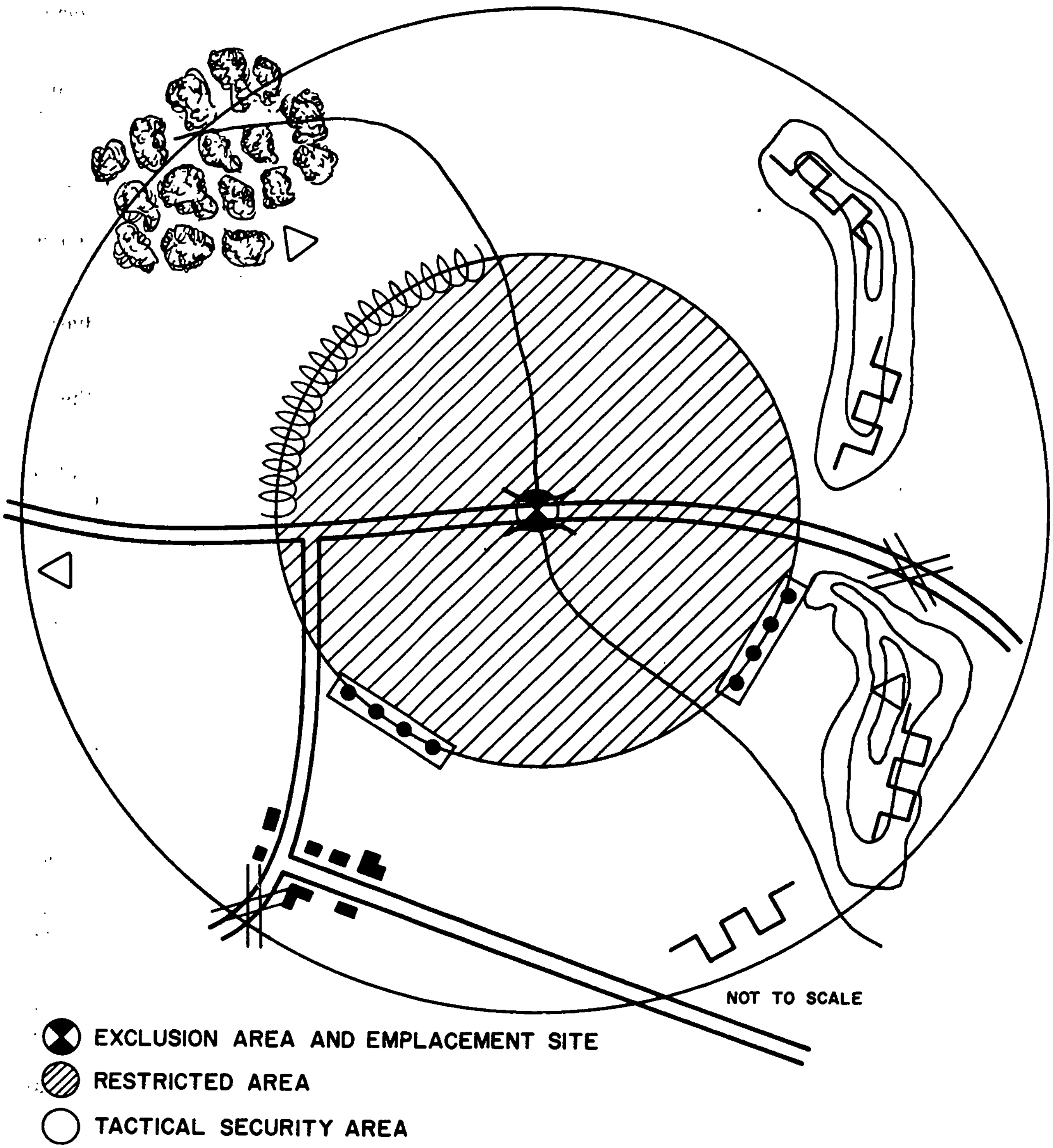


Figure 3–4. Security of an ADM emplacement site.

(1) Mission.

(2) Currently released munitions and authorizations to fire.

(3) Allocation, current and anticipated.

(4) Munition availability.

(5) Carrying capacity of emplacement units.

(6) Security.

(7) Transportation capability of support units.

i. Nuclear munitions are stored and issued to ADM teams by special ammunition units. Issues are made using supply point distribution procedures. The details of ammunition service are contained in FM 9-6.

3-24. Tactical Accountability

The decisive character of nuclear weapons and their limited availability make detailed accounting necessary. Information pertaining to ADM location, availability, authorization to fire, and expenditure is made available to the members of the TOC, the artillery fire direction center, and the staff engineer. In addition, the TOC and the engineer need information on ADM readiness status, operational capabilities of engineer emplacement units, and the travel time between logistical and tactical locations. This information is maintained in a manner to permit ready display to the commander and staff officer. Suggested forms or methods by which needed information can be kept at various staff agencies are discussed in FM 101-31-1.

3-25. Security

a. Security is concerned with safeguarding classified defense information and material from unauthorized disclosure as well as protection of the ADM and ADM firing party from enemy interference. Three types of active security measures are generally associated with an ADM mission (fig 3-4):

(1) *Physical security of the ADM and related defense information and material* is that protection afforded to deny physical, audible, and visual access by unauthorized personnel to ADM and associated equipment. Only authorized personnel (normally, only ADM team members and ordnance personnel) are permitted physical access to ADM. Responsibility for physical ADM security commences for the tactical commander with ADM pickup and continues until detonation; such security measures as transporting the munition in closed containers and erecting camouflage nets over emplacement sites are typical precautionary measures. This type of security is further related to national policy regarding disclosure of classified atomic defense information (Restricted Data). At the time of pickup, an *exclusion area* in the immediate vicinity of the munition is established and maintained throughout transportation, emplacement, and until detonation. Only authorized ADM personnel are permitted within the exclusion area, although security forces of the escort guard or demolition guard may be called upon to assist in security enforcement immediately outside the exclusion area. Exclusion areas are clearly marked, when appropriate, by expedient means such as concertina wire, or are designated within the confines of a covered vehicle or structure. FM 19-30 contains recommended physical security techniques.

(2) *Local security* provides immediate protection of the ADM and ADM team from enemy interference or sabotage during transport and emplacement. A *restricted area* around the munition is established which extends outward from the exclusion area. The size of the restricted area varies in accordance with the tactical situation and the size of the assigned escort or demolition guard. During transport it is the area in which security forces are located or will deploy in the event of a halt (FM 19-25). At the emplacement site, the restricted area may be reinforced by the installation of protective minefields, warning devices, and obstacles. Such protective devices are carefully noted, however, in the event that return to the emplacement site becomes necessary. Personnel other than those designated by the demolition guard commander are not allowed access into the restricted area.

(3) *Tactical security* encompasses those measures which are beyond the capability of the demolition guard; this type of security is generally provided by the tactical disposition of the executing unit. Tactical security may be provided by offensive and delaying action as well as defensive operations. Ideally, observed enemy ground fire should be excluded from the emplacement site. The executing unit is also responsible for maintaining open routes of withdrawal for the demolition guard and firing party. Although the requirement for tactical security in rear areas may be less severe than in forward areas, adequate provisions must be made for countering an attack by enemy guerrillas and infiltrators as well as airmobile units.

b. Passive security measures such as cover, concealment, camouflage, decoy emplacements, communications security, and surreptitious infiltration (either ground, water, or air) to the emplacement site also contribute to the security of ADM missions.

c. Once the ADM has been armed and the demolition guard and firing party withdrawn, security of the site until detonation is still maintained by the executing unit. Ground and aerial surveillance and long-range direct and indirect fires (e.g., tank and artillery) are possible methods of maintaining security once the emplacement site is evacuated.

d. The critical mission of ADM teams makes them a prime target for enemy attack. These teams are normally so small and so armed that they are only capable of self defense and protection of the munition and associated materiel. Tactical commanders must be prepared to augment these teams with well trained security forces to safeguard pickup, delivery, emplacement, and target execution.

3-26. Safety

a. Safety is a continuing function of command. ADM, like other demolition materials, involve potential danger. The safety of troops and other personnel is of primary importance. Safety rules are mandatory for peacetime operations during operational readiness maneuvers, exercises, and training; no deviation is authorized. Safety rules are promulgated by Department of the Army letters and disseminated through appropriate command directives. Their purpose is to incorporate the maximum safety consistent with operational requirements.

b. If there is an accident involving ADM, the commander having possession of the munition at the time of the accident is responsible for notifying emergency teams to assist in rescue, recovery, and damage assessment. Explosive ordnance disposal (EOD) units of the ammunition service structure should be called upon to render safe, recover, and dispose of unexploded munitions or, in the event of a low order detonation, to recover and dispose of classified components and radioactive materials. FM 3-15 provides guidance for nuclear accident radiological contamination control. ADM team safety activities are stated in the technical manuals for each munition, in associated safety publications, and in the unit SOP.

c. Temporary storage safety is governed in general by the quantity safe distance criteria which govern the temporary storage of high explosive and nuclear materials. Particular storage requirements for each demolition are covered in the prefire manual for that munition.

CHAPTER 4

COMBAT ENGINEER UNITS

Section I. ENGINEER STAFF RESPONSIBILITIES

4-1. General

The field army, corps, and division engineer staff officers rely heavily on the staffs of their engineer organizations in the preparation, planning, and conduct of ADM missions. Normally, the staff engineer delegates to members of his unit staff responsibility for the detailed preparation, planning, and conduct of ADM missions. Key personnel of engineer brigades, combat groups, and combat battalions charged with primary staff responsibility in ADM operations are the intelligence officer (S2), the operations officer (S3), and the supply officer (S4). Other staff officers such as the assistant division engineer, adjutant (S1), reconnaissance officer, liaison officer, and communications officer perform duties in ADM operations as specifically directed by the commander or as outlined in the unit SOP. Moreover, each subordinate engineer commander assumes an engineer staff role when in direct support of or attached to a combat maneuver element and is, in such circumstances, also responsible for advising the supported commander in engineering aspects of ADM employment.

4-2. Intelligence Officer (S2)

Responsibilities normally assigned to the engineer S3 in ADM employment include:

a. The collection and evaluation of potential ADM targets to include structural, geologic, and cultural characteristics.

b. Terrain and weather analyses pertinent to ADM targeting.

c. Ground and aerial reconnaissance of selected ADM targets.

d. The collection from artillery and hydrologic elements of meteorological data for use in target analysis.

e. The processing and dissemination of ADM reconnaissance.

f. The maintenance of a current ADM reference file and ADM target folders.

g. Security measures applicable to ADM storage, movement, and emplacement in coordination with the S3, S4, and supported and supporting units.

h. The supervision of administrative personnel procedures to insure that only those authorized by current Army regulations are granted access to ADM defense information.

4-3. Operations Officer (S3)

The engineer operations officer has the primary staff responsibility for ADM employment. Specifically, his responsibilities include:

a. Preparation of the unit ADM SOP and technical advice for and coordination of the ADM SOP of supported and subordinate units.

b. Maintenance of unit ADM training records.

c. Supervision of the unit ADM training program.

d. Detailed evaluation of selected ADM targets based on command guidance, the unit SOP, staff recommendations, and the requests of supported units.

e. Recommendations as to the requirements for ADM teams and other engineer support required for specific targets.

f. Fallout and surface water contamination prediction from friendly ADM employment in coordination with the S2 and appropriate CBR element.

g. Coordination of matters relating to ADM operations with other staff members, subordinate units, and supported units to include points and times of ADM pickup, emplacement construction, rendezvous points, security detachments, transportation means, and routes to emplacement sites.

h. In cooperation with the S4, maintenance of records to show current status of available ADM to include actual locations, unit or installation custodian, and state of readiness.

4–4. Supply Officer (S4)

The supply officer has primary staff responsibility for the provision of ADM and associated equipment. Specifically, the S4:

a. Procures and issues construction materials and required ADM tools, sets, and kits to subordinate units.

b. Coordinates pickup and transportation procedures for ADM through close liaison with the supporting SASP.

4–5. Intelligence Reports

a. Strategic intelligence studies prepared at the National level by the Department of Defense (DOD) or by oversea commands provide detailed information concerning major geographical areas and are often useful in preliminary ADM targeting.

b. Route Reconnaissance Reports. Most important for terrain information at lower levels are local reports which summarize data obtained by physical route reconnaissance. Such reports are of particular value in providing current, detailed information about routes of communication. The preparation of these reports is discussed in FM 5–36.

c. Demolition Reconnaissance Records (DA Form 2203–R). The preparation of these conventional demolition records is discussed in FM 5–25.

4–6. ADM Target Reconnaissance

a. Successful execution of ADM missions usually depends on prior reconnaissance of the target area and emplacement site. In most cases, ground reconnaissance is required to provide necessary data for detailed target analysis; however, reconnaissance by aircraft can locate potential targets and speed engineer reconnaissance teams to the general target location. The intelligence officer bears staff responsibility for the location and processing of target data. Nevertheless, all combat engineer officers and designated enlisted personnel must recognize potential ADM targets and be familiar with the method of reporting target information.

b. ADM target reconnaissance requires that members of the reconnaissance teams have a general knowledge of nuclear effects and how these effects achieve target damage. The reconnaissance team leader should be capable of determining the governing nuclear effect for each ADM target to insure that appropriate information is reported for complete target analysis. Although ADM are most often used against point targets, the reconnaissance team must not forget that ADM are also capable of large area destruction. Once the characteristics of the specific target are recorded, the reconnaissance team proceeds to investigate the surrounding area for other elements that may be affected by the burst. The location or proposed location and type of protection afforded friendly troops in the vicinity of ground zero is vital in planning ADM missions. Other considerations such as the location of nearby forests or population settlements may also be important. In cratering, soil type is of critical significance as well as the proximity of bypasses which may reduce an obstacle's effectiveness. Chapter 6 outlines the specific information upon which detailed target analysis is based.

c. Command sites and alternate command sites are selected during reconnaissance. Concealed routes of withdrawal to areas of protection against nuclear effects are also selected for the demolition guard and firing party. Each route is reconnoitered and the withdrawal time noted.

d. If emplacement holes or other emplacement methods beyond the capabilities of ADM teams are required, such information together with an estimate of the number and type of engineers, equipment, and time necessary to prepare the target for demolition is recorded. When aerial delivery of ADM is contemplated, suitable landing areas are also reconnoitered and reported by the reconnaissance party.

e. To facilitate a uniform method of recording and reporting poential ADM targets, reconnaissance forms similar to that shown in appendix D may be locally produced. Such forms provide uniformity in reporting target information and are designed for electrically transmitted as well as written reports.

4–7. Engineer ADM Training

a. Schools for training ADM specialists have many facilities and aids that are difficult or impossible to duplicate in the field. Engineer units obtain and utilize school-trained personnel whenever possible. Moreover, unit training in coordinated ADM operations must be continuously conducted. On-the-job training is required to develop proficiency in technical procedures and to provide additional qualified specialists. On-the-job training conducted by units should make maximum use of standard and expedient training equipment and school-published training materials to enhance instruction. Personnel must be given instruction on the unit ADM SOP as well as their individual specialties. Unit training records are maintained as a basis for periodic refresher training.

b. Skilled personnel and construction equipment may be required to support the ADM firing party by the preparation of the emplacement and command sites. Practical exercises in these functions provide excellenet training for the personnel involved. The organization of an element to accomplish the above support functions should be included in the unit SOP. Reconnaissance personnel should be trained to recognize potential ADM targets.

c. ADM firing party personnel should be cross-trained in all test and prefire procedures to provide depth and thereby insure that the team will function efficiently in the event of casualties.

d. In addition to nomal training records, engineer units maintain ADM training records. These records reflect the names of personnel qualified to perform prefire and test procedures, their security clearances, their type of training (school trained or unit trained), manuals available in a current ADM reference file, and whether or not personnel have read appropriate manuals and changes.

e. Inspections should be conducted to determine the technical proficiency of personnel and to evaluate other factors affecting the unit's ability to conduct ADM missions. To better determine a unit's ability to deliver and emplace ADM reliably, a nuclear weapons exercise should be conducted as a phase of field exercises. Such exercises, conducted under conditions similar to those expected to be encountered in an actual mission, provide a basis for determining the unit's ability to perform the following:

(1) Pickup, handling, transporting, and storing munitions.

(2) Partial storage monitoring.

(3) Unpackaging and repackaging procedures.

(4) User maintenance.

(5) Prefire and test procedures.

(6) Procedures for delayed or canceled missions.

(7) Target reconnaissance.

(8) Emplacement procedures.

(9) Accident and incident control and reporting.

(10) Troubleshooting procedures.

(11) Preparation and maintenance of records and reports.

(12) Safety and security procedures.

(13) Emergency destruction procedures.

4–8. Transportation of ADM

During transport, engineer personnel normally accompany ADM from the special ammunition supply point (SASP) to the emplacement site. Practically any vehicle of suitable capacity can be used, including Army aircraft or boats, and, for some munitions, pack animals or men, subject to the restriction imposed by paragraph 4–10. Transportation requirements may include lifting and loading equipment for handling the larger munitions. Wreckers, cranes, rail systems, or fabricated ramps are some expedients that may be used. Tactical security considerations determine the vehicular convoy composition and the strength of the security forces necessary for escort. The overall command of the convoy may be specified in the orders to the courier officer, the demolition guard commander, or in the engineer unit ADM SOP if no other unit is involved. To insure reinfoircement in case of an emergency, the courier officer or demolition guard commander maintains continuous communication with higher headquarters. Figure 4–1 shows the composition of a typical ADM convoy.

4–9. Storage and Maintenance

a. Depending upon the disposition of ADM, engineer units may be directed to carry ADM as presdcribed nuclear load (PNL).

b. Temporary storage of war reserve ADM must meet the requirements listed in appropriate technical manuals and Army regulations (app A). These requirements are for war reserve ADM only and do not pertain to unclassified training items or simulated munitions used for exercise purposes. Except in emergency, ADM are not stored until these facilities are available. However, in fluid tactical situations, increased reliance is placed on the use of armed guards instead of fixed installations.

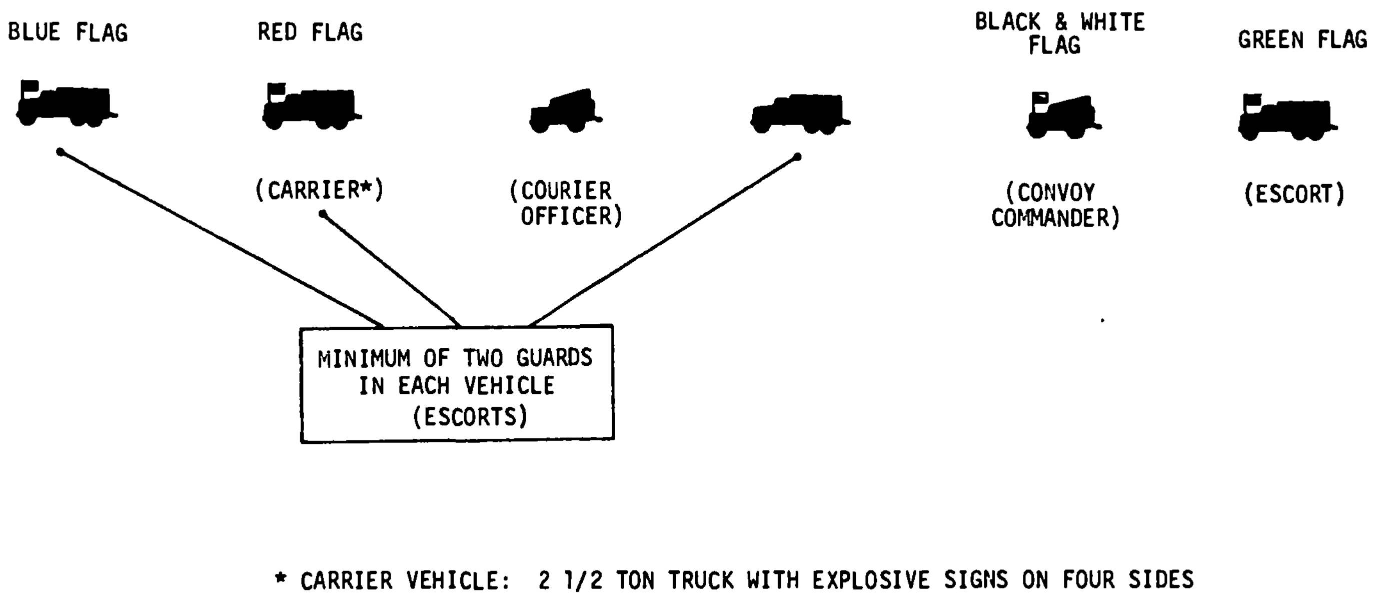


Figure 4-1. Composition of a typical ADM convoy.

c. Engineer units having custody of ADM are responsible for certain inspection and maintenance duties. Inspections generally are limited to partial storage monitoring in accordance with the instructions contained in applicable technical manuals. The engineer unit may request advice and assistance from special ammunition units. Also the engineer unit SOP should provide general guidelines in both storage and maintenance procedures.

4–10. Test and Prefire Procedures

The time required to perform the test and prefire procedures of an ADM depends largely upon the proficiency of the demolition firing party. Normally, ADM components remain in the shipping containers as far forward as possible and are unpackaged at the emplacement site. If time and the tactical situation so require, a portion of the test and prefire operations may be performed in a secure rear area. Thereafter, the munition is handled and transported with extreme care so that tests are not invalidated or the munition rendered unreliable. Detailed prefire procedures are contained in the technical manuals for each munition.

4–11. ADM Denial

a. The primary means of ADM denial is the maintenance of adequate security measures. Under conditions where these measures may not provide adequate denial and capture of the munition is threatened, the senior commander having possession of the munition must take alternative steps to deny it to the enemy. The method of denial chosen will be predicated upon the nature of the threat, the time available to execute denial measures, the environment in which the munition is stored, and the resources available to accomplish denial.

b. The primary, overriding objective of denial of ADM is to render the munition tactically useless to the enemy. Efforts to deny the munition design features and active material to the enemy, if not accomplished concurrently with tactical denial measures, will be attempted only after accomplishment of the primary objective is assured.

c. The most desirable form of denial of a threatened ADM is physical removal from the area of the threat; that is, local repositioning or evacuation. Should such relocation prove impractical, selective evacuation of sensitive and/or key munition components should be considered. Under no circumstances should munitions relocation place the munition or munition component in a more precarious situation.

d. Under emergency conditions where no form of ADM relocation is possible or advisable, and gainful and expeditious employment of the munition against the enemy is impossible, destructive denial becomes necessary. The destructive denial methods for each ADM system are described in the appropriate user technical manual. In general, violent means of destructive denial, by initiation of warhead HE, should be elected if the situation permits this greater degree of destruction to be achieved. If the denial of the threatened munition by violent means is unacceptable, disablement of selected key components provides a simple, rapid, though less effective method of denial of munition tactical utility. Such disablement may be followed by violent destruction to enhance denial of ADM design information and of acquisition of active material if subsequent alterations to the tactical situation permit.

e. ADM are of sufficient importance, and sensitivity, as to warrant the personal concern of and decision by the commanders involved in establishing ADM denial procedures to be followed. Unit SOP instructions for denial should cover all details necessary for the individual who executes them, including:

(1) Origin of the decision to carry out emergency denial. This may include delegation by the commander of authority to execute munition relocation or destruction denial.

(2) Step-by-step procedures including differences in procedures such as may be required in movement, emplaced, in a position of readiness, or at a storage site.

(3) Instructions for the location of necessary denial equipment to insure ready accessibility under all circumstances of storage, movement, in position of readiness, and in firing configuration.

(4) Instructions for the disposition of classified documents such as technical manuals, demolition firing orders, and unit ADM SOP.

4–12. Timer Operation

a. To insure positive control and safety for ADM missions in which a timer option is employed, accurate timer calculations are essential. Moreover, in the event of a canceled or delayed mission, it is important for the protection of recovery or disarming personnel that the time of detonation has been precisely determined and recorded. Timers may be used as either a primary or secondary (backup) means of detonation. When timers are employed, it is *not* possible to state that an ADM will fire at a specific time. There is always a time span or *span of detonation* involved.

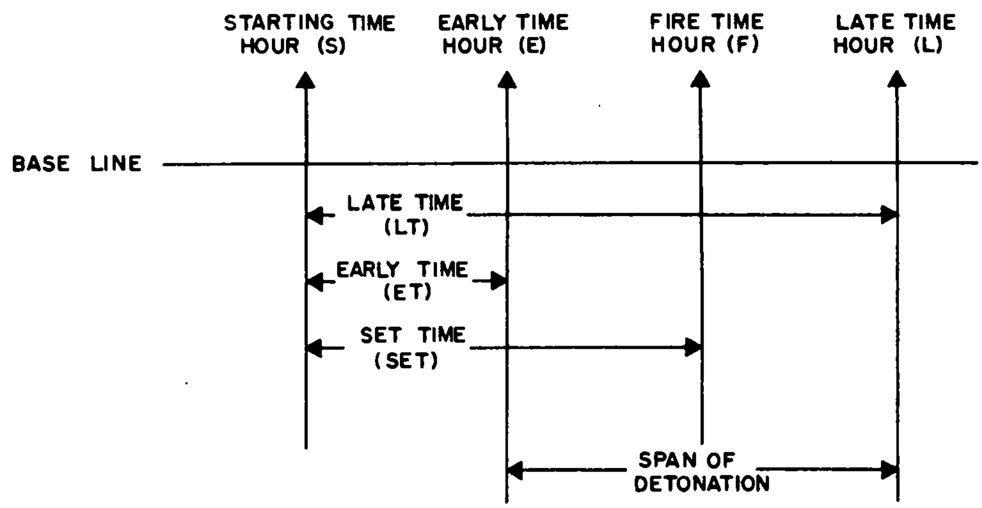


Figure 4-2. Time relationships.

b. The span of detonation is that total time period between the earliest possible time of detonation and the latest possible time of detonation. This time span is due to the integral timer error. *Early time hour* is the earliest possible time that the munition can detonate taking timer error into account. Similarly, *late time hour* is the latest possible time that the munition can detonate. *Fire time hour* is that time when the munition would detonate if the timer functions with no error. In other words, *fire time hour* is the date-time group resulting from the addition of the time period set on the timer to the time of day the timer is started. *Fire time hour* falls between *early time hour* and *late time hour*. *Starting time hour* is the point in time (date-time group) that the timer is started. *Set time* is the time period actually set on the timer and encompasses the entire period from *starting time hour* to *fire time hour*. An illustration of these time relationships appears in figure 4-2.

Note: In figure 4-2, the times above the base line are points in time (date-time groups); e.g. 230845Z. The times below the base line are periods of time; e.g. 2 hours 30 minutes.

c. There are four basic types of timer calculations that the prefire team may be required to make.

(1) AT (Detonate the munition at a stated time)—Given the starting time hour and the fire time hour: find the early time hour, the late time hour, and the set time.

(2) SPAN (Detonate the munition no earlier than a stated time and no later than another stated time)—Given the early time hour and the late time hour: find the starting time hour, the fire time hour, and the set time.

(3) NET (Detonate the munition no earlier than a stated time)—Given the starting time hour and the early time hour: find the late time hour, the fire time hour, and the set time.

(4) NLT (Detonate the munition no later than a stated time)—Given the starting time hour and late time hour: find the early time hour, the fire time hour, and the set time.

d. When a timer is used to back up the remote option, a special problem arises. This problem is to calculate the *set time* for the timer so that it will positively run down and initiate the ADM no earlier than the time prescribed to detonate the munition with the remote option, but as close to that time as possible. The calculation for the timer option in this case is made by using the time prescribed for the remote option as *early time hour*, a NET type calculation.

e. Example problem:

(1) *Given.* You are ordered to use the timer option to detonate an ADM at 1500 (fire time hour) and to start the timer at 1200 (starting time hour).

(2) *Find:*

(*a*) Set time.

(*b*) Early time hour.

(*c*) Late time hour.

(3) *Solution:*

(*a*) Set time equals fire time hour minus starting time hour. 1500—1200 = 3 hours. *Answer:* 3 hours.

(*b*) Early time hour equals fire time hour minus timer error (para 2-7*c*) of 5 minutes per hour of set time. 1500—0015 = 1445. *Answer:* 1445.

(*c*) Late time hour equals fire time hour plus timer error. 1500 + 0015 = 1515. *Answer:* 1515.

4-13. Remote Option

The remote option permits detonation of the ADM exactly at a prescribed time or immediately on receipt of an order to do so. Since the timer option does not permit this, the occasions when the remote option is used as a secondary means of detonation, with the timer option as the primary, will be rare. However, should the remote option be used to back up the timer option, there is a problem of when to start firing with the secondary; at early time hour, at fire time hour, or upon complete timer rundown? Instructions in regard to this must be explicitly spelled out in the ADM firing order.

Section II. ENGINEER ADM UNITS

4-14. General

To provide ground forces with a capability for atomic demolition munitions employment, engineer ADM teams and platoons have been organized. These ADM units provide technical requisites for the execution of ADM missions; however, additional combat and combat service support must be furnished before mission implementation. Normally, ADM teams are assigned or attached to other combat engineer organizations for logistical and administrative support. Upon receipt of an ADM mission and in accordance with the type, magnitude, and number of targets in the employment area, ADM units usually are attached for command and control to the tactical organization charged with the execution of the mission and for the duration of the specific operational phase. ADM units are capable of providing technical advice for ADM employment; technical supervision in the preparation of sites to meet ADM emplacement requirements; performance of all prefire checks; and, on order, detonation of the munition. The engineer emplacing element may provide physical security for the munition and associated classified equipment. The safeguarding of ADM defense information is a command responsibility which ultimately rests with the ADM unit leader. The ADM unit leader must explain the security precautions required in safeguarding ADM defense information to and coordinate security requirements with the supported unit commander. The supported unit must assist in establishing and meeting the security requirements.

4-15. Atomic Demolition Munition Teams

In order to achieve maximum flexibility and to reduce manpower and training requirements, three types of ADM teams are organized (TOE 5-570). Each team is dependent, however, upon the unit to which attached for combat support, combat service support, and tactical and local security.

a. Atomic Demolition Munitions Platoon Headquarters, Separate (TEAM MA).

(1) This team provides qualified personnel and necessary equipment for the command and control of an ADM platoon composed of from two to six atomic demolition munitions teams (MC). The team may be attached to an engineer combat group or battalion (Army), other US combat units and task forces, or allied military organizations. The team consists of a platoon leader, platoon sergeant, general clerk, radiotelephone operator, and light truck driver.

(2) The platoon leader commands the platoon and is responsible for its training and technical employment. In addition, he serves as a special advisor in ADM operations to the unit to which attached. Upon detachment of subordinate teams for a specific ADM mission and in accordance with the tactical situation and size of the ADM platoon, the platoon leader may assume command of a portion of the platoon, placing the remainder of the platoon under the command of the platoon sergeant; or he may conduct liaison between the deployed ADM teams and the supported headquarters coordinating matters of ADM employment and associated matters of communications, supply, and security.

(3) The platoon headquarters is fully mobile and has organic radios for communications between elements of the platoon and higher headquarters.

b. Atomic Demolition Munitions, Liaison (TEAM MB). This team consists of an ADM liaison officer and a driver. The liaison officer acts in the capacity of a special staff officer providing technical knowledge and advice for ADM employment. The team may be attached to a US army unit or allied unit which requires technical assistance in ADM employment. When attached to an allied unit, necessary communications must be provided by the supported unit. In addition to this staff function, Team MB performs liaison between the headquarters to which attached and other supporting or attached ADM teams. The team is furnished a 1/4-ton utility truck and an AN/VRC-47 radio set.

c. Atomic Demolition Munitions Squad (TEAM MC). This team consists of the team leader and four ADM specialists and is responsible for the assembly, preparation for firing, and detonation on order and, if necessary, the recovery, disassembly, or destruction of ADM. The ADM team is dependent on the unit to which attached for ADM storage, resupply, additional transport, tactical and local security, site preparation, and similar types of combat and combat service support. The squad may be assigned on the basis of one or more to the engineer combat battalion (Army), other US Army combat units and task forces, allied forces, or to increase the capability of the divisional ADM platoon. When two or more of these teams are formed into a platoon, Team MA provides the necessary command and control. Each Team MC is fully mobile and is equipped with sufficient radios for both internal and external communications. The squad may be divided to provide two ADM firing parties under conditions of extensive ADM use. The second firing party must, however, be supported with transport and communications.

4-16. Divisional ADM Platoon

a. Each engineer battalion organic to the armored, infantry, and infantry (mechanized) divisions includes an ADM platoon. These platoons include a platoon headquarters and two ADM squads. Platoon headquarters consists of the platoon leader, platoon sergeant, a senior ADM specialist, a light vehicle driver with additional duty as radio operator, and a general clerk. Each ADM squad consists of a squad leader, two senior ADM specialists, and two ADM specialists. The platoon is fully mobile and is equipped with sufficient radios for both internal and external communications. The ADM platoons are organized under TOE 5-146 (armored and mechanized infantry divisions) and TOE 5-156 (infantry division).

b. The responsibilities and operations of the ADM platoon leader are similar to those outlined for the platoon leader of Team MA. In addition, the platoon leader serves as a special advisor for ADM technical employment within the division. The capability of the divisional ADM platoon may be augmented by the attachement of one to four ADM squads (Team MC) under which circumstances the platoon leader assumes command of all attachments.

c. Close coordination is maintained with the engineer battalion staff to insure that procedures are established to provide each ADM mission with adequate and timely support. The ADM platoon leader maintains particularly close liaison with the engineer battalion operations section and may be called upon to assist in the technical preparation of the atomic demolition plan and the unit ADM SOP.

Section III. ENGINEER COMBAT SUPPORT

4-17. General

As previously noted, ADM units do not have the capability of conducting independent operations. Successful ADM employment requires detailed staff planning and coordination. Routinely, ADM units are assigned or attached to engineer combat battalions prior to operational employment, and it is the responsibility of these battalion headquarters to insure that efficient ADM standing operating procedures have been established and engineer personnel are trained to accomplish ADM missions. Engineer battalion commanders and staffs continually supervise and coordinate the activities of assigned or attached ADM units. The success or failure of ADM employment rests, to a large extent, on the prior training and efficiency of the supporting combat engineer battalion as a whole. All combat engineer commanders must be familiar with the special considerations of ADM operations and emplacement site preparation, and their units must be ready to respond immediately to the requirements of the specific situation.

4-18. Security

Local security of ADM normally is furnished by nonengineers. However, it is incumbent on all engineer combat units, platoon and above, to be capable of providing well-trained security guards when called upon. Under certain circumstances, engineers may be required to escort ADM from the pickup site to the emplacement site. Combat engineer units can also be designated as demolition guards, in which case local security of the ADM mission becomes a direct engineer responsibility. Moreover, engineer combat units, based on their close association with ADM, may be called upon to establish basic ADM security procedures for the entire command.

4-19. Construction Support

a. ADM emplacement methods vary from surface bursts to deep underground burial. As ADM teams have no organic equipment for preparation of emplacement holes, other engineers are often required to support emplacement operations. Engineers may also construct field fortifications for the protection of ADM command sites or improve access routes to emplacement sites. Moreover, the security of ADM sites may be significantly augmented by the installation of mines, barbed wire, and similar obstacles. Such engineer support is beyond the capabilities of ADM teams and is effected through coordination at battalion and higher unit headquarters.

b. The cratering curves presented in chapter 6 demonstrate the influence of depth of burial on crater dimensions. In tactical ADM operations the depth of burial ordered for a given mission will depend on the effects desired, the tactical situation, and the availability of time, manpower, and suitable construction equipment. Even when burial at optimum depth might not be feasible, burial at depths less than optimum will significantly increase crater dimensions over those obtained from a surface burst.

4-20. Methods of Emplacement

a. Emplacement methods fall under the general categories of deliberate and hasty emplacement. *A deliberate emplacement* is one which is specifically prepared to optimize the desired effects of a particular munition to accomplish a particular mission. Deliberate emplacement may require the use of tunneling or drilling procedures to provide underground emplacements or the construction of a demolition chamber at the desired location on a bridge or other surface structure. *Hasty emplacement* refers to expedient methods of surface emplacement to include attachment of the ADM to existing structures and shallow burial, and the use of existing shafts and tunnels. Hasty emplacements normally are used only when there is insufficient time or equipment available to prepare a deliberate emplacement and will normally require the use of a higher yield and acceptance of greater safety hazards to produce the same degree of destruction.

b. The physical characteristics of ADM and environmental limitations determine to a large extent the possibility of rapid subsurface emplacement. A list of required emplacement diameters for the hypothetical family of ADM is presented in table 2-1. Subsurface limitations are given in paragraph 2-7*d*.

c. In tactical situations where burial is required while emplacement resources are limited and secrecy is important, engineer handtools are used to bury the ADM as deep as practical. In less restrictive situations, powered equipment or demolitions may be employed in preparing the emplacement.

(1) The powered earth auger offers a rapid means of excavating emplacement shafts up to 20 inches in diameter and 9 feet deep. This item is organic to the Engineer Light Equipment Company and the Engineer Construction Battalion and also may be available from a Class VII equipment pool.

(2) Steel pipe pile, closed at the bottom, may be driven to considerable depths in some soil media. Where piling of suitable diameter is available, it offers an excellent means of emplacement. Engineer construction and construction support units have organic pile-driving equipment.

(3) Civilian construction firms and/or commercial drilling equipment may be used for prechambering in certain situations. Rotary drill rigs with special bits and large diameter powered earth augers may be issued to engineer units for digging emplacement shafts.

(4) In appropriate situations, military explosives may be used alone or in conjunction with either powered equipment or handtools to prepare ADM emplacements.

d. Paragraph 6-8 contains additional information on emplacement criteria.

4-21. Preparation of Command Sites

a. Supporting engineer units are often designated to prepare primary and alternate command sites. Although priority is given to the preparation of the primary command site, alternate sites are normally planned, coordinated, and prepared. Alternate sites insure completion of the mission, provide flexibility, and permit safe firing under variable meteorological conditions.

b. Command sites (and any other sites designated for protection of demolition guard or firing party personnel at the time the munition is detonated) are far enough from the ADM to insure that the demolition guard and firing party are not subjected to initial nuclear effects greater than that specified by the commander. Locations should also consider anticipated fallout, although a change in meteorological conditions may dictate detonation of the ADM from an alternate command site. Intervening terrain features may reduce some of the initial nuclear effects; however, provision must be made to keep the emplacement site under observation. If direct observation of the emplacement site is not possible, observation may be maintained by aerial surveillance.

CHAPTER 5

ADM TARGET ANALYSIS

Section I. GENERAL

5-1. Factors Considered in ADM Target Analysis (STANAG 2130)

a. General.

(1) ADM target analysis is an examination of potential targets and surrounding areas to determine military importance, priority of demolition, and munitions required to obtain a desired level of damage. The purposes of analysis are to compare the respective advantages of conventional and nuclear demolitions in achieving desired target damage, to select the most suitable munition available, to predict the effects of the detonation, to permit the selection of the desired ground zero (DGZ) and depth of burial (DOB), and to compare the actual with predicted results for further application.

(2) Nuclear targets are classified according to size as follows:

(*a*) *Point targets.* A point target is a single element type of target such as a bridge or dam. ADM are used to destroy point targets by the cratering effect. However, bridges and other aboveground targets sensitive to blast may be damaged by the blast effect of an ADM. Predicted damage by blast for point targets is expressed as a percentage probability of achieving the desired level of damage. Normally, a probability of 90 percent is sought. The probability of achieving a specified level of damage is a function of the radius of damage (R_D) and the displacement distance (d), if any.

(*b*) *Area targets.* Larger targets which occupy a sizable portion of terrain are termed area targets. In analyzing this type of target, a 30-percent fractional coverage of the target area generally is considered the minimum coverage acceptable for destruction of a target. Associated with this 30-percent minimum coverage is the requirement of a high degree of assurance (90 percent) of achieving the desired results.

b. Assumptions. Analysis is based on the following assumptions:

(1) *Reliability.* It is assumed that the ADM will be successfully detonated.

(2) *Area targets.* ADM normally are employed after detailed ground, air, and map reconnaissance of the target area; however, if detailed information is not available, elements of area targets are assumed to be uniformly distributed.

(3) *Atmospheric conditions.* The influence of atmospheric conditions on initial nuclear effects usually is not considered by the target analyst.

(4) *Terrain.* If a nuclear detonation occurs within a narrow defile, initial nuclear effects may be reinforced within the valley and reduced outside of the valley because of the shielding afforded by the terrain.

(5) *Burial.* In many instances, damage is predicted upon adequate ADM burial. In tactical situations, the target analyst must be familiar with the burial capabilities of emplacement units and base his analysis on practical construction limitations.

5-2. Data for ADM Target Analysis

a. Tables in appendixes B and C of this manual and in FM 101-31-3 present technical data to be used in ADM target analysis for the hypothetical ADM family. See FM 101-31-2 for tables associated with stockpile weapons. These ADM damage tables provide data for most demolition targets. Troop safety tables and contingent effects tables are also included.

b. The troop safety tables (table B-11) simultaneously consider initial nuclear effects and the degree of risk to friendly troops in a particular condition of vulnerability. The tables give the minimum distances that friendly troops must be separated from ground zero to preclude casualties under various conditions of risk and vulnerability. These minimum safe distances (MSD) are based on initial effects only and do not take into account residual radiation or radiation history (para 5-5).

c. The damage tables (table B-1 and B-2) consider ADM nuclear effects based on surface and/or subsurface bursts. For each ADM, radii of damage against various target elements are shown.

d. The contingent effects tables consider only surface burst effects. For each munition, the tables present the distance to which various effects extend. These effects are:

(1) Tree blowdown (table B-9).

(2) Safety radii for aircraft in flight (table B-12).

(3) Fire areas (table B-7).

e. The crater dimensions tables (tables B-3 through B-6) give approximate diameter and depth of crater in various media. For each ADM, dimensions are given for surface emplacement, shallow depth of burial, and optimum depth of burial.

f. The tables in FM 101-31-2 have been computed for ADM in the United States stockpile, whereas those in appendixes B and C have been computed for the hypothetical family of ADM. The formats, however, are similar. One who understands the techniques of using the unclassified tables can readily make the transition to the classified tables contained in FM 101-31-2.

5-3. Recommendations

One purpose of target analysis is to select the most suitable ADM for destroying the target under consideration. After target analysis has been completed, the following recommendations are presented to the commander:

a. Primary and alternate yields with associated munition types.

b. Depth of burial.

c. Location of ground zero.

d. Point of detonation, if applicable.

e. Time of burst and firing options.

f. Estimated results.

g. Troop safety distance.

Section II. TECHNIQUES OF ADM TARGET ANALYSIS (STANAG 2130)

5-4. General Procedure for Analyzing Targets

The following general procedural steps are those used by the target analyst. They serve only as a guide. Some steps may be omitted or changed in order to meet the needs of the experienced target analyst. These procedural steps closely parallel techniques outlined in FM 101-31-1.

a. Step 1—Identify Pertinent Information. The target analyst identifes the pertinent portions of the SOP and becomes familiar with the special guidance expressed by the commander. He determines information concerning ADM allocations and authority to expend, as well as information regarding target location, nature, shape and size; the distance to friendly troops; target priorities; and transportation requirements of ADM.

b. Step 2—Determine Data for:

(1) *Estimating damage to the target.* There are three methods of estimating damage to targets when ADM are employed; the visual method, the numerical method, and special ADM methods. The method used will depend on the nature of the target and the governing primary effect (fig 5-1). The unit SOP may contain information regarding the extent and level of damage required for specific types of targets.

(*a*) *Visual method.* This method is used to estimate damage to irregular area targets (where the length of the target is greater than or equal to twice the width), such as trench lines or port facilities. Radii of damage for various target categories are located in the damage tables. The target analyst superimposes the appropriate radius of damage over the target and visually estimates the fraction of the target area covered. This is expressed as a percentage of the total target area.

(*b*) *Numerical method.* This method is used to estimate damage to approximately circular area targets (the length of the target is less than twice the width). The targt analyst uses the radius of target, and the displacement distance, if any, in conjunction with nomographs devised for estimating target coverage. The numerical method is also used for estimating the probability of damaging a point target when airblast, rather than cratering, constitutes the governing effect.

(*c*) *Special ADM methods.* Special methods, based primarily on crater parameters, have been developed for ADM target analysis. These methods are used for specific point targets which utilize the cratering and ground shock effects, such as bridges, dams, and tunnels.

(2) *Limiting requirements.* Restrictions placed on the employment of ADM are referred to as "limiting requirements," and are considered in two distinct areas—troop safety and the preclusion of damage and/or obstacles that could interfere with the accomplishment of the tactical mission.

(*a*) *Troop safety.* The target analyst checks the distance that separates friendly troops from ground zero to insure that they are not exposed to a risk exceeding that specified by the commander.

(*b*) *Contingent effects and preclusion of damage.* The target analyst checks to insure that undesirable results, usually consisting of obstacles to movement (tree blowdown and/or forest fires), damage to structures and facilities (bridges, supply dumps), or damage to heavily populated civilian areas, do not occur.

(*c*) *Select the desired ground zero.* To obtain the maximum effectiveness of an ADM, the target center, or the center of mass of a target, is selected initially as the desired ground zero. However, limiting requirements, or the engagement of multiple targets with a single device, may require the desired ground zero to be displaced.

(*d*) *Final evaluation of target damage or coverage.* When displacement of the desired ground zero is required, or when engaging multiple targets, a prediction of the final damage or coverage of the target must be made. These results will be a factor in the selection of an ADM.

c. Step 3—Evaluate the ADM Selected and the Overall Tactical Situation. In this step, the most suitable ADM is selected to engage each target—the best ADM-target combination must be determined. This determination involves consideration of several factors, some of which are:

(1) The highest priority target will receive first consideration.

(2)The ADM selected must be within the total number of each type that have been allocated.

(3) If all other considerations are equal, the minimum yield ADM that will do the job should be selected.

d. Step 4—Make Recommendation. After the target analysis has been completed, a recommendation is presented to the commander. The recommendation should include:

(1) *ADM.* The ADM to be used is shown by both model and yield. For example, CHARLIE/0.1 KT ADM.

(2) *Depth of burial (DOB).* Give the exact depth in meters where applicable. In addition, when an emplacement hole must be constructed, an estimate of the time and resources required for construction must be included.

(3) *Desired ground zero (DGZ).* Desired ground zero is the point on the earth's surface at or below which the detonation will occur. DGZ is generally designated by UTM map coordinates.

(4) *Emplacement position.* In cases where structures are involved, the emplacement position (burst point) is also specified. For example, base of center pier. When a demolition chamber must be constructed, an estimate of the time and resources required must be included.

(5) *Time of burst and firing options.* The time of burst and firing options are determined by both tactical and technical considerations, such as the scheme of maneuver and timer error; they are shown as a date-time group and timer or remote, respectively.

(6) *Troop safety.* The distance to which the effects for negligible risk to unwarned, exposed personnel extend is normally portrayed graphically to the commander. If friendly troops are located within this distance, a graphic presentation is provided depicting the resultant risk and/or protection required. (For further discussion of troop safety see para 5-5 and chap 7.)

5-5. Troop Safety

a. When compared to conventional explosives, employment of ADM in tactical operations involves a more rigorous analysis regarding the safety of friendly troops.

b. Troop safety may influence the selection of yield, ground zero, time of burst, and scheme of maneuver. When the SOP or commander's guidance concerning troop safety cannot be met, the following corrective actions may be taken to provide the degree of safety desired.

(1) Move location of ground zero.

(2) Increase the depth of burial.

(3) Use a lower yield ADM.

(4) Withdraw troops to safe distances.

(5) Accept a higher degree of risk to friendly troops.

(6) Increase the protection of friendly troops.

(7) Use conventional demolitions.

(8) Cancel the mission.

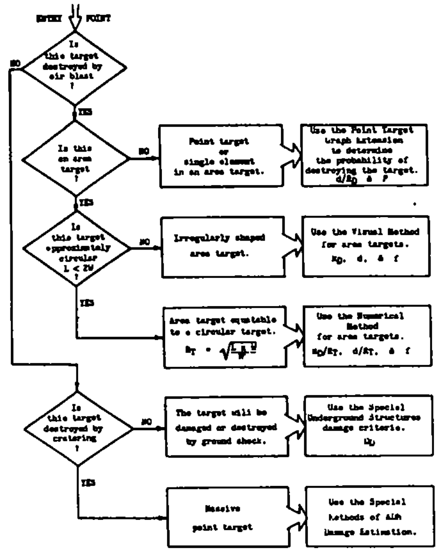


Figure 5-1. Methods of damage estimation.

c. The ADM target analyst uses the minimum safe distance (MSD) to make troop safety calculations. The MSD considers the distance to which certain nuclear effects extend. The following definitions are used in determining the appropriate MSD (app H):

(1) There are three *degrees of risk* associated with troop safety consideration—*negligible, moderate,* and *emergency*. These are defined in terms of the incidence (occurring within four weeks) of casualties or nuisance effect as shown in table 5-1. A nuisance effect is an injury which may cause a significant decrease in a solider's performance but wil not result in a casualty. Risk criteria are determined by the effect which governs (extends farthest from ground zero).

