

FM 10131-1

2

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DEPARTMENT OF THE ARMY FIELD MANUAL

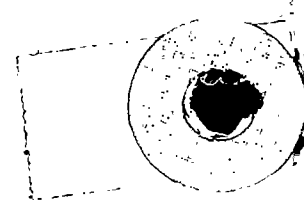
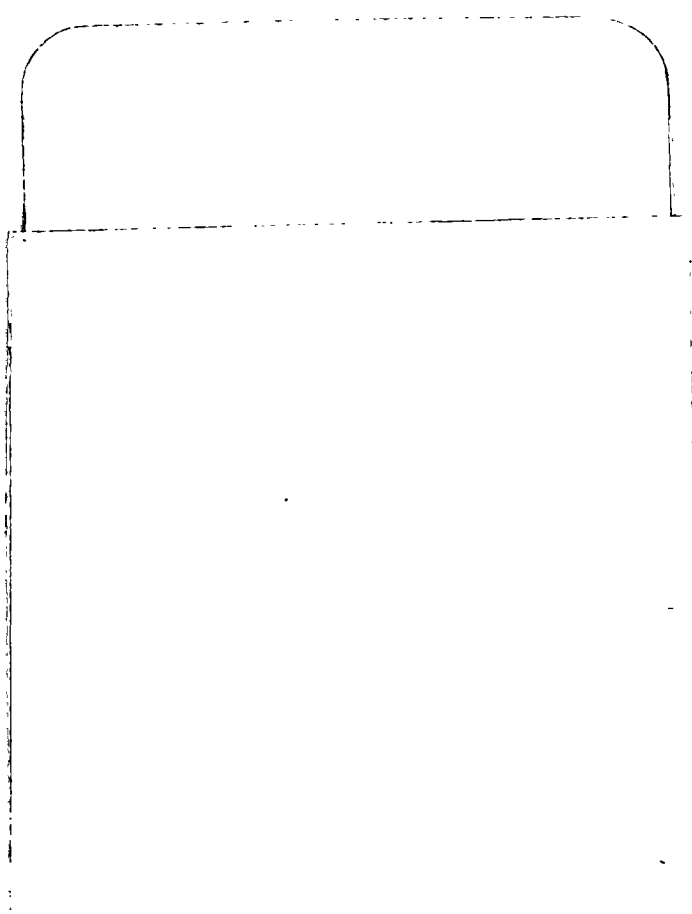
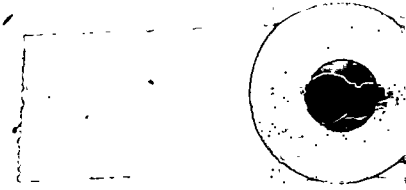
MARINE CORPS FLEET MARINE FORCE MANUAL

FM 101-31-1
FMFM 11-4

STAFF OFFICERS' FIELD MANUAL NUCLEAR WEAPONS EMPLOYMENT DOCTRINE AND PROCEDURES

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**DEPARTMENTS OF THE ARMY AND THE NAVY
FEBRUARY 1968**



Change

No. 1

DEPARTMENTS OF THE ARMY
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WASHINGTON, D.C., 19 December 1969

**STAFF OFFICERS' FIELD MANUAL
NUCLEAR WEAPONS EMPLOYMENT
DOCTRINE AND PROCEDURES**

FM 101-31-1/FMFM 11-4, 15 February 1968, is changed as follows:

1. Remove old pages and insert new pages as indicated below.

Remove pages ✓

1-1 and 1-2
2-1 and 2-2
2-15 and 2-16
3-1 through 3-6
3-9 through 3-12
4-7 through 4-14
5-1 through 5-4
6-3 and 6-4
B-1 through B-4
B-11 and B-12
B-23 and B-24
B-31 and B-32
B-43 and B-44
B-55 and B-56
B-59 and B-60
B-65 and B-66
Glossary-1

Insert pages ✓

1-1 and 1-2
2-1 and 2-2
2-15 through 2-16
3-1 through 3-6
3-9 through 3-12
4-7 through 4-13
5-1 through 5-4
6-3 and 6-4
B-1 through B-4
B-11 and B-12
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DEPARTMENTS OF THE ARMY
AND THE NAVY

WASHINGTON, D.C., 15 February 1968

STAFF OFFICERS' FIELD MANUAL

NUCLEAR WEAPONS EMPLOYMENT

DOCTRINE AND PROCEDURES

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*This manual supersedes FM 101-31-1, 1 February 1963, including all changes.



CHAPTER 1

INTRODUCTION

1-1. Purpose

This manual provides guidance to commanders and staff officers in the operational and logistical aspects of nuclear weapon employment in combat operations.

1-2. Scope

a. The doctrine presented in this manual is basically concerned with nuclear weapon employment within the field army and the Fleet Marine Force. When the manual discusses special ammunition logistics and vulnerability analyses, the scope is extended to include the area of operations.

b. Guidance is presented for the employment of nuclear weapons in the attack of targets on or near the earth's surface.

c. The complete manual series (FM 101-31-1, FM 101-31-2, and FM 101-31-3) includes the following information:

(1) The U.S. Army and the U.S. Marine Corps doctrine for employment of nuclear weapons.

(2) The effects expected from nuclear weapons.

(3) Techniques of target analysis.

(4) Command and staff procedures in nuclear weapon employment.

(5) Guidance for conducting tactical operations in a nuclear environment.

(6) Defensive measures, individual and unit, to reduce the effects of enemy-delivered weapons.

(7) Tabular information concerning target response and troop safety for a family of hypothetical weapons and for stockpile weapons.

(8) Pertinent portions of STANAGs 2083, 2103, 2104, 2111, SOLOGs 89, 123, 128, 130 and SEASTAG 2083.

d. This manual repeats information presented in other field manuals only as required for clarity or consistency. The manual should, therefore, be used in conjunction with other applicable manuals. For a discussion of the employment of nuclear weapons in the air defense role, see FM 44-1A.

★1-3. Recommended Changes

Users of this manual are encouraged to submit recommendations to improve the manual. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. 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, U.S. Army Combat Developments Command Institute of Nuclear Studies, Fort Bliss, Texas 79916. Originators of proposed changes that would constitute a significant modification of approved Army doctrine may send an information copy, through command channels to the Commanding General, U.S. Army Combat Developments Command, Fort Belvoir, Virginia 22060, to facilitate review and followup. Marine Corps users of this manual will submit comments to the Commanding General Marine Corps Development and Education Command (ATTN: 45R) Quantico, Virginia 22134.

1-4. Organizations of the Manual Series

The material is divided into three separate manuals—

a. This manual provides doctrine applicable to active nuclear warfare. It contains the U.S. Army and U.S. Marine Corps concepts for nuclear weapon employment and the command and staff actions required to carry out these concepts. Appendix B presents detailed technical procedures concerning target analysis.

b. FM 101-31-2 contains classified defense information concerning the nuclear weapons in the U.S. stockpile. It provides the data necessary for target analysis. It presents items of information concerning technical procedures that are not included in this manual because of their security classification. FM 101-31-2 is designed for use in *active nuclear combat*, *field training exercises* (FTX), and *command post exercises* (CPX).

FM 101-31-2 (Modified) is intended to be used by NATO members in actual combat, FTX, and CPX.

c. FM 101-31-3 provides data concerning a family of hypothetical nuclear weapons. It provides the data necessary for target analysis. FM 101-31-3 is designed specifically for use in unclassified training of the staff officer, particularly the nuclear weapon employment officer. It is not intended for field exercises or command post exercises by U.S. Forces, but can be so used by non-U.S. forces. The illustrative problems in appendix B, this manual, use data from FM 101-31-3.

d. The organization of the material in FM 101-31-2 and FM 101-31-3 is, in most cases, identical. Differences between the U.S. stockpile weapons and the family of hypothetical weapons exist; these differences are intentional and are designed to protect the security of the actual weapons. Facility in the use of FM 101-31-3 will insure facility in the use of FM 101-31-2.

1-5. Concepts for Nuclear Weapons Employment

The doctrine in this manual is based on the following basic concepts:

a. The U.S. Army and U.S. Marine Corps are organized, equipped, and trained to fight in nuclear warfare, nonnuclear warfare, or under the threat of nuclear warfare. In the latter case, units are prepared to take the actions indicated in this manual should nuclear warfare begin.

b. Nuclear weapons may be employed within the area of operations when the theater commander announces that their use has been authorized.

c. Once nuclear warfare has commenced, the

authority to employ nuclear weapons is decentralized.

d. United States nuclear weapons may be employed in support of Allied forces, using either United States or Allied delivery means. The nuclear warhead section (to include artillery projectiles) remains under the control of United States military personnel until time of launching or firing.

e. A commander who plans to employ a nuclear weapon coordinates with any adjacent unit commander into whose zone, or sector, militarily significant weapon effects are expected to extend. Lacking concurrence, the commander requests authority to fire from the next higher commander who controls both sectors.

f. Nuclear firepower is a form of combat power. Nuclear weapons may, on occasion, be used alone to accomplish tasks that might otherwise require the maneuver of close combat units; however, most tasks require a combination of fire and maneuver. Plans for the employment of nuclear firepower, nonnuclear firepower, and maneuver forces are integrated to provide decisive results.

g. Nuclear weapons are employed to destroy or degrade enemy combat capabilities. Consistent with the requirements imposed by the tactical mission, casualties among civilian personnel are held to a minimum. Destruction of manmade structures or natural terrain features, tree blowdown or fire areas, and creation of high-intensity residual contamination areas may create undesired obstacles to movement. Consistent with military objectives, unnecessary destruction and contamination should be held to a minimum.

h. Commanders employ the smallest and most readily available weapon with a suffi-

ciently high probability of providing the coverage that insures the desired results.

i. Commanders employ surface bursts when surface bursts accomplish the results desired more effectively than do Airbursts. (Factors to be considered are presented in para 4-10.)

j. Commanders conduct poststrike analysis as required.

1-6. Terms and Definitions

Terms and definitions useful for a better understanding of this manual may be found in AR 320-5 and in JCS Pub 1. Certain terminology is oriented toward nuclear weapon

employment and is not found in the aforementioned publications. To provide definitions of terms and phrases peculiar to nuclear weapon employment, a glossary is contained in the back of this manual.

1-7. Nuclear Play

For maneuver control, FM 105-5 and the FM 105-6 Nuclear Play Calculator series of field manuals has been designed. FM 105-6-1, FM 105-6-2, and FM 105-6-3, cover the unclassified and classified portions of nuclear gaming and include techniques and tables that allow considerations of probabilities to be entertained in the gaming.

CHAPTER 2

INITIAL EFFECTS OF NUCLEAR WEAPONS

Section I. GENERAL

2-1. General

a. The effective employment of nuclear weapons requires an understanding of the effects produced by these weapons, the response of various target elements to these effects, the distance at which damage or casualties may be produced, the methods of estimating the results of nuclear bursts under various conditions, and the variability of the predicted results.

b. This chapter presents a general qualitative discussion of initial nuclear weapon effects and their military significance. TM 23-200 presents a quantitative discussion of effects, and provides the nuclear weapon employment officer with a means by which he can determine the distance to which various effects extend.

2-2. Description of Nuclear Detonations

a. Release of Energy. The magnitude of the energy released in a nuclear explosion exceeds enormously the energy released in a nonnuclear explosion. Two types of nuclear reactions produce energy—fission and fusion. A fusion reaction is approximately three times as efficient per kilogram of fuel as is a fission reaction. The energy released (yield) by a nuclear detonation is measured in thousands of tons of TNT equivalent (kiloton (KT)), or in millions of tons of TNT equivalent (megaton (MT)). As a result of the sudden release of immense quantities of energy, a fireball is formed. The fireball rapidly grows in size and rises high into the atmosphere. The initial temperature of the fireball ranges into millions of degrees, and the initial pressure ranges to millions of atmospheres.

b. Partition of Energy. Transfer of energy from the weapon to the surrounding media begins with the actual nuclear explosion and is exhibited as three distinct effects.

(1) *Blast.* Mechanical shock effects are pro-

duced by a high-pressure impulse or wave as it travels outward from the burst.

(2) *Thermal radiation.* Heating effects result as objects in the surrounding area absorb thermal energy released by the burst.

(3) *Nuclear radiation.* Ionizing effects are produced when nuclear radiation emitted by the burst is absorbed.

c. Variation Parameters. The percentage of the total energy emitted, appearing as blast, thermal radiation, or nuclear radiation, depends on the altitude at which the burst takes place (subsurface, surface, air) and on the physical design of the weapon.

2-3. Damage Criteria and Radius of Damage

a. General. Two specific types of information pertaining to the military use of nuclear weapons have been developed through weapon tests. These specific effects data appear in TM 23-200.

(1) The thermal, blast, or nuclear radiation levels required to cause a particular degree of damage to a materiel or a personnel target element.

(2) The distance to which the required levels will extend from a given weapon.

b. Damage Analysis. The nuclear weapon employment officer uses data derived from effects (*a* above) to estimate the damage that a specific weapon will cause to a target. By knowing the approximate damage each weapon will cause, he selects the most appropriate weapon to accomplish the mission from those available for use.

★*c. Degrees of Materiel Damage.*

(1) *Damage* to materiel is classified by degrees as light, moderate, or severe. These degrees of damage are described in (*a*) through (*c*) below.

(*a*) *Light damage* does not prevent the immediate use of an item. Some repair by the user may be needed to make full use of the item.

(b) *Moderate damage* prevents use of an item until extensive repairs are made.

(c) *Severe damage* prevents use of the item permanently. Repair, in this case, is generally impossible or is more costly than replacement.

(2) *Moderate damage* usually is all that is required to deny the use of equipment. In most situations, this degree of damage will be sufficient to support tactical operations. There may be situations, such as the attack of a bridge, in which only severe damage will produce the desired results.

d. *Personnel Casualties*. Personnel casualties (combat ineffectives), unlike damage are not classified as to degree. Whenever personnel cannot perform their duties as a result of the weapon(s) employed against them, they are considered casualties. Some personnel will be effective immediately following attack but will later become combat ineffective because of the delayed effects of nuclear radiation.

e. *Personnel Casualties Versus Materiel Damage*. For most tactical targets, it is desirable to base target analysis on casualties rather than on damage to materiel. Exceptions are targets such as missile launchers, bridges, and other key structures.

f. *Radius of Damage*. The primary tool used in estimating damage to the target is referred to as the radius of damage (RD). 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 weapon 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. Appendix B presents a more detailed discussion of the concept of radius of damage.

2-4. Types of Burst—Definition and Significance

Nuclear weapons may be burst at any point from deep below the surface to very high in the air. Tactically, nuclear bursts are classified according to the manner in which they are employed. The terms listed below and their associated definitions are used in the remainder of this manual. For technical definitions of the various heights of burst, see TM 23-200.

a. *Subsurface Burst* (less than 0 meter height of burst). This type of burst generally is used to cause damage to underground targets and structures and to cause cratering.

b. *Impact or Contact Surface Burst* (0 meter height of burst). This type of burst is used to cause fallout, ground shock and cratering, and may be used against hard underground targets located relatively near the surface of the earth.

c. *Nuclear-Surface Burst*. This type of burst causes fallout because the fireball touches the surface. Because of this fallout producing aspect, employment of this type of burst is limited.

d. *Low Airburst*. This type of burst is used for the most effective coverage of damage to the great majority of ground targets of inter-

est to troops in the field. As used in this manual, this height of burst will preclude fallout. It is the height of burst most frequently used.

e. High Airburst. A high airburst is used in special cases for maximum coverage of "soft" ground targets, such as light frame buildings,

and to reduce the intensity of induced radiation in the vicinity of the ground zero. However, this height of burst reduces the radius of damage for most target elements and, consequently, receives little attention.

Section II. BLAST AND SHOCK

2-5. Airblast, General

a. Airblast is produced by nearly all types of bursts. In general—

- (1) The airburst produces the most damage from the blast effect along the ground. When the blast wave from an airburst strikes the earth, it is reflected by the earth's surface. The reflected blast wave then reinforces the incident blast wave, producing overpressures higher than those in the incident wave. This increase in overpressure results in a greater area coverage for blast effects since the distance to which low magnitude overpressures or dynamic pressures extend are increased. This increase in in distance provides an additional damage-producing capability for "soft" targets which are destroyed or damaged by the relatively low pressures.
- (2) The surface burst produces less total area coverage for blast damage than the airburst to most military targets. This is because there is less reinforce-

ment of the blast wave. Furthermore, some of the blast energy is used to produce a crater, and some of the blast energy is transmitted as ground shock.

- (3) The subsurface or underground burst produces the least blast damage to most military targets. Again, there is less reflection and reinforcement of the blast wave. Also, more blast energy is used to produce a larger crater, and some of the blast energy is transmitted as ground shock. The deeper the weapon is burst, the less airblast is produced.

b. The pressure is highest at the leading edge of a blast wave. As the blast wave moves away from the fireball, the pressure at the leading edge steadily decreases, and the pressure behind the leading edge drops off to normal. Figure 2-1 shows the relative pressures behind the blast wave at a short distance from the burst. After the blast wave has traveled a greater distance from the fireball, the pressure in the air behind the blast wave drops below that of the surrounding

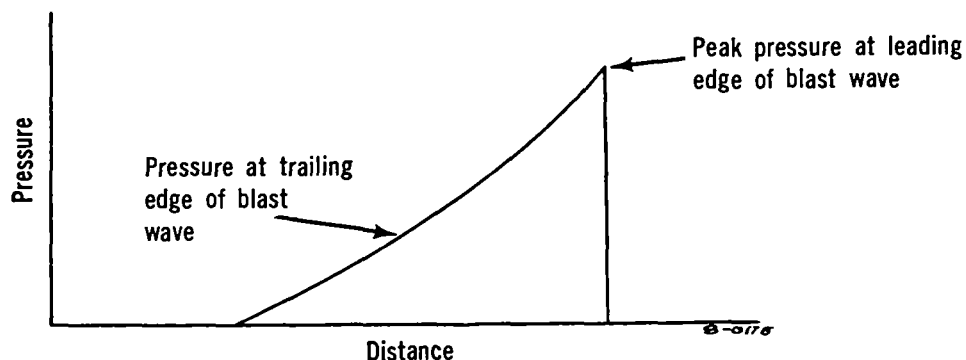


Figure 2-1. Variation of pressure within the blast wave.

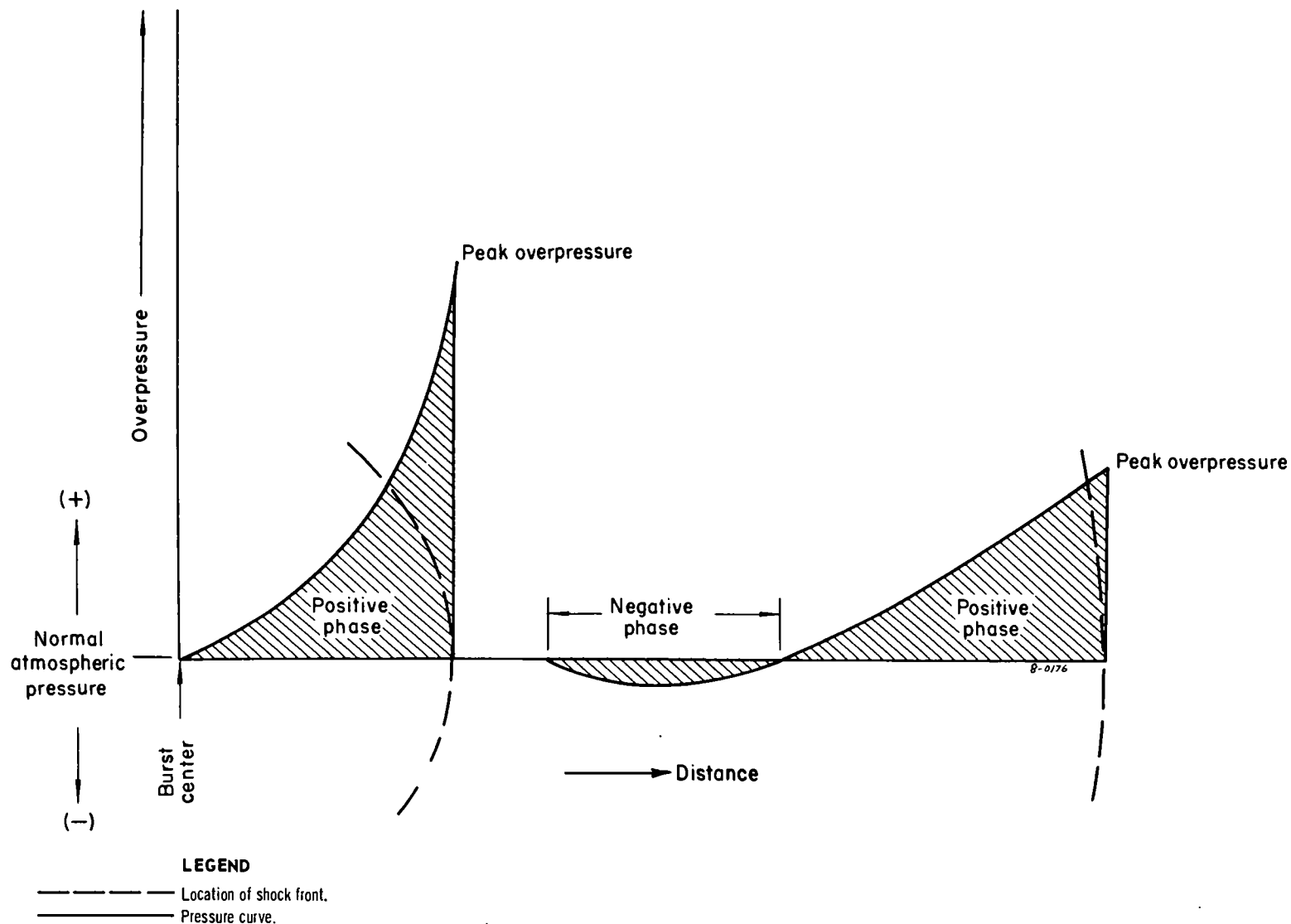


Figure 2-2. Overpressure versus distance from the burst center.

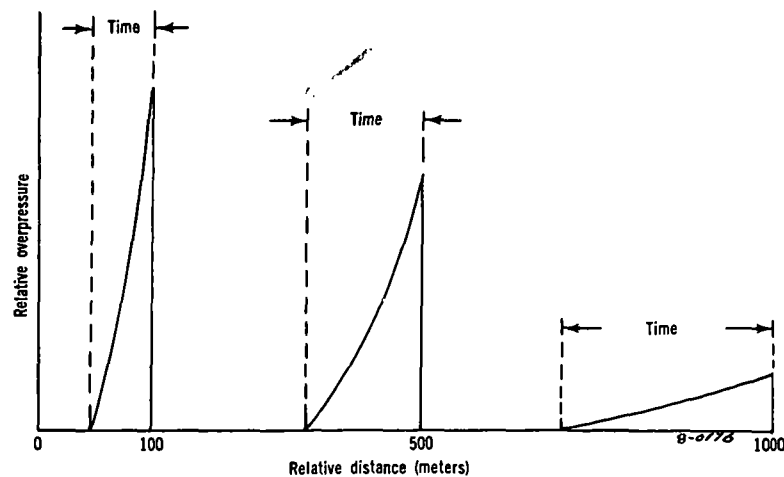


Figure 2-3. The duration of the blast wave increases with the distance from the ground zero.

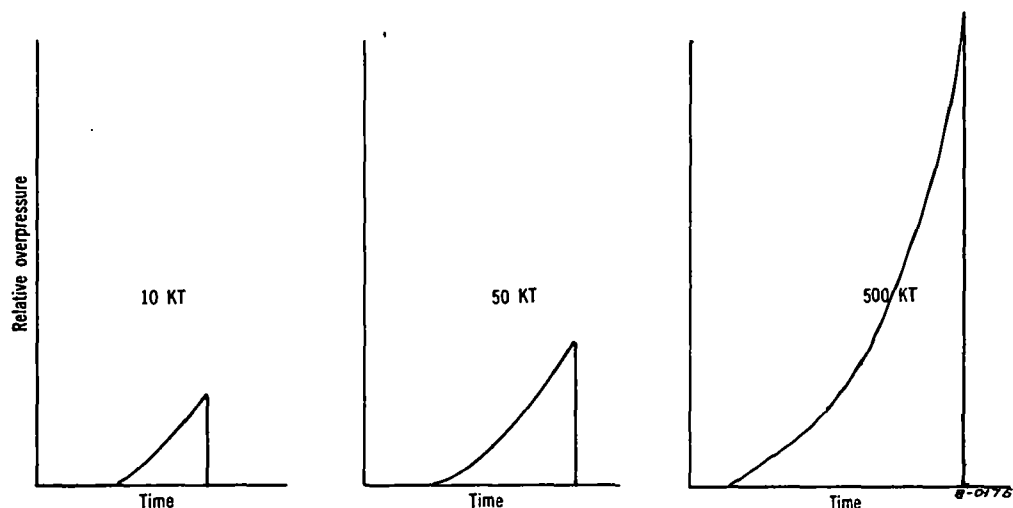


Figure 2-4. The duration of the blast wave increases with the yield at the same distance from GZ.

atmosphere and a "negative phase" is formed. Figure 2-2 shows a blast wave at two different distances from its origin during its expansion. The negative phase is shown behind the blast wave after it has expanded.

c. Both the positive and the negative phases produce damage; high pressures in the positive phase cause the most damage. In analyzing a target for probable blast effect, the effects of the negative phase are disregarded.

2-6. Damaging Pressures

As the blast wave moves outward in all

directions, it exerts two types of damaging pressures on all materiel in its path—

a. *Static Overpressure.* This is a squeezing or crushing force that surrounds the object and continues to apply pressure from all sides until the pressure returns to normal. During the time that the blast wave passes an object, a static pressure differential exists. The side nearest the burst receives high pressures before the side away from the burst. This pressure differential produces a temporary force away from the burst that causes damage in addition to that caused by the squeezing of the

object At *any* given point away from the ground zero, the highest static overpressure reached during passage of the blast wave is called the "peak" static overpressure for that point. Targets that are sensitive to, and are damaged primarily by, static overpressures are called *diffraction targets*.

b. Dynamic Pressure. As the blast wave moves away from the burst point, it is accompanied by high winds. Dynamic pressure is a measure of the forces associated with these winds. This pressure causes damage by pushing, tumbling, or tearing apart target elements. However, there is no simple correlation between peak static overpressure and peak dynamic pressure. Targets that are damaged primarily by dynamic pressure are called *drag-type targets*. Most materiel targets are drag sensitive. Personnel become casualties when they are subjected to weapon-produced translational motion.

2-7. Propagation of Airblast Wave

The duration of damaging overpressures is relatively short as the blast wave passes any given point. As the blast wave moves away from the ground zero, the duration of the blast wave increases; however, the peak overpressure decreases (fig. 2-3). The duration of the blast wave also increases (at the same distance from the burst point) as the yield increases (fig. 2-4). For a given peak overpressure along the earth's surface, the duration of the blast wave depends on the height of burst, the distance from the ground zero, the yield, and the surface conditions.

2-8. Modifying Influences on Airblast Wave

a. Weather. Rain and fog may cause attenuation of the blast wave, because energy is dissipated in evaporating the moisture in the atmosphere.

b. Surface Conditions. The reflecting quality of the surface over which a weapon is detonated can significantly influence the distance to which blast effects extend. Generally, reflecting surfaces, such as ice, snow, and water, increase the distance to which static over-

pressures extend. Generally, they decrease the distance to which dynamic pressures extend.

c. Topography. Most data concerning blast effects are based on flat or gently rolling terrain. There is no field method for calculating changes in blast pressures due to hilly or mountainous terrain. In general, pressures are greater on the forward slopes of steep hills and are diminished on reverse slopes when compared with pressures at the same distance on flat terrain. Blast shielding is not dependent on line-of-sight considerations because blast waves easily bend (refract) around apparent obstacles. The influence of small hills or folds in the ground is considered negligible for target analysis procedures. Hills may decrease dynamic pressures and offer some local protection from flying debris.

d. Cities or Built-Up Areas. These areas are not expected to have a significant effect on the blast wave. Structures may provide some local shielding from flying debris. Some local pressure increases may result from structures channeling the blast wave. However, the general airblast characteristics in cities and urban areas are considered essentially the same as those for open terrain.

e. Forests. Forests will not have a significant effect on blast wave characteristics, which are essentially the same as those for open terrain.

f. Height of Burst. The height of burst determines the extent to which the blast wave is reflected and influences the strength of incident and reflected blast waves. In general—

- (1) Low heights of burst increase the distances at which hard materiel targets will be damaged. Target elements in this category include tanks, personnel carriers, personnel in foxholes, artillery pieces, and missile launchers.
- (2) High heights of burst increase the distances at which soft targets are damaged. Target elements in this category include exposed personnel, most buildings, and forests.
- (3) Only rarely will it be necessary to

select a height of burst other than the impact or low airburst option to attain maximum results against a military target. The precomputed weapon tables shown in FM 101-31-2 and FM 101-31-3 present to the nuclear weapon employment officer only these burst options.

- (4) The effects tables in FM 101-31-2 and FM 101-31-3 provide data for target analysis using other heights of burst if tactical considerations warrant. (See Annex B-V for details.)

2-9. Ground Target Response to Blast

a. The blast effect of a nuclear weapon is important as a damaging agent against materiel and as a casualty producer. In fact, blast may be the only effective damage or casualty producer against some types of targets. For example, troops in a city may have some protection from thermal radiation and initial nuclear radiation: most of the immediate casualties will probably come from collapsing buildings and flying glass and debris caused by blast.

b. Most types of military equipment are drag sensitive and are damaged primarily by the dynamic pressures associated with the passage of the blast wave.

c. Parked aircraft, structures, bridges, and forests are damaged by a combination of static and dynamic pressures.

d. Mines may be detonated by static overpressures.

e. The direct effects of blast against personnel are from both static overpressures and dynamic pressures.

- (1) High static overpressures are required to cause immediate deaths, provided no translational motion occurs. Lower overpressures may cause severe internal injuries, especially to the lungs or abdominal organs. Eardrum rupture, which is painful but not necessarily disabling, may result from still lower overpressures. Personnel in shelters, gun emplacements,

and other types of field fortifications may become casualties if the blast pressures build up by multiple reflections within such inclosures.

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

f. Indirect effects of blast are not included in the data in this manual, FM 101-31-2, or FM 101-31-3 because they are unpredictable. These are considered bonus effects and are caused by—

- (1) Flying debris, stones, and sand being converted to missiles by the blast wave and causing damage or casualties. Casualties as a result of the missile effect are unpredictable, because of the unpredictability of the protection of personnel in the target area. Sand and dust may limit visibility and movement in the target area up to several hours after a detonation.
- (2) Buildings or fortifications collapsing on personnel.

2-10. Obstacles

Rubble within built-up areas and tree blow-down from nuclear blast often extend to considerable distances beyond the primary target area. The resulting obstacles may be of major proportions and often may block avenues of approach or hinder the accomplishment of the military mission.

2-11. Cratering and Ground Shock, General

a. When a nuclear weapon is burst beneath, on, or near the surface, a portion of the blast energy, coupled with the vaporizing effect of the thermal radiation, scoops up and throws out a large quantity of earth, resulting in the formation of a crater. Destruction of deep underground targets, the blocking of defiles, and the creation of obstacles may best be accomplished by cratering and ground shock effects.

- b. The type of soil in the area affects the

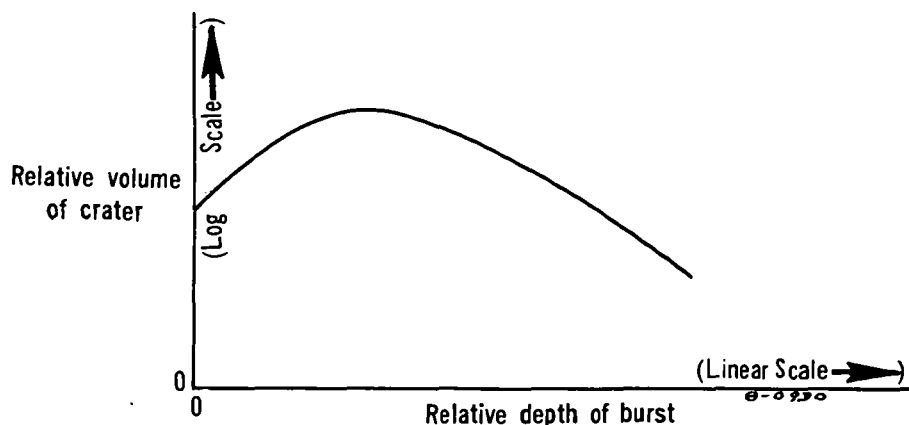


Figure 2-5. The size of the crater varies with the depth of burst for a given weapon.

size of the crater because different soils have different densities and cohesive characteristics. As the depth of burst increases, the size of the crater increases to a maximum, then decreases (fig. 2-5). It is normally impractical to deliver or emplace weapons deep enough to produce craters significantly larger than those produced by a surface burst, unless existing tunnels or mines can be used for emplacement of the weapons; however, even shallow burial will enhance crater dimensions over those resulting from a surface burst. Atomic demolition munitions (ADM) may, however, be deliberately emplaced in previ-

ously prepared positions that maximize their effectiveness.

c. The shock wave produced by the nuclear detonation is transmitted through the surrounding earth, the degree of transmission being dependent on the soil characteristics. In general, ground shock is attenuated much more rapidly than is airblast. As a result, the distance to which militarily significant damage to an underground target extends normally is not great. Because the repair of underground structures and utilities is difficult, moderate damage may be sufficient to satisfy the tactical requirement.

Section III. THERMAL RADIATION

2-12. General, Definition and Description

a. Thermal radiation is the heat and light produced by the nuclear explosion. The instantaneous release of an enormous quantity of energy in a very small space results in the attainment of an initial temperature at the center of the fireball that ranges into the millions of degrees. This center temperature rapidly falls as the fireball expands and energy is transmitted to the surrounding medium. It is a phenomenon of nuclear weapons detonated in the atmosphere that thermal energy is emitted in two distinct pulses. Figure 2-6 represents relative rate of delivery of thermal energy as a function of time.

b. The *first* pulse is not militarily significant, because the energy emitted during this time consists primarily of X-ray and ultraviolet radiations. These are readily attenuated in air and do not travel beyond the distances within which other effects predominate.

c. The energy emitted during the second pulse is visible light and infrared radiation. This energy extends to great distances and is responsible for most of the thermal damage of military significance.

d. Approximately 20 percent of the total thermal energy is delivered by the time the second thermal pulse reaches its maximum

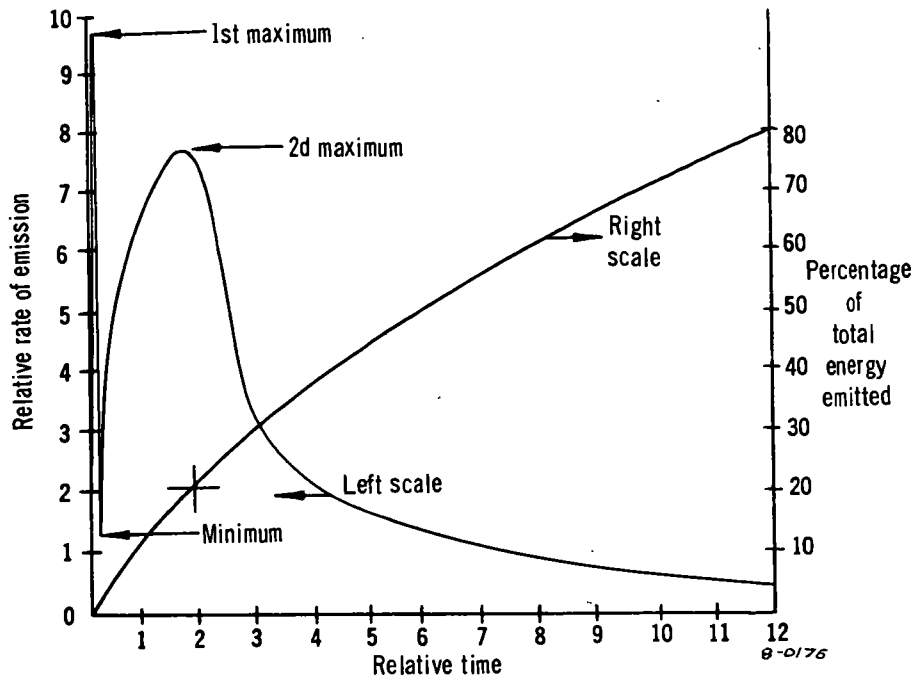


Figure 2-6. Thermal pulses.

emission rate. From the standpoint of protection against skin burns, evasive action must be taken prior to this time. The length of time over which the second pulse is delivered, and the time at which the second maximum occurs, increase with weapon yield, as follows:

Yield (KT)	Time to second maximum (seconds)
1	0.03
10	0.10
50	0.23
100	0.32
500	0.73
1,000	1.00
10,000	3.30
50,000	7.30

e. It is apparent from the data contained in d above, that it is virtually impossible to take evasive action to prevent skin burns from the smaller yield weapons.

f. The total quantity of thermal energy available is directly proportional to the yield for the same type weapon.

2-13. Characteristics

Within the atmosphere, the principal characteristics of thermal radiation are that it—

- Travels at the speed of light.
- Travels in straight lines.
- Can be scattered.
- Can be reflected.
- Can be easily absorbed or attenuated.
- Has an emission time that increases with yield.

2-14. Modifying Influences

a. *Weather.* Any condition that significantly affects *visibility* or the transparency of the air will significantly affect transmission of thermal radiation. Clouds, fog, snow, or rain absorbs thermal energy and causes a reduction in intensity as the thermal radiation passes through. Artificial smoke, depending on the concentration, can stop up to 90 percent of the thermal energy. On the other hand, clouds above the burst may reflect thermal radiation on the target in addition to that which is received directly.

b. *Terrain.* Large hill masses, trees, or any opaque object along the fireball-to-target line

may provide some protection to a target element. Trucks, buildings, or even another individual may protect an individual from thermal radiation. Foxholes provide good protection. However, personnel protected from direct line-of-sight radiation from the fireball may receive thermal injury because of reflection from buildings or other objects. Good reflecting surfaces, such as water, snow, or smooth sand, may reflect heat on the target and intensify the thermal radiation effect. Even the backs and sides of open foxholes will reflect thermal energy. The reflection capability of typical foxhole materials varies from 8 percent for wet black soil to 93 percent for snow. Because of atmospheric scattering and foxhole reflections, thermal casualties may be caused at a greater range than can be casualties from other effects. It is extremely difficult and unreliable to predict enemy *casualties* from thermal effects.

c. Height of Burst. The amount of thermal energy produced by a nuclear detonation is essentially the same whether the weapon is burst in the air, on the surface, or underground. However, the target area will receive maximum thermal effect from an airburst, provided there is no shielding or attenuation of the radiation. For surface bursts, the target receives only about one-third the thermal energy it would receive from an airburst. No significant amount is received from a subsurface burst.

2-15. Target Response to Thermal Radiation

a. General. Essentially all of the thermal radiation *absorbed* by a target element is immediately converted into heat and may cause injury, damage, or even ignition of combustible materials.

b. Personnel. Personnel are extremely vulnerable to the effects of thermal radiation. They can be dazzled by the light or burned by the heat. Burns have greater tactical significance than does dazzle. Burns are classified as follows:

- (1) *First-degree burns*—redness of the skin (like moderate sunburn).

- (2) *Second-degree burns*—blistering of the skin.
- (3) *Third-degree burns*—charring of skin and tissue beneath the surface of the skin.

c. Casualties. The severity, location, and size of the burn determine whether personnel become casualties. Second- and third-degree burns are considered to produce casualties; first-degree burns do not.

d. Visual Effects. The flash of light produced by a nuclear explosion is many times brighter than the sun. This light can dazzle personnel or produce permanent retinal burns. These effects can be produced at greater distances from the burst than can skin burns. Sufficient thermal energy arrives so fast that reflex actions, such as blinking, give only limited protection.

- (1) Dazzle (flashblindness) is a temporary loss of vision.
 - (a) Dazzle from a burst during daylight hours persists for about 2 minutes. Only the personnel facing directly toward the burst or a reflective surface can be dazzled.
 - (b) At night, dazzle affects almost all personnel in the target area. Recovery may be expected within 10 minutes in personnel facing the burst and within about 3 minutes in all others.
- (2) Loss of night vision persists for longer periods. Recovery of night adaptation may be experienced in as little as 15 minutes, depending on the level of visual thermal energy received.
- (3) Retinal burns are painless, but they result in permanent blindspots. A 20-kiloton weapon has produced retinal burns 15 kilometers from the burst. Retinal burns can be sustained only when the fireball is within the field of vision. The chance that individuals will be looking directly at the fireball is small. Thus, retinal burns are considered tactically insignificant.

e. Forest Fires.

- (1) Whether fires of consequence will be started depends on availability of forest fuels, tree canopy, season and recent weather (hot, dry, wet), wind and humidity, and topography (steep or level terrain).
- (2) Forest fuels are generally a mixture of dry (surface litter, fallen branches, dead leaves, and dry grass) and green (living branches, green grass, and other living foliage) fuels. Thermal radiation does not normally ignite green fuels. However, the dry fuels can ignite and cause the burning of the green fuels.
- (3) The tree canopy smokes and chars but does not ordinarily sustain ignition. The tree canopy materially reduces or eliminates the exposure of the ground surface to radiant energy. Ignition occurs on the ground in open areas.

f. Fires in Urban Areas. There are two general ways in which fires can originate in a city hit by a nuclear weapon—

- (1) Ignition by direct thermal radiation of fuels such as paper, trash, window curtains, dry grass or leaves, and dry-rotted wood.
- (2) Indirect effect of the destruction caused by the blast wave. Fires can be started by upset stoves, electrical short circuits, and broken gaslines.

g. Secondary Fires. Secondary flame burns may occur from ignition of clothing. In areas where fires are likely to result from the detonation, large numbers of burn casualties may occur among individuals trapped in the wreckage of burning buildings or in forest fires. Individuals in shelters may die of asphyxiation even though otherwise protected from the other casualty-producing effects.

2-16. Military Significance of Thermal Radiation

a. Although personnel can be burned at great distances from the burst, thermal radiation usually cannot be depended on to produce the casualties desired on the battlefield. For this reason, thermal radiation is not considered in estimating damage to enemy forces.

b. In considering the safety of friendly troops, thermal radiation as well as the other effects must be considered. Second-degree burns will generally produce combat ineffectives.

c. Dazzle during daylight is not generally an important consideration. However, at night, dazzle and loss of night vision may reduce combat effectiveness. Normal limits of visibility for three atmospheric conditions are shown below.

Atmospheric condition	Visibility (km)
Clear -----	50
Haze -----	10
Fog -----	2

Section IV. INITIAL NUCLEAR RADIATION

2-17. General

a. Initial nuclear radiation is defined as that nuclear radiation which is emitted by a nuclear explosion within the first minute after the burst. The nuclear radiation emitted after 1 minute is "residual radiation." A discussion of residual radiation is contained in chapter 5.

b. Nuclear radiation consists of a flow of

particles such as neutrons, alpha and beta particles, and electromagnetic energy such as gamma (X-ray) radiations. In the fission and fusion reactions that lead to a nuclear explosion, gamma rays and neutrons are emitted. The radioactive decay of the fission products commences immediately, producing beta particles and gamma radiation. Fusion reactions do not produce appreciable amounts of residual radioactive products in comparison to

those produced by the fission reaction that is required to initiate the fusion reaction. The fission reactions produce large amounts of radioactive products.

c. The alpha and beta particles have an extremely limited range in air, have little ability to penetrate, and are of little significance unless the emitters come in contact with the skin or are inhaled or ingested. The neutrons and initial gamma radiation are highly penetrating. Because of the range to which each of these travels, the neutrons and gamma rays are the chief initial nuclear radiation casualty producers. Thus, in initial nuclear radiation, neutrons and gamma radiation are of concern, and the alpha and beta particles are disregarded.

2-18. Units of Measurement

a. For scientific and technical reasons, nuclear radiations are measured in a variety of units, to include the "roentgen" (r), "roentgen equivalent physical" (rep), "roentgen equivalent man" (rem), and the "rad." For practical military use, all types of radiation are measured in "rad." This unit of measurement is used interchangeably with, and in lieu of, the other units previously mentioned.

b. The *rad* is a unit of measurement of the absorbed dose of radiation.

2-19. Characteristics of Initial Nuclear Radiation

a. The principal characteristics of initial nuclear radiation are—

- (1) It travels at about the speed of light.
- (2) It travels essentially along straight lines, although a major portion of the total radiation is scattered within the ranges normally of interest.
- (3) A portion is absorbed by the atmosphere through which it passes.
- (4) It has high penetrating power.

b. The gamma rays travel at the speed of light. Neutrons travel more slowly, but still at an extremely fast rate. Most neutrons are

emitted in less than 1 second after the burst. The initial gamma radiation is received by a target over a period of time, depending on weapon yield. With low-yield weapons, this time is extremely short. With weapons in the megaton range, the time is long enough so that it may be possible to avoid some of the radiation. For example, dropping into a fox-hole immediately upon sensing the flash of light could allow a person to escape up to 50 percent of the initial gamma radiation he would otherwise have received from a high-yield burst.

c. Initial nuclear radiation travels in a straight line. Neutrons and gamma rays collide with nuclei of the medium through which they pass and are scattered in different directions. This scattering effect is so great in the target area that nuclear radiation travels in all directions. Thus it is difficult to get complete protection from scattered nuclear radiation.

2-20. Modifying Influences

The amount of gamma and neutron radiation received by a target depends primarily on the yield of the weapon used. However, other factors help determine the amount.

a. *Weather.* For a given weapon, the range for various quantities or doses of initial nuclear radiation is affected primarily by the relative air density. The denser air at sea level absorbs more radiation than does the thinner air at high altitudes. As the altitude of the burst increases, the relative air density is decreased and initial nuclear radiation travels farther. No other atmospheric phenomenon affects initial nuclear radiation so markedly.

b. *Terrain.* Target terrain may significantly influence initial nuclear radiation. Minor terrain irregularities, such as ditches, gullies, and small folds in the ground, offer a little protection. Major terrain features between individuals and the burst, such as large hills and mountains, provide almost complete protection from initial nuclear radiation. Forests provide negligible protection.

c. *Height of Burst and Target Elevation.*

- (1) *Height of burst.* See *a* above. For surface and subsurface bursts, the initial radiation is sharply attenuated through the absorption of radiation energy by the matter nearby or surrounding the burst.

- (2) *Target elevation.* The radiation received by a target is greater when it is above the terrain than when it is on the surface. Targets such as personnel in aircraft, 100 meters or more above the terrain, may receive as much as 1.5 times the dose they would receive on the surface at the same distance from the burst.

d. Weapon Design. In general, the larger the yield of the weapon, the larger the dose of initial nuclear radiation received at a given slant range. Weapon design or configuration and yield greatly influence the neutron and gamma ray portions of the dose.

2-21. Shielding and Attenuation

a. One of the factors influencing the amount of radiation received by a target is the shielding that may exist between the detonation and the target. Any material will absorb some nuclear radiation. Because of the high penetrating power of neutrons and gamma rays, considerable thickness of intervening material or very dense material are required to provide significant protection to personnel. Dense materials, such as lead, offer excellent protection against gamma rays. Readily available materials such as water or concrete offer the best protection against neutrons. Soil is a fair neutron shield. Generally, sufficient material to protect against gamma rays will protect against neutrons from the same source unless that material is extremely dense.

b. The dose received by a man inside a building, a tank, or a foxhole is less than that which he would receive if he were in the open at the same distance from the ground zero. How much less depends on how much radiation is absorbed or attenuated by the intervening material. The ratio of the dose *inside*

the shielding material to the *outside* dose is called the transmission factor and is used to calculate the dose received through the shielding material, as follows:

$$\text{Transmission factor} = \frac{\text{dose inside}}{\text{dose outside}}$$

c. Transmission factor tables contained in FM 101-31-2 and chapter 18, FM 101-31-3 show the approximate transmission factors for neutron, initial gamma, and residual radiation for different conditions of protection. These factors represent the percentage of the outside dose received by the shielded target.

2-22. Target Response to Initial Nuclear Radiation

(This paragraph is based on STANAG 2083.)

a. General.

- (1) Personnel are most vulnerable to initial nuclear radiation. The response of an individual to nuclear radiation depends on several factors, including—
 - (a) The total dose accumulated from previous radiation exposure.
 - (b) The periods over which the doses are received.
 - (c) The periods of recuperation between radiological exposure.
 - (d) The physical condition, sex and age of the individual at the time of the radiological exposure.
 - (e) The presence or absence of any additional injuries.
- (2) The total amount of initial and residual nuclear radiation received (gamma radiation and neutrons) is called the total dose.
- (3) An "acute dose" is the total dose received all at one time or accumulated over a short period of time. There is little difference in the effect on an individual when he receives a total dose all at one time or the same total dose, in small increments, over a period of about 24 hours. For

this reason, any total dose received within 24 hours is considered an acute dose. It is emphasized that acute dose, as used in this manual, dose not imply severity or criticality; the term is used exclusively to connote the time within which the dose is received. A "chronic dose" is the total dose received over a longer period of time.

- (4) The time it takes for a previously unexposed individual in good health to sicken or to die depends primarily on the total dose received and on individual body tolerances. Some individuals are stronger and more resistant than others, and some will have partial body shielding. To produce the same biological effect on these individuals requires a larger total dose.
- (5) Some experimental data indicate that the human body may be capable of repairing most, but not all, of the damage resulting from radiation.

b. Personnel.

(1) *Biological response of personnel.*

- (a) Exposure of the whole body, or of a large part of it, to sufficient amounts of penetrating ionizing radiation causes radiation sickness and death. Because of limited experience, and individual body tolerances, it is impossible to predict the effect on an individual from a specified dose of radiation. However, the average effect on a large group may be predicted with enough accuracy for military purposes.
- (b) All radiation is potentially harmful and should be avoided. Tactically, it may be necessary to accept some radiation exposure. Nevertheless, the commander should appreciate the *significance of the exposure and weigh this carefully against any immediate or*

short-range advantage he may gain (para 5-6).

- (c) Table 2-1 shows the expected response of humans to radiation. The data in this table are based on the following assumptions:

1. The individuals are healthy, rested, and well-fed.
2. They have had no previous exposure.
3. Their whole bodies have been exposed to radiation.
4. They have received an acute dose (either initial or residual).
5. They have received no other injuries.

- (2) *Casualties.* Quantitative total doses from nuclear radiation have been given the following qualitative meanings in the remainder of this manual:

- (a) *5,000 rad.* Immediate casualties.
- (b) *3,000 rad.* Casualties within 1 hour. This criterion was used in the computation of the coverage tables and is referred to as "prompt casualties."

- (c) *650 rad.* Casualties within a few hours. This criterion was used in the computation of the coverage tables and is referred to as "delayed casualties."

- (3) *Recovery.* Recovery from radiation injury is uncertain for humans. Experimental evidence indicates that the body recovers very little in the first 30 days and damage to blood-forming tissues may not be fully repaired after a year. The consequence of doses up to a few hundred rad in a month or less is not well understood in terms of how such doses might influence a unit's combat effectiveness. Damage to white blood cells occurs at very low radiation levels and increases rapidly with increasing radiation intensity. One result of low white-blood-cell count is

Table 2-1 Biological Response to Nuclear Radiation

<i>Estimated exposure range (rads)</i>	<i>Initial symptoms</i>	<i>Onset of symptoms</i>	<i>Incapacitation</i>	<i>Hospitalization</i>	<i>Duration of hospitalization</i>	<i>Final disposition</i>
50 to 200.....	None to transient mild headache.	Approximately 6 hours after exposure.	None to slight decrease ability to conduct normal duties.	Hospitalization required for less than 5 percent in upper part of exposure range.	45 to 60 days in upper part of range.	Duty. No deaths anticipated.
200 to 500.....	Headaches, nausea, and vomiting; malaise. Symptoms not relieved by antiemetics in upper part of exposure range.	Approximately 4 to 6 hours after exposure.	Can perform routine tasks. Sustained combat or comparable activities hampered for period of 6 to 20 hours.	Hospitalization required for 90 percent of exposed personnel in this range. Hospitalization follows latent period of 17 to 21 days' duration.	60 to 90 days.....	Some deaths anticipated; probably less than 5 percent at lower part of range, increasing toward upper end.
500 to 1,000.....	Severe and prolonged nausea and vomiting; difficult to cure. Diarrhea and fever early in upper part of exposure range.	Approximately 1 to 4 hours after exposure.	Can perform only simple, routine tasks. Significant incapacitation in upper part of exposure range; lasts more than 24 hours.	Hospitalization required for 100 percent of exposed personnel. Latent period short, 7 to 10 days in lower range to none in upper range.	90 to 120 days for those surviving.	Approximately 50-percent deaths at lower part of range, increasing toward upper end; all deaths occurring within 45 days.
Greater than 1,000..	Severe vomiting, diarrhea, and prostration.	Less than 1 hour after exposure.	Progressive incapacitation, following an early capability for intermittent heroic response.	Hospitalization required for 100 percent of exposed personnel. No latent period.	3 to 30 days.....	100 percent deaths occurring within 30 days.

an increased susceptibility to secondary infection, which, on the septic battlefield, would greatly complicate treatment of normal injuries. In addition, certain portions of the radiation damage may be irreparable.