Table 5-1. Degree of Risk Definitions.

Degree of risk	Incidence of	
	Casualties	Nuisance effect
Negligible	1%	2.5%
Moderate	2.5%	5%
Emergency	5%	no limit

(*a*) At a *negligible risk* distance, troops are completely safe with the possible exception of a temporary loss of night vision or dazzle. A negligible risk from exposure to nuclear radiation is possible only when an individual or unit has an insignificant radiation dose history which will cause no decrement in combat effectiveness. An insignficant accumulated dose is interpreted to mean that blood changes will probably not be detectable. A negligible risk is acceptable in any case where the use of nuclear bursts is desired. *A negligible risk is not exceeded unless significant advantages are to be gained.*

(*b*) At a *moderate risk distance,* the anticipated effect on troops from a single exposure to a nuclear burst is tolerable, or at worst, a minor nuisance. A moderate risk from exposure to nuclear radiation occurs either when an individual or unit has a significant radiation exposure history, but has not yet shown symptoms or radiation sickness, or when a planned single dose is sufficiently high that exposure to up to four or five doses alone, or in conjunction with previous exposure, would constitute a significant radiation exposure history. A moderate risk is considered acceptable in close support operations; for example, to halt an enemy advance. *A moderate risk is not exceeded if troops are expected to operate at essentially full efficiency after a friendly burst.*

(*c*) At an *emergency risk* distance, the anticipated effect on troops from a single exposure to a nuclear burst may result in some temporary shock, mild burns, and a few casualties; however, casualties should never be extensive enough to nuetralize a unit. An emergency risk from exposure to nuclear radiation occurs either when a unit has a radiation exposure history which is at the threshhold for onset of combat ineffectiveness from radiation sickness, or when a planned single dose is sufficiently high that exposure to up to two or three such doses, alone or in conjunction with previous exposures, would approach or exceed the threshhold for combat ineffectiveness from radiation sickness. An emergency risk should be accepted only when absolutely necessary and should be *exceeded only in extremely rare situations which might loosely be called "disaster" situations.* No attempt is made to define a "disaster" situation. The commander must determine these extremely rare situations for himself and decide which criteria are appropriate to use in attempting to salvage such a situation.

(2) Closely associated with the degrees of risk is the *vulnerability* of the individual soldier. The danger to an individual from a nuclear detonation depends principally upon the degree to which he is protected from nuclear effects. For example, an individual who is well protected can safely be much closer to ground zero than one in the open. The degree of protection of the individual is dependent upon the amount of advance warning the individual has received. One or more of the following three conditions of *personal vulnerability* can be expected at the time of burst: unwarned, exposed; warned, exposed; and warned, protected.

(*a*) *Unwarned, exposed* persons are assumed to be standing in the open at burst time, but have dropped to a prone position by the time the blast wave arrives. They are expected to have areas of bare skin exposed to direct thermal radiation, and some personnel may suffer temporary loss of vision (dazzle). Such a condition may prevail in an offensive situation where the majority of the attacking infantry are in the open, and a warning of the burst has not been disseminated.

(*b*) *Warned, exposed* persons are assumed to be prone on open ground, with all skin areas covered, and with an overall thermal protection at least equal to that provided by a two-layer summer uniform. Such a condition may occur when a nuclear weapon is employed against a target of opportunity during an attack and sufficient time exists to broadcast a warning; troops have been warned, but do not have time to dig foxholes.

(*c*) *Warned, protected* persons are assumed to have some protection against heat, blast, and radiation. The degree of protection depends upon the shielding properties, the blast-wave modifying factors, and the blast vulnerability of the vehicles or fortifications inclosing the personnel. Armored vehicles are assumed to be "buttoned-up" since the personnel are warned. A warned, protected condition may occur when nuclear weapons are used in a preparation prior to an attack. Protected categories include tanks, armored personnel carriers, foxholes, weapons emplacements, and command posts and shelters.

(*d*) Note that there is no category for *unwarned, protected.* Although protection may be available to personnel, it is assumed that they will not be taking advantage of it unless warned of an impending burst.

d. In determining the degree of risk to which troops will be subjected, the target analyst needs to know the location of friendly elements, their degree of protection at the time of the detonation and their radiation exposure history. As part of a general defensive barrier plan where numerous ADM are to be detonated in a close time interval, the target analyst must consider the cumulative or "build-up" effect of numerous ADM, each of which alone may constitute only a negligible risk.

e. When examining troop safety in connection with a target analysis, table B-11 (app B) must be consulted to determine if the weapon yield being investigated falls in range where radiation is the governing troop safety criteria. If radiation does not govern, the unit's radiation history does not have to be considered. If radiation does govern, the unit's radiation history must be considered and both table B-11 and criteria shown in table 7-1 should be interpreted as follows:

(1) For units with no past cumulative radiation dose (RS-0 units), read direct from Troop Safety table B-11 for the appropriate risk and degree of vulnerability.

(2) For units with a past cumulative dose up to 70 rad (RS-1 units), any further radiation exposure must be considered a moderate or an emergency risk. There can be no negligible risk for personnel in this category.

(3) For units with a past cumulative dose from 71 to 150 rad (RS-2 units), any further radiation exposure must be considered an emergency risk. Even though a further exposure to nuclear radiation is an emergency risk, the effects to this unit would include some sickness, but rarely incapacitation.

(4) For units with a past cumulative dose of more than 150 rad (RS-4 units), all further exposures must be considered an emergency risk. Any further exposure is dangerous. This unit should be exposed only if unavoidable because additional exposure will result in sickness, incapacitation, and probably some deaths.

5-6. Contingent Effects

a. Contingent Effects. Contingent effects are divided into bonus effects which are desirable and limiting effects which are undesirable.

b. Bonus Effects. When an ADM is employed, there are many effects other than the governing effect with assist in destruction. Some bonus effects are predictable, others are not. The target analyst checks to see whether a predictable bonus effect exists at a certain point by obtaining the radius of damage for the effect from the contingency tables. For example, in an airfield denial operation, cratering a runway with a FOXTROT/5 KT surface burst could produce a bonus effect of severaly damaging by blast structures such as hangars and maintenance shops out to a radius of 245 meters (table B-1).

c. Limiting Effects. Limiting effects are those which are undesirable and, consequently, place restrictions on the employment of the munition. These restrictions are referred to as limiting requirements. Examples of effects which may be undesirable are the creation of obstacles to friendly movement as a result of tree blowdown, rubble, forest and urban fires, residual radiation, or undesirable damage in the vicinity of the burst. The target analyst determines whether undesirable effects will be created and determines the radius of the limiting effects from the contingent effects tables.

5-7. Analysis of Specific Target Types

a. The capability of ADM to destroy a specific target depends on many factors, the most important of which is the yield. When making a target analysis and selecting the yield, it is desirable to employ the lowest yield which provides the acceptable degree of damage to the target.

b. In chapter 6 special methods for analyzing ADM targets are presented. General analysis of each target type and specific factors regarding ADM employment are considered. Detailed analysis of typical ADM targets following the procedural steps outlined in paragraph 5-4 are presented in appendix G.

5-8. Validity of Effects Data

a. Nuclear testing has produced the effects data on which target analysis is based. The validity of these data, however, is extremely variable; when required, validity application of these factors for each nuclear effect is given in DASA EM-1. For target analysis purposes, the validity factors are not considered. Therefore, refinement of the data in the recommended target analysis procedures is not justified. However, the target analyst should have an understanding of the data.

b. Curves and other technical data are provided by the text so that reasonable estimates of yields or damage can be made. The data on which the curves are based have, in general, a degree of accuracy of plus or minus 25 percent.

CHAPTER 6

SPECIAL ADM TARGET ANALYSIS

Section I. INTRODUCTION

6–1. General (STANAG 2130)

Unlike other nuclear systems, ADM are employed to destroy hard targets and create obstacles rather than cause personnel casualties. Nuclear cratering, therefore, is usually the governing effect, whereas other nuclear effects are considered bonus effects, or problems to be controlled or eliminated, depending on the mission. In addition, the unique characteristic of no delivery error considerably simplifies target analysis techniques. This chapter, therefore, presents modifications to the general target analysis methods outlined in FM 101–31–1 and provides special techniques for the analysis of typical ADM targets.

6–2. ADM Target Analyst

Because some ADM targets are structures, the ADM target analyst must not only be qualified in estimating the effects of nuclear detonations but be familiar with basic construction design. Moreover, the surface and subsurface employment of ADM is significantly influenced by the surrounding media. Current cratering curves divide the media into four types; dry and wet soil, and dry and wet rock. Thus, the target analyst is required to differentiate only between these types. ADM target acquisition requires target location and detailed description of the target including critical structural dimensions, burial limitations, and soil characteristics.

Section II. TACTICAL CRATERING

6–3. General

One of the potential military uses of ADM of prime significance is the creation of terrain obstacles. The nuclear cratering effect has been previously discussed in general terms in chapter 2. The purpose of this section, therefore, is to present techniques of using ADM to displace large masses of soil or rock to deny land routes of communication in support of tactical operations. A nuclear detonation in soil or rock forms a crater by crushing, compacting, fracturing, and displacing the medium. The material adjacent to the explosion is vaporized and melted. Large quantities of soil or rock are thrown out of the ground. Some material falls back into the crater as fallback material. Most of the remainder of the "throwout" material falls on the crater lip as ejecta material; a small portion of the finer particles is carried up in a large dust cloud which will form a large circular pattern (base surge) around the crater or will be carried downwind for considerable distances. Crater size is generally dependent on three factors: yield, depth of burial, and the surrounding medium.

a. Yield. Crater dimensions increase with increased yield. A tenfold increase in yield will generally double the dimensions.

b. Depth of Burial. Increase in the depth of burial will increase size until a depth of burial is reached at which crater dimensions are maximum; at greater depths crater size will decrease until no crater, or a subsidence crater, is formed. Depth of burial is the most significant factor in producing craters for ADM employment.

c. Surrounding Medium. For a given yield and equivalent depth of burial, craters in rock will be smaller than in soil, and a wet medium will produce larger craters than a dry one.

6–4. Crater Nomenclature and Dimensions

Figure 6–1 shows a cross section of a typical crater in rock and the significant dimensions and zones associated with cratering.

a. Fallback. Fallback consists of material which has been thrown into the air and then fallen back into the crater. It fills up a portion of the *true* crater formed by the detonation, producing the final (*apparent*) crater shape.

b. Ejecta. Ejecta consists of material which has been thrown out of the crater. It assists in lip formation and produces a missile hazard and a base surge dust cloud. Continous ejecta forms a portion of the lip out to a distance of about one apparent crater diameter from the crater edge.

c. Rupture Zone. This zone consists of material which has been severely fractured and crushed, but which has not undergone significant displacement. It is adjacent to the true crater formed by the detonation. The radius of the rupture zone (R_R) is about one and one-half times the radius of the apparent crater.

d. Plastic Zone. This zone is in the cratered medium beyond the rupture zone in which stresses have caused permanent deformation, but not significant crushing or fracturing in the medium. Structures in the plastic zone are vulnerable to damage.

e. Elastic Zone. This zone extends beyond the plastic zone. The properties of the material in this zone have not been significantly affected by the detonation, although strong ground pressures have been transmitted through the medium.

f. Apparent Crater. The apparent crater is that portion of the visible crater below the original ground surface. The apparent crater radius (R_A) and depth (H_A) are the dimensions of primary interest in the creation of crater obstacles. They are determined from the cratering curves presented in paragraph 6-7. Other crater dimensions are derived from them.

g. True Crater. This is the crater actually formed by the detonation. The fallback material fills up a portion of the true crater to form the apparent crater. The true crater forms the boundary between the fallback material and the rupture zone.

h. Apparent Lip. The apparent lip of a crater is composed of the true lip and the ejecta lip. The true lip is formed by the upward displacement of the ground surface above the rupture zone. The ejecta lip is formed by the material thrown out of the crater onto the lip. The apparent lip defines the limits of the visible crater above the preshot ground elevation. The radius of the apparent lip crest (R_{AL}) constitutes the total crater obstacle. It is about 15 percent larger than the apparent crater radius.

i. Volume. The volume of the apparent crater (V_C) is equal to $\frac{\pi}{2} H_A(R_A)^2$. This dimension is of value in calculating the amount of backfill required to breach the crater obstacle.

6-5. Cratering Mechanisms

It is necessary to study the mechanisms associated with nuclear cratering phenomena to obtain an adequate understanding of the results to be expected at various depths of burial and their significance in ADM employment. These mechanisms are: crushing, compaction, and plastic deformation; spalling; gas acceleration; and overburden collapse. To some degree, these mechanisms are present in all subsurface cratering detonations. However, their relative importance in contributing to crater formation is significantly affected by the depth of burial. These mechanisms will be discussed below, and related to the depths of burial shown in figure 6-2.

a. Crushing, Compaction, Plastic Deformation. This phenomenon is present in both chemical and nuclear underground explosions. As the high pressure explosion gases expand against the medium immediately surrounding the explosion, a spherical shock wave is generated. For chemical explosives the initial shock pressures are on the order of 100 to 200 thousand atmospheres; for a nuclear explosive they are as large as 10 to 100 million atmospheres, depending on the initial cavity size. In nuclear explosions the surrounding medium is initially melted and vaporized as the shock front passes through it. As the shock front moves outward in a spherically diverging shell, the medium behind the shock front is put into radial compression and tangential tension. This results in the formation of radial cracks directed outward from the cavity. The peak pressure in the shock front becomes reduced due to spherical divergence and the expenditure of energy in the medium. For shock pressures above the dynamic crushing strength of the medium, the material is crushed, heated, and physically displaced, forming a cavity. In regions outside this limit the shock wave will produce permanent deformation by plastic flow, until the peak pressure in the shock front has decreased to a value equal to the plastic limit of the medium. This is the boundary between the plastic zone and the elastic zone (fig 6-1). This cratering mechanism is most significant in contributing to crater size for bursts at or just below ground surface (fig 6-2a), or at subsidence depths of burial.

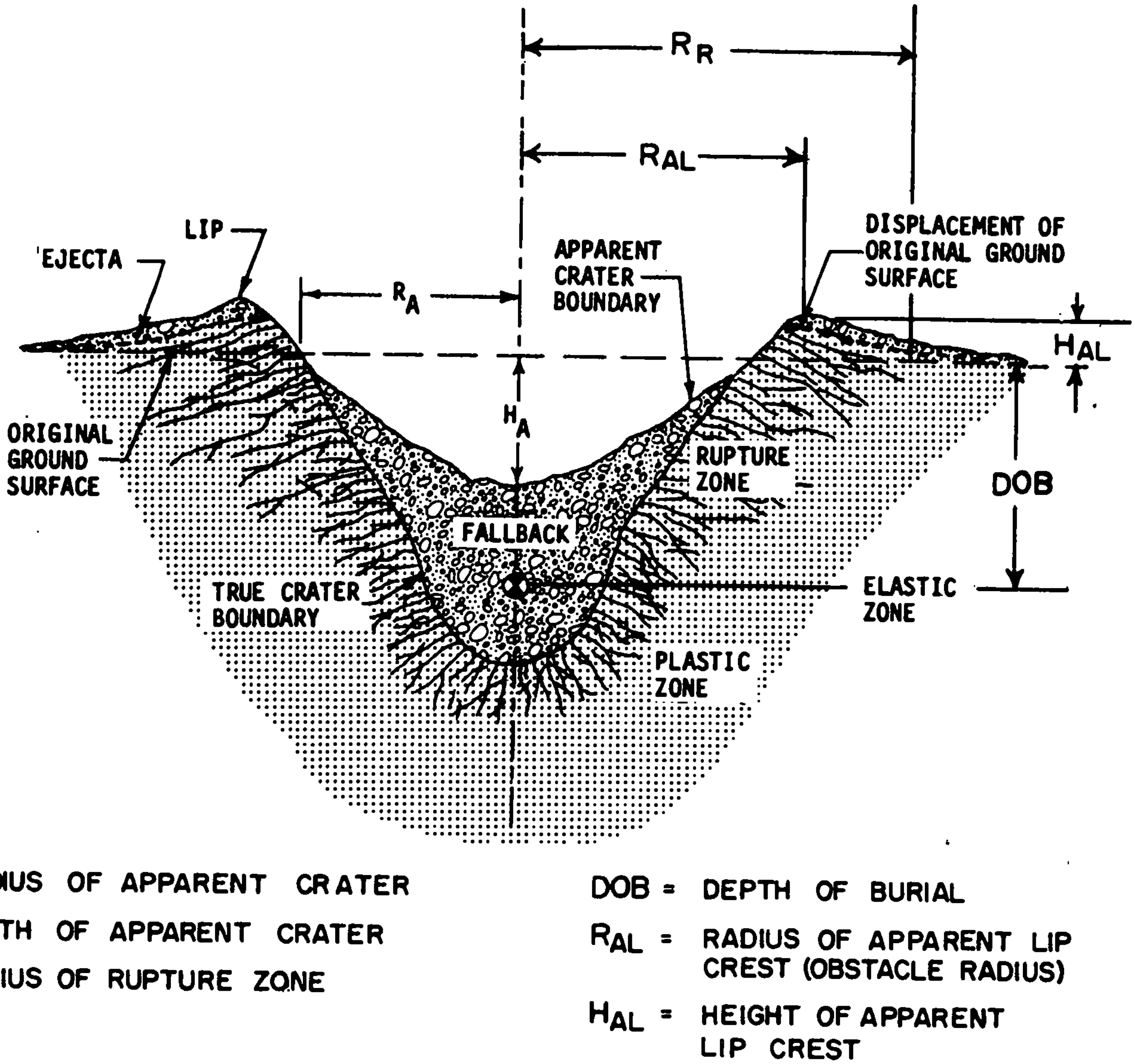


Figure 6–1. Crater nomenclature.

b. Spalling. The above description of the first milliseconds of an explosion does not include the effects of any free surface which will cause the spall mechanism. When the shock (compressive) front encounters a free surface, it must match the boundary condition that the pressure (normal stress) be zero at all times. This results in the generation of a negative stress, or rarefaction, wave which propagates back into the medium. Thus the medium which was originally under high compression is put into tension by the rarefaction wave. This phenomenon causes the medium to break up and fly upward with a velocity characteristic of the total momentum imparted to it. In a loose soil material, this "spalling" makes almost every particle fly into the air individually, while in a rock medium the thickness of the spalled material is generally determined by the presence of pre-existing fracture patterns and zones of weakness. As the distance from ground zero increases the peak pressure decreases. Therefore, the tensile stress decreases until it no longer exceeds the tensile strength of the medium. In addition the velocity of the spalled material decreases in proportion to the peak pressure. The spall mechanism produces an extended rupture and plastic zone near the ground surface and contributes significantly to the true lip height of the crater. This mechanism appears to be dominant in determining crater size at shallow depths of burial (fig 6–2b). Shallow depth of burial is

$15W^{0.3}$ meters. The yield, W, is expressed in kilotons.

c. Gas Acceleration. The two mechanisms described above are short term ones lasting only a fraction of a second. The gas acceleration mechanism, however, is a longer process which imparts motion to the medium around the detonation by the expansion of gases trapped in the explosion-formed cavity. The gases are produced in the surrounding material by vaporization and chemical changes induced by the heat and pressure of the explosion. At depths of burial at which crater dimensions are maximum, the gases produced will give appreciable acceleration to overlying material

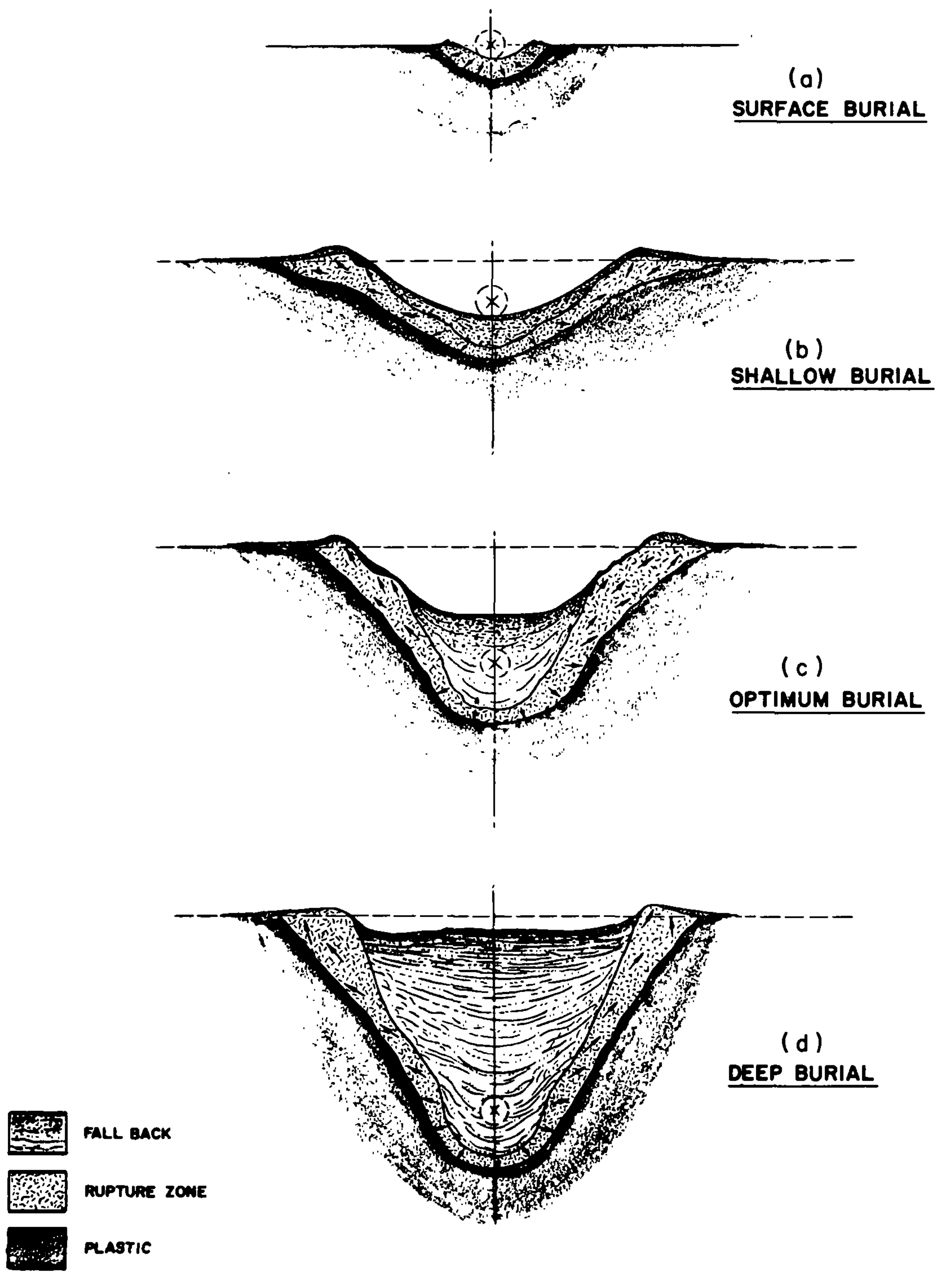


Figure 6–2. Crater profiles vs depth of burial.

during its escape (venting) through cracks extending from the cavity to the surface. At shallow depths of burial the spall velocities are so high that the gases are unable to exert any pressure before venting occurs. For very deep explosions the weight of the overburden precludes any significant gas acceleration of the overlying material. Gas aceleration is the dominant mechanism at optimum depth of burial (fig 6–2c). Optimum depth of burial varies with the surrounding material from approximately $34W^{0.3}$ meters for dry rock to approximately $49W^{0.3}$ meters for dry soil.

d. Overburden Collapse. At deep depths of burial the mechanism of overburden collpase (subsidence) becomes dominant. This effect is closely linked to the crushing, compaction and plastic deformation mechanism which produces an underground cavity. At these depths of burial spall and gas acceleration will not impart sufficient velocity to the overlying material to physically eject it from the crater. Therefore, most throwout returns to the crater as fallback material. In effect, the crater volume would be largely determined by the underground cavity formed by the detonation, as shown in figure 6–2d. In a rock medium the bulking action of the rock, when it is disoriented from its original fracture pattern, could produce a volume greater than the underground cavity. This could result in no crater, or indeed, even a mound above the ground rather than a crater. A nuclear detonation which produced such a mound is shown in figure 6–3. At depths of burial about twice that of optimum or deeper, another type of subsidence occurs. In this situation the spall and gas acceleration have no significant effect on the overlying material. Only an underground cavity is formed. When the pressure in the cavity decreases below overburden pressure, the roof of the cavity begins to collapse. In most media this collapse will continue upward forming a "chimney" of collapsed material. In soil, where the density of the material will not

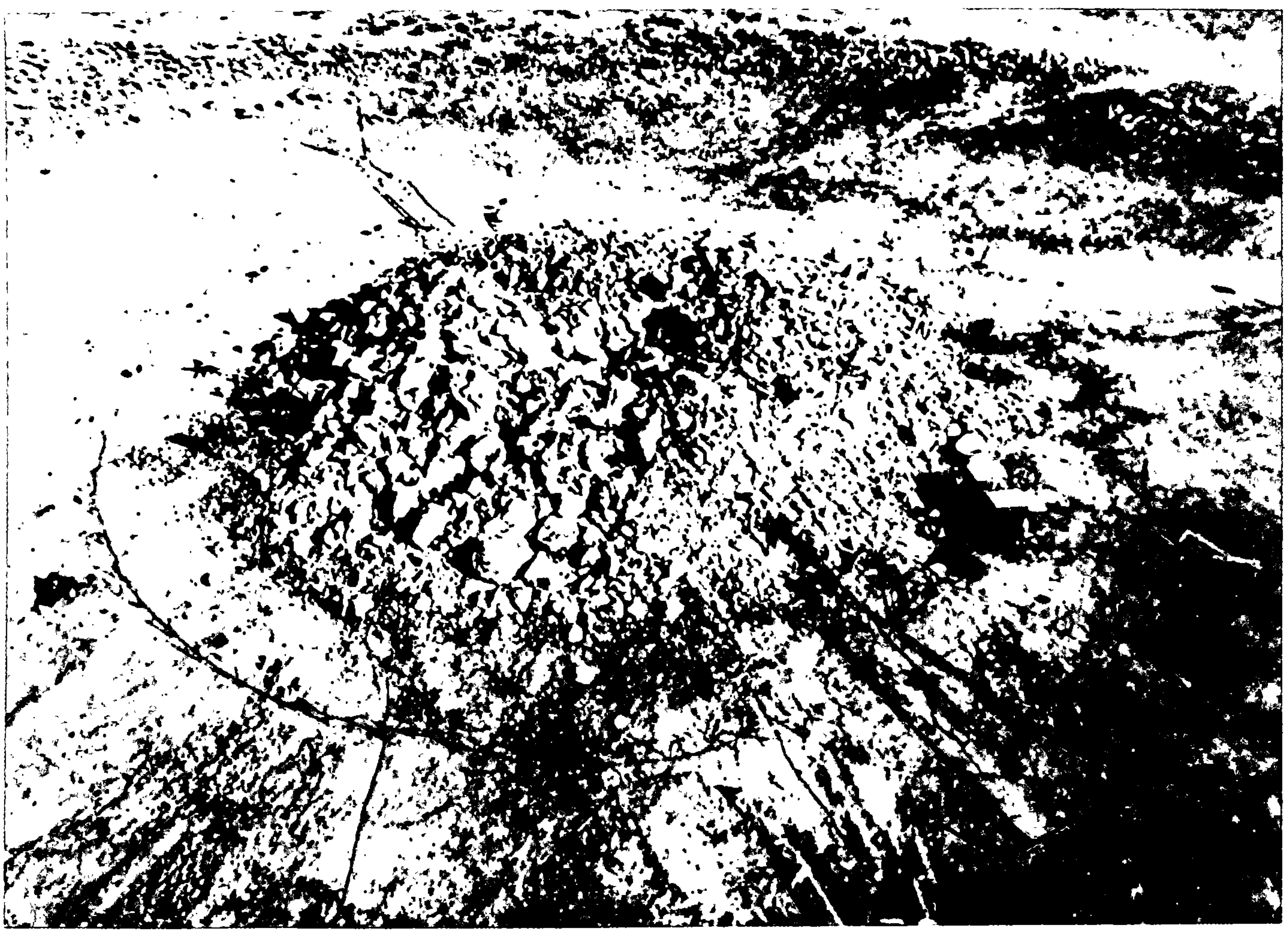
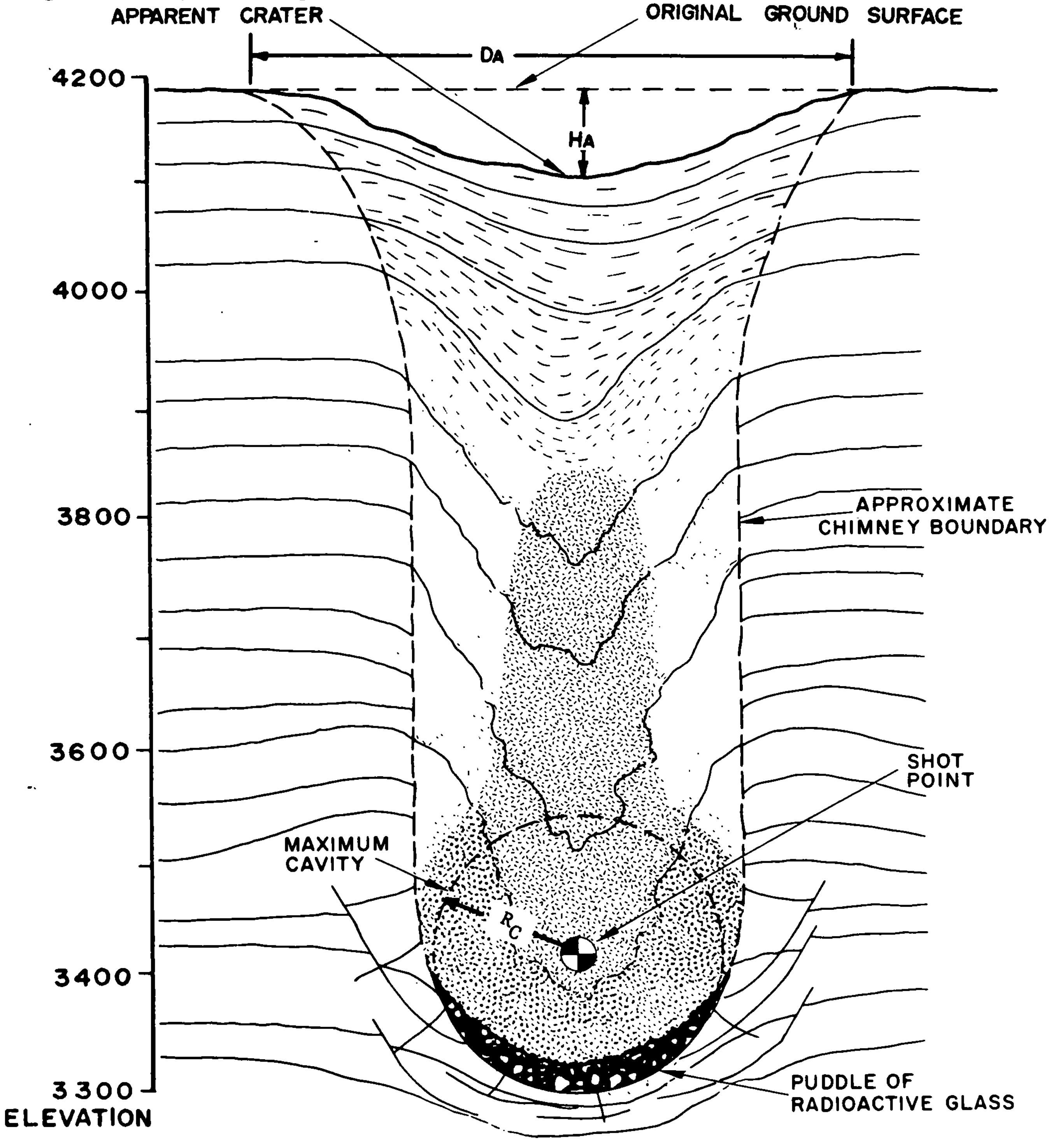


Figure 6–3. Mound produced by a deep nuclear detonation.

significantly change after it has fallen, the volume of the cavity will be transmitted to the surface, forming a "chimney" of collapsed material. In phenomenon is illustrated in figure 6–4, based on post-shot exploration of a subsidence crater. In rock, the bulking of the fallen rock would be



D_A = Diameter of apparent crater

$D_A = 73\ W^{0.3}$ meters or $240\ W^{0.3}$ feet

H_A = Depth of apparent crater

$H_A = 12\ W^{0.3}$ meters or $40\ W^{0.3}$ feet

R_C = Radius of cavity

$R_C = 18\ W^{0.25}$ meters or $60\ W^{0.25}$ feet

W = Yield in kilotons

Figure 6–4. Subsidence crater dimensions.

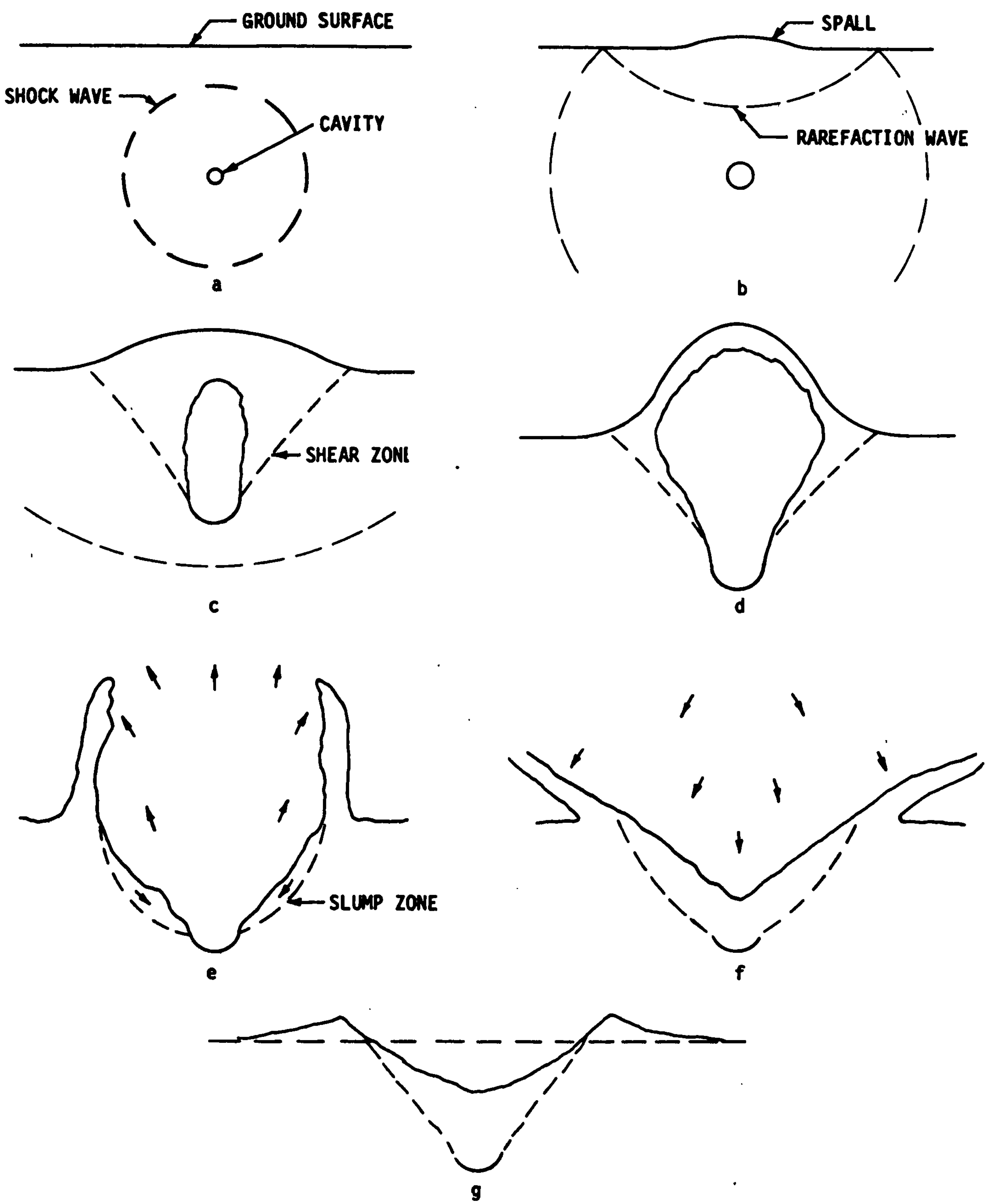


Figure 6–5. Crater formation at optimum depth of burial.

expected to take up much or all of the volume of the cavity. Thus, either a smaller subsidence crater would be produced, or the chimney would not reach the surface. Normally, subsidence craters are not used as terrain obstacles because of the absence of a crater lip, the gentle slope of the crater wall, and the relative uncertainty of crater parameters.

6–6. Optimum Depth of Burial

As mentioned previously, at a certain depth of burial called "optimum" a maximum size crater will be produced with a given yield in a specific medium. It is at this depth of burial that the cratering mechanisms combine to achieve optimum cratering efficiency. A qualitative description of events occurring at optimum depth of burial is an aid to the full understanding of the cratering phenomenon. The events are illustrated in figure 6–5.

a. Figure 6–5a. Immediately after detonation cavity formation begins, caused by crushing, compaction and plastic deformation. The cavity expands with spherical symmetry. At the same time, the shock wave moves away from the point of detonation much faster than the cavity expands, producing high compressive forces in the medium. The amplitude of this compression decreases as it proceeds away from the shot point. Depending on the dynamic compressive strength of the medium, concentric zones of vaporization, melting, crushing, and plastic and elastic deformation are produced.

b. Figure 6–5b. The reflection of the shock wave from the free surface results in a tensile or rarefaction wave which breaks up the medium in layers roughly parallel to the surface, and causes it to spall away from the ground surface with an upward velocity. Spall begins at the surface and successively progresses downward toward the

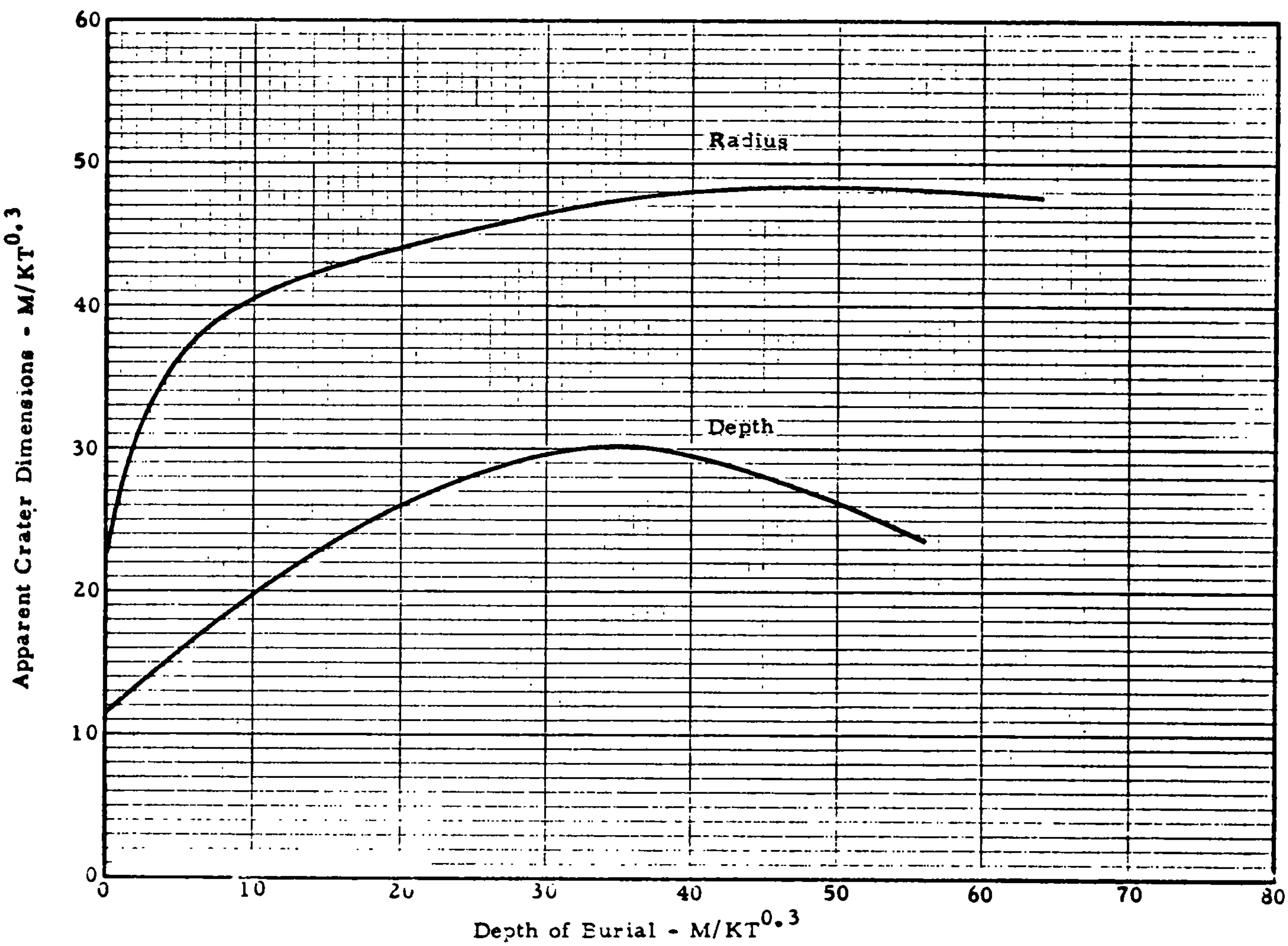


Figure 6–6. Apparent crater dimensions versus depth of burial in dry soil (< 50% saturation; ≦ 10% moisture content). Normalized to 1–KT.

shot point. Note that cavity expansion is still spherical, since it has not "felt" the weakness caused by spalling at the surface.

c. Figure 6–5c. After the rarefaction wave passes the cavity, the weakness of the overlying material now in tension is "felt" by the cavity. Therefore, the cavity begins expanding asymmetrically toward the surface. This begins to create shear zones close to which the true crater will eventually be formed. Note that spalled material is continuing to rise. The shape of the mound is consistent with the spall velocity of the individual particles being spalled.

d. Figure 6–5d. The expansion of gases begins to accelerate the overlying material and increases the velocity of the spalled material. In addition, gas pressures impart a horizontal component of force to the material in motion assisting in ejection of this material out of the crater area.

e. Figure 6–5e. The cavity erupts (vents) through the surface, further accelerating material as the constricted gases rush through the fissures in the mound, carrying a large amount of material (ejecta). The sudden loss of pressure in the cavity produces a "rebound" effect on the highly stressed surrounding medium. This results in slump zones formed in the rupture zone which slip to a more stable position in the cavity.

f. Figure 6–5f. Fallback begins to fill up the crater and ejecta falls on the crater lip. Note that a portion of the surface material folds back on itself forming a portion of the ejecta lip.

g. Figure 6–5g. The final crater configuration has reached a state of equilibrium.

6–7. Cratering Curves and Scaling Laws

a. Figure 6–1 shows certain crater dimensions. Two of them, the apparent radius (R_A) and the apparent depth (H_A) are determined from the cratering curves presented herein. Other pertinent dimensions are derived from them as follows:

(1) Radius of apparent lip crest (R_{AL}) equals 1.15 R_A.

(2) Height of apparent lip crest (H_{AL}) equals 0.25 H_A.

(3) Radius of rupture zone (R_R) equals 1.5 R_A.

b. Empirical scaling laws have been derived from past cratering tests. These are used to determine the relationship between apparent crater dimensions and depth of burial for any yield, by normalizing all dimensions to those applicable to a yield of 1 KT. The yield, W, is expressed in kilotons. The scaling laws are summarized below.

Subsurface burst ($DOB_s > Om$)

Depth of Burial	*Radius of Crater*	*Depth of Crater*
$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$	$\frac{R_{A1}}{R_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}}$	$\frac{H_{A1}}{H_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}}$

Surface burst ($DOB_s = Om$)

Radius of Crater	*Depth of Crater*
$\frac{R_{A1}}{R_{A2}} = \frac{W_2^{1/3}}{W_1^{1/3}}$	$\frac{H_{A1}}{H_{A2}} = \frac{W_1^{1/3}}{W_2^{1/3}}$

c. Figures 6–6 through 6–9 give apparent crater radius and depth as a function of depth of burial for varous media. These curves are for a 1-kiloton ADM. The scaling laws given above must be used to find these dimensions for other yields.

6–8. Effects of Tamping and Stemming

a. Tamping. The curves in paragraph 6–7 are all based on no tamping for surface bursts. Tamping of surface shots will have some beneficial effect on energy coupling, although it cannot be stated quantiatively. If operational requirements and logistical support allow, tamping of surface bursts MAY be accomplished. One and one-half meters of earth or sandbags around and over the munition is recommended.

b. Stemming. The curves in paragraph 6–7 are also based on fully stemmed detonations for buried shots. In the actual tests, the emplacement holes were filled with material ranging from sand and gravel to concrete plugs. Under these circumstances crater size prediction, using these curves, would be valid. However, in a tactical situation a

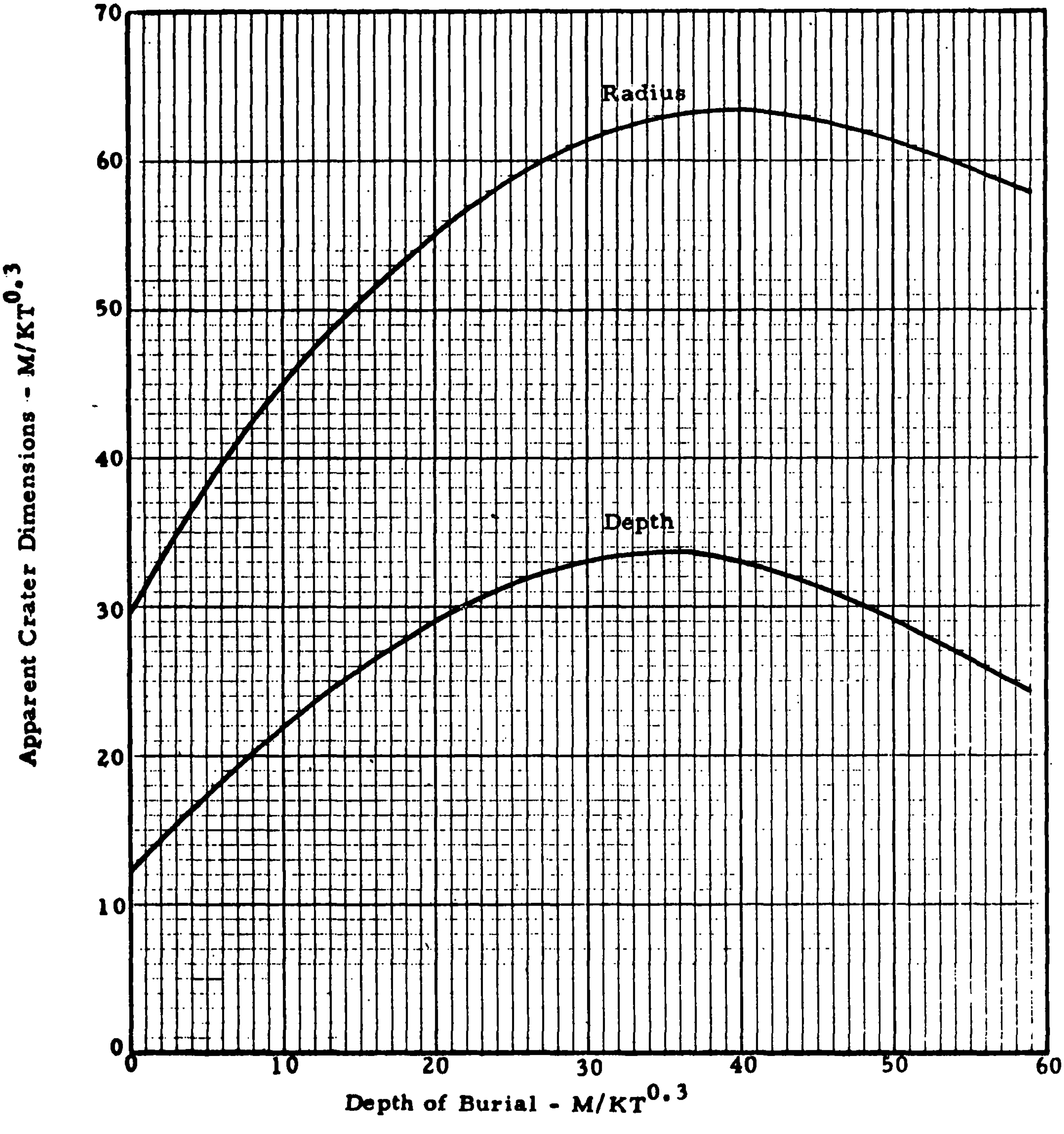


Figure 6-7. Apparent crater dimensions versus depth of burial in wet soil (50% to 90% saturation; > 10% moisture content). Normalized to 1-KT.

fully-stemmed emplacement hole is usually not desirable, for the following reasons:

(1) Additional engineer support and materials would be required on all subsurface ADM missions.

(2) Emplacement of an ADM would take a considerably longer time.

(3) Deep emplacement might not be possible if the weight of the stemming material exceeds the backfill limitations of the ADM.

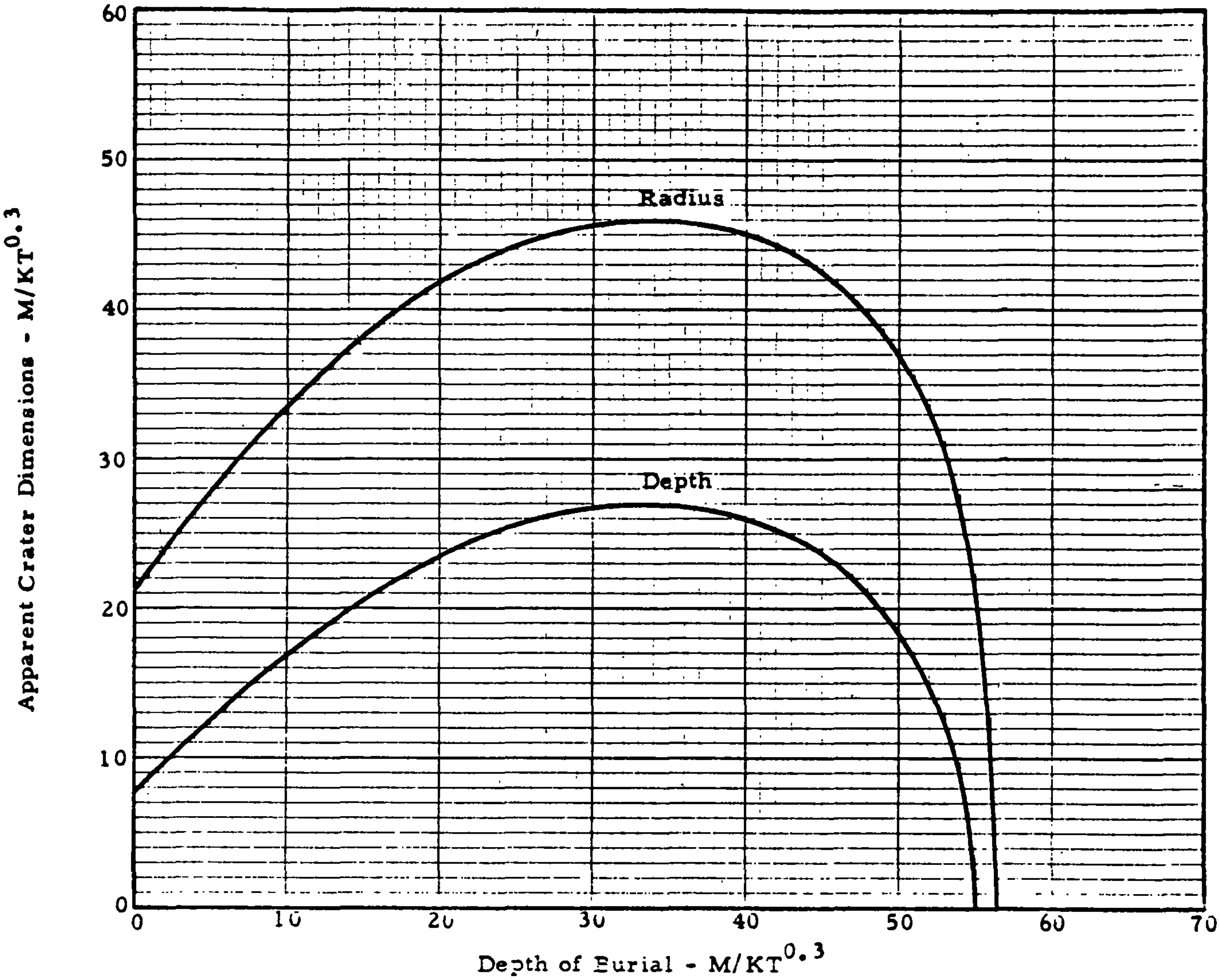


Figure 6-8. Apparent crater dimensions versus depth of burial in dry rock (< 50% saturation; ≤ 3% moisture content). Normalized to 1-KT.

(4) If the mission is aborted, recovery of the ADM would be difficult or even impossible in a tactical situation.

(5) There is a certain loss of control and security when an ADM emplacement hole is fully stemmed.

c. Modifications to Full Stemming. General guidelines can be presented, which, if used with the proper degree of engineering judgment, will allow ADM employment in situations where full stemming is not used.

(1) *Water stemming.* In many areas of the world, the height of the ground water table will result in water-filled emplacement holes. The difference in crater size between a solid-filled hole and a water-filled hole would be militarily insignificant. Thus the curves in paragraph 6-7 can be used without change for full water stemming. Two obvious requirements would be that the ADM have a negative buoyancy and that the water pressure would not exceed the allowable hydrostatic pressure on the ADM.

(2) *Partial stemming.* The use of at least 1.5 meters of stemming material over the munition will produce a crater almost as large as fully stemmed detonation. Stemming materials could be loose sand or gravel, or water. Thus the curves in paragraph 6-7 can be used without change for 1.5 meters of stemming or more. Figure 6-10 illustrates a typical stem design for subsurface emplacement of an ADM.

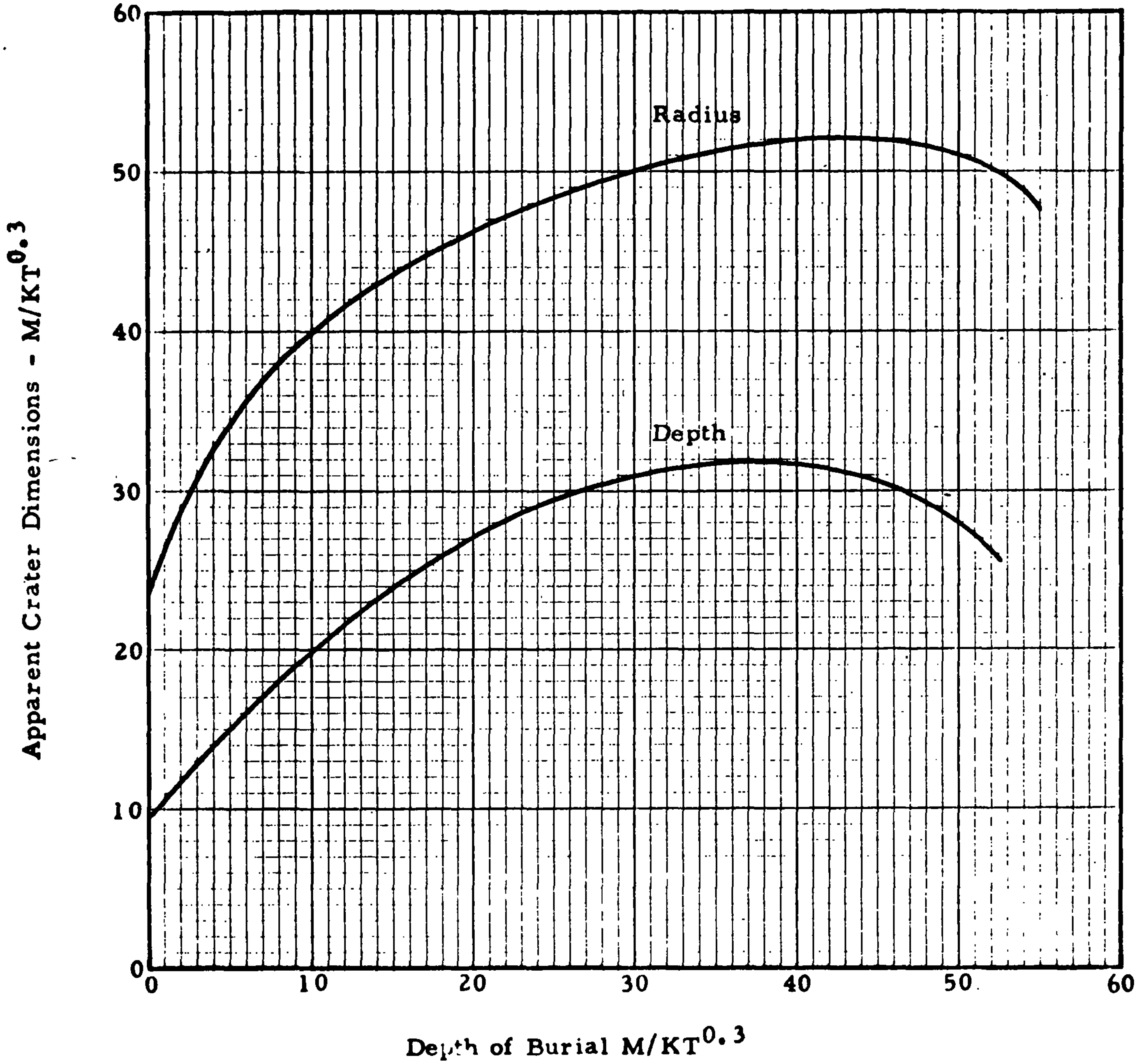


Figure 6-9. Apparent crater dimensions versus depth of burial in wet rock (50%—90% saturation; > 3% moisture content). Normalized to 1-KT.

(3) *Unstemmed holes.* The quickest method of underground ADM employment would be emplacement in an unstemmed hole. This would eliminate all the disadvantages associated with buried ADM and provide a technique of rapid emplacement and recovery. In an unstemmed emplacement hole some of the energy from the explosion will certainly escape before it can contribute to crater formation. However, it is expected that most of the energy would be transmitted into the medium. Current research indicates that crater dimensions from an unstemmed emplacement hole would be about ten percent smaller than these from a fully stemmed detonation. Using this correction factor, crater size from unstemmed emplacement holes can be predicted from the curves in paragraph 6-7.

d. With partial stemming or no stemming, there would be an increase in the amount of fallout. However, is is not expected that there would be any significant change in its area distribution. In

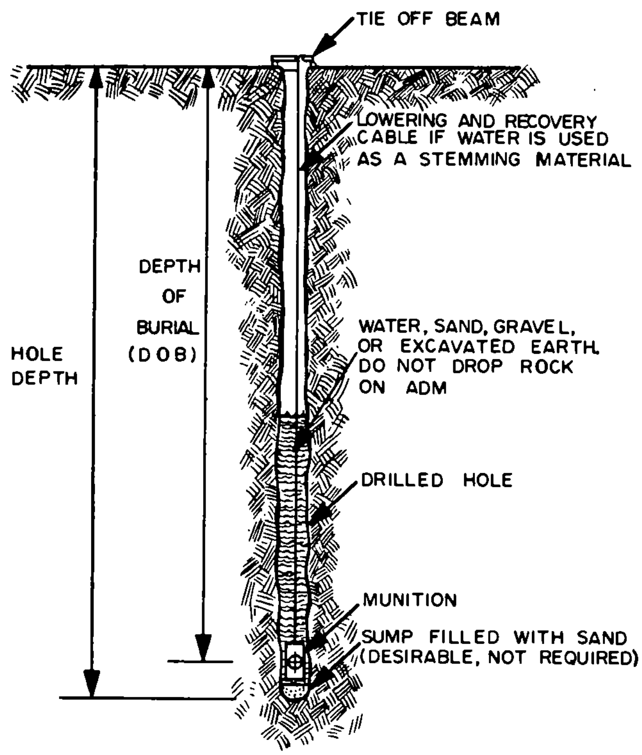


Figure 6–10. Typical stem design for subsurface emplacement of an ADM.

other words, the downwind distances to Zones I, IA, and II would not be significantly affected, although the intensity of radioactivity within these zones would be increased somewhat.

6–9. Illustrative Example

a. Given: A FOXTROT/5KT ADM is to be detonated in wet soil at a depth of burial of 50 meters. The ground water table is 45 meters below the surface so the ADM will be covered by about 5 meters of water.

b. Find: The apparent radius (R_A), the apparent depth (H_A), and the obstacle radius (R_{AL}) of the resulting crater.

c. Solution: Use figure 6–7 and the scaling laws.

(1) $$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

$$\frac{50}{DOB_2} = \frac{5^{0.3}}{1} = \frac{1.62}{1}$$

$$DOB_2 = \frac{50}{1.62} = 30.8 \text{ meters}$$

(2) From figure 6-7, using a DOB of 31 meters, read $R_{A2} = 62m$ and $H_{A2} = 33m$.

(3) $\frac{R_{A1}}{R_{A2}} = \frac{W_1^{0.8}}{W_2^{0.8}}$

$\frac{R_{A1}}{62} = \frac{1.62}{1}$

$R_{A1} = 62(1.62) = 100.4$

(4) $\frac{H_{A1}}{H_{A2}} = \frac{W_1^{0.8}}{W_2^{0.8}}$

$\frac{H_{A1}}{33} = \frac{1.62}{1}$

$H_{A1} = 33(1.62) = 53.5$

(5) $R_{AL} = 1.15\ R_A = 1.15(100.4)$

$R_{AL} = 115.5$

d. Answer: $R_A = 100.4m$

$H_A = 53.5m$

$R_{AL} = 115.5m$

6-10. Apparent Crater Characteristics

a. Shape of the Apparent Crater. The shape of the apparent crater varies with the depth of burst of the ADM. Craters resulting from surface detonations have gentle slopes and are relatively shallow in depth while detonations in the vicinity of optimum depth of burial produce craters with relatively steep slopes. Although the shape of the apparent crater varies with depth of burial, the crater cross section remains approximately parabolic.

b. Apparent Crater Lip. The apparent crater lip consists of the material lying above the original preshot ground surface. Formation of the apparent lip results from the upwward displacement of the ground surface and the deposit of throwout material around the periphery of the crater. The upthrust portion of the lip is defined as the true crater lip, while the material deposited on top of the true crater lip (ejecta) combines with the true lip to form the apparent crater lip. The characteristics of the apparent crater lip depend on the yield, depth of burial, and the media in which the detonation occurs. Lip height and diameter achieve their greatest dimension in rock media.

6-11. True Crater Characteristics

a. General. The true crater is defined as the boundary between the fallback material and the underlying material which has been crushed and fractured but has not experienced significant vertical displacement. The characteristics of the true crater are of primary interest to the engineer when considering military applications involving the demolition of hard targets.

b. True Crater Radius. The true crater radius is defined as the radius of the circle that best describes the intersection of the preshot ground surface with the walls of the true crater. For depths of burst less than optimum, the true crater radius and the apparent crater radius are approximately equal.

c. True Crater Depth. The expansion of the high-pressure gases generated by a nuclear explosion in soil or rock produces a cavity surrounding the detonation. The depth of the true crater is equal to the depth of burst of the ADM plus the radius of the cavity created by the detonation. The ultimate cavity size depends on the growth rate of the cavity, the propagation velocity of the stress wave produced by the detonation, the depth of burst, and the yield of the ADM. In the range of yields and depths of burst of interest to the military engineer, the cavity radius (R_C) is approximately equal to $14W^{1/4}$ meters. The true crater depth (H_T) may be determined from the equation:

$$H_T = DOB + R_C$$
$$= DOB\ (\text{in meters}) + 14W^{1/4}\ \text{meters.}$$

d. Shape of True Crater.

(1) The shape of the true crater varies with depth of burial. The true crater profile for depths of burst up to $15W^{0.3}$ meters is approximately parabolic.

(2) For depths of burst greater than $15W^{0.3}$ meters, the outline of the cavity becomes discernible and the sides of the true crater approach a conical configuration.

(3) The true crater shape of subsidence craters is approximated by a cylinder of radius 10 percent greater than the cavity radius and a depth slightly greater than the depth of burial.

e. True Crater Lip. The lip of the true crater is formed from the upward displacement of the ground surface arising from the expansion of the cavity formed by the energy released from the device. The amount of displacement that occurs is dependent upon the properties of the media, the ADM yield, and depth of burial. As the depth of burial is increased to optimum, the height of the true crater lip is significantly increased.

6-12. Characteristics of Rupture and Plastic Zones

a. Rupture Zone in Rock Media. The rupture

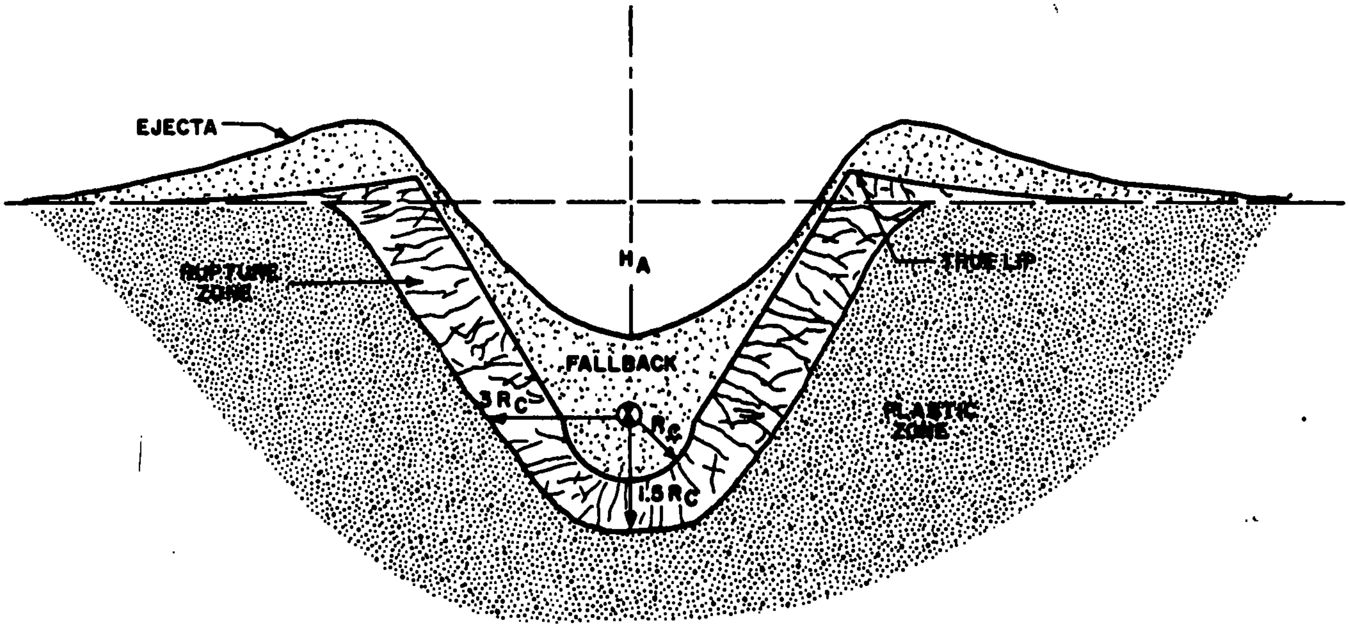


Figure 6–11. Typical crater cross section in rock showing shape and extent of rupture zone.

zone resulting from a cratering detonation in a rock medium extends beyond the true crater boundaries for varying distances depending upon the scaled depth of interest. For shallow or optimum depths of burial directly below the ADM where the confining pressures are high, the rock may be fractured to a distance of 1.5 cavity radii (1.5 R_C) from the point of detonation. The sides of the rupture zone in the vicinity of the point of detonation may extend to 3 cavity radii ($3R_C$). The rupture zone at the surface extends approximately 1.5 times the appparent radius of the crater (1.5 R_A) from ground zero. Figure 6–11 shows the probable shape and extent of the rupture zone in rock.

b. Plastic Zone in Rock Media. Since the fracture and yield stresses in most rock media are almost equal, the plastic zone, if it exists at all, extends only slightly beyond the rupture zone.

c. Characteristics of Rupture and Plastic Zones in Soil. The extent of the disturbed region resulting from an explosion in soil media is determined primarily by the shearing stresses produced by the detonation. When a soil medium is subjected to shearing stresses greater than the shearing strength of the soil, plastic deformation occurs. Since the material in both the rupture and plastic zones of a soil medium is subjected to permanent deformation as a result of shear failure, it is most difficult to differentiate between the rupture and plastic zones.

6–13. Craters as Obstacles

a. Crater Properties and Shape. The effectiveness of a crater as an obstacle depends primarily on the slope of the crater sides and the properties of the medium cratered. The depth of loose material on the crater sides and the moisture content of the soil become important factors at near critical slopes. Test results indicate that a slope of approximately 30° is critical for tracked vehicles in dry soil (desert alluvium). More gentle slopes may be negotiated by such vehicles without assistance, whereas greater slopes require that some type of assistance be provided. Craters produced at the same scaled depth of burial in the same media generally will have the same cross section shape regardless of the yield. In dry soil, the critical slope for tracked vehicles will occur at depths of burial of 0 meters and greater. In hard rock, such as basalt or granite, the size of the rubble in the crater may be expected to preclude vehicle passage without regard to the steepness of the slope. The rubble near the lip of a crater formed in rock may also provide an effective barrier to vehicular movement and should be considered a bonus effect. Obstacle width of a crater is considered to be the apparent lip diameter (D_{AL}), and is that width that would initially have to be bridged or reduced by bulldozing or some other means. Figure 6–12 shows an M–60 tank being lowered into a crater in rock as part of a test (Project TANK TRAP) to determine the

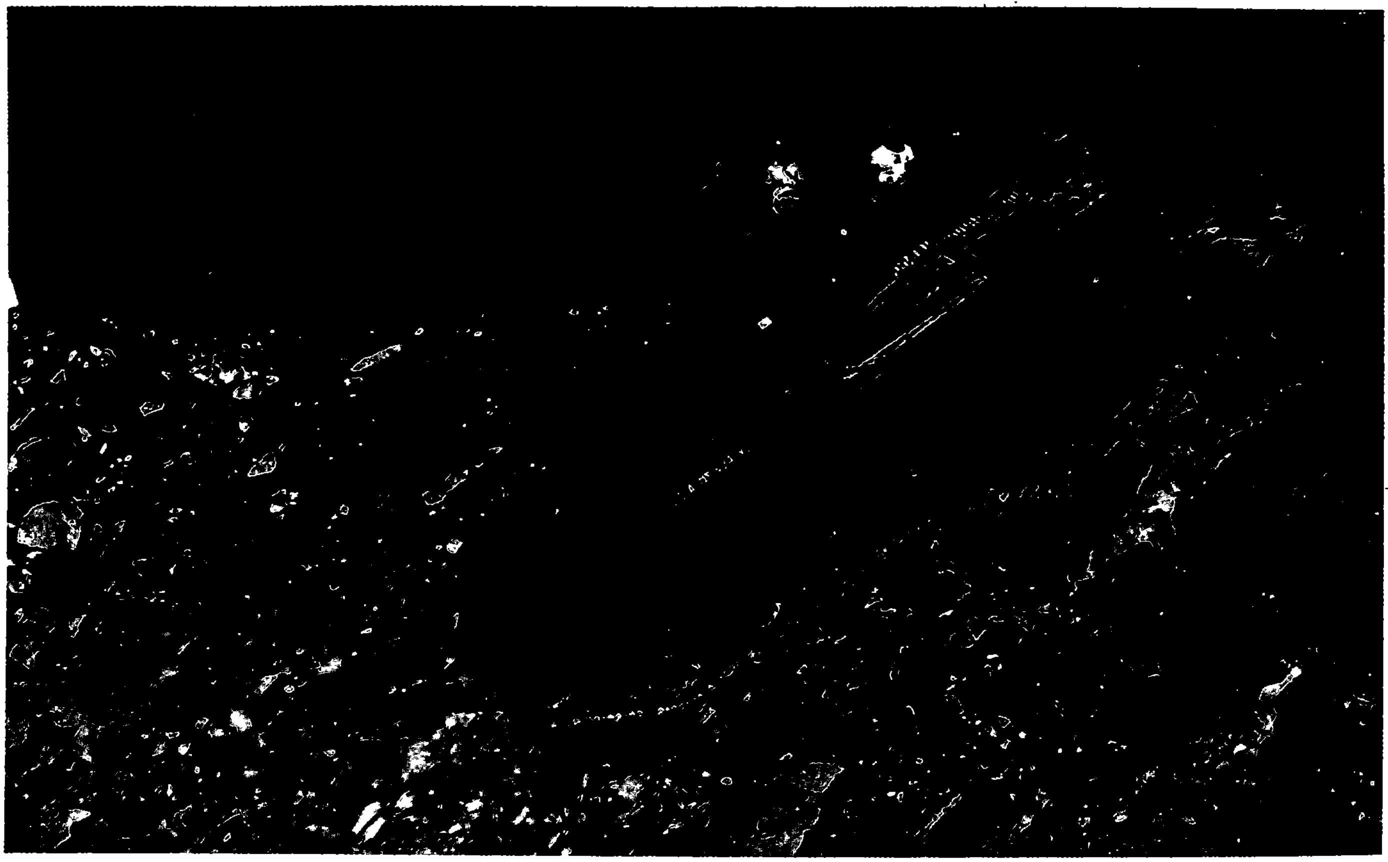


Figure 6-12. M-60 tank being lowered into crater.

obstacle value of craters. The tank could not descend into the crater without assistance. Figure 6-13 shows the tank at the crater bottom. It could not get out of the crater without assistance from a tank retriever. Note the relative size of the rocks.

b. Optimum Burial. The most effective depth of burial to produce an obstacle to tracked vehicles is optimum depth of burial. In addition to producing maximum crater radius, optimum burial produces other effects which could be used to advantage in ADM employment.

(1) Maximum uplift of the rupture zone producing higher lips.

(2) Maximum ejecta of material contributing to lip height and obstacle value.

(3) Steepest crater slopes, reducing trafficability.

(4) Maximum crater volume, increasing breaching time.

(5) Large reduction of thermal and initial nuclear radiation effects.

(6) Large reduction of blast effects.

(7) Underground containment of most residual radiation (fallout).

(8) Higher concentration of induced radiation in the crater.

6-14. Cratering of Roads and Railroad Beds

a. General. Craters produced by ADM provide a rapid, effective means of denying the enemy use of high-speed avenues of approach (roads) and railroads. One crater at a critical point (a narrow defile or a high embankment) can create an obstacle that is insurmountable without a major effort. Even in relatively flat, open terrain, a series of craters would compel the enemy to undertake time consuming repairs before he could use the road or railroad.

b. Yield Determination. The target analyst determines the required yield using the following procedure:

(1) Determine the desired obstacle width. This should be greater than the enemy's assault bridging capability. The obstacle width is taken to be the diameter of the apparent lip crest (D_{AL}).

Figure 6-13. M-60 tank at bottom of crater.

(2) Reduce this value by dividing by 1.15. This gives the apparent crater diameter.

(3) Select a depth of burial based on practical considerations. Existing culverts may provide a ready solution to this factor.

(4) Determine the required yield from the appropriate cratering curve (fig 6-6 through 6-9) and the scaling laws.

c. Illustrative Example.

(1) *Given:* You are directed to crater a divided highway consisting of two 12-meter traveled ways separated by a 4-meter turfed median strip. Shoulders are 4 meters wide. The enemy's assault bridging capability is 32 meters. The subgrade in the target area is dry soil. The water table is 20 meters below the surface. Your unit has a capability to drill emplacement holes down to 15 meters. Allocated ADM include the ALPHA/0.01KT, the BRAVO/0.05KT, and the CHARLIE/0.10KT.

(2) *Find*: The lowest yield ADM to produce an effective obstacle.

(3) *Solution*:

(*a*) Determine obstacle width. You decide to crater the road from outside to outside of shoulder (36 meters). This exceeds the enemy's bridging capability and precludes use of the shoulders as a possible bypass.

(*b*) $\frac{D_{AL}}{1.15} = D_A$

$$\frac{36}{1.15} = 31.3, \text{ say } 32 \text{ meters}$$

$\frac{D_A}{2} = R_A = \frac{32}{3} = 16$ meters, the required apparent radius.

(*c*) Use figure 6-6 and the scaling laws to determine the required yield. Start with the smallest available ADM (ALPHA/0.01 KT).

$$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

$$\frac{15}{DOB_2} = \frac{.01^{0.3}}{1} = \frac{.25}{1}$$

$$DOB_2 = 60$$

From figure 6-6, R_A for a 1-KT ADM at a DOB of 60 is 48.

$$\frac{R_{A1}}{R_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

$$\frac{R_{A1}}{48} = \frac{.25}{1}$$

$R_{A1} = 12$ meters. This is too small to meet the requirement. Try the BRAVO/0.05 KT ADM.

$$\frac{15}{DOB_2} = \frac{.05^{0.3}}{1} = \frac{.41}{1}$$

$$DOB_2 = 36.6$$

From figure 6-6, R_A for a 1-KT ADM at a DOB of 36.6 is 47.6.

$$\frac{R_{A1}}{47.6} = \frac{.41}{1}$$

$R_{A1} = 19.5$ meters, which is satisfactory since it exceeds the requirement of 16 meters.

If the emplacement hole is unstemmed the crater radius must be reduced by 10 percent. This results in an R_A of 17.5 meters which is still satisfactory.

(4) *Solution*: Use a BRAVO/0.05KT ADM at a DOB of 15 meters.

6-15. Landslides

a. General.

(1) One of the best locations to produce a barrier is in a defile. A blocked defile can stop an enemy advance and cause him to mass in an area where he can be destroyed by nuclear weapons. ADM emplacement positions and yield requirements for blocking defiles depend primarily on the steepness of side slopes and width of the defile. Access through steep-sided cuts can be denied by blocking the cut with a landslide produced by the ejecta material from an ADM buried in one of the sides of the defile.

(2) In general, good results can be expected if the side slopes of the defile are at least 30 degrees. For flatter slopes, a significant landslide may not occur; also there is a possibility that vehicles may be able to detour around the landslide with little difficulty.

b. Yield Selection and Emplacement

(1) The creation of a landslide across a defile can be assured if the slopes of the defile are steep and a conservative estimate of the amount of material ejected by the detonation is made. Therefore, by making several conservative assumptions, a guide to the creation of landslides can be made.

(2) Figure 6-14 is a curve for ADM yield selection based on the width of the defile to be blocked and burial of the ADM at optimum DOB. Emplacement must be at an elevation such that the true crater produced by the detonation will not intersect the bottom of the defile. Therefore, the ADM must be emplaced at a height above the bottom of the defile at least equal to the DOB as shown in the sketch in figure 6-14. The landslide volume is the volume of material from the true crater produced by the detonation. No consideration has been given to the additional volume of material on the slope above the crater that would normally be expected to fail. This would add a considerable amount of bonus material to the landslide. The curve in figure 6-14 has been calculated on a basis of a height of landslide at least 20 meters high, with the angle of repose of the material being 30 degrees, the approximate angle of repose for soil.

(3) If the landslide is composed of hard rock, passage to vehicles will be extremely difficult, and would be possible only after significant engineer effort. However, if the material is soil, there is a possibility that the landslide could be traversed by tracked vehicles after minor engineer effort.

c. Illustrative Example.

(1) *Given:* The commander desires to block a roadway in a defile between two large mountains. At one point the road passes through a gap of 85 meters and the slopes are 35 degrees. At this point the medium is dry soil.

(2) *Find*: ADM required to block the road and the emplacement position.

(3) *Solution*:

(*a*) Width of the gap is 85 meters.

(*b*) From figure 6-14, yield is 0.7 KT

(*c*) Closest ADM is the ECHO/1 KT

Answer: ECHO/1 KT ADM, emplaced at optimum depth (49 meters), at least 49 meters up the slope.

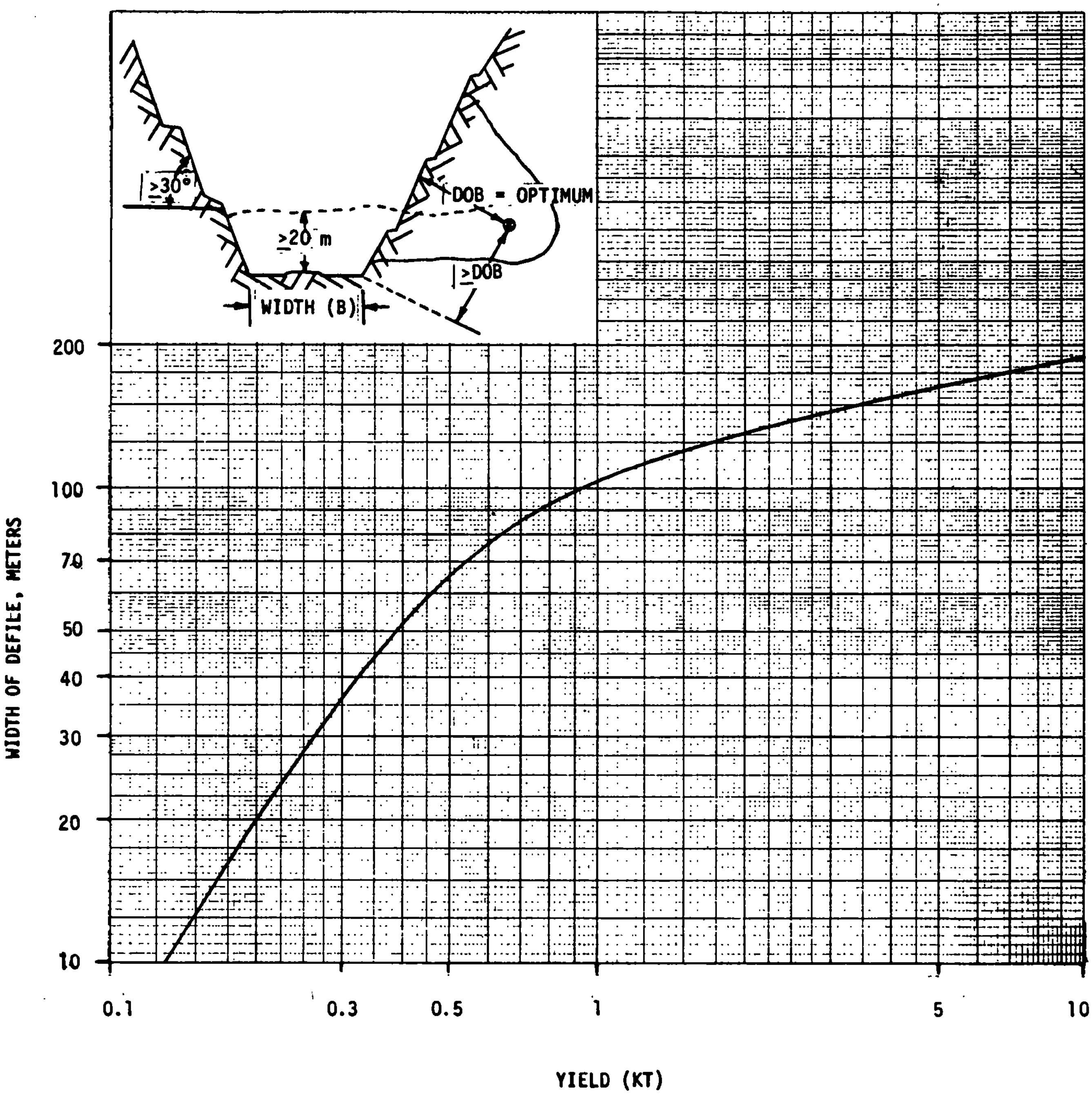


Figure 6–14. Yield determination for creation of landslides.

6–16. Site Selection

a. Obviously, the best place for a crater is in a defile with steep sides. Cratering a defile effectively eliminates it as an avenue of approach. If all or most of the defiles in a corridor were so blocked, the enemy's mobility and flexibility would be seriously hindered.

b. Even where no defiles exist craters are effective in destroying multilane highways. The crater would compel the enemy to construct a wide detour. Such an obstacle every few miles would render the highway virtually useless as a high-volume, high-speed avenue of approach. Whenever possible, highways should be cratered at locations where construction of a bypass is impossible or difficult.

c. Craters may be placed anywhere a barrier minefield would ordinarily be located. If the area is too broad to be blocked by a single crater, or if safety limitations do not allow use of the large yield needed to produce the required single crater, a row of smaller-yield, linear cratering detonations could be used. Spacing ADM 1.5 crater radii apart produces an effective linear crater obstacle. The use of craters instead of large minefields can result in considerable savings in time, manpower, and materials.

Section III. BRIDGES

6–17. General

a. This section provides a guide for the use of ADM in fixed bridge demolition. There are many cases in which bridges may be quickly and efficiently destroyed with conventional explosives, and such possibilities should always be considered before expending critical nuclear material. However, for the purposes of this text, bridge demolition is assumed to be a task calling for ADM.

b. Bridge demolition begins with an examination of bridge construction. In order to effectively destroy a bridge with minimum yield, manpower, time, and equipment it is necessary that the target analyst be familiar with the various types of bridges, how they are constructed, and the location of vulnerable points.

6–18. Damage Criteria

a. To determine how ADM may be best used in bridge destruction, the most suitable effect of a nuclear detonation is selected, damage criteria are established, and the most suitable emplacement location for the ADM is chosen.

b. Most nuclear weapons employment methods consider blast overpressure as the governing effect for bridge destruction. This text, however, with the exception of paragraph 6–23, considers blast solely as a bonus effect, and the cratering action of ADM is presented as the principal means of bridge demolition.

6–19. Desired Damage

In bridge demolition, effective denial is achieved by the removal or destruction of a section of the traveled way. Three demolition alternatives according to time and manpower available for emplacement are provided to collapse at least one span.

a. Pier or Abutment Base Option. Destruction by ADM at or near the base of a pier or abutment provides the best use of the cratering action of a nuclear detonation.

(1) *Pier destruction.* This achieves maximum damage in that two spans are collapsed, a pier is removed, and the river bottom is cratered at the point where a replacement pier might be built.

(2) *Abutment destruction.* This achieves bridge destruction with the lowest yield and greatest control of effects. In case of single span bridges, or if pier demolition is not desired, destruction of an abutment is recommended.

b. Abutment or Pier Top Option. When circumstances such as lack of equipment, manpower, or time do not permit placement of the ADM for pier or abutment base destruction, the pier or abutment top option affords a means of exploiting cratering effects.

c. Traveled Way Option. With limited time available, the damage criterion recommended is complete breach of the traveled way. The ADM is placed directly on the traveled way and tamped with at least 1.5 meters of sandbags.

6–20. Determination of Yield for Abutment and Pier Destruction

Since cratering is the process which achieves major bridge damage, it is necessary to relate crater dimensions to those of the critical bridge components. Determination of yield essentially involves measuring widths of traveled ways, piers, and abutments and ascertaining what yields produce crater dimensions of approximately equal measurements. It must be recognized, of course, that any plan for using ADM in demolition operations must include an evaluation of the bonus or limiting effects of the detonation such as blast, ground shock, thermal, and nuclear radiation.

a. Demolition of Bridge Abutments.

(1) *Emplacement behind abutment.*

(*a*) The best ADM position for the demolition of a bridge abutment is behind the abutment buried at a depth equal to or greater than one-half of the height of the abutment as shown in figure 6–15, position 1. Detonation of the ADM at a

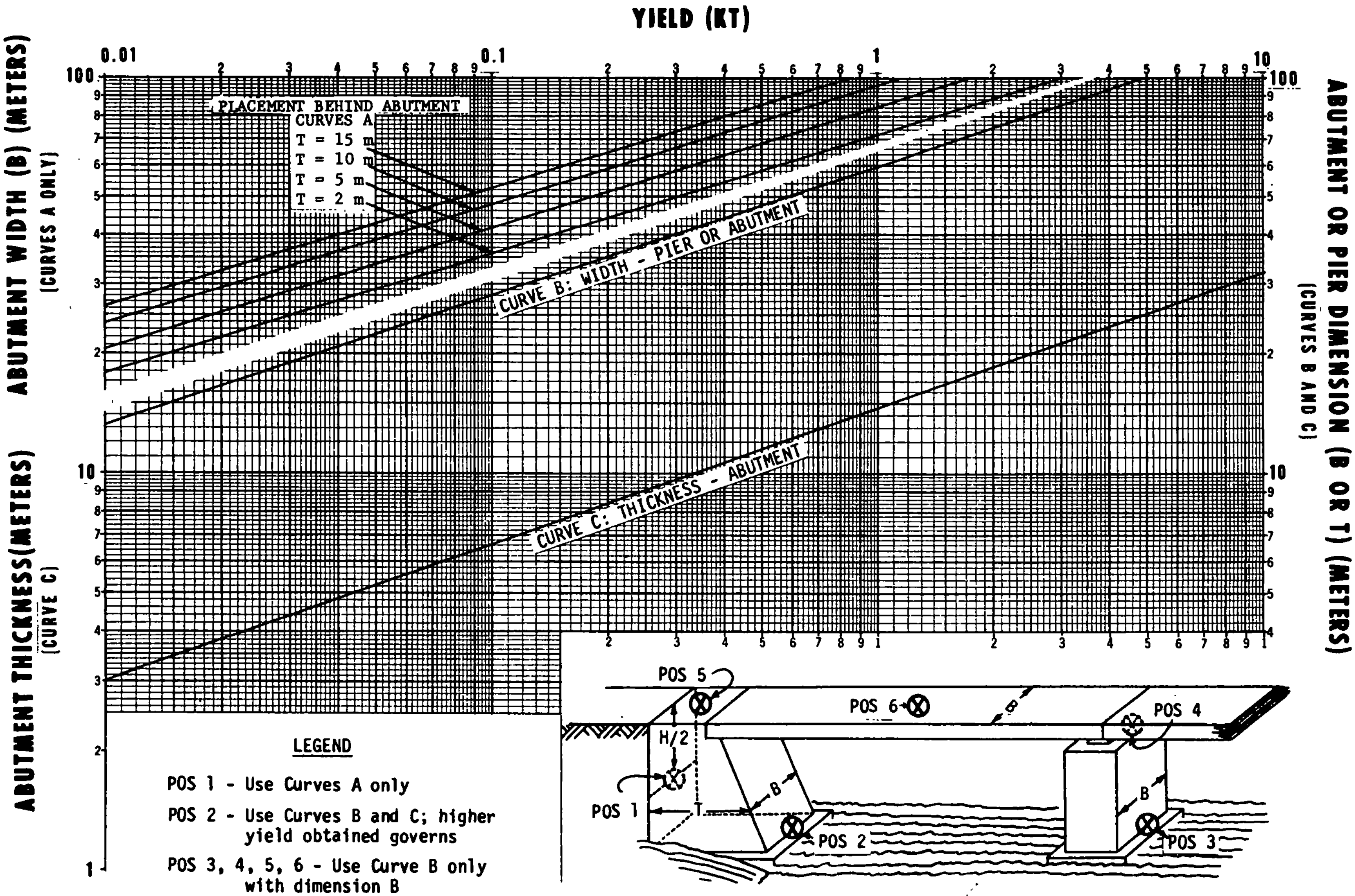


Figure 6-15. ADM yield selection for bridge demolition.

depth equal to at least ½ H insures that a significant portion of the abutment is destroyed.

(*b*) The yield requirement for ADM emplacement behind the abutment is determined by the width (B) of the abutment. Since the ADM is buried at a depth of at least ½ H, the thickness of the abutment is always breached if a yield is used which is sufficient to produce a crater with a diameter of rupture zone equal to the width of the abutments. Figure 6–15 gives yield requirements for destroying bridge abutments by the detonation of ADM buried behind the abutment. The curves are based on the yield required to produce a diameter of rupture zone in hard rock equal to the abutment width (B) using the thickness of the abutment (T) as the effective depth of burst. The ADM yield required to destroy an abutment may be determined from figure 6–15 for the range of abutment dimensions given. For abutment thickness other than those for which curves are given, use the curve for the thickness which is *closest to but less than* the actual abutment thickness. The curves in figure 6–15 indicate that smaller yields are required as the abutment thickness increases. This is due to the enhancement of cratering effects as the depth of burial (thickness of abutment) increases.

(2) *Emplacement on face of abutment.*

(*a*) If the characteristics of the ADM, the tactical situation, or the non-availability of emplacement construction equipment preclude placing the ADM behind the abutment, the nuclear explosive may be placed on the face of the abutment (fig 6–15, position 2).

(*b*) The detonation of an ADM on the face of an abutment above the water level produces a crater in the abutment similar to the crater resulting from a surface burst in hard rock. If the ADM is placed underwater some increase in crater dimensions is achieved because of the tamping effect of the water, but no attempt is made in the yield selection criteria presented in this manual to numerically evaluate this increase.

(*c*) The yield requirements for destruction of an abutment by detonation of an ADM on the face of the abutment are determined by both the width (B) and the thickness (T) of the abutment. A yield should be selected which produces a diameter of rupture zone equal to the abutment width (B), and a depth of rupture zone equal to the thickness (T). Figure 6–15 gives curves for determining required yields for abutment destruction. The higher yield determined from either curve B or C for an abutment of given dimensions (B and T) governs.

(*d*) If an abutment has a demolition chamber (a chamber specifically incorporated by design to facilitate bridge denial), the ADM is detonated in the chamber. Figure 6–15 is used to select the required yield. The thickness of the abutment is considered to be the horizontal distance from the center of the AD emplaced inside the chamber to the face of the wall adjacent to the backfill.

b. Demolition of Bridge Pier.

(1) The best ADM emplacement position for pier demolition is at the base of the pier (fig 6–15, position 3). If the device cannot be placed at the base of the pier, it is placed as close to the base as is practicable.

(2) Selection of a yield to destroy a pier depends on the width (B) of the pier. The combined effects of spall, vaporization, crushing, and plastic deformation will breach the pier thickness (T) if an ADM is used which is of sufficient yield to produce a diameter of rupture zone in rock equal to the width (B) of the pier. Therefore, the width curve used for the face of the abutment (curve B) may be used in this case. For some tall piers, the thickness may be one-fourth or more of the pier width. In this case, the pier thickness may be the controlling dimension, and a yield should be selected that will assure a rupture depth equal to the thickness.

6–21. Determination of Yield for Abutment or Pier Top Destruction

The abutment or pier top option (fig 6–15, position 4) is recommended when destruction of the abutment or pier face cannot be accomplished. Placement is under the traveled way on top of a pier or abutment; or, on an arch bridge, at the base of the arch rings on either the top of the pier or on the abutment shelf. For any of these situations, yield determination depends on the width of the pier top or abutment top. To determine yield, enter figure 6–15 with the pier or abutment top width (B), read left to width curve (curve B), and up to the yield.

6–22. Determination of Yield for Traveled Way Destruction

There are three positions on the roadway where the ADM may be placed; directly over a pier or abutment (fig 6–15, positions 4 and 5), or at the midpoint of a span (fig 6–15, position 6). In all cases, the traveled way width (B) is the dimension of primary concern. Yield determination is made by entering figure 6-15 with the traveled way width (B), reading left to width curve (curve B), and up to the yield.

6-23. Blast Criteria for Bridge Destruction

In addition to their vulnerability to cratering effects, steel truss and floating bridges are particularly vulnerable to destruction by the blast effects of ADM. When it is desired to take advantage of the blast effect, the ADM is positioned so that upon detonation the blast wave impacts side-on to the bridge. Radius of damage for blast effects to steel truss and floating bridges are given in appendix B and FM 101-31-2.