★(4) *Repeated exposure.* On a nuclear battlefield, units will probably be exposed regularly (i.e., at least several times a month) to some degree of radiation risk from friendly as well as from enemy nuclear weapons. 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 nonsymptomatic doses. To assist the commander, friendly units are divided into three categories based on previous exposure history. Criteria for each category are given in table 2-2.

(a) *Radiation status—1 (RS-1).* RS-1 applies to a unit that has no dose or has a militarily negligible radiation exposure history (total dose of less than 75 rad).

(b) *Radiation status—2 (RS-2).* RS-2 applies to a unit that has received a significant but not a dangerous dose of radiation. This category may include a dose range in which most personnel are just below the sickness threshold (however, some sickness may be expected). If the situation permits, units in this category should be exposed less frequently and to smaller doses than RS-1 units.

(c) *Radiation status—3 (RS-3).* RS-3 applies to a unit that has already received a dose of radiation which makes further exposure dangerous. In other words, this unit should be exposed only if unavoidable because additional exposure in the immediate future would result in sickness and probably some deaths.

c. *Materials.* Most material objects are unaffected by initial nuclear radiation. However,

★Table 2-2. Dose Criteria for Placing Units in Radiation Status Categories

Radiation status category	Numerical criteria total cumulative dose (rad)
RS-1	Less than 75
RS-2	75-150
RS-3	Greater than 150

photographic and X-ray films are rendered useless by exposure to only small quantities of radiation. Some types of communications equipment may be temporarily or permanently damaged by exposure to relatively large amounts of radiation.

2-23. Summary of Military Significance of Initial Nuclear Radiation

a. Initial nuclear radiation effects may often produce casualties among personnel protected from blast and thermal effects.

b. 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 significantly reduce combat effectiveness for a long period of time.

c. Troop safety is a major consideration as far as nuclear radiation is concerned. Adequate protective shielding is difficult to acquire. It is reasonable to assume that friendly personnel and the enemy will receive repeated doses of nuclear radiation. The size and frequency of doses received in past operations, the extent of recovery of damage (this is an unknown factor and will not be considered in assessments of troop radiation status), and the urgency of the tactical situation will, among other things, determine the degree to which friendly troops can be exposed during a nuclear attack.

Section V. COMBINED EFFECTS AND SPECIAL CONSIDERATION

2-24. Combined Effects

a. A person may receive some injury from blast or thermal radiation that is insufficient to make him ineffective, and he may receive a dose of nuclear radiation that, by itself, will not cause ineffectiveness. However, the combination of these effects may cause him to become a casualty. Nuclear radiation can delay the healing of wounds and

burns and can increase the possibility of complications.

b. While there will be many casualties from combined effects, such as outlined above, estimating these casualties is difficult. In arriving at his recommendation as to the weapon and yield to be used, the nuclear weapon employment officer bases his estimation of dam-

age on the governing casualty-producing effect. When a weapon is employed, contingent effects, such as induced contamination, some probability of fallout, smoke, fire tree blow-down, and damage to industrial or urban areas, are considered. These contingent effects may be considered as a bonus or they may be unacceptable from an operational standpoint. In either event, the commander must be informed of their existence.

2-25. Arctic Environment and Extreme Cold

a. General. Nuclear weapon effects are altered by ice, snow, high winds, and low temperatures. General knowledge of the alterations to individual effects is essential so that sound operational decisions may be made.

b. Blast.

- (1) *Effect of low temperatures on blast radii.* At temperatures about -45°C (-50°F), damage radii for materiel targets such as tanks, artillery, and military vehicles can increase by as much as 20 percent. If the temperature in the target area is known to be -45°C (-50°F) or colder, the validity of the estimate of damage might be increased somewhat by the inclusion of a 20-percent increase in the radii of effect for *drag-type targets*.
- (2) *Surface reflectivity.* As indicated in paragraph 2-8b, reflecting surfaces, such as ice, snow, and water, increase the distance to which given static overpressures extend and decrease the distance to which given dynamic pressures extend. Muskeg and tundra decrease the distances to which given overpressures extend, and probably increase the distances to which given dynamic pressures extend. Areas of extremely irregular and broken ice-caps, even though ice and snow, affect blast waves in a manner similar to muskeg and tundra. The effects of surface reflectivity are not considered in target analysis.

(3) *Contingent effects.* The cratering effect in ice and frozen soil is similar to the cratering effect in solid rock, however the crater size will probably be larger than that in rock. Crater dimensions in soil covered with deep snow are reduced.

(4) *Trafficability.* The following considerations affect the planning of movements:

- (a) Shock of blast disturbance of permafrost may reduce trafficability.
- (b) Nuclear weapon effects may interfere with movement over frozen waterways and, in the spring, cause a spring breakup.
- (c) Nuclear weapon effects may produce avalanches in mountainous areas in appropriate seasons.

c. Thermal. While thermal effects normally are not considered in selecting the governing effect, a significant adjustment may be required in troop safety distances in the arctic.

- (1) In conditions of extreme reflectivity (e.g., snow, ice, clouds), coupled with good visibility, the minimum safe distances (para 3-7 and 4-6) for unwarned, exposed and for warned, exposed personnel are increased by 50 percent.
- (2) There will be some increase in the numbers of unwarned personnel suffering a loss of visual acuity, particularly at night.
- (3) Because of the materials habitually used for clothing, personnel in the arctic environment may be less vulnerable to thermal effects. In addition, the cold temperatures reduce thermal effects to most materials. A frost covering on combustible materials reduces their susceptibility to thermal damage. Surface fires in dry tundra grasses may occur.

d. Nuclear Radiation.

- (1) At very low temperatures, the atmospheric density increases to such an

extent that as much as a 25-percent reduction can be expected in the distances to which significant levels of nuclear radiation extend. If the temperature in the target area is known to be -45°C (-50°F) or colder, the estimate of casualties among protected personnel is more valid if the radius of damage for casualties, due to radiation, is reduced by 25 percent.

- (2) The seasonal occurrence of extended periods of high winds in arctic areas may greatly extend fallout areas. A corresponding reduction of dose rates close to the ground zero may be expected as a result of the increased distribution. Further, falling or wind-driven snow may create areas of high concentration. Associated with the high concentration, winds may be expected to clear effectively some areas of fallout contamination.
- (3) Where the earth's surface is covered with ice or snow, there is some reduction in the induced radiation activity in the underlying soil. A detonation over a thick ice and/or snow cover could result in essentially no significant induced radiation.
- (4) Large, poorly drained areas and frozen soil of low permeability limit the natural flushing of radioactive material.

e. Other Considerations.

- (1) The time required for subsurface shelter construction and the increased use of above-surface shelters generally increase the vulnerability of troops in the field to nuclear weapon effects. When shelters are constructed underground, they usually are more resistant to weapon effects than is similar construction in temperate climates. However, because frozen soil and water are excellent transmitters of ground shock, these underground structures are more susceptible to damage than similar structures in temperate climates.

- (2) Because logistical problems are greatly increased in the arctic, most types of supply are critical. Loss of supplies because of nuclear detonations will have a greater impact on arctic operations than will a similar loss in nonarctic areas.
- (3) The increased susceptibility of personnel to injury, with coincident difficulties of medical care, enhances the effects of a nuclear detonation in arctic operations.

2-26. High-Altitude Effects

As described in paragraph 2-20, the decreasing air density associated with increasing altitude provides a burst environment for nuclear weapons that can greatly alter effects. The amount of thermal radiation received by an aircraft varies widely with atmospheric conditions, orientation of the aircraft with respect to the burst, the ground-reflecting surfaces, and the clouds. Scatter and reflection may result in an aircraft receiving two or three times the thermal radiation received by a target on the ground. Conversely, when a heavy cloud layer is between the burst and the aircraft, the thermal radiation received may be negligible. Nuclear radiation is propagated to greater ranges at higher altitudes. Blast effects are decreased due to the decreased density of the surrounding medium. Nuclear bursts at high and extremely high altitudes also cause considerable problems with electromagnetic wave propagation types of communications (see DA Pam 39-3).

2-27. Validity of Effects Data

As discussed in paragraph 2-3, nuclear weapon testing has produced the effects data on which target analyses are based. Although TM 23-200 presents the validity factors associated with the data for each effect, the validity of effects data is not considered in the target analysis procedures described in chapter 3, in appendix B, and in tables in this manual. The target analyst should realize that errors in effects data accuracy exist and that

these errors may be quite gross. Refinement of the data, or precision in using the data, greater than that indicated in the outlined procedures, is not justified. Since variations in effects of weapons when used in a tropical

environment are not as pronounced as those caused by an arctic or high altitude environment, no special discussion of the tropical environment modification of the effects is included in this manual.



CHAPTER 3

TARGET ANALYSIS

Section I. GENERAL

3-1. Factors Considered in Target Analysis

(This paragraph is based on SOLOG No. 89.)

a. General.

(1) In the general sense, target analysis is defined as the examination of targets to determine the capabilities of available weapon systems for the attack of such targets (see AR 310-25 for complete definition). With respect to the employment of nuclear weapons, it is the process used to select the appropriate weapon system that will meet the commander's requirements, within the knowledge available. This chapter discusses, in general terms, the procedures for target analysis. Appendix B presents detailed techniques for the use of target analysis.

(2) It is important that an estimate be made of the results to be expected from a nuclear attack. Usually, this will include what fraction of the target area is expected to be covered by the weapon effects. Nuclear weapons usually are employed on a one-shot basis; even if more than one weapon is used, there is only one weapon for each desired ground zero. Unlike other fires, in which distribution over the target area is obtained by firing many rounds and allowing the inherent delivery errors to place the rounds randomly throughout the target area, the effects of a nuclear weapon on the target will vary, depending on the delivery errors of the single round. Consequently, it is necessary to make an estimate of the results on the target based on the relationship among the characteristics of the target, the effects of the weapon measured by its radius of damage, and the delivery errors. The estimation of the results usually is expressed as a fraction or a percentage of the target. When 30 percent of the target is covered by the particular radius of damage, it is expected that 30 percent of the target will be destroyed. Figure 3-1 shows this relationship.

b. *Assumptions.* Target analysis is based on the following assumptions:

(1) *Reliability.* Casualty and damage estimation is predicated on the assumption that a nuclear weapon *will arrive at the target area at the desired time and a nuclear detonation will take place.* Because many delivery systems do not provide a high assurance of successful delivery, it may be desirable to provide an alternate means to attack the target in the event the first weapon fails to function properly. This alternate means may be another nuclear weapon, nonnuclear firepower, or maneuver forces, depending on the nature and importance of the target and the alternate means available. This is discussed further in paragraph 3-10.

★(2) *Targets.* When intelligence indicates the size and shape of the target, and the distribution of elements within the target, these data are used by the target analyst. Otherwise, the target elements are assumed to be uniformly distributed, and the area is assumed to be circular. The radius of the target is based on the best information available.

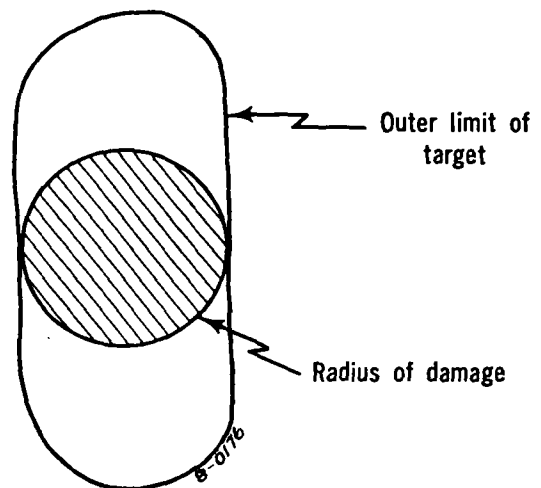


Figure 3-1. Relationship of target size and damage radius in damage estimation.

Should a sizeable error in the target radius exist, a situation similar to that discussed in paragraph B-II-4, annex B-II could result.

(3) *Atmospheric conditions.* The effect of atmospheric conditions on blast and radiation *usually* is not considered by the target analyst. In cases of heavy rain or snow in the target area, weapon effects radii will vary slightly from those listed in FM 101-31-2 and FM 101-31-3.

(4) *Terrain.* Nuclear effects may be modified by terrain extremes such as high mountains. If a weapon is burst in a valley, shielding of effects may occur outside the valley, with reinforced effects within the valley. No reliable system exists for modification of analysis in the field of weapon effects due to terrain considerations.

c. System Errors.

(1) *General.* Dispersion influences the selection of the desired ground zero (DGZ) and the desired height of burst. It also affects such factors as damage to the target, troop safety, fallout, tree blowdown, and induced contamination. Consideration is, therefore, given to delivery errors.

(2) *Effect of horizontal dispersion.*

(a) There is a dispersion pattern unique to each type of nuclear weapon delivery system. Cannon and rocket artillery form a generally elliptical pattern, whereas guided-missile rounds and air-delivered weapons form a circular pattern (fig. 3-2). Because nuclear target analysis is premised on a "single shot," it is assumed that the distribution of errors connected with nuclear delivery systems will follow the laws of probability. It is also assumed that gunnery techniques will place the center of the "dispersion pattern" at the desired ground zero.

(b) It is apparent that a burst occurring at the outer limits of the dispersion pattern will cause the center of the weapon effects to be offset from the desired ground zero. Because the desired ground zero usually is selected at the center of target, a burst near the outer limits of the dispersion pattern may result in a substantial decrease in the damage to the target. This emphasizes the need for post-strike analysis whenever possible.

1. Figure 3-3 shows a burst occurring at the center of the target. In this case, about 30 percent of the target is covered by the radius of damage.

2. Figure 3-4 shows a burst occurring at the outer edge of the elliptical dispersion pattern.

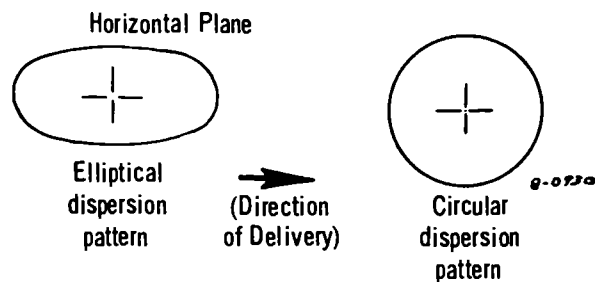


Figure 3-2. Horizontal dispersion patterns.

In this case, very little of the target is covered. Obviously, the size and shape of the target, the radius of damage, and the size and shape of the dispersion pattern affect the amount of the target that will be damaged by a single burst.

3. In considering this, the target analyst assumes that the burst will occur near the outer edge of the dispersion pattern and estimates the fraction (percentage) of the target covered by the weapon effect of interest. Under these circumstances, there is a high assurance that the weapon will cause *at least* that fraction of damage.

(3) *Effect of vertical dispersion.* The burst pattern in the air formed by a large number of weapons set with a timer fuze to detonate at the same height of burst, and delivered under nearly identical conditions, is ellipsoidal (egg shaped). The height-of-burst distribution pattern extends above and below the desired height of burst (fig. 3-5). It is apparent that a large vertical error may result in a burst occurring a significant distance

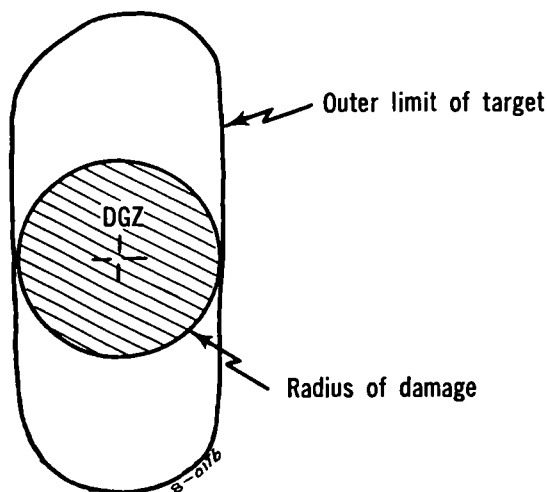


Figure 3-3. Burst occurring at the center of the target.

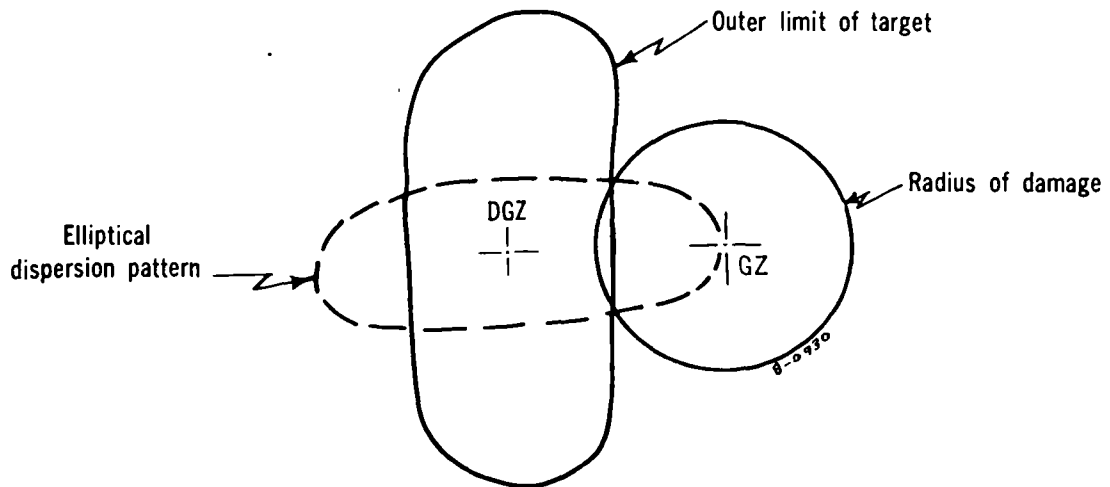


Figure 3-4. Burst occurring at the outer limit of the dispersion pattern.

above or below the desired height. In such cases, the weapon may detonate close enough to the surface to produce fallout or so high in the air that the effects on the target will be significantly reduced. Consequently, vertical dispersion (PEh) is considered in selecting a height of burst. Radar fuzes greatly reduce the problem of vertical dispersion, as shown in figure 3-6.

★ *d. Target Location Errors.* Each target acquisition means has an associated target location error. This error may vary within the same type of equipment due to operator interpretation of data or to individual equipment variations. The evaluation of the extent of the error and the gross effect this error has on the analysis of the target can be determined only by the target analyst and the intelligence officer through field experience. This is discussed further in paragraph B-II-4, annex B-II.

3-2. Data for Target Analysis

(This paragraph is based on SOLOG No. 89.)

a. Tables in FM 101-31-2 and FM 101-31-3 present the data to be used in target analysis. The basic tables are referred to as weapon selection tables (WST). The weapon selection tables consist of coverage tables, safety distance tables, and effects tables. Examples of these tables are included in appendix B.

b. The coverage tables present the information with which to estimate damage. A set of indexes is presented that simultaneously considers delivery errors, weapon effects, and target size and composi-

tion. For a given target category, yield, and delivery system with a known range and height-of-burst option, the index gives an estimate of the damage that can be expected from the attack. Coverage tables also present the radius of damage (para 2-3) for each range and height-of-burst option. The indexes and radii of damage have been computed using the casualty- or damage-producing effect that extends the greatest distance. This effect is referred to as the *governing effects*.

c. The *safety distance tables* simultaneously consider delivery errors and weapon effects in evaluating the "limiting requirements" which may be imposed on the use of nuclear weapons. These limiting requirements are imposed to avoid undesirable effects caused by nuclear weapons in the form of casualties to friendly troops; creation of obstacles to movement, to include fire areas; damage to installations desired for the use of friendly troops, such as bridges and buildings; and damage to friendly light aircraft in flight. The tables give the minimum distances that friendly troops; light aircraft; installations; and, in the case of preclusion of obstacles to movement, the critical area must be separated from the desired ground zero. In the case of troop safety, this distance is called the minimum safe distance (MSD) and is given for various conditions of risk and vulnerability. In the other cases mentioned, it is called the *least separation distance* (LSD). (Annex B-III, appendix B contains a detailed description of limiting requirements.)

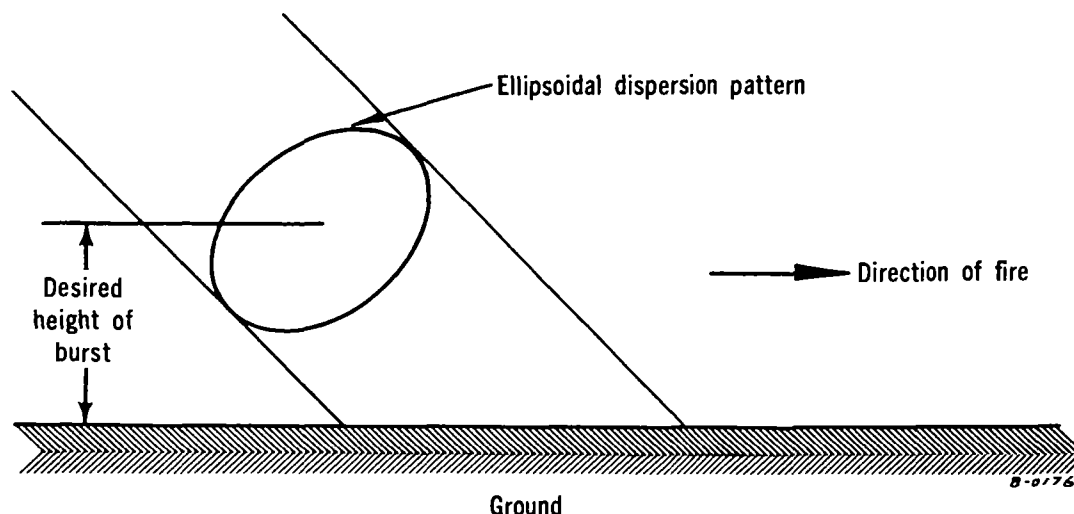


Figure 3-5. Timer fuze vertical dispersion pattern.

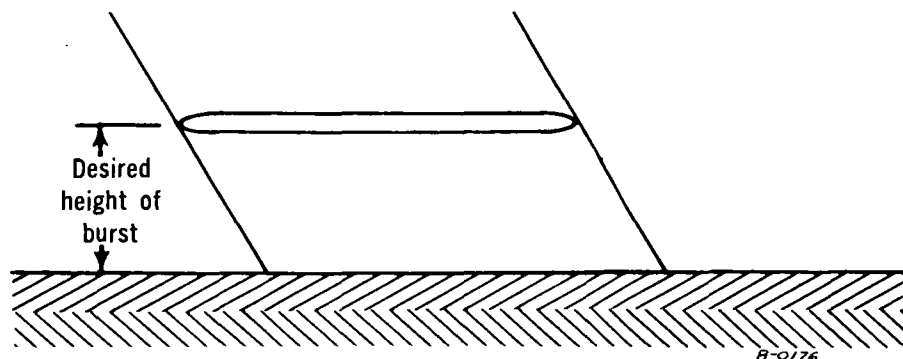


Figure 3-6. Radar fuze vertical dispersion pattern.

(1) In the troop safety portion of the tables, these minimum safe distances are shown for each—

- (a) Delivery system.
- (b) Yield.
- (c) Height-of-burst option.
- (d) Degree of risk to friendly elements.
- (e) Condition of protection (or vulnerability) of friendly troops.
- (f) Range increment (for range-dependent systems).

(2) In the preclusion-of-damage portion of the tables, the least separation distances are shown for preclusion of damage to—

- (a) Fixed bridges.
- (b) Buildings.

(c) Light aircraft in flight.

(3) In the preclusion of obstacles portion of the tables, the least separation distances are shown for preclusion of obstacles caused by—

- (a) Tree blowdown.
- (b) Fires.

d. The *effects tables* consider only weapon effects and height of burst. For each weapon, radii of damage for use against various target elements are shown.

3-3. Recommendations

A target analysis is conducted to select the best weapon for attack of a target. After the target analysis has been completed, a recommendation is

presented to the commander. The recommendation should include the following information:

- a. Weapon system.
- b. Height-of-burst option.
- c. Desired ground zero.

d. Time of burst.

e. Estimated results.

f. Troop safety.

A detailed description of each of the elements above is contained in appendix B.

Section II. TECHNIQUES FOR TARGET ANALYSIS

★ (This section is based on SOLOG No. 89.)

3-4. General Procedure for Analyzing Targets

The following general procedures are used by the target analyst. The detailed steps, to include examples, are contained in appendix B.

a. The target analyst identifies the pertinent portions of the organization's standing operating procedure (SOP) and becomes familiar with the special guidance expressed by the commander. He determines information concerning allocations, authority to expend, and available weapon systems as well as target information, such as shape, vulnerability, size, distance to friendly troops and their radiation exposure status, ranges to the available delivery means, and the limiting requirements (app B).

b. He determines data for—

(1) Damage estimation, to facilitate his determining whether to use the *index method*, the *visual method*, or the *numerical method* (fig. 3-7). He considers point targets and area targets in damage estimation.

(a) A *point target* is defined as a target with a single target element (e.g., a bridge (span) or a building).

(b) An *area target* is defined as a target with multiple target elements distributed over a definable area. (In this context a troop unit, vehicle park, or other such target would not be considered a target element even though it may be part of a larger defined target.)

(2) Limiting requirements, as they pertain to troop safety and damage and obstacle preclusion.

(3) The selection of the most beneficial desired ground zero, taking into con-

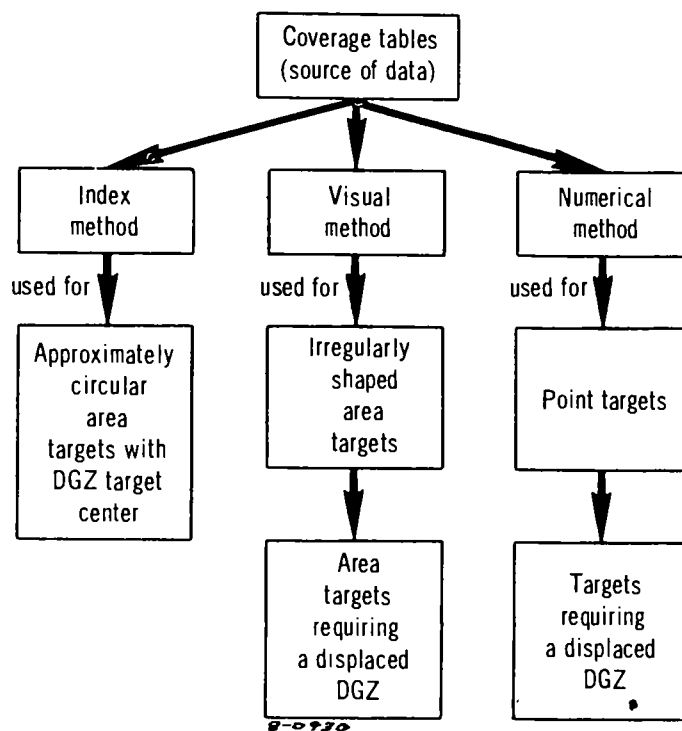


Figure 3-7. Methods of damage estimation.

sideration the limitations of (2) above.

- (4) Final evaluation of coverage of the projected target with the weapon systems available for use.

c. He evaluates the coverage of the projected target with the weapons available for use and the overall tactical situation in the area of interest.

d. He makes a recommendation for the commander's approval.

3-5. Expected Coverage for Area Targets

a. Damage to the target may be estimated, using any of the three methods mentioned in paragraph 3-4. If the target is circular, nearly circular, or can be assumed circular, and the desired ground zero used is at the target center, the index method is the most accurate and the most meaningful to use. If the target is irregularly shaped, the visual method is used. In other cases, either the visual or the numerical method may be used. A damage estimation chart is included in annex paragraph B-II-3, B-II, appendix B.

b. Unit SOP contain information regarding the extent of damage required for specific-type targets. The guidance in the SOP occasionally will be modified by the commander. The following information may be used as a guide in developing the SOP:

- (1) A *destroyed unit* is a unit that has been rendered *completely* ineffective. The unit will have lost command facilities, materiel, and many key personnel. The loss will be sufficiently extensive to require withdrawal from action, complete reorganization, replacement of many personnel, resupply, and extensive retraining. Any casualties and damage caused by thermal effect and missile effect are considered bonus effects. Bonus effects contribute to the effectiveness of the attack, but caution should be exercised in allowing these hoped-for bonus effects to influence the recommendation of the target analyst.

Field experience in the actual use of nuclear weapons will further clarify the application of bonus effects to the overall target analysis. Coverage of 30 to 50 percent of most combat units is *generally* sufficient to destroy the unit. However, care must be exercised in the use of the 30 percent figure, because the posture of the unit, its mission, and its operational equipment may dictate either *higher* or *lower* coverage figures for target destruction.

- (2) A *neutralized unit* is a unit that has been rendered incapable of *interfering* with a particular tactical operation. The unit will have lost some key personnel, command facilities, and materiel. The losses should be sufficiently extensive to require some local reorganization, improvisation of command and control facilities, minor repairs, and limited resupply to make the unit combat effective. Effects such as missile effect, thermal effect, and damage to communications and supply systems normally are considered bonus effects in the attack of troop units. The same cautionary statements concerning the influence of bonus effects on destruction of a unit apply to the expected neutralization of a unit. Coverage of 10 or more percent of a unit generally will be sufficient criterion to consider the unit neutralized, provided other factors are not overpowering.

3-6. Probability of Destroying Point Targets

Fractional coverage of a point target has no meaning; the target is so small that the target will be completely covered or completely missed by the radius of damage. Estimation of the damage to point targets, therefore, consists of determining the probability of the target receiving the desired degree of damage rather than estimating the fraction of the target to be covered. The probability of destroying a point target is a function of weapon effects, distance from DGZ to the point target,

and delivery error. The probability of destroying a point target is determined using the numerical method. This method uses graphs provided in FM 101-31-2 and FM 101-31-3. These graphs simultaneously consider weapon effect, the displacement (d), and delivery errors. Appendix B contains detailed instructions for point target analysis.

3-7. Troop Safety

a. In comparison with the use of nonnuclear weapons, the use of nuclear weapons in close tactical support involves a much greater degree of risk to the safety of friendly troops.

b. Troop safety may influence the selection of yield, the delivery system, the desired ground zero, the time of burst, and the scheme of maneuver. When the SOP or command guidance concerning troop safety cannot be met, the following actions may be taken:

- (1) Move the desired ground zero.
- (2) Use a more accurate delivery means.
- (3) Use lower yield weapons(s).
- (4) Withdraw troops.
- (5) Accept less coverage.
- (6) Accept a higher degree of risk of damaging friendly units.
- (7) Increase the protection of friendly troops.
- (8) Use other forms of combat power, such as nonnuclear fires or maneuver elements.

c. The nuclear weapon employment officer uses a minimum safe distance to make troop safety calculations. The minimum safe distance considers both delivery error and the distance to which certain weapon effects extend. The following definitions are used in determining the appropriate minimum safe distance:

- (1) There are three *degrees of risk* associated with troop safety considerations—*negligible*, *moderate*, and *emergency*.
 - (a) At a *negligible risk* distance, troops will receive less than a 5-

rad dose and are completely safe from militarily significant thermal effects. However they may experience a temporary loss of vision (dazzle). A negligible risk from exposure to nuclear radiation is possible only when an individual or a unit has an insignificant radiation-dose history, which will cause no decrement in combat effectiveness. An insignificant accumulated dose is interpreted to mean that blood changes probably will not be detectable. A negligible risk is acceptable in any case in which the use of nuclear weapons is desirable. *Negligible risk should not be exceeded unless significant advantage will be gained.*

- (b) A *moderate risk* condition normally is used only for those nuclear weapon yields where radiation is the governing troop safety criteria. 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 of 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 exposures, would constitute a significant radiation exposure history. A moderate risk is considered acceptable in close support operations; for example, to create a gap in enemy forward positions or to halt an enemy attack. A moderate risk should not be exceeded if troops are expected to operate at full efficiency after a friendly burst.
- (c) For *emergency risk* conditions, the anticipated effect on troops from a single exposure to a friendly weapon may result in some temporary shock, mild burns, and a few casualties; however, casualties should never be extensive enough

to neutralize a unit. An emergency risk from exposure to nuclear radiation occurs either when a unit has a radiation-exposure history that is at the threshold 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 threshold for combat ineffectiveness from radiation sickness. *An emergency risk should be accepted only when it is absolutely necessary*, and should be exceeded only in extremely rare situations that 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 explosion depends principally on the degree to which he is protected from the weapon effects. For example, a man who is well protected can safely be much closer to the ground zero than can be a man in the open. The degree of protection of the unit is considered in target analysis to be dependent on the amount of advance warning the unit has received. One or more of the following three conditions of *personnel 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 dazzle. For example, such a condition can be expected to prevail in an offensive situation when the majority of the attacking infantry are in the open and 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. For example, such a condition may prevail 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 assumed degree of protection is that protection offered to personnel who are in "buttoned-up" tanks or crouched in foxholes with improvised overhead thermal shielding. When only a lesser degree of protection is available (e.g., only tracked carriers are available), personnel cannot be considered warned, protected. The target analyst would consider such personnel as exposed. A warned, protected condition generally is expected to prevail when nuclear weapons are used in a preparation prior to an attack.

(d) It should be noted that there is no category for *unwarned, protected*. Although protection may be available to personnel, it cannot be assumed that they will be taking advantage of it unless they are warned of an impending burst. Procedures for warning friendly personnel are discussed in paragraph 4-6.

(3) For each *combination* of negligible and emergency degree of risk and condition of personnel vulnerability, there is an associated "risk distance" known as the radius of safety. It is the horizontal distance from the *actual* ground zero *beyond which* the weapon effects are acceptable. Because a round may burst at the end of the dispersion pattern nearest to friendly troops, a buffer distance is added to the radius of safety. The buffer distance provides a very high assurance (99 percent) that unacceptable weapon effects will not reach friendly troops. The size of the buffer distance is dependent on the horizontal delivery error at the applicable range. The sum of the radius of safety and the buffer distance is the minimum safe distance shown in the safety distance tables in FM 101-31-2 and FM 101-31-3. Although these tables contain the minimum safe distances for the various stated combinations of risk

Table 3-1. Yields for which Radiation is the Governing Troop Safety Criterion

Yield (KT)	Exposed		Protected
	Unwarned	Warned	Warned
Less than 8	Yes	Yes	Yes.
8-15	No	Yes	Yes.
16-200	No	No	Yes.
More than 200	No	No	No.

Note. Yes means that radiation is the governing criterion. No means that radiation is not the governing criterion.

and vulnerability, selection of an appropriate MSD is dependent upon whether or not radiation is the governing criteria.

d. Depending on weapon yield, the governing effect in establishing the minimum safe distance may be blast, thermal radiation, or initial nuclear radiation. For weapon yields in which nuclear radiation is the governing troop safety criterion (table 3-1), it is necessary that the unit's radiation-exposure history be considered. FM 3-12 discusses the procedures whereby unit radiation-exposure histories are determined and records maintained.

e. To consider a unit's radiation-exposure history properly, it is important that the quantitative meaning of the various minimum safe distances be understood insofar as nuclear radiation troop safety criteria are concerned. The following discussion refers to figure 3-8 and considers troops with no previous radiation exposure history.

(1) Line X represents the emergency risk MSD. For units located in area A, between the DGZ and line X, there is a very high assurance that these units will be exposed to more than 50 rad (an emergency risk). The assurance decreases as the distance from the DGZ to the friendly troops decreases. Such units are exposed to more than an emergency risk.

(2) There is a very high assurance that units located on line X or in area B will receive 50 rad or less and, therefore, will be exposed to no more than an emergency risk. Furthermore, units located in area B beyond a line visualized to be about midway between lines X and Y will receive no more than a moderate risk (20 rad or less).

(3) Following the same reasoning, there is a very high assurance that units located on line Y or beyond will receive 5 rad or less and, therefore, will be exposed to no more than a negligible risk. The risk to a unit located beyond line Y decreases with the increase in distance from the DGZ until at some point, not mathematically defined or tabulated in any manual, there is no longer any risk of radiation exposure.

☆f. When examining troop safety in connection with target analysis, table 3-1 must be examined to determine if the weapon field being investigated is within the 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 status must be ascertained and the appropriate Troop Safety Table consulted. The following procedures apply:

(1) RS-1 (Units with a past cumulative radiation dose of less than 75 rad). Road direct from the safety distance table for the appropriate weapon system contained in FM 101-31-3.

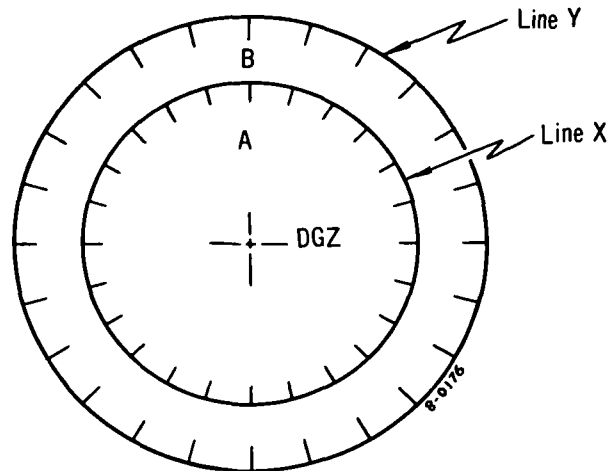
(2) RS-2 (Units with a past cumulative radiation dose of from 75 to 150 rad). For units in this category, any future radiation exposure must be considered a moderate or emergency risk. There can be no negligible risk for personnel in this category. When investigating troop safety, the negligible risk column and appropriate degree of vulnerability must be used to determine the MSD for moderate risk. Similarly, the moderate risk value must be used for determining emergency risk radii. (The moderate risk value is obtained by linear interpolation halfway between the negligible and emergency risk value in the safety distance table.)

(3) RS-3 (Units with a past cumulative radiation dose of more than 150 rad). All future radiation exposures must be considered emergency risks for units in this category. There can be no negligible or moderate risk for personnel in this category. The negligible risk column and appropriate degree of vulnerability must be used to determine the MSD for emergency risk.

3-8. Contingent Effects

a. *Contingent Effects.* The coverage tables are computed using the governing effect—that effect which extends the greatest distance to cause the desired degree of damage to the principal target elements. Contingent effects are effects other than the governing effect. They are divided into bonus effects, which are desirable, and limiting effects, which are undesirable.

b. *Bonus Effects.* When a nuclear weapon is used on a target, there will be many effects other than the governing effect that will assist in the destruction of enemy elements. These are termed "bonus effects." Some are predictable, others are not. The desirability of achieving bonus effects on the primary target element or on another target element may influence the selection of a nuclear weapon. The target analyst checks to see whether a predictable bonus effect may exist at a certain point by obtaining the radius of damage for the



LEGEND

Line X—Emergency risk MSD, FM 101-31-2, -3.
Line Y—Negligible risk MSD, FM 101-31-2, -3.

Figure 3-8. Minimum safe distance.

effect from the effects tables. He then estimates the effect on the target by considering the effect of horizontal dispersion.

c. Limiting Effects. Limiting effects are effects that are undesirable and, consequently, may place restrictions on the employment of the weapon. These restrictions are referred to as limiting requirements. Examples of effects that may be unde-

sirable in a given instance are the creation of obstacles to friendly movement as a result of tree blowdown, rubble, and forest and urban fires. The target analyst determines whether undesirable effects will be created. He does this by considering the radius of the limiting effect. He determines the least separation distance (LSD) from the safety distance tables.

Section III. SPECIAL CONSIDERATIONS

3-9. Time of Attack

a. Tactical Considerations.

(1) *General.* A set rule for selecting the time for firing a nuclear preparation should not be made. To achieve surprise, it may be desirable to fire all weapons at the same time or as close together as possible. Because well-trained troops may become prone as soon as they observe the flash of the first burst, surprise may often be achieved by delaying the delivery of subsequent rounds. Sometimes better results may be obtained by firing on targets at irregular time intervals. Weapons supporting a secondary attack may be fired first to assist in locating reserves or to cause the premature commitment of the enemy's reserve.

(2) *Time for tactical damage assessment.* When a less reliable weapon system is employed

(para 3-10), a backup weapon, if available, should be placed in an on-call status. In planning the nuclear attack, time should be allowed for making a tactical damage assessment of the first round to determine whether the backup weapon should be fired. This time interval will vary, depending on such factors as—the surveillance method used to determine if the first weapon hit the target, if it detonated, and if the target sustained the desired degree of damage; communications; visibility; and the maneuver plan (para VI-1, app B).

b. Preinitiation Considerations. The radiation from one nuclear weapon may cause a subsequent weapon to detonate prematurely. Such an occurrence is called "preinitiation." If two weapons are to be fired so that they may land within 10,500 meters of each other, the special data provided in

FM 101-31-2 and chapter 3, FM 101-31-3 should be used. A more detailed discussion of preinitiation is included in FM 101-31-2.

3-10. Reliability

a. The reliability of a weapon system is the probability that the weapon **will get to the target area at the desired time and a nuclear detonation of the expected order of magnitude will take place**. Reliability is a function of crew training, maintenance, communications, command, weather, terrain, delivery system, and weapon design. The reliability of any weapon system varies to such an extent that fixed values cannot be established; experience will dictate the reliability of a given system.

b. Reliability is not a consideration in selecting a weapon for attack of a target except as follows:

(1) The most reliable systems are employed against the most important targets—those critical to the success of the mission.

(2) Against other than the most important targets, less reliable systems are employed before the more reliable. This permits retention of the more reliable weapon systems for attack of future targets.

c. A backup weapon, if available, should be placed in an on-call status when a less reliable weapon system is employed.

3-11. Analysis of the Vulnerability of Friendly Troops

a. Target analysis procedures are used to estimate the possible results of an enemy nuclear attack on friendly dispositions or installations (annex B-VII, app B). Based on current intelligence and the enemy's past use of nuclear weapons, the yield of the weapon most likely to be employed against friendly elements is estimated.

b. Special tables are presented in figure B-VII-1, FM 101-31-2 and FM 101-31-3 that gives the radii to be used in analyzing the vulnerability of friendly dispositions. The target analyst assumes that the enemy can deliver a weapon at the point where it will do the greatest damage to the friendly installation, disregarding the effect of delivery errors. The target analyst then estimates what fraction of friendly dispositions might be endangered by such an attack.

c. The analysis of present and planned friendly dispositions is a continuing process. The commander must be kept informed of

vulnerability conditions so that he can make decisions concerning changes in existing or planned dispositions. While dispersion decreases the risk of destruction from nuclear attack, it increases the possibility of defeat in detail and complicates the problem of control. The degree to which units can be dispersed in any situation will depend on the mission of the

command and on the risk of destruction the commander is willing to accept. Accomplishment of the mission and avoidance of formations that present profitable targets to the enemy are frequently conflicting requirements. The commander takes full advantage of all characteristics of the battle area that contribute to the fulfillment of both requirements.



CHAPTER 4

COMMAND RESPONSIBILITIES, STAFF PROCEDURES, AND TECHNIQUES OF EMPLOYMENT

4-1. General

a. The command actions and staff procedures involved in the employment of nuclear weapons are an integral part of the normal sequence of command and staff actions. The command, logistical, intelligence, and operational actions required for effective employment of nuclear weapons are carried out concurrently rather than sequentially. These concurrent command and staff actions are portrayed graphically in figure 4-1.

b. Commanders exercise the same thoroughness in planning the use of nuclear weapons as they do in planning the employment of their major tactical units. To achieve economy of nuclear firepower, coordination and concurrent planning of nuclear fires, nonnuclear fires, and maneuver are essential. Nuclear fires may render a ground assault on the target area unnecessary because of damage inflicted, and often impracticable because of obstacles created. Often the use of nuclear weapons will be the decisive element of the attack or the defense. Even the threat of use of such weapons may inhibit movement or concentration of large forces.

c. At a low level of nuclear weapon usage, fire and maneuver receive equal consideration by the commander in determining the appropriate combat power to be applied. At higher levels of usage, the effects of these weapons saturate the battle area, and maneuver becomes more difficult. In such cases, tactical plans are dictated by the capability of nuclear weapons to influence the battle.

4-2. Control of Nuclear Ammunition

a. Because of the great combat power af-

forded by nuclear weapons, and their limited supply, the commander and staff carefully control the supply, expenditure, and resupply of this type of ammunition.

- (1) Nuclear ammunition falls into the category of "special ammunition." Special ammunition is ammunition so designated by the Department of the Army because of requirements for extraordinary control, handling, or security. Special ammunition includes—
 - (a) Nuclear and nonnuclear warhead sections; atomic demolition munitions; nuclear projectiles; and associated spotting rounds, propelling charges, and repair parts.
 - (b) Missile bodies—(less missiles combining high-density, low maintenance, and conventional ammunition features), related components of missile bodies (less repair parts), and missile propellants.
- (2) A complete round is included within the meaning of special ammunition. Certain items that are closely related to special ammunition are supplied through special ammunition class V channels (e.g., associated test and handling equipment and special tools).
- (3) The availability of complete nuclear rounds will be too limited in the foreseeable future to permit them to be handled by the required supply rate, available supply rate, automatic resupply, and basic load concepts used with conventional ammunition. The system for distributing nuclear am-

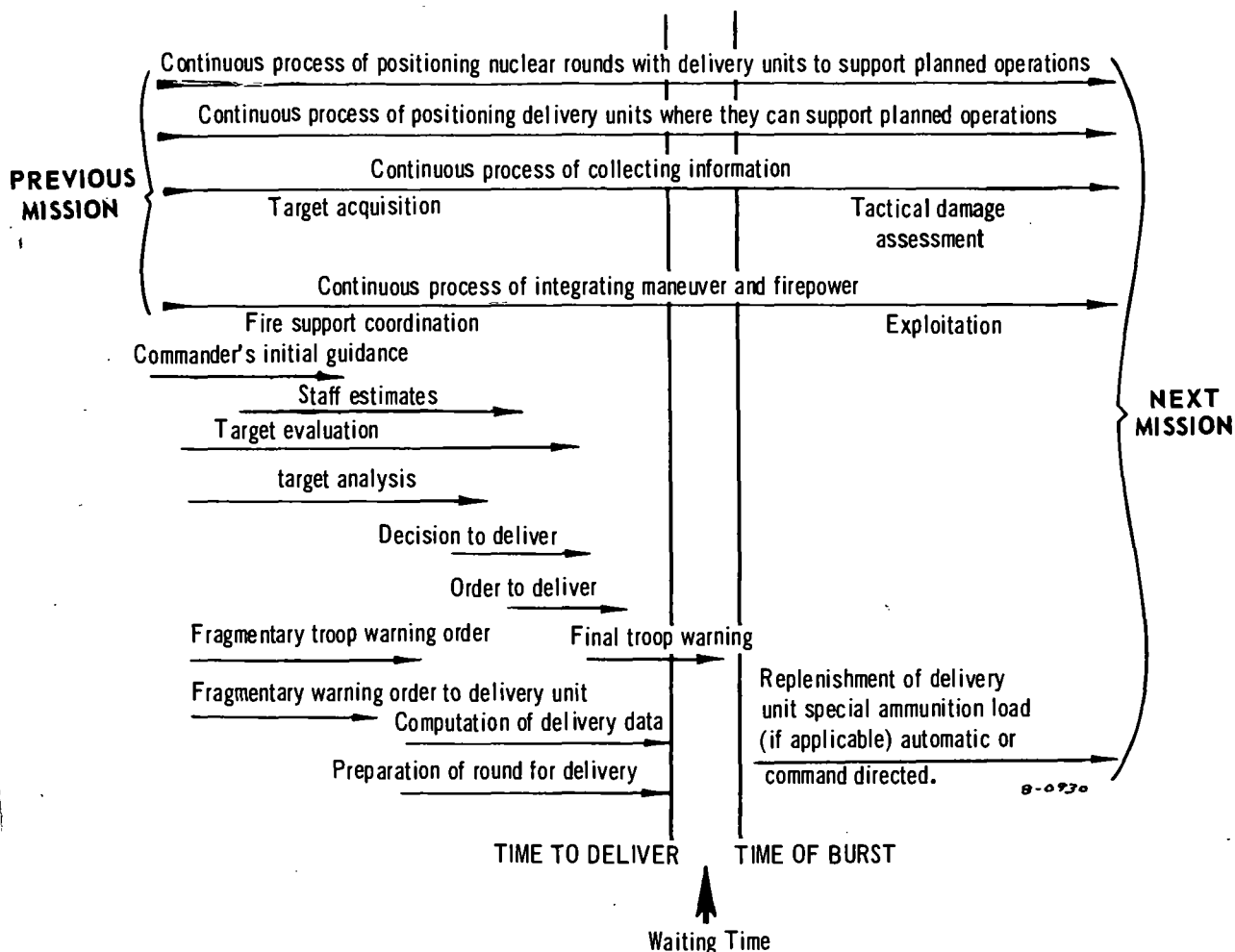


Figure 4-1. Concurrent command and staff actions for nuclear weapon employment.

munition is outlined in paragraph 4-13.

b. An allocation of nuclear rounds is a specified number of complete nuclear rounds that a commander may plan to expend during a specified period of time or during a specified phase of an operation. Allocation of nuclear weapons does not include the authority for their expenditure. The authority to expend nuclear weapons may be granted concurrent with their allocation or at a later date. This authority is subject to normal requirements for warning, coordination, and other restrictions imposed by higher authority. A commander cannot authorize the expenditure of a

nuclear, a chemical, or a biological round unless he has been specifically authorized to do so; or unless he is disposing of the round in compliance with emergency denial operating procedures.

c. Both allocations and expenditures are expressed as a specific number of complete rounds in terms of delivery system and yield.

d. The duration of the allocation and authorized expenditure periods generally will be dictated by the commander's visualization of the operation. He retains rounds 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 period. The

duration of the period varies at different command levels. The field army commander usually is provided weapons for a longer period than is the corps commander and the corps commander for a longer period than is the division commander.

e. Reserve maneuver forces may receive an allocation of nuclear weapons depending upon their anticipated employment.

f. The commander who has been authorized to expend weapons may or may not have the delivery unit under his control; e.g., weapons to be delivered by Air Force or Navy components in support of the ground battle. In authorizing expenditure of nuclear rounds to a subordinate commander who does not have the delivery unit organic or attached to his command, the authorizing commander specifies any special fire request channels to be used.

g. A commander who allocates or authorizes the expenditure of nuclear rounds to a subordinate commander may withdraw or change the allocation in the same manner that he withdraws or attaches troop units. Reduction in the allocation is made only when it is absolutely essential and with as much prior notification as is possible. Subordinate units develop tactical plans around the nuclear weapons in their allocation and modify the plans as necessary when the authority to expend nuclear weapons is received or the allocation is changed.

h. Each commander who is provided nuclear rounds considers—

- (1) Retaining a portion for the attack of targets in support of his own tactical plan.
- (2) Providing a portion to his major subordinate unit commanders for support of their tactical plans.
- (3) Maintaining a nuclear weapon reserve with which to influence the battle as it progresses, and in anticipation of his needs in future phases of the operation.

i. In allocating and authorizing the expenditure of nuclear rounds, the commander considers the following:

- (1) Missions assigned subordinate units. Consideration is given to which units must have weapons for successful accomplishment of their assigned tasks.
- (2) Numbers, types, and yields of weapons available.
- (3) The number, size, location, and composition of targets that subordinate units may be expected to acquire and to engage.
- (4) The capability of organic or supporting units to deliver the type of weapons allocated.
- (5) The range, reliability, accuracy, mobility, and responsiveness of available delivery means. Troop safety requirements may dictate that smaller yields and more accurate delivery systems be given to subordinate commanders for close-in targets, with larger yields being retained by higher echelons for attack of larger and deeper targets.
- (6) The other combat power available to assist in the accomplishment of the mission, such as chemical or biological ammunition, conventional weapon systems, and maneuver units.
- (7) The capability of subordinate units to accomplish the coordination necessary with other headquarters and with the Navy or the Air Force.
- (8) The degree of susceptibility to countermeasures of the available weapon systems.
- (9) The restrictions imposed by higher authority on the allocation received.
- (10) Requirements for a reserve.

j. Weapons may be provided the commander of a unit made up of forces from countries other than the United States. These weapons may be delivered by either U.S. or non-U.S. delivery units. In the latter case, atomic demolition munitions, missile warhead sections, and artillery projectiles are retained under the control of U.S. personnel in accordance with directives of the U.S. commander or with theater directives until time of launching or firing.

4-3. Acquisition of Surface Targets

a. Target acquisition is that part of intelligence activities which involves detection, identification, and location of ground targets. The information obtained is used for target analysis, target evaluation, and employment of weapons. Information is collected from all sources and agencies.

b. The effectiveness of a nuclear attack depends, to a great extent, on the accuracy, completeness, and timeliness of intelligence. Specific information of target areas, to include location, size, shape, composition, concentration, vulnerability, recuperability, and permanence or direction and speed of movement, is continually sought by all intelligence collection agencies. The degree to which this information is complete and accurate influences the accuracy of the damage estimation and the validity of the target analysis. The degree to which the information is timely influences the effectiveness of the attack.

c. The limited visual field of an observer frequently restricts his ability to observe in its entirety an area target appropriate for attack with nuclear weapons. A single observer seldom has the capability to provide sufficient target information on which to base a target analysis and a decision to fire. This limitation demands that a detailed collection plan be developed and that target information be collected from all available sources. A target suitable for attack with nuclear weapons frequently may be acquired at a higher echelon of command by the analysis and the integration of apparently unrelated items of information received from several sources.

d. Because of the foregoing aspects of target acquisition, the importance of the commander's initial staff planning guidance cannot be overemphasized. Such guidance provides the basis for developing the essential elements of information and the detailed collection plan. The commander isolates those enemy activities which, if they should materialize, would seriously affect the accomplishment of his mission. He then establishes the priorities of the intelligence collection effort.

Failure to establish these priorities, or failure to concentrate the collection effort on those enemy activities which would pose a serious threat to accomplishment of the mission, risks overextending the capabilities of the collection agencies. Such overextension results in inadequate target acquisition.

e. A detailed plan for the collection of target information is developed and revised continually throughout an operation (para II-4, app B).

- (1) An analysis of the terrain, a study of the enemy order of battle, and an understanding of enemy tactics will produce a list of areas in which the enemy might locate reserves, logistical installations, command posts, nuclear delivery units, or other profitable targets.
- (2) This list is studied to determine which areas, if occupied, adversely affect the accomplishment of the mission. The areas on this list are held to a minimum to avoid overextension of the collection agencies. Also, too large a list may degrade the capability of the (Army) tactical operations center (TOC) or (Marine) fire support coordination center (FSCC) to record and to interpret target information.
- (3) When time permits, these prospective target areas are subjected to more intensive surveillance than is the remainder of the battle area. The items of information collected from this surveillance are used to determine the characteristics of the target.

f. A list of prospective target areas forms the basis for a list of suspected targets. A suspected target is one whose existence is known, but whose location is unknown; or it may be a location concerning which there is doubt whether it is occupied. Suspected targets are engaged with nuclear weapons when evaluation of the target indicates that a nuclear attack is justified. Target evaluation is discussed in paragraph 4-11a.

g. The enemy can be expected to present targets for only a short period of time. Between the time of sighting the target and the actual delivery of the weapon, the target may change its shape, location, or vulnerability. Information on these targets must be collected, and the target must be analyzed and evaluated in a relatively short period of time. Whenever enemy activity generates a remunerative target and the target has the capability to move or to dissipate, the target is engaged as soon as possible.

h. Fixed targets (e.g., bridges, fortifications) may be included in a schedule of fires and attacked in a more deliberate manner.

4-4. Command Guidance

a. The magnitude and nature of nuclear weapon effects have a profound influence on ground operations. Therefore, command guidance to the staff before the commencement of planning is vital. The commander devotes at least the same thought and effort to his development of initial staff planning guidance concerning nuclear weapon employment as he does to the employment of maneuver forces and other fires. If there is little time for staff planning, this guidance may consist of a decision by the commander at the outset. When more time is available, the guidance may include specific courses of action for the staff to consider during the development of staff estimates.

b. In developing his initial staff planning guidance, the commander considers the requirements of all elements of the general staff. In addition, he provides guidance for the artillery commander and, at field army level, for the air defense artillery commander.

c. The commander provides such additional guidance as may be required throughout the planning process up to the time nuclear weapons are fired.

d. It is essential that commanders and staff officers understand the effects of nuclear weapons, the capabilities and limitations of the various delivery systems, the combat service support requirements involved, and the proce-

dures for employing these weapons. However, these officers receive technical advice from the nuclear weapon employment officer on matters incident to the use of such weapons.

e. Initial staff planning guidance normally falls into the following categories:

- (1) Type of targets to be attacked (scheduled or on-call).
- (2) General statement concerning number, size, yields, and delivery systems that should be released to subordinate commanders for execution.
- (3) Desired nuclear weapon reserve.

f. The commander's initial staff planning guidance for the use of nuclear weapons varies in content with the echelon concerned.

- (1) At division this guidance normally is confined to the type of targets to be attacked with nuclear weapons and the weapon reserve desired. The division commander may also give guidance concerning weapons to be used in the support of maneuver units. The initial guidance in this regard is usually general until such time as the concept of the operation is determined. Because of the immediate and profound impact nuclear weapons have on operations at the division echelon, the commander's guidance normally is quite detailed in the areas mentioned above. He frequently indicates specific weapons that will constitute his nuclear weapon reserve. A division nuclear weapon reserve is retained for attack of targets of opportunity rather than for future operations.
- (2) At corps, initial staff planning guidance normally is provided concerning the type of targets to be attacked with nuclear weapons under corps control, a general guide as to weapons to be released to major subordinate commanders for execution, and the general nature of the corps nuclear weapon reserve. Because of the scope and area of

corps operations, the corps is the lowest echelon that retains a substantial reserve of nuclear weapons for future phases of an operation. Because corps possesses the resources for delivering a decisive blow on the enemy, command guidance includes the nuclear fires desired in connection with the commitment of the corps reserve maneuver force.

- (3) At field army the commander's initial staff planning guidance is more general than that at lower echelons. Because field army plans an operation weeks or even months in advance of the event, initial staff planning guidance seldom concerns the attack by field army of specific targets with nuclear weapons. Rather, the field army commander provides guidance that permits the staff to develop allocations of weapons to major subordinate commanders for each future phase of the field army operation; to develop the mix of yields and delivery systems that subordinate commanders will be authorized to fire in support of their current operations; and to provide an appropriate field army reserve of nuclear weapons for the entire operation or specified period for which an allocation has been received. The field army commander also provides guidance on priorities in the employment of nuclear air defense weapons. Because of his responsibility in regard to nuclear weapon logistical support, the field army commander provides guidance in this area. Finally, he provides guidance on his policies (and policies imposed by higher headquarters) concerning limiting requirements (*g* below). This guidance may include such areas as limitations on fallout, protection of friendly civilians, and avoidance of damage to transportation complexes.

g. Damage criteria and troop safety considerations are SOP matters. Command guid-

ance in these respects is appropriate only when departures from the SOP are desired. The SOP should state the required coverage to destroy a target and the required coverage to neutralize a target. Based on the SOP, the nuclear weapon employment officer determines the extent and nature of the damage required and recommends the weapon system best suited for this task. Similarly, the commander will normally, as SOP, desire negligible risk to his own and to adjacent forces. The staff, including the nuclear weapon employment officer, automatically takes this into account in its analysis and operational planning. If a risk greater than negligible must be taken, or if friendly troops must be warned of the attack, the employment officer so indicates when he makes his recommendations (para B-2d(7), app B). Creation of obstacles to friendly movement and other undesirable effects are also matters the staff and the nuclear weapon employment officer normally can foresee and minimize without being given specific guidance. These limiting requirements may include one or more of the following:

- (1) No significant fallout.
- (2) No damage to a particular installation or area.
- (3) Induced contamination near the ground zero held to a minimum.

h. The following is an example of a division commander's initial guidance to his staff: "Use no more than three nuclear weapons to neutralize the Aggressor reserves. Use at least two weapons to support the brigade making the main attack. Be sure that the available nuclear weapons are dispersed so that the cavalry squadron and the supporting attack and reserve brigades can be supported with nuclear fire, if necessary. Retain all nuclear weapons, other than those scheduled, in reserve for employment against targets of opportunity."

i. The following is an example of a corps commander's initial guidance to his staff:

"Aggressor has organized the area between our current positions and the Blue River for a determined defense. The decisive battle during the coming operation will be fought west of the Blue

River. Although we have a limited number of nuclear weapons for this operation, I am willing to expend 30 to 40 percent of them in penetrating the Aggressor main and secondary defensive belts and in advancing to the Blue River. Corps fires will be used to engage Aggressor nuclear delivery means and those reserve maneuver forces that have the capability to adversely affect the outcome of the battle. These fires will be delivered as soon as the targets are located. These fires, together with subordinate unit nuclear fires, will insure that we inflict maximum casualties and damage to Aggressor units west of the Blue River and will insure our successful attack to secure crossings over the Blue River.

"Once we are across the Blue River, we must be ready to exploit our crossings and to move rapidly through the passes of the Silver Mountains and seize the communications center of Foxville. Be extremely cautious in planning the employment of nuclear weapon in the Silver Mountains, because I want no obstacles to our advance created in these critical areas.

"Retain one-fourth to one-half of our nuclear weapons in reserve for the attack to seize Foxville, because I anticipate a stubborn enemy defense there, and for the defense against the Aggressor counterattacks that are sure to follow when we seize Foxville.

"Divisions will not be given authority to expend weapons over 50-kiloton yield."

j. The following is an example of a field army commander's initial guidance to his staff:

"The offensive to seize the passes through the Ruff Mountains is the most critical part of the coming operation. Once we have seized the passes and repulsed Aggressor counterattacks, we should regroup and advance rapidly to the northeast to seize the India-Bravo-Mike industrial complex, link-up with elements of the 12th Army Group, and destroy the enemy entrapped in the pocket thus formed.

"With the advance to the Ruff Mountains so critical, I am willing to expend one-half of the available nuclear weapons to destroy Aggressor resistance west of the mountains and to inflict maximum casualties and damage to his reserves in this area. Plan on a small nuclear weapon expenditure in the exploitation from the mountains to seize the India-Bravo-Mike complex. Insure that we retain a reserve of nuclear weapons for use during the initial attack to seize the mountain passes, to prevent any sizable reinforcement by reserves now located east of the mountains, and to destroy the Aggressor forces entrapped in the pocket.

"Surface bursts may be authorized by corps commanders, provided significant fallout is confined to the corps zone of action.

"Air defense is SOP. Available nuclear weapons released to air defense units for that purpose will not be employed in a surface-to-surface role without specific approval by me.

"The success of this offensive depends heavily on the delivery of nuclear fires when required. Insure that the special ammunition supply points supporting

the corps are located well forward for this operation, and that all nuclear delivery units have a maximum special ammunition load. If required, give transportation priority to movement of nuclear weapons."

4-5. Fire Support Coordination

★a. Fire support coordination is the coordinated planning and directing of fire support so that targets are adequately attacked by appropriate means of weapons available. This would include all fires on surface targets, whether planned or targets of opportunity, regardless of the source of these fires.

b. Proper fire support coordination integrates firepower and maneuver. The fire support element (FSE) of the tactical operations center in the Army and the fire support coordination center (FSCC) in the Marines performs the target analyses that result in a recommended plan for the employment of nuclear weapons. In the Army, if these plans involve means other than normal surface-to-surface delivery units, they are coordinated as follows:

(1) Atomic demolition munitions with the engineer element.

(2) Air-delivered weapons with the tactical air support element (TASE).

(3) Air defense weapons employed in a surface-to-surface role with the air defense element.

c. During the fire support coordination process, measures are taken to insure that predicted effects of contemplated nuclear fires will not adversely affect projected operations. When undesirable effects of nuclear fires cannot be prevented, the implications of these effects are indicated, and alternative courses of action are recommended to the commander for decision.

d. During the process of fire support coordination, a series of recommendations is developed that will produce the following specific results:

(1) Dispersal and positioning of nuclear weapons and release to executing units in a manner that most effectively supports the commander's concept of operations within his allocation.

(2) Establishment of liaison and communications between nuclear delivery units and supported units.

(3) Actions to insure troop safety. The nuclear weapon employment officer checks for troop safety as part of each target analysis. To accomplish this check, it is necessary to have data indicat-

ing the location and radiation exposure history of friendly forces. FM 61-100 prescribes procedures such as the use of phase lines, for the reporting of location and for the control and coordination of movement. During the fire support coordination process, recommendations on the specific procedures to be employed are developed.

e. A detailed discussion of the duties of the fire support coordinator and of fire support coordination procedures is contained in FM 6-20-1 and FM 6-20-2.

★4-6. Warning of Friendly Nuclear Strikes

(This paragraph is based on STANAG No. 2104.)

a. Advance warning of a nuclear strike is required to insure that friendly forces do not receive casualty-producing weapon effects. For strikes at distant enemy targets, advance warning is required only for adjacent units and aircraft likely to be affected by such strikes. When a nuclear weapon is part of a schedule of fires, there is usually adequate time to alert those personnel in an area where significant effects may be received. If it does not interfere with the mission, troops out to the limits of visibility should be warned. On the other hand, when weapons are employed against surface targets of opportunity, an SOP is required that will permit rapid notification of personnel who could be affected by the weapons. When very low yield nuclear weapons are employed against targets of opportunity or when nuclear weapons are employed in the air defense role, there may not be sufficient time to warn friendly personnel. The difficulty of warning all personnel can be appreciated if the various activities in the forward battle areas are visualized. Messengers, wire crews, litter bearers, aid men, and others move about frequently in the performance of their duties. Often they may not be in the immediate vicinity of troop units when warning of an impending nuclear attack is disseminated. Small detachments of combat support troops, such as engineers, may be working in isolated areas where they may be subjected to casualty-producing effects if they are not warned. Effects that are completely tolerable to troops in tanks or foxholes can cause considerable casualties among those in the open in the same area (para 6-3).

(1) Notification concerning friendly strikes is a time-consuming process unless procedures are

carefully established and rehearsed. Dissemination of warning earlier than is necessary may permit the enemy to learn of the planned strike, with a resultant decrease in the effectiveness of the attack.

(2) When there is insufficient time to warn personnel within the limits of visibility, only those personnel who might receive tactically significant weapon effects are given a nuclear strike warning. Warning of units not requiring the information causes them to assume a protective posture that interferes with the accomplishment of their mission. There is generally no requirement to warn subordinate units when the target analysis indicates no more than a negligible risk to unwarned, exposed troops.

(3) Aircraft, particularly light aircraft, can be damaged by low 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 one where damaging overpressures 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 liaison personnel. At corps and division level, the notification of the planned employment of a weapon 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) Time permitting, air defense artillery will report via command and control nets to the Army Air Defense Command Post (AADCP) the intention to engage hostile aircraft with nuclear weapons, stating estimated time, altitude and GEOREF of the nuclear burst. The AADCP will transmit a warning message to its associated TOC and Sector Operation Center/Control and Reporting Center (SOC/CRC), and these agencies may transmit alerts to their respective airborne aircraft.

★(d) Warnings to aircraft in Marine Corps operating areas will be initiated by the FSCC which passes the warning to the Tactical Air Commander usually via the Tactical Air Command Center (TACC) and/or the Direct Air

Support Center (DASC) and/or the Supporting Arms Control Center (SACC).

(4) When very low yield weapons are employed against targets of opportunity, operational requirements may dictate some relaxation of the requirement for positive warning.

b. Nuclear strike warning (STRIKWARN) messages are disseminated as rapidly as possible. The requirement for speed frequently will be in conflict with a requirement for communications security. Authentication procedures and encoding instructions for nuclear strike warning messages are included in unit signal operation instructions.

(1) The amount of information to be encoded is held to a minimum to expedite the dissemination.

(2) Strike warnings are broadcast in the clear when insufficient time remains for the enemy to react prior to the strike.

c. Procedures for warning of friendly nuclear strikes are included in the subparagraphs below.

(1) Warning responsibilities are as follows:

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

(b) Commanders authorized to release nuclear strikes will insure that strikes affecting the safety of adjacent and other commands are coordinated with these 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 commander responsible for issuing the warning should inform—

(a) Subordinate headquarters whose units are likely to be affected by the strike.

(b) Adjacent headquarters whose units are likely to be affected by the strike.

(c) His next higher headquarters, when units not under the command of the releasing commander are likely to be affected by the strike.

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

(4) Figure 4-2 shows the zones of warning for friendly nuclear strikes. The number of zones shown will be less whenever the data for two or more minimum safe distances (MSD) are the same (e.g., where MSD 2 is the same as MSD 3, only zones 1 and 2 would apply for the friendly nuclear strike.) Table 4-1 explains the protection requirements for personnel located in any of the warning zones.

(5) Figure 4-3 shows the format in which all friendly nuclear strike warnings will be given. Figure 4-4 shows examples of friendly nuclear strike warning messages. Notification passed to those agencies or facilities responsible for disseminating warnings to airborne aircraft will include the least safe distance for light aircraft in hundreds of meters (four digits) as part of item India following the data for MSD 3. (Examples of MSD determination are presented in annex B-III, app B.)

★(6) The STRIKWARN message contains lines YANKEE and ZULU to transmit fallout prediction data from surface bursts for yields of 0.15 KT and higher. However, no formal procedure has been established to transmit fallout prediction data for friendly ADM subsurface bursts

Table 4-1. Protection Requirements for Friendly Nuclear Strikes

Area ^a	Corresponding to—	Zone	Requirement
DGZ to MSD 1.....		1.....	Evacuation of all personnel. ¹
From MSD 1 to MSD 2.....	Limit of negligible risk to warned, protected personnel. ²	2.....	Maximum protection. ³
From MSD 2 to MSD 3.....	Limit of negligible risk to warned, exposed personnel. ²	3.....	Minimum protection. ⁴
MSD 3 and beyond.....	Limit of negligible risk to unwarned, exposed personnel. ⁵		No protective measure, except against dazzle.

¹ If evacuation is not possible, or if a commander elects a higher degree of risk, maximum protective measures will be required.

² Negligible risk should normally not be exceeded unless significant advantages will be gained.

³ Maximum protection denotes that personnel are in "huttoned-up" tanks or are crouched in foxholes with improvised overhead shielding.

⁴ Minimum protection denotes that 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 summer uniform.

⁵ Minimum safe distances are increased by 50 percent when conditions of extreme reflectivity and good visibility exist. (See paragraph 2-25c(1).)

⁶ MSD means minimum safe distance. When surface bursts are used, the fallout hazard will be considered and appropriate buffer distances included.

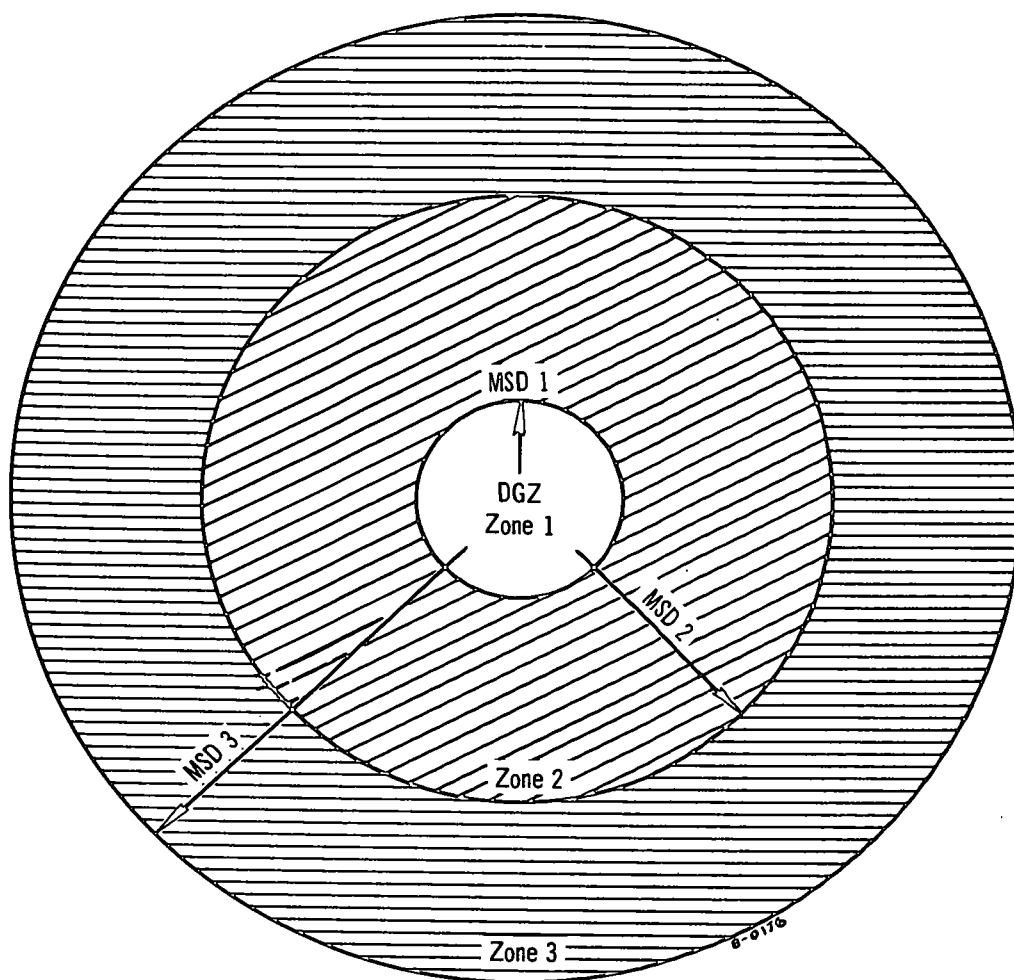


Figure 4-2. Zones of warning for friendly nuclear strikes.

with yields from 0.01 KT to 100 KT and for surface bursts with yields of 0.1 KT or less. Therefore, as an interim measure, line ZULU INDIA is added to the STRIKWARN message to cover the case of fallout resulting from very low yield nuclear detonations.

(7) When nuclear strikes are canceled, units previously warned will be notified in the clear by the most expeditious means as follows: "Code word (target number). Canceled."

(8) The amount of information to be encoded is held to a minimum to expedite dissemination. Items Delta and Foxtrot (fig. 4-3) will not be sent in the clear unless the time will not allow encoding and decoding.

(9) Unit SOP should require that strike warning 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).

d. Normally it is not necessary or desirable to transmit the strike warning message in the format shown in figure 4-3 to company-/battery-size units. Any such unit located in zone 3 (fig. 4-2) or closer to the desired ground zero should, by SOP, receive a message containing specific orders on the protective measures to be implemented by that unit. The message should include—

(1) A proword indicating that the message is a nuclear strike warning.

(2) A brief prearranged message that directs the unit to observe a specific protective measure (including evacuation to an alternate position if within Zone 1). The SOP should state the period

of time during which the personnel must remain protected.

(3) Expected time of burst.

e. All available communications means are used to permit rapid dissemination of warnings of the employment of nuclear weapons against targets of opportunity. These means include—

(1) Sole-purpose telephone circuits, wire or radio relay.

(2) FM and AM voice radio nets.

(3) Continuous wave and radioteletypewriter nets.

(4) One-way voice radio nets. This communication does not give the recipient the capability of acknowledgment; the recipient may be required to acknowledge over a different means of communications. The range and coverage of this net may cause the message to be sent to units that do not need to be warned.

f. A fragmentary warning order may be issued while a fire mission is being processed to alert unit personnel that they are in an area in which they may receive the effects of a weapon being considered for employment. The personnel are cautioned to remain alert for a followup message that will cancel, confirm, or alter the warning. The followup message is sent whenever the time of burst is determined or the decision is made not to fire the weapon.

g. While units outside the area in which effects may be received normally are not sent a nuclear strike warning message, effective liaison may require that strike data be passed to adjacent units as a matter of SOP, particularly for those friendly strikes that are in close proximity to a boundary between major units. Information concerning these strikes is of operational concern (e.g., information used to update situation maps in the TOC that portray areas radiological contamination and obstacles to maneuver of friendly forces).

4-7. Fire Requests

a. When a commander has a requirement for nuclear fires and has the weapon but not the authority to fire, he may request authorization to fire from the next senior releasing commander. When

the commander has neither the weapon nor the authority to fire, he may request delivery of nuclear fires from the next higher commander. (Fig. 4-5 shows an example of a division nuclear fire request to corps.) Simultaneously, the fire direction center (FDC) or the tactical air control center is alerted. Requests contain sufficient information to permit a complete evaluation of the fire mission. As a minimum, a request contains a description of the target, the results desired, and the desired time of burst. The request may contain additional information, such as limiting requirements, location of the desired ground zero, acceptable risk to friendly troops, or location and degree of protection of nearest friendly troops. If the target has been analyzed by the requesting agency, the request for fires may specify the desired weapon and yield.

b. The next higher releasing commander may approve or disapprove the request. In some cases, he may submit a request to his next higher commander for release of a weapon more suitable than any presently available to him.

c. Upon approval or disapproval of a fire request, the requesting agency is notified. Whenever possible, a commander who disapproves a request provides the requesting agency with the reason for the disapproval and will substitute another type of fire support whenever possible.

4-8. Fire Orders

a. Once a fire mission has been approved, fire support agencies are given the necessary orders to cause the weapons to be delivered on the target.

(1) Orders to Army delivery units include—

(a) Unit to deliver the weapon.

(b) Firing site, if applicable.

(c) Delivery system/yield.

(d) Height of burst in meters or height-of-burst option.

(e) When applicable, fuzing option desired (e.g., contact backup or contact preclusion).

(f) Desired ground zero.

(g) Time of burst/latest time of burst.

(h) Resupply instructions, if applicable.

(2) If air-delivered weapons have been provided an Army unit, the message to the tactical air control center includes—

STRIKWARN

- Alfa** : Code word indicating nuclear strike (target number).
- Delta** : Date-time group for time of burst in Zulu time. The time after which the strike will be canceled (Zulu time).
- Foxtrot** : DGZ (UTM grid coordinates).
- Hotel** : Indicate air or surface bursts.
- India** : For all bursts:
MSD 1 in hundreds of meters (four digits).
MSD 2 in hundreds of meters (four digits).
MSD 3 in hundreds of meters (four digits).
LSD for light aircraft in flight in hundreds of meters (four digits).
- Yankee** : For all bursts when there is less than a 99-percent assurance of no militarily significant fallout.
Direction measure clockwise from grid north to the left, then right, radial lines (degrees or mils--state which) (four digits each).
- Zulu** : For all bursts when there is less than a 99-percent assurance of no militarily significant fallout.
Effective windspeed in kilometers per hour (three digits).
Downwind distance of zone I (km) (three digits).
Cloud radius (km) (two digits).
- Zulu India** : Effective wind speed to the nearest kilometer per hour (three digits).
Downwind distance of zone I to the nearest tenth of a kilometer (four digits).
Downwind distance of zone II to the nearest tenth of a kilometer (four digits).
Cloud radius to the nearest tenth of a kilometer (three digits).

Figure 4-3. Format of STRIKWARN message for friendly nuclear strikes.

1. Airburst $\geq$ 99 percent assurance of no military significant fallout.
STRIKEWARN. ALFA TUBE 0006. DELTA PQ WM OT AR/AS DG WY OF.
FOXTROT YM AB IM SK. HOTEL AIR. INDIA 0028 0041 0072 0079.
2. All bursts < 99 percent assurance of no military significant fallout.
STRIKEWARN. ALFA TUBE 0007. DELTA PQ WM OT AR/AS DG WY OF.
FOXTROT YM AB IM SK. HOTEL SURFACE. INDIA 0028 0033 0058
0062. YANKEE 0062 0102 DEGREES. ZULU 016 012 04.

0-0622

★Figure 4-4. Examples of STRIKEWARN message.

- (a) Yield.
- (b) Permissible circular error probable (CEP).
- (c) Height of burst in meters; or, in the case of radar-fuzed weapons, height-of-burst option.
- (d) When applicable, fuzing option desired (e.g., contact backup or contact preclusion).
- (e) Desired ground zero.
- (f) Time of burst/latest time of burst.
- (g) Applicable coordination measures. For example—

- 1. Special signal procedures, such as marking of the initial point, and abort signals.
- 2. Flak suppression measures.
- 3. Special air defense coordination procedures.

b. Early notification to the delivery unit reduces delays in firing. Advance information with which to occupy firing sites, compute firing data, and prepare the nuclear round is desirable. On some occasions, this information is given to the delivery unit prior to the time a decision is made to employ the weapon.

c. Fire support agencies may be ordered to prepare an alternate nuclear weapon system (either of the same type or of a different type) or to plan nonnuclear fires in the event the first weapon fails.

4-9. Employment of Atomic Demolition Munitions

a. Certain nuclear munitions are designed for emplacement at the desired ground zero by engineer personnel or by other qualified personnel who have been specially trained. Nuclear munitions employed in this manner are called atomic demolition munitions. Generally, ADM are employed against the same type of targets as are nonnuclear demolitions. ADM are also used to create large-scale obstacles and to produce fallout. They have the advantage of delaying repair or use of an area because of residual radiation. Once a decision has been made to employ ADM, suitable munitions are made available to the commander within whose area they can be used advantageously. For detailed description of ADM employment and analysis see FM 5-26.

b. An atomic demolition plan includes—

- (1) Target number and description.
- (2) Type of ADM, yield, depth of burst, and location of the desired ground zero.
- (3) Designation of emplacing unit.
- (4) Designation of supporting units, with coordination instructions.
- (5) Methods of firing.
- (6) Security instructions, including designation of the unit to furnish se-



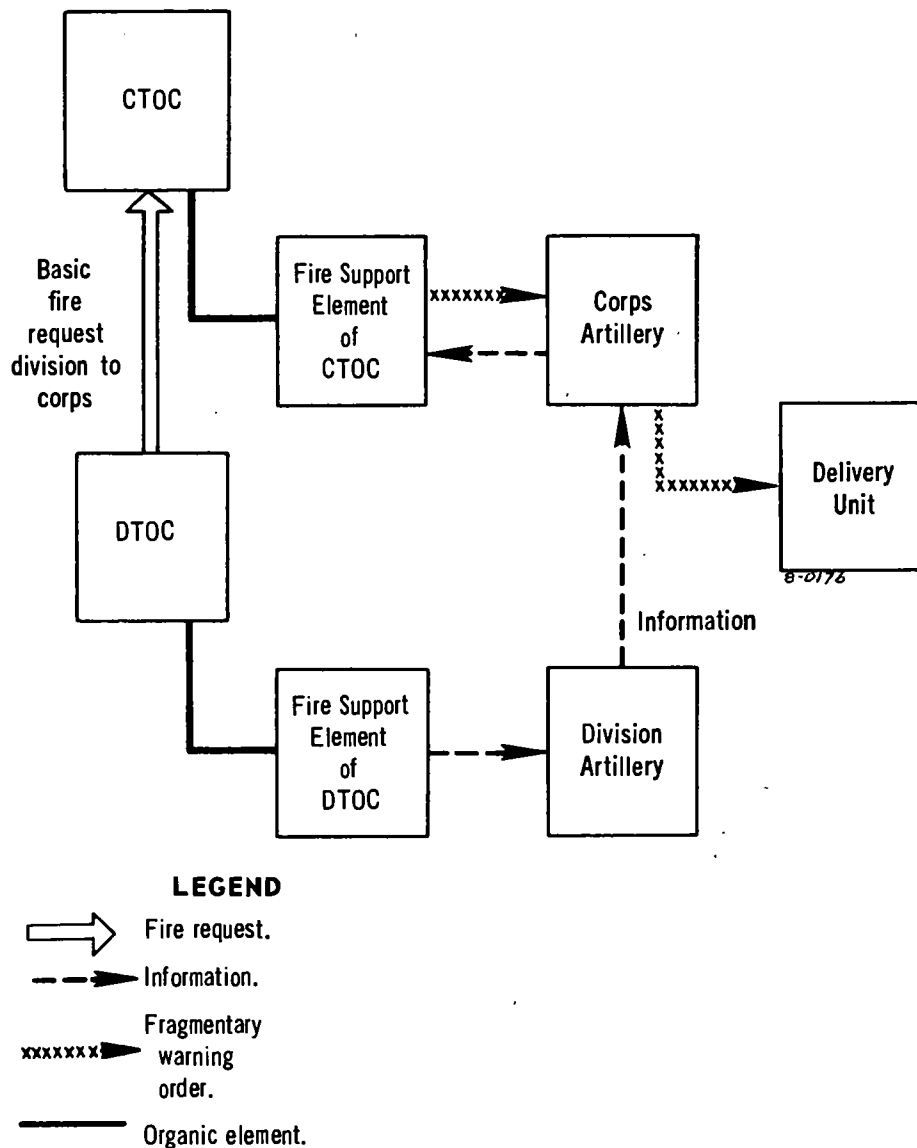


Figure 4-5. Example (Army) of division fire request to corps.

- curity and whether mines or antidisturbance devices will be installed.
- (7) Time of emplacement and final arming.
 - (8) Time of detonation or circumstances under which ADM is to be fired.
 - (9) Authority to abort the mission and/or to order emergency evacuation or destruction.

- (10) Coordination instructions for warning and evacuating friendly ground, air, and naval forces or a civilian populace.
- (11) Tactical coordination among higher, lower, and adjacent commanders.
- (12) Logistical coordination.
- (13) Special signal requirements.

c. During retrograde movements, ADM are emplaced in terrain held by friendly elements.

ADM employed in this manner are integrated with barrier plans and with denial plans. Provisions are made for demolition guards and communications in the same manner as that outlined in FM 31-10. Procedures to detonate the ADM are specifically directed by the commander who directs the installation of the ADM; these procedures identify the commander or other person who is authorized to order detonation.

d. When ADM are employed in enemy-held terrain, emplacement teams may be infiltrated into the target area, airlifted by helicopter, or dropped by aircraft. The commander who directs the employment of the ADM also directs the mode of transportation and insures that the necessary means of movement and security are provided.

e. Although it is possible to employ ADM against personnel, it is not a recommended use, and it is more appropriate to employ them against fixed targets because—

- (1) Enemy personnel in the target area may intercept the emplacement team while the ADM is being emplaced, or may capture or render inoperative the ADM prior to detonation.
- (2) The time required to emplace ADM militates against employing them against targets that have movement capability.

f. Atomic demolition munitions may be employed to produce fallout; to destroy structures; and to produce cratering, fires, and tree blowdown. They may also be used against installations that are not likely to be moved prior to the time the weapon is detonated. They have specific application in destroying hard targets such as tunnels, dams, airfields, railroad yards, ports, causeways, major bridges, and underground installations; in denying key terrain or facilities to the enemy; and in creating obstacles to enemy movement.

g. Because ADM produce fallout, a fallout prediction is always made. Plans for employment of the ADM generally are made far in advance of detonation; however, meteorological conditions at the time of burst may be

different from those existing at the time of the original fallout prediction. To preclude inadvertent fallout on friendly troops, a final fallout prediction is made immediately prior to detonation. Results of this fallout prediction may cause the commander to cancel the mission, to modify the tactical plan, or to move troops out of the fallout pattern.

h. Security of ADM employment plans is essential. Compromise of plans may result in loss of the emplacement team or in seizure of the munition. See FM 5-26 for details of security.

i. Detailed procedures for employment of ADM are contained in FM 5-26. Effects tables by target category are included in FM 101-31-2, chapter 10, FM 101-31-3, and TC 3-15.

4-10. Use of Fallout

(This paragraph is based, in part, on STANAG No. 2103.)

a. Intentional surface bursts are employed whenever fallout is desired. Fallout is used as the principal desired effect whenever it contributes to the accomplishment of the mission in a better manner than do the initial effects.

b. The lethal area of a weapon is greatly extended by the production of fallout. Any increase in yield produces an increase in initial effects; a correspondingly greater increase in the fallout pattern occurs with the same increase in fission yield. This is portrayed in figure 4-6.

c. Because of the large area covered by fallout patterns, authority for the use of surface bursts is held at a higher level than is normal for airbursts.

d. Fallout is employed to restrict the use of areas to the enemy, as an obstacle to his movement, or as a spoiling attack to throw his tactical plans off balance. When target information is vague, or when the target area appears to be thinly occupied, the large area covered by a fallout pattern gives special advantage. As discussed below, present methods of predicting fallout do not give the capability of accurate target coverage estimation.

e. Exploitation of a friendly burst is accomplished through coordination of firepower and maneuver elements. While it is preferable that friendly units avoid the fallout pattern, the units can cross the pattern with reduced risk if they move quickly and if they have a good degree of radiation protection while they are crossing. The protection provided by various means of transportation, as well as by various structures, is shown in FM 101-31-2 and chapter 18, FM 101-31-3.

f. As is the case with other obstacles, a fallout pattern can be crossed by a determined enemy. Pattern crossings can be made with relative impunity by highly mobile, well-shielded troops, such as personnel in tanks. Crossing the pattern can be made more costly to the enemy—regardless of the crossing means used—if the pattern area is covered by fire. Repeated surface bursts in the same area may be required to maintain the restricted area at the desired level of contamination.

g. The effect of fallout on future operations is considered in the planning of surface bursts. Fallout assumes great importance if a given locality is to be used a short time after the burst, especially if prolonged occupancy is foreseen.

h. A fallout prediction is prepared when friendly surface bursts are employed. The predicted hazard area is larger than the actual area on the ground that will be covered by militarily significant fallout. Because of the uncertainties of weather and nuclear burst input data, the precise location of fallout within the predicted area of hazard cannot be reliably predicted but must be ascertained by monitoring and survey after fallout has settled. There is, however, a reasonably high assurance that the expected fallout will not occur outside the predicted area of hazard. Because of the lack of precise information on the dose rates inside the predicted area, and the type of protection afforded to enemy troops, no attempt is made to estimate casualties as is done with the initial effects of the weapon. The fallout prediction is used to aid in operational planning, to warn or alert personnel, and to plan radiolog-

ical surveys. Procedures for fallout prediction are contained in TM 3-210.

i. Standing operating procedures in all units provide for radiological monitoring whenever surface bursts are employed. These SOP also establish methods of assembling the information necessary to make radiological contamination charts.

j. After radiological contamination charts have been plotted, probable dose-stay time calculations are performed. Based on the total dose expected to be received during movement through the fallout pattern, the commander estimates the risk involved in executing his planned maneuver. As a result of this evaluation, the commander may change his maneuver plan, accept a risk of increased casualties, or delay his movement until the pattern has decayed to an acceptable level.

4-11. Estimate of the Situation

An estimate of the situation is a logical and orderly examination of all factors affecting the accomplishment of the mission. Factors affecting the decision to employ nuclear weapons are included in *a* through *d* below.

a. Target evaluation is the orderly process of examining a target to determine its importance and to establish its priority for attack. It encompasses an analysis of the tactical mission and an evaluation of target intelligence.

- (1) The first element in target evaluation is a determination of the target's relative importance. In this determination, consideration is given to the effect attack of the target will have on the accomplishment of the mission. The commander also considers the effect of not attacking the target. Part of this determination of target importance is accomplished in determining the priority of target surveillance in the development of the intelligence collection plan.
- (2) Target intelligence influences the evaluation of the target in the following manner:

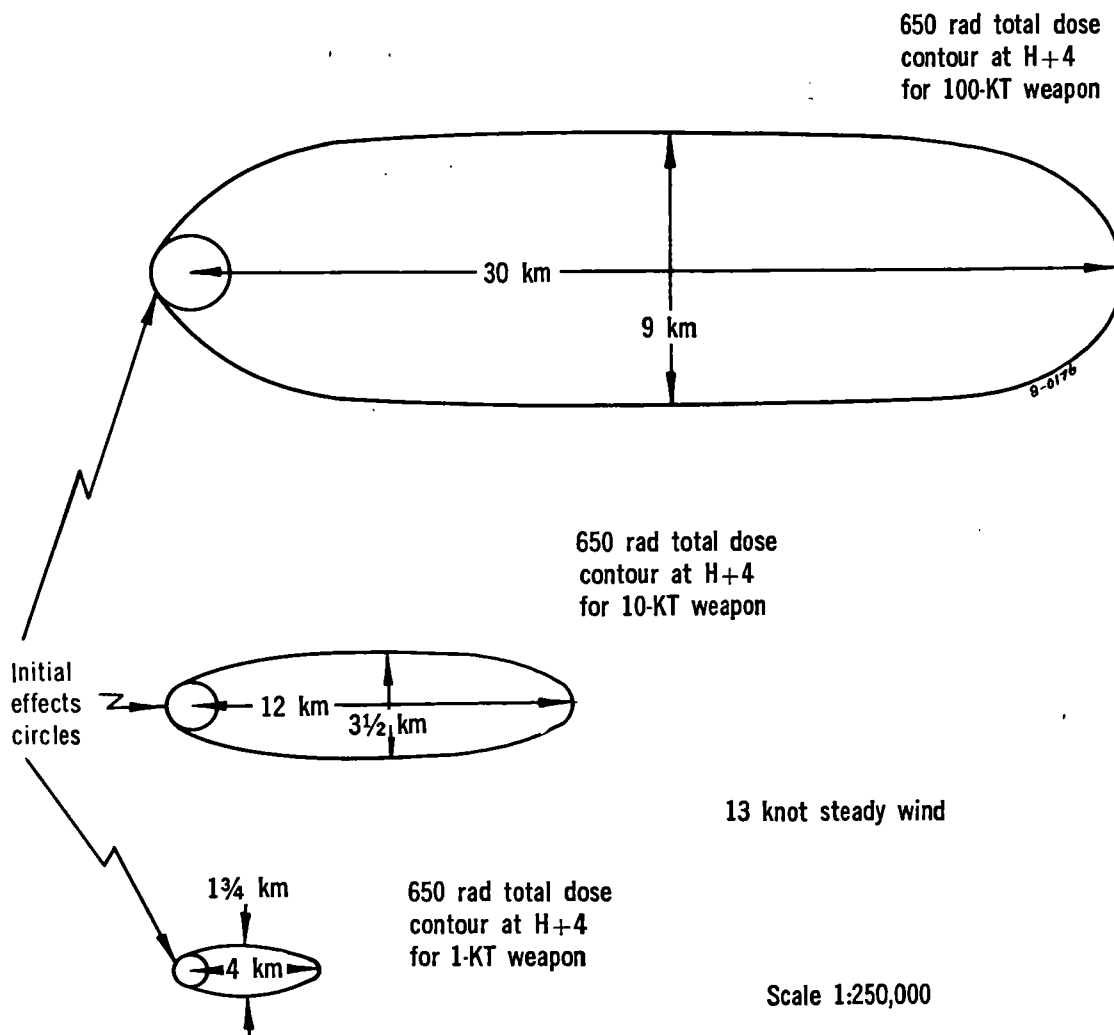


Figure 4-6. Comparison of initial effects and residual effects from 100-, 10-, and 1-kiloton surface bursts.

- (a) The commander may decide that a suspected target is so important that he must attack it even though friendly intelligence agencies may not have been able to collect significant information on the target.
- (b) Conversely, the commander may decide that a target is not of sufficient importance to warrant attack unless there is considerable certainty that the attack will be remunerative. In this respect, combat intelligence will seldom have the

capability to provide complete target information. *Delay of nuclear attacks until detailed intelligence is developed may impede the effectiveness of the attack.* On the other hand, engagement of a target without some indication of its characteristics may cause an unwarranted waste of combat power.

b. Once targets have been evaluated and given a priority for attack, the commander determines whether to engage them with nuclear fires, nonnuclear fires, maneuver

forces, or some combination of these means. The considerations that affect the attack of a target with a maneuver force and with non-nuclear fires are not discussed in this field manual.

c. There are many considerations that influence the decision to attack a target with nuclear weapons.

- (1) The availability of weapons is considered in the estimate. This availability is governed by the authority to fire and by the physical location by both the delivery unit and the weapon(s) to be delivered.
- (2) The time available to employ the weapon(s) influences the decision. Targets that are capable of moving may disappear subsequent to acquisition and prior to engagement if the timelag is significant.
 - (a) Time may be required to move the weapon(s), the delivery unit, or both, if they are not in a position from which the target can be engaged.
 - (b) Time is required for target evaluation, target analysis, fire direction, and preparation of the round for firing.
 - (c) Time is required to—
 1. Warn subordinate units.
 2. Coordinate with adjacent units into whose sector weapons effects may extend.
 3. Notify friendly aircraft.
- (3) The capability of the enemy to interfere with the friendly nuclear attack influences the decision. Means by which the enemy might interfere include attack of the friendly nuclear delivery means with either a maneuver force or firepower, electronic countermeasures, or interference with command and control facilities.
- (4) The results of target analysis affect the estimate of the situation.
 - (a) The commander may consider that the results expected from a nuclear

attack with a particular weapon are insufficient to warrant the expenditure of that nuclear weapon. If the insufficient results are because the reliability of the weapon system is low, the commander may decide that the importance of the target is so great that a more reliable means must be used in its attack.

- (b) Targets of a magnitude appropriate for attack with nuclear weapons are frequently ill-defined. Consequently, predictions of target coverage should not be given undue weight by the commander in making his decision.
- (c) Analysis of the target may indicate that a nuclear attack will produce undesirable results. For example, the commander may decide that the target is not sufficiently important to warrant a risk to friendly troops greater than a negligible risk. Or, target analysis may indicate that obstacles may be created that will impede the accomplishment of the mission more than the expected results will assist.
- (d) When target analysis indicates that the requirements established in the SOP cannot be met, the commander may decide to modify or revise the requirements so that the weapon(s) can be used. This revision of requirements may include one or more of the following:
 1. Accepting less damage to the target.
 2. Accepting a higher degree of risk for friendly troops.
 3. Delaying the nuclear attack to permit friendly troops to acquire greater protection.
 4. Accepting the possibility of obstacles or induced contamination in certain areas.
 5. Accepting the possibility of damage to industrial complexes, struc-

tures, materiel, or objects that it is desirable to leave undamaged.

6. Accepting a higher probability of fallout.

d. As a result of the estimate of the situation, the commander decides the proper method of engaging each target. The authority to engage a target with a nuclear weapon normally is retained personally by the commander. In appropriate circumstances, the commander delegates this authority to a specifically designated representative.

4-12. Tactical Damage Evaluation

a. Tactical plans are based on the condition of the target area predicted in the target analysis. Once the nuclear attack has been made, the *primary* or an *alternate* plan is executed, depending on the results achieved. In some cases, the decision may be made to fire a backup weapon. The impact of damage, casualties, obstacles, or contaminated areas on the planned operation is considered prior to the commitment of exploiting forces. Situations may arise in which changes of direction or even cancellation of an attack is possible or necessary.

b. Following a friendly nuclear burst, every reasonable effort is made to determine the damage to enemy forces and their reaction to the attack and to obtain information concerning residual radioactivity, fires, and obstacles.

4-13. Distribution of Nuclear Ammunition

a. Commanders and staff officers continuously evaluate the capabilities and limitations of logistical systems to support nuclear weapon employment. Because of the decisive character and limited availability of nuclear ammunition, the distribution of this ammunition is an operational as well as a logistical problem. A special ammunition logistic element (SALE) is established at the army and corps tactical operations center to logistically assist the tactical commanders in expediting the supply of special ammunition (see FM 54-8 (Test)).

b. The nuclear ammunition logistical system

is tailored 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) Simplicity and uniformity in procedures.
- (3) Minimum handling of nuclear ammunition.
- (4) Security of classified or critical materiel and installations.

c. The terms "special ammunition load" (SAL), "special ammunition stockage" (SAS), and "special ammunition supply point" (SASP) are defined in AR 320-5.

d. The tactical commander controls the distribution of nuclear ammunition by—

- (1) Determining the number of nuclear rounds that will be carried as part of the special ammunition load of organic or attached delivery units that are retained under his control.
- (2) Designating any nuclear rounds from his reserve or the reserve of a higher commander desires to have carried in the special ammunition load of a delivery unit that is under the control of a subordinate commander. Thus, the special ammunition load of a given delivery unit may include those weapons available to the organization to which the unit is organic or attached, as well as rounds to be delivered in support of higher, lower, or adjacent echelons.
- (3) Arranging for the stockage of nuclear rounds as part of the special ammunition stockage of a special ammunition installation not under his control; directing the stockage of nuclear rounds in special ammunition installations under his control.

e. The positioning of nuclear rounds for security and operational purposes may result

in a commander having more or fewer rounds positioned in his command than he is authorized to fire. In the latter case, procedures are established by which the additional rounds can be obtained, or fired, by another command.

f. When the availability of nuclear rounds permits, consideration is given to placing rounds in all nuclear delivery units. This permits dispersal of ammunition. Ammunition is usually positioned at some time during the allocation phase, before authority is given to employ the weapon. In many cases, this permits greater responsiveness after the weapons are released to executing commanders for employment.

g. Replenishment of the special ammunition load and the special ammunition stockage is accomplished by directed individual issue. Because of the limited supply of nuclear rounds and the requirement for varying the location of rounds to meet the changing tactical situation, directed individual replenishment is most feasible.

h. The number of nuclear rounds carried as part of a special ammunition load may vary among similar types of delivery units in the same command.

i. Distribution of nuclear munitions is affected by—

- (1) Mission.
- (2) Currently released weapons and authorizations to fire.
- (3) Allocation, current and anticipated.
- (4) Ammunition availability.
- (5) Carrying capacity of the delivery units. Consideration is given to the other types of ammunition being carried in the special ammunition load.
- (6) Security.
- (7) Transportation capability of support units.

j. Nuclear rounds are stored and issued to delivery units by ordnance special ammunition units. The complete nuclear round is issued to nuclear munition delivery users at special ammunition supply points. The details of ordnance ammunition support procedures are contained in FM 9-6-1 and ammunition service in FM 54-8 (Test).

4-14. Tactical Accountability

a. The decisive character of nuclear weapons and their limited availability make detailed recordkeeping necessary. Information pertaining to weapon location, availability, authorization to fire, and expenditure is made available to the members of the tactical operations center and the artillery fire direction center. In addition, the tactical operations center and the artillery fire direction center need information on ammunition readiness status, fire capabilities of nuclear delivery units, and the traveltime between logistical and tactical locations. This information is maintained in a manner that permits ready display to the commander and staff officers. Suggested forms or methods by which needed information can be kept at various staff agencies are discussed in b through d below. Similar records are kept on other types of special ammunition.

b. Planning information required for employment of nuclear ammunition is shown in figure 4-7. This is an example of an appropriate record and should be modified to meet the needs of the commander at each echelon. They demonstrate use of the sample charts by a corps headquarters. Because fewer types of nuclear rounds are available to a division, the charts at division level should be considerably reduced in size and complexity. Figure 4-7 portrays information on allocations, expenditures, and rounds carried in delivery units and special ammunition supply points. All entries indicate complete-round information, i.e., warhead section or shell and the associated missile and/or the propellant required to deliver the weapon on a target.

c. Information for use in the tactical operations center and the artillery fire direction center, in addition to the two figures described above, is shown in considerable detail in figures 4-8 and 4-9. The charts in these figures may require modification to meet the needs of the commander at each echelon and may, for convenience, be combined to form a single operations board. When a large number of weapons are in the special ammunition load, a separate weapon status chart for each type of delivery system available to the commander (e.g., Honest John, Sergeant, Pershing) should

be placed on the operations board together with the air-delivered weapon status chart. The operations board is used in conjunction with the partial nuclear ammunition summary and fire capabilities overlay to visualize the actual distribution of nuclear rounds.

- (1) Figure 4-8 accounts for *each* individual nuclear round that the headquarters has retained under its direct control (not those allocated to subordinate commanders). Location and

readiness status of each round are indicated. The time and date each round is expended are recorded on this form.

- (2) Figure 4-9 indicates the readiness status of each air-delivered weapon allocated to the command. Time and date of expenditure are recorded on this chart.

d. Additional information required to carry out logistical planning is shown on figure 4-10.

NUCLEAR AMMUNITION EXPENDITURE SUMMARY

HQ, 1st Corps
Posted 121800 Jul

Nuclear ammunition (delivery system/yield) ¹																						
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Total	MRC /0.5 KT	MRC /1 KT	MRC /2 KT	FFR/5 KT	FFR/10 KT	FFR/50 KT	LGM/2 KT	LGM/5 KT	MGM/20 KT	MGM/100 KT	HGM/500 KT	ADM/0.5 KT			Air delivered					Remarks
																	Air/10 KT	Air/20 KT	Air/50 KT			
1st Corps 8-18 July		50	6	3	3	4	6	5	4	5	4	2		3			1	2	2			
Expended to date		15		1	2	1	2	2	3	1	3											
Unexpended		35	6	2	1	3	4	3	1	4	1	2		3			1	2	2			
Allocation of unexpended rounds	Corps targets	4									1	1						1	1			
	21st Inf Div	6	1			1		1	1	2												For period 11-13 Jul
	52d Inf Div (Mech)	5	1	1			2	1														
	28th Armd Div	3	1			1				1												
	Corps res	17	3	1	1	1	2	1		1		1		3			1	1	1			
30th Army Res as of 12 Jul		150	21	12	9	9	14	11	8	13	4	7	6	8			7	8	13			For period through 1 Aug
Distribution of 1st Corps special ammunition load as of 121800 Jul																						
1st Corps	in delivery units	17	1	3	1	2	2	2	3	3	1											
	in SASP	17	5	2	1		1		1	1	1	2	3									
21st Inf Div		6	2			2		2														
52d Inf Div (Mech)		5	1			1	2	1														
28th Armd Div		4	1			1	2															
Total		49	10	5	2	6	7	5	4	4	1	2	3									

¹Delivery system and yields correspond to delivery systems shown in FM 101-31-3.

LEGEND

MRC—Medium-range cannon. MGM—Medium guided missile.
FFR—Free-flight rocket. HGM—Heavy guided missile.
LGM—Light guided missile. ADM—Atomic demolition munition.

Figure 4-7. Example of nuclear ammunition expenditure summary.