6-24. Illustrative Example

a. Given: A bridge similar to the sketch in figure 6-15 is scheduled for destruction. Dimensions are as follows:

Abutment:	Width (B)	35 meters
	Thickness (T) at ½ H	8 meters
	Thickness (T) at base	12 meters
Pier:	Width (B)	30 meters
Traveled Way:	Width (B)	25 meters

b. Find: The ADM yield required at each of the emplacement positions (1 through 6).

c. Solution:

(1) *Behind abutment buried ½ H:* B = 35 meters, T = 8 meters. There is no T = 8 meter curve (curves A), therefore read across to T = 5 meters (next lower thickness). W = 0.036 KT; use BRAVO/0.05 KT ADM.

(2) *Face of abutment:* B = 35 meters; W = 0.20 KT (curve B); T = 12 meters; W = 0.56 KT (curve C); 0.56 KT governs; use ECHO/1.0 KT ADM.

(3) *Face of pier:* B = 30 meters; W = 0.12 KT (curve B); use DELTA/0.5 KT ADM.

(4) *Top of pier:* B = 30 meters; W = 0.12 KT (curve B); use DELTA/0.5 KT ADM.

Top of abutment: B = 35 meters; W = 0.20 KT (curve B); use DELTA/0.5 ADM.

(5) and (6) *Traveled way:* B = 25 meters; W = 0.07 KT (curve B); use CHARLIE/0.1 KT ADM.

Section IV. DAMS

6-25. General

a. The development of ADM has provided a capability for readily destroying large dams; one nuclear detonation can accomplish what could not have been done previously by hundreds of tons of TNT. In addition, the destruction potential of ADM is enhanced by the sudden release of large quantities of water below the dam.

b. Damage to power production equipment, turbines, and similar facilities are usually best accomplished by conventional explosives and, therefore, are not discussed in this manual. If these facilities are considered appropriate for destruction by ADM, blast criteria for industrial equipment and buildings are applicable. (See app B and FM 101-31-2.)

c. Dams may be categorized in four general types: gravity, arch, buttress, and earthfill. The characteristics of each type present different methods of demolition to achieve an effective breach. It is essential, therefore, that the target analyst recognize basic dam types in order to obtain the best results from ADM employment.

d. The yields to be obtained from the curves that have been included in this section are for a single breach. If the purpose of breaching is to create a large flood, it may be necessary to burst two or more ADM simultaneously to remove instantaneously a large portion of the structure.

6-26. Gravity and Arch Dams

a. Gravity Dams. Gravity dams are constructed of concrete or masonry and have massive cross sections. They often rise to heights of 150 meters or more. Because of the volume of material to be shattered, gravity dams are best breached by placement of the ADM in an inspection gallery. If more than one gallery exists, the one which is lowest and nearest to the upstream heel of the structure is selected.

b. Emplacement Positions. Curves for selection of ADM yields to destroy concrete gravity dams

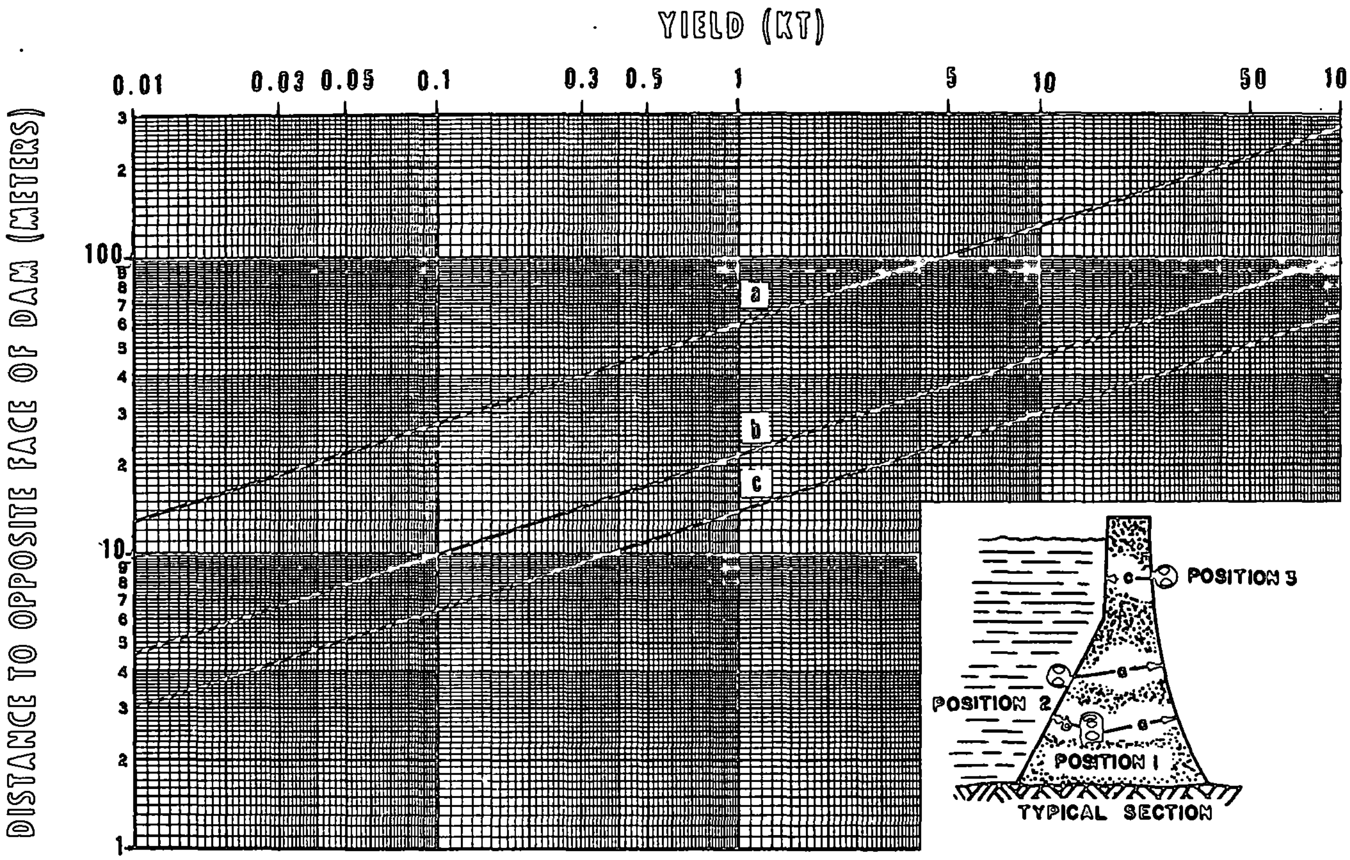


Figure 6–16. Yield selection criteria for gravity and arch dam destruction.

are given in figure 6–16 for three emplacement locations.

(1) Placement in an inspection gallery (position 1). The yields required for breaching the distance to the upstream face and the downstream face are determined separately by using the appropriate curves in figure 6–16 (*curves a and b*); the larger of the two is the governing yield for demolition of the dam.

(2) Placement on the upstream face of the dam (position 2). The water depth should be at least twice the distance to be breached or 15 meters (50 feet), whichever is the smaller. The criterion of destruction which *curve a* represents is breaching the distance to the downstream face of the dam.

(3) Placement on the downstream face of the dam below the water level (position 3). The destruction criterion which *curve c* represents is breaching the distance to the upstream face of the dam.

c. Arch Dams. Arch dams are usually thin, relatively short, and comparatively high. They are constructed of masonry or concrete, usually in V-shaped gorges. The thinness of the cross section allows use of a smaller yield ADM than is required for the more massive gravity dams. Furthermore, the stability of an arch dam is dependent upon the arch abutments; for this reason, the dam is also vulnerable to collapse from demolition of its abutments. In all other respects, the procedure for selection of ADM yields for demolition of arch dams is exactly the same as for gravity dams.

d. Illustrative Example.

(1) *Given:* A dam similar to the sketch shown in figure 6–16 is being considered for destruction. The emplacement positions to be checked are the following:

(*a*) Placement in an inspection gallery, 15 meters from the upstream face, and 26 meters from the downstream face.

(*b*) Placement on the upstream face, 15 meters below water level where the distance to the downstream face is 18 meters.

(*c*) Placement on the donwstream face, 30

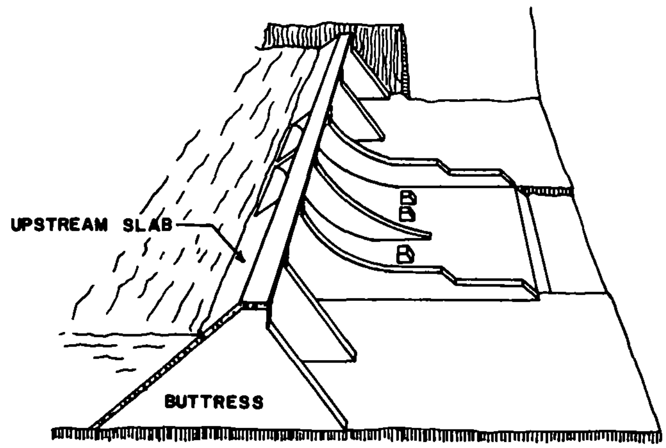


Figure 6–17. Buttress dam.

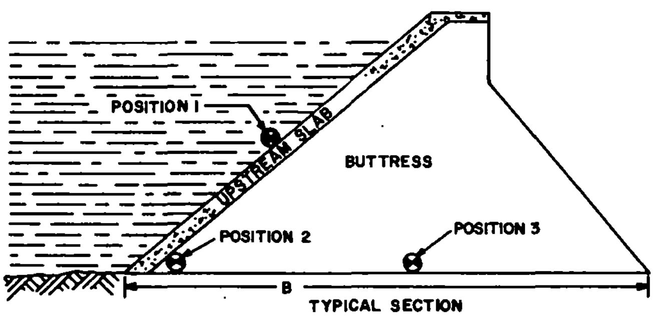


Figure 6–18. ***ADM emplacement positions for buttress dam destruction.***

meters below the crest of the dam, where the distance to the upstream face is 20 meters.

(2) *Find:* The ADM required at each position.

(3) *Solution:*

(*a*) For position 1: From figure 6–16, when a = 26m, W = 0.08 KT; when b = 15m, W = 0.35 KT. The governing yield is the larger, 0.35 KT. Use a DELTA/0.5 KT ADM.

(*b*) For position 2: From figure 6–16, when a = 18m, W = 0.027 KT. Use a BRAVO/ 0.05 KT ADM.

(*c*) For position 3: From figure 6–16, when c = 20m, W = 3 KT. Use a FOXTROT/5 KT ADM.

6–27. Buttress Dams

a. Hollow buttressed dams (fig 6–17) usually consist of a series of parallel, equidistant, concrete buttresses covered by a watertight, sloping upstream face. All the structural elements of the buttress dam are constructed of reinforced concrete and generally are thinner than the structural components of either arch or gravity dams. By destroying a buttress, at least two spans of the dam will collapse. The emplacement positions (fig 6–18) which will be discussed are: placement below the water level on the upstream face of the dam (position 1), placement below the water level on the downstream face of the dam (position 2), and placement in contact with the buttress itself (position 3).

b. Yield selection for the destruction of buttress dams depends primarily on the extent of damage desired since the majority of the structural components are comparatively thin and therefore easily breached. If the intent is solely to release the impounded water, the upstream slab supported by the buttresses is easily breached. The required ADM yield (positions 1 and 2) may be determined from figure 6–16 for emplacement on the upstream face (curve a) or for emplacement on the downstream face of the slab (curve c). The same considerations used in analyzing gravity and arch dams are applicable in this case. Since the buttress itself functions much like a bridge pier, yield determination for the destruction of a buttress (position 3) follows the same procedure described for bridge piers (para 6–10*b*) where the width of the base of the buttress (B) is equated to the pier width.

6–28. Earth Dams

a. An *earth dam* is similar to an earthfill except that it contains an impervious core such as clay or a watertight blanket on the upstream face. A typical earth dam is shown in figure 6–19. The width of the crest of most earth dams is less than 40 feet (12 meters), and the upstream and downstream slopes are seldom steeper than a horizontal to vertical ratio of 3 to 1 or 33 percent.

b. Earth dams may be effectively destroyed by detonating an ADM beneath or on the center of the crest of the dam. Detonation of the ADM below the crest of the dam requires a smaller yield due to enhancement of cratering effects, and the amount of radioactivity released to the atmosphere is correspondingly reduced for comparatively deep depths of burial. The yield required to destroy an earth dam may be determined graphically or from curves for particular crest widths and slope ratios.

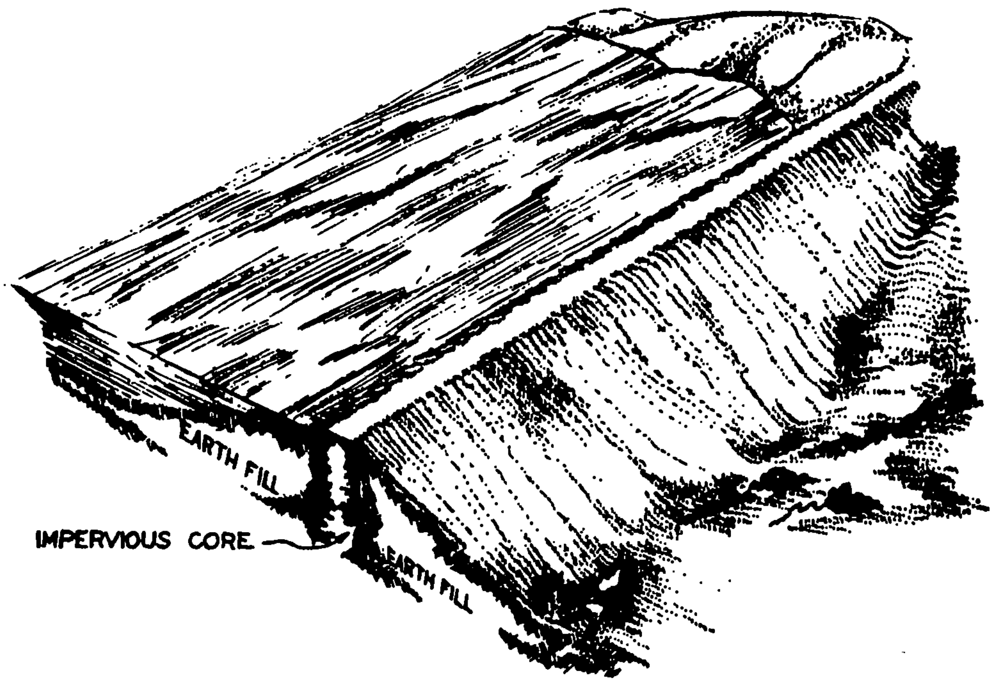


Figure 6-19. Typical earth dam.

The criterion used is based on achieving a true crater with dimensions of sufficient magnitude to allow for an initial breach of at least 10 feet (3 meters) below the water level. This breach will provide a sufficient outflow of water so that erosive forces will cause complete destruction.

c. Figures 6-20 through 6-22 provide the means for quickly determining the required yield for a surface burst, shallow depth of burial (DOB = 15 $W^{0.3}$ meters), and optimum depth of burial (DOB = 49 $W^{0.3}$ meters). These figures may be used for crest widths up to and including 12 meters and for the slope ratios shown. ADM emplacement must be on or beneath the center of the crest. For other configurations use the method outlined in paragraph *e*, below.

d. Illustrative Example.

(1) *Given:* You are directed to destroy an earth dam with the following characteristics; crest width—12 meters; slope ratio—4 to 1; and water level—4 meters below crest. Time considerations dictate emplacement on the surface.

(2) *Find:* ADM required.

(3) *Solution:* Use figure 6-20. Enter at 4-meter freeboard, read up to 4:1 slope curve, and left to a yield of 4 KT.

(4) *Answer:* Use a FOXTROT/5 KT ADM.

e. To determine the yield and depth of burial to destroy any earth dam, draw a cross section of the dam to scale. Considering the ADM available and the emplacement capabilities, a choice is made that will produce a crater which meets the criterion for destruction (para *b*, above). The choice is arrived at by trial and error starting with the lowest of the available yields. The resultant crater is plotted to scale on the cross section of the dam. A line is drawn from the true depth (H_T) and the radius R_A. At the intersection of this line with the upstream face of the dam, the distance to the water level is measured. This distance must be at least 3 meters. If it is less, a second trial must be made using either a higher yield or an increased depth of burial. This process is continued until a satisfactory resultant crater is obtained. This method is valid only for ADM emplacement on or beneath the center of the crest.

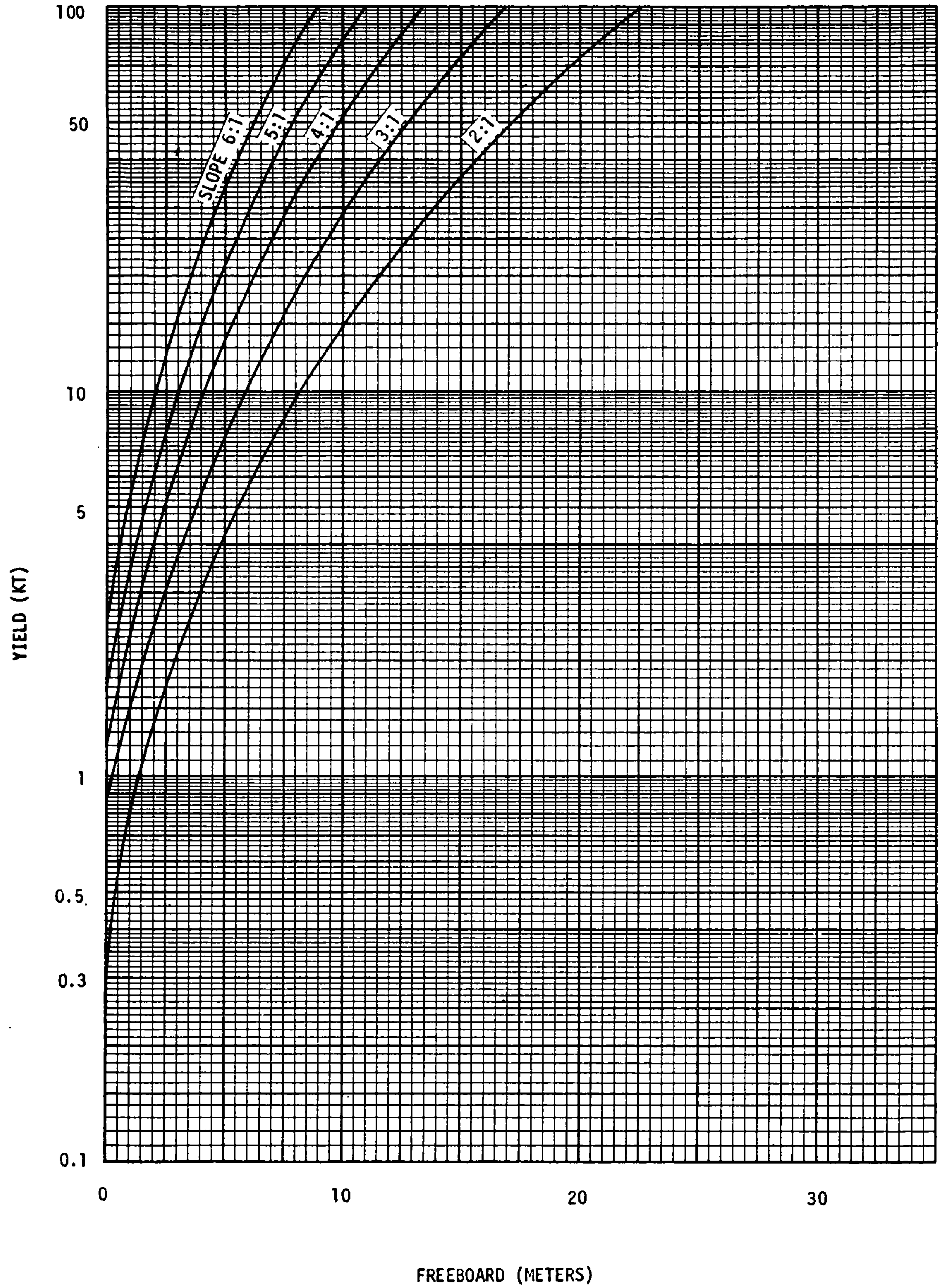


Figure 6-20. ADM yields versus freeboard for earth dam destruction, surface burst.

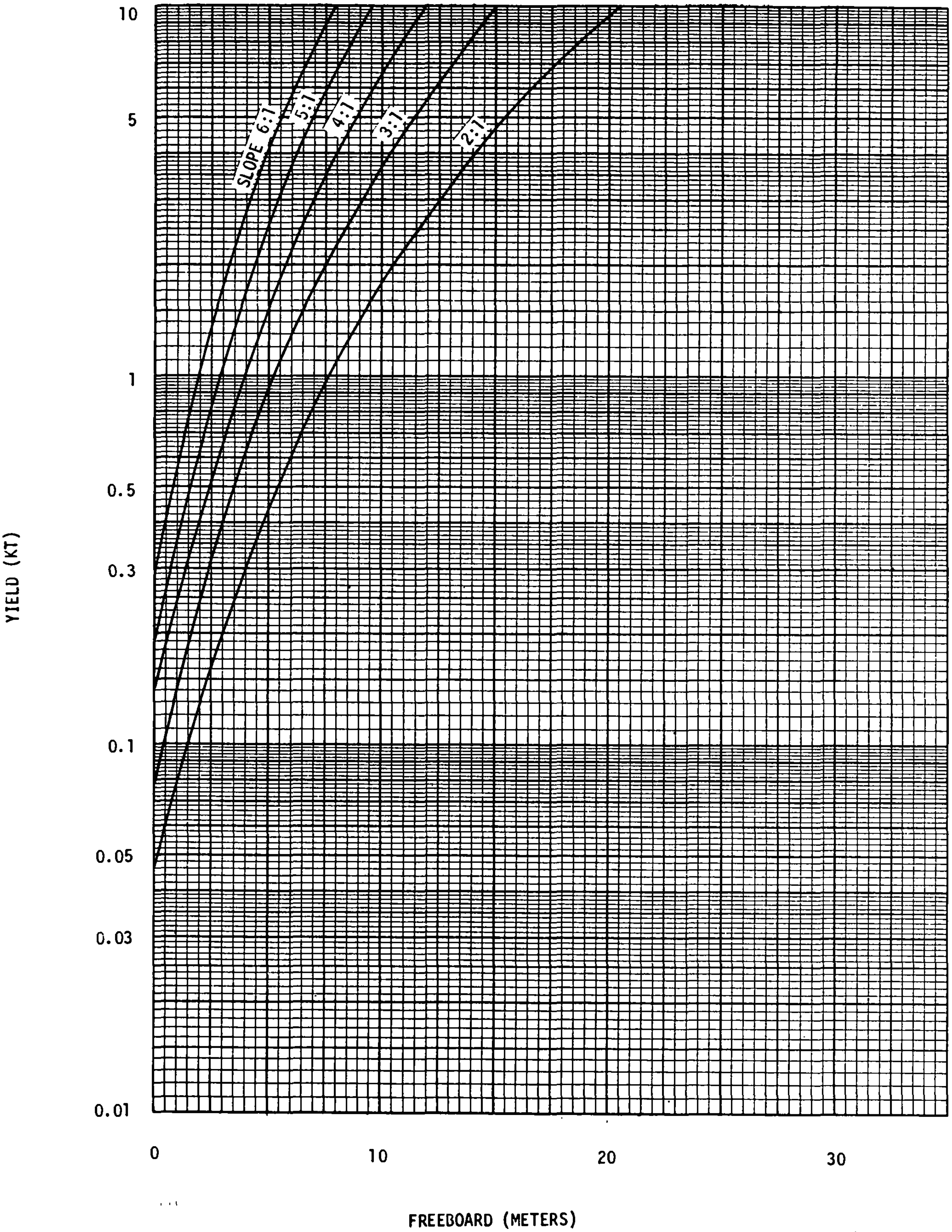


Figure 6-21. ADM yields versus freeboard for earth dam destruction, shallow depth of burial.

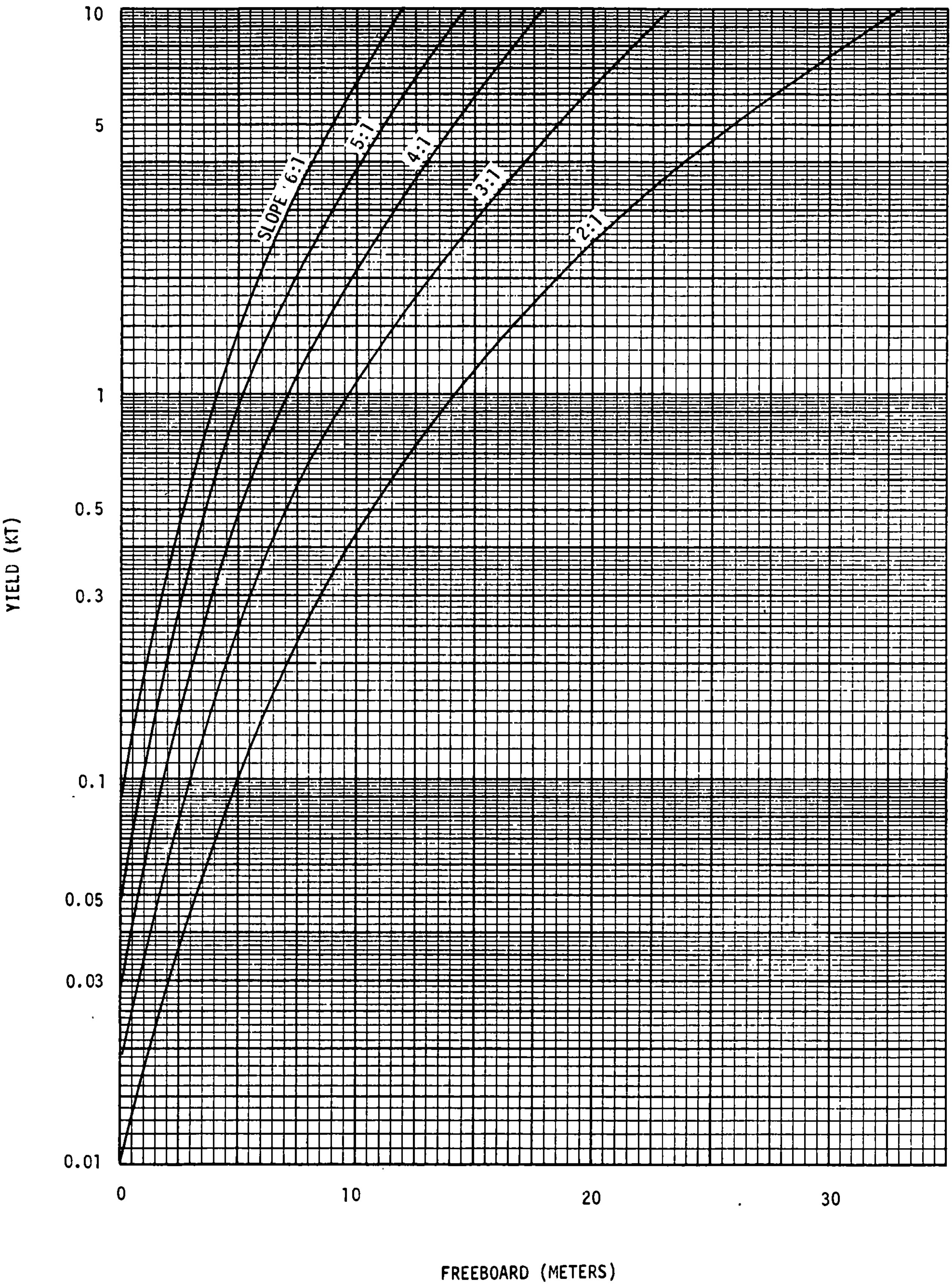


Figure 6-22. ADM yields versus freeboard for earth dam destruction, optimum depth of burial.

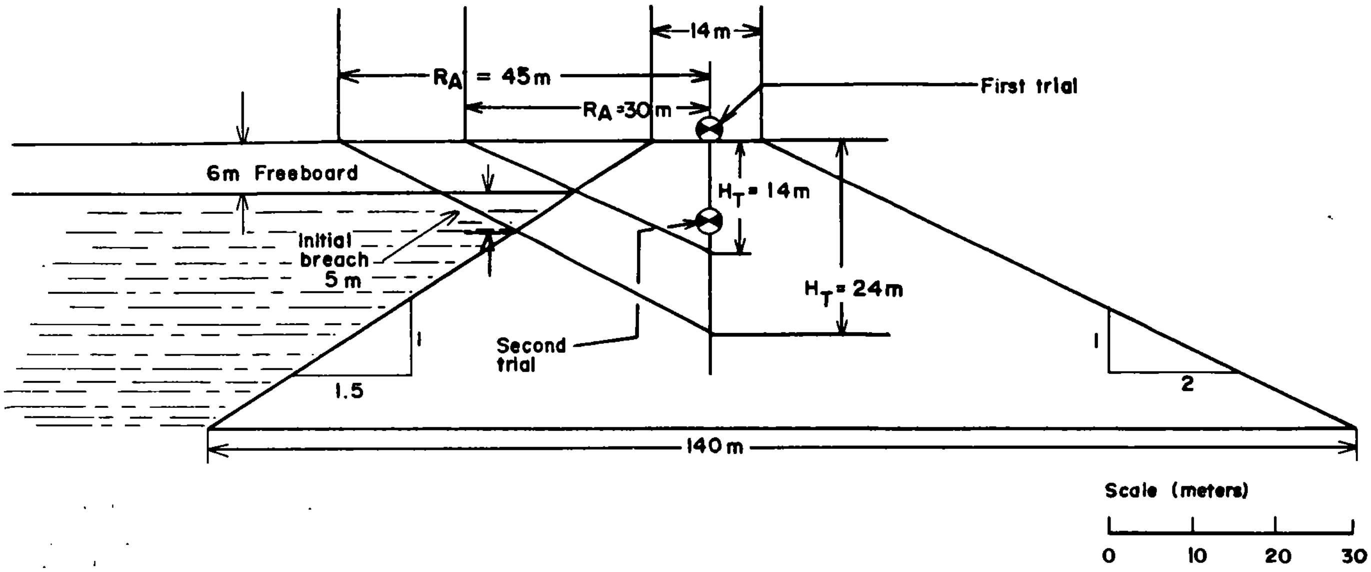


Figure 6–23. Graphical solution to earth dam problem.

f. The following example illustrates the procedure outlined in the preceding paragraph.

(1) *Given:* An earth dam is scheduled for demolition. Its cross section, plotted to scale, is shown in figure 6–23. Two ADM have been allocated, an ECHO/1 KT and a FOXTROT/5 KT. Fallout is not a limiting factor. Emplacement capabilities permit burial to a depth of 10 meters. Medium is wet soil.

(2) *Find:* The yield and emplacement position required to destroy the dam.

(3) *Solution:*

(*a*) The lower yield (1 KT) and the least difficult emplacement position (on the surface at the center of the crest) are considered first.

(*b*) From figure 6–7, R_A for a 1 KT surface burst is 30 meters. $H_T = DOB + 14\ W^{1/3}$ meters $= 0 + 14(1) = 14$ meters.

(*c*) These values are plotted to scale on the dam cross section and a line connecting them is drawn. The intersection of this line and the upstream face of the dam is just at the water level. Hence, this yield and emplacement position are inadequate.

(*d*) In view of the known burial capability, a trial at a DOB of 10 meters is analyzed before going to a higher yield. From figure 6–7, a 1 KT burst a a DOB of 10 meters gives an R_A of 45 meters. $H_T = 10 + 14 = 24$ meters. Plotting these values shows that the initial breach will be 5 meters below water level which meets the criterion for destruction of earth dams.

(4) *Answer:* Use an ECHO/1 KT ADM, emplaced 10 meters below the center of the crest.

6–29. Emplacement Upstream From Dam

The breaches achieved with ADM placed at the previously discussed locations are produced primarily by the cratering effect of the blast. A nuclear detonation upstream, so that the dam is outside the cratering radius, can also cause failure by the action of the hydrostatic pressure and shock waves generated by the detonation. This effect may result in the overturning, sliding, or cracking of the structure. See DASA EM–1 regarding the effect of blast and shock on dams.

6–30. Gate Blowout

a. An important function in the operation of any dam is the regulation of flow over or through the structure. In most cases, this is accomplished by flood (spillway) gates which regulate flow over the top of the structure and sluice gates which control the flow in tunnels through the dam. Some dams have only one type of outlet while others have both.

b. The strength of sluice gates has been found to be such that any nuclear detonation large enough and close enough to blow out the gates also causes cracking and probable failure of the dam itself.

c. Depending upon the design of the dam, the spillway gates may extend along the entire dam or only along a small portion of its length. Spillway gates are usually the most vulnerable part of the dam. Although accessible taintor gates (a common spillway gate) are usually more vulnerable to conventional demolition charges applied to the lower radial strut, they may be blown out by the hydrostatic shock wave generated by an underwater nuclear detonation upstream from the reservoir. This may be achieved without severe damage to the dam itself. The distance, of course, depends upon the size of the munition and the installation and strength of the gates. Other types of spillway gates may be expected to react similarly.

6-31. Downstream Flood

In any plan for destruction of a dam, one of the important considerations is the magnitude of the resulting flood. Many factors combine to determine the size and destructiveness of such a flood. It is beyond the scope of this manual to provide a detailed system of analysis for flood prediction. If the extent of such a flood must be estimated accurately, the actual conditions at and below the dam should be analyzed by a military hydrologist.

Section V. CANALS

6-32. General

a. Canals vary considerably in complexity. At one extreme is the single level canal, dug through an area only slightly above sea level and requiring no locks or lifts; at the other extreme is the canal which must raise ships over a terrain barrier. These multi-level canals employ systems of locks and gates, storage reservoirs, and pumps.

b. As a rule, the more complicated the system, the easier it is to put it out of operation and the more difficult it is to repair. Because of the differences in size and construction of canals, however, no specific directions for demolition applicable to all cases are possible. Each target must be analyzed individually to determine its vulnerable points.

c. Inland waterways and their auxiliary facilities are subject primarily to the effects of blast, cratering, hydrostatic pressure, and ground shock. In the selection and placement of an ADM for the disruption of an inland navigation system, the governing effect is determined, and an ADM of appropriate yield is selected.

d. Nuclear detonations are very effective when properly employed; however, there are occasions when conventional explosives can be used more efficiently or when nuclear detonations would cause an undesirable level of damage. Thus, a detailed analysis of the canal system is necessary to insure that avaialable munitions are employed effectively and that undesired damage is avoided.

6-33. Single Level Canals

The single level canal is the most difficult to put out of operation. Its relative invulnerability lies in its simplicity. It is a ditch connecting two natural bodies of water. Its water supply is inexhaustible, and no mechanism is required to regulate the waterflow. The only practicable way to put a single level canal out of service is to block it. This may be accomplished with varying degrees of success by earthslides or ships.

a. Blocking With Earthslide. Blocking a canal with an earthslide is possible only in rare circumstances. The optimum conditions demand a soil with low cohesive strength and a relatively steep bank, high enough to leave a sufficient volume of earth after the blast to form a canal-blocking slide. Because cuts for canals are usually designed expressly with slide prevention in mind, the occurrence of these conditions is infrequent. However, when they do occur, the discussion on the creation of landslides in paragraph 6-15 is applicable.

b. Use of Block Ships. The sinking of ships in a canal is an effective, expedient means of blocking. Conventional explosives or other means of scuttling normally are used for this purpose.

6-34. Variable Level Canals

a. The variable level canal, as a rule, cannot be considered as a single feature distinct from its surroundings. It is more likely a part of a larger system which exploits one or more watersheds. In addition to providing navigable waterways, such a system may involve power generation, water conservation, flood control, irrigation, and fish migration. Disruption of the facilities which permit navigation on such a system is likely to affect all the other functions as well.

b. If it is desirable to damage only the navigational facilities and to leave the remainder of a system intact, extreme care is necessary when employing ADM against specific targets.

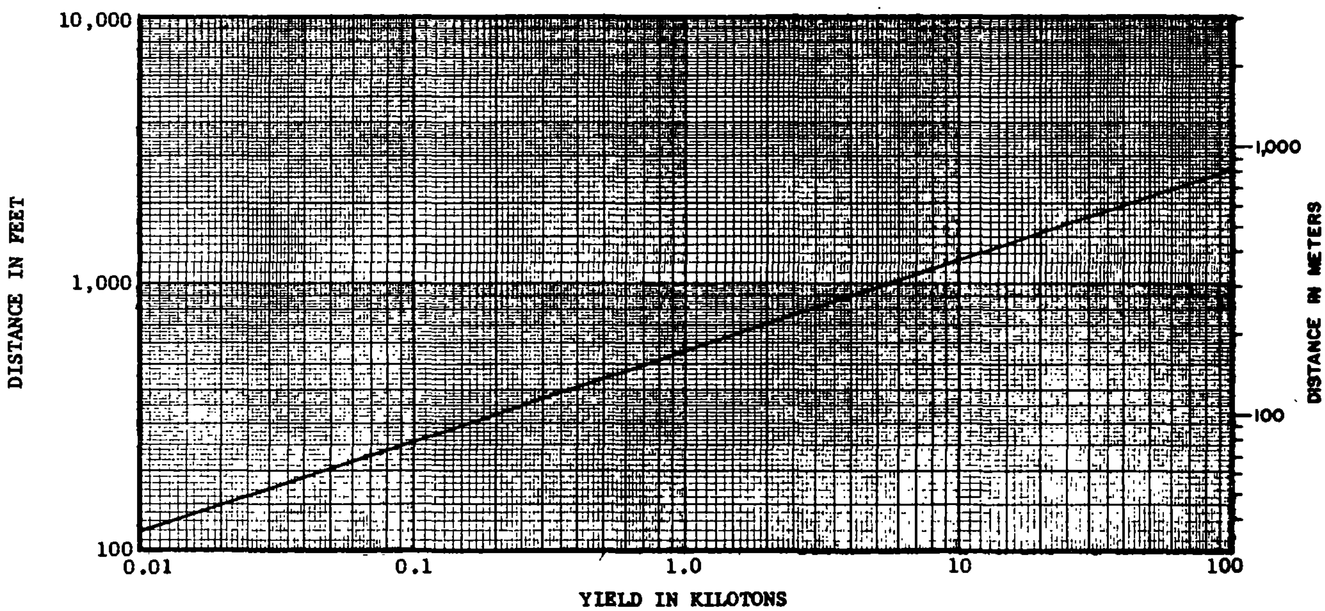


Figure 6-24. Distance versus yield for destruction of downstream gates.

(1) *Dams.* In planning denial of a navigational system, the basic mission must be borne in mind. If it is desired to achieve the greatest possible damage, destruction of the dam which impounds the water for the system may be more profitable than an attack on the lock facilities that allow vessels to bypass the dam. Destruction of the dam not only prevents navigation—even with all its other facilities intact—but puts an end to power generation, irrigation, and flood control. Additional damage may be done by the release of the impounded water. If the dam is to be the target, the data and methods presented in paragraphs 6-26 through 6-28 are used.

(2) *Locks.* A lock is the most common system for raising or lowering vessels. To pass a vessel headed downstream, the lower gate is closed, and by means of a system of valves and ducts, the lock chamber is filled with water. The vessel enters the chamber and the upper gate is closed behind it.

Through additional valves and ducts, the water is drained out of the chamber to the lower level of the canal. The lower gate is then opened and the vessel can proceed. The lower gate must be the full height of the chamber; the upper gate need extend only from the highest water level to a safe margin below the deepest draft vessel handled. The essential elements are the gates, lock chamber, operating machinery, and valves.

(*a*) *Machinery*. When limiting effects preclude the use of ADM large enough to damage harder features, valves and machinery may be attacked with conventional explosives. However, when the gates and chambers are targeted, no specific attention to valves and machinery is required, for a nuclear explosion which damages the gates and chamber will most likely damage this equipment as well.

(*b*) *Lock chambers*. Lock chambers are generally constructed of concrete or masonry. In rendering a chamber unusable, cratering is the governing effect. The best results are gained by ADM placement on the face of the end wall near the gate. Ground shock may also result in damage and is considered a bonus.

(*c*) *Gates*.

1. Lock gates may be hinged at the side or bottom; they may slide vertically below the bottom of the channel or be raised above the channel; they may slide horizontally into the side walls or move on rails against the side walls. Gates are vulnerable to hydrostatic shock and dynamic pressures. Although they are designed to withstand static pressure, a large detonation will exceed the safety factor. The donwstream gate is particularly vulnerable because its large surface presents a greater area on which the pressure can act. When the lock is full, it is already loaded on the chamber side with the static pressure for which it was designed whereas the other side is virtually unsupported.

2. For maximum destruction, the ADM is placed underwater in the upstream end of the chamber near the upper gate or against the upstream chamber wall thereby destroying the gates and cratering the chamber. For best results the lock is full with all gates and valves closed at the time of detonation. If placed as recommended, any yield can be expected to destroy the upper gate; the yield required to remove the lower gate may be determined from figure 6–24. Time or limited access may preclude optimum placement of the ADM. If so, considerable damage can be done to locks and gates by detonating an ADM in the near vicinity of the facility.

3. A lock chamber may be equipped with more than one set of gates to adjust the length of the lock to the length of the vessel to be passed. Another feature frequently found is a gate upstream of the main gate to permit the entire lock system to be drained for inspection and maintenance. *For maximum effect, all gates and valves are closed before detonation.*

(*d*) *Multiple locks*.

1. Locks frequently are built side by side to conserve water by passing upstream and downstream traffic at the same time. To save water, adjacent chambers of double locks are usually connected so that the water drained from one can be run into the other until the levels are equal. The ducts connecting the chambers offer a good location for placing a munition underground between two chambers, thus destroying both at once.

2. Parallel locks are not always adjacent; they are sometimes separated by water conservation basins which may require a separate demolition in each lock chamber.

(3) *Lifts*. Extreme changes in elevation may be accomplished by means of a lift, a form of elevator which raises or lowers a large trough of water in which the ship is floating. The ship moves into and out of the trough in much the same manner as it enters and leaves a lock; the lifting mechanism may be hydraulic or mechanical or a combination of both. The weight of the trough may be counterbalanced by using identical troughs in a double lift with both supported on hydraulic columns running in interconnected chambers, by a system of floats, or by counterweights.

(*a*) *Double hydraulic counterpoise*. The double hydraulic counterpoise lift can be destroyed by an ADM placed so that the resultant crater breaches both cylinders.

(*b*) *Float counterpoise lift*. The cratering action of an ADM placed on the surface at the foot of one of the towers will breach two of the float chambers and destroy the tower, thereby severely damaging the trough. The most critical components of the whole lift system are its elevating screws; placement against a screw destroys at least one of them. The upstream tower is the favored location so as to make bonus damage more likely to the upper canal level and loss of water to the system resulting in flooding.

(4) *Pumps.*

(*a*) Water generally flows through a lock system by gravity, and pumps are not essential to the operation. In areas where water is scarce, water may be returned to a storage reservoir or to another lock by pumping rather than released to flow down stream. Destruction of the pumps in such a system decreases its capability by preventing the conservation of the water but does not completely prevent the use of the locks.

(*b*) When there is no natural water supply and the entire canal system is artificial, the pumps are vital.

(*c*) An ADM of any size will temporarily disrupt the operation of a pumping station by destroying the building, controls, powerlines, and other facilities; however, the items most difficult to replace are the pumps themselves. In a large pumping station, the pumps may be distributed over an area so large that one munition of reasonable yield will not cause the required damage to them all. In such a case, conventional demolition charges applied to each pump are more efficient and practical.

(5) *Channels.* When a canal is above the surface of the adjoining ground, it may be drained by blowing out one of the embankments in the same manner as breaching an earthfill dam.

(6) *Aqueducts.* Canals are particularly vulnerable where they cross roads, valleys, or other waterways on aqueducts. An aqueduct is nothing more than a bridge which carries water; thus destruction of an aqueduct is performed in the same manner as that of any bridge of similar construction.

Section VI. TUNNELS

6-35. General

This section is provided for the analyst interested in the destruction of or damage to underground or underwater tunnels using ADM. Curves and technical data have been provided so that reasonable estimates of yields and damage may be made.

6-36. Damage Criteria, Underground Tunnels

In general, blocking a tunnel for a distance of 30 meters, by filling it with rock and debris from an ADM detonation, is considered adequate for denial. Two degrees of damage, extending for this distance, are considered in this text, severe and moderate.

a. Severe Damage. A tunnel undergoing severe damage is considered destroyed and generally requires use of standard tunneling procedures to repair. The volume of broken material varies from 80 to 100 percent of the volume of the original tunnel. Dislodged material completely fills the tunnel opening. Under certain conditions, the tunnel may be completely closed with solid rock. In the absence of other guidance, 30 meters of severe damage should be assumed for tunnel destruction.

b. Moderate Damage. At this level of damage, the tunnel will require significant rehabilitation effort to be used. However, standard tunneling procedures may not be required. The tunnel will be partially filled and large amounts of broken material will have to be removed. Floor heave may be extensive and the tunnel floor will probably require releveling prior to normal use by wheeled vehicles. A moderately damaged tunnel may be passable on foot without recovery work.

6-37. Emplacement Positions

a. Surface. An ADM may be placed on the surface of the ground above the tunnel. It is not necessary to place it directly over the tunnel but it should be placed as close to the tunnel as possible. The distance from the ADM to the nearest wall of the tunnel (burst-to-tunnel distance, BTD) determines the required yield.

b. Underground. For purposes of tunnel destruction, an underground burst is one that occurs at a point below the ground surface but not within the tunnel. As an ADM is buried deeper, more energy is coupled into the earth, and the resultant ground shock is increased. The required yield is a function of the burst-to-tunnel distance and the depth of burial (DOB).

c. Burst Offset From Tunnel. ADM may be emplaced in shafts (adits) leading off from the tunnel. Damage can be estimated from the dimensions of an apparent crater in rock by equating the offset distance to the DOB. The limit of damage along the tunnel floor is estimated as being equal to the length of the rupture zone (1.5 times the apparent crater radius). Emplacement procedures should include complete stemming of

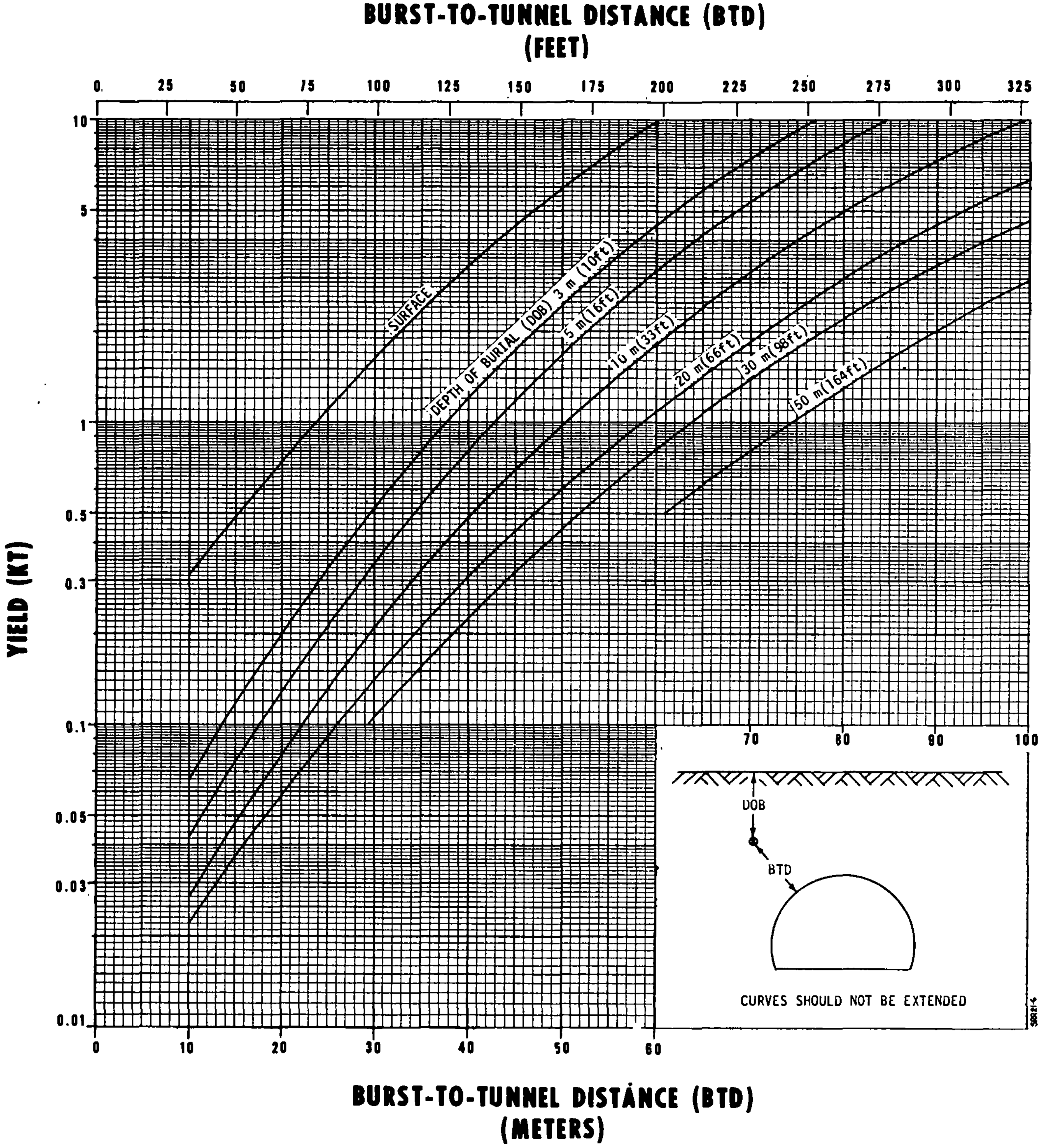


Figure 6-25. ADM yields for tunnel destruction; 30 meters of severe damage.

the emplacement shaft with at least one meter of sandbags or similar material.

d. Burst On Tunnel Floor. The damage caused by a nuclear explosion in an open tunnel is a special case of the above, that is, the offset distance is zero. The ADM should be placed at the side of the tunnel to produce better energy coupling with the medium.