[illegible]

DELIVERY UNIT	TRAVEL TIMES (MINIMUM)

- NOTE 1. This chart is maintained on the operations board in the FSE and FDC, together with the air-delivered weapon status chart (fig. 4-9).
2. Under the *Unit* column, more than one delivery unit may be indicated.
3. A separate sheet is used for each delivery system under the operational control of the headquarters.
4. Under the *Time fired* column, the actual time-date that the weapon is fired is listed. This is the official expenditure record for the FSE and the FDC.
5. The four readiness statuses correspond in general to—
 - a. I (weapon in shipping container).
 - b. II (weapon assembled in rendezvous area).
 - c. III (weapon assembled, in firing position).
 - d. IV (weapon assembled, checked out, and firing data computed).
6. Under the appropriate weapon readiness status column, the location of each weapon is shown by an abbreviated code. For example:

Location	Code
SASP 610	S-610
Bn svc area	Bn
Bn rendezvous area C	C
Bn firing position 4	FP 4

7. Weapons in transit are carried in the *Remarks* column.

Figure 4-8. Example of weapon readiness status and expenditure chart.

AIR-DELIVERED WEAPON STATUS

Delivery system/yield		Time required	Remarks
	Number		

8-0176

- NOTE 1. This chart is maintained in the TASE of the TOC.
- 2. Under the *Delivery system/yield* column, list all the air-delivered weapons available to the headquarters and the number of weapons.
 - 3. Under the *Time required* column, list the delivery time. This includes flight time plus the time required for the aircraft to become airborne.
 - 4. Expenditures are indicated in the *Remarks* column.

Figure 4-9. Example of air-delivered weapon status chart.

4-15. Security of Nuclear Weapons and Delivery Sites

a. Nuclear delivery units and logistical units are comparatively small. The austere organization of the units may not provide sufficient personnel to perform all of the required security missions. The critical primary mission of these units makes them the target of enemy attacks. Commanders augment the units with the security forces necessary to safeguard

delivery sites, storage sites, radars, communications facilities, guns, launchers, or weapons.

b. Detailed procedures are established concerning actions to be taken by delivery units to preclude capture of nuclear weapons. SOP specify the circumstances under which the weapon is to be evacuated from the delivery site or is to be destroyed. Destruction means may include firing the weapon into a predetermined disposal area in enemy-held territory or

HQ 1st Corps
Posted 1800 D+2

LOGISTICAL SUMMARY

		Rockets				Missiles				Cannon				Atomic demolition munitions	Remarks	Total in SASP
		Free flight				Light	Medium	Heavy	Short range	Medium range						
Yield																
SASP	609															
	610															
	611															
Depot	970															
Overall total in SASP and depots																

UNITS SUPPORTED BY EACH SASP OR DEPOT

SASP No. 609 1st Corps HQ, 20th Inf Div, and 102d Abn Div	Depot 970 All corps units Depot
SASP No. 610 20th Inf Div	
SASP No. 611 55th Inf Div	
SASP No.	

6-0176

NOTE 1. This chart is maintained by agencies that control and coordinate tactical and logistical operations. It supplements the ammunition expenditure summary shown in figure 4-7. This chart indicates weapons present in the logistical installations.

2. Weapons in transit are shown in the *Remarks* column until their arrival at SASP is confirmed.

Figure 4-10. Example of nuclear ammunition logistical summary.

destroying the nuclear components by demolitions.

4-16. Nuclear Safety

a. To preclude an inadvertent burst, detailed technical safety procedures have been established. These safety procedures, established for peacetime operations, apply to wartime operations to the extent practicable.

(1) Positive measures are established for peacetime operations to—

(a) Prevent weapons involved in accidents or incidents (or jettisoned weapons) from producing a nuclear yield.

(b) Prevent the deliberate arming, launching, firing, or releasing of weapons, except on execution of emergency war orders or when directed by competent authority.

(c) Prevent the inadvertent arming, launching, firing, or releasing of weapons.

(d) Provide for adequate security.

(2) Procedures concerning the handling and storage of nuclear weapons are published in the technical manuals and the theater commander's directives that pertain to each nuclear weapon system.

- (3) Supervision of weapon handlers is required to insure compliance with established safety procedures.

b. If a nuclear accident occurs, either because of a mistake or because of enemy action, immediate action will reduce the extent of the disaster. SOP specify the actions to be taken by surviving personnel. See FM 3-15 for details.

- (1) The accident is reported to the next higher headquarters. This report includes the location and the nature of the accident.
- (2) If a surface burst has occurred, fall-

out will result; a fallout prediction is made and those units affected by the fallout are directed to take the action required.

- (3) Control points are established to control entry into areas of high levels of contamination.
- (4) Previously organized salvage parties are sent into the area. These parties are trained in decontamination procedures.

c. Enemy duds are reported to the next higher headquarters.

CHAPTER 5

OPERATIONS IN RESIDUAL RADIATION AREAS

5-1. General

a. Nuclear radiation that results from a nuclear explosion and persists longer than 1 minute after burst is termed "residual radiation." Residual radiation can contaminate the airspace over the area of operations, the terrain itself, or both, depending primarily on the height of burst of the weapon. Contamination of the airspace is for a relatively short period of time, and the radiation hazard to aircraft flying within the area is minimal. Residual radiation consists primarily of gamma and beta radiations, both of which present a serious personnel hazard. The gamma radiations are by far the more significant because of their range and penetrating power. Residual radiation can appear on the ground as induced contamination, which is found within a relatively *small* circular pattern around the ground zero; and as fallout, which is found in a large, irregular pattern encompassing the ground zero and extending for long distances downwind from the burst point.

(1) When a weapon is exploded at a height to preclude damage or casualties to ground targets, *neither* induced contamination *nor* fallout of tactical significance occurs. However, if rain (or snow) falls through the nuclear cloud, tactically significant *fallout* may result.

(2) When the height of burst is lowered below that indicated above to produce damage or casualties on the ground, but is kept above the fallout-safe height, induced contamination occurs. Fallout considerations are the same as those in (1) above.

(3) When a surface burst is employed, both induced contamination and significant fallout result. The fallout pattern can be expected to overlap and to mask the entire induced contamination pattern.

(4) Shallow subsurface bursts produce both induced contamination and fallout patterns on the ground.

b. Induced contamination and fallout have certain characteristics in common.

(1) Both persist for relatively long periods.

(2) Fallout consists largely of very fine particles and covers large areas. Induced contamination may be found to a depth of about one-half meter. For these reasons, the areas affected by both types of radiation are difficult to decontaminate.

(3) The size, shape, and location of fallout patterns are sensitive primarily to the wind structure. The size and intensity of the area of induced contamination are extremely sensitive to the variability of the soil composition. For these reasons, areas affected by both types of radiation are difficult to predict; However, fallout prediction is by far the more difficult and important problem.

c. The large areas contaminated by fallout pose an operational problem of great importance. Potentially, fallout may extend to greater distances and cause more casualties than any other nuclear weapon effect. It exerts an influence on the battlefield for a considerable time after a detonation. Induced contamination is relatively *limited in area*, and *minor* tactical changes normally can be made to avoid any serious effects.

d. The biological response of humans to residual radiation is essentially the same as their response to initial radiation. The total dose of radiation absorbed by an individual is the sum of the initial radiation doses and the residual radiation doses he has received. Biological response to radiation is discussed in detail in paragraph 2-22.

5-2. Induced Contamination

a. All radioactive materials decay. The rate at which this decay takes place depends on the soil elements themselves. Some (e.g., sodium) decay slowly and others (e.g., aluminum) decay rapidly. This decay rate, measured in terms of "half-life," and the element's gamma radiation intensity determine the significance of the induced radiation hazard. The distance to which a 2-rad-per-hour dose rate extends 1 hour after burst is considered the limit of significant induced activity. Estimates of the extent of the 2-rad-per-hour contour, are con-

tained in table B-III-1, FM 101-31-2 and chapter 18, FM 101-31-3.

b. Whenever a nuclear attack is being planned, the nuclear weapon employment officer advises the commander and the staff of the possible hazard of induced contamination. After the attack, a radiological contamination chart is made from the reports of radiological survey teams. In comparison with other nuclear weapon effects, however, induced radiation *does not pose a threat* of major military significance.

(1) It may be extremely hazardous for troops to enter and to stay in an area of induced contamination. Because of the great destruction near the ground zero, where induced contamination may be found, there is seldom a requirement for troops to enter and stay in the area. In the event occupancy is necessary, radiation is monitored to insure that allowable total doses are not exceeded.

(2) Thirty minutes after burst, troops in vehicles may usually pass through the ground zero and foot troops may usually pass within 300 meters of the ground zero without undue radiation risk. (It is emphasized that this is true only if the burst was at sufficient altitude to preclude fallout. The area around GZ 30 minutes after fallout producing bursts will be subject to extremely high dose rates.)

The area of induced contamination is relatively *small*, and it should be possible to avoid it or to traverse it rapidly.

5-3. Fallout

☆a. Radioactive fallout also decays. The decay rate from a single weapon can be determined fairly accurately by using the M1 radiac calculator. For a quick estimate of fallout decay, the intensity can be considered to decrease by a factor of ten as the time after burst increases by multiples of 7. Thus a 50-rad-per-hour dose rate (measured at H+1 hour) decays to a five-rad-per-hour dose rate in 7 hours and to less than one-half rad-per-hour dose rate at H+49 hours.

b. Use of fallout is discussed in paragraph 4-10.

c. Reduced to fundamentals, the major aspects of fallout deposition are as follows:

(1) Fallout is formed whenever the nuclear fireball intersects the ground.

(2) The heavier fallout particles start reaching the ground around the ground zero

within a few minutes after burst. The lighter particles reach the ground farther downwind at later times. Figure 5-1 illustrates how total dose may vary with time and distance.

(3) The size, shape, and location of the areas contaminated by fallout depend largely on the winds that blow the particles that rise with the nuclear cloud and then fall back to earth. Changing wind directions can subject some locations to long periods of fallout deposition.

(4) Greatest intensity is usually close to the ground zero, but high-intensity "hotspots" and low-intensity "areas" may occur throughout the pattern because of winds or rain.

d. The total radiation dose absorbed by an individual is a function of radiation intensity, exposure time, and protection.

e. Residual radiation is absorbed or reflected in the same manner as prompt gamma radiation. See paragraph 2-21b for shielding considerations.

f. FM 3-12 provides procedures to compute permissible exposure times and total doses in fallout areas. The M1 radiac calculator can also be used to compute total doses and exposure times in single weapon fallout areas.

5-4. Prediction of Fallout Areas

(This paragraph is based on STANAG No. 2103.)

a. A tactical fallout prediction system must be a compromise between speed and simplicity, on the one hand; and the time-consuming complexity that increases accuracy, on the other. The present U.S. Army method of predicting fallout gives only a warning sector, somewhere within which most of the fallout is expected to occur.

b. The U.S. Army and U.S. Marine Corps method of fallout prediction is explained in TM 3-210. The prediction results in portrayal of an area that is expected to contain most of the significant fallout. A detailed prediction is prepared in the tactical operations center, based on the best available weather and weapon data. Brigade and lower units use the M5 fallout predictor and effective wind message to estimate the hazard area; the M5 predictor is applied using less precise data. Both predictions present a *graphical* portrayal of the expected hazard. The hazard area is subdivided into—

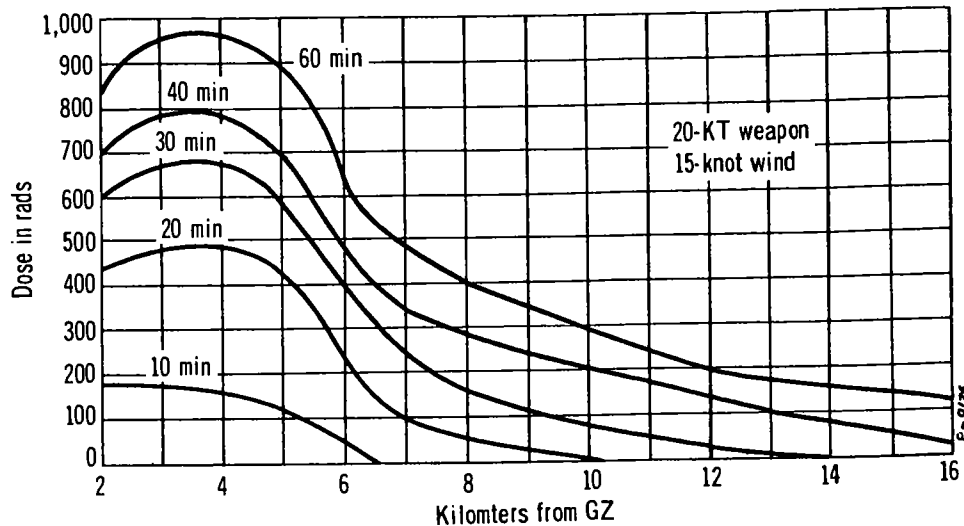


Figure 5-1. Total dose variation as a function of time after bursts and distance from the burst.

(1) An area within which countermeasures may have to be taken immediately (divided into two separately defined sub-areas); and

(2) An area in which early, but not immediate, action may have to be taken to counter the threat of unacceptable doses.

c. The basic inaccuracies in fallout prediction permit this method to be used in depicting suspect areas for early monitoring and survey, as well as for planning movement of units, but not as a basis for executing operational moves (para 5-5a(1)). The method also permits prediction of the areas outside which friendly troops are likely to have relative immunity from the fallout hazard.

d. In an active nuclear war, it is reasonable to expect fallout at a given location occasionally to be caused by more than one nuclear burst, thereby causing multiple overlapping fallout patterns. See FM 3-12 and TM 3-210 for the proper technique to handle such situations.

★5-5. Basis for Standing Operating Procedures for Operations in Fallout Areas

a. Command decisions in any fallout situation are based on consideration of two opposing factors: the demands of the tactical situation and the hazards due to radiation. At one extreme, the total energies of the unit are directed toward keeping the radiation exposure at a minimum. At the other

extreme, the demands of the tactical situation are clearly dominant.

(1) *Radiation hazard dominant.* In general, two courses of action are considered: early movement from the fallout area and remaining in position.

(a) *Early movement.*

1. When air or surface transport means are available, evacuation from the area as soon as possible normally is the best course of action.

2. When the shielding provided by the exit means is approximately equal to or better than that available in the position (and in the absence of air evacuation means), movement from the area is accomplished as soon as the minimum-dose exit route can be determined. (See FM 3-12 for details.)

3. Fallout predictions are *not* sufficiently accurate to be used as a sole basis for such moves. Therefore, movements normally are based on measured dose rates and dosimeter readings obtained *after* the fallout has begun. From such readings, the direction of decreasing intensities and the limits of the fallout pattern nearest the unit are determined. From this, a minimum-dose exit route is selected. A method for determining the optimum time for exit of fallout areas is given in FM 3-12.

4. All available shielding measures are taken within the position until evacuation or movement has begun.

(b) *Remaining in position.* When the total dose expected in the position is significantly less than that which would occur by moving, the best solution is to remain in position for approximately 6 hours after the burst, at which time movement from the pattern can be made or decontamination operations can be begun.

(2) *Tactical demand dominant.*

(a) When the tactical demand clearly governs, the unit continues to place primary emphasis on the accomplishment of its mission. The unit takes action whenever possible to keep radiation exposure to a minimum. These actions usually con-

sist of decontamination and the use of available shielding.

(b) Decisions to shift emphasis toward countermeasures against radiation are dependent on a capability to predict with reasonable accuracy the times at which the crucial radiation doses will be reached. Such predictions can be made when the peak dose rate and the time to peak (in minutes after burst) are known. When such predictions cannot be made because unit survey meters have gone off scale, it can be assumed that the unit will be exposed to incapacitating radiation doses within a few minutes unless immediate countermeasures are taken.

b. Sample SOP are found in FM 3-12 and FM 61-100.

5-6. Exposure of Personnel to Nuclear Radiation (Based on STANAG 2083)

a. Ground forces operating in a nuclear environment must expect exposure of personnel to radiation. Operations may dictate such exposure as a normal hazard of battle. For tactical planning purposes, when considering troops with no previous radiation exposure history (RS-1), an acute dose of 5 rad constitutes a negligible exposure, 50 rad a serious (emergency) exposure.

b. The effect on an exposed individual depends on the total dose accumulated from previous radiation exposures; duration of time over which the doses were received; type, energy, and geometry of the source of the radiation; periods of recuperation between radiological exposure; *individual response* because of physical condition, sex and age at time of exposure; and the presence or absence of any additional injuries or incapacitations. The effect on a single individual cannot be accurately predicted. The average effect on a large group can be predicted with sufficient accuracy for military purposes. *Groups* of personnel who have accumulated, in small increments within 1 year, a total body dose of about 350 rad may not

demonstrate short-term symptoms of radiation sickness. However, these personnel may be expected subsequently to demonstrate lowered efficiency and increased susceptibility to long-term radiation effects. Additionally, when such a dose has been accumulated by a group within a short period (e.g., less than 1 week), it can be expected that significant further short-term exposure will lead to early ineffectiveness in even the more resistant individuals of the group.

c. The recommendation to admit personnel suspected of nuclear radiation injury to medical channels is made by the unit surgeon, based on *symptoms* and *physical findings* and *not* on an actual or calculated physical measurement of exposure.

d. Commanders consider the potential consequences of using personnel exposed to significant but nonsymptomatic doses, especially in situations likely to result in further exposure to radiation. To arrive at a timely decision on whether to continue use of these personnel, the commander uses all available means to determine the level of radiation exposure of his command. FM 3-12 discusses techniques for determining this level and for classifying units into categories that relate to the total cumulative radiation dose received (para 2-22).



CHAPTER 6

PROTECTIVE MEASURES

Section I. GENERAL

6-1. General

a. This chapter considers those situations in which personnel and materiel are exposed to some degree of nuclear weapon effects against which protection can be provided in the field.

b. Training in protective measures to be taken and establishment of correct operating procedures prepare the individual soldier for survival on the nuclear battlefield. Neither the threat of nor the use of enemy nuclear weapons can be permitted to interfere with the accomplishment of assigned missions. Forces able to protect themselves from nuclear weapon effects can maintain their combat capability.

c. The degree of protection that an individual or a unit is able to achieve in a given situation is determined by the preparedness of the unit or the individual at the time of the nuclear burst. The preparedness of the unit or the individual is dependent on such factors as—

- (1) Time and materials available for the individual to prepare shelter.
- (2) Training of the individual in protective measures.
- (3) Sound unit SOP.

d. General guidance on protective measures is presented in this chapter; *details* are available in other publications referenced in this chapter. Figure 6-1 shows doctrinal threshold figures regarding troop safety criteria.

6-2. Principles of Protection

The principles of protection include dispersion, shielding, minimization of the time of exposure, and radiological decontamination.

a. Dispersion.

- (1) For a given weapon, the distance between the desired ground zero and friendly troops (and their degree of protection) determines the risk of damage to them (para 3-7). The distances between units and between elements within a unit are a measure of the unit's vulnerability to nuclear attack (para 3-11). The dispersion desired in any given situation is determined by evaluation of such factors as mission, terrain, enemy target acquisition and nuclear delivery capability, and friendly unit dispositions. Dispersal of friendly forces achieves dual benefits.
 - (a) A well-dispersed unit that moves only under the cover of darkness and observes rigid camouflage discipline is difficult to detect and to attack.
 - (b) Even if it is detected and attacked, the well-dispersed unit will suffer fewer casualties than if it were not dispersed.
- (2) While dispersion is desirable to reduce the vulnerability to nuclear attack, sufficient troop density must be maintained to accomplish the mission. Acceptable degrees of dispersion cannot be specified for all situations. The commander on the scene determines the permissible dispersion for each situation, giving primary consideration to the accomplishment of the mission.

b. *Shielding.* Shielding consists of providing

EFFECT	RISK LEVEL	VULNERABILITY CATEGORY																																
		UNWARNED EXPOSED				WARNED EXPOSED																												
B L A S T (psi)	Negligible	$V_{1, ER 2.5}$ <table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>ΔP</td><td>/</td><td>6.5</td><td>4.2</td><td>2.8</td><td>1.9</td><td>1.25</td></tr><tr><td>ER</td><td>8</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr></table>									W	0.01	0.1	1	10	100	1000	ΔP	/	6.5	4.2	2.8	1.9	1.25	ER	8	/	/	/	/	/			
	W	0.01	0.1	1	10	100	1000																											
	ΔP	/	6.5	4.2	2.8	1.9	1.25																											
ER	8	/	/	/	/	/																												
Moderate	$V_{2.5, ER 5}$ <table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>ΔP</td><td>/</td><td>8</td><td>5.5</td><td>3.5</td><td>2.1</td><td>1.5</td></tr><tr><td>ER</td><td>8</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr></table>									W	0.01	0.1	1	10	100	1000	ΔP	/	8	5.5	3.5	2.1	1.5	ER	8	/	/	/	/	/				
W	0.01	0.1	1	10	100	1000																												
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ER	8	/	/	/	/	/																												
Emergency	V_5 <table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>ΔP</td><td>15</td><td>9.2</td><td>6</td><td>4</td><td>2.75</td><td>1.75</td></tr></table>									W	0.01	0.1	1	10	100	1000	ΔP	15	9.2	6	4	2.75	1.75											
W	0.01	0.1	1	10	100	1000																												
ΔP	15	9.2	6	4	2.75	1.75																												
T H E R M A L cal/cm ²	Negligible	$1B$ $Q_{2.5}$ <table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>0.85</td><td>1.0</td><td>1.15</td><td>1.3</td><td>1.5</td><td>1.75</td></tr></table>						W	0.01	0.1	1	10	100	1000	Q	0.85	1.0	1.15	1.3	1.5	1.75	$1Us$ $Q_{2.5}$ <table><tr><td>W</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>3.6</td><td>4.5</td><td>6.3</td><td>8.8</td></tr></table>			W	1	10	100	1000	Q	3.6	4.5	6.3	8.8
	W	0.01	0.1	1	10	100	1000																											
	Q	0.85	1.0	1.15	1.3	1.5	1.75																											
W	1	10	100	1000																														
Q	3.6	4.5	6.3	8.8																														
Moderate	$1B$ Q_5 <table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>.95</td><td>1.1</td><td>1.3</td><td>1.5</td><td>1.75</td><td>2.0</td></tr></table>						W	0.01	0.1	1	10	100	1000	Q	.95	1.1	1.3	1.5	1.75	2.0	$1Us$ Q_5 <table><tr><td>W</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>4</td><td>5.2</td><td>7.2</td><td>10</td></tr></table>			W	1	10	100	1000	Q	4	5.2	7.2	10	
W	0.01	0.1	1	10	100	1000																												
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W	1	10	100	1000																														
Q	4	5.2	7.2	10																														
Emergency	$2B$ Q_5 <table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>1.5</td><td>1.7</td><td>1.9</td><td>2.2</td><td>2.9</td><td>4</td></tr></table>						W	0.01	0.1	1	10	100	1000	Q	1.5	1.7	1.9	2.2	2.9	4	$2Us$ Q_5 <table><tr><td>W</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>4.7</td><td>6.1</td><td>8.8</td><td>12.5</td></tr></table>			W	1	10	100	1000	Q	4.7	6.1	8.8	12.5	
W	0.01	0.1	1	10	100	1000																												
Q	1.5	1.7	1.9	2.2	2.9	4																												
W	1	10	100	1000																														
Q	4.7	6.1	8.8	12.5																														
NUCLEAR single shot	Negligible	RS-1 5 rad			RS-2 ..		RS-3 ..																											
	Moderate	20 rad			5 rad		..																											
	Emergency	50 rad			20 rad		5 rad																											

W = Yield in kilotons

 ΔP = Incident overpressure Q_{2Us} = Incident thermal flux-2° burns under summer uniform Q_{1B} = Incident thermal flux-1° burns to bare skin

V = Translational impact injury to prone personnel

ER = Ear drum rupture

RS = Unit radiation exposure category

Subscripts to Q, V, and ER denote probable percent of command affected by specified level of effect.

Figure 6-1. Troop safety criteria.

individuals and equipment with physical protection to reduce weapon effects. The best protection is afforded by deep underground shelters. Such structures are expensive in time and materials; their construction on the battlefield usually is not feasible. Reliance is placed on hasty field fortifications, such as trenches, foxholes, emplacements, revetments, bunkers, and simplified underground shelters. Tanks provide considerable protection against the effects of a nuclear explosion. Armored personnel carriers provide considerable protection against blast and thermal effects and some protection against initial nuclear radiation. Tracked carriers also provide some protection against residual radiation. Wheeled vehicles provide no protection against blast or initial nuclear radiation. Vehicle tarpaulins provide considerable protection against thermal radiation. Sandbags on the beds of trucks provide some protection against residual radiation. See FM 101-31-2 and chapter 18, FM 101-31-3 for appropriate transmission factors.

c. Minimization of the Time of Exposure. Techniques for minimization of the time of exposure to radiation are discussed in chapter 5.

d. Radiological Decontamination. Radiological decontamination is the process of reducing to an acceptable level the hazard of radioactivity from residual contamination. Radioactive contaminants are fission products, fusion products, unfissioned active material, and matter in which radioactivity has been induced. Some methods of decontamination are surface cleansing or scraping, sealing, and disposal. Decontamination processes do not neutralize or destroy radioactivity. These processes seek to diffuse and dilute the contamination to a safe level. Individual decontamination measures reduce radiation hazards that would result from ingestion or inhalation of radioactive particles coming in contact with the skin and clothing. Area decontamination requires organization, supervision, and considerable time, effort, and materiel. Decontamination procedures are discussed in detail in TM 3-220.

Section II. INDIVIDUAL PROTECTIVE MEASURES

6-3. General

a. Paragraph 4-6 discusses a warning system that permits timely notification of intended friendly employment of nuclear weapons. This system is also used to warn friendly troops in the isolated cases when enemy nuclear weapon employment is known in advance. For friendly employment, adequate warning is required to allow the individual to achieve the degree of protection assumed in the target analysis leading to a given burst. In the case of possible enemy employment, each individual observes the best protective procedures that his situation permits (table 6-1).

b. *Specific* references that should be consulted for more detailed information pertaining to protective measures are FM 21-40 and FM 21-41.

6-4. Enemy Employment

a. Proper reaction to attack offers the individual

some chance for survival and early continuation of his mission. All personnel are trained to react rapidly, as follows:

- (1) If exposed, move no more than a few steps to seek shelter.
- (2) Drop flat on the ground.
- (3) Close eyes.
- (4) Protect exposed skin surfaces.
- (5) Remain prone until after the blast wave has passed or debris has stopped falling.

b. Enemy nuclear weapons are expected to be followed by attacks involving enemy infantry, armor, or both. Individuals and units prepare to repel enemy followup operations, which may be accompanied by conventional artillery fire and use of chemical and biological agents.

Section III. UNIT PROTECTIVE MEASURES

6-5. Standing Operating Procedures

a. For the *friendly* employment of nuclear weapons, the SOP establishes the normal troop safety criteria, radiation exposure control procedures, maximum and minimum warning times, warning, system procedures, and fallout prediction dissemination procedures.

b. Damage assessment, control, and repair responsibilities as well as monitoring and survey, decontamination, and reporting responsibilities are established.

c. Minimum separation distances between critical installations, such as command posts; nuclear delivery means; and reserve units are specified.

d. The succession to command, the shift of control among headquarters, and alternate means of communications, transport, supply, and evacuation are established.

e. A complete SOP minimizes the disruption caused by nuclear attack and establishes suitable patterns of action for surviving individuals, units, and staff sections. Commanders modify the SOP on a case-by-case basis as circumstances require.

★6-6. Training

Individual and unit training emphasizes the protective actions leading to survival in nuclear war. This training embraces a knowledge of weapon effects, fallout, evasive actions, decontamination, and relative worth of battlefield shelters. Recovery plans are rehearsed and integrated into the scenarios of field exercises. Training in operations in areas of residual contamination is tied to instruction in monitoring and survey techniques (para 6-7).

6-7. Monitoring and Survey

a. Radiological monitoring involves the use of radiac instruments to detect and to measure ionizing radiation. (The individual who uses these instruments is known as the monitor.) Radiac instruments are of two types: *survey meters* to

measure dose rate and *dosimeters* to measure total dose. Monitoring provides warning of a hazard that, except for the use of radiac instruments, would go unmeasured. Monitoring is included in normal reconnaissance and intelligence activities and does not appreciably interfere with the primary mission of the monitor or his unit.

b. Radiological survey is the systematic, organized use of survey parties whose mission is to determine the location, extent, and dose rate of residual radiation in an area. When monitoring data are insufficient to the needs of brigade, division, and higher echelons, surveys may be directed to obtain essential information upon which to base tactical and combat service support plans. In the Army, the chemical officer and in the Marines, the NBC defense officer supervise the planning of surveys, the processing of survey data, and the marking of hazardous areas. Commanders at all echelons are responsible for the training of survey parties and for performing surveys as required or directed.

c. The information gained from the activities of radiological monitors and survey parties provides a basis for decisions on the requirement for protection, entry, stay, and departure times from contaminated areas and for movement of units and supplies.

d. Detailed procedures for monitoring and survey operations are discussed in FM 3-12.

6-8. Control and Communications

a. The problems of command and control multiply as tactical units disperse to avoid detection and attack. Even in the best trained units, some confusion will follow a nuclear attack because of surprise, shock, physiological and psychological casualties, materiel damage, and reduced visibility. An important means of maintaining or restoring command and control is the communications network, both within and between units.

b. Unless units are strictly controlled during the immediate post attack phase, communications will be overloaded by reports and requests

for information. Communications equipment is protected from physical damage from weapon effects to preserve this vital control element. The SOP specifies the emergency use of all communications means, restrictions, and alternate means. It also specifies the conduct of units in the event all communications are lost.

6-9. Terrain

Gross terrain features, such as hills, ridges, forests, and streambeds, offer protection from

weapon effects. Terrain interposed between a nuclear detonation and a unit can protect that unit from thermal effects and significantly reduce the blast and initial nuclear radiation effects. The regularity, condition, and nature of the reflecting surface affect the distance to which blast overpressures will extend on the ground. Forests beyond the range of significant tree blowdown offer protection in the form of thermal shielding to troops deployed therein.

Table 6-1. Types and Degrees of Protection for Personnel Against Nuclear Weapons Effects

Type of protection	Degree of protection		Initial effects		
	Blast	Thermal	Initial radiation	Induced	Residual radiation Fallout
In the open -----	None -----	None to fair. Clothing protects against heat, depending on nature of material and number of layers. Air between layers of clothing provides insulation.	None -----	None -----	None.
Stone, brick, or concrete walls.	Fair, depending on material, thickness, and type of construction.	Excellent against direct rays. None against rays reflected to back side of wall.	Some from direct radiation. None from scattered radiation.	None -----	None.
Ditches, slit trenches.	Good, depending on orientation relative to the ground zero.	Good, depending on depth and orientation. Rays can be reflected to inside.	Good, depending on depth and orientation. Radiation can be scattered to inside.	None -----	None against entry of fallout particles. Fair against radiation from surrounding area. Decontamination of ditches is difficult.
Culverts -----	Good, depending on orientation relative to the ground zero, depth, and construction.	Excellent, depending on orientation. Rays can be reflected into openings.	Excellent, depending on orientation and depth. Radiation can be scattered into openings.	Good, depending on depth and closing of openings with earth, sandbags, and other material.	Good, provided openings are closed with earth or other material and continuous decontamination is practiced.
Ravines and gullies -	Fair -----	Excellent against direct rays. Some thermal may be scattered.	Some from direct radiation. None from scattered radiation.	None to fair -----	None to fair.
Open foxholes and trenches.	Good -----	Excellent against direct rays. Thermal can be reflected into foxhole.	Excellent against direct radiation. None from scattered radiation.	Questionable. Degree of protection depends on removing radioactive soil from surrounding area and inside foxhole or trench.	Excellent, provided foxhole is covered with poncho, shelter half, or other material to exclude fallout and particles; decontamination is continuous after fallout is complete.

Covered foxholes and trenches (1-meter earth cover).	Excellent -----	Excellent -----	Excellent -----	Protection is better than that in open foxholes. More personnel will survive initial effects than those in open foxholes. Scraping 2 inches from the surface inside foxhole will drastically reduce induced contamination inside foxhole.	Excellent, provided decontamination is continuous after fallout is complete.
Emplacements or shelters (1-meter earth cover).	Excellent -----	Excellent -----	Excellent -----	Questionable. See above.	Excellent.
Built-up areas (outdoors).	None to fair. Depends on distance from the ground zero, type of structure, reflection of blast wave, and missiles.	None to excellent, depending on orientation with the ground zero.	None to excellent, depending on orientation with the ground zero.	None to fair -----	None from falling particles. Fair after cessation of fallout.
Residential buildings (one-family frame):					
Upper floors ---	None to fair -----	Excellent from direct radiation. None from secondary fires.	None -----	Fair -----	None to fair.
Basements ---	Good from direct blast. Hazard of collapse of upper floors into basement.	Excellent -----	Good -----	Excellent -----	Excellent.
Apartments and office buildings:					
Upper floors --	Fair -----	Excellent -----	None to fair -----	Excellent -----	Excellent.
Basements ---	Good -----	Excellent -----	Good -----	Excellent -----	Excellent.
Light-metal industrial buildings.	None -----	Good -----	None -----	Fair -----	Fair.
Tents -----	None -----	Good -----	None -----	None -----	None.
Forests -----	None -----	Fair to good, depending on canopy cover, density of stand, and location of individual in respect to edge of forest toward the ground zero.	None -----	None -----	None. Fallout deposited on foliage may increase radiation effects.

Table 6-1. Types and Degrees of Protection for Personnel Against Nuclear Weapon Effects—Continued

Type of protection	Degree of protection			Residual radiation	
	Blast	Initial effects Thermal	Initial radiation	Induced	Fallout
Wheeled vehicles ---	None -----	None to fair -----	None -----	Shielding is fair. Mobility will reduce exposure time when leaving or crossing the area.	Shielding is fair. Mobility will reduce exposure time when leaving or crossing the area.
Armored carriers --	Good -----	Excellent -----	Fair -----	Shielding is fair. Mobility will reduce exposure time when leaving or crossing the area.	Shielding is fair. Mobility will reduce exposure time when leaving or crossing the area.
Tanks -----	Excellent -----	Excellent -----	Excellent -----	Shielding is excellent. Mobility will reduce exposure time when leaving or crossing the area.	Shielding is excellent. Mobility will reduce exposure time when leaving or crossing the area.

APPENDIX A

REFERENCES

A-1. Army Regulations

AR 40-14	Control and Recording Procedures, Occupational Exposure to Ionizing Radiation.
AR 50-2	Nuclear Weapon Accident and Incident Control (NAIC).
AR 55-203	Movement of Nuclear Weapons Components and Nuclear Weapons Material.
AR 95-55	Nuclear Weapon Jettison.
AR 220-58	Organization and Training for Chemical, Biological, and Radiological (CBR) Operations.
AR 320-5	Dictionary of United States Army Terms (Short Title: AD).
AR 320-50	Authorized Abbreviations and Brevity Codes.
(O) AR 700-65	Nuclear Weapons and Nuclear Weapons Material.

A-2. Field Manuals

FM 310	Employment of Chemical and Biological Agents.
(S) FM 3-10A	Employment of Biological Agents (U).
(C) FM 3-10B	Employment of Chemical Agents (U).
FM 3-12	Operational Aspects of Radiological Defense.
FM 3-15	Nuclear Accident Contamination Control.
FM 5-26	Employment of Atomic Demolition Munitions (ADM)
FM 6-20-1	Field Artillery Tactics.
FM 6-20-2	Field Artillery Techniques.
(S) FM 9-2A	Special Ammunition Logistical Data (Classified Data) (U).
FM 9-6-1	Ammunition Service in the Theater of Operations TASTA-70.
(Test)	
FM 21-30	Military Symbols.
FM 21-40	Chemical, Biological, and Nuclear Defense.
FM 21-41	Soldier's Handbook for Defense Against Chemical and Biological Operations and Nuclear Warfare.
FM 31-10	Barriers and Denial Operations.
(S) FM 44-1A	U.S. Army Air Defense Employment (U).
FM 54-8 (Test)	The Administrative Support Theater Army TASTA-70.
FM 61-100	The Division.
(S) FM 101-31-2	Staff Officers' Field Manual; Nuclear Weapons Employment Effects Data (Classified) (U).
FM 101-31-3	Staff Officers' Field Manual; Nuclear Weapons Employment Effects Data (Unclassified).
FM 105-5	Maneuver Control.
(C) FM 105-6-1	Nuclear Play Calculator (U).
FM 105-6-2	Nuclear Play Calculator.

FM 105-6-3 Nuclear Play Calculator Aggressor.

A-3. Technical Manuals

TM 3-210	Fallout Prediction.
TM 3-220	Chemical, Biological, and Radiological (CBR) Decontamination.
TM 5-225	Radiological and Disaster Recovery at Fixed Military Installation.
TM 5-311	Military Protective Construction (Nuclear Warfare and Chemical and Biological Operations).
(C) TM 23-200	Capabilities of Nuclear Weapons (U).
TM 55-602	Movements of Special Freight.

A-4. Other Publications

DA Pam 39-3	Nuclear Weapons.
JCS Pub 1	Dictionary of United States Military Terms for Joint Usage (Short Title: JD).
TB 385-2	Nuclear Weapons Firefighting Procedures.
TB CML 92	Calculator Set, Nuclear M28.
TB CML 120	Area Predictor Radiological Fallout, M5.
TC 3-15	Prediction of Fallout from Atomic Demolition Munitions (ADM).

APPENDIX B

TARGET ANALYSIS

B-1. General

a. Target analysis is a comparison of the characteristics of the target(s) to be attacked with the effects that the available weapon(s) and delivery system(s) can produce. The analysis results in the selection of the most suitable weapon system for attack and in the prediction of damage that should be sustained in the target area as a result of the attack.

b. The target analyst must be proficient in analyzing targets for attack with chemical, biological, and nuclear weapons. Procedures and data for use in analyzing targets for attack with chemical and biological weapons are found in FM 3-10, FM 3-10A, and FM 3-10B.

c. This appendix outlines the procedures that the target analyst follows in analyzing targets suitable for nuclear attack. An understanding of the general discussion of target analysis in chapter 3 of this manual will assist the analyst in an understanding of the detailed explanations set forth in this appendix.

d. This appendix is organized as follows:

(1) Annex B-I discusses probabilities and procedures used in computing a probability. Annex B-I also discusses the concept of damage and defines the term "radius of damage" (RD).

(2) Annex B-II discusses the three methods used to compute damage estimation: index method, visual method, and numerical method.

(3) Annex B-III discusses limiting requirements and their influence on nuclear weapon employment. The discussion of limiting requirements is divided into troop safety and preclusion of damage/obstacle considerations.

(4) Annex B-IV discusses the desired ground zero, the effects on target coverage when the desired ground zero is displaced from the target center, and the procedures used in selecting the desired ground zero.

(5) Annex B-V discusses the special considerations necessary when targets cannot be

equated to one of the major categories listed in FM 101-31-2 and FM 101-31-3, or when nonstandard delivery errors are present in a weapon system.

★(6) Annex B-VI discusses poststrike analysis based on the refinement of damage estimation from known data, using the numerical or the visual method of damage estimation.

(7) Annex B-VII discusses friendly vulnerability and the procedures used to predict the results of an assumed enemy nuclear attack on friendly troop dispositions and/or installations.

★B-2. General Procedures for Performing Target Analysis

Figure B-1 outlines a four-step procedure for use as a guide in performing target analysis. Analysts will normally develop procedures that best fit their own experience, ability, and command guidance; however, use of the outlined procedure will insure a complete and correct analysis. An explanation of the information required in performing the steps listed in figure B-1 is included in *a* through *d* below.

a Step 1. Identify Pertinent Information. Step 1 includes target information, friendly information, and information that normally will be found in standing operating procedures and received from command guidance.

(1) *Target information.*

(a) Location, size, and shape of the target.

(b) Category of target element (e.g., personnel).

(c) Distribution of target elements within the target complex and their degree of protection against weapon effects.

(d) Stability of the target.

(2) *Friendly information.*

(a) Weapons available.

(b) Location of available weapons.

(c) Location of delivery means.

(d) Location of firing positions.

(e) Location of friendly troops in zone(s)

TARGET ANALYSIS PROCEDURE

1. Identify Pertinent Information
 - a. Target information.
 - b. Friendly information.
 - c. SOP and command guidance.
2. Determine Data for—
 - a. Damage estimation.
 - (1) Index method.
 - (2) Visual method.
 - (3) Numerical method.
 - b. Limiting requirements.
 - (1) Troop safety.
 - (2) Damage and obstacle preclusion.
 - c. DGZ selection.
 - d. Final coverage.
3. Evaluate Weapon Systems and the Tactical Situation
4. Make Recommendation

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Figure B-1. Target analysis procedures.

of planned burst, their degree of protection from weapon effects, and their radiation exposure status.

(f) Location of installations not to be damaged.

(g) Response times. The state of training and amount of time required by a unit to deliver its weapon (response time) must be considered along with the stability of a target. General planning guidance for each weapon system is given in FM 101-31-2. However, the analyst must acquire more definitive guidance from the units assigned to the command.

(3) *Standing operating procedures and command guidance.*

(a) Desired damage to the target.

(b) Degree of acceptable risk to preclude undesirable effects on friendly units.

(c) Prohibitions against the creation of obstacles.

(4) *Remarks.*

(a) Some of the target information contained in (1) above, will frequently be missing. Consequently, the target analyst must coordinate with the G2 and make assumptions concerning the size and composition of the target. When target intelligence does not indicate otherwise, the target elements are assumed to be uniformly distributed in a random orientation; the area is assumed to

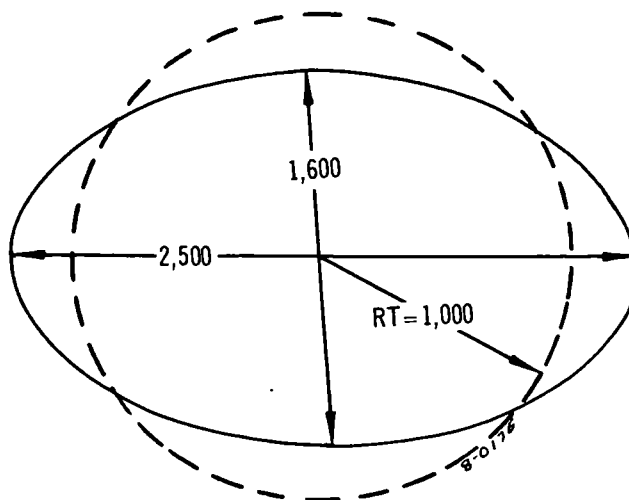


Figure B-2. Determination of the target radius.

be circular; and a radius is determined based on the best information available.

(b) If the target is circular, or nearly so, the radius of target (RT) is the radius of the target circle. If the target is more nearly elliptical or rectangular in shape, with its major dimension less than twice the length of the minor dimension, the radius can be established by drawing a circle that includes an area outside the target equal to the target area outside the circle (fig. B-2). The radius may also be established by visual inspection with a circular map scale. When the major dimension is equal to, or more than, twice the length of the minor dimension, the target cannot be equated to a circle and the visual method must be used.

(c) Based on the target information, the target analyst determines which category of target best fits the target under analysis.

1. For each weapon system and yield, tables are provided for four target vulnerability categories: exposed personnel (prompt and delayed casualties); protected personnel (prompt and delayed casualties); wheeled vehicles; and tanks and artillery.

2. Target vulnerability categories have been established for the primary types or ground tactical targets expected. These categories can be equated to other types of targets as shown in the equivalent target table in FM 101-31-2 and chapter 18, FM 101-31-3. (The equivalent target table is reproduced as figure B-II-2 in annex B-II to

this appendix.) The accuracy of such application is usually consistent with target intelligence and knowledge of weapon effects.

b. Step 2. Determine Data.

(1) Estimate damage to the target.

(a) Depending on the characteristics of the target, there are three methods of estimating damage: index, visual, and numerical.

1. Index method. The indexes in the coverage tables contained in FM 101-31-2 and FM 101-31-3 are an indication of the suitability of a particular weapon system for attack of a given target. Coverage tables have been designed for targets consisting of exposed personnel, protected personnel, tanks and artillery, and wheeled vehicles. Other targets of similar vulnerability are equated to one of the four major categories in the equivalent target table (fig. B-II-2, annex B-II to this app). Using the indexes in the coverage tables, the analyst can estimate the effectiveness of an attack.

2. Visual method. The radii of damage in the coverage tables have been precomputed taking into consideration the vertical dispersion associated with the system at the range of interest. The target analyst applies the appropriate radius visually to the target, considering horizontal dispersion. He then visually estimates how much of the target area is covered by the radius of damage.

3. Numerical method. The target analyst uses the radius of damage, the radius of target, the displacement distances, and the characteristics of the horizontal dispersion pattern to enter the area target graph. The result of this operation presents the analyst with an estimate of the coverage of the target or the probability of destroying it. The estimate of coverage of a circular area target is more accurate if the index method is used. Therefore, the numerical method is used primarily for estimating damage to point targets, or when the desired ground zero is displaced from the center of a circular area target.

4. Special methods. Because of certain differences regarding target analysis when considering the use of Atomic Demolition Munitions, the techniques described herein must be modified. For analysis of targets with ADM the reader is referred to the detailed explanation in FM 5-26.

(b) A detailed explanation of the techniques employed in each of the three methods of target analysis is contained in annex B-II.

(2) Consider limiting requirements.

(a) Restrictions placed on the employment of nuclear weapons 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.

1. Troop safety. The target analyst checks the distance that separates friendly troops from the desired ground zero to insure that the troops will not be exposed to a risk exceeding that specified by the commander.

2. Preclusion of damage/obstacles. The target analyst checks to insure that undesirable results are avoided. These undesirable results usually consist of obstacles to movement (tree blow-down and/or fires), damage to structures (bridges, supply dumps) or damage to heavily populated civilian areas.

(b) A detailed explanation of limiting requirements is contained in annex B-III.

(3) Select the desired ground zero. To obtain the maximum effectiveness of a weapon, the target center, or the center of mass of a target, is selected initially as the desired ground zero. However, limiting requirements, or the attack of multiple targets with a single weapon, may require the desired ground zero to be displaced. The effects of this displacement and a detailed explanation of the techniques used in selecting the desired ground zero are contained in annex B-IV.

(4) Predict the final coverage. When displacement of the desired ground zero is required, or when attacking multiple targets, a prediction of the final coverage of the target must be made, using either the visual or the numerical method of damage estimation (annex B-II). This predicted final coverage will be a factor in the selection of a weapon system.

c. Step 3. Evaluate Weapon Systems and the Tactical Situation. In this step, the most suitable weapon system is selected to attack each target; the best weapon-target combination must be determined. This determination involves consideration of several factors, some of which are as follows:

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

(2) The weapons selected must be within the total number of each type that have been authorized for expenditure.

C 1, FM 101-31-1/FMFM 11-4

(3) Based on command guidance, the more responsive, reliable, and accurate weapon system may be retained for later employment on targets of opportunity.

(4) If all other considerations are equal, the

minimum yield weapon with a sufficiently high probability of providing the coverage that insures the desired results should be selected.

d. Step 4. Make Recommendation.

(1) *General.* After the target analysis has

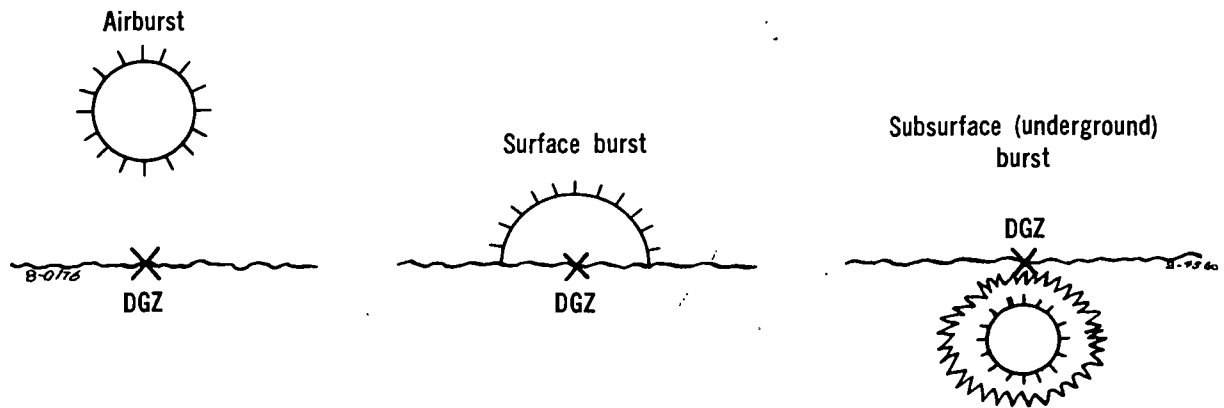


Figure B-3. Desired ground zero.

been completed, a recommendation is presented to the commander. The recommendation should include—

- (a) Weapon system.
 - (b) Height-of-burst (HOB) option.
 - (c) Desired ground zero.
 - (d) Time on target (TOT).
 - (e) Latest time on target.
 - (f) Predicted results.
 - (g) Troop safety.
- (2) *Weapon system.* The weapon system is shown by both delivery system and yield (e.g., free-flight rocket/2 KT or Honest John/____KT). If confusion may arise as to the weapon, the Mark number may also be shown (e.g., Honest John/MK____/____KT).
 - (3) *Height-of-burst option.* The height-of-burst option normally will be indicated as low air or impact. The exact height of burst in meters is required by delivery units when a timer-fuzed weapon is employed, and it is included in the fire order. The recommendation to the commander generally includes only the height-of-burst option, which indicates the significance of possible surface contamination. FM 101-31-2 contains specific information as to the information included in the fire order for each weapon system.
 - (4) *Desired ground zero.* The desired ground zero is the point on the earth's surface at, above or below which the detonation is desired (fig. B-3). It is designated by map coordinates.
 - (5) *Time on target.* The time of burst is determined by both tactical and technical considerations, such as preinitiation, time allowed for casualties to occur, and the maneuver plan. It is provided as a date-time group (DTG) (e.g., 240830). The latest acceptable time on target must also be shown, because it will be a major factor in troop warning considerations.
 - (6) *Predicted results.* The coverage of area targets or the probability of destroying a point target is always provided. The coverage for the primary target element using the index method of target analysis normally will be described as an index-number percentage, or a probability (e.g., .3/.4 for protected personnel). The .3 means that there is a high (90 percent) assurance of at least 30-percent coverage from a single round; because the indexes have been rounded off to the nearest tenth, the .3 indicates a probable minimum coverage between .25+ and .35-. The .4 means that, on the average, a coverage of 40 percent (between .35+ and

NUCLEAR TARGET ANALYSIS WORKSHEET

Target No. _____ OTG of selection _____ Method of weapon selection _____ Analyst _____ Target No. _____

WEAPON SYSTEM						TARGET INFORMATION					
Firing position						Description					
Yield						Category					
Range						Radius					
RO min						Location					
CD 90						Coverage desired (prompt) (delayed)					
HOB (option/meters)						TROOP SAFETY					
Initial coverage											
TROOP SAFETY											
Rad govn effect		(yes)	(no)	(yes)	(no)	(yes)	(no)	(yes)	(no)	(yes)	(no)
MSD											
Troop distance to DGZ											
Displacement											
PRECLUSION OF											
Obstacle	Damage										
LSD	Min dist										
Distance to OGZ											
Displacement											
RD/RT	RO/CD 90										
CD 90/RT	d/CD 90										
d/CD 90	d/RD										
d max											
FINAL DISPLACEMENT											
RD/RT	RD/CD 90										
CD 90/RT	d/CD 90										
d/CD 90	d/RD										
FINAL COVERAGE											
PDSTRIKE DATA				SUPPLEMENTAL DATA				REMARKS			
Actual TDT		RD	Dazzle dist at TDT								
Actual GZ coord		RT	LSD: Army acct in flt								
Dist GZ-tgt cen		d	LSD: tree blowdown								
Actual yield		RT	LSD: fire								
Actual HOB		d	Radius								
RD 50 or RD min		RD	Crater Depth								
Coverage			Fallout prediction required			(yes) (no)					
RECOMMENDATION / FIRE ORDER											
Unit				Firing Point							
Tgt No.		DGZ Grid				Tgt Alt					
Delivery system		Warhead				Yield					
HOB option		HOB				Backup fuze					
Desired TDT				Latest TDT							
Predicted coverage											
Best troop safety											
				unwrnd ex		wrnd ex		wrnd prot			
				MSO 3		MSO 2		MSO 1			
NEG											
EMERG											

Figure B-4. Example of target analysis worksheet.