6–38. Yield Determination

a. General. The first step in yield determination is he selection of the point at which the ADM is to be placed. Where possible, placement is far enough from the tunnel portals so that the limit of desired damage is contained within the tunnel. If the tunnel length is insufficient, emplacement is at the midpoint. Additional damage may be

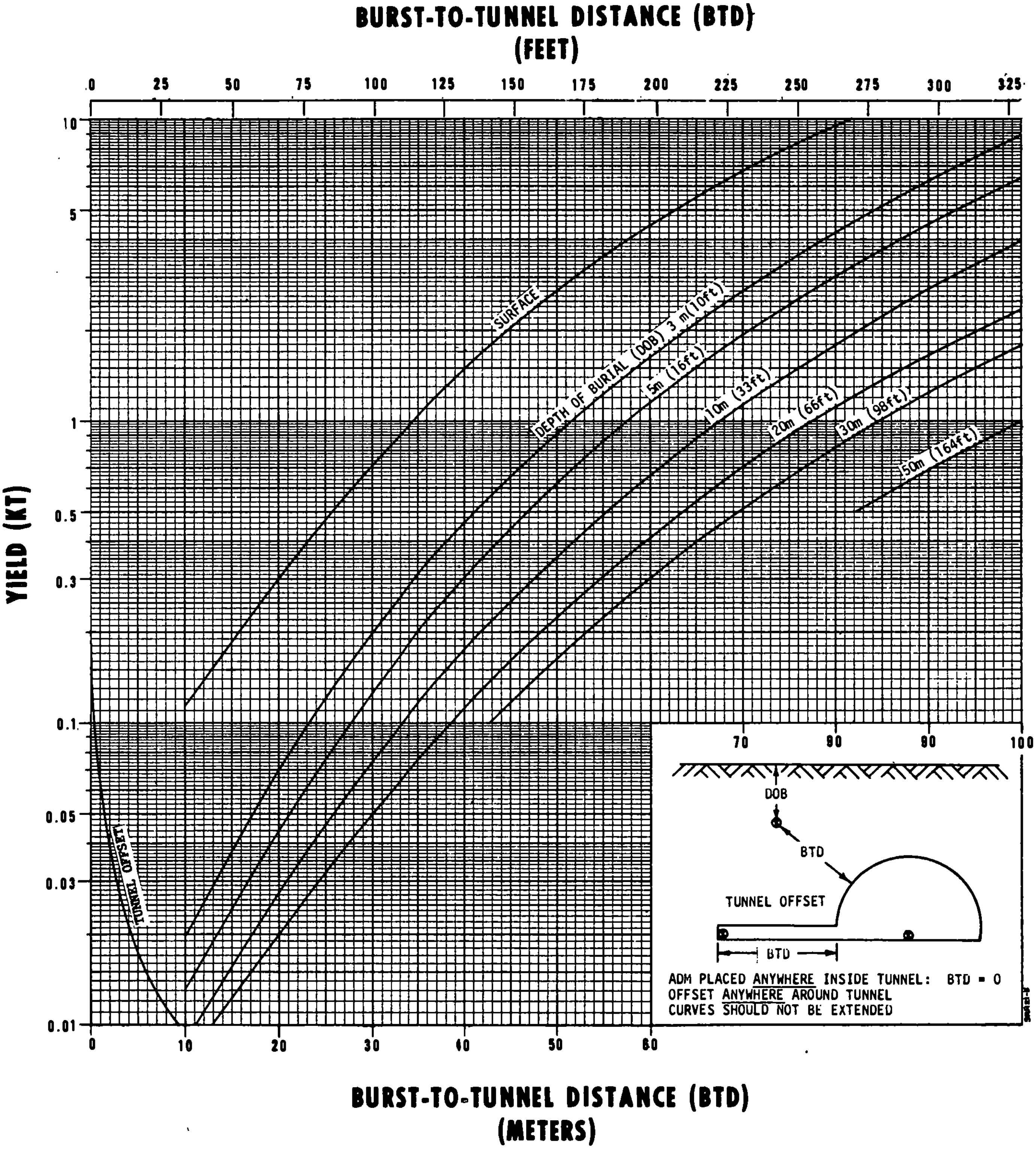


Figure 6–26. ADM yields for tunnel destruction; 30 meters of moderate damage.

achieved if the tunnel passes through a fault zone or similar nonstable geological conditions.

b. Severe Damage. Figure 6-25 is used to determine the yield required to produce 30 meters of *severe* damage for surface and underground bursts only. Enter the graph with the pre-determined BTD, read up to the proper DOB curve (interpolate if necessary), and left to the required yield.

c. Moderate Damage. Figure 6-26 is used to determine the yield required to produce 30 meters of *moderate* damage for surface and underground bursts; for bursts offset from the tunnel; and for bursts on the tunnel floor.

(1) For surface and underground bursts the procedure is the same as for severe damage.

(2) For bursts offset from the tunnel enter with the offset distance (this is equated to BTD), read up to tunnel offset curve, and left to required yield.

(3) For bursts on the tunnel floor enter figure 6-26 with a BTD of zero, and read up to a yield of 0.186 KT. Thus, for this emplacement mode the yield is constant. A BRAVO/0.05 KT ADM emplaced on the tunnel floor will produce 30 meters of moderate damage.

6-39. Illustrative Examples

a. Surface Emplacement.

(1) *Given:* Burst-to-tunnel distance is 40 meters.

(2) *Find:* The minimum ADM required to produce 30 meters of severe damage.

(3) *Solution:* Use figure 6-25. Enter graph with BTD of 40 meters, read up to surface curve, and left to a yield of 3.3 KT. Use a FOXTROT/5.0 KT ADM.

b. Underground Emplacement.

(1) *Given:* Depth of burial 10 meters. Burst-to-tunnel distance 45 meters.

(2) *Find:* The minimum ADM required to produce 30 meters of moderate damage.

(3) *Solution:* Use figure 6-26. Enter graph with a BTD of 45 meters, read up to the 10m DOB curve, and left to a yield of 0.25 KT. Use a DELTA/.5 KT ADM.

c. Offset Burst.

(1) *Given:* Offset distance of emplacement is 5 meters.

(2) *Find:* The minimum ADM required to produce 30 meters of moderate damage.

(3) *Solution:* Use figure 6-26. Enter with a BTD (offset distance) of 5 meters, read up to curve, and left to a yield of 0.017 KT. Use a BRAVO/0.05 KT ADM.

6-40. Underwater Tunnels

a. Damage Criterion. Flooding is the desired level of damage in destruction of an underwater tunnel. In order to achieve flooding, it is necessary to breach the tunnel casing and the overburden to allow the water to force itself into the tunnel.

b. Placement of ADM. Two emplacement positions are possible for nuclear demolition of an underwater tunnel. Normally, the ADM is placed in the tunnel against the roof; however, if access to the tunnel is not possible, then the ADM may be emplaced on the river or harbor bottom directly over the tunnel.

c. Radioactivity. Radiation resulting from nuclear demolition of underwater tunnels cannot be predicted at present with any degree of certainty. It is possible that radioactive material will be blown out either end of the tunnel together with fallout and base surge contamination.

6-41. Placement in Tunnel

By placing an ADM against the inside top of an underwater tunnel, breaching of the tunnel casing and the overburden is achieved in the same manner as described for an ADM emplaced on the downstream side of a gravity dam.

a. Rock Overburden. If the tunnel is under rock, then the tunnel casing, which usually is reinforced concrete, and the overburden can be considered as the same material.

b. Other Than Rock Overburden. This terminology is used for overburden of all type soils that might be encountered on river or harbor bottoms: sand, clay, silt, muck, or in any combination. Crater dimensions for a given yield in rock (concrete) are about one-half those in saturated soils; therefore, it is assumed valid to use one-half the height of overburden ($\frac{1}{2}$ H_0) for yield determination where other than rock overburden exists.

c. Yield Determination. Figure 6-27 enables rapid determination of required yield by giving the required damage distance as a function of yield. Simply enter with the appropriate distance according to type of overburden, ($H_0 + T$) or ($\frac{1}{2} H_0 + T$), then read over to the curve and down to the yield.

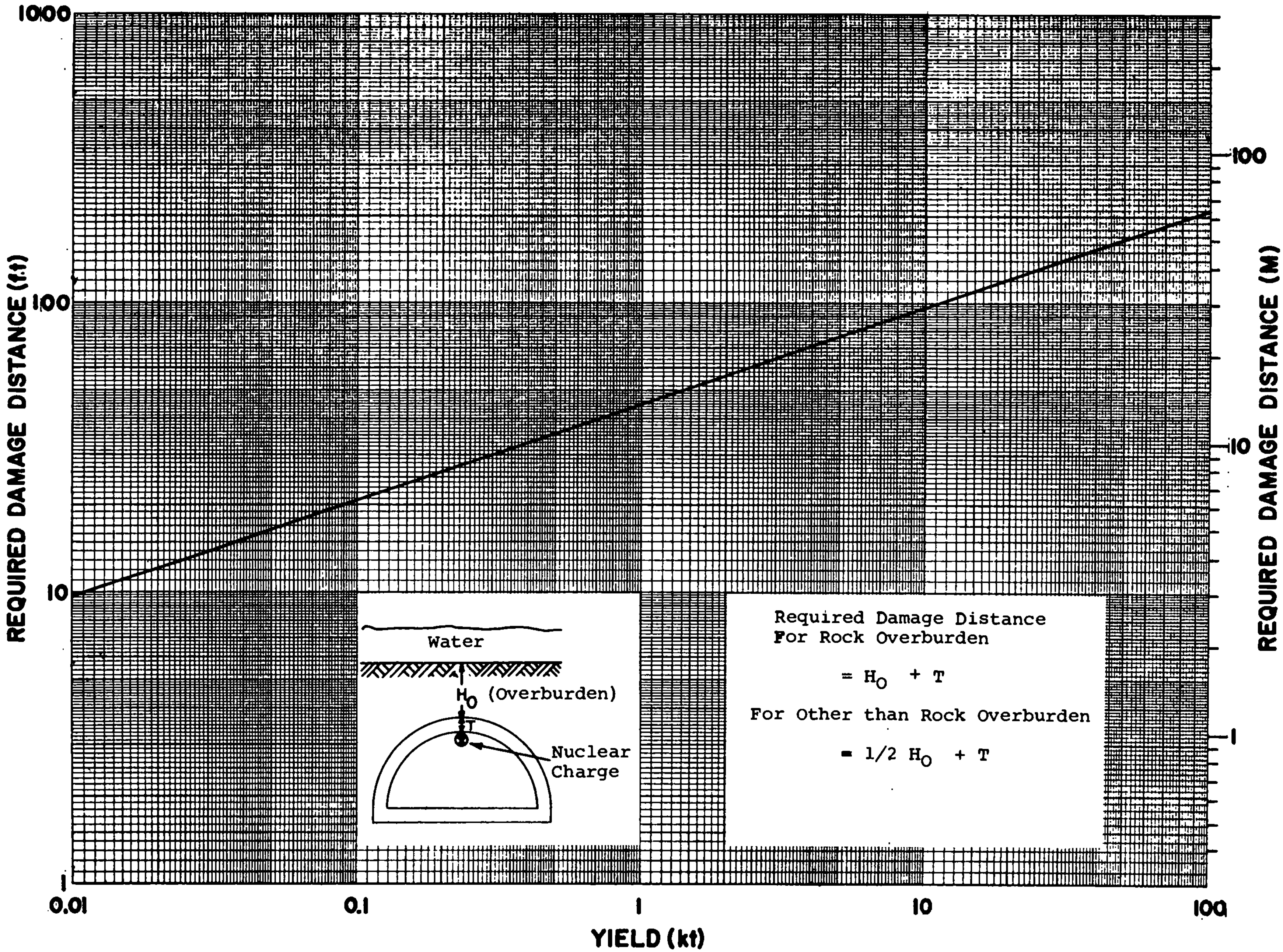


Figure 6–27. Yield determination for underwater tunnel destruction (burst inside tunnel).

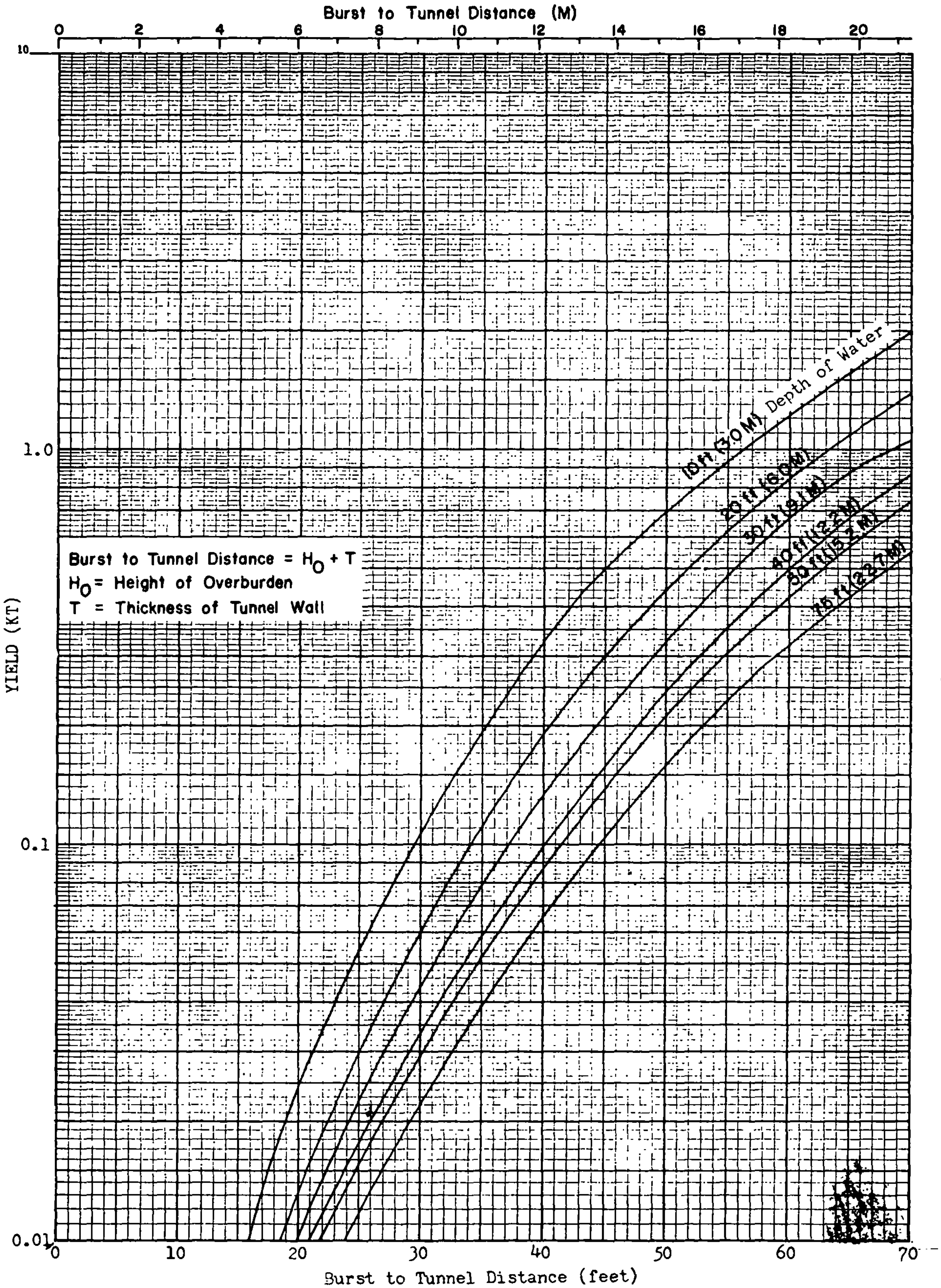


Figure 6-28. Yield versus burst-to-tunnel distance for varying depths of water (rock overburden).

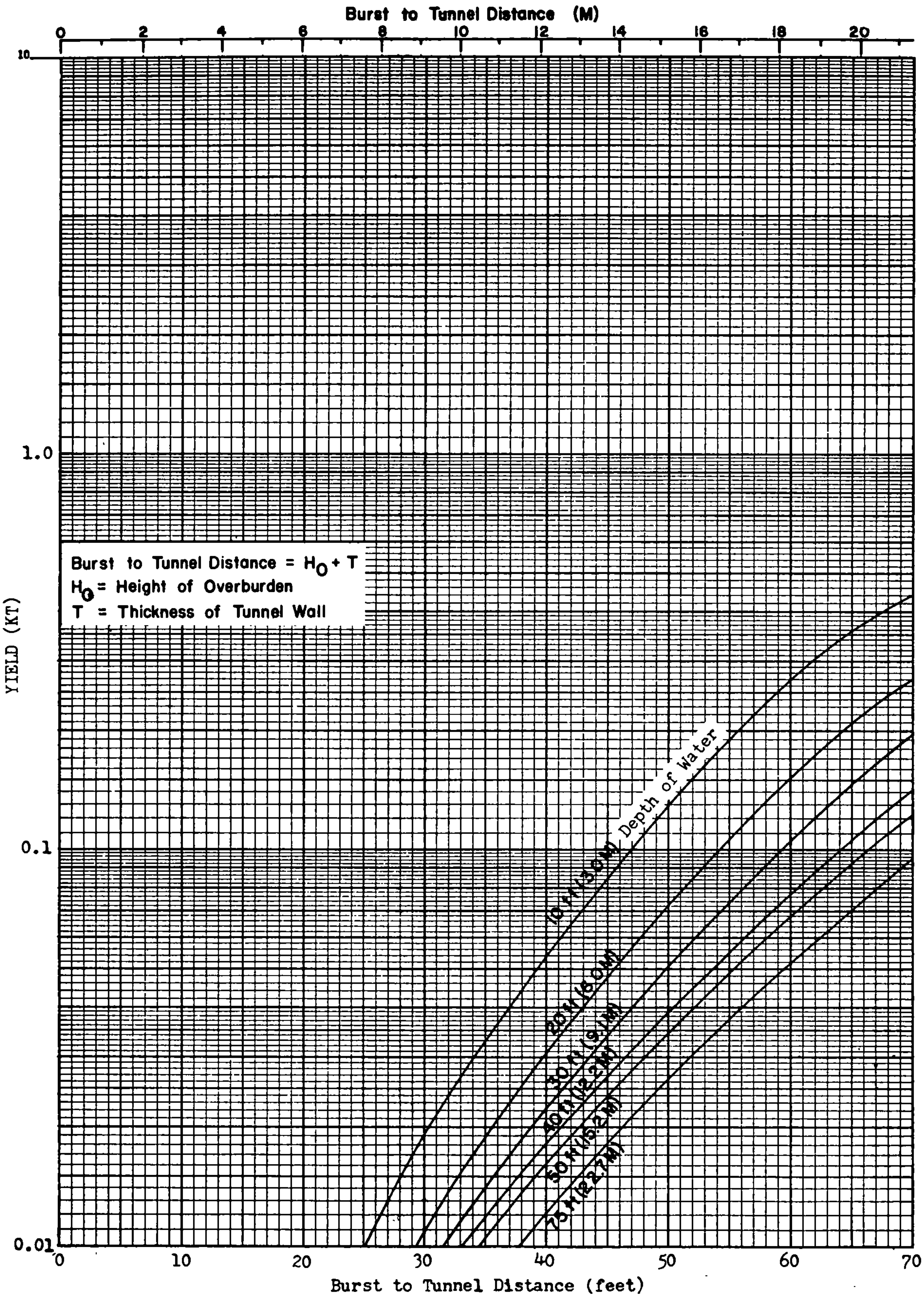


Figure 6–29. Yield versus burst-to-tunnel distance for varying depths of water (other than rock overburden).

6–42. Placement on River or Harbor Bottom

This emplacement mode achieves flooding of the tunnel by cratering action in the overburden. As the amount of overburden increases, rupture of the tunnel casing may be accomplished by spalling. The yardstick for yield determination is the burst to tunnel distance. For underwater tunnels this burst to tunnel distance is equal to the height of overburden (H_O) plus thickness of the tunnel casing (T). Computation of the burst to tunnel distance also takes into account the depth of burial or depth of water in this case. These computations are accomplished in figures 6–28 and 6–29, which give burst to tunnel distances for varying depths of crater as a function of yield for rock and other than rock overburden, respectively.

6–43. Illustrative Examples

a. Placement Inside Tunnel With Rock Overburden.

(1) *Given:* Depth of water—20 feet. Depth of rock overburden—15 feet. Thickness of tunnel casing—4 feet.

(2) *Find:* Yield required to flood tunnel.

(3) *Solution:* Since placement is inside tunnel, the depth of rupture concept is applicable with rock overburden. Enter figure 6–27 with required damage distance, $H_o + T = 15 + 4 = 19$ feet, read over to curve, and down to yield of 0.078 KT.

b. Placement on Bottom of River With Rock Overburden.

(1) *Given:* Depth of water—20 feet. Depth of rock overburden—15 feet. Thickness of tunnel casing—4 feet.

(2) *Find:* Required yield.

(3) *Solution:* Burst to tunnel distance 20 $H_o + T = 19$ feet. Enter figure 6–28 (rock overburden) with burst to tunnel distance of 19 feet, read up to 20-foot depth of water, and over to yield of 0.011 KT.

c. Placement Inside Tunnel With Other Than Rock Overburden.

(1) *Given:* Depth of water—20 feet. Depth of overburden—15 feet. Thickness of tunnel casing—4 feet.

(2) *Find:* Required yield.

(3) *Solution:* $\frac{1}{2} H_o + T = 7.5 + 4 = 11.5$ feet. Enter figure 6–27 with 11.5 feet, read over to curve, and down to yield of 0.017 KT.

d. Placement on River Bottom With Other Than Rock Overburden.

(1) *Given:* Depth of water—20 feet. Depth of overburden—15 feet. Thickness of tunnel casing—4 feet.

(2) *Find:* Required yield.

(3) *Solution:* Burst to tunnel distance = 19 feet. Enter figure 6–29 with burst to tunnel distance of 19 feet. An answer cannot be read; therefore, the minimum yield of 0.01 KT may be used.

Section VII. AIRFIELDS

6–44. General

a. The most effective way to destroy the operational capabilities of an airfield is to demolish the runway complex. The runway complex is the single, indispensable element of any field. Supporting facilities such as hangars, shops, warehouses, and communication equipment are not absolutely essential for emergency operations.

b. Since runway characteristics vary for different airfields, the ADM emplacement locations required for destruction of a specific runway complex depend on the size, layout, and importance of the particular airfield. The following paragraphs discuss the general method of approach for using atomic demolition munitions as cratering charges to destroy the operational capabilities of runways.

6–45. Emplacement Criteria

a. The destruction of an airfield runway complex generally requires multiple-charge detonations. One of the most important factors which must be considered in developing emplacement criteria is the minimum separation distance required between atomic demolition munitions to prevent the first detonation from damaging an adjacent munition. The safe separation distance for the hypothetical family of ADM is 100 meters (3300 feet) for separately detonated surface bursts (para 2–7*e*). Occasionally, the requirement of separation distances can be overcome by detonating one device and returning at a later time to emplace and detonate the other. However, the level of radioactivity released to the atmosphere by the detonation of the first ADM places a signif-

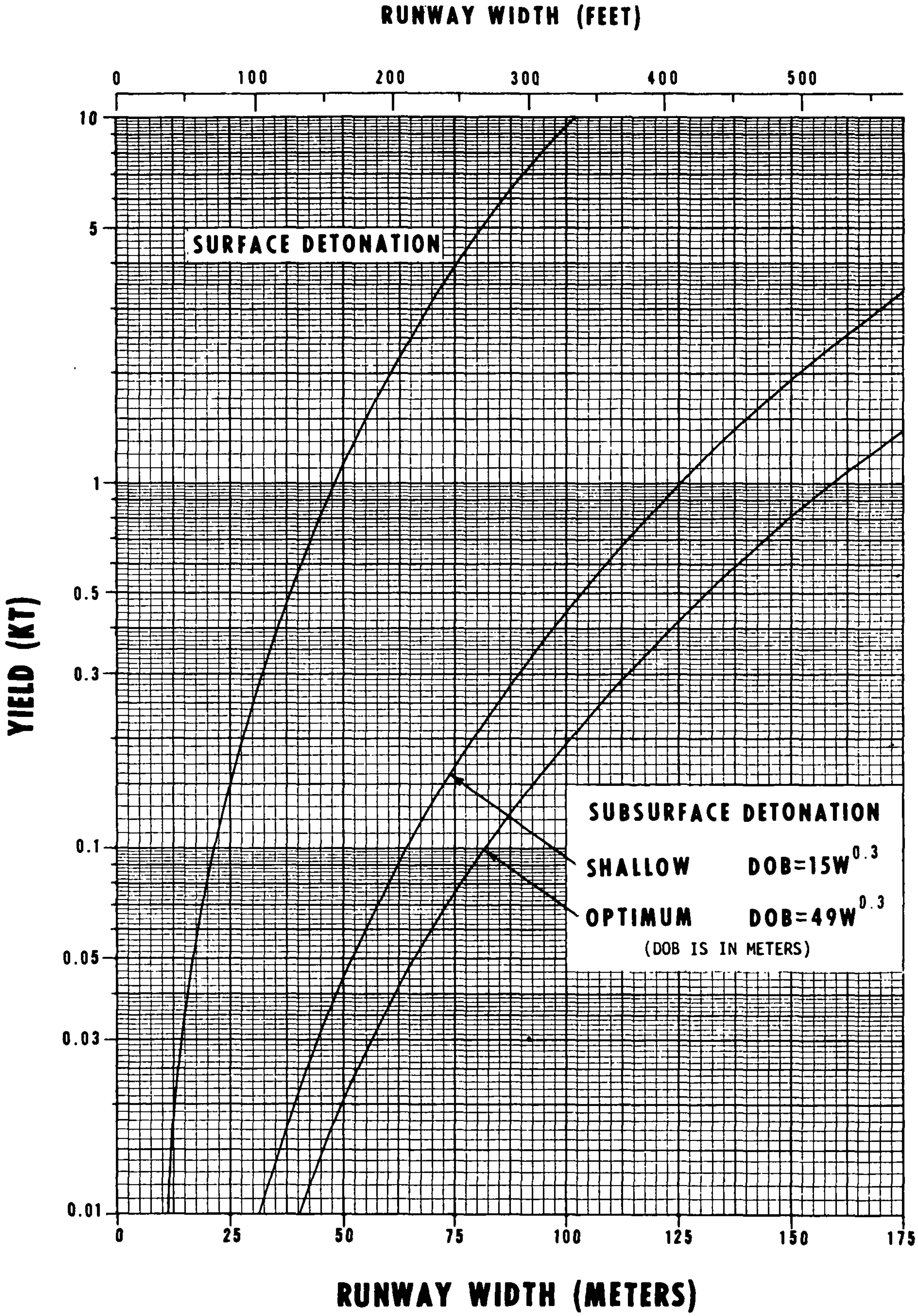


Figure 6-30. Yield selection criteria for runway demolition.

icant limitation on reentry capabilities for emplacing and detonating subsequent ADM.

b. Also important in determining emplacement locations is the degree of destruction desired with regard to supporting facilities and the runway complex. The detonation of any ADM on the runway denies immediate use of the airfield to nearly all types of aircraft because of local radioactivity levels and debris created by the explosion. For long-term denial, however, the runway complex must be analyzed to determine the most effective placement of ADM to insure that the maximum continuous length of undamaged runway remaining after device detonation is less than the length required for takeoff and landing of a given aircraft.

6-46. Yield Selection

a. General. The yield required to crater a runway depends on the depth of burst of the ADM, the width of the runway, and the characteristics of the subgrade material on which the runway is constructed. The yield and depth of burst is selected so that the diameter of the rupture zone along the surface is at least equal to the runway width.

b. Surface Emplacement. If the operational situation precludes burial of the ADM beneath the runway or placement in drainage culverts or utility ducts under the runway, it is necessary to detonate the munition on the surface of the runway. For surface or near surface detonations, concrete is used as the governing medium for

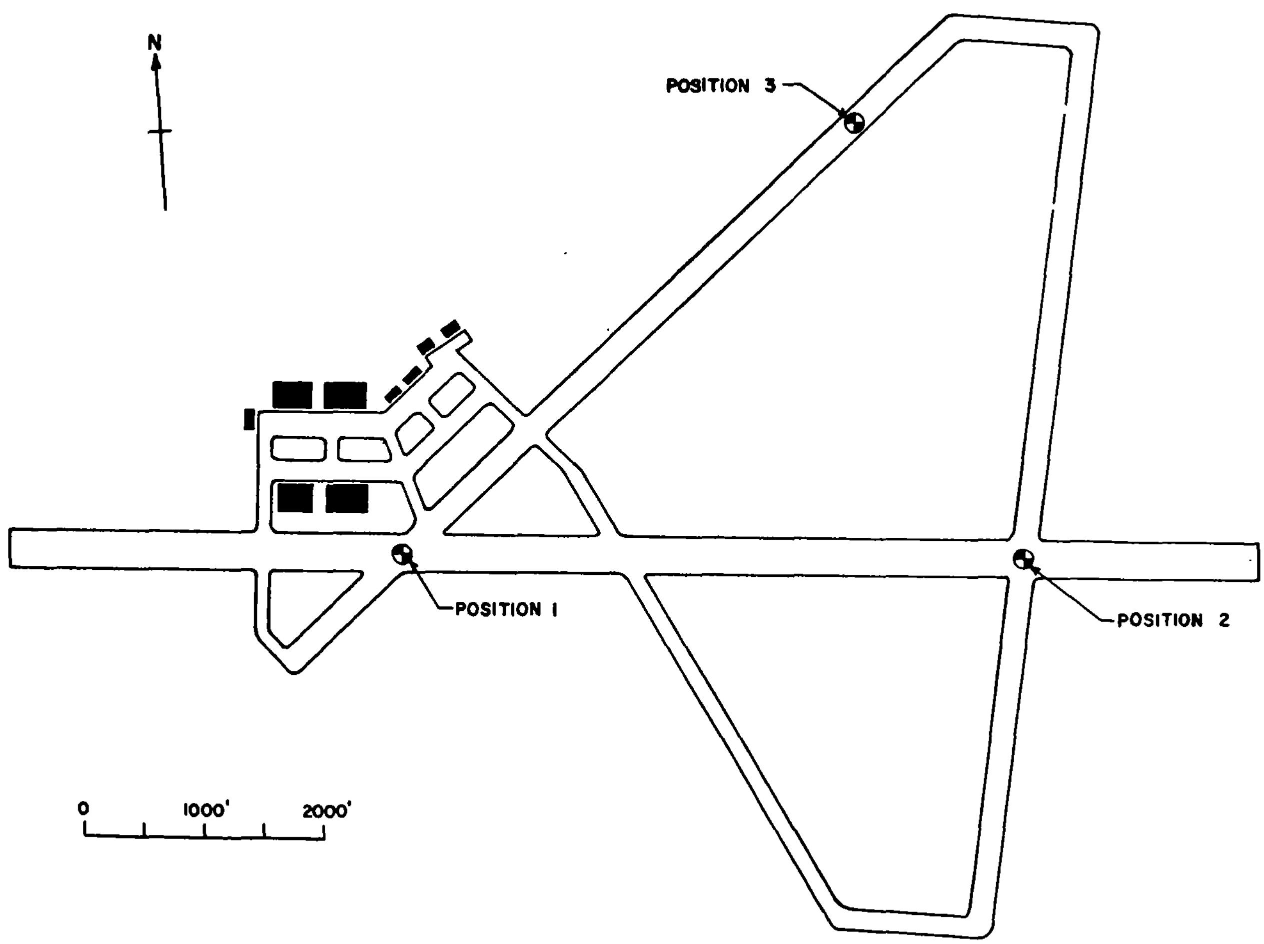


Figure 6-31. Airfield layout and ADM emplacement positions for illustrative example.

determining crater dimensions. Figure 6–30 gives a curve for determining surface burst yield requirements for varying widths of runway. This curve is based upon cratering in rock.

c. Subsurface Emplacement. For subsurface detonations other than near surface bursts, the concrete runway slab has little effect on the dimensions of the crater produced. The governing medium for subsurface detonations, therefore, is the subgrade material which is assumed to have cratering characteristics similar to dry soil. Figure 6–30 gives curves, based on cratering data in dry soil, for determining runway cratering yield requirements for shallow and optimum depth of burial. Should these depths differ from emplacement capabilities, the procedures outlined in paragraph 6–7 for crater size prediction should be followed, based on the maximum depth attainable.

d. Illustrative Example. The following example illustrates the recommended procedure for determining the yield requirements, depth of burst, and emplacement locations for demolition of runways.

Given: Figure 6–31 shows the layout of an airfield designed to handle heavy jet bombers. A demolition mission is planned with the objective of denying the use of the runway facilities for jet bombers and fighters. The maximum continuous length of undamaged runway which can remain after the demolition mission and accomplish the objective is 4900 feet (1500 meters).

Find: The ADM yields and emplacement positions for detonation at the surface and at shallow and optimum depths of burst. For the subsurface detonations determine the depth of burst. Assume a minimum separation distance of 3300 feet (1000 meters) for multiple ADM surface detonations.

Solution:

(1) *Emplacement positions.* The location of the ADM on the runway complex is the same for surface and subsurface detonation. Analysis of the runway layout indicates that a minimum of three ADM (identified as positions 1, 2, and 3 in fig 6–31) are required to deny all runways. Detonation of ADM at positions 1 and 2 reduces the undamaged length of the main east-west runway and the north-south runway to less than 4900 feet. A detonation at position 3, together with the detonation at position 1, reduces the undamaged length of the SW-NE runway to less than 4900 feet.

(2) *Yield selections—surface detonations.*

(*a*) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6–30 for surface burst and runway width of 300 feet, yield required is 7.4 KT.

Answer: Use GOLF/15 KT

(*b*) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6–30 for surface burst and runway width of 200 feet, yield required is 2.1 KT.

Answer: Use FOXTROT/5 KT

(3) *Yield selection—subsurface detonations (shallow DOB).*

(*a*) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6–30 for shallow DOB and runway width of 300 feet, yield required is 0.32 KT.

Answer: Use DELTA/0.5 KT

$$DOB = 50\ (0.5^{0.3})\ ft = 50\ (0.81) = 40.5\ ft$$

(*b*) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6–30 for shallow DOB and runway width of 200 feet, yield required is 0.082 KT.

Answer: Use CHARLIE/0.1 KT

$$DOB = 50\ (0.1^{0.3})\ ft = 50\ (0.5) = 25\ ft$$

(4) *Yield selection—subsurface detonations (optimum DOB).*

(*a*) Positions 1 and 2: Width of E-W runways = 300 feet (governing width). Referring to figure 6–30 for optimum DOB and runway width of 300 feet, yield required is 0.14 KT.

Answer: Use DELTA/0.5 KT

$$DOB = 160\ (0.5^{0.3})\ ft = 160\ (.81) = 130\ ft$$

(*b*) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6–30 for optimum DOB and runway width of 200 feet, yield required is 0.039 KT.

Answer: Use BRAVO/0.05 KT

$$DOB = 160\ (0.5^{0.3})\ ft = 160\ (0.41) = 66\ ft$$

(5) *Summary of yield requirements.*

Yield Required

Position No.	Surface	Subsurface Shallow DOB	Subsurface Optimum DOB
1	15 KT	0.5 KT	0.5 KT
2	15 KT	0.5 KT	0.5 KT
3	5 KT	0.1 KT	0.05 KT

The yield requirements listed above are indicative of thr advantage to be gained by subsurface emplacement as compared to surface bursts. Furthermore, the radioactivity released from the subsurface detonations are much smaller than for surface bursts. In addition, the fraction of radioactivity released to the atmosphere by a subsurface detonation at optimum depth of burial is less than 15 percent of that of a surface detonation of the same yield.

Section VIII. MISCELLANEOUS ADM TARGETS

6-47. General

Special target analysis techniques for ADM in which cratering for point targets is the governing effect were discussed in paragraphs 6-3 through 6-46. It should not be forgotten, however, that ADM have a mass destruction capability and are suitable for employment on targets susceptible to nuclear effects other than cratering. Moreover, target analysis is not complete until the target area is analyzed for contingent effects. Either the visual or numerical method of target analysis is applicable for analyzing area targets utilizing the damage tables and contingent effects tables in appendix B or FM 101-31-2. This section discusses in general terms other targets appropriate for ADM attack in which the cratering effect may not govern.

6-48. Railroad Marshaling Yards

A railroad marshaling yard is an area target susceptible to blast and cratering effects. Repair facilities, roundhouses, engine sheds, and rolling stock are primarily damaged by blast while turntables and switching facilities are most effectively damaged by cratering. In cratering a railroad yard, the depth of crater is less important than width since any significant disruption of the rails requires major rehabilitation. Blast damage criteria for various yields are shown in the damage tables; cratering data may be obtained from paragraphs 6-3 through 6-13. In populated areas, subsidence craters should be considered to preclude all nuclear effects to local inhabitants.

6-49. Ports

a. There are two general method by which port facilities may be denied. The first is to use one or more large yield ADM to demolish the entire port as an area target. The second method is to employ a number of small yield ADM to destroy key port installations. The method of employment is, of course, dependent on the layout and size of the ports and the number and type of ADM available.

b. If one or more large yield ADM are used to attack the entire port as a single target, many of the facilities most essential to the port's operation, such as wharves and tidal locks, will remain largely undamaged. Above ground structures and equipment susceptible to blast and thermal effects will be damaged in accordance with the yield and distance from ground zero. Fires, mostly of secondary origin, will contribute to destruction. Since this method of attack destroys only those facilities near ground zero, it will hinder but not completely deny the use of a large port. The principal advantages of this method are the economy of ADM employed and the short time and little effort required for preparation.

c. If the second method is employed, a number of relatively small yield ADM consistent with separation distances may be selectively emplaced to demolish key harbor installations. Some of these facilities, such as the road and rail net serving the port, have already been discussed. Only those facilities peculiar to port operations are discussed below.

(1) The wharves are essential to port operations. Destruction of all the wharfage, therefore, completely denies the use of the port for an extended period. However, total destruction requires the use of numerous ADM and extensive emplacement effort. There are two general types of wharf construction: deck docks supported by piles, which are susceptible to blast and thermal effects; and quay walls made from concrete or masonry, which are best attacked utilizing the cratering effect prescribed for concrete dams or bridges.

(2) Tidal locks are necessary in some ports to maintain an adequate depth of water in the harbor area. Such facilities are attacked in a fashion similar to that prescribed for canal locks.

(3) Breakwaters are frequently necessary to protect wharf areas from wave action. Creating a large enough gap in a breakwater will handicap operations at the wharves but will rarely deny use of any of them. If it is desired to breach breakwaters, however, techniques similar to those prescribed for breaching gravity dams are applicable.

(4) The destruction of ship repair facilities is not considered here but rather under industrial plants. Methods of destroying drydocks, however,

are comparable to the techniques prescribed for canala locks.

d. Only by destruction of the wharves can a port be denied for an extended period of time. However, demolition of wharves generally requires a large number of ADM which may result in overdestruction in the port area and a radiation hazard to the surrounding population.

6-50. Industrial Plants and Power Facilities

a. The use of ADM permits rapid and long term denial of industrial and power installations; however, such plants are usually located in or near heavily populated areas. As a consequence, it may be necessary to limit overdestruction and confine radiation. Each industrial facility must be analyzed separately to determine the best method of denial. Two general approaches are available in attacking a large installation. One relatively large yield ADM may be selected to destroy the entire facility, or smaller ADM may be selected, consistent with safe separation distances, to destroy critical portions of the installation. In either event, the primary nuclear effect is generally blast overpressure.

b. The area target technique involves the selection of a yield which insures moderate to severe damage for the entire installation area. Residual radiation in the surrounding area may be reduced by placing the ADM on a tall structure with little mass such as a smokestack.

c. With selective destruction techniques, the most important elements or areas of the plant are chosen for destruction. If the installation has its own powerplant and if substitute power is not readily available, destruction of the powerplant denies use of the entire facility. Other elements crucial to operations of specified target complexes would be the blast furnaces in a steel mill or the cracking plant in a petroleum refinery. However, before employing ADM, consideration should be given to the use of conventional demolitions against targets of this type.

CHAPTER 7

TROOP AND INSTALLATION SAFETY

Section I. INTRODUCTION

7-1. General

The surface or subsurface detonation of an ADM not only produces a crater but usually is accompanied by the release of nuclear radiation, radioactive materials, blast, ground shock, missiles, dust, and thermal radiation. Employment of ADM includes an evaluation of these nuclear effects which may result in hazards to friendly troops and the civil population; contamination of water sources; or damage to installations of military, political, or humanitarian importance.

7-2. Contingency Effects Tables

The contingency nuclear effects tables in appendix B and FM 101-31-2 provide general guidance for estimating the range to which certain effects extend. For tactical surface bursts, these tables usually are sufficient. However, when in close proximity to friendly troops or populated areas, it is necessary for the ADM target analyst to determine the influence of a variety of nuclear phenomena. Moreover, some nuclear effects such as fallout and blast overpressures can be suppressed, if not eliminated, by appropriate subsurface detonation. Consequently, this chapter in conjunction with chapter 2 discusses in more detail the extent of specific effects.

Section II. NUCLEAR RADIATION

7-3. General

The nuclear radiation emitted and the radioactive material produced by a surface or shallow subsurface nuclear detonation is significant; thus troop safety from nuclear radiation is an important consideration. Adequate protective shielding is difficult to acquire. Moreover, it is reasonable to assume that personnel in the combat zone may receive repeated radiation doses. The amount and frequency of doses received in past operations and the urgency of the tactical situation must be considered in determining the degree of friendly troop exposure.

7-4. External Radiation Hazard

The external radiation hazard from a surface or underground nuclear detonation consists of initial and residual radiation. The biological response of the human body, however, is essentially the same for both (FM 101-31-1).

a. Initial nuclear radiation often produces casualties among personnel protected from blast and thermal effects and is of considerable significance in assessing the radiation hazard.

b. Exposure to gamma radiation from fallout is perhaps the most far-reaching type of residual radiation hazard.

c. The total dose of radiation absorbed by an individual includes both the initial and residual radiation doses received. Although partial recovery of the human body from nuclear radiation damage does occur with the passage of time, the biological effects from repeated doses received during a relatively short period of a few weeks are essentially cumulative.

d. In view of the regularity of exposure, the nonrecoverability in the first 30 days, and the slow overall recovery, the commander must also consider the consequences of using personnel previously exposed to significant but nonsymtomatic doses. To assist the commander, friendly units are divided into four categories based on previous exposure history. FM 3-12 discusses techniques for classifying units. The categories are described in paragraph 5-5*e*.

e. Military personnel operating in a nuclear environment may expect radiation exposure as a normal combat hazard. Table 7-1 relates a unit's current radiation status (based on total past cumulative dose) to numerical troop safety criteria for future operations. The table assumes that no body recovery from radiation injury occurs.

f. Delay in the onset of the effects from comparatively small doses of nuclear radiation may permit some personnel to remain effective long enough to influence a specific operation. Nevertheless, the delayed effects may considerably reduce future combat effectiveness. In addition, severe stress during this delay in onset of effects may cause a more rapid and severe response, further reducing future combat effectiveness.

Table 7-1. Nuclear Radiation Degree-of-Risk Exposure Criteria

Radiation status category	Total past cumulative dose (rad)	Single exposure risk criteria (rad)		
		Negligible	Moderate	Emergency
RS-0	0	50	70	150
RS-1	> 0, ≤ 70	-------	50	70
RS-2	> 70, ≤ 150	-------	-------	50
RS-3	> 150	-------	-------	------

Notes 1. Radiation status categories are based on previous exposure to radiation.
2. Reclassification of units from one radiation status category to a less serious one is done by the commander upon advice of the surgeon after ample observation of actual state of health of the exposed personnel has been made.
3. All exposures to radiation are considered to be total body and simply additive. No allowance is made for body recovery from radiation injury.
4. Risk levels are graduated within each status category to provide more stringent criteria as the total radiation dose accumulated becomes more serious.

7-5. Shielding and Attenuation

The amount of radiation received at any point is dependent on the distance from the point of a nuclear detonation and the nature of the intervening material. All matter will absorb some nuclear radiation, and thus provide some shielding. Shielding against gamma rays is provided mainly by mass; an equal weight of one material is about as effective as any other, so the denser the material, the better it serves as a gamma shield. This is why lead usually is used to protect against gamma rays. Neutrons, on the other hand, are captured much more readily by some elements than by others, and the value of the shielding depends almost entirely on what it is made of. Lead is a very poor shield against neutrons. One of the better elements for shielding against neutrons is hydrogen, which is concentrated in water and organic matter. To shield against both neutrons and gamma rays, such materials as concrete and damp earth are a good compromise.

7-6. Military Significance of the Initial Nuclear Radiation Exposure Hazard

a. A knowledge of the variation of initial radiation intensities with the range from a nuclear detonation is necessary in oder to assess the immediate external radiation. At the present time, initial radiation data are available for air and surface detonations only (app B and FM 101-31-2). The shielding of the initial radiation by dust and debris produced by a subsurface explosion, as well as absorption by the surrounding media, will cause a considerable reduction in the exposure dose at any given distance. The extent of this reduction, however, cannot be quantitatively estimated at this time.

b. In the downwind direction from a nuclear detonation, both initial radiation and fallout contribute to the total dose of nuclear radiation.

7-7. Factors Influencing Fallout Distribution

The distribution and intensity of gamma radiation resulting from radioactive fallout is primarily dependent on the following factors:

a. The kinds and quantities of radioactive materials produced by the explosion.

b. The fraction of the radioactive materials produced that escapes to the atmosphere.

c. The dimensions of the main cloud.

d. The wind speed and direction up to maximum cloud height.

e. The dimensions of the base surge cloud. The base surge cloud is a physical phenomenon of nuclear detonations occurring beneath the surface of either ground or water (a surface burst does not create a base surge). It is formed in essentially the same manner for either underground or underwater bursts and consists of a low level radioactive cloud surrounding ground zero. The significance of the base surge cloud radius is considered in troop safety because there could be a very high radiation dose rate within its confines. For the underwater burst, the base surge is transient, and its contribution to residual radiation is expected to be minor. The underground burst base surge, on the other hand, may contribute significantly to residual radiation. (See DASA EM-1 for further details.)

7-8. Nuclear Radiation

a. The nuclear radiation generated in cratering explosions is distributed in three ways—

(1) A large fraction is trapped by particles of debris and *ejecta* which fall back into the crater or on the lip and become buried in the rubble.

(2) A smaller fraction escapes from the crater, is deposited on large dust particles, and becomes a part of the dust cloud. These large radioactive particles are deposited as local fallout.