SHORT RANGE CANNON
1.0 KT

SAFETY DISTANCE TABLE

(Distances in meters)

RANGE	TROOP SAFETY						PRECLUDE DAMAGE			PRECLUDE OBSTACLES			
	UNWARNED EXPOSED		WARNED EXPOSED		WARNED PROTECTED		MOD DAMAGE TO FIXED BRIDGES	LIGHT DAMAGE TO BUILDINGS	LIGHT A/C IN FLIGHT	TREE BLOWDOWN		FIRES	
	NEG	EMER	NEG	EMER	NEG	EMER				DECIDUOUS	CONIFEROUS	DRY FUEL	GREEN FUEL
2000	1900	1400	1900	1400	1600	1200	300	1300	2300	400	400	1000	700
3000	1900	1400	1900	1400	1600	1200	300	1400	2300	400	400	1000	700
4000	1900	1500	1900	1500	1600	1200	400	1400	2400	400	400	1000	700
5000	1900	1500	1900	1500	1700	1200	400	1500	2500	400	400	1000	700
6000	2000	1500	2000	1500	1700	1200	400	1500	2500	500	500	1100	700
7000	2000	1500	2000	1500	1700	1300	400	1500	2600	500	500	1100	700
8000	2000	1500	2000	1500	1700	1300	400	1600	2700	500	500	1100	700
9000	2000	1500	2000	1500	1700	1300	400	1600	2700	500	500	1100	700
10000	2000	1600	2000	1600	1700	1300	400	1700	2800	500	500	1100	700

Figure B-5. Example of portions of the safety distance table.

SHORT RANGE CANNON 1.0 KT

PROMPT CASUALTIES TO EXPOSED PERSONNEL LOW AIRBURST

COVERAGE TABLE

(Distances in meters)

RANGE	EFFECTIVENESS								PROB. MIN. RD	ACCURACY DATA			
	RADIUS OF TARGET									CD 90	CEP	HOB	PEH
	600	700	800	900	1000	1100	1200	1300					
2000	.9/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	602	25	14	49	5
3000	.9/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	601	38	21	55	8
4000	.9/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	599	51	28	62	10
5000	.9/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	597	64	35	73	13
6000	.8/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	595	77	42	80	15
7000	.8/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	592	90	49	90	18
8000	.8/.9	.7/.7	.6/.6	.5/.5	.4/.4	.3/.3	.3/.3	.2/.2	590	102	56	97	20
9000	.8/.8	.7/.7	.6/.6	.4/.5	.4/.4	.3/.3	.2/.3	.2/.2	586	116	63	108	23
10000	.8/.8	.7/.7	.6/.6	.4/.5	.4/.4	.3/.3	.2/.3	.2/.2	583	128	70	115	25

Figure B-6. Example of coverage table.

SHORT RANGE CANNON 1.0 KT

EFFECTS TABLE (Distances in meters)

HOB	PERSONNEL CASUALTIES IN APC'S		PERSONNEL CASUALTIES IN MDM TANKS		PERSONNEL CASUALTIES IN EARTH SHELTERS		PERSONNEL CASUALTIES IN MULTI-STORY APARTMENTS		PERSONNEL CASUALTIES IN FRAME BUILDINGS		SEV DAM TO SUP DEP	MOD DAM TO PKD HEL	SEV DAM TO ELEC EQUIP	SEV DAM TO OPEN GRID	SEVERE DAMAGE TO BRIDGES	
	PRMPT	DELAY	PRMPT	DELAY	PRMPT	DELAY	PRMPT	DELAY	PRMPT	DELAY				RADAR ANT	FIXED	FLOAT
550	110	530	0	310	0	0	220	580	260	600	0	1040	0	0	0	0
525	200	560	0	350	0	0	270	600	300	620	0	1070	0	0	0	0
500	250	580	0	380	0	0	320	630	340	640	0	1110	0	0	0	0
475	300	600	0	410	0	0	350	640	380	660	0	1160	0	0	0	0
450	330	620	0	440	0	0	380	660	420	680	0	1330	0	0	0	0
425	360	640	140	460	0	0	410	680	440	690	0	1410	0	0	0	0
400	390	650	200	490	0	130	440	690	520	710	0	1430	0	0	0	0
375	420	670	240	500	0	190	460	710	580	720	0	1420	0	0	0	0
350	440	680	280	520	0	230	480	720	630	730	0	1410	0	0	0	0
325	460	690	310	540	0	270	490	730	660	740	0	1390	0	710	0	0
300	470	700	330	550	0	290	510	740	680	750	0	1360	0	720	0	0
275	490	710	350	570	10	320	540	750	700	760	0	1330	0	710	0	0
250	500	720	370	580	120	340	550	760	700	770	0	1310	40	710	0	0
225	510	730	390	590	160	360	550	770	690	780	0	1280	90	690	0	0
200	520	740	400	600	190	370	560	780	670	790	0	1250	130	670	0	0
175	530	740	410	600	210	380	570	780	650	790	0	1210	160	640	0	0
150	540	750	420	610	230	390	570	790	630	800	50	1170	180	620	0	130
125	550	750	430	620	250	400	580	790	600	800	80	1130	190	600	180	140
100	550	760	440	620	260	410	580	790	590	810	100	1090	210	570	180	170
75	560	760	440	620	260	410	590	800	600	810	120	1050	220	540	180	180
50	560	760	440	630	270	420	590	800	600	810	130	1020	230	520	170	170
25	520	720	410	580	240	380	550	760	560	770	130	980	220	490	150	150
0	520	720	410	580	240	380	550	760	560	770	80	930	180	460	140	140

Figure B-7. Example of effects table.

.45—) can be expected. Using the Area Target Analysis method or Point Target Analysis method give a singular percentage figure for expected coverage or probability of destruction. Additional information pertaining to the results of contingent effects in the target area is provided as part of the recommendation. This may be done by portraying graphically the area of tree blowdown, fire hazard, and/or damage to various target elements.

- (7) *Troop safety.* The distance to which the effects for negligible risk to unwarned, exposed personnel extend is portrayed graphically to the commander. If this distance includes friendly troops, the graphical presentation also depicts risk involved and protection required. (See table 4-1 and para 4-6.) Troop safety is discussed further in annex B-III.

B-3. Target Analysis Worksheet

A target analysis worksheet (fig. B-4) has been designed to assist the nuclear weapon employment officer in analyzing targets to be attacked. This worksheet systematically leads the analyst through the required steps of target analysis using nuclear weapon systems.

B-4. Tables for Use in Target Analysis

Figures B-5, B-6, and B-7 are examples of the tables that the target analyst will use in analyzing targets. (See also FM 101-31-2 and FM 101-31-3.)

a. Figure B-5, Safety Distance Table. The

safety distance tables present the distance that the desired ground zero must be separated from the area of interest to preclude inflicting casualties on friendly troops; causing damage to areas and/or structures in which no damage is desired; or causing obstacles (e.g., tree blowdown or fire) that will interfere with the scheme of maneuver.

b. Figure B-6, Coverage Table. The coverage tables provide information in the form of coverage indexes required by the analyst to predict coverage of (damage to) a target. The computation of the indexes is based on a 90-percent assurance of achieving at least the amount of coverage shown. The average coverage (second number in each index) is based on a 50 percent assurance. Data considered in these computations are probable errors (PE) of the delivery system at target range, radius of target, weapon yield, weapon height of burst, and target category. Data used in the computation of the indexes in the coverage tables, as well as the data required to perform either the visual or the numerical method of damage estimation, are found in the accuracy data columns. These columns provide the analyst with the probable mainimum radius of damage, the circular distribution 90 (CD90), the circular error probable, the height of burst, and the height-of-burst probable error (PEh). A detailed explanation of each is contained in annex B-I.

c. Figure B-7, Effects Table. The effects tables provide the analyst with the radii of damage for each effect of interest at various heights of burst for the four primary target categories and for various other targets likely to appear on the tactical battlefield.

ANNEX B-I

PROBABILITY AND CONCEPT OF DAMAGE

(This annex is based on SOLOG No. 89.)

B-I-1. General

In conventional artillery fires, weapon effects are obtained by firing many rounds and allowing the inherent delivery errors to place the rounds randomly throughout the target area. In nuclear fires, weapon effects are dependent on the delivery errors of a single round. Consequently, it is necessary to predict the weapon effects on the target. This prediction is accomplished based on a comparison of the weapon effects with the characteristics of the target; and includes the effects of the weapon, measured by its radius of damage and the delivery errors. To analyze targets properly, a nuclear weapon employment officer should possess an understanding of probability and concept of damage as presented in this annex.

★B-I-2. Definition of Probability

Probability may be defined as the chance of a certain event occurring. It may be expressed as the ratio, fraction, or percentage of the number of favorable (or unfavorable) events to the total number of possible events. Thus, probability may be expressed in terms of success or failure. For instance, the probability of a coin falling "heads" is $\frac{1}{2}$ (1 in 2), 0.5, or 50 percent (usually expressed as 0.50). The probability that the coin will *fail* to fall "heads" is 0.50. The probability that a die will stop rolling with the 2 spot up may be stated as $\frac{1}{6}$ (1 in 6) or 0.167, and the probability that it will not show a 2 spot is $\frac{5}{6}$ or 0.833. The probability that a nuclear weapon will fall within a given distance of the desired ground zero or will burst within a given distance of the desired height of burst may also be determined. The terms "probability," "assurance" and "chance" are synonymous within this manual.

B-I-3. Assumptions

a. Analysis is based on the assumption that a given nuclear weapon will function at approxi-

mately the rated yield within the established accuracies of the delivery system. This assumption simplifies target analysis procedures, but the implications should be understood. The influence of the *reliability* of a weapon system (its probability of getting the weapon to the target and detonating it) on the overall probability of a successful attack must be considered. Cannon- and rocket-delivered weapons have reliabilities of essentially 1.0. The more intricate weapon systems (e.g., guided missiles) have reliabilities less than those of cannon and rockets.

b. Based on the assumption that a nuclear weapon delivery system will perform successfully, probability considerations are applied at the desired burst point in the target area. The probability of success will be affected principally by the delivery accuracy of the system.

B-I-4. Effects of Horizontal and Vertical Accuracy

a. General. The assumption is made that many rounds are fired from an artillery piece at a given range at the same target under identical conditions. The rounds falling in the impact area will form an elliptical pattern. The mean point of impact (MPI) for this pattern can be determined. Variation from this mean is called "dispersion," and the pattern is referred to as the "normal distribution pattern." The shape of the pattern formed in the impact area will vary among delivery systems; but, for damage estimation purposes, these dispersion deviations are mathematically converted to circular equivalent patterns, which are called circular errors probable (CEP). In target analysis involving the employment of nuclear weapons, it is assumed that the distribution of errors connected with nuclear delivery systems will conform to this normal distribution pattern. It is also assumed that the mean point of impact will coincide with the desired ground zero.

b. Horizontal Dispersion. Horizontal dispersion associated with nuclear target analysis is expressed in two terms—circular error probable and circular distribution 90 (CD90).

(1) *Circular error probable.*

(a) By definition, 1 CEP represents the radius of a circle within which one weapon has a 50-percent probability of arriving. Figure B-I-1 represents the normal circular distribution pattern around the mean point of impact for a large number of weapons. A 2-CEP circle, which is twice the radius of a 1-CEP circle, includes approximately 94 percent of the weapons fired or dropped. A 4-CEP circle contains essentially all such weapons. Some erratic rounds, although very few, may fall outside the 4-CEP circle.

(b) It should be noted that 99 percent of all rounds fired will fall on one side of the tangent to the 2-CEP circle (fig. B-I-2). This factor is a consideration in determining troop criteria.

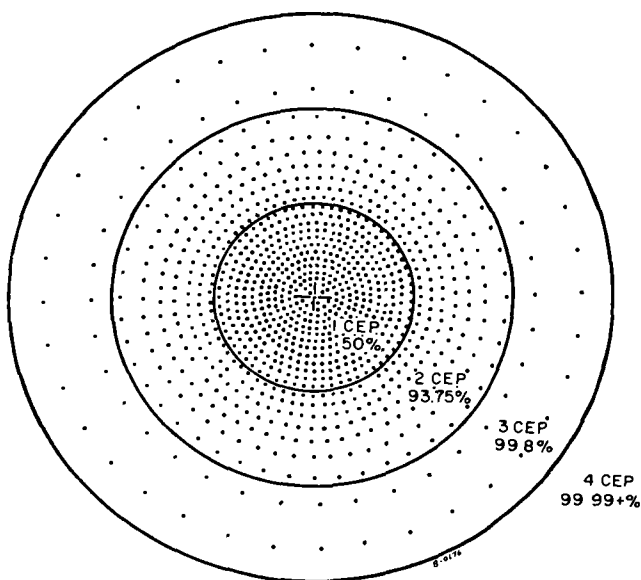


Figure B-I-1. Normal circular pattern.

(c) Circular error probable data have been precomputed for each weapon system and are provided in the accuracy data portion of the coverage tables in FM 101-31-2 and FM 101-31-3.

(2) *Circular distribution 90.*

(a) By definition, the circular distribution 90 represents the radius of a circle around the desired ground zero within which one weapon has a 90-percent probability of arriving. An understanding of the circular distribution 90 is important to the analyst, because it is the circular distribution error used in all methods of target analysis to insure at least a 90-percent probability of obtaining a specified amount of coverage.

(b) Circular distribution 90 data have been precomputed for each weapon system and are provided in the accuracy data portion of the coverage tables in FM 101-31-2 and FM 101-31-3.

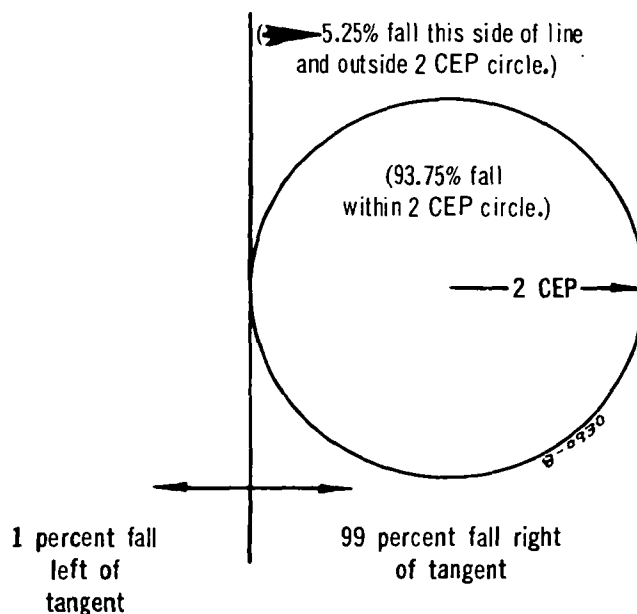


Figure B-I-2. Tangent to the 2-CEP circle.

c. Vertical Dispersion.

- (1) The vertical error for all weapons is measured in the vertical plane in terms of probable error (PE), and is expressed as the "height-of-burst probable error" (PEh). A probable error is defined as the error in range that a weapon may be expected to exceed as often as not. It is a distance on *both* sides of the mean within which a single round has a 50-percent probability of falling. The height-of-burst distribution pattern is considered in the vertical plane. Figure B-I-3 shows the normal distribution burst points above and below the mean. It is assumed that virtually all weapons will burst within 4 PE above and below the mean.
- (2) The height-of-burst probable error associated with each weapon system has been precomputed for each weapon system and is included in the accuracy data portion of the coverage tables in FM 101-31-2 and FM 101-31-3.

d. Probability and Normal Distribution.

- (1) A study of normal error distribution about a reference point (such as the desired ground zero or the desired height of burst) provides a means of predicting where a nuclear weapon will burst in space in relation to the target. It can be predicted that 50 percent of the nuclear weapons delivered will burst within 1 PE or within 1 CEP of the desired point. In other words, there is a 50-percent probability that a weapon will burst within these limits. Similarly, there is a 90-percent probability that a weapon will burst within the circular distribution 90.
- (2) Table B-I-1 may be used to calculate, for a *distance expressed as a multiple of probable errors*, the associated probability that a nuclear weapon will function within that distance. Similarly, figure B-I-1 provides a

means of predicting the probability that a weapon will function within a given number of circular errors probable from a desired point. However, table B-I-1 provides a more convenient means of determining probabilities associated with distance from a desired point.

- (3) Each of the fractions in the probability (*P*) column in table B-I-1 expresses the probability that a weapon will burst no farther away (in one direction) from the aiming point (the desired ground zero or the desired height of burst) than the distance (*d*) shown in the multiplying factor (*MF*) column. *MF* is the distance (*d*) expressed in multiples of probable error (*PE*); i.e., $MF = \frac{d}{PE}$.

Table B-I-1. Probability as a Function of Multiples of Probable Error

$\frac{d}{PE} = MF$	<i>P</i>	$\frac{d}{PE} = MF$	<i>P</i>	$\frac{d}{PE} = MF$	<i>P</i>
<i>MF</i>		<i>MF</i>		<i>MF</i>	
0.1	0.03	1.8	0.390	3.5	0.491
0.2	0.05	1.9	0.400	3.6	0.492
0.3	0.08	2.0	0.410	3.7	0.494
0.4	0.11	2.1	0.420	3.8	0.495
0.5	0.13	2.2	0.430	3.9	0.496
0.6	0.16	2.3	0.440	4.0	0.497
0.7	0.18	2.4	0.447	4.1	0.497
0.8	0.21	2.5	0.450	4.2	0.498
0.9	0.23	2.6	0.460	4.3	0.498
1.0	0.25	2.7	0.466	4.4	0.498
1.1	0.27	2.8	0.471	4.5	0.499
1.2	0.29	2.9	0.475	4.6	0.499+
1.3	0.31	3.0	0.479	4.7	0.499+
1.4	0.33	3.1	0.482	4.8	0.499+
1.5	0.34	3.2	0.485	4.9	0.499+
1.6	0.36	3.3	0.487	5.0	0.499+
1.7	0.37	3.4	0.489		

- (a) For example, assume that the air-burst range probable error (PERr) is 50 meters and it is desired to know the probability of a round landing within 100 meters of the desired ground zero (over and short).

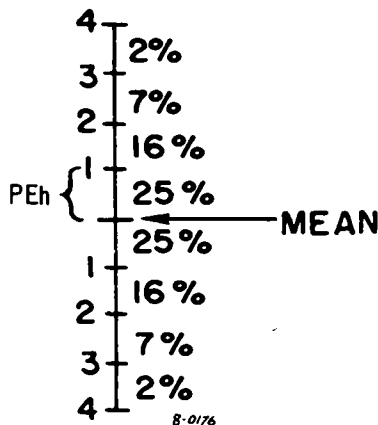


Figure B-I-3. Vertical dispersion.

In this case,

$$\frac{d}{PE} = \frac{100}{50} = 2.0 = MF.$$

Entering the table with $MF = 2.0$, read a probability equal to 0.41 (41 percent). However, this $P = 0.41$ factor considers only one side of the mean. In other words, there is a 41-percent probability of a round landing beyond the desired ground zero no farther away than $2 PE$ (100 meters). Likewise, there is a 41-percent probability of a round landing short of the desired ground zero no farther away than $2 PE$. There is, then, an 82-percent ($0.41 + 0.41$) probability of a round landing *within* $2 PE$ of the desired ground zero.

- (b) As another example, assume that the PER is 50 meters. It is desired to know the distance from the desired ground zero (over and short) within which there is 90-percent probability of a round landing. There is a 45-percent probability that a round will land short of and a 45-percent probability that it will land beyond the desired ground zero. Entering the table with $P = 0.45$, it is seen that $MF = 2.5$. Therefore, $d = MF \times PE = 2.5 \times 50 = 125$ meters. It can be stated, therefore, that there is a 90-percent

probability that a round will land *within* 125 meters of the desired ground zero.

e. *Use of Probability and Target Analysis.*

- (1) Delivery accuracy and its associated probability are reflected in the coverage tables included in FM 101-32-2 and 101-31-3.
- (2) When applied to the employment of nuclear weapons, probability calculations provide a reasonable means of predicting the results of a nuclear attack on a target. Because of this, sound tactical plans can be prepared to exploit these results.

B-I-5. Concept of Damage from Initial Effects

a. To predict the results of a nuclear explosion on a target, the nuclear weapon employment officer must visualize the pattern of damage or casualties that will be inflicted on a target area by the initial effects of the weapon. Assume that figure B-I-4 represents a target consisting of uniformly distributed ve-

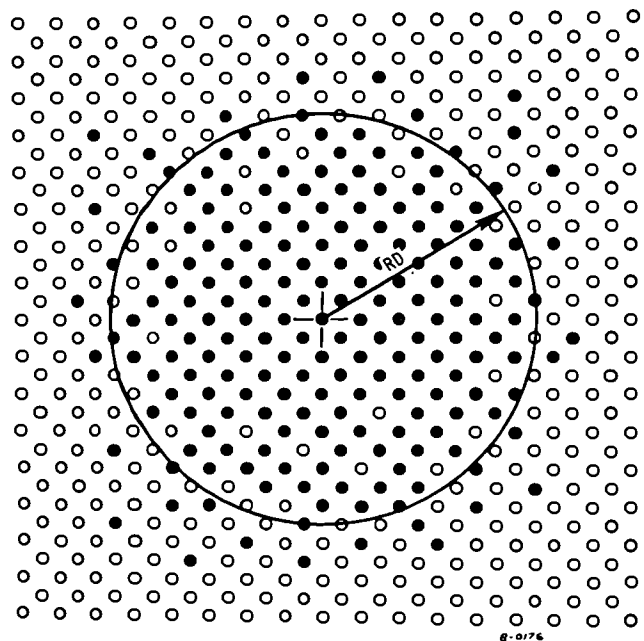


Figure B-I-4. Relationship of radius of damage to damage or casualty pattern.

hicles, with each small circle representing a vehicle. In this example, only moderate damage to the vehicles is of interest.

b. If a nuclear weapon were burst over the center of this target, all the vehicles directly under the burst point would be damaged. All those a short distance from the ground zero would be at least moderately damaged, and some would be severely damaged (represented by the black circles in fig. B-I-4). As the distance from the ground zero increases, the number of vehicles escaping moderate (or severe) damage would increase, until a distance is reached at which no vehicles receive moderate damage. Of those that escape at least moderate damage, the ones closer to the burst point will have a higher probability of receiving at least light damage. However, in this case, only moderate damage is of interest. (A light damage pattern from the same size weapon against this target would have this same "shotgun-scatter" appearance, but would be considerably larger than the moderate damage pattern.)

c. Figure B-I-4 shows the damage or casualty pattern produced by a nuclear weapon burst over a target large enough to contain all the possible moderate damage. However, before this pattern of damage can be used as a mental image of damage distribution, a yardstick, or unit of measure, is needed to visualize the appropriate-size pattern for each yield and burst height combination. The radius of damage, as obtained from the accuracy data portion of the coverage tables in FM 101-31-2 and FM 101-31-3, fills this requirement for a unit of measure. Once the nuclear weapon employment officer has determined the relationship of the radius of damage to the overall damage pattern, he can estimate the amount of damage in a target area by comparing the

radius of damage circle with the target area. (The relationship of the radius of damage to the damage pattern is shown in fig. B-I-4.)

d. The radius of damage is defined as that distance from the burst point at which a specified target element has a 50-percent probability of receiving the specified degree of damage. In figure B-I-4, note that within the radius of damage some vehicles escape moderate damage, but an approximately equal number are moderately damaged outside the radius of damage. Also, note that approximately one-half of the vehicles at the exact radius of damage distance from the ground zero receive moderate damage. Actually, about 85 percent of the target elements *inside* a radius of damage receive at least the degree of damage being considered. Or, if casualties are being considered, about 85 percent of the personnel inside the radius of damage who are vulnerable to the effect being considered become casualties. It is convenient, however, to consider damage or casualties as virtually complete within a radius of damage. Although some target elements escape the desired damage inside the radius of damage, there is an equal number outside the radius of damage that receive the desired damage. The important point is *that the fraction of damage or casualties is estimated to be the same as the fraction of the target area covered by the radius of damage circle.*

e. The radius of damage is a quantity measured for every weapon and is dependent on the *type* of target, the *yield* and the *design* of the weapon, the *degree* of damage desired, and the *height* of burst. The probability of inflicting the desired damage on a target is contingent on the shape and size of the target, the radius of damage, the location of the desired ground zero, and the system delivery errors.

ANNEX B-II

DAMAGE ESTIMATION

(This annex is based on SOLOG No. 89.)

B-II-1. General

a. Estimates of the expected results of an attack by each of the available nuclear weapons is necessary to determine the best weapon to use in a particular situation. The estimate concerning the weapon finally recommended will assist the commander in visualizing the condition of the target area after the attack. For example, the plan of maneuver of a unit that expects 10 percent destruction of a target may be different from that of a unit which expects 50 percent destruction of the same target.

b. The estimate of the expected results usually is expressed as a percentage of the target covered. For example, if 30 percent of the target is covered by a particular radius of damage, *it is assumed that 30 percent of the target elements of interest will receive the specified level of damage.* Thus, the estimate of damage would be expressed as 30-percent coverage of the target.

c. The unit SOP generally expresses the coverage desired by the commander in the attack of various types of targets. When the situation is different from that assumed in the SOP, the commander may modify the guidance for desired coverage. It is easier to cause casualties among personnel than it is to damage material. Since casualties among users and operators will make material ineffective, the major criterion for weapon selection is normally the estimate of personnel casualties.

B-II-2. Methods of Damage Estimation

a. Depending on the characteristics of the target, there are three methods of estimating damage: the index method, the visual method, and the numerical method:

b. The *index method* is used to estimate damage to area targets when the target is assumed to be circular; when the desired ground zero is at the target center; and when

the target is, or is equatable to, one of the four major target categories. The indexes in the coverage tables contained in FM 101-31-2 and FM 101-31-3 have been computed using a more precise method than can be used in the field. Because of this degree of precision, the index method is used whenever the above-mentioned target conditions apply. The indexes have been based on weapon system delivery error data. When delivery errors are discovered to vary beyond 25 percent from the data shown in the accuracy data portion of the tables, interim procedures are used. These procedures are discussed in annex B-V.

c. The *visual method* can be used for any area target, but *must* be used to estimate damage to an area target when the target is not equatable to a circle. It is also used to analyze targets for which there are known target acquisition errors (para B-II-4).

d. The *numerical method* is used to—

- (1) Estimate the probability of damaging point targets.
- (2) Estimate damage to circular area targets that are not included in one of the four major target categories.
- (3) Determine the maximum distance that the desired ground zero may be displaced from a point target, or from the center of a circular area target, or determine the probability of damaging a secondary target located some distance from GZ as determined for the primary target.
- (4) Estimate damage to circular area targets when the desired ground zero is displaced from the target center.

B-II-3. Damage Estimation Chart

a. A damage estimation chart (fig. B-II-1) has been devised to assist the target analyst in selecting the proper method of damage esti-

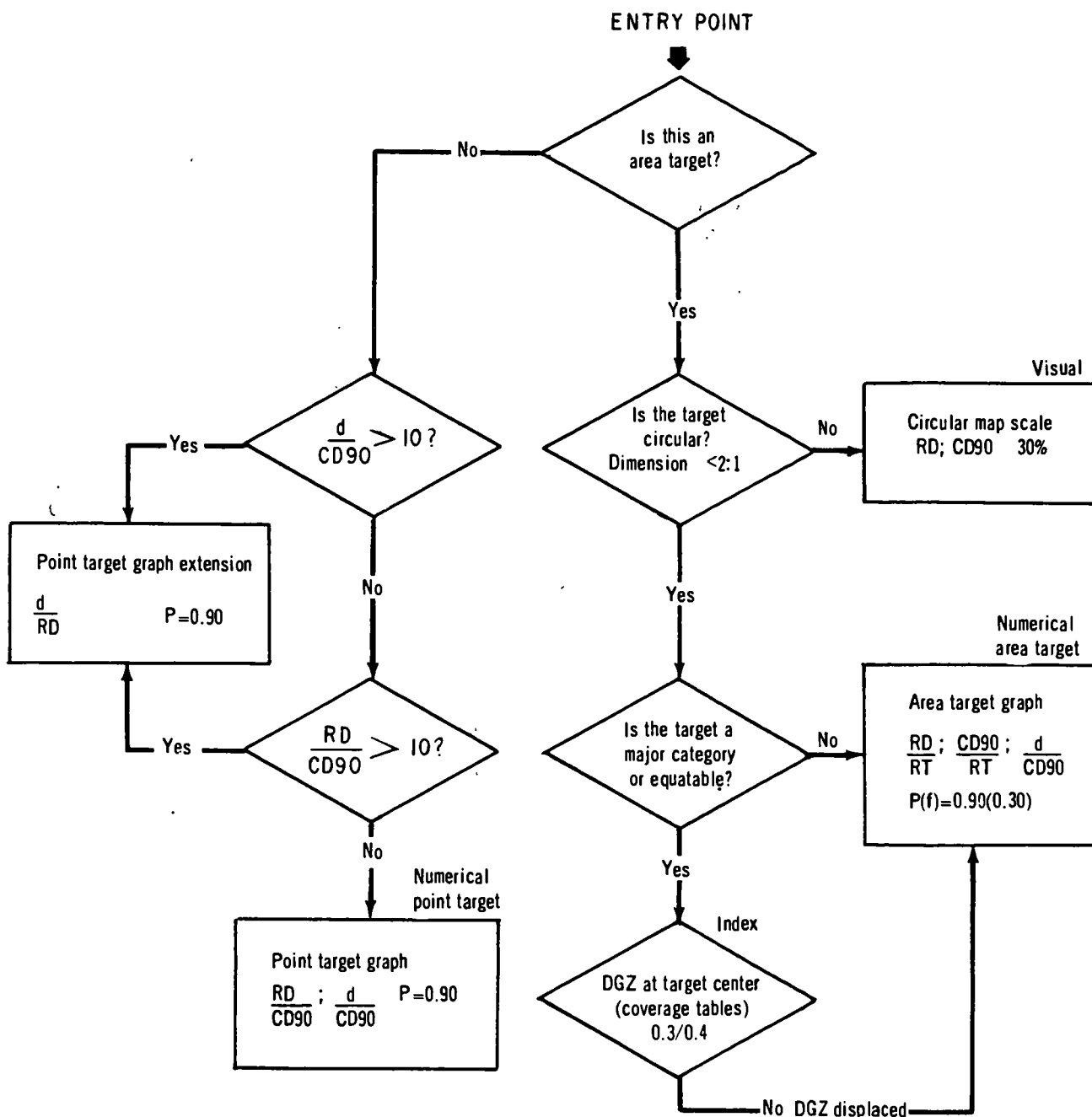


Figure B-II-1. Damage estimation chart.

mation to use in analyzing his target. This chart not only provides the analyst with the method to be used but also with the items that are required to perform the analysis by the indicated method. The Equivalent Target Table from FM 101-31-2 and FM 101-31-3 has been reproduced as figure B-II-2.

b. A detailed explanation of the procedures used in performing the *index method* of damage estimation is found in tab B-II-1 the *visual method* in tab B-II-2, and the *numerical method* in tab B-II-3 to this annex.

EQUIVALENT TARGET TABLE

Exposed personnel	Protected personnel	Wheeled vehicles	Tanks and artillery
Primary: Personnel in the open, thermal effects not considered.	Primary: Personnel in foxholes.	Primary: Moderate damage to wheeled vehicles.	Primary: Moderate damage to tanks and other tracked combat vehicles and severe damage to artillery.
Secondary: Personnel in the upper stories of frame buildings.	Secondary: None.	Secondary: Moderate damage to amphibious vehicles on land, truck-mounted engineer equipment, and missile and rocket launchers.	Secondary: Prompt casualties to personnel in armored vehicles for yields of 150 KT or below. Delayed casualties to personnel in armored vehicles for yields of >150 KT < 320 KT. Moderate damage to infantry weapons, Track-mounted engineer equipment, and railroad locomotives. Severe damage to telephones; switchboards; double-apron barbed wire; and highway, railroad, and floating bridges.

B-0930

Figure B-II-2. Equivalent target table.

B-II-4. Target Location Errors

The assumption is made in target analysis that the reported location of the target is correct. All target acquisition means have associated inaccuracies; however, these inaccuracies *normally* are not considered in target analysis. The target analyst should be aware of the ramifications of ignoring a target location error, and the impact it will have on the target analysis and the expected results of the nuclear strike (e.g., selection of a weapon yield too small to achieve desired level of assurance and/or coverage of the target). When an analyst is aware of inaccuracies, he should take them into consideration by adding the target

acquisition error to the circular distribution 90 and by performing a visual target analysis (para B-II-2-2e).

B-II-5. Elimination of Unsuitable Weapons

Tables are included in FM 101-31-2 and FM 101-31-3 to assist the analyst in rapidly eliminating obviously unsuitable weapon systems. These tables show the maximum target radii associated with each weapon system, associated range, yield, and target vulnerability category. The target radii shown are the maximum that will permit a minimum coverage of .3. These tables provide a quick means of eliminating from consideration those yields

and various delivery systems that are not sufficiently effective against the target under analysis. It should be noted that these tables can be used only with the *index* method of target

analysis. These tables can also be used to eliminate unsuitable weapons due to the minimum and maximum ranges of the delivery system.

TAB B-II-1

INDEX METHOD OF DAMAGE ESTIMATION

B-II-1-1. General

The index method of damage estimation is the fastest and most accurate field method available to a target analyst. Whenever the following four conditions can be met, the index method of damage estimation should be used:

- a. The target is an area target.
- b. The target is circular, or equatable to a circle. This assumption should be made unless there is specific target information to the contrary.
- c. The target element is, or is equatable to, one of the four major target categories. (Fig. B-II-2, FM 101-31-2, and chapter 18, FM 101-31-3 define the target elements that are equatable to one or more of the major target categories.)
- d. The desired ground zero is located at the target center.

B-II-1-2. Coverage Indexes

a. In the coverage tables in FM 101-31-2 and FM 101-31-3, for each range and target radius two decimal numbers are given, separated by a divider (e.g., .3/.4). Together, these numbers comprise an index of weapon coverage. The first number (.3) is the probable minimum fractional coverage of the target, based on a 90-percent assurance; the second number (.4) is the average coverage. Figures B-II-1-1 and B-II-1-2 are examples of these coverage tables.

b. General rules for the use of coverage indexes are included in (1) through (5) below.

- (1) *Suitable destruction index values.* In analyzing nuclear targets, 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 assurance (90 cent) of achieving the desired results. Because of this, the probable minimum coverage of .3 normally is selected as the minimum acceptable probable minimum fractional coverage. This means that for successful rounds there is a 90-percent assurance of covering at least 25 percent of the target area. (Note that .3 covers values between .25 and .35.) Because the probability of assurance is less with an average coverage, the average coverage of a target generally will be greater than the probable minimum coverage. Therefore, a value of .4 has been selected as the lower limit. This means that the average coverage of the target will be from 35 to 45 percent for successful rounds. Thus, .3/.4 is selected as the normal lower limit for a suitable destruction index value. A weapon with an index greater than .3/.4 should never be eliminated as being too large. Elimination of weapons with excessive coverages should be undertaken *only* when a smaller weapon is available that will produce the desired results. (Para 3-5 includes a detailed discussion of destroyed unit.)

- (2) *Suitable neutralization index values.* If neutralization rather than destruction of the target is acceptable, a probable minimum coverage as low as .1, combined with an average coverage of .2 or greater, is normally satisfactory. Thus, .1/.2 is selected as the normal lower limit for a suitable neutralization index value. Elimination of weapons with excessive coverage should be done only when a smaller weapon is available that will produce the desired results. (Para 3-5 includes a detailed discussion of a neutralized unit.)

SHORT RANGE CANNON
1.0 KT

PROMPT CASUALTIES TO PROTECTED PERSONNEL
LOW AIRBURST

COVERAGE TABLE

(Distances in meters)

RANGE		EFFECTIVENESS							PROB. MIN. RD	ACCURACY DATA			
		RADIUS OF TARGET								CD 90	CEP	HOB	PEH
	400	500	600	700	800	900	1000	1100					
2000	.9/.9	.8/.8	.6/.6	.4/.4	.3/.3	.3/.3	.2/.2	.2/.2	450	25	14	49	5
3000	.9/.9	.8/.8	.6/.6	.4/.4	.3/.3	.3/.3	.2/.2	.2/.2	448	38	21	55	8
4000	.9/.9	.8/.8	.6/.6	.4/.4	.3/.3	.3/.3	.2/.2	.2/.2	446	51	28	62	10
5000	.9/.9	.7/.8	.6/.6	.4/.4	.3/.3	.3/.3	.2/.2	.2/.2	443	64	35	73	13
6000	.9/.9	.7/.7	.6/.6	.4/.4	.3/.3	.3/.3	.2/.2	.2/.2	441	77	42	80	15
7000	.9/.9	.7/.7	.6/.6	.4/.4	.3/.3	.2/.3	.2/.2	.2/.2	436	90	49	90	18
8000	.9/.9	.7/.7	.5/.6	.4/.4	.3/.3	.2/.3	.2/.2	.2/.2	433	102	56	97	20
9000	.8/.9	.7/.7	.5/.5	.4/.4	.3/.3	.2/.2	.2/.2	.2/.2	428	116	63	108	23
10000	.8/.9	.7/.7	.5/.5	.4/.4	.3/.3	.2/.2	.2/.2	.2/.2	424	128	70	115	25

Figure B-II-1-1. Example of coverage table, prompt casualties to protected personnel.

SHORT RANGE CANNON
1.0 KT

DELAYED CASUALTIES TO PROTECTED PERSONNEL
LOW AIRBURST

COVERAGE TABLE

(Distances in meters)

RANGE	EFFECTIVENESS								PROB. MIN. RD	ACCURACY DATA			
	RADIUS OF TARGET									CD 90	CEP	HOB	PEH
	200	400	600	800	1000	1200	1400	1600					
2000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	635	25	14	49	5
3000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	634	38	21	55	8
4000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	633	51	28	62	10
5000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	631	64	35	73	13
6000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	629	77	42	80	15
7000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	626	90	49	90	18
8000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	624	102	56	97	20
9000	.9/.9	.9/.9	.9/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	620	116	63	108	23
10000	.9/.9	.9/.9	.8/.9	.6/.6	.4/.4	.3/.3	.2/.2	.2/.2	618	128	70	115	25

Figure B-II-1-2. Example of coverage table, delayed casualties to protected personnel.

(3) *Unsuitable index values.* An unsuitable index is one in which the index is less than the minimum required. For example, a .1/.1 index would normally be unsuitable for neutralization of a target and therefore is not listed with those indexes considered suitable. An index in excess of the minimum required is never considered unsuitable, even though indiscriminate use could lead to a waste of combat power. Table B-II-1-1 displays the indexes considered suitable when using the index method of damage estimation.

Table B-II-1-1. Index Guidance Criteria

Commander's guidance	Minimum coverage	Maximum coverage	Results
10-----	0.1/0.2-----	0.9/0.9-----	Neutralization.
20-----	0.2/0.3-----	0.9/0.9-----	Neutralization.
30-----	0.3/0.4-----	0.9/0.9-----	Destruction.
40-----	0.4/0.5-----	0.9/0.9-----	Destruction.
50-----	0.5/0.6-----	0.9/0.9-----	Destruction.
60-----	0.6/0.7-----	0.9/0.9-----	Destruction.
70-----	0.7/0.8-----	0.9/0.9-----	Destruction.
80-----	0.8/0.9-----	0.9/0.9-----	Destruction.

(4) *Large index-number variations.* A wide difference (more than .4) between the indexes (e.g., .3/.8) results when a large weapon, with its inherent inaccuracies, is employed against a target.

(5) *Determination of coverage index values.* To determine the coverage index for the target being considered, the target analyst selects the appropriate coverage table.

(a) A coverage table is provided for each target category, delivery system, yield, and low airburst and surface burst options.

(b) The target analyst enters the appropriate coverage table, using the appropriate radius of target and the nearest range. Interpolation between ranges is not required. If the given range is exactly halfway between two listed ranges, he enters at the nearest listed range in even-numbered thousands (e.g., if a given range is 10,500 meters, round off *downward* to 10,000 meters; if a given range is 11,500 meters, round off *upward* to 12,000 meters).

(c) Figures B-II-1-1 and B-II-1-2 show examples of coverage tables for a short-range can-

non with a 1-kiloton yield and a low airburst option against protected personnel. If the target range is 8,000 meters and the radius of target is 600 meters, the following extract of the tables results:

★1. If the plan of maneuver requires prompt casualties, the 3,000-rad or the translational-effect criterion is used: an index of .5/.6 results (fig. B-II-1-1).

2. If delayed casualties are acceptable, the 650-rad criterion is used; an index of .9/.9 results (fig. B-II-1-2).

3. The estimate of damage, in this case, indicates that there is—

(a) Fifty-percent probable minimum coverage and 60-percent average coverage for prompt casualties to protected personnel; or

(b) Ninety-percent probable minimum coverage and 90-percent average coverage for delayed casualties to protected personnel.

(d) When it is necessary to interpolate between target radii in the coverage tables, a straight-line interpolation is used, and rounding off is always downward (e.g., .38=.3). An example problem is given below.

Data from table:	Radius of target			
	800	900	1,000	1,200
	.6/.9	.4/.6	.3/.4	.2/.2

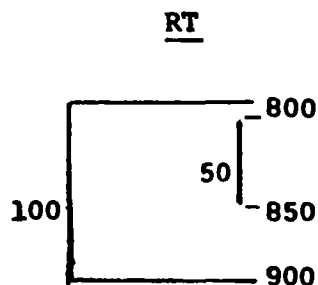
1. *Given:* RT=850 meters.

2. *Find:* The coverage index.

3. *Solution:*

(a) The 850-meter *RT* falls exactly halfway between two indexes listed in the table; thus, interpolate halfway between the two indexes, *considering the number on each side of the divider* separately, to obtain .5/.75. Round off downward to the nearest tenth, or .5/.7.

(b) The same solution can be reached using the standard interpolation formula, again considering the number on each side of the index divider separately, as follows:

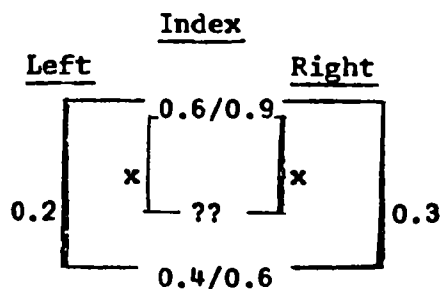


$$\text{Left: } \frac{50}{100} = \frac{x}{0.2}$$

$$100x = 0.2(50)$$

$$x = 0.1$$

$$0.6 - 0.1 = 0.5$$



$$\text{Right: } \frac{50}{100} = \frac{x}{0.3}$$

$$100x = 0.3(50)$$

$$x = 0.15$$

$$0.9 - 0.15 = 0.75$$

The interpolated index is .5/.75; round off downward to the nearest tenth, or .5/.7.

(c) Other interpolations, using the same example problem, are as follows:

<i>RT</i>	<i>Interpolated index</i>
920	.38/.56 = .3/.5
1,100	.25/.3 = .2/.3

B-II-1-3. Average Coverage

If an attack were directed against a small area target, some fraction of the target would be damaged. If this attack could be repeated many times, the identical fraction of damage would not result each time; rather, some distribution of values of fractional damage centered around some particular average value would result. This average fractional damage represents the *average coverage* of this particular area. This damage is symbolized

by $\bar{f}$ (f-bar). The probability (P) of damaging a point target to some desired level and the average coverage ($\bar{f}$) of a small area target have the same meaning. For example, assume that the average coverage of a small area target is .60 ($\bar{f} = .60$) for severe damage. This is interpreted to mean that, on the average, 60 percent of the target will receive severe damage and the remaining 40 percent will be damaged to some degree less than severe. This $\bar{f}$ factor is similar to the average coverage in the combined coverage index. However, because no assurance (probability) is associated with this average coverage and the radius of damage is so great in relation to the target, the analyst considers only the probability of destroying the target.

TAB B-II-2

VISUAL METHOD OF DAMAGE ESTIMATION

B-II-2-1. Introduction

a. The visual method of damage estimation is the *only* method that can be used to analyze irregularly shaped area targets. Targets that are noncircular, or cannot be equated to a circle, are always analyzed using the visual method of damage estimation. A typical example of an irregularly shaped area or linear target would be a trenchline.

b. Whenever the desired ground zero is displaced from the target center for any reason, either the visual or the numerical method of damage estimation may be used to analyze the target.

B-II-2-2. Visual Method

a. *General.* The visual method of damage estimation consists of a visualization of the fractional target coverage by the expected radius of damage of the weapon. To facilitate this visualization, circular map scales are provided in the envelope inside the back cover of this manual.

b. *Circular Map Scale.* The circular map scale is a series of concentric circles and arcs drawn at regular intervals on transparent material. For the 1:50,000 scale, the interval between each circle and arc is 100 meters up to the 1,000-meter circle; thereafter, the interval is 200 meters. For the 1:100,000 scale, the interval is 200 meters up to the 2,000-meter circle; thereafter, the interval is 400 meters. Visual interpolation can be made when the distance of interest lies between the circles or the arcs. The numbers on the circles and the arcs represent hundreds of meters.

c. *Radius of Damage.* The radius of damage is determined from the coverage table in the same manner as that for the coverage index (tab B-II-1). To determine the radius of damage for the target being considered, the target analyst selects the appropriate coverage table based on the target category, the delivery system, the yield, and the low airburst

and surface burst options. He enters the table at the nearest listed range (interpolation between ranges is not required; if the given range is *exactly halfway* between two listed ranges, the nearest even range is used). The analyst moves across the table to the accuracy data column marked *Prob. Min. RD* and extracts the probable minimum radius of damage. For visual analysis using ADM see FM 5-26.

- (1) Figure B-II-2-1 shows an extract of the accuracy data columns from a coverage table for a short-range cannon with a 1-kiloton yield and a low airburst option against exposed personnel (delayed casualties). If the target range of the weapon is 8,000 meters, a probable minimum radius of damage of 804 meters is extracted from the table.

RANGE	PROB. MIN. RD	CD 90	CEP	HOB	PEH
2000	813	25	14	49	5
3000	812	38	21	55	8
4000	811	51	28	62	10
5000	810	64	35	73	13
6000	808	77	42	80	15
7000	806	90	49	90	18
8000	804	102	56	97	20
9000	802	116	63	108	23
10000	800	128	70	115	25

Figure B-II-2-1. Example of accuracy data columns, (extracted from table for Short Range Cannon, 1 KT, Low Airburst, delayed casualties against exposed personnel.)

Figure B-II-2-1. Example of accuracy data columns.

- (2) If prompt casualties had been desired, the coverage table for *prompt* casualties would have been used. However, because delayed casualties are acceptable in this example, the analyst enters the coverage table for delayed casualties (650 rad) and extracts a radius of damage of 804 meters.

d. Circular Distribution 90.

- (1) The circular distribution 90 (CD90) column is located in the coverage tables adjacent to the probable minimum radius of damage column (fig. B-II-2-1). Circular distribution 90 data are extracted in the same manner as that described in *c* above.
- (2) There is a high assurance (90 percent) of a round bursting within the distance (CD90) of the desired ground zero.

e. Procedure for Determining the Damage, Using the Radius of Damage and the Circular Distribution 90.

- (1) The target analyst draws on the circular map scale a circle whose radius is CD90 (102 meters in this case) and a circle whose radius is the RD (804 meters in this case, since delayed casualties are acceptable) (fig. B-II-2-2).
- (2) The analyst selects a point on the circumference of the CD90 circle and fixes this point on the DGZ. He rotates the CD90 circle around the selected point and the DGZ to evaluate the effect of horizontal error on achieving the desired fraction of damage and makes an estimate of the amount of the target covered with the RD. Figure B-II-2-3 demonstrates the procedure for accomplishing this operation.
- (3) In the upper sketch of figure B-II-2-3, there is approximately a 50-percent overlap of the target and the RD. If the burst were to occur at the location of the center of the circular map scale, all of the target elements within the RD would receive the expected damage. The fraction of damage from such a burst would be expressed as 50 percent. If the circular map scale is offset to the "worst case," the situation shown in the lower sketch of figure B-II-2-3 results; i.e., the RD overlaps approximately 30 percent of

the target. All of the target elements within the RD would receive the expected damage. The fraction of damage from such a burst would be expressed as 30 percent.

- (4) There is a 90-percent assurance of a round falling no farther from the DGZ than the distance (CD90). It can be stated, therefore, that 90 percent of the time the burst will cause at least as much damage as the worst-case burst demonstrated above.
- (5) In the foregoing example, the mini-

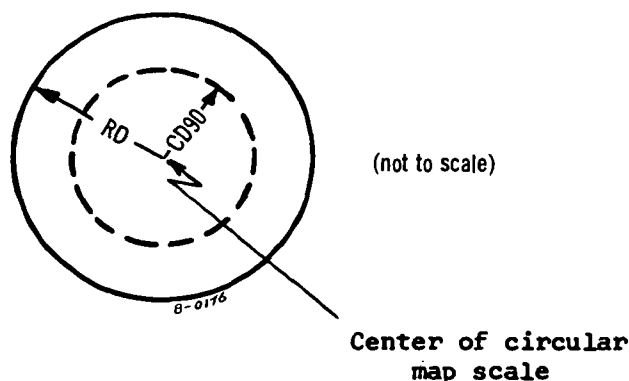


Figure B-II-2-2. Radius of damage and circular distribution 90 circles.

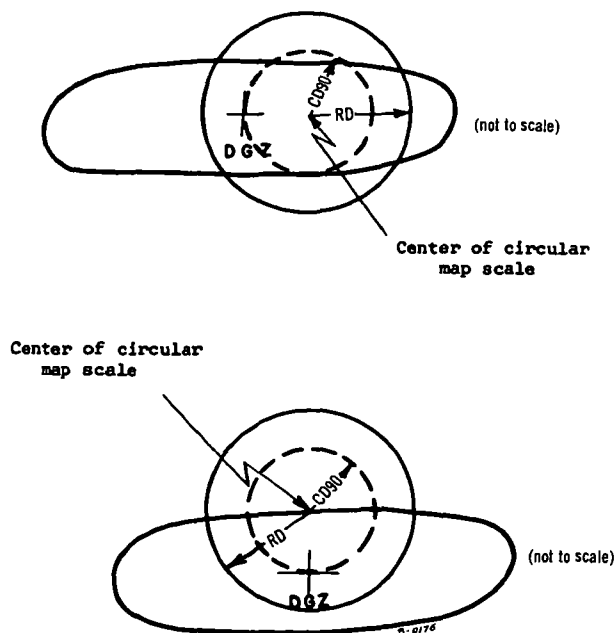


Figure B-II-2-3. Visual estimate of target coverage.

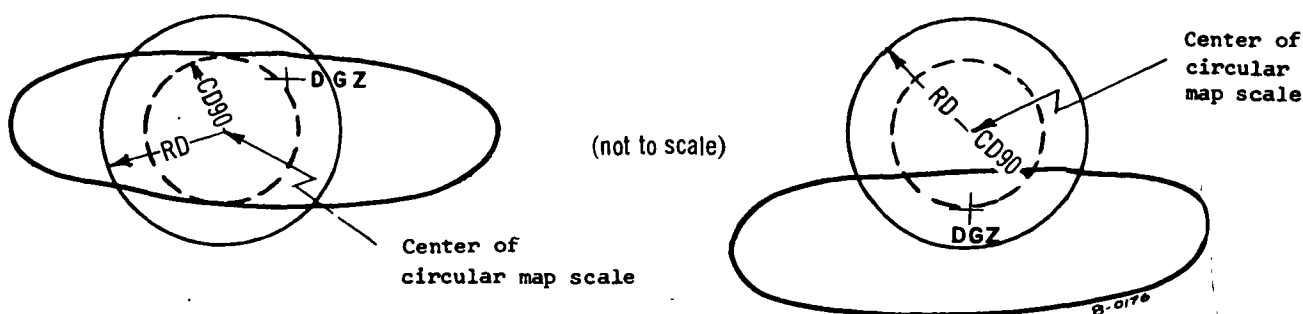


Figure B-II-2-4. Influence of displacing the desired ground zero.

imum expected fraction of damage is one-third, because 90 percent of the time at least one-third of the target will receive the expected coverage.

f. Displaced Desired Ground Zero.

- (1) As discussed in annex B-IV, it may be necessary to displace the desired ground zero from the target center. In such a case, the procedure outlined in *e* above is followed, using the displaced desired ground zero as the reference point from which to offset the circular map scale.
- (2) The following example portrays the influence of displacing the desired ground zero when the RD is 804 meters and the CD90 is 102 meters (fig. B-II-2-4):
 - (a) In the left-hand sketch of figure B-II-2-4, the RD covers approximately-half of the target. This is the optimum coverage that will occur from a burst landing a distance (CD90) from the DGZ.
 - (b) The worst-case burst is shown in the right-hand sketch of figure B-II-2-4. Approximately 25 percent of the target is covered by the RD. Ninety percent of the time the coverage will be at least 25 percent. The minimum expected fraction of damage, in this case, is 25 percent.

g. Bonus Damage. The preceding discussion of the visual method of damage estimation has been primarily concerned with the ex-

pected damage to the primary target element. There may be many other target elements damaged in the target area. Damage to these elements is considered a bonus and, thus, is termed "bonus damage."

- (1) There may be circumstances in which damage to a secondary target element is desired. In these instances the DGZ may be displaced toward the secondary target to enhance damage to it provided the commander's guidance is still met concerning the desired degree of damage to the primary target. If the requirement for such bonus damage affects the selection of a weapon, the influence of dispersion must be considered. The procedure for doing this is similar to that for estimating the coverage for the primary target element.
 - (a) For those target categories for which coverage tables have been computed, the estimate of bonus damage can be made in the same manner as that for the primary target element.
 - (b) For other target categories, the procedure is outlined in annex B-V to this appendix.
- (2) An estimate of the area of possible bonus damage to other target elements will assist in visualization of the condition of the target area after the burst. In such cases, the influence of delivery errors is not considered. The radii of the effects of interest are marked on the circular

map scale. The center of the circular map scale is then placed over the desired ground zero. This portrayal may accompany the recommendation to the commander.