(3) A much smaller fraction escapes from the crater, is deposited on minute dust particles or remains a gas, and may be carried for great distances and contribute to worldwide fallout.

b. The relative amount of the activity which escapes as local fallout depends on how deep the ADM is buried compared to the depth of the resulting crater. For cratering detonations at optimum depth of burst, it has been estimated that less than 25 percent of the total radioactive debris is released to the atmosphere. Of this small amount about 60 percent is distributed in the main cloud and 40 percent in the base surge. Until data are available for shallow depths of burst, this distribution of radioactive debris is also assumed for shallow burial.

7-9. Fallout Prediction Procedures

Nuermous fallout prediction procedures have been developed. Most of them are for specific applications. The procedures presented in paragraphs 18-24 and 27-32 of TM 3-210, Fallout Prediction, are recommended for use in tactical situations to determine those areas within which exposed, unprotected personnel may receive a militarily significant total dose of nuclear radiation in the first several hours after actual arrival of fallout. Table 7-2, based on TM 3-210, illustrates typical downwind distances of Zones I, IA, and II for surface and subsurface bursts. Note that there is an initial increase in the downwind distance of Zone I as depth of burst is increased from surface to shallow, and that there is a significant decrease for all zones as the depth of burst is increased to optimum.

Table 7-2. Downwind Distances of Zones I, I-A, and II (kilometers)

Model/Yield (kt)	Surface Burst DOB = O			Shallow Burial DOB = $49W^{0.3}$ m			Optimum Burial DOB = $15W^{0.3}$ m		
	ZONE I	ZONE IA	ZONE II	ZONE I	ZONE IA	ZONE II	ZONE I	ZONE IA	ZONE II
ALFA/0.01	0.47	0.76	1.08	0.53	0.73	0.93	0.05	0.08	0 11
BRAVO/0.05	0.93	1.67	2.40	1.05	1.55	2.04	0.09	0.17	0.24
CHARLIE/0.1	1.47	2.59	3.70	1.66	2.40	3.14	0.15	0.26	0.37
DELTA/0.5	4.40	6.60	8.80	4.97	6.23	7.48	0.44	0.66	0.88
ECHO/1	5.7	8.6	11.4	6.5	8.1	9.7	0.57	0.86	1.14
FOXTROT/5	13.0	19.5	26.0	14.7	18.4	22.1	1.30	1.95	2.60
GOLF/15	18.0	27.0	36.0	20.2	25.7	30.6	1.80	2 70	3.60

Notes. An effective wind speed of 15 knots (27 Km/hr) is assumed. Downwind distances are based on fallout prediction using TM 3-210.

ZONE I: A zone within which there will be areas where exposed, unprotected personnel may receive doses greater than 50 rad in relatively short periods of time (less than 1 hour after arrival of fallout).

ZONE I-A: A zone within which there will be areas where exposed, unprotected personnel may receive doses greater than 50 rad in relatively short periods of time (less than 4 hours after actual arrival of fallout).

ZONE II: A zone within which the total dose to exposed, unprotected personnel is not expected to exceed 50 rad when remaining in the area for not more than 4 hours after the actual arrival of fallout.

Section III. BLAST

7-10. General

a. The direct effects of blast are an important troop safety consideration.

(1) High overpressures estimated at 45 to 55 psi for nuclear explosions cause immediate deaths while lower overpressures on the order of 20 to 35 psi may cause severe internal injuries especially to the lungs or abdominal organs. Eardrum rupture, which is painful but not necessarily disabling, may result from overpressures as low as 5 psi. Personnel in field fortifications may become casualties at lower incident blast overpressures built up by multiple reflections within small inclosures to casualty-producing levels.

(2) Translation, the process by which personnel and material objects are picked up and thrown, is the basis for prediction of blast casualties to personnel in the open.

b. Secondary effects of blast also produce personnel casualties.

(1) Flying debris, stones, and sand are converted to missiles by the blast wave, thereby causing casualties to unprotected personnel. Hot, dust-laden gases may cause burns. Airborne dust may cause irritation and possible suffocation as well as limit visibility and movement within and adjacent to the target area.

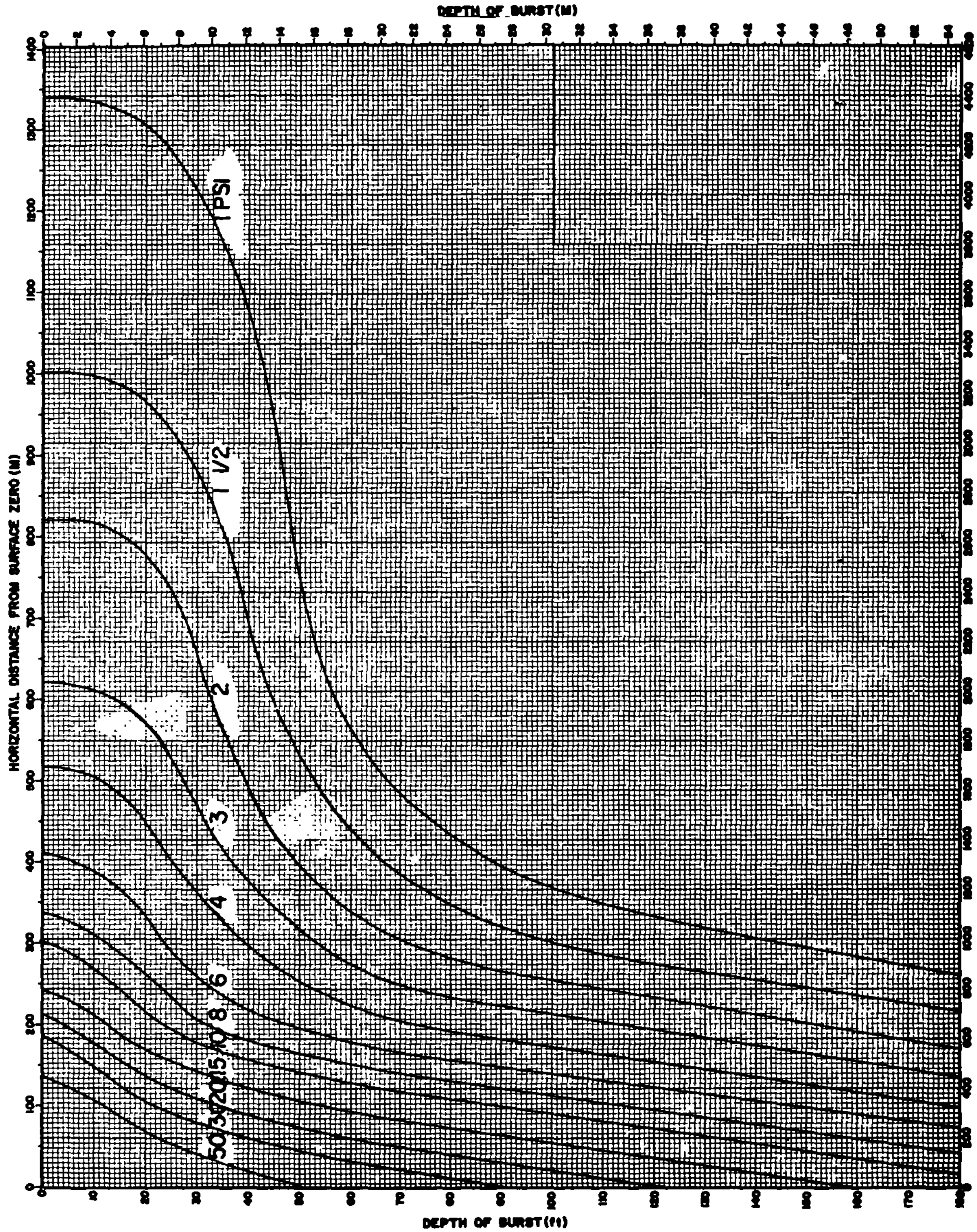


Figure 7-1. Air overpressures at the surface from surface/ subsurface bursts, in dry soil (normalized to 1 kiloton).

(2) Buildings or fortifications may collapse on personnel.

7–11. Degree of Risk and Damage Criteria

a. Tactical Employment.

(1) In tactical operations involving the use of atomic demolition munitions, the primary area of concern is the close-in region in which structures of military significance and personnel are subjected to damaging overpressure levels from blast. The following criteria have been established for determining troop safety distances for warned, protected personnel (foxhole protection):

Degree of Risk	*Blast Overpressure-psi*
Negligible	4.0
Moderate	7.5
Emergency	10.0

(2) The above blast criteria, however, do not preclude all blast injuries to protected personnel. Personnel in tanks subjected to 10 psi overpressure will probably receive no significant injuries. Personnel in foxholes, however, may become indirect blast casualties as a result of foxhole collapse. An overpressure of 4 psi (negligible risk) does not cause sufficient damage to either tanks or foxholes to produce either direct or indirect casualties.

(3) Damage criteria for structures and field fortifications of tactical significance are given in appendix C.

b. Preclusion of Damage Operations. When it is desired to preclude damage to nearby structures, potential blast damage from ADM must be evaluated. Normally, 1 psi overpressure is used as the criterion for preclusion of light damage due to blast.

7–12. Prediction of Close-in Blast for Cratering Detonations

a. Close-in blast overpressures resulting from subsurface detonations are considerably less than those generated by an air or surface burst at the same ground zero. Figure 7–1 is a family of curves representing peak air overpressures on the surface as a function of depth of burst and surface range for a yield of 1 KT in a dry soil medium. In a rock medium, blast is reduced to a much greater extent. If the distances in figure 7–1 are reduced by 50 percent, they may be used for cratering detonations in a rock medium at depths greater than 50 $W^{0.3}$ feet (15 $W^{0.3}$ meters). The depth of burst and the range to which a given peak overpressure extends are directly proportional to the cube root of the yield:

$$\frac{R_1}{R_2} = \frac{DOB_1}{DOB_2} = \frac{W_1^{1/3}}{W_2^{1/3}}$$

Where R_1 is the range of a given overpressure for a yield of one kiloton (W_1); R_2 is the corresponding range of the same overpressure for any given yield (W_2); DOB_1 is the depth of burst for a yield of one kiloton; and DOB_2 is the corresponding depth of burst for any given yield (actual depth of burst).

b. The following example illustrates the recommended procedure for predicting close-in blast overpressure levels resulting from cratering detonations:

(1) *Given*: It is planned to detonate a FOXTROT/5KT ADM at a depth of 20 meters in soil as part of a preplanned barrier operation.

(2) *Find:* The distance to which 4 psi overpressure will extend.

(3) *Solution:* Determine depth of burst for one kiloton by applying the scaling law.

$$\frac{DOB_1}{DOB_2} = \frac{W_1^{1/3}}{W_2^{1/3}} \; ; \; \frac{DOB_1}{20} = \frac{1^{1/3}}{5^{1/3}}$$

$$DOB_1 = \frac{20}{1.71} = 11.7 \text{ meters}$$

Enter figure 7–1 with DOB_1 of 11.7 meters, read down to the 4 psi curve, and left to an R_1 of 300 meters. Determine R_2 by applying the scaling law.

$$\frac{R_1}{R_2} = \frac{W_1^{1/3}}{W_2^{1/3}} \; ; \; \frac{300}{R_2} = \frac{1^{1/3}}{5^{1/3}}$$

$$R_2 = 300\ (1.71) = 513\text{m}$$

(4) *Answer:* 513 meters

Section IV. MISSILE HAZARD

7–13. General

One of the hazards associated with nuclear cratering is the ejection of large particles of debris which travel along ballistic paths as missiles and are deposited at considerable distances from ground zero. These missiles are potential casualty-producing agents and can also cause severe damage to structures and equipment. Figure 7–2 shows the venting of a 100-KT detonation. A number of missiles, each trailing the dust plume

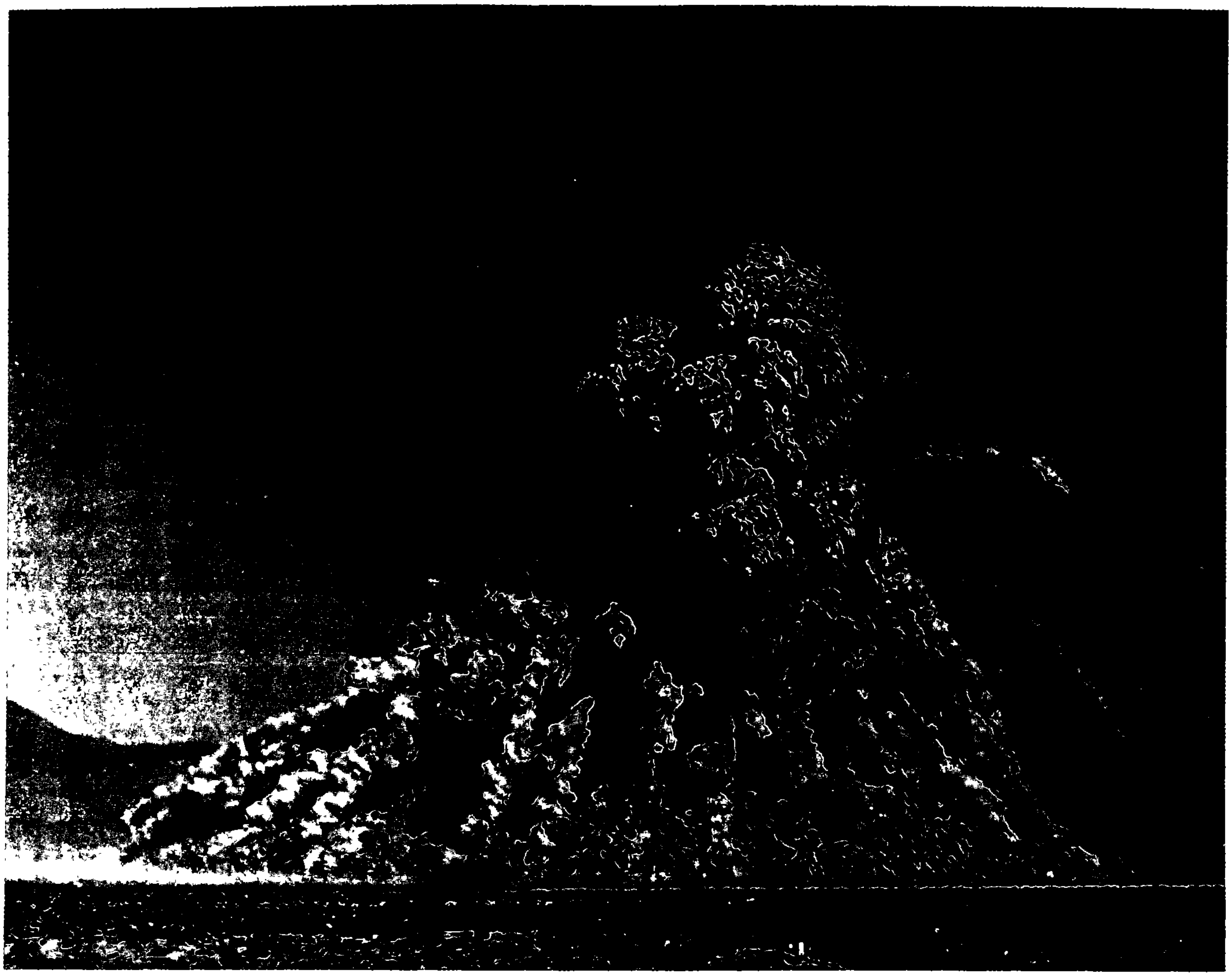


Figure 7-2. Venting of a 100-kiloton detonation showing missiles.

which marks its trajectory, are visible in the figure.

7-14. Description of Missiles Ejected by Cratering Detonations

a. General.

(1) The *ejecta* resulting from a nuclear cratering detonation is distributed randomly over a large area surrounding the crater in three zones from the crater edge outward as follows: the crater lip; the area in which mounds or rays of *ejecta* may be found; and the region of dust and missiles. A typical *ejecta* pattern is shown in figure 7-3.

(2) The distance to the outer edge of the crater lip is considered to be the average distance from ground zero at which there is no significant difference in preshot and postshot elevation. This distance (R_L) varies between 1.5 and 2.5 times the apparent crater radius depending on the depth of burst of the ADM. Between the crater lip and the region of dust and missiles, and overlapping both areas, is a region in which the *ejecta* may be distributed in a pattern characterized by a concentration of material in radially or tangentially oriented longitudinal mounds. The radially oriented mounds or rays usually begin in the lip and may be continuous from the lip to their outer extremity. In rock or soil containing a high percentage of boulders, the rays may consist only of elongated concentrations of rocks rather than mounds of material. As used in this section, the

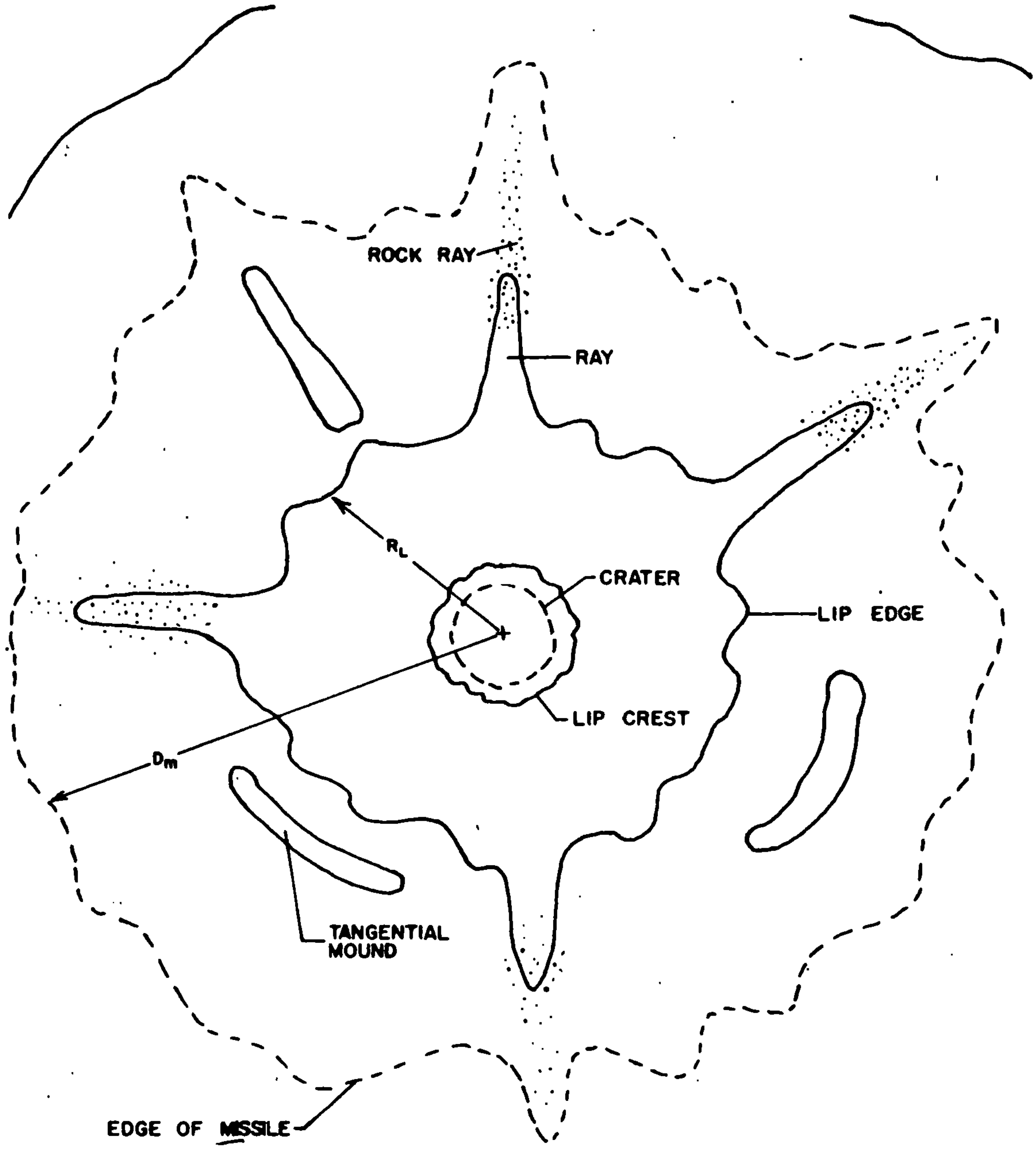


Figure 7-3. Typical ejecta pattern.

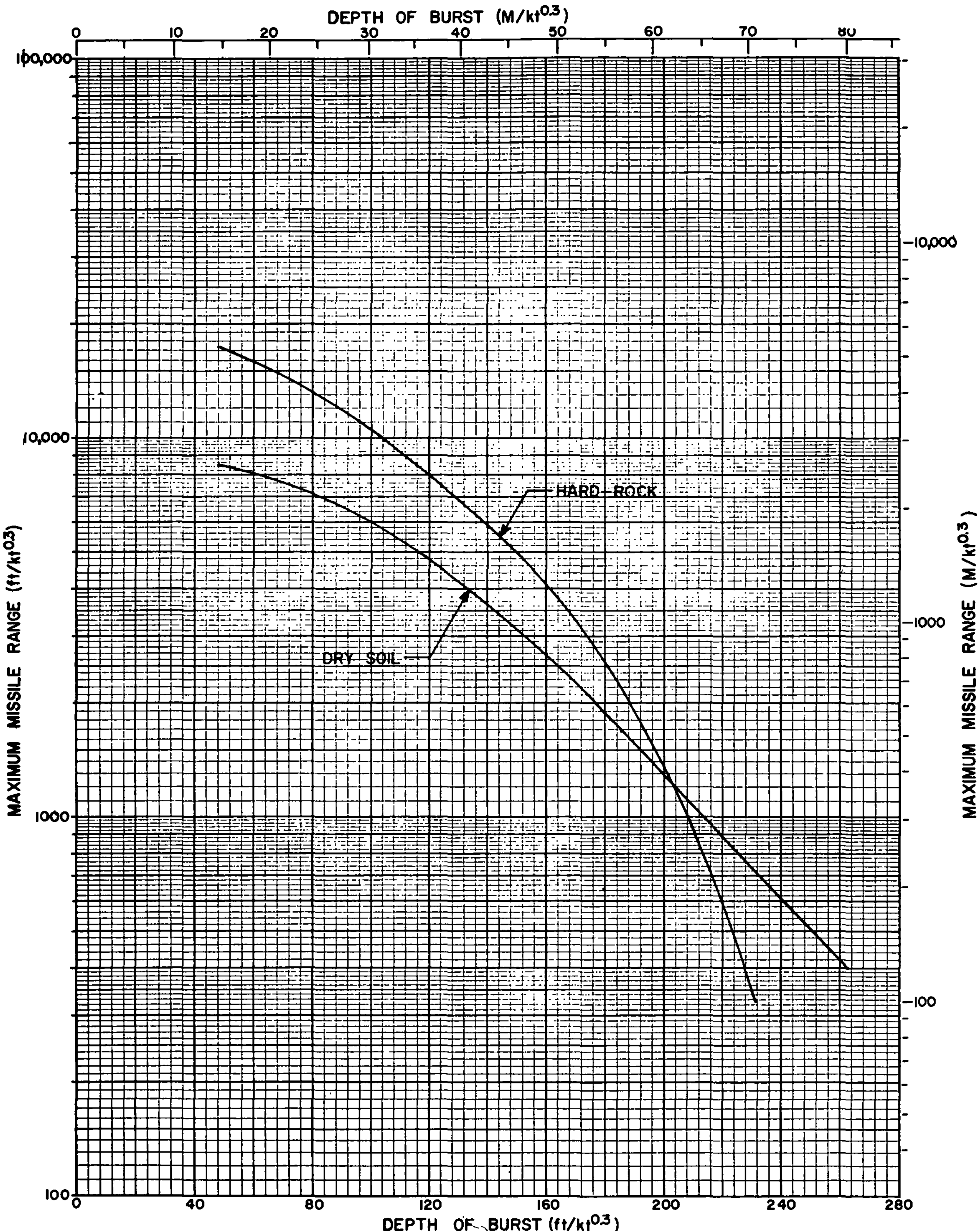


Figure 7-4. Maximum missile ranges for subsurface bursts in dry soil and hard rock, normalized to 1 kiloton.

term *missiles* refers to boulders, rock fragments, or masses of solid earth that travel along ballistic paths from ejection to impact.

(3) The missile hazard is not considered a limiting effect for ADM employment. However, personnel within the area should be cautioned, and equipment which may be damaged should be moved or protected.

b. Missile Sizes and Weights.

(1) Missiles vary in weight from less than a pound to several tons. In general, at the more distant ranges, the largest and smallest sizes are not usually found. At the intermediate ranges all sizes appear to be present except the largest missiles which weigh several tons and are rarely found beyond the edge of the lip.

(2) The Armed Services Safety Board has indicated that a 1-pound missile is capable of producing a fatal injury; data in this section are based on this criterion.

c. Missile Impact.

(1) The impact of a missile from a cratering detonation on a surface other than rock usually creates an elongated, shallow crater with a lip thrust up on the side away from the explosion. The missiles from a detonation in soil usually disintegrate upon impact.

(2) Upon impact, rock missiles either shatter —sending a shower of fragements over the surrounding area—or rebound. Because the larger rock missiles are tumbling in flight, the rebound pattern is usually erratic; one missile, therefore, is capable of causing multiple damage.

d. Missile Velocities. The estimated initial velocities of missiles resulting from nuclear cratering explosions in dry soil range between 400 and 1200 feet per second. The initial velocities of missiles from cratering detonations in hard noncarbonate rock range between 100 and 400 feet per second.

7–15. Maximum Missile Range

a. Figure 7–4 gives curves which can be used to estimate the maximum ranges of missiles from a cratering detonation. It should be noted that there is a wide variation in the distance to the outermost missile at various orientations around a crater. The curves in figure 7–4 represent an upper limit of missile ranges for the materials indicated.

b. It is recommended that the dry soil curve in figure 7–4 be used for nuclear detonations in all dry soils except those having a high percentage of boulders. The hard rock curve should be used for rock, for dry soils having a high percentage of rocks or boulders, and for wet soils. For nuclear detonations in a gas-forming rock such as limestone, the maximum missile ranges determined from the hard rock curve should be increased by 20 percent to account for the anticipated increase in range resulting from greater gas acceleration.

c. The following example illustrates the recommended procedure for estimating the maximum range of missiles from cratering detonations.

Given: A CHARLIE/0.1 ADM is to be detonated at a depth of burst of 60 feet in hard rock.

Find: The maximum missile range (D_m) for the detonation.

Solution:

$$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

$$\text{Substituting: } \frac{60}{DOB_2} = \frac{(0.1)^{0.3}}{(1)^{0.3}}$$

$$DOB_2 = \frac{60(1)^{0.3}}{(0.1)^{0.3}}$$

$$= \frac{60}{0.5}$$

$$= 120 \text{ ft for a 1 KT yield}$$

Using this DOB and the hard rock curve in figure 7–4, d_m (for 1 KT) = 8,000 ft.

$$\frac{d_m}{D_m} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

$$\text{Substituting: } \frac{8000}{D_m} = \frac{(1)^{0.3}}{(0.1)^{0.3}}$$

$$D = \frac{8000(0.1)^{0.3}}{(1)^{0.3}}$$

$$= \frac{8000(0.5)}{1}$$

$$= 400 \text{ ft}$$

Answer: D_m = 4,000 feet or 1,220 meters.

Section V. THERMAL RADIATION

7–16. General

In subsurface bursts, if the fireball does not penetrate through the ground surface, practically all the thermal radiation released by the detonation is used in the vaporization and melting of the medium surrounding the device. Even for shallow depths of burst in which the fireball penetrates the ground surface, the intensity of thermal radiation received at a given distance from the detonation is considerably less than for the surface burst.

7-17. Intensities From Subsurface Bursts

The variation of thermal radiation intensities with distance from the detonation has been documented for airbursts and surface bursts. No data are available, however, which can be used to quantitatively estimate the thermal radiation intensities at varying distances from subsurface bursts. Below scaled depths of approximately 15 $W^{0.3}$ feet (5 $W^{0.3}$ meters), the radius of the base surge cloud from a detonation is greater than the distances to which militarily significant levels of thermal radiation are transmitted. For the purpose of assessing the thermal radiation hazard from subsurface bursts, therefore, it is assumed that—

a. For scaled depths of bursts less than 15 $W^{0.3}$ feet, the thermal effects predicted for a surface burst may be used to estimate the intensities to be expected from a subsurface burst.

b. For scaled depths of bursts of 15 $W^{0.3}$ feet or deeper, there is no militarily signficant thermal radiation at distances beyond the area engulfed by the base surge cloud. For scaled depths of burst of 50 $W^{0.3}$ feet or deeper, the fireball is contained under ground and there are no thermal radiation effects to consider.

Section VI. GROUND SHOCK

7-18. General

Cratering with ADM results in the transmission of energy into the ground as well as into the air. Most of the energy transferred to the ground is in the vicinity of ground zero. A small percentage of the energy results in ground shock which is measurable at considerable distances from the point of detonation. This ground shock may be of sufficient magnitude to cause significant damage to structures in the vicinity of the detonation. Thus, ground shock could be the primary damage consideration when burial reduces other nuclear effects.

7-19. Factors Affecting Damage by Ground Shock

a. Geology. Transmission of shock waves between the shot point and structures of interest is dependent on the geology of the area. The shot point geology, the media upon which a structure stands, and the intervening geology have profound effects on the amount of ground shock experienced by a structure. For example, if an ADM is detonated in hard rock, the resulting shock experienced by two structures at equal distances from the shot point, one located on rock and the other on alluvium, can vary by a factor of ten, with the structure located on alluvium experiencing the greater shock. Most of the ground shock measurements which have been made during tests are for fully-contained underground nuclear explosions. Therefore, ground shock predictions are currently based on the data for fully-contained underground nuclear detonations.

b. Type and Location of Structures.

(1) *Underground structures.* Within the regions of the rupture and plastic zones of a crater, damage to underground structures due to ground shock will range from complete collapse to damage sufficient to seriously impair the operational capability of the structure. The plastic zone, therefore, can be established as the limit beyond which no militarily significant ground shock damage to underground structures will occur.

(2) *Surface structures.* Evaluation of ground shock damage to surface structures must include the vulnerability of structures ranging from those specifically designed to resist the force of ground shock, to normal residential-type buildings. The criteria for precluding ground shock damage to structures are based on residential-type buildings so the damage to stronger structures will also be precluded.

c. Damage Criteria. Two sets of criteria, acceleration and surface velocity, are normally used to evaluate ground shock damage. Based on high explosive tests, a ground acceleration of 0.3g will cause cracking and falling of plaster. An equivalent amount of damage occurs with a peak surface velocity of about 10 cm/sec. Of the two criteria, velocity appears to more closely correlate with damage from a nuclear detonation. Therefore, a peak surface velocity of 10 cm/sec is used as the criterion to evaluate the extent of light damage to surface structures due to ground shock from an underground nuclear detonation.

7–20. Prediction of Ground Shock

Table 7–3 represents the surface range from ground zero to a peak surface velocity of 25 cm/sec for the hypothetical ADM family in hard rock and alluvium cratering detonations. These ranges do not apply to the region in which the media has been subjected to fracturing or plastic deformation (plastic zone) as a result of a cratering detonation. In linear cratering from multiple charge row detonations, assume a single yield equal to the total yield to be detonated simultaneously, with the detonation occurring at the center of the row of charges.

7–21. Illustrative Example

Given: An ECHO/1 kiloton ADM is to be detonated at optimum depth in rock.

Find: The distance at which residential-type structures will be subjected to light damage (peak surface velocity of 25 cm/sec).

Solution: Enter table 7–3 with 1KT and read over to the column for rock. Read a distance of 910 meters.

Answer: 910 meters.

Table 7–3 Ground Shock Range (meters) for Nuclear Detonations Range to peak surface ground shock velocity of 25 cm/sec

Model/Yield (kt)	Dry soil	Hard rock
ALFA/0.01	110	150
BRAVO/0.05	210	280
CHARLIE/0.10	280	370
Delta/0.5	520	700
Echo/1	680	910
Foxtrot/5	1270	1710
Golf/15	1940	2620

APPENDIX A

REFERENCES

A–1. Army Regulations (AR)

40–14	Control and Recording of Occupational Exposure Ionizing Radiation
40–27	Personnel Radiation Exposures
50–1	US Army Nuclear Weapons Surety Program
50–2	Nuclear Weapon Accident and Incident Control
50–3	Personnel Security Standards for Nuclear Weapon Duty Positions
55–203	Movement of Nuclear Weapons, Nuclear Components, and Related Classified Nonnuclear Material
55–228	Transportation by Water of Explosives and Hazardous Materials
75–15	Responsibilities and Procedures for Explosive Ordnance Disposal
95–55	Nuclear Weapon Jettison
190–60	Physical Security Standards for Nuclear Weapons
380–5	Safeguarding Defense Information
380–20	Restricted Areas
380–25	Visitors
380–55	Safeguarding Defense Information in Movement of Persons and Things
380–150	Access to and Dissemination of Restricted Data
385–25	Studies and Reviews, Nuclear Weapon Systems Operational Surety Program
385–30	Safety Color Code Markings and Signs
385–40	Accident Reporting and Records
385–65	Identification of Inert Ammunition and Ammunition Components
604–5	Clearance of Personnel for Access to Classified Defense Information and Materiel
611–15	Nuclear Duty Position Reliability Program

A–2. Field Manuals (FM)

3–12	Operational Aspects of Radiological Defense
3–15	Nuclear Accident Contamination Control
5–1	Engineer Troop Organizations and Operations
5–15	Field Fortifications
5–25	Explosives and Demolitions
5–30	Engineer Intelligence
5–36	Route Reconnaissance and Classification
5–135	Engineer Battalion, Armored, Infantry and Infantry (Mechanized) Divisions
9–6	Ammunition Service in the Theater of Operations
19–25	Military Police Traffic Control
19–30	Physical Security
20–32	Landmine Warfare
21–30	Military Symbols
21–40	Chemical, Biological, Radiological, and Nuclear Defense
24–18	Field Radio Techniques
24–20	Field Wire and Field Cable Techniques

30-10	Terrain Intelligence
31-10	Denial Operations and Barriers
(C)32-5	Signal Security (SIGSEC) (U)
101-31-1	Staff Officers' Field Manual; Nuclear Weapons Employment
(S)101-31-2	Staff Officers' Field Manual; Nuclear Weapons Employment (U)
101-31-3	Staff Officers' Field Manual; Nuclear Weapons Employment

A-3. Technical Manuals (TM)

3-210	Fallout Prediction
3-220	Chemical, Biological, and Radiological (CBR) Decontamination
5-545	Geology
8-215	Nuclear Handbook for Medical Service Personnel
(C)9-1100-205-12	Operator and Organizational Maintenance Manual: XM129E1, XM129E2, XM159E1, and XM159E2 Atomic Demolition Charges; XM130E1 Training Atomic Demolition Charge (U).
9-1100-205-20P	Organizational Maintenance Repair Parts and Special Tools List (illustrated parts breakdown): XM129E1, XM129E2, XM159E1, and XM159E2 Atomic Demolition Charges; XM130E1 Training Atomic Demolition Charge
(C)9-1100-226-12	Operator and Organizational Maintenance (prefire procedures for employment): XM167, XM172, and XM175 Atomic Demolition Charges; XM3 and XM4 coder-transmitters (U)
(S)9-1100-226-20P	Organizational Maintenance Repair Parts and Special Tools List (illustrated parts breakdown): XM167, XM172, and XM175 Atomic Demolition Charges; XM3 and XM4 coder-transmitters (U)
(S)39-0-1	Numerical Index to Joint Atomic Weapons Publications (including related publications) (U)
(C)39-0-1A	Numerical Index to Joint Atomic Weapons Publications (including related publications) (Army Supplement)) (U)
55-602	Movement of Special Freight
(C)55-1100-205-12 Series	Air Transportability Procedures: Atomic Demolition Charge XM129E1, XM129E2, XM159E1, and XM159E2 in Army Aircraft (U)
55-1100-226-12 Series	Air Transportability Procedures: Atomic Demolition Charge XM167, XM172, and XM175 and Remote Command Equipment in Army Aircraft

A-4. Other Publications

(C) DASA EM-1	Capabilities of Nuclear Weapons (U)
DA Pam 39-3	The Effects of Nuclear Weapons
ASubjScd 5-18	Atomic Demolition Munitions
TB 9-1100-807-15	Loading, Tiedown and Unloading of Nuclear Weapon Shipping and Storage Containers on Tactical Vehicles
TB 9-2300-280-30	Installation of Universal Tie-down Anchors
TB IG-5	Inspector General Technical Proficiency Inspection
DA Form 2203-R	Demolition Reconnaissance Record
DA Form 2706	Assignment Certificate
DA Form 3064-R	Request for Atomic Demolition Munition Support
DA Form 3065-R	Atomic Demolition Munition Firing Order
DA Form 3066-R	ADM Reconnaissance Record
DA Form 3179	Nuclear Duty Position Evaluation Request
DA Form 3180	Nuclear Duty Position Screening Evaluation
DA Form 3181	Nuclear Duty Position Medical Notification
TOE 5-146	HHC, Engr Bn, Armd and Mech Inf Division
TOE 5-156	HHC, Engr Bn, Inf Division
TOE 5-570	Engr Combat Support Teams

APPENDIX B

HYPOTHETICAL ADM EFFECTS TABLES

B-1. General

This appendix provides an unclassified reference for instruction in the employment of atomic demolition munitions. The data contained herein are based on unclassified sources; consequently, the limitations of this manual must be recognized. This appendix may be used in basic instruction in units and in service schools where utilization of classified reference material is not desirable.

B-2. Contents

The following tables are included in this appendix:

(1) Severe and moderate blast damage for surface bursts.

(2) Subsurface blast damage reduction distances.

(3) Crater dimensions for dry soil.

(4) Crater dimensions for wet rock.

(5) Crater dimensions for dry rock.

(6) Crater dimensions for wet rock.

(7) Fire areas for surface burst.

(8) Thermal criteria for fuel ignition.

(9) Tree blowdown for surface burst.

(10) Extent of blast overpressures for surface and subsurface bursts.

(11) Troop safety distances for surface burst.

(12) Light aircraft in flight safety radii for surface burst.

Table B-1. Severe/Moderate Blast Damage Radii for Surface Bursts (metesr)

Material classification		ALPHA 0.01	BRAVO 0.05	CHARLIE 0.10	DELTA 0.50	ECHO 1	FOX-TROT 5	GOLF 15
Wheeled military vehicles Railroad cars	Mod	70	95	110	185	230	550	825
Engr truck mounted equip	Sev	45	75	90	125	175	325	510
Tanks and artillery Railroad locomotives	Mod	45	65	80	115	160	300	475
Engr earthmoving equip	Sev	30	55	65	75	115	195	380
Communications equip	Sev	85	120	160	230	300	625	980
Supply dumps	Sev	20	30	35	60	80	155	275
Truss & float bridges	Mod	60	90	105	150	190	420	725
	Sev	40	60	75	105	175	340	525
Field fortifcations	Mod	35	55	70	85	125	210	320
Earth covered surface shelters	Sev	35	60	65	80	100	200	290
Monumental-type multistory wall-bearing bldgs.	Mod	150	210	250	350	575	840	1,475
Multistory, wall-bearing bldgs (apt house type)	Sev	100	165	200	275	400	680	1,100
Multistory, reinforced bldgs (small windown area) Multistory, steel frame office bldgs.	Mod	65	100	130	200	350	450	950
Blast resistant reinforced concrete bldgs. Light steel frame industrial bldgs.	Sev	50	65	85	125	160	245	700
Oil storage tanks	Mod	225	285	365	505	640	1,150	1,890
Parked combat aircraft	Sev	150	205	255	340	450	800	1,680
Wood frame bldgs.	Mod	210	295	335	500	800	1,205	1,860
	Sev	140	195	250	350	690	930	1,310

Table B-2. Blast Damage Reduction Distances, Subsurface Burst (meters)

DOB (meters)	ALPHA 0.01	BRAVO 0.05	CHARLIE 0.10	DELTA 0.50	ECHO 1	FOXTROT 5	GOLF 15
1	2	4	6	8	10	18	40
2	5	8	10	12	15	23	51
3	10	19	22	25	30	54	88
4	17	22	23	30	40	79	128
5	27	35	40	48	60	115	180
6	35	42	50	61	80	155	255
7			60	80	100	190	338
8				105	130	220	433
9				145	165	275	535
10					205	335	628
15						410	735
25							830

Note. To determine the blast damage radii to various material targets for subsurface detonations, the distances given in this table must be subtracted from the blast damage radii associated with surface bursts as shown in table B-1. Should the result be a negative number, consider that the damage radius is zero.

Table B-3. Crater Dimensions for Dry Soil

Model/Yield (kt)	Approximate crater dimensions (meters)								
	Surface			$15W^{0.3}$ meters (shallow)			$40W^{0.3}$ meters (optimum)		
	DOB	Diameter	Depth	DOB	Diameter	Depth	DOB	Diameter	Depth
ALPHA/0.01	0	10	2.6	3.7	21.5	6	12	24	7
BRAVO/0.05	0	16	4.4	6	35	9	21	39	11
CHARLIE/0.10	0	20	5.5	7.5	43	11.5	24.5	48	14
DELTA/0.50	0	35	8.6	12	70	19	40	78	22
ECHO/1.0	0	44	12	15	86	23	49	96	27
FOXTROT/5.0	0	75	20.5	24	139	37	80	156	44
GOLF/15.0	0	109	30	33.7	194	52	110	216	61

Table B-4. Crater Dimensions for Wet Soil

Model/Yield (kt)	Approximate crater dimensions (meters)								
	Surface			$15W^{0.3}$ meters (shallow)			$40W^{0.3}$ meters (optimum)		
	DOB	Diameter	Depth	DOB	Diameter	Depth	DOB	Diameter	Depth
ALPHA/0.01	0	13	2.6	3.7	25.5	6.5	10	31.5	8
BRAVO/0.05	0	22	4.4	6	42	10.6	16.4	51.6	13.5
CHARLIE/0.10	0	27.6	5.5	7.5	51	13	20	63	16.5
DELTA/0.50	0	47.4	8.6	12	82.6	21	32.4	102	26.7
ECHO/1.0	0	60	12	15	102	26	40	126	33
FOXTROT/5.0	0	103	20.5	24	165	42	65	204	53
GOLF/15.0	0	148	30	33.7	230	58.5	90	284	74

Table B–5. Crater Dimensions for Dry Rock

Model/Yield (kt)	Approximate crater dimensions (meters)								
	Surface			$15W^{0.3}$ meters (shallow)			$40W^{0.3}$ meters (optimum)		
	DOB	Diameter	Depth	DOB	Diameter	Depth	DOB	Diameter	Depth
ALPHA/0.01	0	9	1.7	3.7	19	5	3.5	23	6.7
BRAVO/0.05	0	15.5	3	6	31	3.4	14	37.7	11
CHARLIE/0.10	0	19.3	3.6	7.5	33	10	17	46	13.5
DELTA/0.50	0	33	6.3	12	61.5	16.6	27.5	74.5	21.3
ECHO/1.0	0	42	8	15	76	20.5	34	92	27
FOXTROT/5.0	0	72	13.6	24	123	33	55	149	43.7
GOLF/15.0	0	104	19.7	33.7	171	46	76.5	207	60.7

Table B–6. Crater Dimensions for Wet Rock

Model/Yield (kt)	Approximate crater dimensions (meters)								
	Surface			$15W^{0.3}$ meters (shallow)			$40W^{0.3}$ meters (optimum)		
	DOB	Diameter	Depth	DOB	Diameter	Depth	DOB	Diameter	Depth
ALPHA/0.01	0	5	2.2	3.7	21.7	7	10.7	26	7.7
BRAVO/0.05	0	3.5	3.7	6	35.6	11.3	17.6	42.6	12.7
CHARLIE/0.10	0	10.5	4.6	7.5	43.5	14.5	21.5	52	15.5
DELTA/0.50	0	13	7.9	12	70.4	23.5	34.3	84	25
ECHO/1.0	0	23	10	15	87	29	43	104	31
FOXTROT/5.0	0	39	17	24	141	47	69.6	163.4	50
GOLF/15.0	0	56.3	24.7	33.7	195	65	96.7	234	69.7

*Table B–7. Fire Areas for Surface Burst**

Model/Yield (kt)	Expected radii for ignition of wildland fuels during fire season-meters							
	Dry climate (25 percent relative humidity)				Damp climate (75 percent relative humidity)			
	Class I	Class II	Class III	Class IV	Class I	Class II	Class III	Class IV
ALPHA/0.01	225	200	200	175	225	200	200	175
BRAVO/0.05	300	300	275	250	300	300	275	250
CHARLIE/0.10	375	375	325	350	375	375	325	350
DELTA/0.5	500	500	400	400	500	500	400	400
ECHO/1	700	600	500	500	600	600	500	400
FOXTROT/5	1,200	1,100	1,000	300	1,100	1,100	900	700
GOLF/15	1,300	1,600	1,500	1,400	1,600	1,600	1,500	1,300

* For description of fuel classes, see table B–8

Table B-8. Thermal Criteria for Fuel Ignition

Forest fuels		Ignition energy (CAL/CM)			
		Relative humidity 25 percent		Relative humidity 75 percent	
Class	Description	1 kt	15 kt	1 kt	15 kt
I	Broadleaf and coniferous litter mixture of fine grass, broken leaves and duff, and thin translucent broad leaf leaves.	2	3	3	4
II	Hardwood and soft wood punk in various stages of decay	3	4	3	4
III	Cured or dead grass	4	5	4	5
IV	Conifer needles and thick nearly opaque broadleaf leaves	5	7	8	11

*Table B-9. Tree Blowdown for Surface Burst**
(All distances in meters)

Model/Yield (kt)	Obstacles to movement							Casualties to exposed personel		
	Foot and wheeled vehicle movement				Tracked vehicle movement					
	Type I	Type II	Type III	Type IV	Type I	Types II, IVd(b)	Types III, IVf(a)	Type I	Types II, IVd(b)	Types, III, IVf(a)
ALPHA/0.01	50	75	75	200	50	75	75	50	75	75
BRAVO/0.5	100	125	125	250	100	125	125	100	125	125
CHARLIE/0.10	125	135	135	275	125	135	135	125	135	135
DELTA/0.5	150	200	200	350	150	200	200	150	200	200
ECHO/1	200	300	300	500	200	300	300	200	300	300
FOXTROT/5	400	600	600	1,000	400	600	600	400	600	600
GOLF/15	900	1,200	1,350	1,800	900	1,200	1,350	900	1,200	1,350

* These radii apply to contact surface bursts.

General description of forest stand types and criteria are—

(1) Type I. Improved natural or planted conifer (evergreen) forests with uniform tree spacing height and diameter: occurs in Western Europe.

(2) Type II. Naturally occurring unimproved conifer forests that have developed under unfavorable growing conditions with random tree spacing, height, and diameter: occurs in Western Europe and Southeast Asia.

(3) Type III. Unimproved conifer forests that have developed under favorable growing conditions, characterized by random tree spacing and diameter, uneven crown canopy and irregular clearings; occurs in Western Europe and Southeast Asia.

(4) Type IV. Deciduous forests. Deciduous trees are trees that shed their leaves annually. The radius of tree blowdown depends on whether the trees have their leaves or have shed them. For this reason type IV forests are further subdivided as follows:

(a) Type IVf. Deciduous forest that is foliated (in leaf).

(b) Type IVd. Deciduous forest that is defoliated (leaves have been shed).