- (a) If the radius of the effect of interest is shown in the safety distance table, the nuclear weapon

employment officer uses this radius on the circular map scale.

- (b) If the radius of damage of interest is shown in the effects table, the nuclear weapon employment officer enters the table at the desired height of burst for the target element of interest. He uses this radius on the circular map scale.

TAB B-II-3

NUMERICAL METHOD OF DAMAGE ESTIMATION

B-II-3-1. General

The numerical method of damage estimation involves the use of graphs and tables in conjunction with effects data to provide a numerical description of the minimum expected damage that a particular nuclear weapon will inflict on a particular target. It provides an estimation of damage to circular area targets and considers system inaccuracies, weapon yield, and various burst heights or damage criteria. It is the only method suitable for analyzing point targets and is particularly suitable for determining maximum possible displacement distance in conjunction with the desired results. *However, the analyst must not become so impressed with the apparent precision and completeness of a numerical target analysis that he is not cognizant of its shortcomings.* In general, the probabilities of fractional coverages derived from the numerical method are conservative, because compound probabilities are not considered. For numerical estimation using ADM see FM 5-26.

B-II-3-2. Graphs and Tables

Included in FM 101-31-2 and FM 101-31-3 are graphs and tables for use in numerical damage estimation. Instructions for the use of these graphs and tables and selected examples are given in subsequent paragraphs.

B-II-3-3. Damage Estimation of a Point Target

Single buildings, bridges, and similar targets are treated as point target. However, the size of the point target must be considered in conjunction with the radius of damage of the weapon. Associated with the engagement of the point target is the probability of damaging it to a desired degree. For example, assume that there is an 80-percent probability of moderately damaging a target. The expression $P=0.80$ means that there are 80 out of 100 chances that the target will receive moderate damage and 20 out of 100 chances

($1.00 - 0.80 = 0.20$) that it will receive less than moderate damage. It does *not* mean that if there were 100 targets 80 would be moderately damaged and 20 would remain untouched.

a. Concept of Point Target Damage Estimation. The radius of damage is a distance at which a single target element (point target) has a 50-50 chance ($P=.50$) of being damaged to the desired degree. In estimating the damage to a single target element (point target analysis), the analyst is not concerned specifically with the percentage of the target that will be covered by the damage circle, as defined by the radius of damage. Rather, he is concerned with the probability that the level of effects for the weapon in question will inflict the desired degree of damage on the target element. The radius of damage has been computed and is tabulated in the coverage tables in FM 101-31-2 and FM 101-31-3 for most target elements of interest and normally used degrees of damage. The radius of damage is one of the factors used to determine the probability of a point target being damaged under various conditions of target location with respect to the desired ground zero.

- (1) Referring to figure B-II-3-1, it can be determined visually that the probability (P) of damaging target A is .50 when no delivery error is considered and the distance of the point target from the GZ is equal to the RD . As distance (d) is decreased, P increases. For target B , P is greater than .50. As d increases, P decreases. For target C , P is less than .50.
- (2) When a delivery error is interjected, the effect of a third variable ($CD-90$) must be considered. In figure B-II-3-2, the probability of the weapon detonating at GZ1 is the same as the probability of its detonating at GZ2. If it detonates at GZ1, there is more than a 50-percent probability that the target element shown will be

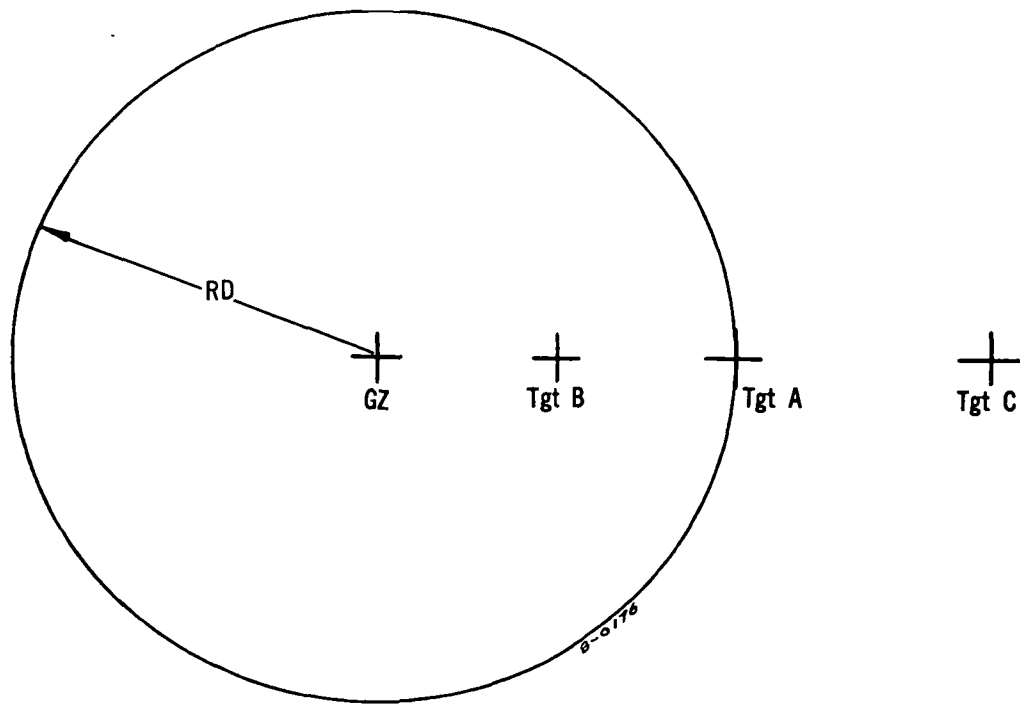


Figure B-II-3-1. Effect of displacement of the ground zero from a point target.

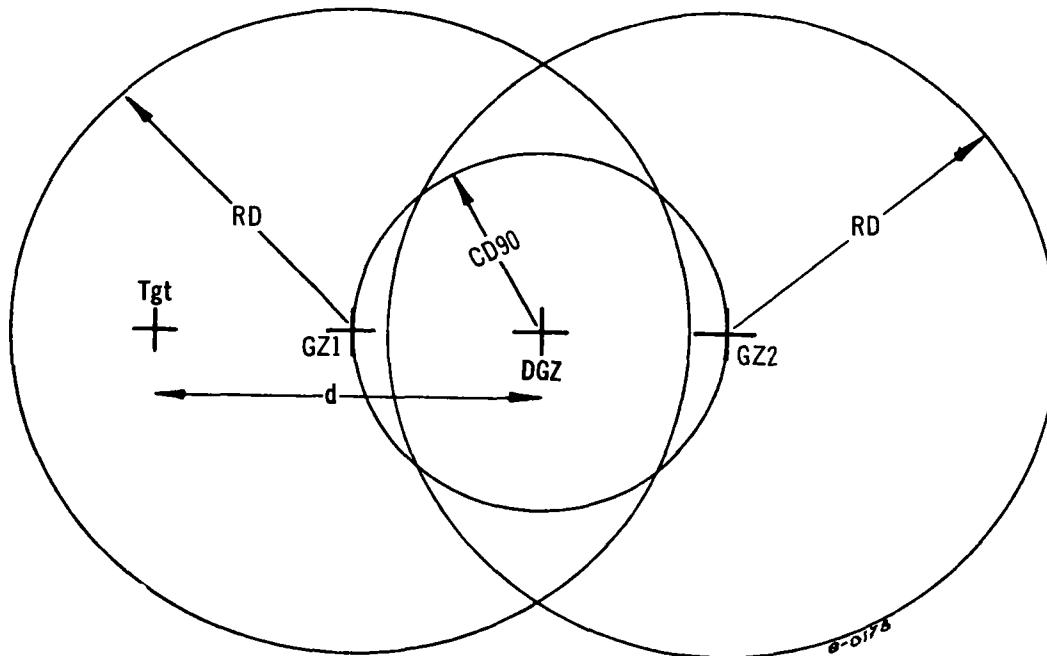
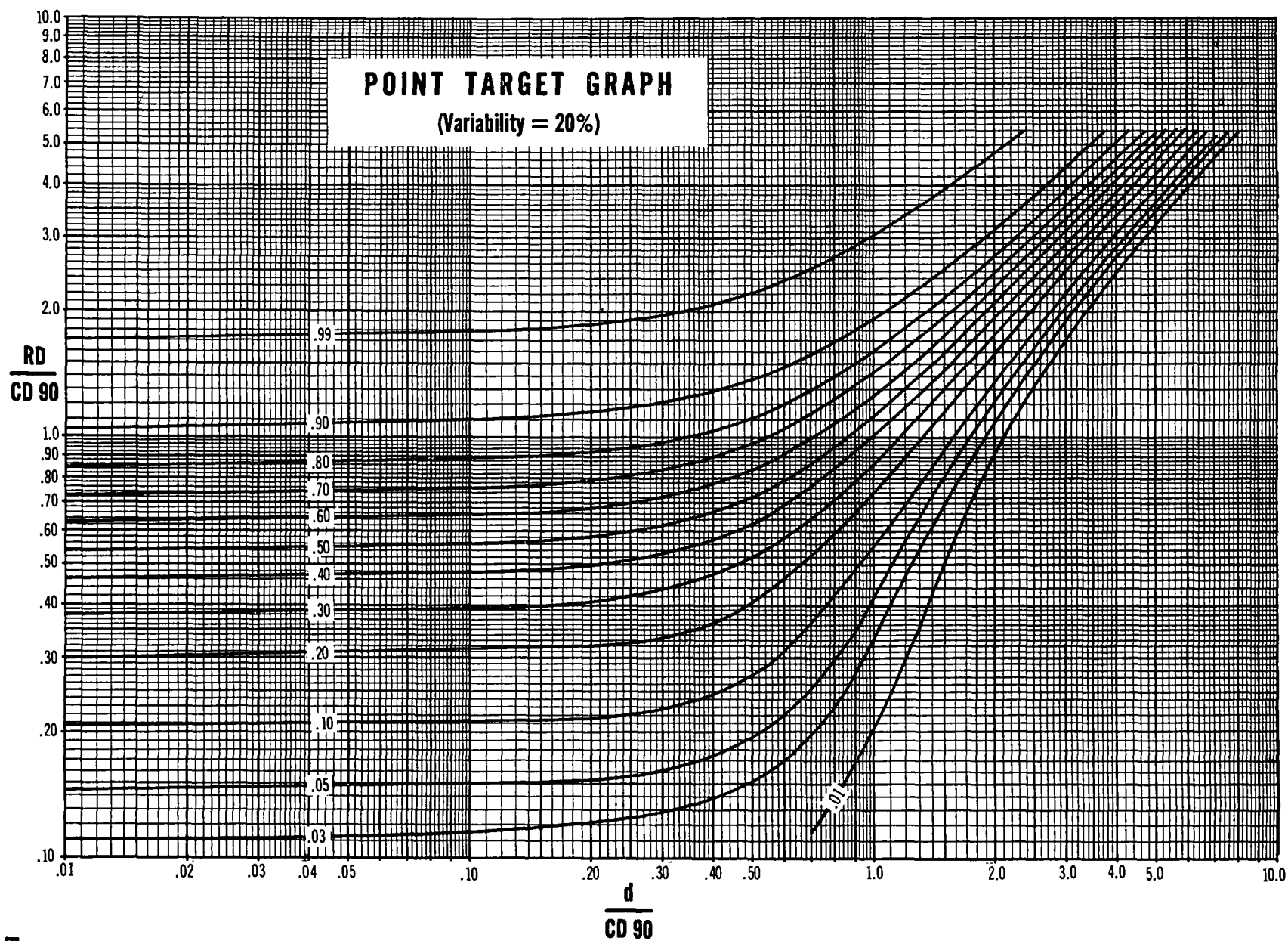


Figure B-II-3-2. Effect of dispersion on the probability of damaging a point target.

damaged to the desired degree. If, on the other hand, the weapon detonates at GZ2, there is less than a 50-percent

probability that this target will receive the desired damage. It is difficult, if not impossible, to estimate



★Figure B-II-3-3. The point target graph.

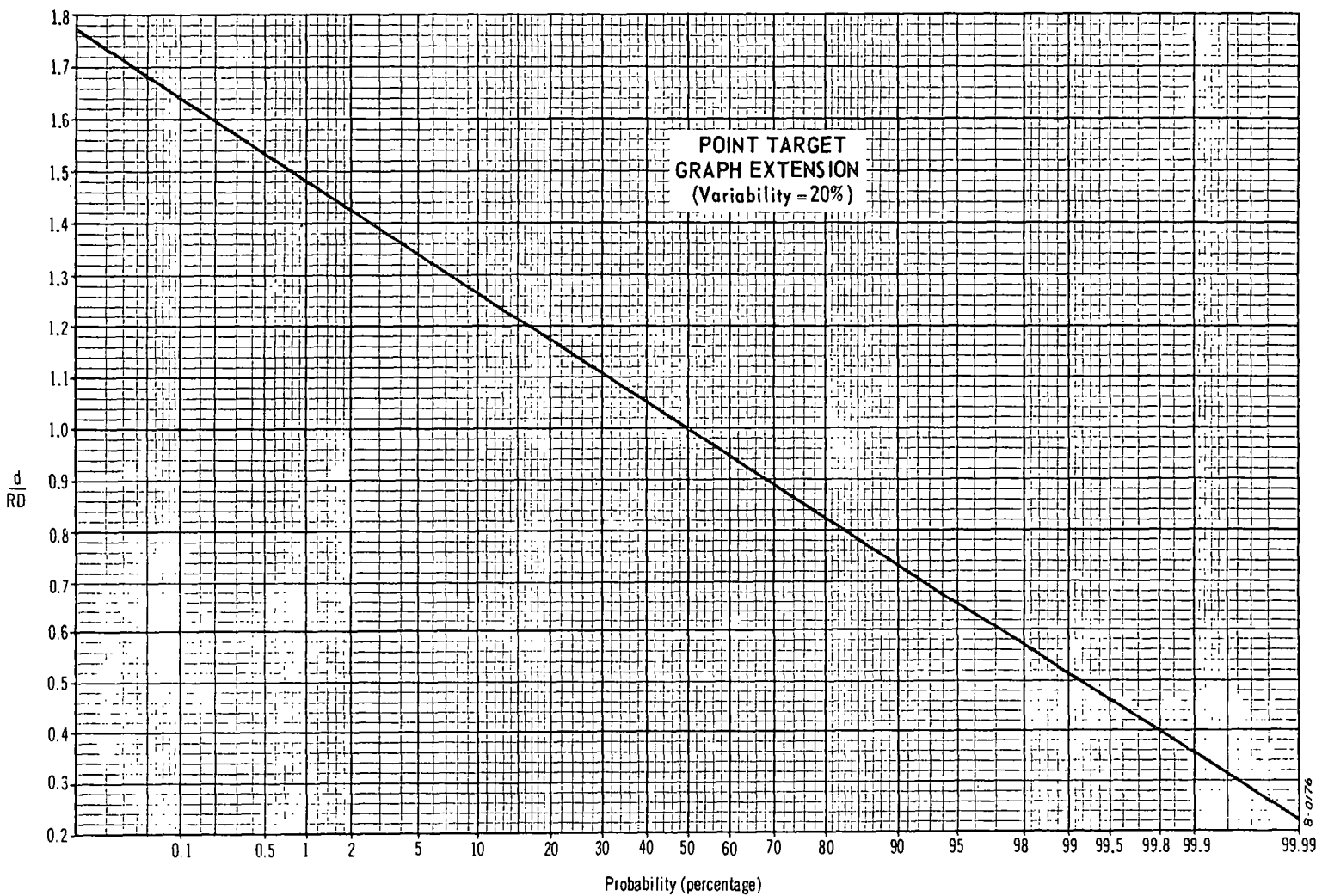


Figure B-II-3-4. The point target graph extension.

visually a meaningful probability of inflicting a specified degree of damage to a point target. Probability charts based on RD , d , and $CD90$ have been developed to estimate this probability.

b. Point Target Graphs. FM 101-31-2 and chapter 18, FM 101-31-3 contain two graphs that are used for estimating damage to point targets: the point target graph and the point target graph extension. These two graphs are reproduced in figures B-II-3-3 and B-II-3-4, respectively.

(1) *Description of the point target graph.*

- (a) The point target graph (fig. B-II-3-3) contains a family of probability (P) contours representing the probability of achieving the desired degree of damage to a point target. The vertical axis represents the ratio $\frac{RD}{CD90}$, while the horizontal axis

represents $\frac{d}{CD90}$. For any given con-

dition of radius of damage (RD), horizontal dispersion ($CD90$), and displacement distance (d) of the desired ground zero, the probability of achieving the desired degree of damage to a point target may be calculated.

- (b) The point target graph scale extends along the horizontal axis ($\frac{d}{CD90}$ ratio) and the vertical axis

($\frac{RD}{CD90}$ ratio). When the value of

either of these ratios exceeds the values as shown on the point target graph, the point target graph extension (fig. B-II-3-4) must be used. (When the values of the ratios on the point target graph exceed the maximum value, the RD or the d is so large with respect to the $CD90$ that the delivery error will be insignificant in comparison.)

(2) *Description of the point target graph extension.*

- (a) The point target graph extension (fig. B-II-3-4) shows the probability (P) of achieving the desired degree of damage to a point target when the horizontal dispersion is 0; or when the radius of damage (RD) or the displacement distance (d) is so large, with respect to the circular distribution 90 ($CD90$), that the delivery error will be insignificant in comparison.

- (b) The vertical axis represents the ratio $\frac{d}{RD}$, while the horizontal axis shows the percentage of probability of achieving the desired degree of damage.

- (c) Entering the point target graph extension from the vertical axis with the proper $\frac{d}{RD}$ ratio, the analyst moves horizontally to the right until he intersects the diagonal line. At the point of intersection, he moves down the graph and reads the percentage of probability of achieving the desired degree of damage to the point target.

c. Use of the Point Target Graph and the Point Target Graph Extension. The following example illustrates the use of figures B-II-3-3 and B-II-3-4. Assume that the target is a building.

- (1) *Given:* $RD = 1,000$ meters (for severe damage to structures)
 $CD90 = 200$ meters.

(2) *Find:* The probability of achieving severe damage to the building as a point target, when it is —

- (a) 900 meters from the DGZ.
(b) 1,600 meters from the DGZ.

(3) *Solution:*

- (a) Refer to figure B-II-3-3.

1. *Step 1.* Establish the proper ratios for entry into the graph when

$$\frac{RD}{CD90} = \frac{1,000}{200} = 5.0 \text{ and}$$

$$\frac{d}{900} = \frac{4.5}{200} = 4.5.$$

2. *Step 2.* Enter the graph with these ratios and, at the point of intersection, read $P = 0.66$, or a 66-percent probability of causing severe damage to the building.

- (b) The $\frac{d}{CD90}$ ratio is $\frac{1,600}{200} = 8.0$, which is not on figure B-II-3-3. Therefore, use figure B-II-3-4. (Notice that the ratio on the vertical axis of the graph is $\frac{d}{RD}$ the horizontal scale is probability.)

Determine the ratio $\frac{d}{RD} = \frac{1,600}{1,000} = 1.6$. Entering from the vertical axis of figure B-II-3-4 with this ratio value and intersecting the diagonal line, read from the horizontal axis a probability of approximately 0.2 percent.

d. Probability of Not Damaging a Point Target. In many instances, the probability that a point target, such as a bridge or a building, will not be damaged to a severe or a moderate degree is of interest. The point target graphs indicate the probability of achieving a particular degree of damage to a point target, depending on the radius of damage used. The probability of not damaging a point target to a specified degree is simply $1 - P$ of damaging it. When it is desired to *achieve* a specified level of damage to a point target, the analyst uses the appropriate radius of damage taken from the coverage tables in FM 101-31-2 and FM 101-31-3. It should be remembered that this is a probable *minimum* radius of damage. There is a high assurance that the radius of damage will be at least this size. When it is desired *not to inflict* a specified degree of damage on a target, the analyst uses the probable *maximum* radius of damage. The probable

maximum radius of damage is one that will *not be exceeded* 90 percent of the time. This radius of damage is determined from the effects table in the same manner as that discussed in annex B-V. A requirement to avoid the destruction of an installation comes under the subject of limiting requirements. A discussion of limiting requirements is included in annex B-III.

e. Criteria for Weapon Selection.

- (1) *Point target as the primary target element.* Damage to a single target element (e.g., bridge, missile launcher) is expressed as the probability of that target element receiving the damage specified. A high assurance ($P=90$) of success normally is sought.
- (2) *Point target as a secondary target element.* Damage to targets, composed of one or many target elements can be determined with the desired ground zero at or displaced from the center of the primary target. The ability to increase the probability of damage to a point target may be limited by the specified minimum limits of target coverage to the primary target. (Annex B-IV discusses the displacement of the desired ground zero.)

B-II-3-4. Damage Estimation for a Circular Area Target

The index method of damage estimation is the primary method of predicting damage to circular area targets. However, when a target is not one of the four major target categories or when the desired ground zero is displaced from the target center, the numerical method of damage estimation should be used. The area target graph is used in making this estimation. This graph is contained in FM 101-31-2 and chapter 18, FM 101-31-3 and is reproduced in figure B-II-3-5.

a. Area Target Graph. The primary use of the area target graph (fig. B-II-3-5) is to estimate the fractional damage to a circular

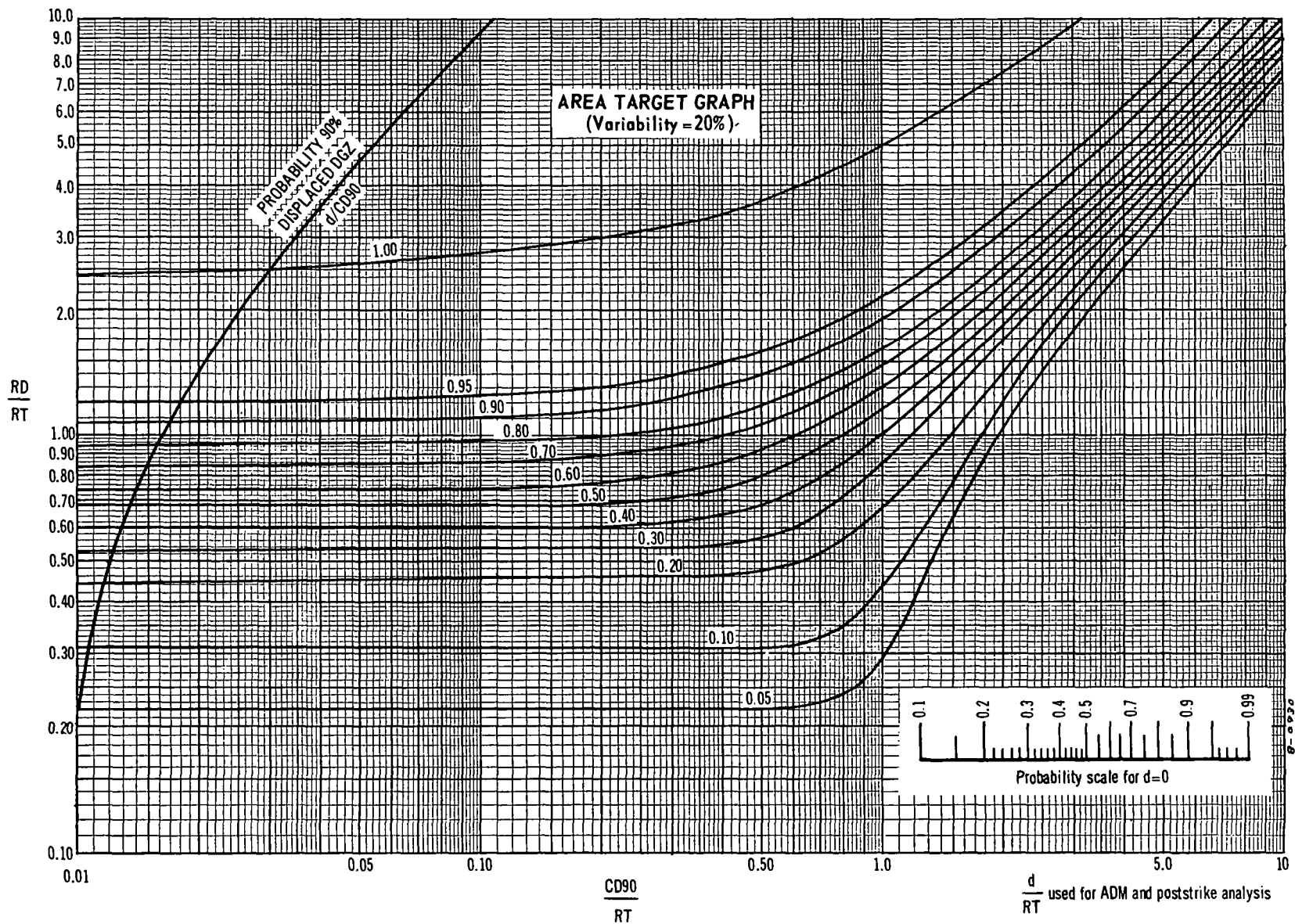


Figure B-II-3-5. The area target graph.

area target when the desired ground zero is displaced from the target center. The area target graph can also be used to—

- (1) Estimate damage to nonequatable targets.
- (2) Compute the maximum allowable displacement (d_{max}) of the desired ground zero.
- (3) Estimate the expected damage for employment of atomic demolition demolitions (ADM).
- (4) Perform a poststrike analysis.
- (5) Estimate damage for other than a 90-percent assurance of success.

b. Procedure for Damage Estimation When the Ground Zero Is Displaced.

- (1) Enter the appropriate coverage table with the proper range and extract the probable minimum RD and the $CD90$.
- (2) Compute the ratios $\frac{RD}{RT}$ and $\frac{CD90}{RT}$.
- (3) Enter the area target graph with the $\frac{RD}{RT}$ ratio value on the vertical axis and the $\frac{CD90}{RT}$ value on the horizontal axis. The point at which these two entry ratios intersect is the expected fractional coverage when the DGZ is located at the target center.
- (4) Compute the $\frac{d}{CD90}$ ratio.
- (5) With a pair of dividers, measure the horizontal distance between the ratio value on the vertical axis and the $\frac{d}{CD90}$ displaced DGZ curve.
- (6) Apply the distance determined in (5) above, horizontally to the right of the point of intersection ((3) above) and read the fractional coverage.
- (7) All fractional coverages determined in this manner have an associated 90-percent assurance of achieving

that coverage. Coverage is expressed as .90(.30), which means that there is a 90-percent assurance of achieving at least 30-percent coverage.

- (8) An example of this procedure is as follows:

(a) *Given:* $RD = 1,000$ meters
 $RT = 1,000$ meters
 $CD90 = 250$ meters
 $d = 400$ meters.

- (b) *Find:* The probable minimum fractional coverage.

(c) *Solution:* $\frac{RD}{RT} = \frac{1,000}{1,000} = 1.0$
 $\frac{CD90}{RT} = \frac{250}{1,000} = 0.25$
 $\frac{d}{CD90} = \frac{400}{250} = 1.6.$

Following the steps outlined in (1) through (7) above, the minimum fractional coverage is determined to be 64 percent, which is expressed as .90(.64).

c. Procedure for Damage Estimation for Nonequatable Targets. This procedure is explained in detail in annex B-V, paragraph B-V-3.

d. Procedure for Computation of Maximum Allowable Displacement of the Desired Ground Zero.

- (1) Enter the appropriate coverage table with the proper range and extract the probable minimum RD and the $CD90$.
- (2) Compute the ratios $\frac{RD}{RT}$ and $\frac{CD90}{RT}$.
- (3) Enter the area target graph with the $\frac{RD}{RT}$ value on the vertical axis and the $\frac{CD90}{RT}$ value on the horizontal axis. The point at which these two entry ratios intersect is the expected fractional coverage when the DGZ is located at the target center.

- (4) With a pair of dividers, measure the horizontal distance from the intersection ((3) above) to the damage curve representing the minimum desired fractional coverage.
- (5) Hold the dividers parallel to the horizontal axis and, with one divider leg on the vertical axis, move up the vertical axis until the distance set on the divider matches the distance between the vertical axis and the $\frac{d}{CD90}$ displaced DGZ curve. At this point, read the $\frac{d}{CD90}$ ratio value.
- (6) Using the ratio value obtained in (5), above, and the $CD90$ value, solve for the d_{max} . This value is the maximum distance that the DGZ can be displaced from the target center and still have a 90-percent assurance of achieving the desired fractional coverage.
- (7) An example of this procedure is as follows:
 - (a) *Given:* $RD = 1,000$ meters
 $RT = 800$ meters
 $CD90 = 200$ meters
 Minimum coverage desired —.90 (.60).
 - (b) *Find:* The d_{max} .
 - (c) *Solution:* $\frac{RD}{RT} = \frac{1,000}{800} = 1.25$
 $\frac{CD90}{RT} = \frac{200}{800} = 0.25$.

Following the steps outlined in (1) through (6), above, the graphical solution yields $\frac{d}{CD90} = 3.3$

$$d = 3.3 \times 200 = 660$$

$$d_{max} = 660 \text{ meters.}$$

e. Procedure for Damage Estimation for Employment of Atomic Demolition Munitions.

- (1) Determine the RD from the ADM ta-

bles (FM 101-31-2 and chapter 15, FM 101-31-3).

- (2) Compute the ratio $\frac{RD}{RT}$.
- (3) Enter the area target graph with the $\frac{RD}{RT}$ ratio value on the vertical axis and read the fractional coverage from the left edge of the graph. This is the coverage expected if the DGZ is located at the target center. Since there are no delivery errors associated with the ADM, the fractional coverage obtained is expressed as $f = X$ percent.
- (4) If the DGZ is displaced from the target center, the ratio $\frac{d}{RT}$ is substituted for $\frac{CD90}{RT}$ on the area target graph. Compute this ratio.
- (5) Read the fractional coverage at the intersection of the ratio values on the area target graph ($f = X$ percent).
- (6) An example of this procedure is as follows:
 - (a) *Given:* $RD = 200$ meters
 $RT = 150$ meters
 $d = 200$ meters.
 - (b) *Find:* The probable minimum fractional coverage (f).
 - (c) *Solution:* $\frac{RD}{RT} = \frac{200}{150} = 1.33$
 $\frac{d}{RT} = \frac{200}{150} = 1.33$.

Following the steps outlined in (1) through (5) above, read the value of f as 42 percent.

f. Procedure for a Numerical Poststrike Analysis. The procedure is explained in detail in annex B-VI, paragraph B-VI-2b.

g. Procedure for Damage Estimation for Other Than a 90-Percent Assurance of Success.

- (1) The DGZ must be located at the target center.
- (2) Compute the ratios $\frac{RD}{RT}$ and $\frac{CD90}{RT}$.

- (3) Enter the area target graph with the ratio values determined in (2), above. The point at which these two entry ratios intersect is the expected fractional coverage for a 90-percent assurance of success.
- (4) On the probability scale located in the lower right-hand corner of the graph, measure the distance between the index at 90 percent to the desired assurance.
- (5) Apply the distance obtained in (4), above, horizontally and in the same direction, to the point of intersection of the $\frac{RD}{RT}$ and $\frac{CD90}{RT}$ ratio values.
- (6) Read the fractional coverage, which will be expressed as a percentage of coverage for the desired degree of assurance.

ANNEX B-III

LIMITING REQUIREMENTS

B-III-1. General

Restrictions placed on the employment of nuclear weapons are referred to as "limiting requirements." These limiting requirements are imposed to avoid undesirable effects caused by nuclear weapons in the form of—

- a. Casualties to friendly troops.
- b. Creation of obstacles to movement, to include fire areas.
- c. Damage to installations desired for the use of friendly troops, such as bridges and buildings.
- d. Damage to friendly light aircraft in flight.

B-III-2. Troop Safety

(This paragraph is based on SOLOG No. 89.)

a. In comparison with the use of nonnuclear weapons, the use of nuclear weapons in close tactical support involves a much greater degree of risk to the safety of friendly troops.

b. Troop safety may influence the selection of the yield, the delivery system, the desired ground zero, the time of burst, and the scheme of maneuver. When the SOP or command guidance concerning troop safety cannot be met, the following actions may be taken:

- (1) Move the desired ground zero.
- (2) Use a more accurate delivery means.
- (3) Use a lower yield weapon(s).
- (4) Withdraw troops.
- (5) Accept less coverage.
- (6) Accept a higher degree of risk of damaging friendly units.
- (7) Increase the protection of friendly troops.
- (8) Use other forms of combat power, such as nonnuclear fires or maneuver elements.

c. The nuclear weapon employment officer uses a minimum safe distance (MSD) to make troop safety calculations. The minimum safe

distance considers both the delivery error and the distance to which certain weapon effects extend. The following definitions are used in determining the appropriate minimum safe distance:

(1) There are *three degrees of risk* associated with troop safety considerations—*negligible, moderate, and emergency.*

(a) At a *negligible risk* distance, troops will receive less than a 5-rad dose and are completely safe from militarily significant thermal radiation. However they may experience a temporary loss of vision (dazzle). A negligible risk is acceptable in all cases. *Negligible risk should not be exceeded unless significant advantages will be gained.*

(b) A *moderate risk* condition normally is used only for those nuclear weapon yields where radiation is the governing troop safety criteria. A moderate risk is considered acceptable in close support operations; for example, to create a gap in enemy forward positions or to halt an enemy attack. A moderate risk should not be exceeded if troops are expected to operate at full efficiency after a friendly burst.

(c) At an *emergency risk* distance, the anticipated effects levels may cause some temporary shock and a few casualties. A number of long-term casualties may be produced if personnel have been previously exposed to nuclear radiation. Personnel may be temporarily incapacitated from the blast wave. Collapsing foxholes may cause some casualties. For these reasons, there may be a decrease in the combat efficiency of the unit. *An emergency risk should be accepted only when*

it is absolutely necessary to gain a significant military advantage.

- (2) Closely associated with the degrees of risk is the *vulnerability* of the individual soldier. The danger to an individual from a nuclear explosion depends principally on the degree to which he is protected from the weapon effects. For example, a man who is well protected can safely be much closer to the ground zero than can be a man in the open. The degree of protection of the unit is considered in target analysis to be dependent on the amount of advance warning the unit has received. One or more of the following three conditions of *personnel vulnerability* can be expected at the time of burst: unwarned, exposed; warned, exposed; or 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 dazzle. For example, such a condition can be expected to prevail in an offensive situation when 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. For example, such a condition may prevail 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 as-

sumed to have some protection against heat, blast, and radiation. The assumed degree of protection is that protection offered to personnel who are in "buttoned-up" tanks or crouched in foxholes with improvised overhead thermal shielding. When only a lesser degree of protection is available (e.g., only tracked carriers are available), personnel cannot be considered warned protected. The target analyst would consider such personnel as exposed. A warned, protected condition is generally expected to prevail when nuclear weapons are used in a preparation prior to an attack.

- (d) It should be noted that there is no category for *unwarned, protected*. Although protection may be available to personnel, it cannot be assured that they will be taking advantage of it unless they are warned of an impending burst.
- (3) For each *combination* of degree of risk and condition of personnel vulnerability, there is an associated "risk distance" known as the radius of safety. It is the horizontal distance from the *actual* ground zero *beyond which* the weapon effects are acceptable. Because a round may burst at the end of the dispersion pattern nearest to friendly troops, a buffer distance is added to the radius of safety. The buffer distance provides a very high assurance (99 percent) that unacceptable weapon effects will not reach friendly troops. The size of the buffer distance is dependent on the horizontal delivery error at the applicable range. The sum of the radius of safety and the buffer distance is the minimum safe distance shown in the safety distance tables in FM 101-31-2 and (ch 18) FM 101-31-3. The minimum safe distance value listed is the minimum distance in meters that must separate friendly troops from the desired ground zero

FREE FLIGHT ROCKET 10.0 KT

TROOP SAFETY

RANGE	UNWARNED EXPOSED		WARNED EXPOSED		WARNED PROTECTED	
	NEG	EMER	NEG	EMER	NEG	EMER
10000	4800	3900	2800	2500	2400	1900
11000	4900	3900	2800	2500	2500	2000
12000	4900	3900	2900	2500	2500	2000
13000	4900	4000	2900	2600	2500	2000
14000	5000	4000	2900	2600	2600	2100
15000	5000	4000	3000	2600	2600	2100
16000	5000	4100	3000	2700	2600	2100
17000	5100	4100	3000	2700	2700	2200
18000	5100	4100	3100	2700	2700	2200
19000	5100	4200	3100	2800	2700	2200
20000	5200	4200	3100	2800	2800	2300
21000	5200	4200	3200	2800	2800	2300
22000	5200	4300	3200	2900	2800	2300
23000	5300	4300	3200	2900	2900	2300
24000	5300	4300	3300	2900	2900	2400
25000	5300	4400	3300	3000	2900	2400
26000	5400	4400	3300	3000	2900	2400
27000	5400	4400	3300	3000	3000	2500
28000	5400	4500	3400	3000	3000	2500
29000	5500	4500	3400	3100	3000	2500
30000	5500	4500	3400	3100	3100	2500

Figure B-III-1. Example of troop safety portion (range-dependent system) of safety distance table.

so that the specified degree of risk *will not be exceeded*. If troops are farther from the desired ground zero than the distance listed, there is no troop safety problem.

d. In determining the expected degree of risk to which troops will be exposed, the target analyst needs to know the location and radiation exposure history of friendly elements and the degree of protection they are expected to have at the time of burst.

B-III-3. Determination of Minimum Safe Distance for an Airburst

a. The negligible and emergency risk distances for the three vulnerability conditions (para B-III-2c(2)) are listed in the safety distance tables. These tables are located in

the target coverage tables for airburst, under the appropriate weapon system and yield, in FM 101-31-2 and FM 101-31-3. There are two types of safety distance tables—range-dependent system and range-independent system. An example of a range-dependent system table in the free-flight rocket with a 10-kiloton yield (FFR/10 KT). A portion of this table is reproduced in figure B-III-1. An example of a range-independent system table is the light guided missile with a 10-kiloton yield (LGM/10 KT). A portion of this table is reproduced in figure B-III-2.

b. To use figure B-III-1, enter with the target range rounded off to the nearest 1,000 meters. (Do not interpolate. If the target range lies *exactly halfway* between two listed ranges, enter at the largest listed range (e.g., if the target range is 10,500 meters, use an entry

LIGHT GUIDED MISSILE

TROOP SAFETY

YIELD	UNWARNED EXPOSED		WARNED EXPOSED		WARNED PROTECTED	
	NEG	EMER	NEG	EMER	NEG	EMER
2 KT	2200	1700	2200	1700	1900	1500
5 KT	3100	2500	2400	1900	2100	1600
10 KT	4700	3700	2700	2300	2300	1800
20 KT	6900	5400	3700	3200	2500	2000

Figure B-III-2. Example of troop safety portion (range-independent system) of safety distance table.

range of 11,000 meters). If the target range is other than exactly halfway between two listed ranges, round off upward or downward to the next higher or lower listed range (e.g., if the target range is 10,400 meters, use an entry range of 10,000 meters; if the target range is 10,600 meters, use an entry range of 11,000 meters.) Read the minimum safe distance opposite the entry range under the vulnerability condition and degree of risk specified. Examples of the use of the troop safety portion of the safety distance table are as follows:

(1) *Example 1 (range-dependent system).*

- (a) *Given:* Delivery system—free-flight rocket
Yield = 10 KT
Range = 24,600 meters
HOB—low air
Vulnerability condition—unwarned, exposed personnel
Degree of risk—negligible.

(b) *Find:* The MSD.

- (c) *Solution:* Enter figure B-III-1 with the range of 25,000 meters. Moving to the right, under the column for unwarned, exposed personnel, negligible risk, read the MSD as 5,300 meters. This is the minimum distance that must separate the DGZ and friendly troops so that

the troops will be subjected to no more than a negligible risk.

- (2) *Example 2 (range-independent system).* To use figure B-III-2, enter with the weapon yield (10 KT in this case) and read the MSD under the appropriate column for the vulnerability condition and the degree of risk specified (4,700 meters in this case).

B-III-4. Preclusion of Obstacles

a. The large amount of destructive energy released from a single nuclear detonation creates serious obstacles to the movement of friendly troops. These obstacles take the form of neutron-induced gamma activity (NIGA), fallout, tree blowdown, and fires.

b. The preclusion of these obstacles can influence the selection of the yield, the delivery system, and the desired ground zero. When the SOP or command guidance concerning the preclusion of obstacles cannot be met, the following actions may be taken:

- (1) Move the desired ground zero.
- (2) Use a more accurate delivery means.
- (3) Use lower yield weapon(s).
- (4) Accept less coverage.
- (5) Accept a higher probability of producing obstacles.

(6) Use other forms of combat power, such as nonnuclear fires or maneuver elements.

★ *c.* The nuclear weapon employment officer uses a least separation distance (LSD) to make preclusion-of-obstacle calculations. Both the delivery error and the distance to which certain weapon effects extend are incorporated in the least separation distance. If the least separation distance extends from the desired ground zero to the point of interest, there is better than a 90-percent probability that obstacles will not be produced at that point.

d. A discussion of obstacles to the movement of friendly troops is included in (1) through (5) below.

(1) *Neutron-induced gamma activity.* When a nuclear detonation takes place in the proximity of the earth's surface, free neutrons from this detonation bombard the elements in the soil, making some of them radioactive. The subsequent decay of these radioactive elements produces the residual nuclear radiation known as neutron-induced gamma activity, and is a definite hazard to troops occupying or passing through the area. The distance to which this obstacle-producing effect will extend is extremely variable and cannot be predicted to within a reasonable degree of accuracy. Therefore, the areas within the distances shown in table B-III-1 are considered hazard areas and require monitoring for accurate information on radiation intensity and size of the pattern.

Table B-III-1. Estimated 2-Rad-Per-Hour Radius of Induced Contamination

Yield	Horizontal radius (meters)
1 KT-----	400
10 KT-----	700
100 KT-----	1,000
1 MT-----	1,400

(2) *Fallout.* Militarily significant fallout from surface or near-surface bursts is also a nuclear radiation hazard to troops who must occupy or cross these contaminated areas. The distance to which fallout will extend can be estimated using the procedures outlined in TM 3-210. The actual location of fallout within the predicted area of hazard must be ascertained by radiological monitoring and survey.

(3) *Tree blowdown.* Uprooted trees, broken

crowns, and fallen limbs can present a considerable obstacle to foot and wheeled- and tracked-vehicle movement. However, the distances to which tree blowdown will occur is predictable, and these distances are listed in the safety distance tables included in FM 101-31-2 and FM 101-31-3 under the columns for preclusion of obstacles (fig. B-III-3). These distances are the least separation distances required between the desired ground zero and the point at which tree blowdown is to be precluded. For the purpose of determining the least separation distance for tree blowdown, trees are classified into two groups.

(a) *Deciduous.* Deciduous trees lose their leaves at the end of the growing season.

(b) *Coniferous.* Coniferous trees are of the evergreen family.

Knowing the type of trees in the area of interest, the target analyst can enter the appropriate safety distance table for the delivery system and yield (at the nearest listed range) and extract the least separation distance from the proper column for tree blowdown. Because the least separation distance is not dependent on the target category, any of the safety distance tables for the delivery system, yield, and height of burst may be used ((5) below).

(4) *Fires.* The thermal energy emitted from a nuclear detonation is capable of starting fires at considerable distances from the ground zero. These distances are predictable for normal atmospheric conditions. However, the distance to which these fires, once started, will extend is dependent on terrain, type of fuel, wind velocity, and other parameters and cannot be predicted. The least separation distances required to preclude ignition of fires are listed in the safety distance tables in FM 101-31-2 and FM 101-31-3 under the columns for preclusion of obstacles (fig. B-III-3). For the purpose of determining the least separation distances for fires, fuels are classified into two groups: dry and green (see descriptions in FM 101-31-2 and FM 101-31-3). Knowing the type of fuel in the area of interest, the target analyst can enter the safety distance table for the appropriate delivery system and yield (at the nearest listed range) and extract the least separation distance from the proper column for fires.

FREE FLIGHT ROCKET 10.0 KT

RANGE	PRECLUDE DAMAGE			PRECLUDE OBSTACLES			
	MOD DAMAGE TO FIXED BRIDGES	LIGHT DAMAGE TO BUILDINGS	LIGHT A/C IN FLIGHT	TREE BLOWDOWN		FIRES	
				DECIDU- OUS	CONIFER- OUS	DRY FUEL	GREEN FUEL
15000	1100	4000	6700	1400	1300	3200	2100
16000	1100	4100	6800	1400	1300	3200	2100
17000	1100	4200	6900	1400	1300	3200	2100
18000	1100	4200	6900	1400	1400	3200	2200
19000	1200	4300	7000	1500	1400	3300	2200
20000	1200	4400	7100	1500	1400	3300	2200
21000	1200	4400	7200	1500	1400	3300	2200
22000	1200	4500	7300	1500	1400	3300	2200
23000	1200	4500	7300	1500	1500	3300	2200
24000	1200	4600	7400	1500	1500	3300	2200
25000	1200	4600	7500	1600	1500	3400	2300

Figure B-III-3. Example of preclusion-of-damage/-obstacles portions of the safety distance table.

(5) *Example of use of the safety distance table.*

- (a) *Given:* Delivery system — freeflight rocket
Yield=10 KT
Range=23,400 meters
HOB—low air
Type of trees—coniferous
Type of fuel—dry.

(b) *Find:* The LSD for tree blowdown and the LSD for fire.

(c) *Solution:*

1. *Step 1.* Enter figure B-III-3 with the range of 23,000 meters. (Remember that LSD is not dependent on target category.) Moving to the right, under the column for tree blowdown coniferous, read the LSD as 1,500 meters. This is the least distance that must separate the DGZ and the area of interest to preclude tree blowdown.

2. *Step 2.* To find the LSD for fire, use the same procedure as that in

1, above, but move to the column for fires, dry fuel, and read the LSD as 3,300 meters.

B-III-5. Preclusion of Damage

a. Preclusion of damage to bridges or buildings is often dictated by the tactical or the political situation. Because of this, the least separation distances necessary to preclude damage are listed in the safety distance tables in FM 101-31-2 and FM 101-31-3 under the columns for preclusion of damage (fig. B-III-3). Also listed are the least separation distances for light aircraft in flight.

b. The procedure for extracting the least separation distances for damage is the same as that for obstacles (para B-III-4d(5)). The subheadings under the main heading *Preclude Damage* are discussed in (1) through (3) below.

- (1) *Moderate damage to fixed bridges.* Moderate damage to a bridge is defined as damage that reduces the load-carrying capability of the bridge by 50 percent. If the desired ground zero and the bridge are separated by the least separation distance, there is a 90-percent probability that the bridge will not be moderately damaged.

- (2) *Light damage to buildings (1 psi).* Light damage to buildings is defined as the blowing in of windows and doors and the cracking of interior partitions. Normally, light damage to frame buildings is associated with 1-psi overpressure. If the desired ground zero and the nearest building are separated by the least separation distance, there is a 90-percent probability that the building will not receive light damage.

- (3) *Light aircraft in flight.* The least separation distances given for light aircraft in flight include the consideration that, if the desired ground zero and the aircraft are separated by the least separation distance, there is a 99-percent probability that the aircraft will be able to continue its mission.

c. It will be necessary for the analyst to determine the preclusion of damage to structures and materiel other than those listed in the safety distance tables. In these instances, the analyst will use the procedures listed in annex B-V to this appendix with data extracted from the effects tables found in FM 101-31-2 and FM 101-31-3.

ANNEX B-IV

SELECTION OF THE DESIRED GROUND ZERO

B-IV-1. General

(This paragraph is based on SOLOG No. 89.)

In predicting the damage resulting from the detonation of a nuclear weapon, or in predicting the effect of the burst on limiting requirements, calculations are made with reference to the desired ground zero (DGZ). Factors that may affect the selection of the DGZ are discussed in *a* through *g* below.

a. Maximum Weapon Effectiveness. The most important factor in selecting the location of the desired ground zero is the achievement of maximum weapon effectiveness; in other words, the delivery of the most intense weapon effects over the greatest portion of the target. However, other considerations may require that the desired ground zero be displaced from this optimum position. The influence of *all* contributing factors must be analyzed and evaluated in the process of selecting an appropriate desired ground zero.

b. Size, Shape, and Concentration of the Target. Unless known data indicate otherwise, all targets are assumed to be circular and all target elements to be evenly distributed in a random orientation throughout the target area. Except as modified by other considerations, the best location for the desired ground zero is the center of the target. When a large area target, or an irregularly shaped target, is to be attacked with a relatively small weapon, the desired ground zero should be selected within that portion of the target in which maximum damage is desired. If the distribution of target elements is not uniform, the center of mass of the target elements is the best desired ground zero location.

c. Vulnerability. The vulnerability of a target, or target elements, partially determines the radius of damage required to produce the desired results. The location of the desired

ground zero is directly affected by the vulnerability of the various target elements. Those elements with the least vulnerability require the most intense effects that exist around the ground zero.

d. Military Importance. The relative military importance of targets (or target elements) affects the location of the desired ground zero by placing it near the most remunerative target.

e. Horizontal Error and Weapon Yield. Horizontal error and weapon yield influence the selection of the desired ground zero when two or more targets are to be attacked with a single weapon. The fraction of damage to a given target is affected by the horizontal error of the delivery system, the weapon yield, and the height of burst. For a given weapon and delivery system, the circular map scale, or a compass, can be used in locating a desired ground zero to achieve the desired target coverage. However, if the weapon yield, the height of burst, or the delivery means is changed during the target analysis, the location of the desired ground zero may also have to be changed.

f. Limiting Requirements.

- (1) In the attack of targets close to friendly units, troop safety requirements may require that the desired ground zero be displaced from the point where maximum weapon effectiveness would be achieved. The minimum safe distance (MSD) required for troop safety purposes determines the nearest point to friendly units that may be selected as the desired ground zero. A more detailed discussion of the influence of this consideration is contained in annex B-III.
- (2) The preclusion of damage to key installations and the preclusion of obstacles that could impede the scheme

of maneuver are also considerations that can require the desired ground zero to be displaced from the target center.

g. Multiple Bursts. When multiple weapons are employed against a large target, the overlap of the damage radii may affect the selection of the desired ground zero. If two or more weapons are employed close together so that their damage radii overlap, the actual damage may be greater than that predicted because of the reinforced effects. This represents a waste of combat power. Generally, the desired ground zeros in a multiple weapon attack are sufficiently separated so that there is a minimum of overlap of the damage radii. Also considered in multiple weapon attacks is the possibility of degrading the effects of one weapon with the effects from another.

B-IV-2. Methods of Selecting the Desired Ground Zero

a. In selecting the desired ground zero, consideration is given to the various influencing factors discussed above. Initially, the target center should be selected as the desired ground zero; however, at times, it will become necessary to displace the desired ground zero to accomplish the mission. The primary reasons for displacement of the desired ground zero include—

- (1) Limiting requirements.
- (2) Multiple targets.
- (3) A combination of (1) and (2), above.

b. To assist the analyst in selecting the desired ground zero, table B-IV-1 has been devised, using a three-step procedure based on the three primary reasons for displacement (*a* above). The table is designed to answer the following two questions:

- (1) What information is required to determine the location of the desired ground zero—
- (2) What method is used to obtain this information—

c. The following subparagraphs discuss the composition of table B-IV-1:

- (1) Under the columnar subheading *Limiting requirements* are two columns—one for a single limiting requirement (which forces the desired ground zero in one direction) and one for two or more limiting requirements (which forces the desired ground zero in two or more directions). A multiple limiting requirement analysis is one in which the desired ground zero is forced from the target center(s) in two or more directions.

Table B-IV-1. Determining the Displacement of the Desired Ground Zero

Step	Limiting requirements		Reasons for displacement Multiple targets (with one weapon)		Combination of reasons
	One	Two or more	Two or more targets (all area or all point)	One point target and one area target	
1. Determine displacement required (distance and direction).	MSD, LSD		dmax all targets (numerical method).	dmax point target (numerical method).	Combination of techniques in other columns.
2. Locate DGZ (plot if required).	Step 1 locates.	Graphical plot.	Graphical plot.	Graphical plot.	
3. Determine final coverage.	Numerical or visual method.		Numerical or visual method.	Numerical or visual method (area target only).	

- (2) The columnar subheading *Multiple targets (with one weapon)* also contains two columns. The first column considers either all area targets or all point targets. The second column considers the attack on two targets that are mixed (one area and one point).
- (3) The last column is titled *Combination of reasons*. Entry into this column would be applicable when, for example, two or more targets are being attacked with a single weapon and the desired ground zero is forced from the area of maximum coverage because of limiting requirements.

d. The analyst enters the table in the appropriate column stating the reason for the displacement of the desired ground zero and follows sequentially the procedures listed in each of the three steps.

- (1) *Step 1*. Determine the magnitude of the DGZ displacement (i.e., the distance of the displacement required and the direction in which the displacement will be made).
- (2) *Step 2*. Determine the actual location of the new DGZ. Accomplish this mathematically, by using either the target analysis worksheet, when displacement is required in only one direction; or a graphical plot, when two or more limiting requirements (and the associated areas) are used.
- (3) *Step 3*. Compute the final coverage. Whenever the DGZ is displaced, use the visual or the numerical method of damage estimation.

e. Examples of determination of the desired ground zero, using several techniques and procedures, are included in (1) through (5) below.

(1) *Single limiting requirement.*

- (a) *Given*: Delivery system—short-range cannon
 Yield = 1 KT
 Range = 7,000 meters
 HOB—low air

Degree of risk and vulnerability condition—no more than negligible risk to unwarmed, exposed troops located 1,000 meters south of the target center; no other limiting requirements present.

(b) *Find*: The location of the DGZ.

(c) *Solution*:

1. *Step 1*. Determine the displacement required. Using a target analysis worksheet, enter the proper safety distance table in FM 101-31-3 with the range of 7,000 meters. Moving to the right, under the column for preclusion of casualties, negligible risk to unwarmed, exposed personnel, read the MSD for troop safety as 2,000 meters. Because friendly troops are located 1,000 meters south of the target center, displacement for troop safety is, therefore, 1,000 meters north of the target center. The troop safety calculations entered in the target analysis worksheet from step 1 are as follows:

- (a) MSD—2,000 meters.
- (b) Troop distance to the DGZ—1,000 meters south.
- (c) Displacement—1,000 meters north.

2. *Step 2*. Locate the DGZ. When the DGZ is forced from the target center by a single limiting requirement, the displacement computed on the target analysis worksheet is the distance (*d*) used in the computation of the final coverage.

3. *Step 3*. Compute the final coverage. If the target is determined to be circular, the numerical method of damage estimation is used. Using $\frac{RD}{RT}$, $\frac{CD90}{RT}$, and $\frac{d}{CD90}$ to establish the proper ratios, enter

the area target graph to determine the final coverage.

(2) *Multiple limiting requirements.*

- (a) *Given:* Delivery system—free-flight rocket

Yield = 10 KT

Range = 12,000 meters

HOB—low air

Degree of risk and vulnerability condition—no more than negligible risk to unwarned, exposed personnel located 4,500 meters south of the target center

Limiting requirement—no tree blowdown at the intersection of Highways 12 and 14, 900 meters east of the target center

Type of trees—deciduous.

- (b) *Find:* The location of the DGZ.

(c) *Solution:*

1. *Step 1.* Determine the displacement required. Using a target analysis worksheet, enter the proper safety distance table in FM 101-31-3 with the range of 12,000 meters. Moving to the right, under the column for preclusion of casualties, negligible risk to unwarned, exposed personnel, read the MSD for the troop safety as 4,900 meters. Because friendly troops are located 4,500 meters south of the target center, displacement for troop safety is, therefore, 400 meters north of the target center. Now, moving farther to the right (aligned on the 12,000-meter range), under the column for preclusion of obstacles, tree blowdown, deciduous, read the LSD as 1,300 meters. The intersection of Highways 12 and 14 is 900 meters east of the target center. To preclude tree blowdown at the intersection, the DGZ is displaced 400 meters west of the target center. The troop safety and preclusion-of-obstacles calcu-

lations entered in the target analysis worksheet from step 1 are as follows:

(a) *Troop safety.*

(1) MSD—4,900 meters.

(2) Troop distance to the DGZ—4,500 meters.

(3) Displacement—400 meters north.

(b) *Preclusion of obstacles.*

(1) LSD—1,300 meters.

(2) Distance to the DGZ—900 meters east.

(3) Displacement—400 meters west.

2. *Step 2.* Locate the DGZ. Because the DGZ is forced in more than one direction by necessary displacements, the mathematical technique is not used in determining the DGZ displacement. Locate the DGZ by graphically plotting effects arc. An example of this graphical method is shown in figure B-IV-1.

- (a) Graphically draw a line parallel to the friendly frontlines at a distance equal to the troop safety distance (4,900 meters in this case).

- (b) The preclusion - of - obstacles portion of the table indicates that the DGZ must be 1,300 meters away to preclude tree blowdown. Therefore, draw an arc, scaled to this 1,300-meter distance, from the intersecting point of Highway 12 and Highway 14.

- (c) Locate the DGZ by selecting a point as close as possible to the target center, yet outside the troop safety line and the preclusion-of-obstacle arc. Normally, this will be found at the intersection of the line and the arc. Measure the distance from the DGZ to the target center to determine the distance (d)

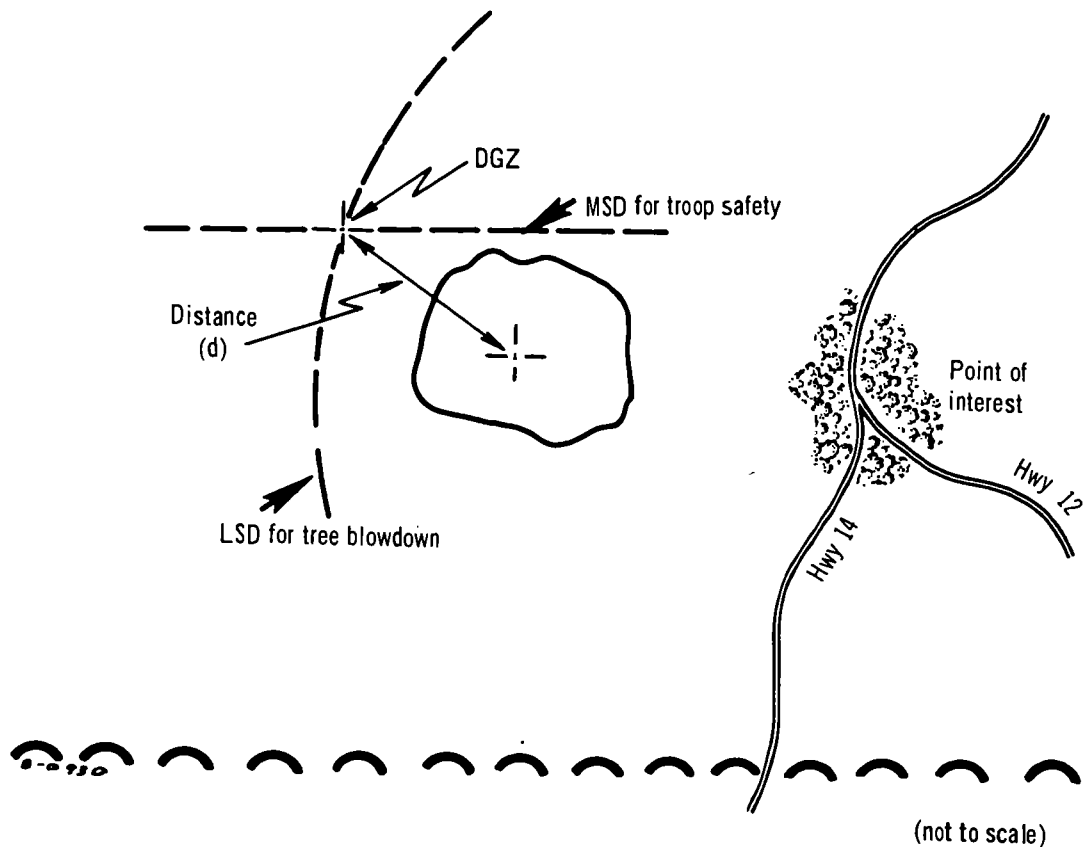


Figure B-IV-1. Graphical solution of the desired ground zero selection (multiple limiting requirements).

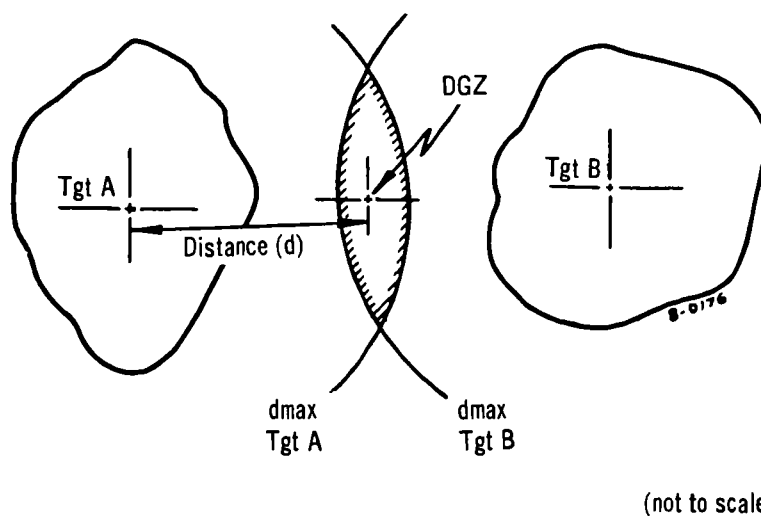


Figure B-IV-2. Graphical solution of the desired ground zero selection (multiple target attack with one weapon) (all area targets or all point targets).

that is used in computing the final coverage.

3. *Step 3.* Compute the final coverage, using either the numerical or the visual method of damage estimation.

- (3) *Attack of multiple targets with a single weapon (all area targets or all point targets).* In analyzing multiple targets for attack with a single weapon, it may be found that the relative location of one target to another will permit the selection of a DGZ at some point in between. This will result in destruction of more than one target. An example of this is shown in figure B-IV-2.

(a) *Given:*

Target A	Target B
<i>RT</i> = 800 meters	<i>RT</i> = 600 meters
<i>RD</i> = 1,900 meters	<i>RD</i> = 1,800 meters
<i>CD90</i> = 250 meters	<i>CD90</i> = 250 meters
Distance tgt A to tgt B = 2,200 meters	
Required coverage of each target—.90(.30).	

- (b) *Find:* The location of the DGZ and the final coverage of targets A and B.

(c) *Solution:*

1. *Step 1.* Determine the displacement required. In analyzing multiple targets of the same type, find the maximum allowable distance (*dmax*) the DGZ can be displaced from the target center and still provide the necessary coverage.

- (a) Compute the *dmax* for target A.
- (b) Compute the *dmax* for target B.

2. *Step 2.* Locate the DGZ.

- (a) Graphically draw arcs from target A a distance equal to the computed *dmax* for target A and from target B a distance equal to the *dmax* for target B. The area of overlap (shaded area) is the area in which a DGZ can be selected to provide the required cover-

age. Again, the best location for the DGZ is the closest point to each of the target centers. In this example, this would be midpoint in the shaded area on a line drawn between the two target centers.

- (b) After selecting the DGZ, measure the distance between the DGZ and each target center to determine the distance (*d*) to be used in computing the final coverage of each target.

3. *Step 3.* Compute the final coverage for each target individually, using either the numerical or the visual method of damage estimation.

- (d) *Consideration of two targets.* When only two targets are considered, the mathematical process is an alternate method of selecting the DGZ. Using figure B-IV-2 as an example, the following procedure is used:

1. *Step 1.* Compute the *dmax* for each target.

2. *Step 2.* Determine the area-of-coverage overlap by adding the *dmax* values and subtracting from the sum the distance separating the target centers.

3. *Step 3.* Compute the actual distance (*d*) by dividing the area-of-coverage overlap by 2 and subtracting the quotient from the *dmax* associated with each target. This difference is the distance (*d*) used in computing the final coverage for each target and is also the distance from each target center at which the DGZ will be plotted.

4. *Step 4.* Compute the final coverage.

5. *Example.* The following is an example of the mathematical proc-

ess, using figure B-IV-2 and the target data given in (a), above.

- (a) *Step 1.* Compute the d_{max} for each target. (Use procedure in annex B-V.)

$$\begin{aligned} & \text{Target A} \\ \frac{CD90}{RT} &= \frac{250}{800} = 0.313 \\ \frac{RD}{RT} &= \frac{1,900}{800} = 2.38 \\ \frac{d}{CD90} &= 8.3 \text{ (from area target graph)} \\ d_{max} &= \frac{d}{CD90} \times CD90 = 8.3 \times 250 = 2,080 \end{aligned}$$

$$\begin{aligned} & \text{Target B} \\ \frac{CD90}{RT} &= \frac{250}{600} = 0.417 \\ \frac{RD}{RT} &= \frac{1,800}{600} = 3.0 \\ \frac{d}{CD90} &= 7.8 \text{ (from area target graph)} \\ d_{max} &= \frac{d}{CD90} \times CD90 = 7.8 \times 250 = 1,950 \end{aligned}$$

- (b) *Step 2.* Determine the area-of-coverage overlap.

$$\begin{array}{r} 2,080 \text{ } d_{max} \text{ tgt A} \\ + 1,950 \text{ } d_{max} \text{ tgt B} \\ \hline 4,030 \text{ total } d_{max} \end{array}$$

$$\begin{array}{r} 4,030 \text{ total } d_{max} \\ - 2,200 \text{ } d \text{ between tgt A and tgt B} \\ \hline 1,830 \end{array}$$

- (c) *Step 3.* Compute the actual distance (d).

$$\frac{1,830}{2} = 915$$

$$\begin{array}{r} \text{Target A} \qquad \qquad \text{Target B} \\ 2,080 \qquad \qquad 1,950 \\ - 915 \qquad \qquad - 915 \\ \hline 1,165 = d \text{ (actual)} \qquad 1,035 = d \text{ (actual)} \end{array}$$

- (d) *Step 4.* Compute the final coverage, using either the numerical or the visual method of damage estimation.
- (e) *Consideration of more than two targets.* When more than two targets are being analyzed, the procedure is identical to that used in the multiple limiting requirements graphical method ((2), above). In this case, the overlap area used in selecting the DGZ is

that which is overlapped by the d_{max} of all targets under consideration. A graphical example is shown in figure B-IV-3.

- (4) *Attack of multiple targets with a single weapon (one point target and one area target).*

- (a) *Step 1.* Compute the d_{max} for the point target only.

- (b) *Step 2.* From the point target, plot the DGZ along a line connecting the point target center and the area target center at a distance equal to the d_{max} (fig. B-IV-4).

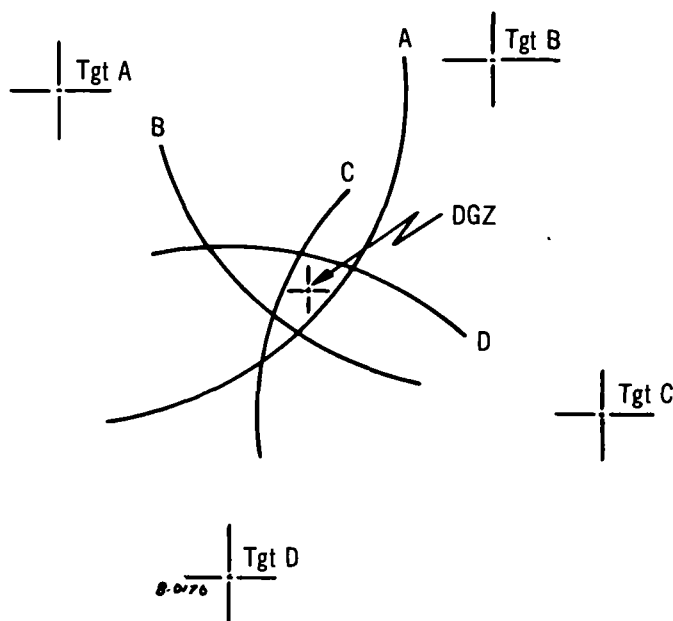
- (c) *Step 3.* Measure the distance (d) from the area target center to the DGZ and compute the final coverage for the area target only.

- (d) *Remark.* In the event the required coverage cannot be obtained with a single weapon attack, the d_{max} should be computed for the target of highest priority. The displacement distance (d) is then measured from the other target, and the final coverage is computed.

- (5) *Combination of reasons for the selection of the desired ground zero.*

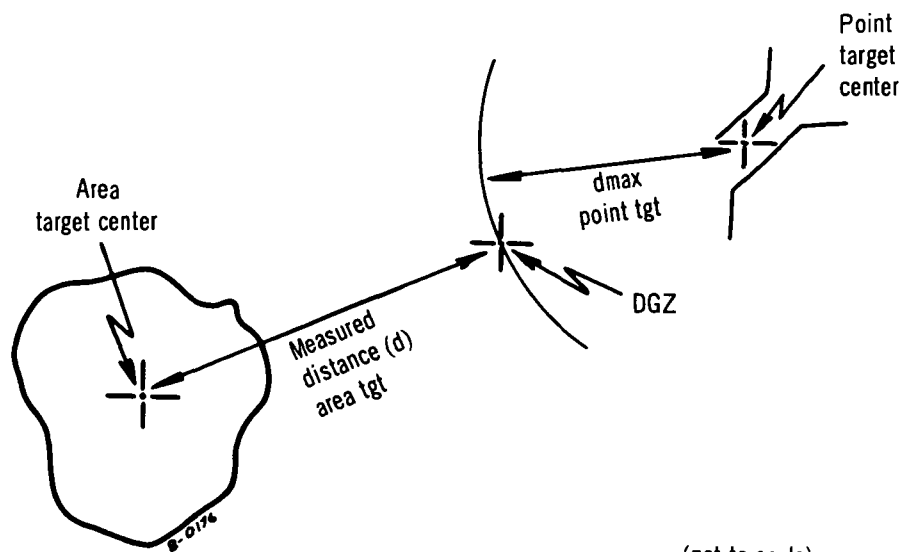
- (a) When a DGZ is selected because of a combination of reasons (multiple targets and/or limiting requirements), the techniques used in each step are the same as those discussed in (1) through (4), above.

1. In step 1, compute the distance and the direction the DGZ is to be displaced. (Safety-preclusion distances are taken directly from the safety distance tables in FM 101-31-3, and the d_{max} is computed.)
2. In step 2, determine the area-of-coverage overlap for multiple targets. However, a limiting requirement may restrict where the DGZ can be located. Although this may not be the location for maximum coverage, it will have to be accepted because of the limiting requirements. An example is shown



(not to scale)

Figure B-IV-3. Graphical solution of the desired ground zero selection (multiple targets).



(not to scale)

Figure B-IV-4. Graphical solution of the desired ground zero selection (multiple target attack with one weapon) (mixed targets).

in figure B-IV-5. In the event a limiting requirement forces the DGZ outside the area-of-coverage overlap, a command decision will be required on which requirement

- and/or restriction will be changed.
3. In step 3, measure the distance (d) to the DGZ from each target center and compute the final coverage, using either the numerical

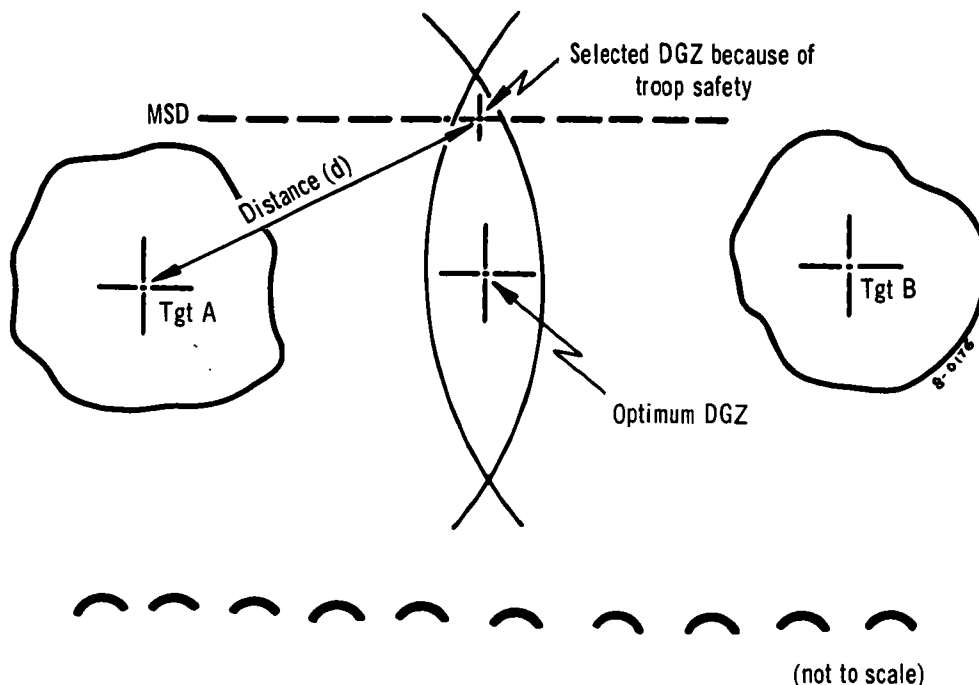


Figure B-IV-5. Graphical solution of the desired ground zero selection (combination of reasons).

or the visual method of damage estimation.

- (b) If it is determined from the procedure in (a) above, that no area-of-coverage overlap exists, or that the fraction of damage to the various targets is not high enough, one or more of the following alternatives can be selected:

1. Use a larger weapon.
2. Accept less, or no, damage to one

or more of the targets by selecting a new DGZ.

3. Use a delivery system with a smaller delivery error.
4. Change the limiting requirements.
5. Use more than one weapon.
6. Move an available delivery system closer to the target to reduce the CD90.
7. Request a different, more effective weapon from the next higher headquarters.

ANNEX B-V

SPECIAL CONSIDERATIONS

B-V-1. General

a. The information presented in the weapon selection tables included in FM 101-31-2 and FM 101-31-3 has been computed using the best available accuracy data. Subsequent test firings, changes in firing technique, or experience in the field may indicate that the accuracy data are not correct. Further research or experience in the field may also indicate that it would be desirable to change a preset height of burst (*HOB*) to maximize weapon effects.

b. A change in the height of burst or the height-of-burst probable error (*PEh*) may cause significant changes to the probable minimum radii of damage and to the coverage indexes.

c. A change in horizontal delivery errors may cause a significant change in the circular distribution 90 (*CD90*), the coverage index, and the minimum safe distance.

d. Until new information concerning delivery accuracy and heights of burst can be distributed to the field, the following procedures may be used by nuclear weapon employment officers in target analysis. The procedures may also be used when, for some special reason, a height of burst other than that shown in the weapon selection tables is required.

B-V-2. Height of Burst

a. The preset heights of burst for some radar-fuzed weapons can be changed by ordnance personnel in the field. Nuclear weapon employment officers and delivery units will be notified of any new height of burst and height-of-burst probable error. The heights of burst for time-fuzed weapons can be varied by the nuclear weapon employment officer through actions at the delivery unit to vary the damage to a particular target element; a new timer height of burst is computed using the procedure outlined in *b* and *c* below. When these new required heights of burst have been determined, the nuclear weapon employment officer follows the procedures outlined in this annex.

★*b.* A height of burst to preclude fallout is determined by the equation

$$HOB = HOB(fs) + db.$$

(1) *HOB(fs)* is the fallout-safe height of burst and is shown in the effects tables in FM 101-31-2 and FM 101-31-3.

(2) *db* is the buffer distance. The size of the buffer distance is dependent on the probability required for fallout preclusion.

(3) Table B-I-1 in annex B-I shows the various probabilities of an event occurring within various multiples of probable error (*PE*). By entering this table with the probability of interest, the buffer distance can be determined as shown below.

c. The target analyst generally is concerned with using one of the burst options provided in the weapon selection tables.

(1) *Low airburst.* This height of burst generally provides the greatest coverage of enemy targets and precludes fallout.

(*a*) This height of burst is computed by adding $3.5 PEh$ to the fallout-safe height of burst. This provides a very high assurance (99 percent) of no significant fallout. ($HOB(99) = HOB(fs) + 3.5 PEh$.)

(*b*) Because of the good "across-the-board" effects obtained at $HOB = 53(W)^{1/4}$ meters (where *W* is the weapon yield in kilotons), this height of burst is used as the lower limit of the low airburst option. This height of burst is shown as *HOB_{opt}* at the bottom of the effects tables.

(*c*) The *higher* of the two heights of burst determined in (*a*) and (*b*) above, is used as the desired height of burst.

(2) *High airburst.* This height of burst may be used in special cases for maximum coverage for damage to "soft" ground targets such as exposed personnel, most buildings (particularly frame) and forests. This height of burst is computed using the equations below. The *higher* of the two *HOBs* is used.

$$HOB = 120 (W)^{1/4} + 3.5 PEh$$

$$HOB = 105 (W)^{1/4} \text{ meters}$$

(where *W* equal the weapon yield in kilotons)

(3) *Impact burst.* This height-of-burst option is used to cause cratering and fallout. Ob-

viously, the height of burst is 0. Changes in the height-of-burst probable error will not influence the height of burst or the radius of damage.

d. If heights of burst other than those shown in *c* above, are desired, they may be computed as indicated below.

★(1) Figure B-I-3 in annex B-I to this appendix indicates that 48 percent of the rounds fired will burst within 3 *PEh* below the desired height of burst. Fifty percent will detonate above the desired height of burst. Therefore, if a buffer distance of 3 *PEh* is added to the fallout-safe height of burst, there will be a 98-percent (50 percent + 48 percent) probability of no significant fallout. ($HOB(98) = HOB(fs) + 3\ PEh$.)

(2) A similar calculation using probability data shows that by adding only 1.9 *PEh* to the fallout-safe height of burst, there will be a 90-percent probability of no significant fallout. ($HOB(90) = HOB(fs) + 1.9\ PEh$.)

(3) Lowering the height of burst below that required for a 90-percent probability of no significant fallout does not appreciably increase the radius of damage, and the risk of fallout increases rapidly with a decrease in the height of burst. Under current doctrine, when a weapon is employed at a height of burst that provides less than a 99-percent probability of no significant fallout, a fallout prediction must be made.

B-V-3. Damage Estimation for Nonstandard Conditions

a. General.

(1) With the exception of special cases, data to determine the amount of coverage/damage to a specified target element are located in the coverage tables in FM 101-31-2 and FM 101-31-3. The information in the coverage tables has been computed using the best available data; however, cases will arise when these data cannot be used for one or more of the reasons listed below.

(a) The target elements are not equatable to one of the four major target categories.

(b) The height of burst is changed to improve or to preclude a specific weapon effect.

(c) The delivery errors used in the computation of the coverage tables are found to be in error.

(2) To assist the nuclear weapon employment officer in computing coverage/damage due to these nonstandard conditions, the procedures in *b* through *g* below, may be used.

b. Radius of Damage.

(1) Determine the height of burst (para B-V-2) and enter the appropriate column for the target element of interest in the effects tables. Vertical dispersion may cause the burst to occur at some height other than that desired; it is necessary to consider the effect of this dispersion.

(2) Probability distribution indicates

that 45 percent of the rounds fired will burst within 2.5 PEh above and 45 percent will burst within 2.5 PEh below the aiming point. The smallest radius of damage shown in the tables within 2.5 PEh above or below the selected height of burst is the probable minimum radius of damage. Through the use of the 2.5- PEh factor, the analyst insures that at least 90 percent of the time the probable minimum radius of damage, as just determined, is equaled or exceeded.

- (3) The procedure to be used for determining the minimum radius of damage is as follows:

- (a) Determine the desired height of burst.
- (b) Multiply $2.5 \times PEh$ (at the range of interest).
- (c) Determine the trial heights of burst. (Trial $HOB = \text{desired } HOB \pm 2.5 PEh$.)
- (d) Enter the proper effects table at the trial heights of burst. Search for the *smallest* radius of damage occurring at or between the trial heights of burst. (If trial heights of burst are not listed in the table, enter at the heights of burst nearest to the trial heights of burst.)
- (e) Determine the probable minimum radius of damage for the target element of interest. (The probable minimum radius of damage is the smallest radius of damage listed between the two trial heights of burst.)

c. *Circular Distribution 90.* The procedure used in computing the circular distribution 90 is not appropriate for use in the field. For interim field use, use 3 horizontal PE or 2 CEP for the circular distribution 90.

- (1) *Cannon- and rocket-delivered weapons.*

- (a) To compute the circular distribution 90 for timer-fuzed weapons, se-

lect the larger error—range probable error (PER) or deflection probable error (PEd) (at range of interest)—and multiply it by 3. ($CD90 = 3 PER$, or $CD90 = 3 PEd$, whichever is larger.)

- (b) To compute the circular distribution 90 for impact-fuzed or radar-fuzed weapons, select the larger error—range probable error or deflection probable error—and multiply it by 3. ($CD90 = 3 PER$, or $CD90 = 3 PEd$, whichever is larger.)

- (2) *Aircraft- and guided-missile-delivered weapons (normally range-independent systems).* Compute the circular distribution 90 by multiplying the circular error probable (CEP) by 2. ($CD90 = 2 CEP$.)

d. *Equivalent Circular Distribution 90 for Cannon- and Rocket-Delivered Weapons.* Whenever a numerical analysis is required, it is necessary to convert horizontal delivery error to an equivalent circular distribution 90. The graphs in FM 101-31-2 and chapter 18, FM 101-31-3 should be used to make this conversion.

e. *Damage Estimation Procedures.* The probable minimum radius of damage and the circular distribution 90, determined in b and c above, may be used to estimate damage visually, as discussed in tab B-II-2 to annex B-II; or by the numerical method, as discussed in tab B-II-3 to annex B-II. The index method (tab B-II-1 to annex B-II) is not applicable when delivery errors vary appreciably from the tactical accuracy data shown in the weapon selection tables or when targets cannot be equated to one of the four major target categories.

f. *Determining Coverage of a Nonequatable Target.* An example in determining coverage of a nonequatable target is shown below.

- (1) *Given:* Delivery system—free-flight rocket

Yield = 10 KT

Range = 18,000 meters

HOB—low air

$RT = 1,400$ meters

Target category—prompt casualties to personnel in multistory apartments

Limiting requirement—preclude fall-out.

- (2) *Find*: The probable fractional coverage. (Use FM 101-31-3, the coverage tables and effects tables associated with the data in (1) above, and the steps outlined in (3) below.)
- (3) *Solution*: Entering the equivalent target table (FM 101-31-2; FM 101-31-3; and fig. B-II-2, annex B-II to this app), the analyst finds that personnel in multistory apartments are not equatable to one of the four major target categories. Because he is unable to use the coverage tables in acquiring the necessary data, the analyst reverts to the effects tables.
- (a) *Step 1*. Enter the proper coverage table with the range of 18,000 meters. Moving to the right, under the columns for HOB and PEh , extract an $HOB99$ of 379 meters, a PEh of 90 meters, and $CD90$ of 463 meters.
- (b) *Step 2*. Determine the trial HOB . ($HOB\ 379 \pm 2.5 \times 90$ (PEh).) Thus, the trial HOB are 154 and 604 meters.
- (c) *Step 3*. Enter the effects table at the nearest listed HOB (165 m. and 605 m.) associated with the trial HOB (154 m. and 604 m.); and, in the column for prompt casualties, personnel in multistory apartments, extract the smallest RD (1,070 m.) occurring at or between the trial HOB . The probable minimum RD (1,070 m.) is the smallest RD at or between the two trial HOB .
- (d) *Step 4*. Using the numerical method of damage estimation, enter the area target graph with the ratios
- $$\frac{RD}{RT} = \frac{1,070}{1,400} = 0.76 \text{ and } \frac{CD90}{RT} = \frac{463}{1,400} = 0.33.$$
- At the intersection of the two ratios, read .90 (.52).

g. Determining Target Coverage When a Height of Burst Other Than HOB99 or HOB-opt Is Required. To determine target coverage when a height of other than that listed as $HOB\ 99$ or HOB_{opt} is required, the target analyst uses the following procedure:

- (1) For equatable targets—
- Determine the desired HOB .
 - At the range of interest obtain the multiplying factor associated with the probability of interest from table B-I-1 and multiply ($MF \times PEh$).
 - Determine the trial height of burst (HOB) (Trial $HOB = \text{desired } HOB \pm 2.5 PEh$).
 - Enter the proper effect table at the trial HOB . Search for the smallest RD occurring at or between the upper and lower trial HOB . (If trial HOB are not listed in the table, enter at the nearest listed HOB .)
 - Determine the probable minimum RD for the target category of interest. (The probable minimum RD is the smallest RD listed between the two trial HOB .)
 - Using the $CD90$ associated with the target range and the probable minimum RD , compute the target coverage, using either the visual or numerical method of damage estimation.
- (2) For nonequatable targets—
- Determine the probable minimum radius of damage, using the procedures in *g*(1) above.
 - Using the circular distribution 90 associated with the target range and the probable minimum radius of damage, compute the target coverage, using either the visual or the numerical method of damage estimation.

B-V-4. Preclusion of Damage

a. Annex B-III discusses in detail the methods and techniques used to preclude damage to a specified target element. For preclusion-of-

damage calculations of target elements listed in the effects tables but not listed in the safety distance tables, use the following procedure:

- (1) Determine the desired height of burst.
- (2) Determine the trial heights of burst. (Trial $HOB = \text{desired } HOB \pm 2.5 PEh$.)
- (3) Enter the proper effects table at the trial heights of burst. Search for the *largest* radius of damage occurring at or between the trial heights of burst.
- (4) Determine the probable maximum radius of damage for the target element of interest. (The probable maximum radius of damage is the largest radius of damage listed at or between the two trial heights of burst.)
- (5) Using the numerical method of damage estimation (tab B-II-3 to annex B-II), compute the least separation distance the desired ground zero must be from the target element for a 90-percent assurance of not causing the type of specified damage to the target element.

b. An example is shown below.

- (1) *Given:* Delivery system—free-flight rocket

Yield = 10 KT

Range = 18,000 meters

HOB —low air

Target category—prompt casualties to protected personnel

Limiting requirements—preclude fallout and severe damage to the fixed bridge located 750 meters east of the target center.

- (2) *Find:* The distance the DGZ must be separated from the bridge.

(3) *Solution:* Entering the safety distance table, the analyst finds no data for preclusion of severe damage to a fixed bridge. Because he is unable to use the safety distance table, the analyst reverts to the effects tables to determine the LSD the DGZ must be in relation to the bridge.

(a) *Step 1.* Enter the proper coverage table with the range of 18,000 meters. Moving to the right, under the columns for HOB and PEh , extract an $HOB99$ of 379 meters, a PEh of 90 meters, $CD90$ of 463 meters and CEP of 254 meters.

(b) *Step 2.* Determine trial HOB . ($HOB = 379 \pm 2.5 \times 90$ (PEh).) Thus, the trial HOB are 154 and 604 meters.

(c) *Step 3.* Enter the effects table at the nearest listed HOB (165 m. and 605 m.) associated with the trial HOB (154 m. and 604 m.); and, in the column for severe damage to fixed bridges, extract the largest RD (490 meters) occurring at or between the trial HOB . The probable maximum RD (490 meters) is the largest RD at or between the two trial HOB .

(d) *Step 4.* Using the numerical method of damage estimation, compute the LSD that the DGZ can be in relation to the bridge. Using the ratio $\frac{RD}{CD90} = 1.06$, enter the point target graph. Move horizontally to the 10-percent probability scale and read the vertical $\frac{d}{CD90} = 1.6$. Multiply the ratio value by the $CD90$ to obtain the LSD (740 meters) that the DGZ must be separated from the bridge for a 90-percent assurance of causing no more than severe damage to the bridge. (In this example, a 10-percent probability of causing severe damage is the same as stating that there is a 90-percent assurance of the bridge not receiving this amount of damage.)

★B-V-5. Computation of Minimum Safe Distance (MSD)

a. Annex B-III discusses in detail the methods and techniques used to prevent casualties to friendly troops. FM 101-31-2 and FM 101-31-3 have listed in the safety distance tables, associated with each major target category, precomputed MSD based on standard conditions. In the event the horizontal or vertical errors (PEh , PER , PEd , or CEP) associated with the weapon system are found to be in error, the following procedure will be used to compute the new MSD .

- (1) Determine the desired height of burst.
- (2) Determine the trial heights of burst. (Trial $HOB = \text{desired } HOB \pm 2.5 PEh$.) If a corrected PEh has been received, this PEh will be used to compute trial HOB .
- (3) Enter the proper effects table at the trial heights of burst. In the appropriate Radius of Safety (RS) column extract the *largest* RS occurring at or between the trial height of burst.
- (4) To insure a 99-percent assurance that friendly troops will not be subjected to greater

than the authorized effects, a buffer distance computed by multiplying the corrected *PER* or *PEd* (whichever is the greater) by 3.5, or the corrected *CEP* by 2 is added to the Radius of Safety. The *MSD* equals the Radius of Safety plus the buffer distance.

b. An example is shown below.

- (1) *Given:* Delivery system—free-flight rocket.

Yield = 50 *KT*

Range = 20,000 meters

HOB = low air

Target Category—prompt casualties to protected personnel

Troop Safety—Negligible risk to warned protected personnel

- (2) As a result of modifications performed on the free-flight rocket, the following corrected probable errors have been received.

Range 20,000 meters

PEh = 50

PER = 100

PEd = 140

- (3) Compute the corrected *MSD*.

(4) *Solution:* In view of the recorded changes in the free-flight rockets horizontal and vertical dispersion pattern, the analyst is unable to use the precomputed *MSD* in the Safety Distance Tables and is required to use data in the Effects Tables to compute a corrected *MSD*.

(a) *Step 1.* Determine the desired *HOB*. Compare *HOB₉₉* to *HOB* optimum and select that with the large *HOB*. Enter the Effects Table for

the free-flight rocket, 50 *KT*, and extract the required information from the bottom of the page.

$$HOB_{99} = HOB_{ts} + 3.5 (PEh)$$

$$HOB_{99} = 121 + 3.5(50)$$

$$HOB_{99} = 296 \text{ meters}$$

In that *HOB₉₉* (296 meters) is greater than *HOB_{opt}* (195 meters), the desired *HOB* = 296 meters.

- (b) *Step 2.* Determine the trial *HOB*.

$$(\text{Trial } HOB = \text{desired } HOB \pm 2.5 \text{ } PEh.)$$

$$\text{Trial } HOB = 296 \pm 2.5(50) =$$

		421
	+	
Desired HOB		296
	-	
		171

(c) *Step 3.* Enter the Effects Table for the free-flight rocket, 50 *KT*, at the trial *HOB* (or nearest listed). In the radius of safety column for negligible risk to warned protected personnel, search for, and extract the *largest* radius of safety (3090 meters) occurring at or between the trial *HOB*.

(d) *Step 4.* To insure a 99-percent assurance that friendly troops will not be subjected to greater than the authorized effect level, a buffer distance is computed multiplying the

corrected $PER(100)$ or $PEd(140)$ whichever is greater by 3.5.

$$140 \times 3.5 = 490 \text{ meters}$$

- (e) *Step 5.* The MSD equals the Radius of Safety plus the horizontal buffer distance.

$$MSD = 3090 + 490 = 3580 \text{ meters}$$

c. Computation of MSD due to changing desired HOB .

- (1) *Given:* Delivery system—free-flight rocket.

$$\text{Yield} = 50 \text{ KT}$$

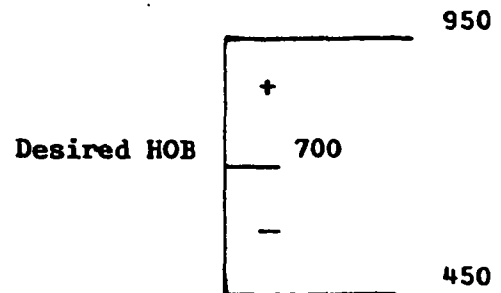
$$\text{Range} = 20,000 \text{ meters}$$

Troop Safety—Negligible risk to warned protected personnel

- (2) To maximize weapon effects against a target of interest it has been determined that the desired HOB for this target should be changed to 700 meters.
- (3) Compute the corrected MSD .
- (4) *Solution:* Because the radius of safety changes with changes in HOB , the precomputed data listed in the safety distance tables for 20,000 meters in this example is incorrect, and a corrected MSD should be computed.
- (a) *Step 1.* Determine the desired HOB .
In this example, it has been predetermined that the desired HOB should be 700 meters.
- (b) *Step 2.* Determine the trial HOB .
(Trial $HOB = \text{desired } HOB \pm 2.5$

PEh .) PEh corresponding with range of 20,000 meters.

$$\text{Trial } HOB = 700 \pm 2.5 (100) =$$



- (c) *Step 3.* Enter the Effects Table for the free-flight rocket, 50KT, at the trial HOB (or nearest listed). In the radius of safety column for negligible risk to warned protected personnel, search for, and extract the *largest* Radius of Safety (3080 meters) occurring at or between the trial HOB .
- (d) *Step 4.* To insure a 99-percent assurance, a buffer distance is computed by multiplying the CEP (corresponding with a range of 20,000 meters) by 2.
$$CEP = 282 \times 2 = 564 \text{ meters}$$
- (e) *Step 5.* The MSD equals the Radius of Safety (3080) plus the horizontal buffer distance (564).
$$MSD = 3080 + 564 = 3644 \text{ meters.}$$

ANNEX B-VI

POSTSTRIKE DAMAGE PREDICTION

B-VI-1. General

a. When nuclear weapons are used to attack targets, poststrike surveillance is accomplished to ascertain degrees of success. Before this surveillance can be completed, the nuclear weapon employment officer refines his prediction of damage by means of a poststrike analysis, based on receipt of the following information:

- (1) The actual location of the ground zero.
- (2) Estimation of the yield.
- (3) The actual height of burst.

b. In many cases, information required to perform a poststrike analysis will be difficult to obtain. However, to insure receipt of this information, coordination should always be made with units in position to observe the nuclear strike, or with units specially equipped and trained (i.e., target acquisition battalions) to perform this type of observation. FM 3-12 provides information concerning nuclear burst surveillance, data collection, and reporting techniques.

c. Two methods are used to estimate poststrike damage, based on the size and the shape of the target. These methods are—

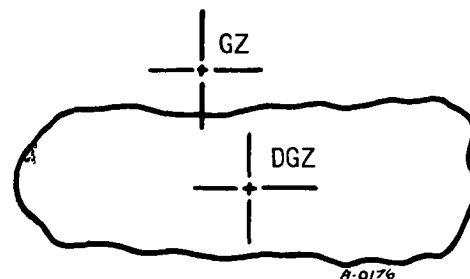
- (1) The visual method.
- (2) The numerical method.
 - (a) Area targets (when circular).
 - (b) Point targets.

d. Each method requires knowledge of the actual location of the ground zero, the realized yield, and the actual height of burst. (Yield and height of burst are used only to establish whether the weapon detonated normally.) Yield is considered normal if it is within ± 10 percent of the designed yield, while the height of burst is considered normal if the detonation occurred with $\pm 2.5 PEh$ of the predicted burst point. If the height of burst occurs beyond $\pm 2.5 PEh$, the procedure found in annex B-V is used. If the yield variation is more than ± 10 percent of the expected yield, no reliable poststrike analysis can be completed.

B-VI-2. Procedures Used in Poststrike Damage Estimation

a. Visual Method.

- (1) The visual method of poststrike damage estimation is used to refine damage predicted against irregularly shaped targets. To use this method, the analyst plots the actual location of the ground zero in relation to the target. Once the ground zero has been plotted, the analyst extracts the probable minimum radius of damage from the accuracy data columns in the coverage tables. Using this radius of damage on the appropriate circular map scale, the analyst places the center of the map scale over the ground zero and visually estimates the fractional coverage of damage.
- (2) An example of the visual method of poststrike prediction is shown below.
 - (a) *Given:* Delivery system—light guided missile
 Yield = 10 KT
 Range = 50,000 meters
 HOB—low air
 Target category—wheeled vehicles.
 - (b) *Poststrike data:* Target—figure B-VI-1
 GZ—figure B-VI-1
 HOB—normal
 Yield—normal.
 - (c) *Find:* The poststrike estimation.



(scale 1:50,000)

Figure B-VI-1. Example of poststrike analysis.

(d) *Solution:*

1. *Step 1.* Enter the proper coverage table with a yield of 10 KT. Moving to the right, under the column for the probable minimum *RD*, extract a probable minimum *RD* of 780 meters.
2. *Step 2.* Draw the *RD* on the circular map scale, place the center of the map scale over the ground zero, and visually estimate a fractional coverage of 20 percent (fig. B-VI-2). Because the weapon has already detonated, no consideration need be given to the probable errors inherent in the delivery system.

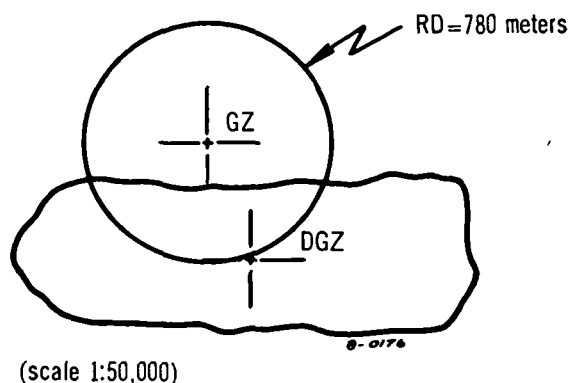


Figure B-VI-2. Visual poststrike damage estimation.

b. Numerical Method. The numerical method of poststrike damage estimation is used against circular area- and point-type targets.

- (1) When this method is used on circular area targets, the analyst must know the actual location of the ground zero (distance) in relation to the target center, the radius of target, and the expected radius of damage. Using the procedures discussed in tab B-II-3 to annex B-II, the analyst enters the area target graph with the ratios $\frac{RD}{RT}$ and $\frac{d}{RT}$ (note that the ratio $\frac{d}{RT}$ has been substituted for the ratio $\frac{CD90}{RT}$); and, at the intersection of the

two ratios, he reads the fractional coverage of damage.

- (2) An example of the numerical method of poststrike prediction against a circular area target is shown below.

(a) *Given:* Delivery system—free-flight rocket.

Yield = 10 KT

Range = 20,000 meters

HOB—low air

RT = 1,000 meters

Target category—prompt casualties to protected personnel.

(b) *Poststrike data:*

GZ = 200 meters north of the target center

HOB—normal

Yield—normal.

(c) *Find:* The poststrike estimation.

(d) *Solution:*

1. *Step 1.* Enter the proper coverage table with the range of 20,000 meters. Moving to the right, under the column for probable minimum *RD*, extract a probable minimum *RD* of 501 meters.

2. *Step 2.* Using the numerical method, enter the area target graph

with the ratios $\frac{RD}{RT} = \frac{501}{1,000} = 0.5$

and $\frac{d}{RT} = \frac{200}{1,000} = 0.2$. At the

intersection of the two ratios, read the fractional coverage of damage ($f = 25$ percent). The probable errors inherent in the delivery system are not considered in poststrike analysis.

- (3) The numerical method of poststrike damage estimation is used for point targets (bridges, missile launchers, and other similar single-element targets). Because no delivery error is associated with the prediction, the analyst enters the *point target graph extension* at the left with the proper

ratio value for $\frac{d}{RD}$. He moves hori-

zontally across the graph until he intersects the diagonal line. Moving vertically to the bottom of the graph, the analyst reads the probability of the target being destroyed.

- (4) An example of the numerical method of poststrike prediction against a point target is shown below.

- (a) *Given:* Delivery system—free-flight rocket

Yield = 10 KT

Range = 15,000 meters

HOB—low air

Target category—missile launcher.

- (b) *Poststrike data:*

GZ=250 meters north of the target center

HOB—normal

Yield—normal.

- (c) *Find:* The poststrike estimation.

- (d) *Solution:*

1. *Step 1.* In the equivalent target table (fig. B-II-2, annex B-II), equate missile launchers to wheeled vehicles. Then, enter the proper coverage table with the range of 15,000 meters. Moving to the right, under the column for probable minimum *RD*, extract a minimum *RD* of 549 meters.

2. *Step 2.* Using the point target graph extension, enter at the left

with the ratio $\frac{d}{RD} = \frac{250}{549} = 0.45$.

Move horizontally across the graph until this line intersects with the diagonal line. Moving vertically to the bottom of the graph, read the probability of destroying the point target as 99 percent.

ANNEX B-VII

FRIENDLY VULNERABILITY

(This annex is based on SOLOG No. 89.)

B-VII-1. General

a. Target analysis procedures are used to estimate the possible results of an enemy nuclear attack on friendly dispositions or installations. Based on current intelligence, or the enemy's past use of nuclear weapons, the weapon yield most likely to be employed against friendly elements is estimated.

b. The radius of vulnerability (R_v) is the radius of a circle within which friendly troops will be exposed to equal to or greater than emergency risk criteria and may become casualties. A vulnerability radii (R_v) table is included in FM 101-31-2 and FM 101-31-3 that gives the radii to be used in analyzing the vulnerability of friendly dispositions. (This table is reproduced in figure B-VII-1.) For friendly target analysis, an assumption is made that the enemy can deliver a weapon at the point where it will do the greatest damage to a friendly installation, *disregarding* the effect of delivery errors. Then, the analyst estimates what fraction of friendly dispositions would be destroyed by such an attack.

c. The analysis of present and planned friendly dispositions is a continuing process. The commander must be kept informed of vulnerability conditions so that he can make decisions concerning changes in existing or planned dispositions. While dispersion decreases the risk of destruction from nuclear attack, it greatly increases the possibility of defeat in detail and complicates the problem of control. The degree to which units can be dispersed in any situation will depend on the mission of the command and on the risk the commander is willing to accept. Accomplishment of the mission and avoidance of formations that present profitable targets to the enemy are frequently conflicting requirements. The commander should take full advantage of all characteristics of the battle area that contribute to the fulfillment of both requirements.

d. Vulnerability may be reduced through one or more of the following means:

- (1) Dispersion.
- (2) Depopulated-center disposition.
- (3) Linear configuration.
- (4) Increased protection.

B-VII-2. Analysis of Friendly Disposition and Installation Vulnerability

The analysis of the vulnerability of friendly dispositions and installations to attack by an enemy-delivered nuclear weapon is performed in the following four steps:

a. *Step 1.* Determine the appropriate yield. Based on current intelligence, or the enemy's past use of nuclear weapons, the intelligence officer assumes a weapon yield that the enemy is likely to use against friendly dispositions or installations.

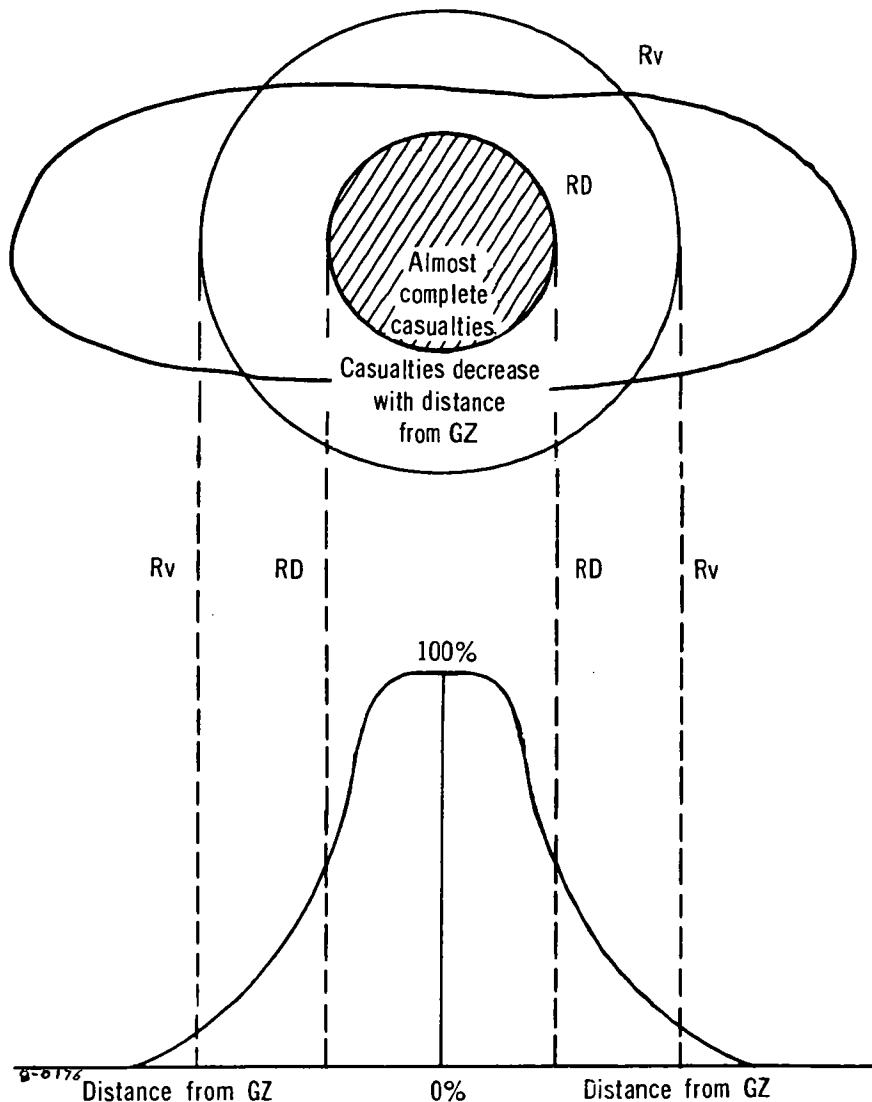
b. *Step 2.* Determine the degree of exposure of friendly units. The assumed conditions of exposure of friendly troops are provided by the G3 (G4 for logistical installations).