Table B-10. Extent of Blast Overpressures for Surface Burst

Model/Yield (kt)	Radii (meters)			
	1 psi	4 psi	8 psi	10 psi
ALPHA/0.01	290	115	75	65
BRAVO/0.05	490	190	125	110
CHARLIE/0.10	610	240	155	140
DELTA/0.5	1,050	410	270	240
ECHO/1	1,325	520	340	300
FOXTROT/5	2,275	890	580	510
GOLF/15	3,320	1,290	850	720

Table B–11. Troop Safety Distances (meters)

Model/Yield (KT)	DOB (m)	Minimum distance for troop vulnerability and degree of risk shown								
		Unwarned exposed			Warnad exposed			Warned protected		
		Neg	Mod	Emer	Neg	Mod	Emer	Neg	Mod	Emer
ALFA/.01	0	650*	550*	380*	650*	550*	380*	600*	510*	350*
	2	460*	450	450	460*	450	450	450	450	450
	4	600	600	600	600	600	600	600	600	600
	8	410	410	410	410	410	410	410	410	410
	12	290	290	290	290	290	290	290	290	290
BRAVO/.05	0	900*	770*	520*	900*	770*	520*	740*	630*	430*
	3	550*	480	480	550*	480	480	480	480	480
	6	1000	1000	1000	1000	1000	1000	1000	1000	1000
	12	800	800	800	800	800	800	800	800	800
	21	500	500	500	500	500	500	500	500	500
CHARLIE/.1	0	1000*	850*	580*	1000*	850*	580*	820*	700*	480*
	3	570*	490*	480	570*	490*	480	480	480	480
	7	1200	1200	1200	1200	1200	1200	1200	1200	1200
	16	870	870	870	870	870	870	870	870	870
	24	590	590	590	590	590	590	590	590	590
DELTA/.5	0	1200*	1020*	700*	1200*	1020*	700*	1050	890	610
	5	750*	740	740	750*	740	740	740	740	740
	12	2000	2000	2000	2000	2000	2000	2000	2000	2000
	25	1500	1500	1500	1500	1500	1500	1500	1500	1500
	40	950	950	950	950	950	950	950	950	950
ECHO/1.0	0	1200*	1020*	700*	1200*	1020*	700*	1150*	980*	670*
	5	800*	680*	660	800*	680*	660	660	660	660
	15	2500	2500	2500	2500	2500	2500	2500	2500	2500
	30	1850	1850	1850	1850	1850	1850	1850	1850	1850
	49	1150	1150	1150	1150	1150	1150	1150	1150	1150
FOXTROT/5	0	2600	2000	1200	1400*	1200*	850	1300*	1110*	750*
	10	1500	1500	1500	1500	1500	1500	1500	1500	1500
	24	4000	4000	4000	4000	4000	4000	4000	4000	4000
	50	2900	2900	2900	2900	2900	2900	2900	2900	2900
	79	1850	1850	1850	1850	1850	1850	1850	1850	1850
GOLF/15	0	3600	3200	1900	1780*	1700*	1200	1720*	1450*	1000*
	18	4200	4200	4200	4200	4200	4200	4200	4200	4200
	36	5800	5800	5800	5800	5800	5800	5800	5800	5800
	72	4100	4100	4100	4100	4100	4100	4100	4100	4100
	108	2900	2900	2900	2900	2900	2900	2900	2900	2900

Notes. 1. For initial effects and base surge only. A fallout prediction must be made.
2. For distances marked with an asterisk nuclear radiation is the governing safety effect based on an RS–0 unit. For RS–1 and RS–2 units the risk level increases one and two levels, respectively; i.e., a negligible risk for an RS–0 unit is equivalent to a moderate risk for an RS–1 unit and an emergency risk for an RS–2 unit.

Table B–12. Light Aircraft in Flight for Surface Burst[1]

Model/Yield (kt)	Aircraft safety radii—meters[2]		
	Light fixed wing	Recon and obsn hel	Transport and util hel
ALPHA/0.01	1400	1500	1400
BRAVO/0.05	2000	2000	1900
CHARLIE/0.10	2600	2600	2500
DELTA/0.5	4000	4000	4000
ECHO/1	5000	5000	5000
FOXTROT/5	9000	9000	7000
GOLF/15	12,000	12,000	11,000

[1] These radii apply to contact surface bursts. See FM 101–31–1.
[2] A buffer distance has been added to these radii of safety.

APPENDIX C

BLAST AND GROUND SHOCK DAMAGE CRITERIA

Table C–1. Damage to Types of Structures Primarily Affected by Blast-wave Overpressure During the Diffraction Phase

Description of structure	Description of damage		
	Severe	Moderate	Light
Multistory blast-resistant reinforced-concrete building with reinforced-concrete walls, designed for 30-psi Mach-region pressure from 1 mt, no windows.	Walls shattered, severe frame distortion, incipient collapse.	Walls breached or on the point of being so, frame distorted, entranceways damaged, doors blown in or jammed, extensive spalling of concrete.	Some cracking of concrete walls and frame.
Multistory reinforced-concrete building with concrete walls, small window area, three to eight stories.	Walls shattered, severe frame distortion, incipient collapse.	Exterior walls badly cracked, interior partitions badly cracked or blown down, structural frame permanently distorted, extensive spalling of concrete.	Windows and doors blown in, interior partitions cracked.
Multistory wall-bearing building, brick-apartment-house type, up to three stories.	Bearing walls collapse, resulting in total collapse of structure.	Exterior walls badly cracked, interior partitions badly cracked or blown down.	Windows and doors blown in, interior partitions cracked.
Multistory wall-bearing building, monumental-type, up to four story.	Bearing walls collapse, resulting in collapse of structure supported by these walls; some bearing walls may be shielded enough by intervening walls so that part of the structure may receive only moderate damage.	Exterior walls facing blast badly cracked, interior partitions badly cracked, although toward far end of building damaged may be reduced.	Windows and doors blown in, interior partition cracked.
Wood frame building, house-type, one or two stories.	Frame shattered so that for the most part collapsed.	Wall framing cracked, roof badly damaged, interior partitions blown down.	Windows and doors blown in, interior partitions cracked.

Table C–2. Damage to Types of Structures Primarily Affected by Dynamic Pressure During the Drag Phase

Description of structure	Description of damage		
	Severe	Moderate	Light
Light-steel-frame industrial building, single-story, with up to 5-ton crane capacity; low-strength walls fail quickly.	Severe distortion collapse of frame.	Some to major distortion of frame; cranes if any not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Heavy-steel-frame industrial building, single-story, with 25- to 50-ton crane capacity; light-weight low-strength walls fall quickly.	Some distortion to collapse of frame.	Some distortion to frame; cranes not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Heavy-steel-frame industrial building, single-story, with 60- to 100-ton crane capacity; lightweight low-strength walls fall quickly.	Severe distortion collapse of frame.	Some distortion to frame; cranes not operable until repairs made.	Windows and doors blown in, light siding ripped off.

Table C-2. Damage to Types of Structures Primarily Affected by Dynamic Pressure During the Drag Phase (cont.)

Description of structure	Description of damage		
	Severe	Moderate	Light
Multistory steel-frame office-type building, three-to ten-story; lightweight low-strength walls fall quickly; earthquake-resistant construction.	Severe frame distortion; incipient collapse.	Frame distorted moderately; interior partitions blown down.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory steel-frame office-type building, three- to ten-story; lightweight low-strength walls fall quickly; non-earthquake-resistant construction.	Severe frame distortion; incipient collapse.	Frame distorted moderately; interior partitions blown down.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory reinforced-concrete-frame office-type building, three-to ten-story; lightweight low-strength walls fail quickly; earthquake-resistant construction.	Severe frame distortion; incipient collapse	Frame distorted moderately; interior partitions blown down; some spalling of concrete.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory reinforced concrete-frame office-type building, three-to ten-story; light weight low-strength walls fall quickly; non-earthquake-resistant construction.	Severe frame distortion; incipient collapsed.	Frame distorted moderately; interior partitions blown down; some spalling of concrete.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Highway truss bridges, spans 150 to 250 ft.	Total failure of lateral bracing; collapse.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some components.
Railroad truss bridges, spans 150 to 250 ft.	Total failure of lateral bracing; collapse.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some components.
Highway and railroad truss bridges, spans 250 to 500 ft.	Total failure of lateral bracing; collapse.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some components.
Floating bridges, U. S. Army standard M3 and M-4, random orientation.	All anchirages torn loose, connections between treadways or balk and floats twisted and torn loose, many floats sunk.	Many bridle lines broken, bridge shifted on abutments, some connections between treadways or balk and floats torn loose.	Some bridle lines broken, bridge capacity unimpaired.

Table C-3. Damage Criteria for Special Underground Structures

Structure	Damage	Damage distance*	Remarks
Relatively small, heavy, well-designed underground targets.	Severe Light	$1\frac{1}{4}R_A$ $2R_A$	Collapse. Of little or no importance structurally.
Relatively long, flexible targets, such as buried pipelines, tanks.	Severe Moderate Light	$1\frac{1}{2}R_A$ $2R_A$ $2\frac{1}{2}$ to $3R_A$	Deformation and rupture. Slight deformation and rupture. Of little or no importance structurally.

* R_A is the apparent crater radius.

Table C–4. Damage Criteria for Field Fortifications

Description of structure	Description of damage		
	Severe	Moderate	Light
Command post and personnel shelter, modular sections 6′ X 8′ with top 3′ to 5′ below ground surface, earth covered, and covered trench entrance.*	Caps and posts broken, large displacement and disarrangement of timbers, revetment failure.	Some caps and posts broken, moderate displacement, some revetment failure.	Damage to minor components, only slight displacement, occasional revetment failure.
Machine-gun emplacement, 7′ X 7′, framework extends 2′ above original ground suface, has open firing ports and open trench entrance; 3′ to 5′ mound of earth covers framework and extends down to the ground surface except at openings.*	Caps and posts broken, large displacement and disarrangement of timbers, revetment failure.	Some caps and posts broken, moderate displacement, some revetment failure.	Damage to minor components, only slight displacement, occasional revetment failure.
Unrevetted trenches and foxholes with or without light cover.	The trench or foxhole is at least 50 percent filled with earth.	The trench or foxhole is at least 10 percent but less than 50 percent filled with earth.	The trench or foxhole is less than 10 percent filled with earth.

* Post, cap, and stringer construction, timber approximately 6″ x 8″, or 12″ in diameter.

APPENDIX D

RECOMMENDED FORMS AND FORMATS

D-1. General

a. This appendix contains a typical target folder and the following ADM forms and formats:

(1) Atomic Demolition Plan (in target folder).

(2) Orders to the Demolition Guard Commander and Demolition Firing Party Commander (STANAG 2017) (in target folder).

(3) Atomic Demolition Munition Firing Order (DA Form 3065-R) (in target folder).

(4) Request for Atomic Demolition Munitions Support (DA Form 3064-R).

(5) ADM Annex for an Engineer Unit SOP.

(6) ADM Reconnaissance Record (DA Form 3066-R).

b. The use of the above forms and formats is discussed in chapters 3 and 4. When completed, the security classification of each form is noted in accordance with AR 380-5.

c. DA Forms 3064-R, 3065-R and 3066-R will be reproduced locally on 8- X 10½-inch paper and may be printed on as many pages as necessary.

D-2. Typical Target Folder

TARGET FOLDER

21 ST INF DIV

TARGET: CAMP ROEDER (I-XXX-4)

LOCATION: SALZBURG

COORDINATES: UN49309660

Figure D-1. Target folder.

(Classification)

Copy Nr 3 of 5 Copies
1st CORPS
SALZBURG, UN480935
241030 Oct____________
055-31

Appendix 5 (Atomic Demolition Plan) to Annex D (Barrier) to OPORD 3
Reference: Map, Salzburg, Sheet 63, AUSTRIA 1:50,000

1. SITUATION
   a. Enemy Forces: Annex B (Intel) to OPORD 3
   b. Friendly Forces: OPORD 3
   c. Atomic Demolition Capabilities:
      (1) Executing commander designate emplacing units.
      (2) ADM allocations: 2 ea ECHO/1KT
          3 ea DELTA/0.3KT
          2 ea CHARLIE/0.1KT
2. MISSION
   Corps emplaces ADM for barrier and denial to deny, impede, and canalize en movement.
3. EXECUTION
   a. Concept of Operation:
      (1) 21st INF DIV will employ ADM against Camp Roeder to deny its use to en (80% of the target area is to receive severe damage) when movement out of Salzburg becomes necessary. Destroy Salzburg Airport with minimum fallout. ADM emplaced under center of runway.
      (2) 54th MECH DIV will ***.

*   *   *   *   *   *   *

   b. Target Tabulation: See TAB-1.
   c. Coordinating instructions:
      (1) All unwarned, exposed friendly troops to receive no more than a negligible risk.
      (2) Executing commander responsible for warning friendly units and civilians in target area IAW STANAG 2104.
      (3) Coordinate with 201st ACR.
4. ADMINISTRATION AND LOGISTICS
   a. ADMINO 21
   b. ADM WB delivered to UN 50109530 on order of 1st CORPS. Emplacement positions WB prepared prior to delivery of ADM.
5. COMMAND AND SIGNAL
   a. Annex G (Signal) to OPORD 3.
   b. Executing commanders responsible for selection of command site(s) and providing security.
   c. Demolition reporting WB IAW STANAG 2017.
   d. Special Communications requirements:

(Classification)

Figure D-1a. Target folder contents. Atomic demolition plan.

(Classification)

(1) Changing from State 1 (SAFE) to State 2 (ARMED): BATMAN
(2) Changing from State 2 (ARMED) to State 1 (SAFE): ROBIN
(3) Emergency firing order: PENGUIN
(4) Special authentication order: PHANTOM
Acknowledge.

BLACK
LTG

Tabs: 1 - Target Tabulation
2 - Special map, SALZBURG 1:1250
3 - Sketch of Emplacement positions (omitted)
4 - Photographs (omitted)

DISTRIBUTION: A

OFFICIAL:

BUTCHER
G3

(Classification)

Figure D-1a—Continued.

Target Tabulation

Target	Code Word	Priority	Completion Date State 1 (SAFE)	Location		Munition	Remarks
				Area Name	Grid Coord		
1. 21st INF DIV 1-XXX-4 (Camp Roeder)	Smart	1	2608000Z Oct	Salzburg	UN49309660	ECHO/1KT	Prepare for demo. Final arming on order of CG, 1st CORPS. Fire ADM on order of CG, 1st CORPS (Code word JOKER). Surface emplacement, min of 1.5 m sandbags around ADM. Wire w/ timer backup. Authority to change or cancel mission from CG, 1st CORPS. Authority to safe munition from executing commander.
1-XXX-6 (Salzburg Airport)	Scrooge	1	260800Z Oct	Salzburg	UN50559525	DELTA/0.3KT	Prepare for demo. Final arming on order of CG, 1st CORPS. Fire ADM on order of CG, 1st CORPS (Code word KINGPIN). Emplacement is preplanned, 34 m shaft located at midpoint of runway. Wire w/ timer backup. Authority to change or cancel mission from CG, 1st CORPS. Authority to safe munition from executing commander.
2. 54th MECH DIV							

* * * * * * *

Figure D-1a—Continued.

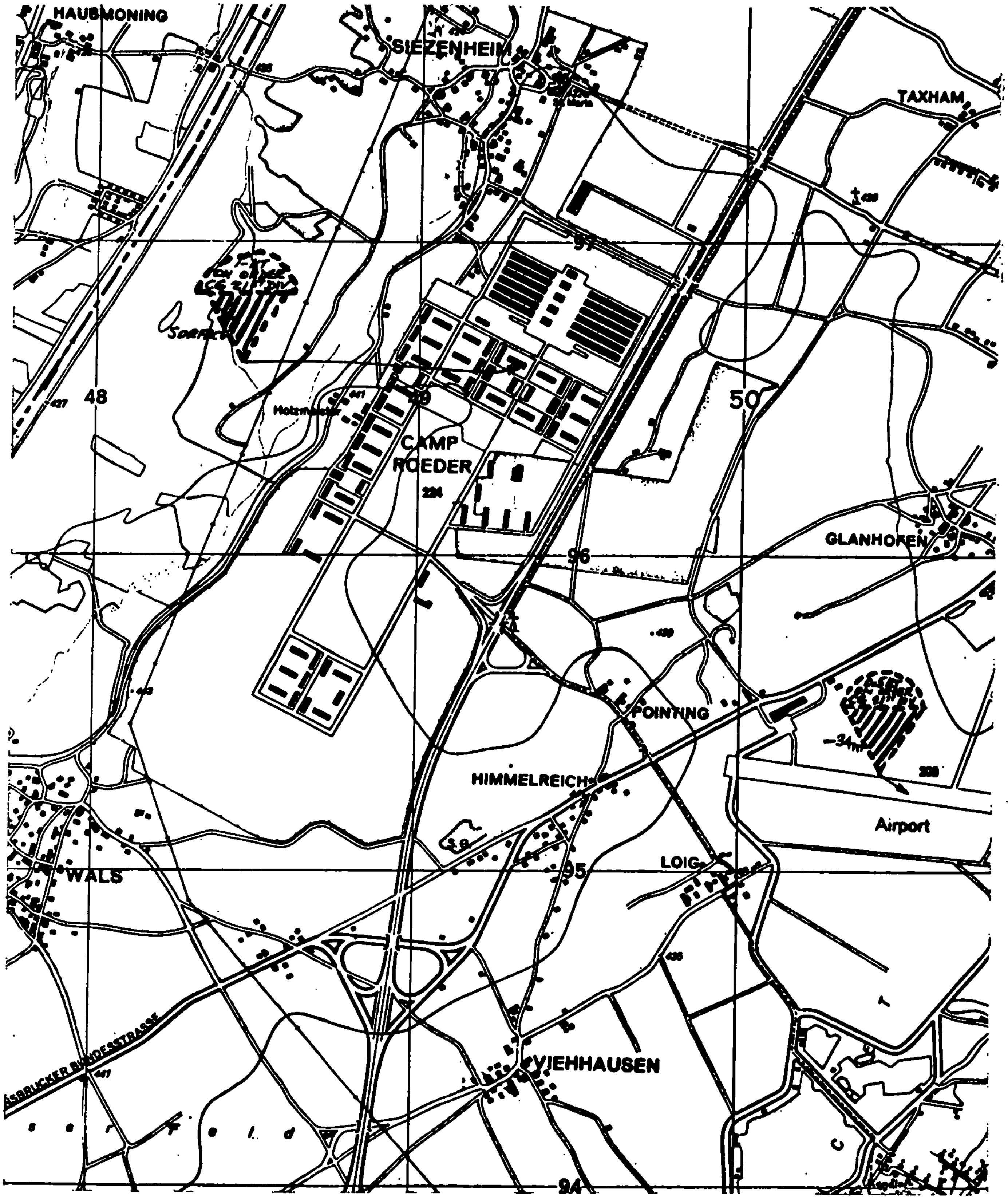


Figure D–1a—Continued.

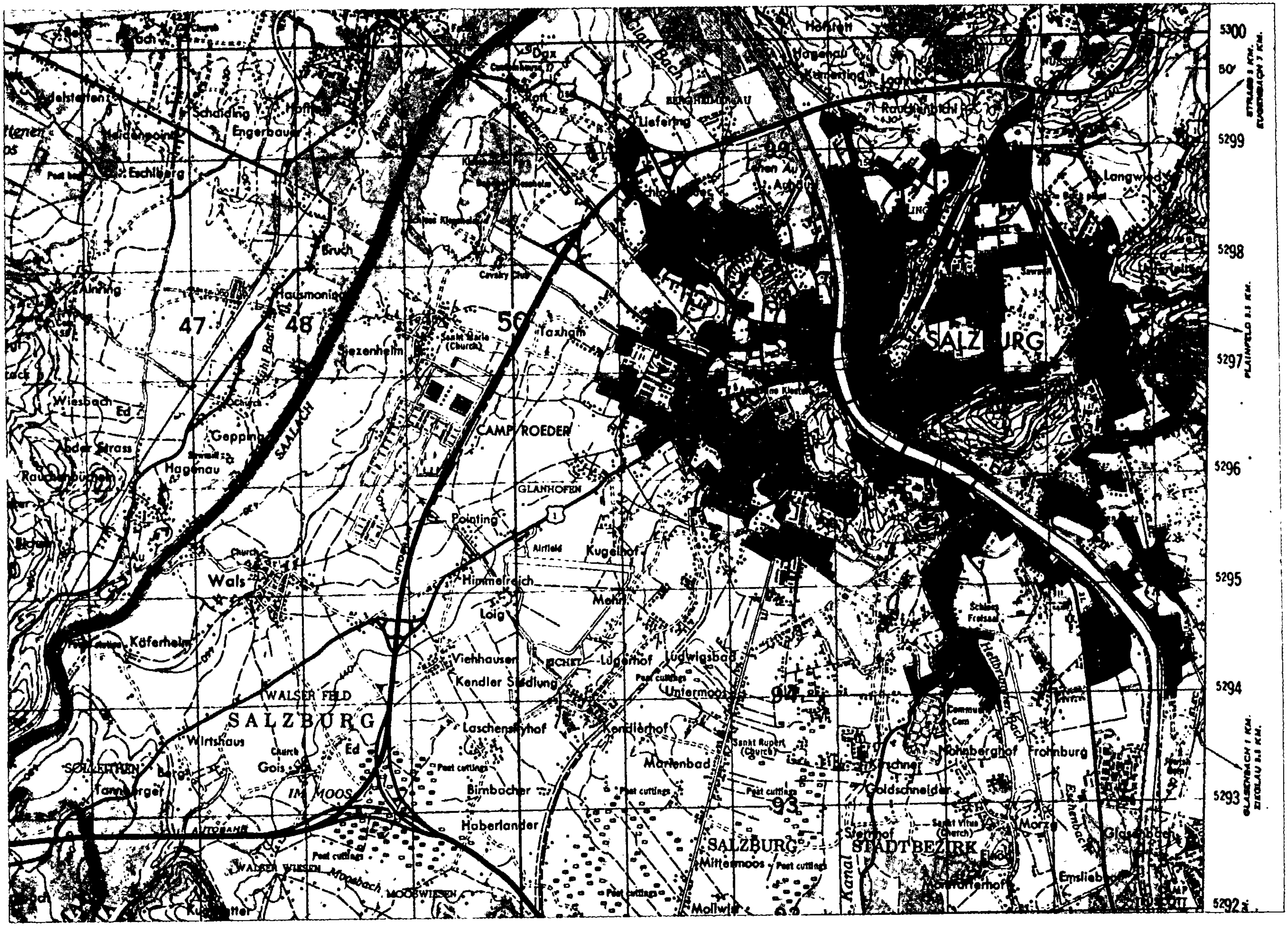


Figure D–1b. Target folder contents.
Map, Salzburg, 1:50,000.

Serial No. *1051* **Security Classification**

ORDERS TO THE DEMOLITION GUARD COMMANDER

Notes: 1 This form will be completed and signed before it is handed to the Commander of the Demolition Guard.
2. In completing the form, all spaces must either be filled in or lined out.
3. The officer empowered to order the firing of the demolition is referred to throughout as the "Authorized Commander."

From *21st INF DIV* To *2 BN 68 INF*

PART I—PRELIMINARY INSTRUCTIONS

1. *a.* Description of target *CAMP ROEDER - AUSTRIAN ARMY CAMP*
   b. Location :
   Map Name and Scale *SALZBURG 1:50000* Sheet No. *63*
   Grid Reference *UN49309660*
   c. Code word ~~or code sign (if any)~~ of demolition target *SMART*
2. The Authorized Commander is *CG 1st CORPS* (given appointment only). If this officer should delegate his authority you will be notified by one of the methods shown in paragraph 4, below.
3. The DEMOLITION FIRING PARTY COMMANDER ~~has been~~/will be provided by *112 ENGR BN (CBT)*
4. All messages, including any code words ~~or code signs (if any)~~ used in these orders, will be passed to you by :
   ~~*a.* normal command wireless net, or~~
   b. special liaison officer with communications direct to the Authorized Commander, ~~or~~
   ~~*c.* telephone by the Authorized Commander, or~~
   ~~*d.* the Authorized Commander personally, or~~
   ~~*e.*~~ ______

(Delete those NOT applicable)

Note: All orders sent by message will be prefixed by the code word ~~or code sign (if any)~~ at paragraph 1c and all such messages must be acknowledged.

PART II—CHANGING STATES OF READINESS

5. The demolition will be prepared initially to the State of Readiness *SAFE* by *0800Z* hours, on *26 OCT* (date).
6. On arrival at the demolition site, you will ascertain from the Commander of the Demolition Firing Party the estimated time required to change from State "1" (SAFE) to State "2" (ARMED). You will ensure that this information is passed to the Authorized Commander and is acknowledged.
7. Changes in the State of Readiness from State "1" (SAFE) to State "2" (ARMED) or from State "2" to State "1" will be made only when so ordered by the Authorized Commander. However, the demolition may be ARMED in order to accomplish emergency firing when you are authorized to fire it on your own initiative.

(Classification)

Figure D–1c. Target folder contents. Orders to the demolition guard commander and demolition firing party commander.

(Classification)

8. A record of the changes in the State of Readiness will be entered by you in the table below, and on the firing orders in possession of the commander of the demolition firing party.

State of Readiness ordered "1" (SAFE) or "2" (ARMED)	Time and date change to be completed	Authority	Time and date of receipt of order

Note: If the order is transmitted by an officer in person, his signature and designation will be obtained in the column headed "Authority."

9. You will report completion of all changes in the State of Readiness to the Authorized Commander by the quickest means.

PART III—ORDERS FOR FIRING THE DEMOLITION

10. The order for firing the demolition will be passed to you by the Authorized Commander.

11. On receipt of this order you will immediately pass it to the Commander of the Demolition Firing Party on his demolition orders form ("Orders to the Demoltion Firing Party Commander").

12. After the demolition has been fired you will report the results immediately to the Authorized Commander.

13. In the event of a misfire or only partially successful demolition you will give the firing party protection until such time as it has completed the demolition and report again after it has been completed.

PART IV—EMERGENCY FIRING ORDERS

Notes: 1. One sub-paragraph of paragraph 14 must be deleted.
2. The order given herein can only be altered by the issue of a new form, or, in emergency by the appropriate order (or code word if used) in Part V.

14. *a.* You will order the firing of the demolition only upon the order of the Authorized Commander, ~~or~~

~~*b.* If the enemy is in the act of capturing the target you will order the firing of the demolition on your own initiative.~~

PART V—CODE WORDS (IF USED)

	Action to be Taken	Code Word
a.	Change State of Readiness from "1" to "2" (see paragraph 7)	BATMAN
b.	Change State of Readiness from "2" to "1" (see paragraph 7)	ROBIN
c.	Fire the demolition (see paragraph 10)	JOKER
d.	Paragraph 14.*a.* is now cancelled. You are now authorized to fire the demolition if the enemy is in the act of capturing it.	PENGUIN
~~e.~~	~~Paragraph 14.*b.* is now cancelled. You will order the firing of the demolition only upon the order of the Authorized Commander.~~	
f.	Special authentication instructions, if any.	PHANTOM

(Classification)

Figure D–1c—Continued.

(Classification)

PART VI

Signature of officer issuing these orders *Paul M. Cownzoksi*

Name (printed in capital letters) PAUL M. COWNZOKSI

Rank MG Appointment

Time of issue 1700Z hours, 25 OCT (date).

PART VII—DUTIES OF THE COMMANDERS OF THE DEMOLITION GUARD

15. You are responsible for :—

a. Command of the demolition guard and the demolition firing party.

b. The safety of the demolition from enemy attack or sabotage.

c. Control of traffic and refugees.

d. Giving the orders to the demolition firing party in writing to change the state of readiness.

e. Giving the orders to the demolition firing party in writing to fire the demolition.

f. After the demolition, reporting on its effectiveness to the Authorized Commander.

g. Keeping the Authorized Commander informed of the operational situation at the demolition site..

16. You will acquaint yourself with the orders issued to the Commander of the Demolition Firing Party and with the instructions given by him.

17. The Demolition Guard will be so disposed as to ensure at all time complete all-round protection of the demolition against all types of attack or threat.

18. The commander of the Demolition Firing Party is in technical control of the demolition. You will agree with him the site of your HQ and of the firing point. These should be together whenever practicable. When siting them you must give weight to the technical requirements of being able to view the demolition and have good access to it from the firing point.

19. You will nominate your deputy forthwith and compile a seniority roster. You will ensure that each man knows his place in the roster, understands his duties and knows where to find this form if you become a casualty or are unavoidably absent. The seniority roster must be made known to the Commander of the Demolition Firing Party.

20. Once the State of Readiness "2 ARMED" has been ordered, either you or your deputy must always be at your HQ so that orders can be passed on immediately to the Commander of the Demolition Firing Party.

(Classification)

Figure D-1o—Continued.

ANNEX "B" (D of A) of STANAG 2017
(Edition No. 2)

Serial No. 1051 Security Classification............

ORDERS TO THE DEMOLITION FIRING PARTY COMMANDER

NOTES:—Parts I, II and III will be completed and signed before this card is handed to the Demolition Firing Party Commander. Paras. 4 and 5 can only be altered by the authority issuing these orders. In such cases a new form will be issued and the old one destroyed.

From CG 21 INF DIV To CO 112 ENGR BN

Part I—Orders for preparing and charging the demolition target

1. a. Description CAMP ROEDER- AUSTRIAN ARMY CAMP - 1800 x 800 m WOOD FRAME CONSTRUCTION
   b. Location:—
   Map Name and Scale SALZBURG 1:50000
   Sheet No. 63 Grid Reference UN49309660
   c. Code word of Demolition Target (if any) SMART
   d. Attached photographs and special technical instructions SEE INCLOSURE (omitted)
   ....
   ....

2. The DEMOLITION GUARD is being provided by (Unit) 68 INF BN

3. You will prepare and charge the demolition target to the STATE OF READINESS SAFE by 0800Z hours on 26 OCT (date). Any changes may only be made on the order of the issuing authority, or by the officer designated in para. 4.d. and will be recorded below.

State of Readiness Ordered "1 (Safe)" or "2 (Armed)"	Time and date change to be completed	Authority	Time and date of receipt of order

NOTE:—All orders received by message will be verified by the code word at para. 1.c. If the order is transmitted by an officer in person, his signature and designation will be obtained in the column headed "Authority".

NATO—UNCLASSIFIED

Security Classification............

Part II—Orders For Firing

NOTE:—The officer issuing these orders will strike out the sub-paras. of paras. 4 and 5 which are not applicable. When there is a Demolition Guard, sub-para. 4.d. will always be used, and para. 5 will always be struck out.

~~4. a. You will fire the demolition as soon as you have prepared it.~~

~~4. b. You will fire the demolition at .... hours on .... (date).~~

~~4. c. You will fire the demolition on receipt of the code word.~~

4. d. You will fire the demolition when the officer whose designation is CO, A/2-68 INF .... has signed para. 8 below.

Emergency Firing Orders (ONLY applicable when there is NO Demolition Guard).

~~5. YOU WILL NOT FIRE the demolition in any circumstances except as ordered in para. 4 above.~~

~~YOU WILL FIRE the demolition on your own initiative if the enemy is in the act of capturing it.~~

Part III—Orders for Reporting

6. After firing the demolition you will immediately report results to the officer who ordered you to fire. In the event of a partial failure, you will warn him, and immediately carry out the work necessary to complete the demolition.

7. Finally you will immediately report the results to your Unit Commanding Officer (see para. 13).
   Signature of Officer issuing these orders Paul M Cowneoksi
   Name (in capitals) PAUL M. COWNEOKSI
   Designation CG 21st INF DIV
   Time of issue 1700 Z hours
   Date of issue 25 OCT

Part IV—Order to Fire

8. Being empowered to do so I order you to fire NOW the demolition described in para. 1.
   Signature............
   Name (in capitals)............
   Designation CO, A/2-68 INF
   Time............
   Date............

NATO—UNCLASSIFIED

READ THESE INSTRUCTIONS CAREFULLY

Part V—General Instructions

9. You are in technical charge of the preparation, charging and firing of the demolition target described. You will nominate your deputy forthwith, and compile a seniority roster of your party. You will ensure that each man knows his place in the roster, understands these instructions, and knows where to find this form if you are hit or unavoidably absent. You will consult with the Demolition Guard Commander on the siting of the firing point.

10. You must understand that the DEMOLITION GUARD Commander (where there is one) is responsible for:—
    a. Operational command of ALL troops at the demolition site. (You are therefore under his command).
    b. Preventing the capture of the demolition site, or interference by the enemy with demolition preparations.
    c. Controlling all traffic and refugees.
    d. Giving you the order to change the STATE OF READINESS from ("1 SAFE)" to "2 (ARMED)" or back to "1 (SAFE)" again. You will inform him of the time required for such a change.
    e. Passing to you the actual order to fire.

11. When there is no demolition guard and you are instructed in para. 4 to accept the order to fire from some particular officer, it is important that you are able to identify him.

12. If you get orders to fire other than those laid down in para. 4 you should refer them to the Demolition Guard Commander or if there is no Demolition Guard Commander, to your immediate superior. If you cannot do this, you will ONLY depart from your written instructions when you are satisfied as to the identity and over-riding authority of whoever gives you these new orders, and you will get his signature in para. 8 whenever possible.

13. The report to your Unit Commanding Officer, as called for in para. 7 should contain the following information (where applicable):—
    a. Identification reference of demolition.
    b. Map reference.
    c. Time and date when demolition was fired.
    d. Extent of damage accomplished, including:—
       Estimated width of gap } In the case of a bridge.
       Number of spans down }
       Size and location of craters in a road or runway.
       Mines laid.
    e. Sketch showing effect of demolition.

Figure D-1c—Continued.

(Security Classification)

ATOMIC DEMOLITION MUNITION FIRING ORDER NO. 1-XXX-4

This order is for ADM employment only.

To (US) ADM Firing Party Commander

You will fire target identified below in accordance with the following instructions. The Mission Officer (par 3b, c) is the representative of the Executing Commander. He is in command of this ADM mission. You will accept any additional instructions or changes from him.

1. TARGET

a. Location (Coordinates)	b. Codeword or Target Number
SALZBURG UN49309660	SMART

c. Description
CAMP ROEDER - AUSTRIAN ARMY CAMP 1800x800m WOOD FRAME TYPE CONSTRUCTION

2. MUNITION DATA

a. Type and Yield ADM	b. Present location of munition
ECHO / 1 KT	DELIVERED TO UN50109530 ON ORDER OF I CORPS

3. CONTROL

a. Executing Commander	b. Mission Officer	c. Alternate
CG 21ST INF DIV	CO, A/2-68 INF	XO, A/2-68 INF

4. EMPLACEMENT DATA (Check one and fill in description)

	d. Description of precise position of ADM on target
a. [X] Surface emplacement	UN49309660. PLACE AT SOUTHEAST CORNER OF BLDG 412 (CORNER OF HIRSHFELD AND RUDER). MINIMUM OF 1.5 METERS SANDBAGGING AROUND ADM.
b. [ ] Emplacement above surface ________ meters	
c. [ ] Emplacement below surface ________ meters	

5. FIRING OPTIONS DESIRED

a. Primary	[ ] Timer	or	[X] Remote (Specify)	WIRE
b. 1st Alternate	[X] Timer	or	[ ] Remote (Specify)	
c. 2nd Alternate	[ ] Timer	or	[ ] Remote (Specify)	

6a. FIRING SITE	6b. ALTERNATE
COORD UN46209610	COORD UN45909790

7. DETONATION (Complete where necessary)

[ ] a. ASAP [X] b. On order [ ] c. Detonate at ________

d. If munition is emplaced on target you will detonate to prevent capture [ ] Yes [X] No

DA FORM 1 Oct 65 3065-R (Security Classification) Replaces edition of 1 Nov 65, which is obsolete.

Figure D–1d. Target folder contents. ADM firing order.

(Security Classification)

8. SECURITY REQUIREMENTS

a. Security force	b. Rendezvous point and time
A/2-68 INF	UN50109530 251400E OCT

9. OTHER INSTRUCTIONS

(NOTE: Include codewords for possible mission change orders, such as, orders to fire the ADM or abort the mission or to improve the readiness.)

a. SAFE TO ARMED: BATMAN
b. ARMED TO SAFE: ROBIN
c. FIRE THE ADM: JOKER
d. FIRING ADM IS NOW AUTHORIZED TO PREVENT CAPTURE: PENGUIN
e. WIRE CROSSINGS OF SAALACH RIVER TO BE MADE AT BRIDGES ONLY
f. PHYSICAL SECURITY OF SITE TO BE MAINTAINED UNTIL H-30min

10. AUTHENTICATION DTG:

By order of	Signature
BLACK, LTG	

11. RECEIPT ACKNOWLEDGED Signature of ADM Firing Party Commander

12. CHANGES

	Time ordered	Time completed	
a. Description of change			Signature of mission officer
b. Description of change			Signature of mission officer
c. Description of change			Signature of mission officer

13. EXECUTION

a. Mission executed at

b. Remarks

Signature of ADM Firing Party Commander	Signature of Mission Officer

MINIMUM DISTRIBUTION

1. Original to ADM Firing Party Commander
2. Copy to Mission Officer
3. Copy to Executing Commander

(Security Classification)

Figure D–1d—Continued.

REQUEST FOR ATOMIC DEMOLITION MUNITIONS SUPPORT (FM 5-26)		TARGET NUMBER
PART I - REQUEST FOR ATOMIC DEMOLITION MUNITIONS		TO (from)
EXPLANATION OF TERMS	LETTER DESIGNATION	TIME SENT (rec)
A. WARNING - The initial element of the message indicates that a request for ADM support follows. Code words differentiate between targets of opportunity and preplanned targets.	ALFA	A.
B. NATURE OF TARGET - The description of the target is as complete as possible for target analysis. If an area target, size designated by limiting coordinates or by a target radius in meters. Details of design and construction *(for structures)* or required crater dimensions are indicated for point targets. Target destruction is the usual desired damage for ADM attack. If neutralization is desired, so designate.	BRAVO	B.
C. DESIRED GROUND ZERO - Location is expressed in UMT coordinates to the nearest 10 meters.	CHARLIE	C.
D. POINT OF DETONATION OR DEPTH OF BURST - The desired depth is expressed as the number of meters below the surface or as a SURFACE burst.	DELTA	D.
E. YIELD - The desired yield is based on the nature of the target and is expressed in kilotons. Fractional yields are expressed as hundredths of a kiloton. For example: 0.01 would be expressed as ZERO POINT ZERO ONE.	ECHO	E.
F. TIME ON TARGET *(TOT)* - Time on target is based on the nature of the target and the scheme of maneuver. Time is expressed in local time as a seven digit date-time group or as on call; e.g. Ø1160ØZ.	FOXTROT	F.
G. FIRING OPTIONS - The desired method and alternate methods of detonation in descending priority are indicated.	GOLF	G.
H. TROOP SAFETY REQUIREMENTS - Troop safety is based on planned disposition of friendly troops at time of burst. Disposition may be expressed as a series of coordinates, a prearranged phase line, or a radius and distance from ground zero.	HOTEL	H.
I. TYPE OF ANALYSIS - If a target analysis has been performed by the requesting unit, the type of analysis performed is specified as visual, numerical, or special ADM.	INDIA	I.
J. SUPPORT REQUIRED - If the requesting unit does not possess an ADM capability, the number of ADM teams required are requested. If additional engineer emplacement personnel and equipment are needed, they are requested. If special transportation of the ADM to the emplacement site *(e.g., aerial delivery)* is desired, such means are requested.	JULIET	J.
K. REMARKS - Add any additional information required. For example, the desired time of burst may be expanded in this column to indicate the earliest or latest permissible times of burst.	KILO	K.

PART II - CONCURRENCES AND COORDINATION

1. RELEASING COMMANDER

☐ APPROVED ☐ DISAPPROVED ______ TIME ______ BY ______ INITIALS

DESIGNATION OF EXECUTING UNIT	AUTHORITY TO FIRE DELEGATED TO:

REMARKS *(Modifications to or reasons for disapproval of ADM request)*

2. STAFF CONCURRENCES

	TIME/INITIALS		TIME/INITIALS
G2		FSCC	
G3		ALO	
G4		CBRE	
Adj HQS		Engr *(fallout prediction)*	

DA FORM 3064-R, 1 Nov 65

D-3. Request for ADM Support (DA Form 3064-R)

Figure D-2. DA Form 3064-R.

3. NOTIFICATION HIGHER HEADQUARTERS		
TIME OF NOTIFICATION	REQUEST FORWARDED TO: *(For action - name of higher headquarters)*	
ACTION TAKEN	EMPLACEMENT AND SUPPORT UNITS	TO BE FIRED AT:
REMARKS		

4. SUBORDINATE AND SUPPORTING UNITS	
a. TIME EMPLACEMENT AND SUPPORTING UNITS NOTIFIED	
(1) DESIGNATION OF EXECUTING UNIT	*(2)* ADM AND YIELD
(3) TIME AND/OR METHOD OF FIRING	*(4)* RENDEZVOUS POINT WITH DEMOLITION GUARD *(coordinates)*
(5) RENDEZVOUS TIME	*(6)* SPECIAL EQUIPMENT REQUIREMENTS
(7) SECURITY REQUIREMENTS	*(8)* METHOD OF TRANSPORTATION
(9) REMARKS	
b. TIME REQUESTING UNIT NOTIFIED	*(1)* MISSION ☐ APPROVED ☐ DISAPPROVED
(2) DESIGNATION OF EXECUTING UNIT	*(3)* CONTROL AND FIRING DELEGATED TO
(4) SECURITY REQUIREMENTS	*(5)* RENDEZVOUS POINT WITH EMPLACEMENT ELEMENTS
(6) REMARKS	
c. WARNING *(time)*	

(1) ARMY AVN	*(2)* TAF	*(3)* TROOP UNITS

5. TACTICAL DAMAGE ASSESSMENT		
GROUND ZERO	DOB OR HOB	YIELD
REMARKS		

Figure D-2—Continued.

D–4. Suggested ADM Unit SOP Format*

(Classification)

XXth Engineer Bn
Fort Belvoir, Virginia
(date)

ANNEX E—Atomic Demolition Munitions (ADM)

1. APPLICATION

This SOP supersedes all previous SOP and applies except as modified by battalion orders. Subordinate unit SOP will conform. Attached units will comply with this SOP.

2. REFERENCES

(List SOP, directives and/or policies of higher headquarters on which this SOP is based.)

3. ADMINISTRATION

a. Responsibilities.
(1) For preparation and periodic review of the SOP.
(2) For requisitioning and posting of changes to all pertinent publications.

b. Records and Reports.
(1) (List required reports to higher headquarters.)
(2) (List required test and maintenance records as specified by pertinent manuals.)
(3) Instructions on Tactical Damage Evaluation Reports.

4. PUBLICATIONS

a. Requisitioning Procedure.

b. Reference Material—Appendix 1.

c. Unsatisfactory Reports.
(1) Preparation and study of proposals.
(2) Submission and review procedures.
(3) Ammunition Condition Report (DA Form 2415) and Equipment Improvement Report.
(4) Recommended changes to DA publications (DA Form 2028).

5. SUPPLY

a. Authority (TOE, TA, TD, EMR, etc.)

b. Equipment Lists (Refer to the appropriate parts list).

c. Requisition procedures (including local requirements).

d. Property accountability (including local requirements).

6. SAFETY

a. General.
(1) A statement allowing no deviation from the approved checklist.
(2) Applicable safety requirements deemed necessary. (Preventive maintenance, driver training, preoperational vehicle checks, etc.)

b. Electrical Safety requirements.

c. Explosive Safety requirements.

d. Nuclear Safety requirements.

e. Disposal of contaminated material

7. TRAINING

ADM training should be conducted in the following areas:

a. Prefire Procedures.

b. Command Site Preparation.

c. Formal Instruction.
(1) Classroom presentation.
(2) Manual study.
(3) Review of SOP and demolition fire orders (DFO).

d. Support Training.
(1) Convoy procedure.
(2) Emplacement site preparation.
(3) Team organization.
(4) Site security.

8. SECURITY

a. Statement of Policy.

(Classification)

* Applicable portions are also pertinent for engineer units below battalion.

(Classification)

(1) Importance.
(2) Possible consequence of violations.
(3) Responsibilities.

b. Document Control.

c. Classified Item Control.

d. Classified Study Procedures.

e. Clearances—Appendix 2.

f. Access List—Appendix 3.

9. TRANSPORTATION

a. Convoy Composition (list 3 or 4 different types: do not attempt to standardize beyond minimum requirements). List these as type I, type II, etc., so that the assemblyman, when instructed as to convoy type for a particular operation, may refer to the ADM SOP.

b. Air Movement Plans. (List details of ADM movement by aircraft to include security and handling requirements.)

(1) Courier Officer (OIC—may also be convoy commander).

(2) Convoy Commander.

(3) Guard Force.

d. Control.

(1) Convoy coordination.

(2) Coordination with tactical security forces.

(3) Procedures in case of unavoidable delay or mechanical breakdown. (Other than an accident or incident.)

10. ORGANIZATION FOR ADM MISSIONS

Note. This paragraph outlines a suggested organization of the ADM firing party for conduct of an ADM mission. Missions in support of allied forces will require modifications.

a. *Team Leaders*. (Indicated by position rather than name) Example: CO, XO, Plt Ldr, Plt Sgt, Sqd Ldr, etc.

b. *Composition and Duties*.

(1) Prefire Team (for composition see table 1).

(*a*) Pickup of ADM equipment—Appendix 4.

(*b*) Transportation procedures.

(*c*) Prefire procedures—Appendix 5.

(*d*) Remote command fire procedures—Appendix 6.

(*e*) Basic immediate security of munition.

(*f*) Emergency disarm procedures—Appendix 7.

(2) Support Team (size dependent on type of mission).

(*a*) Pickup and transportation procedures (mines, camouflage, tentage, etc.).

(*b*) Preparation of the emplacement site (construction, installation of mines; wire; boobytraps; etc.).

(*c*) Preparation of command site(s).

(3) Security Team (size dependent on terrain, tactical situation, etc.).

(*a*) Provide convoy guards during the transportation phase.

(*b*) Establish emplacement site security prior to the arrival of the munition.

(*c*) Provide security at the completed emplacement site until prearranged departure time.

(*d*) Provide security detail at the command site until after detonation.

11. ACCIDENT AND INCIDENT PLAN

This paragraph will cover such contingencies as accidents, incidents, or delays to include explosions, radiological contamination, misfire malfunction, and damage.

a. *General*. It is recommended that a set of code words be prepared, if not already accomplished by higher headquarters, to allow understanding of the situation over an unclassified means of communication.

b. *Accident*.

(1) Definition. (The definition of an accident may be found in AR 385-40.)

(2) Immediate Action. (List local and higher headquarters requirements in full detail when possible.)

(3) Notification. (Person to be notified by name or duty, location, communication channel.)

(4) Continuing Action. (Protective measures, security, control, procedures for requesting EOD teams.)

(5) Follow Up and Reports.

c. *Incident*.

(Classification)

(1) Definition. (The definition of an incident may be found in AR 385-40.)

(2) Immediate Action. (List local and higher headquarters requirements in full detail when possible.)

(3) Notification. (Person to be notified by name or duty, location, communication channel.)

(4) Continuing Action. (Protective measures, security, control, procedures for requesting EOD teams.)

(5) Follow Up and Reports.

12. EMERGENCY DISPOSAL AND DESTRUCTION

a. Priorities of Denial.

b. Authority for Emergency Disposal and Destruction. (List chain of command having the authority to order disposal or destruction.)

c. Methods of Disposal.

d. Methods of Destruction.

e. List of Materials Needed.

APPENDIXES:

Appendix 1—List all FM, TM, TC, Ordnance Special Weapons Technical Instruction, etc., necessary for ADM Firing Party Personnel to scan, read, or study, and the frequency of revision.

Appendix 2—List all cleared personnel within the battalion indicating their proper clearance.

Appendix 3—Include the Permanent Access List and the procedures for escorting visitors into the emplacement site.

Appendix 4—Include here a checklist of pickup requirements. (Signature cards, SASP access requirements, documents, forms and records, ramps, lifting devices, tie down equipment, etc.).

Appendix 5—Include here a prefire checklist for each munition.

Appendix 6—Include here a checklist for remote command site (Location, foxholes, security, firing procedures, change of mission procedure, etc.).

Appendix 7—Include here a checklist for the emergency disarm of all munitions for which there is a checklist in appendix 5.

D-5. Reconnaissance Record (DA Form 3066-R).

ADM RECONNAISSANCE RECORD (FM 5-26)	FILE NUMBER	DATE/TIME

SECTION I - HEADING

	NAME AND POSITION	GRADE	ORGANIZATION
RCN ORDERED BY			
RCN CONDUCTED BY			

SECTION II - ADM TARGET REPORT NUMBER ______________

A. WARNING (Code Word)	ALFA	
B. NATURE OF TARGET (include critical dimensions and desired damage)	BRAVO	
C. GROUND ZERO (UMT grid coordinates)	CHARLIE	
D. DOB OR POINT OF DETONATION	DELTA	
E. GOVERNING NUCLEAR EFFECT	ECHO	
F. TIME OF DETONATION	FOXTROT	
G. METHODS OF FIRING	GOLF	
H. LOCATION OF FRIENDLY TROOPS	HOTEL	
I. ENGINEER SUPPORT REQUIRED	INDIA	
J. SPECIAL EQUIPMENT REQUIRED	JULIET	
K. ADDITIONAL REMARKS	KILO	

NOTE: Target sketches are shown on reverse side.

DA FORM 3066-R, 1 Nov 65

Figure D-3. DA Form 3066-R.

APPENDIX E

CONVERSION TABLES AND FUNCTIONS OF NUMBERS

Table E-1. Meters to feet; feet to meters

(1 meter = 3.2808 Feet; 1 Foot = 0.3048 Meter)

Meters	Feet or Meters	Feet	Meters	Feet or Meters	Feet
0.3048	1	3.2808	15.5449	51	167.3224
0.6096	2	6.5617	15.8497	52	170.6033
0.9144	3	9.8425	16.1545	53	173.8841
1.2192	4	13.1233	16.4593	54	177.1649
1.5240	5	16.4042	16.7641	55	180.4458
1.8288	6	19.6850	17.0689	56	183.7266
2.1336	7	22.9658	17.3737	57	187.0074
2.4384	8	26.2467	17.6785	58	190.2883
2.7432	9	29.5275	17.9833	59	193.5691
3.0480	10	32.8083	18.2881	60	196.8500
3.3528	11	36.0891	18.5929	61	200.1308
3.6576	12	39.3700	18.8977	62	203.4117
3.9624	13	42.6508	19.2025	63	206.6925
4.2672	14	45.9316	19.5073	64	209.9733
4.5720	15	49.2125	19.8121	65	213.2542
4.8768	16	52.4933	20.1169	66	216.5350
5.1816	17	55.7741	20.4217	67	219.8158
5.4864	18	59.0550	20.7265	68	223.0967
5.7912	19	62.3358	21.0313	69	226.3775
6.0960	20	65.6167	21.3361	70	229.6583
6.4008	21	68.8975	21.6409	71	232.9391
6.7056	22	72.1784	21.9457	72	236.2200
7.0104	23	75.4592	22.2505	73	239.5008
7.3152	24	78.7400	22.5553	74	242.7816
7.6200	25	82.0209	22.8601	75	246.0625
7.9248	26	85.3017	23.1649	76	249.3433
8.2296	27	88.5825	23.4697	77	252.6241
8.5344	28	91.8634	23.7745	78	255.9050
8.8392	29	95.1442	24.0793	79	259.1858
9.1440	30	98.4250	24.3841	80	262.4667
9.4488	31	101.7058	24.6889	81	265.7475
9.7536	32	104.9867	24.9937	82	269.0284
10.0584	33	108.2675	25.2985	83	272.3092
10.3632	34	111.5483	25.6033	84	275.5900
10.6680	35	114.8292	25.9081	85	278.8709
10.9728	36	118.1100	26.2129	86	282.1517
11.2776	37	121.3908	26.5177	87	285.4325
11.5824	38	124.6717	26.8225	88	288.7134
11.8872	39	127.9525	27.1273	89	291.9942
12.1920	40	131.2338	27.4321	90	295.2750
12.4968	41	134.5141	27.7369	91	298.5558
12.8016	42	137.7950	28.0417	92	301.8367
13.1064	43	141.0758	28.3465	93	305.1175
13.4112	44	144.3566	28.6513	94	308.3983
13.7160	45	147.6375	28.9561	95	311.6792
14.0208	46	150.9183	29.2609	96	314.9600
14.3256	47	154.1991	29.5657	97	318.2409
14.6304	48	157.4800	29.8705	98	321.5217
14.9352	49	160.7608	30.1753	99	324.8025
15.2400	50	164.0416	30.4801	100	328.0833

Table E–2. Conversion Factors (Linear Measure)

Meters*	Inches	Feet	Yards	Miles		Kilometers	Fathoms
				Statute	Natutical**		
1.0	39.37	3.28083	1.09361	0.0006214	0.0005396	0.001	0.546
.0254	1.0	.0833	.0278	.00001578	.00001371	.0000254	.0139
.3048	12.0	1.0	.3333	.0001894	.0001645	.0003048	.167
.9144	36.0	3.0	1.0	.0005682	.0004934	.0009144	.500
5.0292	198.0	16.5	5.5	.003125	.002714	.005029	2.76
20.1168	792.0	66.0	22.0	.0125	.01085	.02012	11.0
1,609.35	63,360.0	5,280.0	1,760.0	1.0	.8684	1.6094	879.0
1,853.25	72,962.5	6,080.2	2,026.73	1.15155	1.0	1.85325	1,010.0
1,000.0	39,370.0	3,280.83	1,093.61	.6214	.5396	1.0	546.0
219.5	8,640.0	720.0	240.0	.1364	.1184	.2195	120.0
1.829	72.0	6.0	2.0	.00114	.00098	.00183	1.0

* meter = 10 decimeters = 100 centimeters = 1,000 millimeters.

** A nautical mile is the length on the earth's surface of an arc subtended by one minute of angle at the center of the earth.

Table E–3. 1/3 and 0.3 Power of Various Numbers

Number	(No.) 1/3	(No.) 0.3	Number	(No.) 1/3	(No.) 0.3
.01	.22	.25	60	3.91	3.42
.02	.27	.31	65	4.02	3.50
.03	.31	.35	70	4.12	3.58
.04	.34	.38	75	4.22	3.66
.05	.37	.41	80	4.31	3.73
.06	.39	.43	85	4.40	3.80
.07	.41	.45	90	4.48	3.86
.08	.43	.47	95	4.56	3.92
.09	.45	.49	100	4.64	3.98
.10	.46	.50	150	5.31	4.50
.20	.59	.62	200	5.85	4.91
.30	.67	.70	250	6.30	5.24
.40	.74	.76	300	6.69	5.54
.50	.79	.81	350	7.05	5.80
.60	.84	.86	400	7.31	6.04
.70	.89	.90	450	7.66	6.28
.80	.93	.94	500	7.94	6.47
.90	.97	.97	550	8.19	6.63
1	1.00	1.00	600	8.43	6.82
2	1.26	1.23	650	8.66	7.00
3	1.44	1.39	700	8.88	7.13
4	1.59	1.52	750	9.09	7.29
5	1.71	1.62	800	9.28	7.41
6	1.82	1.71	850	9.47	7.58
7	1.91	1.79	900	9.66	7.70
8	2.00	1.87	950	9.83	7.80
9	2.08	1.93	1000	10.00	7.94
10	2.15	1.99	1100	10.30	8.18
11	2.22	2.05	1200	10.60	8.40
12	2.29	2.11	1300	10.90	8.60
13	2.35	2.16	1400	11.20	8.80
14	2.41	2.21	1500	11.40	8.98
15	2.47	2.25	1600	11.61	9.12
16	2.52	2.30	1700	11.90	9.33
17	2.57	2.34	1800	12.10	9.50
18	2.62	2.38	1900	12.40	9.62
19	2.67	2.42	2000	12.60	9.77
20	2.71	2.46	3000	14.40	11.10
25	2.92	2.63	4000	15.90	12.02
30	3.11	2.77	5000	17.10	12.90
35	3.27	2.91	6000	18.20	13.60
40	3.42	3.02	7000	18.10	14.25
45	3.56	3.14	8000	20.00	14.85
50	3.68	3.24	9000	20.60	15.30
55	3.80	3.32	10000	21.50	15.80

APPENDIX F

ADM YIELD DETERMINATION PROCEDURES FOR TARGETS DAMAGED PRINCIPALLY BY BLAST

F-1. General

ADM yield determination procedures for targets damaged principally by blast involve both the visual and numerical methods of damage estimation. Although the procedures are similar to those developed for use with other nuclear weapons, the "no delivery error" characteristic of ADM simplifies the steps involved. The ultimate objective of each method is to establish the required radius of damage. This R_D is then compared with those recorded in the damage tables (app B), and the minimum ADM yield with an R_D equal to or greater than the R_D required is selected.

F-2. Point Targets (Numerical Method)

a. General. Single buildings, bridges, and similar structures are termed point targets. Associated with the engagement of a point target is the probability (P) of damaging the target to a desired degree. For example, an 85 percent probability ($P = 85\%$) of severe damage to the target means the target has 85 out of 100 chances of receiving severe damage and 15 out of 100 chances of receiving less than severe damage.

b. Yield Determination Procedure.

(1) Enter the point target graph extension, figure F-1, with the desired probability of damage (P), expressed as a percentage.

(2) Intersect the diagonal line and establish the value of the d/RD ratio.

(3) Determine the displacement distance (d).

(4) Solve for the radius of damage required: $R_D = \text{d/value of ratio}$.

(5) From the damage tables, appendix B, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Illustrative Example.

Given: The commander desires a high assurance ($P = 90\%$) of causing moderate damage to oil storage tanks located 200 meters from ground zero.

Find: The minimum surface burst ADM yield to meet the commander's guidance.

Solution:

(1) Enter figure F-1 with $P = 90\%$.

(2) $d/R_D = .74$

(3) d = 200 meters.

(4) $R_D = \frac{d}{.74} = \frac{200}{.74} = 270$ meters

(5) From table B-1, appendix B, R_D for the BRAVO/.05 KT ADM is 285 meters.

Answer: BRAVO/.05 KT ADM

F-3. Area Targets (Visual Method)

a. General. The visual method of analysis consists of a visualization of the fraction of the target covered by the radius of damage using ground zero as the reference point. In order to facilitate this visualization, a transparent circular map scale inscribed with a series of concentric circles and arcs at 100m or 200m intervals is used.

b. Yield Determination Procedure.

(1) Draw a scaled representation of the target.

(2) With a circular map scale or a comparable substitute, and using ground zero as a reference point, estimate visually the radius of damage required to achieve the fractional coverage (*f*) desired.

(3) Select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Illustrative Example.

Given: An engineer equipment park measures 100 meters long and 30 meters wide. The commander desires at least moderate damage to 50 percent of the target area. The situation requires the ADM to be emplaced at the entrance to the equipment park which is situated midway along the short axis.

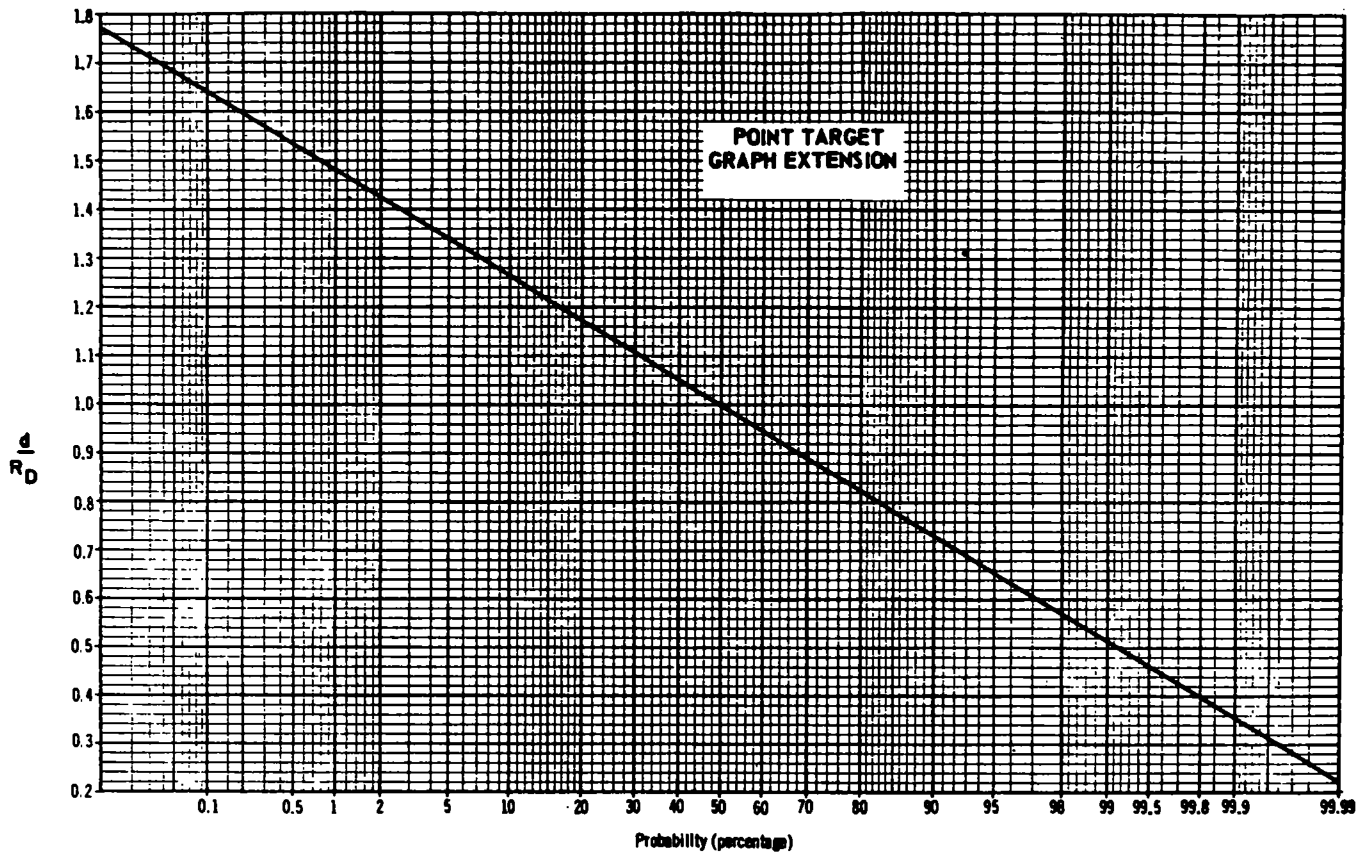


Figure F-1. Point target graph extension.

Find: The minimum ADM yield required to meet the commander's guidance.

Solution:

(1) The engineer equipment park is drawn to scale.

(2) With the circular map scale, the required R_D is found to be slightly greater than 50 meters for at least 50 percent coverage.

(3) From table B-1 the following R_D's for moderate damage are obtained.

	ALPHA *0.01kt*	*BRAVO* *0.05kt*
Engr Truck Mounted Equip	70m	95m
Engr Earthmoving Equip	45m	65m

The BRAVO/0.05 KT ADM is the minimum yield which meets the commander's requirements.

Answer: BRAVO/0.05 KT ADM

F-4. Area Targets (Numerical Method)

a. General. The numerical method of analysis may be used with either circular or approximately circular targets. Ground zero may be at or displaced some distance (*d*) from target center. The numerical method requires the use of the ADM fractional coverage nomograph, figure F-2, which has been devised to replace the graphics required by the visual method.

b. Yield Determination Procedure (GZ at Target Center).

(1) Determine the radius of target (R_T).

(2) Establish the R_D-R_T ratio required to achieve the fractional coverage (*f*) desired. This is read directly from the ADM fractional coverage nomograph (fig F-2) at the point where the fractional coverage curve of interest intercepts the R_D/R_T index.

(3) Calculate the radius of damage required; $R_D = R_T$ (value of ratio).

(4) From the appropriate damage table, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Yield Determination Procedure (Displaced GZ). Except for entering the fractional coverage nomograph with the d/R_T ratio, the procedure follows that outlined in *b* above.

d. Illustrative Example (GZ at Target Center).

Given: Moderate damage to 40 percent of the railroad cars located in a railway marshaling yard is desired. The diameter of the target is 260 meters.

Find: the minimum surface burst ADM yield required to meet the above requirements.

Solution:

(1) $R_T = 260/2 = 130$ meters.

(2) From figure F–2; For $f = .40$, $R_D/R_T = 0.62$.

(3) $R_D = 0.62(R_T) = 0.62(130) = 81$.

(4) From table B–1, R_D for the BRAVO/.05 KT ADM is 95 meters.

Answer: BRAVO/.05 KT ADM

e. Illustrative Example (Displaced GZ).

Given: In the above problem, limiting requirements have caused ground zero to be displaced 100 meters from target center.

Find: The minimum ADM yield required to meet the 40 percent coverage requirements as stated previously.

Solution:

(1) $R_T = 130$ meters, $d = 100$ meters.

(2) Enter figure F–2 with $d/R_T = 100/130 = 0.77$. For $f = 0.40$, $R_D/R_T = 0.83$.

(3) $R_D = 0.83(R_T) = 0.83(130) = 108$.

(4) From table B–1, a CHARLIE/.10 KT ADM has an R_D of 110 meters.

Answer: CHARLIE/.10 KT ADM

F–5. Preclusion of Damage

a. General. In many instances, the probability of not causing damage (Q) will be of interest to the target analyst. This is simply one minus the probability of damaging the target. Preclusion of damage problems involve the use of the point target extension graph (fig F–1) for both point and area targets. In the latter case, the point of the periphery which is nearest ground zero is taken as being representative of the area target. In most instances, the probability will be specified and the separation distance (d) required between ground zero and the target calculated.

b. Procedure.

(1) Figure F–1 indicates the probability of achieving a particular degree of damage; therefore, enter the graph with a value of P = 100% —Q.

(2) Intercept the diagonal line and establish the d/R_D ratio.

(3) Determine the radius of damage (R_D) from appendix B.

(4) Calculate the minimum separation distance (d_{min}) required.

c. Illustrative Example.

Given: A very high assurance (99%) of not causing moderate damage to a highway truss bridge in the vicinity of an ADM target is desired. The yield involved is a BRAVO/.05 KT ADM (surface burst).

Find: The separation distance (d) required to meet the above requirement. Assume that ground zero is located side-on to the bridge.

Solution:

(1) P = 100% − Q = 100% − 99% = 1.0%.

(2) Figure F–1; $d/R_D = 1.49$.

(3) Table B–1, appendix B; $R_D = 90$ meters.

(4) $d = R_D\,(1.49) = (90)\,(1.49) = 134.1$ meters.

Answer: 134 meters.

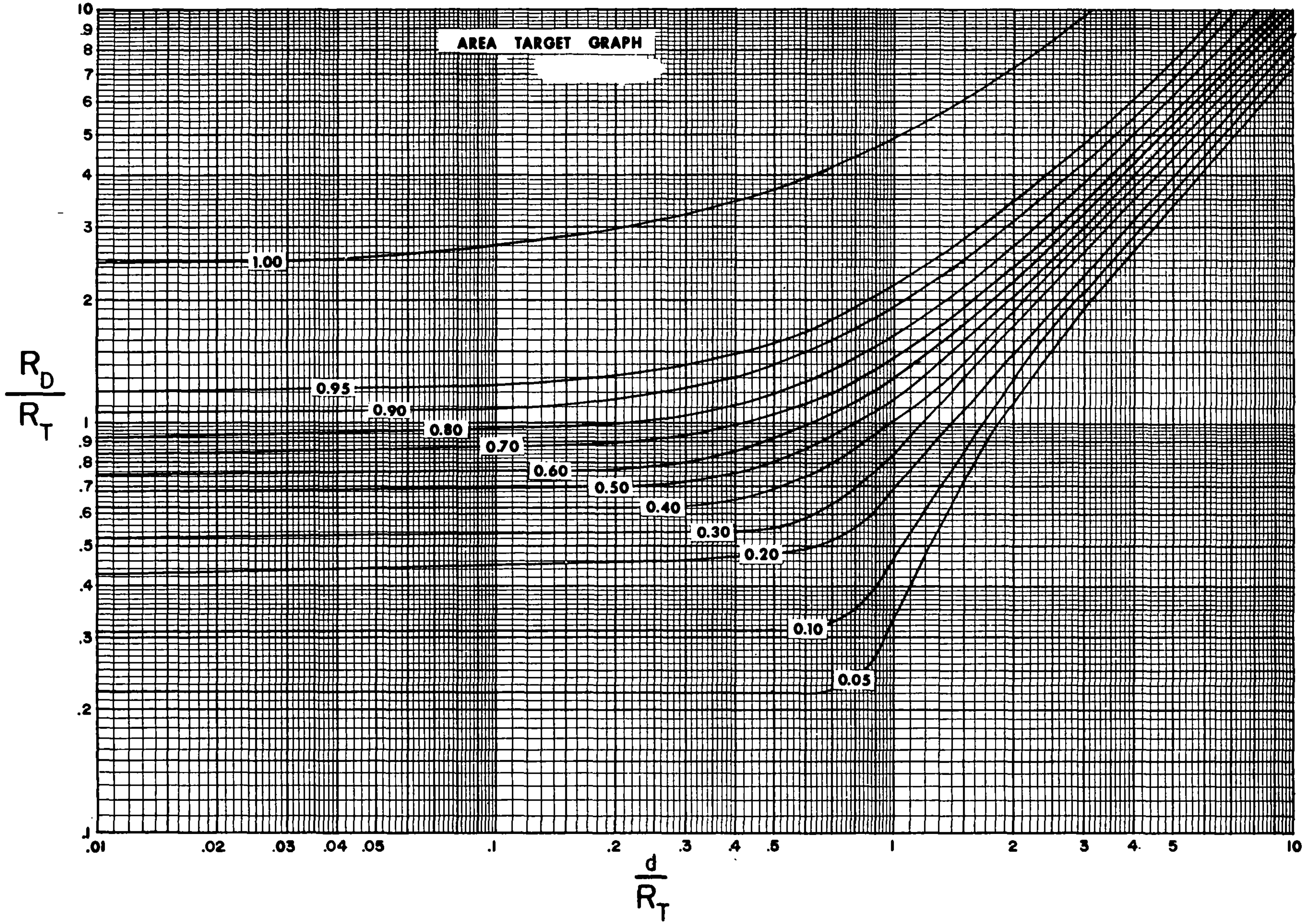


Figure F-2. ADM area target coverage nomograph.

APPENDIX G

ILLUSTRATIVE EXAMPLES IN ADM TARGET ANALYSIS

G-1. General

The examples used in this appendix illustrate the procedural steps outlined in paragraph 5-4 with regard to the detailed analysis of ADM targets. These procedures are provided for guidance only since it is realized that the analyst will develop procedures of a more direct nature commensurate with his experience.

G-2. Illustrative Examples

a. Example Problem No. 1.

(1) *Given:* A rapid withdrawal of friendly troops which may necessitate the denial of pre-stocked wheeled military vehicles is being contemplated. The vehicles are uniformly distributed in the pre-stock site shown in figure G-1. The area is approximately circular with a radius (R_T) equal to 150 meters. The commander desires severe damage to 75 percent of the target. In addition, the commander wants to preclude tree blowdown on Highway 50 as an obstacle to wheeled vehicles and to achieve a high assurance (90%) of not subjecting the village north of the target to an overpressure of 1 psi. The SOP specifies no more than a negligible risk to friendly troops. The closest friendly elements are 1700 meters south of target center, are in the RS-O radiation status category, and are to be considered as warned and protected. Effective fallout winds are from the southwest. The allocation includes the following ADM:

(*a*) DELTA/0.5 KT ADM.

(*b*) ECHO/1.0 KT ADM.

(*c*) FOXTROT/5.0 KT ADM.

(2) *Find:* The most suitable ADM for this denial operation to include the location of ground zero and the fractional coverage to the target.

(3) *Solution:*

(*a*) *Step 1. Identify pertinent information.*

1. Target information. An area target ($R_T = 150m$) composed of wheeled military vehicles.

2. Friendly forces. Troops in the vicinity are warned and protected, 1700 meters southwest of target center. Negligible risk is not to be exceeded.

3. Command guidance. At least 75 percent coverage based on a severe level of damage is desired. Preclude tree blowdown on Highway 50, approximately 375 meters east of target center; provide at least a 90 percent assurance of not subjecting the village, situated 1600 meters north of target center, to 1 psi overpressure.

4. ADM allocation.

DELTA/0.5 KT
ECHO/1.0 KT
FOXTROT/5.0 KT

(*b*) *Step 2. Tentatively select point of detonation.* Initially, target center is selected as the ground zero location. A surface burst is planned in order to maximize the desired effect (airblast) and to facilitate emplacement. The resultant fallout does not affect tactical operations or the civilian population in the village in view of current wind conditions.

(*c*) *Step 3. Eliminate obviously unsuitable weapons.* The nature of this mission is such that none of the ADM allocated are eliminated at this time. Weight and size of the ADM do not pose any operational difficulty.

(*d*) *Step 4. Determine data for—*

1. Estimating damage to the target (table B-1). The numerical method is used although the visual method of damage estimation is also applicable.

	R_D	R_D/R_T	f (fig F-2)
DELTA/0.5 KT	125m	0.83	70%
ECHO/1.0 KT	175m	1.17	94%
FOXTROT/5.0 KT	325m	2.16	98%

2. Troop safety (table B-11). Since troops are in the RS-O radiation status category, the warned-protected, negligible risk safety distances are as follows:

DELTA/0.5 KT	1050m
ECHO/1.0 KT	1150m
FOXTROT/5.0 KT	1300m

3. Bonus effects and limiting requirements (table B-9).

(a) *Tree blowdown distances* (type III forest).

DELTA/0.5kt	200m
ECHO/1.0kt	300m
FOXTROT/5.0kt	600m

(b) *Extent of 1 psi overpressure.* For a 90 percent probability of precluding 1 psi overpressure enter figure F-1 with P = 100% — Q = 100% — 90% = 10%; d/R_D = 1.26. The required separation distance for each ADM in the allocation is listed below (table B-10):

	R_D	$1.26R_D$
DELTA/0.5kt	1050m	1323m
ECHO/1.0kt	1325m	1670m
FOXTROT/5.0kt	2275m	2867m

(*e*) *Step 5. Eliminate unsuitable ADM.* The DELTA/0.5 KT is eliminated since it does not meet the coverage requirement (*f* = 70%). The FOXTROT/5 KT is eliminated since it fails to meet the commander's requirement to preclude 1 psi overpressure to the village north of the target.

(*f*) *Step 6. Evaluation.* Only the ECHO/1.0 KT is evaluated since all other ADM in the allocation have been eliminated. With this munition, displacement 70 meters south of target center is required to meet the 90 percent assurance specified for precluding 1 psi overpressure to the village. Displacing GZ 70 meters, coverage to the target is again computed—

$$R_D/R_T = 175/150 = 1.17$$
$$d/R_T = 70/150 = 0.47$$
$$f = 80\%$$

Fallout is not expected to offset the operation since friendly units are upwind of the fallout effective wind direction and outside the one cloud radius distance from GZ. By inspection, it is apparent that both troop safety and tree blowdown requirements are not affected by this displacement; therefore, further checks are not required.

(*g*) *Step 7. Make recommendations.*

1. Type and yield:
ECHO-1.0 KT ADM

2. DOB:
Surface

3. GZ location:
70m south target center

4. Point of detonation:
N/A

5. Time of burst and option:
On order

6. Estimated results:
f = 80 percent

7. Troop safety distance:
MSD (warned, protected; negligible risk) 1150 meters

b. Example Problem No. 2.

(1) *Given:* It is planned to employ ADM to assist a covering force in delaying the enemy's advance from the north until arrival of the main body. Friendly mechanized forces have taken up delaying positions on the high ground as shown in figure G-2 and are in the RS-O radiation service category. The commander desires to use an ADM to crater the highway to include the width of clearing and to create tree blowdown as an obstacle to tracked vehicular movement in the adjacent type IVf forest for a distance of at least 200 meters. The width of clearing is 24 meters and is underlaid with dry soil. Friendly troops will be warned, protected; further, the SOP specifies negligible risk. The fallout effective wind is from the south. The ADM allocation includes the following:

(*a*) ALPHA/0.01 KT ADM.

(*b*) CHARLIE/0.10 KT ADM.

(*c*) DELTA/0.50 KT ADM.

(2) *Find:* Minimum yield ADM that will meet the stated requirements.

(3) *Solution:*

(*a*) *Step 1. Identify pertinent information.*

1. Target information.
D_A (required) = 24 meters. Radius of tree blowdown (required) = 200 meters.

2. Friendly information. The closest friendly troops are located 1500 meters from center of highway; these troops are warned and protected and negligible risk is specified.

(*b*) *Step 2. Tentatively select point of detonation.* The center of the highway is tentatively selected as the point of detonation. A surface burst (DOB = 0) is selected in view of the tree blowdown requirement.

(*c*) *Step 3. Eliminate obviously unsuitable ADM.* Weight or size limitations of available ADM impose no operational difficulty; therefore, none of the ADM are eliminated as *obviously* unsuitable.

(*d*) *Step 4. Determine data for—*

1. Estimating damage to the target. In this case, a crater which covers the full width of clearing is desired. An examination of table B-3 provides the following data:

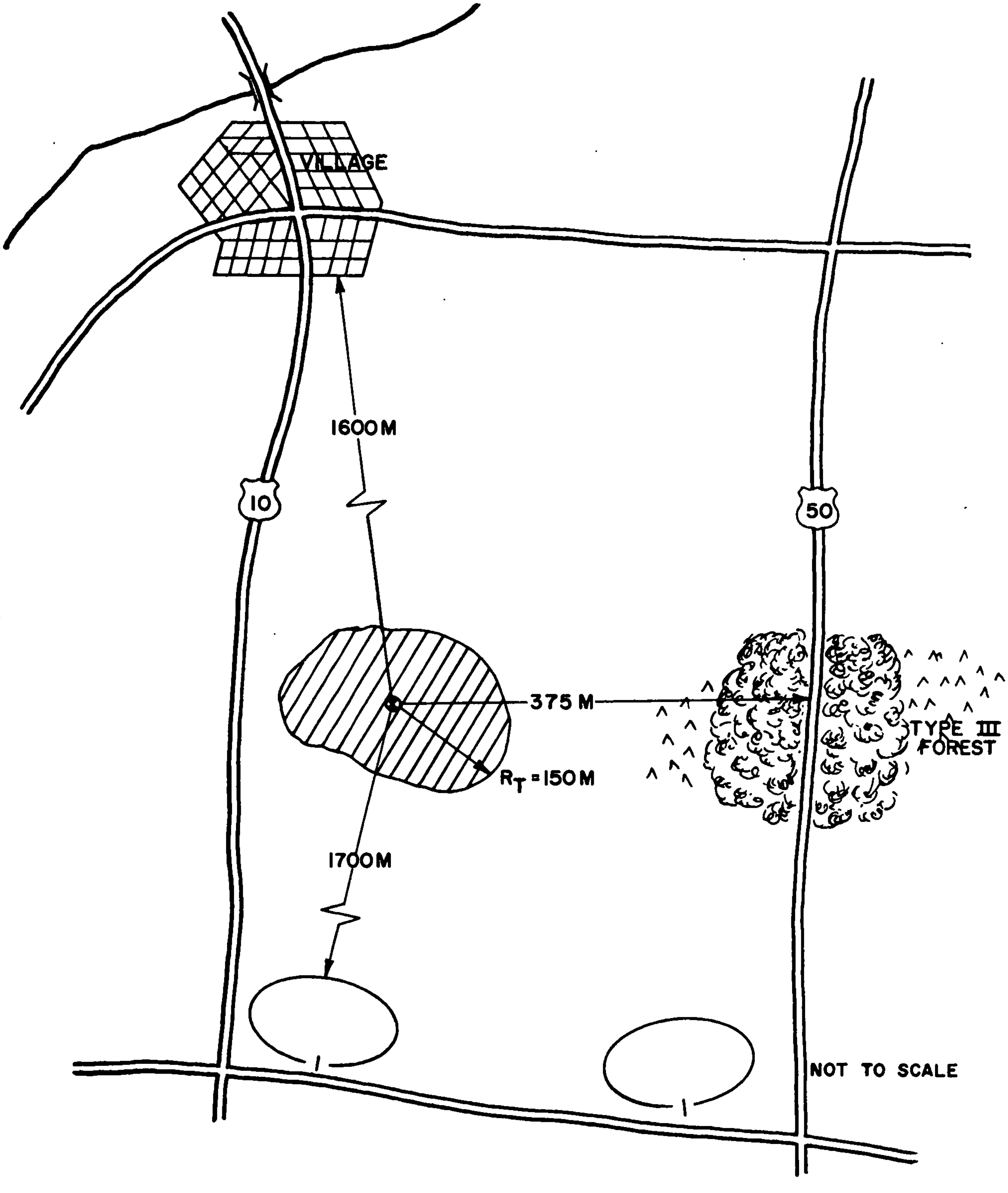


Figure G-1. Sketch for example problem 1.

	D_A	H_A
ALPHA/0.01 kt	10m	2.6m
CHARLIE/0.10 kt	20m	5.5m
DELTA/0.50 kt	35m	8.6m

2. Troop safety. The distance from the tentative point of detonation to friendly lines is 1500 meters. Since troops are in the RS-O radia-

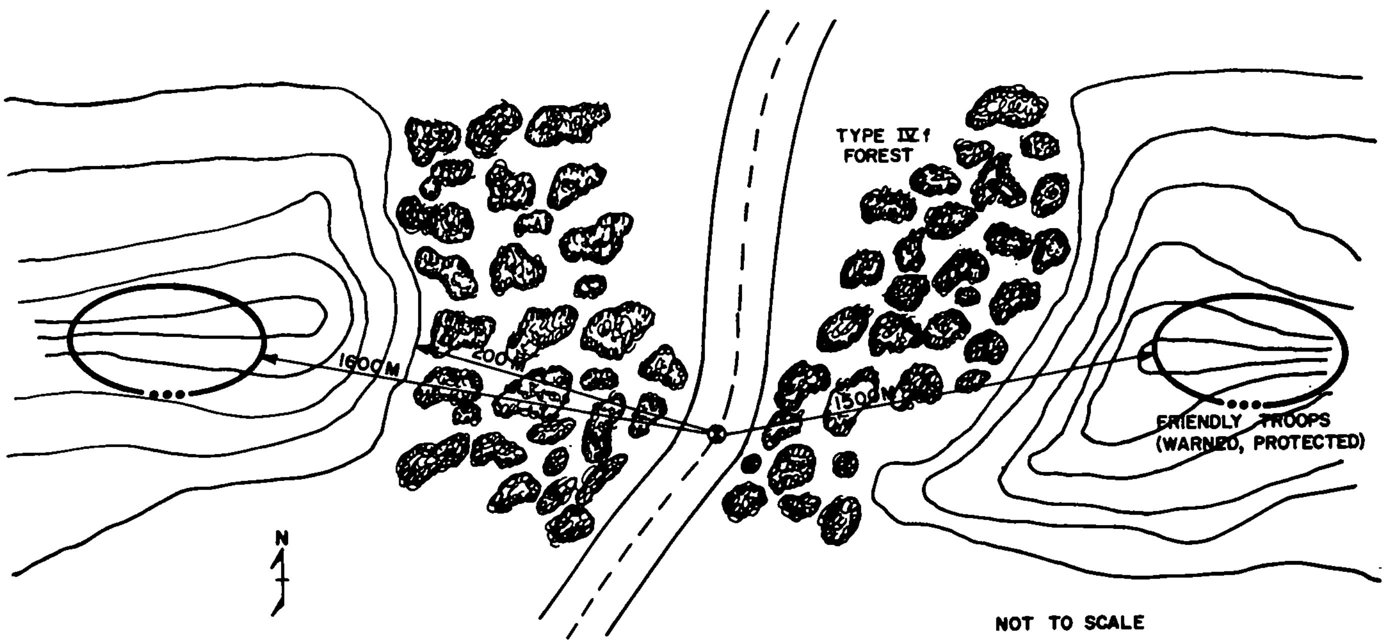


Figure G-2. Sketch for example problem 2.

tion status category the troop safety distances are read direct from table B-11, for negligible risk to warned, protected troops. These distances are:

ALPHA/0.01 kt	600m
CHARLIE/0.10 kt	820m
DELTA/0.50 kt	1050m

3. Bonus effects and limiting requirements. Tree blowdown to prevent tracked vehicle movement extending at least 200 meters is required. Table B-9 indicates that tree blowdown (type IVf forest) extends to the following distances:

ALPHA/0.01 kt	75m
CHARLIE/0.10 kt	135m
DELTA/0.50 kt	200m

(*e*) *Step 5. Eliminate unsuitable ADM.* Since the ALPHA/0.01 KT and the CHARLIE/0.10 KT do not provide a large enough crater, they are eliminated as unsuitable.

(*f*) *Step 6. Evaluation.* There being only one ADM that meets the stated requirements, no further evaluation is made.

(*g*) *Step 7. Make recommendations.*

1. Type and yield:
DELTA/0.5 KT ADM

2. DOB:
Surface burst

3. GZ location:
Center of highway as shown on sketch

4. Point of detonation:
N/A

5. Time of burst and firing option:
On order

6. Estimated results
Crater (D_A = 35m and H_A = 86m plus tree blowdown extending 200 meters from GZ

7. Troop safety:
MSD (warned, protected; negligible risk) 1050 meters

APPENDIX H

FRIENDLY NUCLEAR STRIKE WARNING TO ARMED FORCES OPERATING ON LAND (STANAG 2104)

STANAG No. 2104
(Edition No. 2)
25 November 1970

NORTH ATLANTIC TREATY ORGANIZATION

MILITARY AGENCY FOR STANDARDIZATION

STANDARDIZATION AGREEMENT

SUBJECT

FRIENDLY NUCLEAR STRIKE WARNING TO

ARMED FORCES OPERATING ON LAND

DETAILS OF AGREEMENT (DofA)

AGREEMENT

1. It is agreed that the NATO Armed Forces will adopt the following system of friendly nuclear strike warnings for use at corps level and below. This applies to surface-to-surface and air-to-surface strikes in support of ground forces, and to emplace atomic demolition munitions (ADMs).

GENERAL

2. The requirement for a standard warning message and delineation of notification channels is essential to ensure that timely warning of friendly nuclear strikes is provided so that Armed Forces personnel may take individual measures to protect themselves. For the purpose of the STRIKWARN message, azimuth is the horizontal angle from grid north to a certain point expressed in degrees or mils.

STATEMENT OF DETAILS

3. WARNING RESPONSIBILITIES

a. Responsibility for issuing the warning rests with the executing commander. Responsibility for issuing the STRIKWARN message is to be detailed in national and NATO operational orders and SOPs.

b. Commanders authorized to release nuclear strikes will ensure that strikes affecting the safety of adjacent or other commands are coordinated with those commands in sufficient time to permit dissemination of warnings to Armed Forces personnel and the taking of protective measures. Conflicts must be submitted to the next higher Commander for decision.

4. DETERMINATION OF HEADQUARTERS, FORMATIONS/UNITS TO BE WARNED

a. The commanders responsible for disseminating STRIKWARN should inform:

(1) Subordinate Headquarters whose units are likely to be affected by the strike.

(2) Adjacent Headquarters whose units are likely to be afffected by the strike.

(3) Own next higher Headquarters, when units not under the command of the releasing Commander are likely to be affected by the strike.

b. Each Headquarters receiving a warning of nuclear attack will warn subordinate elements of the safety measures they should take, in the light of their proximity to the Desired Ground Zero (DGZ).

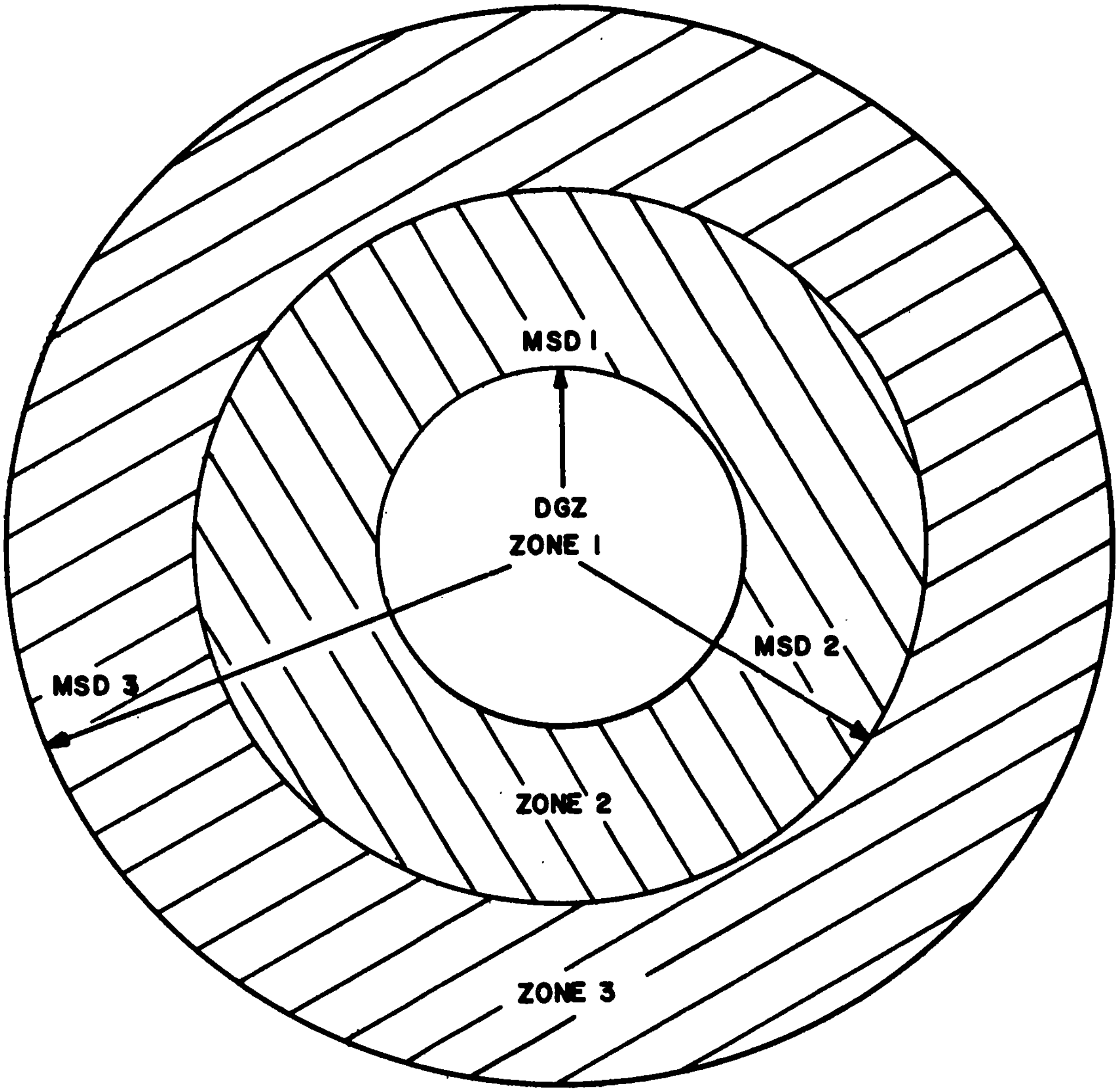


Figure H-1. Zones of warning and protection requirements for friendly nuclear strikes.

Notes. 1. MSD means Minimum Safe Distance.

2. The MSD is equal to a radius of safety (R_s) for the yield, plus a buffer distance (d_b) related to the dispersion normal to the weapon system used and the orientation of friendly forces in relation to the line of fire. When surface bursts are used, the fallout hazard will be considered and appropriate buffer distances included.

c. Each unit concerned, down to the lowest level, will be warned by its next higher level of the safety measures it should take.

5. ZONES OF WARNING AND PROTECTION REQUIREMENTS FOR FRIENDLY NUCLEAR STRIKES

Radius	Corresponding to	Zone	Requirements
DGZ			
		1	Evacuation of all Armed Forces personnel. (See note 2).
MSD 1	Limit of negligible risk* to warned and protected Armed Forces personnel (See note 3).		
		2	Maximum protection. (See note 4).
MSD 2	Limit of negligible risk* to warned and exposed Armed Forces personnel		
		3	Minimum protection. (See note 5).
MSD 3	Limit of negligible risk* to unwarned and exposed Armed Forces personnel.		
More than MSD 3			No protective measure except against dazzle.

Notes. 1. Commanders will be guided by safety criteria as stated in FM 101-31-1, Staff Officers Field Manual, Nuclear Weapons Employment (or appropriate national manuals with the same criteria).
2. If evacuation is not possible or if a Commander elects a higher degree of risk, maximum protective measures will be required.
3. Negligible risk should not normally be exceeded unless significant advantages will be gained.
4. Maximum protection denotes that Armed Forces personnel are in "buttonedup" tanks or crouched in foxholes with improvised overhead shielding.
5. Minimum protection denotes that Armed Forces personnel are prone on open ground with all skin areas covered and with an overall thermal protection at least equal to that provided by a two-layer uniform.
* (as defined in STANAG 2083).

6. WARNING MESSAGES

Warning messages will include the following information (See STANAG 2103):

STRIKWARN

ALFA: Code word indicating nuclear strike (target number)

DELTA: Date/Time group of burst and date/time group after which the strike will be cancelled (both in ZULU time).

FOXTROT: GZ or DGZ (UTM grid coordinates with a minimum of 6 numerical figures)

HOTEL: Indicate air, surface, or subsurface burst.

INDIA: For all bursts:
MSD 1 in hundreds of meters, four (4) digits
MSD 2 in hundreds of meters, four (4) digits
MSD 3 in hundreds of meters, four (4) digits

YANKEE: For all bursts when there is less than a 99% assurance of no militarily significant fallout. Azimuth of left then right radial lines (degrees or mils—state which) four (4) digits each.

ZULU: For bursts greater than 0.1 KT (except subsurface bursts) when there is less than 99% assurance of no militarily significant fallout. Effective wind speed in kilometers per hour to nearest kilometer, three (3) digits. Downwind distance of Zone I to nearest kilometer, three (3) digits. Cloud radius to nearest kilometer, two (2) digits. (Use of the ZULU line precludes use of the ZULU INDIA line.) Note: If effective wind speed is less than 8 KM/hour line ZULU will contain only three significant digits, i.e. "the radius of Zone I."

ZULU INDIA: For bursts 0.1 KT and less, and for all subsurface bursts. Downwind distance of Zone I in hundreds of meters, four (4) digits. Downwind distance of Zone II in hundreds of meters four (4) digits. Cloud radius in hundreds of meters, three (3) digits (use of the ZULU INDIA line precludes use of the ZULU line).

7. EXAMPLE MESSAGES

a. *FOR AIR BURSTS WITH 99% ASSUR-*

ANCE OF NO MILITARILY SIGNIFICANT FALLOUT STRIKWARN. ALFA TUBE SIX. DELTA PQ WM OT AR/AS DG WY OF. FOXTROT MC 123456. HOTEL AIR. INDIA 0022 0031 0045.

b. *FOR BURSTS GREATER THAN 0.1 KT (EXCEPT SUBSURFACE BURSTS) WHEN THERE IS LESS THAN 99% ASSURANCE OF NO MILITARILY SIGNIFICANT FALLOUT* STRIKWARN. ALFA TUBE SIX. DELTA PQ WM OT AR/AS DG WY OF. FOXTROT MC 123456. HOTEL SURFACE. INDIA 0022 0031 0045. YANKEE 0215 0255 DEGREES. ZULU 025 080 18.

c. *FOR BURSTS 0.1 KT AND LESS AND FOR ALL SUBSURFACE BURSTS* STRIKWARN. ALFA TUBE SIX. DELTA PQ WM OT AR/AS DG WY OF. FOXTROT MC 123456. HOTEL SURFACE. INDIA 0022 0031 0045. YANKEE 0215 0255 DEGREES. ZULU INDIA 028 0010 0025 004.

8. IMPENDING STRIKE WARNING

Warning of impending strikes will be initiated no earlier than is necessary to complete warning of Armed Forces personnel. Any available means of communications—land lines if possible—will be utilized to ensure that all Armed Forces personnel requiring warning are notified.

9. ACTION ON CANCELLED STRIKES

When nuclear strikes are cancelled, units previously warned will be notified in the clear by the most expeditious means in the following format:

a. Code Word (Target Number)

b. CANCELLED

10. USE OF CODES

Items DELTA and FOXTROT above will not be sent in clear unless the time of initiating the warning message is such that no loss of security is involved, and when their passage in clear language is essential to troop safety. Only coding systems which meet NATO security criteria will be used.

11. OTHER WARNINGS

It is recognized that it is impractical to obtain warnings of surface-to-air (for instance, air defense) nuclear bursts which may occur at low altitudes, and to disseminate such warnings to Armed Forces personnel. Similarly, it may be impractical to provide warning to the Naval and Air Forces concerned of intended surface-to-surface strikes delivered by weapons within the corps, especially for fleeting targets or when reaction times are short. Nevertheless, it is the responsibility of Army agencies to provide warning to Naval and Air Forces concerned whenever possible.

12. IMPLEMENTATION OF THE AGREEMENT

This STANAG will be considered to have been implemented when the necessary orders/instructions putting the procedures detailed in this Agreement into effect have been issued to the forces concerned.

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By Order of the Secretary of the Army:

W. C. WESTMORELAND,
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Chief of Staff.

Official:
VERNE L. BOWERS,
Major General, United States Army,
The Adjutant General.

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