RADIi OF VULNERABILITY (meters)

Yield	Exposed personnel	Protected personnel	Tanks, APC	Wheeled vehicles	Supply depots
1 KT	1,400	1,100	300	400	200
2 KT	1,500	1,300	300	500	300
5 KT	2,300	1,400	500	800	400
10 KT	3,500	1,600	600	1,100	500
20 KT	5,200	1,800	900	1,500	700
50 KT	7,800	2,600	1,300	2,200	1,000
100 KT	10,500	3,500	1,700	2,900	1,300
200 KT	14,100	4,700	2,200	3,800	1,700
500 KT	20,800	6,900	3,100	5,400	2,400
1 MT	28,100	9,300	4,100	7,200	3,200
2 MT	30,800	10,300	4,500	7,800	3,500
5 MT	41,200	14,000	5,900	10,300	4,400

NOTE: To obtain a radius of vulnerability, enter the yield column at the nearest listed yield.

★Figure B-VII-1. Vulnerability radii table.



NOTE 1. Not to scale.

2. Vertical axis represents probability of individual becoming a casualty.

Figure B-VII-2. Relationship of percentage of casualties to the distance from the ground zero.

c. *Step 3.* Determine the vulnerability radii. Appropriate radii from the vulnerability radii table are obtained and are marked on the appropriate circular map scale.

d. *Step 4.* Estimate the results of the enemy nuclear attack. The circular map scale is superimposed on a map representation of the disposition or installation to be analyzed. The center of the circular map scale is placed over the

center of the greatest concentration. With the aid of the labeled circles, the area is estimated within which casualties may occur, or within which materiel damage will probably occur, if the ground zero were at this location. The ground zero for this type of analysis is selected, on a worst-case basis, as the point that would result in the *greatest* loss to friendly forces. This is the same procedure that is used in the

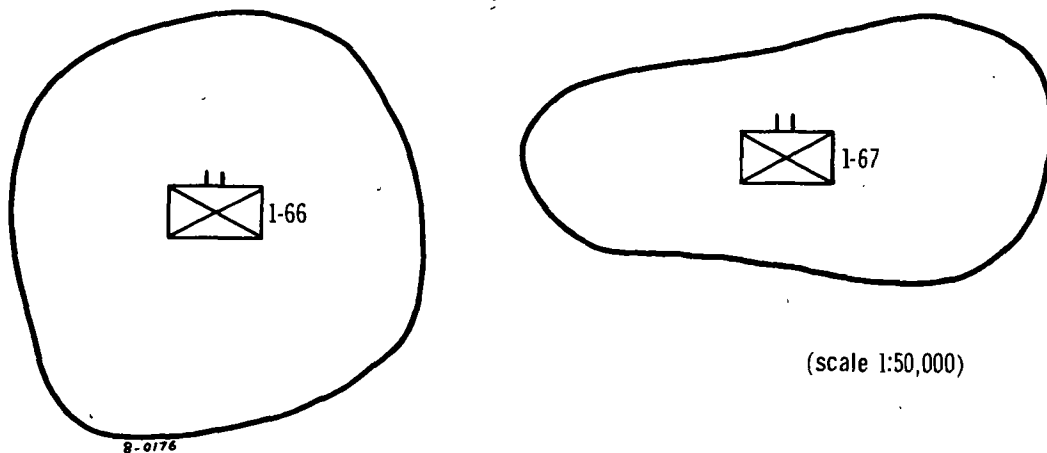


Figure B-VII-3. Vulnerability analysis.

visual method for estimating damage to targets, with the exception that delivery errors are neglected.

B-VII-3. Vulnerability Radii

a. The personnel radii in the vulnerability radii table represent the distances *at which extremely limited* effects extend and at which a few casualties may be expected. *Inside* these radii, casualty percentages increase rapidly as the distance to the ground zero decreases. The criteria for the personnel radii in the vulnerability radii table are the same as those for the emergency risk radii of safety for various vulnerability conditions. From the foregoing discussion, it can be understood that radius of vulnerability for personnel does not have the same meaning as radius of damage. The assumption is made that essentially the equivalent of all personnel within a radius of damage will become casualties. As indicated above, personnel within a radius of vulnerability *may* become casualties; however, not many personnel *will* become casualties (fig. B-VII-2). An example of this difference is illustrated when nuclear radiation criteria are considered. Radii of damage are based on doses of 3,000 and 650 rad or translational effects, while vulnerability radii are based on 50-rad doses.

b. Radii for damage to materiel included in the vulnerability radii table were obtained from the effects tables. The maximum radius

of damage in the column of interest is used as the radius of vulnerability.

c. As shown in figure B-VII-2, a radius of damage can be used with the radius of vulnerability to present a more exact portrayal of vulnerability. The largest radius of damage in the effects table is used for the target element under consideration.

B-VII-4. Example

a. The 1st Bn, 66th Inf, and the 1st Bn, 67th Inf, part of the 1st Bde, occupy reserve areas as shown in figure B-VII-3. The SOP requires that analysis be made of these positions to determine their vulnerability to nuclear attack.

- (1) *Step 1.* Determine the appropriate yield. Based on the current intelligence available, and an analysis of the proximity of enemy forward elements, the G2 estimates that a 10-kiloton weapon is the largest weapon that the enemy is likely to use against these units.
- (2) *Step 2.* Determine the degree of exposure of friendly units. All personnel of both units have foxhole protection. The G3 estimates that many personnel will be in the open at any given time. An assumption is made that those friendly troops in the open will have some bare skin exposed.

- (3) *Step 3.* Determine the appropriate vulnerability radii. Refer to the vulnerability radii table (fig. B-VII-1). On the 10-kiloton line, the *Rv* for troops in the open, no thermal protection, is 3,480 meters. For troops in foxholes, the *Rv* is 1,650 meters. Mark and label these radii on the 1:50,000-scale circular map scale.
- (4) *Step 4.* Estimate the results of the enemy nuclear attack. With the center of the circular map scale placed over the center of 1st Bn, 66th Inf position, it can be seen that the radius of vulnerability for troops in the open without thermal protection extends well beyond the limits of the position (in fact, well into the area of the 1st Bn, 67th Inf). All of the exposed personnel *may* become casualties. The radius of vulnerability circle for troops in foxholes covers nearly all of the area; therefore, it is estimated that nearly all of the protected personnel *may* become casualties. The final estimate concludes that practically all of the personnel of the 1st Bn, 66th Inf, and about one-third of the exposed (without thermal protection) personnel in the 1st Bn, 67th Inf, *may* become casualties if a 10-kiloton weapon is burst over the center of the 1st Bn, 66th Inf. The analysis of the 1st Bn, 67th Inf, is made in the same manner.

b. In analyzing the two units shown in figure B-VII-3, a ground zero between the two units is also assumed. Placing the circular map scale between the two units indicates that essentially all of the exposed personnel in both units *may* become casualties. About one-fourth of the protected personnel in each unit *may* become casualties. A ground zero between these two units, then, is the worst-case ground zero.

B-VII-5. Detailed Analysis of a Friendly Disposition

A detailed analysis of a friendly disposition is shown in the following example:

a. Given:

- (1) G2 advises that the enemy can employ up to a 10-kiloton weapon against friendly positions in a single weapon attack.
- (2) G3 states that, although all personnel have foxhole protection, it is to be assumed that the personnel are exposed and without thermal shielding.
- (3) The commander desires that no battalion receives more than an emergency risk to 50-percent of its personnel or 40-percent loss of wheeled vehicles.
- (4) Friendly troop dispositions are as shown in figure B-VII-4.

b. *Find:* The vulnerability of personnel and wheeled vehicles in these positions.

c. Solution:

- (1) Extract the pertinent *Rv* from the vulnerability radii table. Vulnerability radii for the 10-kiloton weapon are as follows:

Exposed personnel, no thermal shielding	Protected personnel, tanks or foxholes	Wheeled vehicles
3,480 meters	1,650 meters	1,060 meters

- (2) Place these radii on the 1:50,000 circular map scale, labeling each for clarity. Superimpose the circular map scale over the center of mass of each area and estimate the casualties and damage that may result.
- (3) Coverages for a hit in the center of *any* unit are as follows:

	Exposed personnel (percentage)	Protected personnel (percentage)	Wheeled vehicles (percentage)
1st Bn, 93d Inf	100	70	20
1st Bn, 66th Inf	100	90	30
4th Bn, 70th Arty	90	50	20

- (4) It is apparent that a one-weapon attack against any one of the units in (3) above, could expose a large percentage of the unit to emergency risk or higher and may destroy the unit as an effective fighting force. To reduce the vulnerability, *each* unit must enlarge its area of occupation, either by expanding the area or by lengthening the area, as indicated in (a) through (c) below.

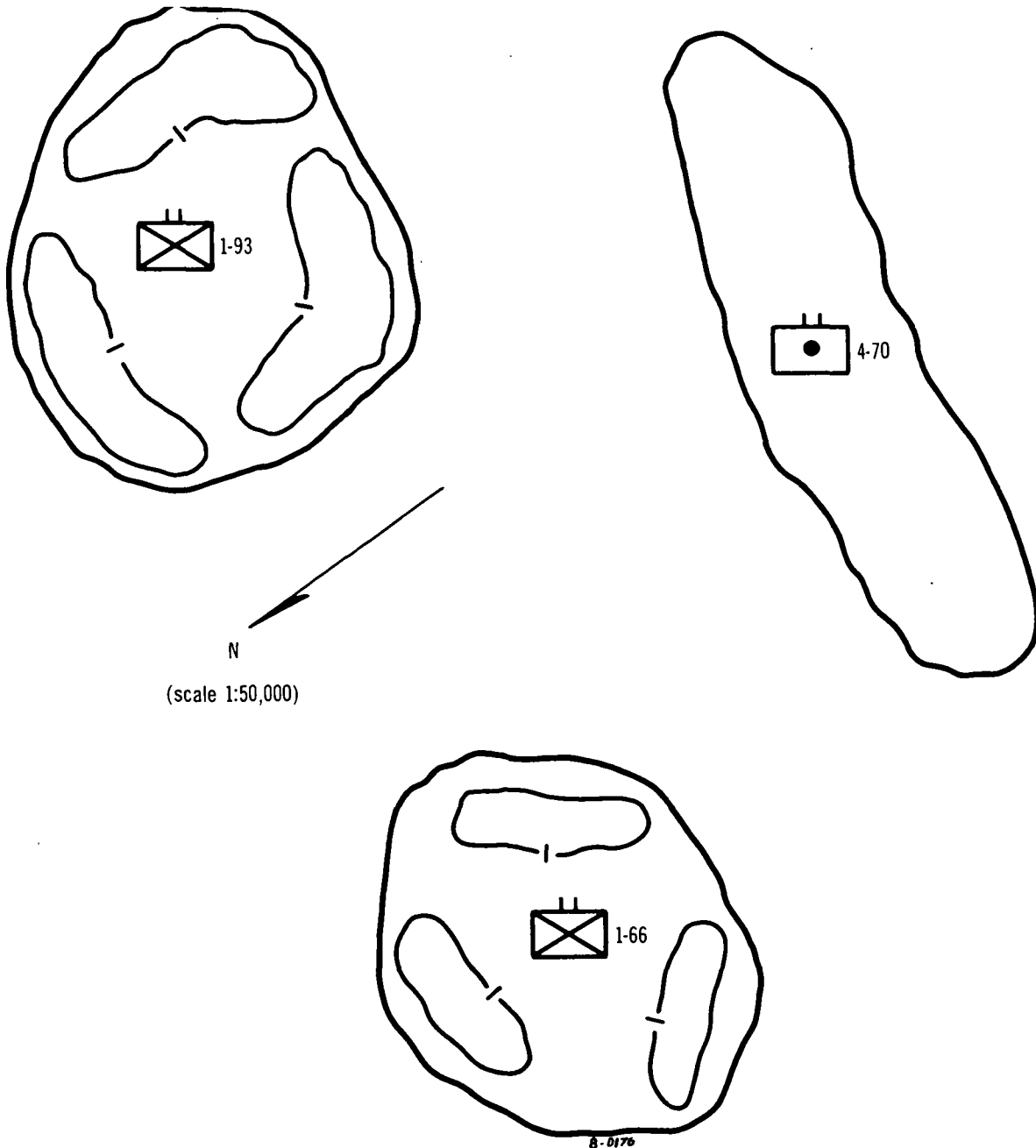


Figure B-VII-4. Friendly troop dispositions.

(a) 1st Bn, 93d Inf. Expand the area occupied outward in a circular formation so that *no personnel* are closer than 1,650 meters from the center of the area. Require that all personnel who have no need to be

exposed be either in foxholes or in armored vehicles. The occupied area will then have a depopulated-center disposition, as shown in figure B-VII-5, and vulnerability will be reduced to an acceptable amount.

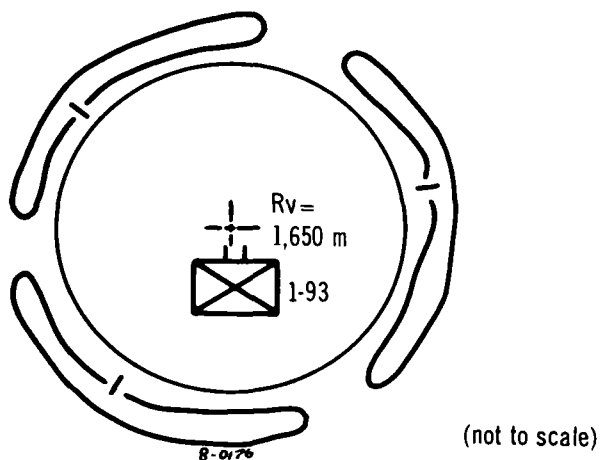


Figure B-VII-5. Typical depopulated-center troop disposition.

- (b) 1st Bn, 66th Inf. Adopt the same action as that recommended for the 1st Bn, 93d Inf.
- (c) 4th Bn, 70th Arty. The artillery crews *must be exposed* to serve their weapons. Notice that the area now occupied is elongated, almost linear. The vulnerability of this unit could be reduced by lengthening the area of occupation to at least 13,920 meters. If this were done, the vulnerability of exposed personnel to emergency risk criteria would be no more than 50 percent, regardless of *where* a 10-kiloton round landed in this area (fig. B-VII-6).

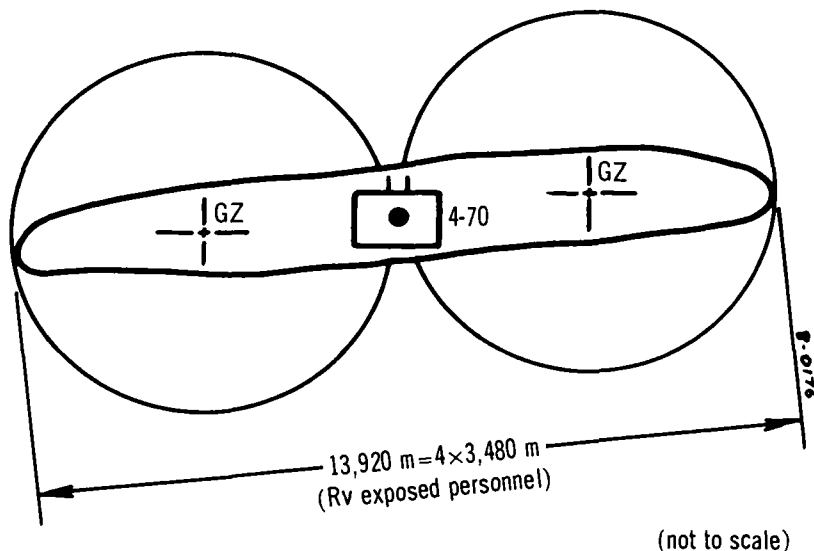


Figure B-VII-6. Elongated troop disposition.

- (5) In addition to the suggested changes in (4) above, it must also be insured that a 10-kiloton weapon, impacting between adjacent units, does not cause excessive loss (fig. B-VII-7).
- (a) Insure that the perimeter of one infantry position is no closer than 3,300 meters ($2 \times 1,650$) to the perimeter of the other infantry position. (1,650 is the radius of vulnerability for protected personnel.)
- (b) Insure that the artillery perimeter is no closer than 6,960 meters ($2 \times 3,480$) to either infantry perimeter. (3,480 is the radius of vulnerability for exposed personnel.)
- (6) The above courses of action would adequately meet command guidance. The commander may *not* be able to accept the recommendations, but he is aware of the *restrictions that his guidance imposed*. There may be *many* reasons why these recommen-

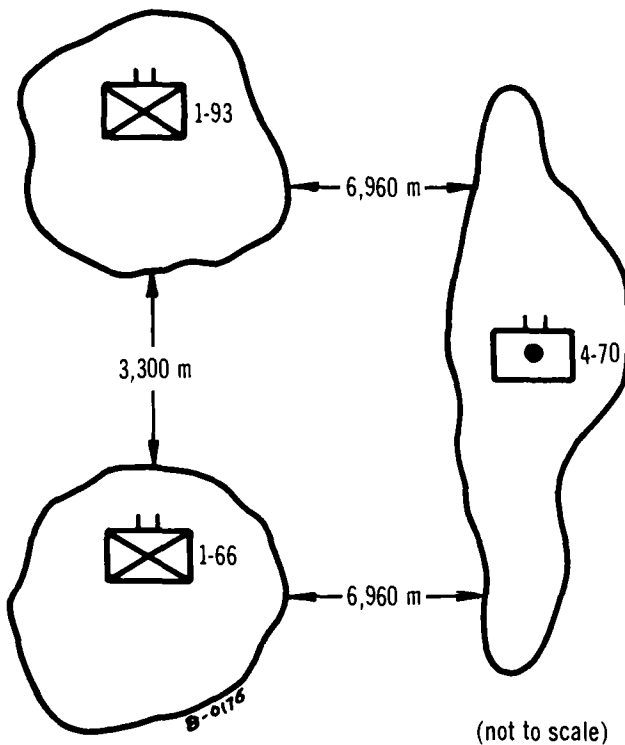


Figure B-VII-7. Separated troop disposition areas.

dations cannot be followed. The recommendations require that *each* infantry unit occupy an area *four times* as large as its original area, causing a large *displacement* of units that may drastically affect unit mission accomplishment. However, the separation distances shown above are the *minimum* required to prevent *one* weapon from affecting more than one unit.

(7) This requirement demonstrates the following two methods of reducing vulnerability:

- (a) For a circular area, *expansion* of the area and *depopulation* of the center.
- (b) For a linear area, *lengthening* of the area.



GLOSSARY

This glossary is provided to enable the user to have readily available terms peculiar to nuclear weapon employment, as used in this manual. Terms that appear in JCS PUB 1 and AR 310-25 are not reproduced herein.

Across the board—Used in connection with weapon effects curves. It indicates that consideration is given to all the effects curves that describe radiation doses, blast effects on various drag-type targets, thermal effects and overpressures.

Alpha Particle—A particle ejected spontaneously from the nuclei of some radioactive elements. It is identified with the helium nucleus, which has an atomic weight of four and an electric charge of plus two.

Atmospheres—A measure of normal atmospheric pressure (e.g., 2 atmospheres indicate two times the normal atmospheric pressure).

Average coverage (f)—The coverage one could expect if a large number of weapons were fired under the same conditions.

Beta Particle—A small particle ejected spontaneously from a nucleus of either natural or artificially radioactive elements. It carries a negative charge of one electronic unit and has an atomic weight of 1/1840.

Circular distribution 90. (CD90)—The radius of a circle around the desired ground zero within which one weapon has a 90-percent probability of arriving.

Fractional coverage (f)—The coverage one could expect if a weapon was fired at a small area target.

Gamma Rays—Electromagnetic radiations, similar to X-rays, but of much higher energy, originating from the atomic nucleus.

Graphical portrayal—A two-dimensional representation (generally to scale) of the distance that the specified effects extend. It is also a visual representation of the results of an analysis.

Least separation distance (LSD)—A distance between Desired Ground Zero (DGZ) and a point of interest at or beyond which there exists at least a 90-percent assurance of preclusion of

obstacles and/or damage. The LSD is the sum of the radius of effects and weapon delivery errors.

Militarily significant weapon effects—Those effects that will have a definite influence on the military capabilities or the degree of risk. See also *Tactically significant weapon effects*.

Minimum-dose exist route—The route of egress from a radioactive-contaminated area that presents the smallest amount of radiation to the existing party or parties.

Neutron—An atomic particle. Neutrons are produced in large numbers in the fission and fusion reactions. Neutrons and gamma radiation constitute the military significant nuclear radiation.

Nonsymptomatic dose—A dose of radiation that may not be detected because the recipient does not display the behavior or physical characteristics that would normally accompany such a dose.

Preinitiation—The premature commencement of fissioning in the active material of a nuclear weapon before the degree of design super-criticality is achieved, resulting in a reduced yield.

QSTAG—Effective 20 September 1967, ABCA Army materiel and non-materiel agreements have been designated Quadripartite Standardization Agreements (QSTAGs). The terms "SOLOG" and "ABCA Army Standard" apply only to agreements promulgated before that date.

Readiness status—Indicate the degree of preparation of both the weapon and the delivery unit for delivery of nuclear fires (to include air-delivered weapons).

Rem (roentgen equivalent, mammal)—Unit of absorbed dose used to express biological damage resulting from different types of radiation.

Rep (roentgen equivalent, physical)—Unit of absorbed dose from any type of radiation, with a magnitude of about 97 ergs per gram of soft tissue (muscle).

SOLOG—(Standardization of Operations and Logistics): A non-materiel agreement among the Armies of the United States, the United Kingdom, Canada and Australia, the "ABCA" nations.

Soft targets—Those targets that are easily damaged by low-magnitude nuclear weapon effects (e.g., exposed personnel, most buildings (particularly frame), forest, and crops).

Surveying (Radiological)—The directed effort to determine the extent and dose rates of radiation in an area.

Tactically significant weapon effects—Those effects that will have a definite influence on the military action currently underway. See also *Weapon system*.

Weapon—An assembled and ready-for-delivery nuclear device in the military configuration. For artillery, a weapon is a complete round; for a rocket, the motor plus the warhead; for a missile,

the complete missile, to include the warhead; for an air-delivered weapon, the warhead in the bomb; and for an atomic demolition munition, the complete munition. See also *Weapon system*.

Weapon system—The complete weapon plus the associated delivery means. See also *Weapon*.

Worst-case burst—In analyzing targets, it indicates the location of the burst that occurs at the outer limits of the acceptable dispersion in both range and elevation. In considering the vulnerability of friendly forces, it indicates the point of maximum damage.

X-ray—Electromagnetic radiations of extremely short wave length.

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FM 101-31-1/FM FM 11-4

CHAPTER 1

INTRODUCTION

1-1. Purpose

This manual provides guidance to commanders and staff officers in the operational and logistical aspects of nuclear weapon employment in combat operations.

1-2. Scope

a. The doctrine presented in this manual is basically concerned with nuclear weapon employment within the field army and the Fleet Marine Force. When the manual discusses special ammunition logistics and vulnerability analyses, the scope is extended to include the area of operations.

b. Guidance is presented for the employment of nuclear weapons in the attack of targets on or near the earth's surface.

c. The complete manual series (FM 101-31-1, FM 101-31-2, and FM 101-31-3) includes the following information:

- (1) The U.S. Army and the U.S. Marine Corps doctrine for employment of nuclear weapons.
- (2) The effects expected from nuclear weapons.
- (3) Techniques of target analysis.
- (4) Command and staff procedures in nuclear weapon employment.
- (5) Guidance for conducting tactical operations in a nuclear environment.
- (6) Defensive measures, individual and unit, to reduce the effects of enemy-delivered weapons.
- (7) Tabular information concerning target response and troop safety for a family of hypothetical weapons and for stockpile weapons.

(8) Pertinent portions of STANAGs 2083, 2103, 2104, 2111, SOLOGs 89, 123, 128, 130 and SEASTAG 2083.

d. This manual repeats information presented in other field manuals only as required for clarity or consistency. The manual should, therefore, be used in conjunction with other applicable manuals. For a discussion of the employment of nuclear weapons in the air defense role, see FM 44-1A.

1-3. Recommended Changes

Users of this manual are encouraged to submit recommendations to improve its clarity or accuracy. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded directly to—The Commanding General, U.S. Army Combat Developments Command Institute of Combined Arms and Support, Fort Leavenworth, Kansas 66027. Originators of proposed changes that would constitute a significant modification of approved Army doctrine may send an information copy, through command channels, to—The Commanding General, U.S. Army Combat Developments Command, Fort Belvoir, Virginia 22060, to facilitate review and followup. Marine Corps users of this manual will submit comments to—Coordinator, Marine Corps Landing Force Developments Activities, Marine Corps Schools, Quantico, Virginia 22134.

1-4. Organizations of the Manual Series

The material is divided into three separate manuals—

a. This manual provides doctrine applicable to active nuclear warfare. It contains the U.S.

Army and U.S. Marine Corps concepts for nuclear weapon employment and the command and staff actions required to carry out these concepts. Appendix B presents detailed technical procedures concerning target analysis.

b. FM 101-31-2 contains classified defense information concerning the nuclear weapons in the U.S. stockpile. It provides the data necessary for target analysis. It presents items of information concerning technical procedures that are not included in this manual because of their security classification. FM 101-31-2 is designed for use in *active nuclear combat*, *field training exercises* (FTX), and *command post exercises* (CPX). FM 101-31-2 (Modified) is intended to be used by NATO members in actual combat, FTX, and CPX.

c. FM 101-31-3 provides data concerning a family of hypothetical nuclear weapons. It provides the data necessary for target analysis. FM 101-31-3 is designed specifically for use in unclassified training of the staff officer, particularly the nuclear weapon employment officer. It is not intended for field exercises or command post exercises by U.S. Forces, but can be so used by non-U.S. forces. The illustrative problems in appendix B, this manual, use data from FM 101-31-3.

d. The organization of the material in FM 101-31-2 and FM 101-31-3 is, in most cases, identical. Differences between the U.S. stockpile weapons and the family of hypothetical weapons exist; these differences are intentional and are designed to protect the security of the actual weapons. Facility in the use of FM 101-31-3 will insure facility in the use of FM 101-31-2.

1-5. Concepts for Nuclear Weapon Employment

The doctrine in this manual is based on the following basic concepts:

a. The U.S. Army and U.S. Marine Corps are organized, equipped, and trained to fight in nuclear warfare, nonnuclear warfare, or under the threat of nuclear warfare. In the latter case, units are prepared to take the

actions indicated in this manual should nuclear warfare begin.

b. Nuclear weapons may be employed within the area of operations when the theater commander announces that their use has been authorized.

c. Once nuclear warfare has commenced, the authority to employ nuclear weapons is decentralized.

d. United States nuclear weapons may be employed in support of Allied forces, using either United States or Allied delivery means. The nuclear warhead section (to include artillery projectiles) remains under the control of United States military personnel until time of launching or firing.

e. A commander who plans to employ a nuclear weapon coordinates with any adjacent unit commander into whose zone, or sector, militarily significant weapon effects are expected to extend. Lacking concurrence, the commander requests authority to fire from the next higher commander who controls both sectors.

f. Nuclear firepower is a form of combat power. Nuclear weapons may, on occasion, be used alone to accomplish tasks that might otherwise require the maneuver of close combat units; however, most tasks require a combination of fire and maneuver. Plans for the employment of nuclear firepower, nonnuclear firepower, and maneuver forces are integrated to provide decisive results.

g. Nuclear weapons are employed to destroy or degrade enemy combat capabilities. Consistent with the requirements imposed by the tactical mission, casualties among civilian personnel are held to a minimum. Destruction of manmade structures or natural terrain features, tree blowdown or fire areas, and creation of high-intensity residual contamination areas may create undesired obstacles to movement. Consistent with military objectives, unnecessary destruction and contamination should be held to a minimum.

h. Commanders employ the smallest and most readily available weapon with a suffi-

CHAPTER 2

INITIAL EFFECTS OF NUCLEAR WEAPONS

Section I. GENERAL

2-1. General

a. The effective employment of nuclear weapons requires an understanding of the effects produced by these weapons, the response of various target elements to these effects, the distance at which damage or casualties may be produced, the methods of estimating the results of nuclear bursts under various conditions, and the variability of the predicted results.

b. This chapter presents a general qualitative discussion of initial nuclear weapon effects and their military significance. TM 23-200 presents a quantitative discussion of effects, and provides the nuclear weapon employment officer with a means by which he can determine the distance to which various effects extend.

2-2. Description of Nuclear Detonations

a. Release of Energy. The magnitude of the energy released in a nuclear explosion exceeds enormously the energy released in a nonnuclear explosion. Two types of nuclear reactions produce energy—fission and fusion. A fusion reaction is approximately three times as efficient per kilogram of fuel as is a fission reaction. The energy released (yield) by a nuclear detonation is measured in thousands of tons of TNT equivalent (kiloton (KT)), or in millions of tons of TNT equivalent (megaton (MT)). As a result of the sudden release of immense quantities of energy, a fireball is formed. The fireball rapidly grows in size and rises high into the atmosphere. The initial temperature of the fireball ranges into millions of degrees, and the initial pressure ranges to millions of atmospheres.

b. Partition of Energy. Transfer of energy from the weapon to the surrounding media begins with the actual nuclear explosion and is exhibited as three distinct effects.

- (1) *Blast.* Mechanical shock effects are produced by a high-pressure impulse or wave as it travels outward from the burst.
- (2) *Thermal radiation.* Heating effects result as objects in the surrounding area absorb thermal energy released by the burst.
- (3) *Nuclear radiation.* Ionizing effects are produced when nuclear radiation emitted by the burst is absorbed.

c. Variation Parameters. The percentage of the total energy emitted, appearing as blast, thermal radiation, or nuclear radiation, depends on the altitude at which the burst takes place (subsurface, surface, air) and on the physical design of the weapon.

2-3. Damage Criteria and Radius of Damage

a. General. Two specific types of information pertaining to the military use of nuclear weapons have been developed through weapon tests. These specific effects data appear in TM 23-200.

- (1) The thermal, blast, or nuclear radiation levels required to cause a particular degree of damage to a materiel or a personnel target element.
- (2) The distance to which the required levels will extend from a given weapon.

b. Damage Analysis. The nuclear weapon employment officer uses data derived from effects (*a* above) to estimate the damage that a specific weapon will cause to a target. By knowing the approximate damage each weapon will cause, he selects the most appropriate weapon to accomplish the mission from those available for use.

c. Degrees of Materiel Damage.

- (1) *Damage* to materiel is classified by degrees as light, moderate, or severe. These degrees of damage are described in (*a*) through (*b*) below.
 - (*a*) *Light damage* does not prevent the immediate use of an item. Some repair by the user may be needed to make full use of the item.
 - (*b*) *Moderate damage* prevents use of an item until extensive repairs are made.
 - (*c*) *Severe damage* prevents use of the item permanently. Repair, in this case, is generally impossible or is more costly than replacement.
- (2) *Moderate damage* is usually all that is required to deny the use of equipment. In most situations, this degree of damage will be sufficient to support tactical operations. There may be situations, such as the attack of a bridge, in which only severe damage will produce the desired results.

d. Personnel Casualties. Personnel casualties (combat ineffectives), unlike damage, are not classified as to degree. Whenever personnel cannot perform their duties as a result of the weapon(s) employed against them, they are considered casualties. Some personnel will be effective immediately following attack but will later become combat ineffective because of the delayed effects of nuclear radiation.

e. Personnel Casualties Versus Materiel Damage. For most tactical targets, it is desirable to base target analysis on casualties rather than on damage to materiel. Exceptions are targets such as missile launchers, bridges, and other key structures.

f. Radius of Damage. The primary tool used

in estimating damage to the target is referred to as the radius of damage (RD). 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 weapon 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. Appendix B presents a more detailed discussion of the concept of radius of damage.

2-4. Types of Burst—Definition and Significance

Nuclear weapons may be burst at any point from deep below the surface to very high in the air. Tactically, nuclear bursts are classified according to the manner in which they are employed. The terms listed below and their associated definitions are used in the remainder of this manual. For technical definitions of the various heights of burst, see TM 23-200.

a. Subsurface Burst (less than 0 meters height of burst). This type of burst generally is used to cause damage to underground targets and structures and to cause cratering.

b. Impact or Contact Surface Burst (0 meters height of burst). This type of burst is used to cause fallout, ground shock and cratering, and may be used against hard underground targets located relatively near the surface of the earth.

c. Nuclear-Surface Burst. This type of burst causes fallout because the fireball touches the surface. Because of this fallout producing aspect, employment of this type of burst is limited.

d. Low Airburst. This type of burst is used for the most effective coverage of damage to the great majority of ground targets of inter-

Table 2-1. Biological Response to Nuclear Radiation.

<i>Estimated exposure range (rads)</i>	<i>Initial symptoms</i>	<i>Onset of symptoms</i>	<i>Incapacitation</i>	<i>Hospitalization</i>	<i>Duration of hospitalization</i>	<i>Final disposition</i>
50 to 200 ---	None to transient mild headache.	Approximately 6 hours after exposure.	None to slight decrease in ability to conduct normal duties.	Hospitalization required for less than 5 percent in upper part of exposure range.	45 to 60 days in upper part of range.	Duty. No deaths anticipated.
200 to 500 --	Headaches, nausea, and vomiting; malaise. Symptoms not relieved by antimetics in upper part of exposure range.	Approximately 4 to 6 hours after exposure.	Can perform routine tasks. Sustained combat or comparable activities hampered for period of 6 to 20 hours.	Hospitalization required for 90 percent of exposed personnel in this range. Hospitalization follows latent period of 17 to 21 days' duration.	60 to 90 days -	Some deaths anticipated; probably less than 5 percent at lower part of range, increasing toward upper end.
500 to 1,000 -	Severe and prolonged nausea and vomiting; difficult to cure. Diarrhea and fever early in upper part of exposure range.	Approximately 1 to 4 hours after exposure.	Can perform only simple, routine tasks. Significant incapacitation in upper part of exposure range; lasts more than 24 hours.	Hospitalization required for 100 percent of exposed personnel. Latent period short, 7 to 10 days in lower range to none in upper range.	90 to 120 days for those surviving.	Approximately 50-percent deaths at lower part of range, increasing toward upper end; all deaths occurring within 45 days.
Greater than 1,000.	Severe vomiting, diarrhea, and prostration.	Less than 1 hour after exposure.	Progressive incapacitation, following an early capability for intermittent heroic response.	Hospitalization required for 100 percent of exposed personnel. No latent period.	3 to 30 days --	100-percent deaths occurring within 30 days.

an increased susceptibility to secondary infection, which, on the septic battlefield, would greatly complicate treatment of normal injuries. In addition, certain portions of the radiation damage may be irreparable.

- (4) *Repeated exposure.* On a nuclear battlefield, units will probably be exposed regularly (i.e., at least several times a month) to some degree of radiation risk from friendly as well as from enemy nuclear weapons. 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 nonsymptomatic doses. To assist the commander, friendly units are divided into three categories based on previous exposure history. FM 3-12 discusses techniques for classifying units. The three categories are—

- (a) *Radiation Status—1 (RS-1).* Units in this category do not have a significant radiation-exposure history.
- (b) *Radiation Status—2 (RS-2).* Units in this category have previously received one-time or accumulated doses that are significant but not dangerous.
- (c) *Radiation Status—3 (RS-3).* Units in this category have received sufficient one-time or accumulated doses to make all except

insignificant future radiation exposure dangerous.

c. *Materials.* Most material objects are unaffected by initial nuclear radiation. However, photographic and X-ray films are rendered useless by exposure to only small quantities of radiation. Some types of communications equipment may be temporarily or permanently damaged by exposure to relatively large amounts of radiation.

2-23. Summary of Military Significance of Initial Nuclear Radiation

a. Initial nuclear radiation effects may often produce casualties among personnel protected from blast and thermal effects.

b. 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 significantly reduce combat effectiveness for a long period of time.

c. Troop safety is a major consideration as far as nuclear radiation is concerned. Adequate protective shielding is difficult to acquire. It is reasonable to assume that friendly personnel and the enemy will receive repeated doses of nuclear radiation. The size and frequency of doses received in past operations, the extent of recovery of damage (this is an unknown factor and will not be considered in assessments of troop radiation status), and the urgency of the tactical situation will, among other things, determine the degree to which friendly troops can be exposed during a nuclear attack.

Section V. COMBINED EFFECTS AND SPECIAL CONSIDERATIONS

2-24. Combined Effects

a. A person may receive some injury from blast or thermal radiation that is insufficient to make him ineffective, and he may receive a dose of nuclear radiation that, by itself, will not cause ineffectiveness. However, the combination of these effects may cause him to become a casualty. Nuclear radiation can delay

the healing of wounds and burns and can increase the possibility of complications.

b. While there will be many casualties from combined effects, such as outlined above, estimating these casualties is difficult. In arriving at his recommendation as to the weapon and yield to be used, the nuclear weapon employment officer bases his estimation of dam-

CHAPTER 3

TARGET ANALYSIS

Section I. GENERAL

3-1. Factors Considered in Target Analysis

(This paragraph is based on SOLOG No. 89.)

a. General.

- (1) In the general sense, target analysis is defined as the examination of targets to determine the capabilities of available weapon systems for the attack of such targets (see AR 320-5 for complete definition). With respect to the employment of nuclear weapons, it is the process used to select the appropriate weapon system that will meet the commander's requirements, within the knowledge available. This chapter discusses, in general terms, the procedures for target analysis. Appendix B presents detailed techniques for the use of target analysis.
- (2) It is important that an estimate be made of the results to be expected from a nuclear attack. Usually, this will include what fraction of the target area is expected to be covered by the weapon effects. Nuclear weapons usually are employed on a one-shot basis; even if more than one weapon is used, there is only one weapon for each desired ground zero. Unlike other fires, in which distribution over the target area is obtained by firing many rounds and allowing the inherent delivery errors to place the rounds randomly throughout the target area, the effects of a nuclear weapon on the target will vary, depending on the de-

livery errors of the single round. Consequently, it is necessary to make an estimate of the results on the target based on the relationship among the characteristics of the target, the effects of the weapon measured by its radius of damage, and the delivery errors. The estimation of the results usually is expressed as a fraction or a percentage of the target. When 30 percent of the target is covered by the particular radius of damage, it is expected that 30 percent of the target will be destroyed. Figure 3-1 shows this relationship.

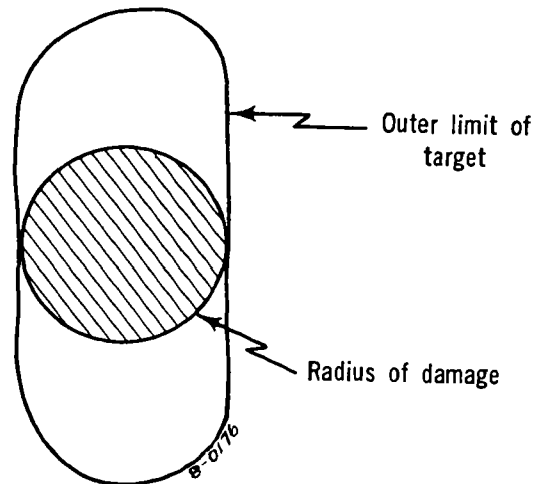


Figure 3-1. Relationship of target size and damage radius in damage estimation.

b. *Assumptions.* Target analysis is based on the following assumptions:

- (1) *Reliability.* Casualty and damage estimation is predicated on the assump-

tion that a nuclear weapon *will arrive at the target area at the desired time and a nuclear detonation will take place*. Because many delivery systems do not provide a high assurance of successful delivery, it may be desirable to provide an alternate means to attack the target in the event the first weapon fails to function properly. This alternate means may be another nuclear weapon, non-nuclear firepower, or maneuver forces, depending on the nature and importance of the target and the alternate means available. This is discussed further in paragraph 3-10.

- (2) *Targets*. When intelligence indicates the size and shape of the target, and the distribution of elements within the target, these data are used by the target analyst. Otherwise, the target elements are assumed to be uniformly distributed, and the area is assumed to be circular. The radius of the target is based on the best information available. Should a sizeable error in the target radius exist, a situation similar to that discussed in appendix B-II-4 could result.
- (3) *Atmospheric conditions*. The effect of atmospheric conditions on blast and radiation *usually* is not considered by the target analyst. In cases of heavy rain or snow in the target area, weapon effects radii will vary slightly from those listed in FM 101-31-2 and FM 101-31-3.
- (4) *Terrain*. Nuclear effects may be modified by terrain extremes such as high mountains. If a weapon is burst in a valley, shielding of effects may occur outside the valley, with reinforced effects within the valley. No reliable system exists for modification of analysis in the field of weapon effects due to terrain considerations.

c. System Errors.

- (1) *General*. Dispersion influences the

selection of the desired ground zero (DGZ) and the desired height of burst. It also affects such factors as damage to the target, troop safety, fallout, tree blowdown, and induced contamination. Consideration is, therefore, given to delivery errors.

(2) Effect of horizontal dispersion.

- (a) There is a dispersion pattern unique to each type of nuclear weapon delivery system. Cannon and rocket artillery form a generally elliptical pattern, whereas guided-missile rounds and air-delivered weapons form a circular pattern (fig. 3-2). Because nuclear target analysis is premised on a "single shot," it is assumed that the distribution of errors connected with nuclear delivery systems will follow the laws of probability. It is also assumed that gunnery techniques will place the center of the "dispersion pattern" at the desired ground zero.
- (b) It is apparent that a burst occurring at the outer limits of the dispersion pattern will cause the center of the weapon effects to be offset from the desired ground zero. Because the desired ground zero usually is selected at the center of target, a burst near the outer limits of the dispersion pattern may result in a substantial decrease in the damage to the target. This emphasizes the need for post-strike analysis whenever possible.

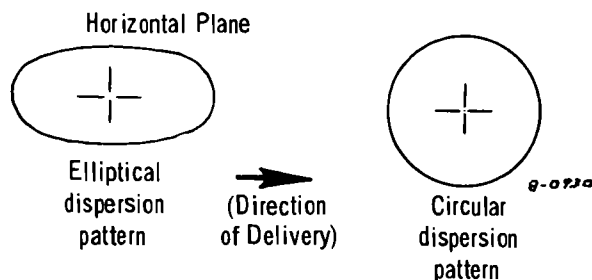


Figure 3-2. Horizontal dispersion patterns.

1. Figure 3-3 shows a burst occurring at the center of the target. In this case, about 30 percent of the target is covered by the radius of damage.

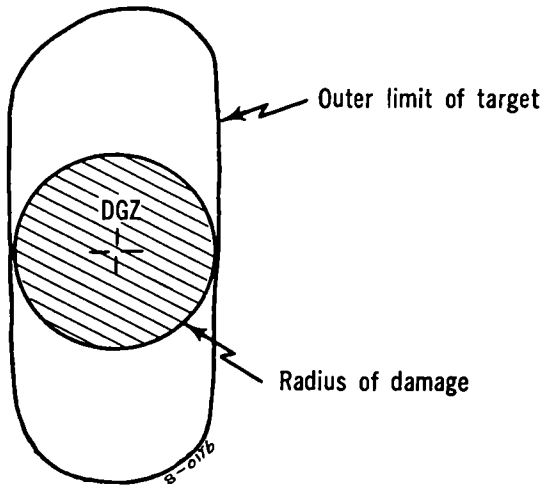


Figure 3-3. Burst occurring at the center of the target.

2. Figure 3-4 shows a burst occurring at the outer edge of the elliptical dispersion pattern. In this case, very little of the target is covered. Obviously, the size and shape of the target, the radius of damage, and the size and shape of

the dispersion pattern affect the amount of the target that will be damaged by a single burst.

3. In considering this, the target analyst assumes that the burst will occur near the outer edge of the dispersion pattern and estimates the fraction (percentage) of the target covered by the weapon effect of interest. Under these circumstances, there is a high assurance that the weapon will cause at least that fraction of damage.

- (3) *Effect of vertical dispersion.* The burst pattern in the air formed by a large number of weapons set with a timer fuze to detonate at the same height of burst, and delivered under nearly identical conditions, is ellipsoidal (egg shaped). The height-of-burst distribution pattern extends above and below the desired height of burst (fig. 3-5). It is apparent that a large vertical error may result in a burst occurring a significant distance above or below the desired height. In such cases, the weapon may detonate close enough to the surface to produce fallout or so high in the air that the effects on the tar-

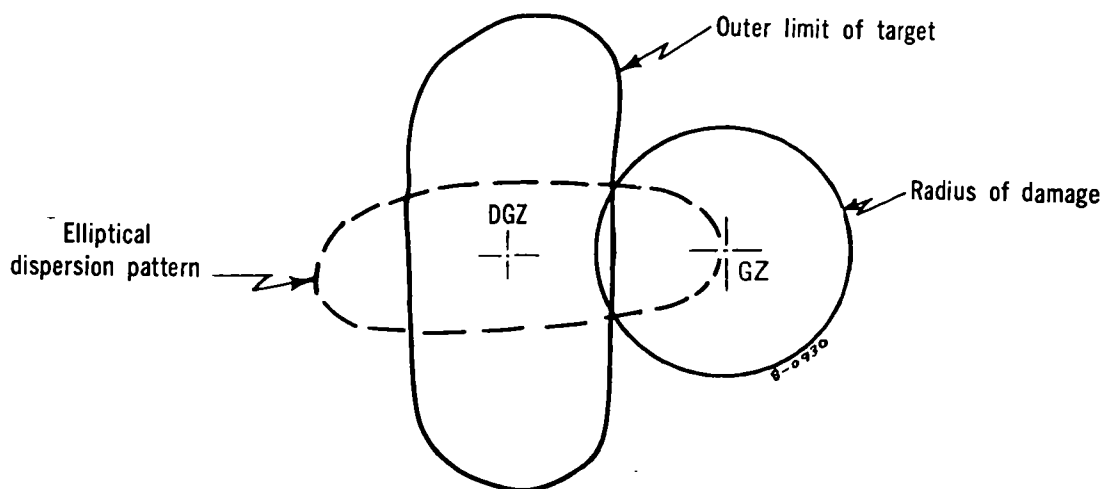


Figure 3-4. Burst occurring at the outer limit of the dispersion pattern.

get will be significantly reduced. Consequently, vertical dispersion (PEh) is considered in selecting a height of burst. Radar fuzes greatly reduce the problem of vertical dispersion, as shown in figure 3-6.

d. *Target Location Errors.* Each target acquisition means has an associated target location error. This error may vary within the same type of equipment due to operator interpretation of data or to individual equipment variations. The evaluation of the extent of the error and the gross effect this error has on the

analysis of the target can be determined only by the target analyst and the intelligence officer through field experience. This is discussed further in appendix B-II-4.

3-2. Data for Target Analysis

(This paragraph is based on SOLOG No. 89.)

a. Tables in FM 101-31-2 and FM 101-31-3 present the data to be used in target analysis. The basic tables are referred to as weapon selection tables (WST). The weapon selection

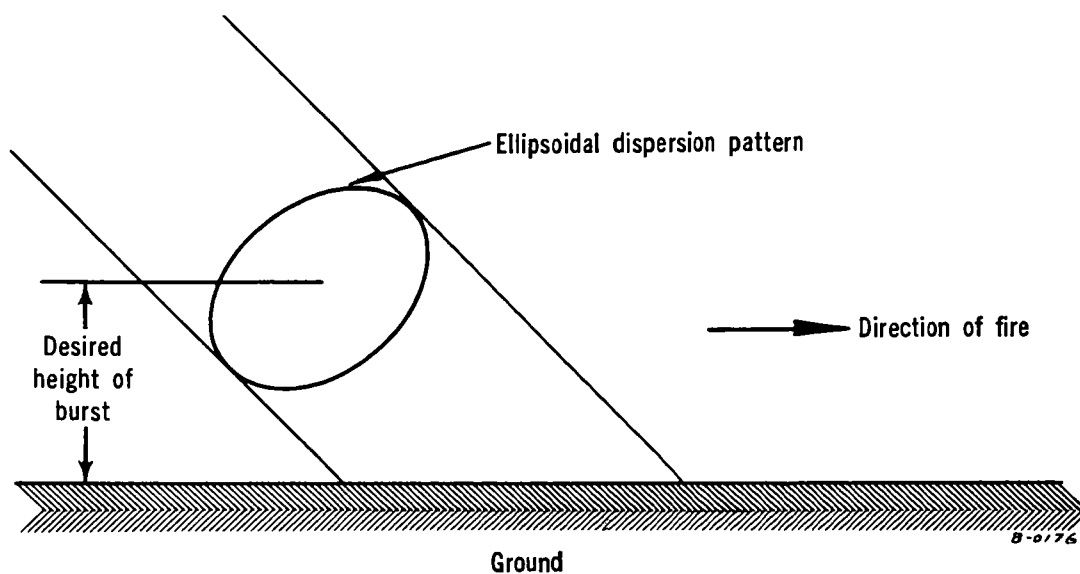


Figure 3-5. Timer fuze vertical dispersion pattern.

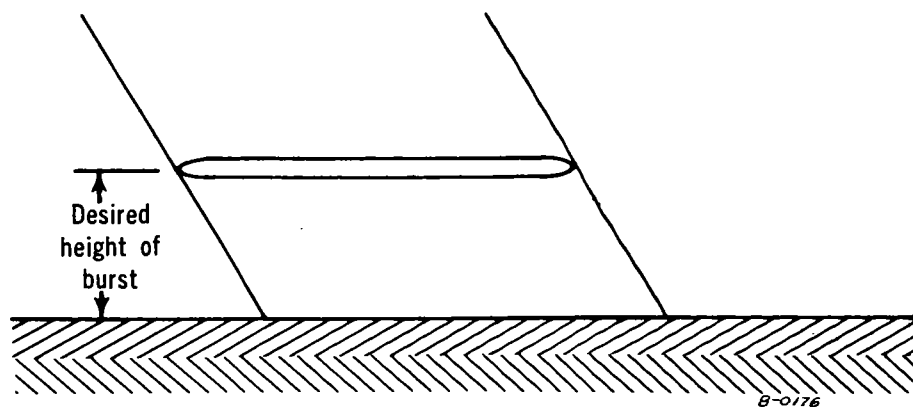


Figure 3-6. Radar fuze vertical dispersion pattern.

tables consist of coverage tables, safety distance tables, and effects tables. Examples of these tables are included in appendix B.

b. The *coverage tables* present the information with which to estimate damage. A set of indexes is presented that simultaneously considers delivery errors, weapon effects, and target size and composition. For a given target category, yield, and delivery system with a known range and height-of-burst option, the index gives an estimate of the damage that can be expected from the attack. Coverage tables also present the radius of damage (para 2-3) for each range and height-of-burst option. The indexes and radii of damage have been computed using the casualty- or damage-producing effect that extends the greatest distance. This effect is referred to as the *governing effects*.

c. The *safety distance tables* simultaneously consider delivery errors and weapon effects in evaluating the "limiting requirements" which may be imposed on the use of nuclear weapons. These limiting requirements are imposed to avoid undesirable effects caused by nuclear weapons in the form of casualties to friendly troops; creation of obstacles to movement, to include fire areas; damage to installations desired for the use of friendly troops, such as bridges and buildings; and damage to friendly light aircraft in flight. The tables give the minimum distances that friendly troops; light aircraft; installations; and, in the case of preclusion of obstacles to movement, the critical area must be separated from the desired ground zero. In the case of troop safety, this distance is called the minimum safe distance (MSD) and is given for various conditions of risk and vulnerability. In the other cases mentioned, it is called the *least separation distance* (LSD). (Annex B-III, appendix B contains a detailed description of limiting requirements.)

- (1) In the troop safety portion of the tables, these minimum safe distances are shown for each—

- (a) Delivery system.

- (b) Yield.

- (c) Height-of-burst option.

- (d) Degree of risk to friendly elements.

- (e) Condition of protection (or vulnerability) of friendly troops.

- (f) Range increment (for range-dependent systems).

- (2) In the preclusion-of-damage portion of the tables, the least separation distances are shown for preclusion of damage to—

- (a) Fixed bridges.

- (b) Buildings.

- (c) Light aircraft in flight.

- (3) In the preclusion of obstacles portion of the tables, the least separation distances are shown for preclusion of obstacles caused by—

- (a) Tree blowdown.

- (b) Fires.

d. The *effects tables* consider only weapon effects and height of burst. For each weapon, radii of damage for use against various target elements are shown.

3-3. Recommendations

A target analysis is conducted to select the best weapon for attack of a target. After the target analysis has been completed, a recommendation is presented to the commander. The recommendation should include the following information:

- a. Weapon system.

- b. Height-of-burst option.

- c. Desired ground zero.

- d. Time of burst.

- e. Estimated results.

- f. Troop safety.

A detailed description of each of the elements above is contained in appendix B.

Section II. TECHNIQUES FOR TARGET ANALYSIS

(This section is based on LOLOG No. 89.)

3-4. General Procedure for Analyzing Targets

The following general procedures are used by the target analyst. The detailed steps, to include examples, are contained in appendix B.

a. The target analyst identifies the pertinent portions of the organization's standing operating procedure (SOP) and becomes familiar with the special guidance expressed by the commander. He determines information concerning allocations, authority to expend, and available weapon systems as well as target information, such as shape, vulnerability, size, distance to friendly troops and their radiation exposure status, ranges to the available delivery means, and the limiting requirements (app B).

b. He determines data for—

(1) Damage estimation, to facilitate his

determining whether to use the *index method*, the *visual method*, or the *numerical method* (fig. 3-7). He considers point targets and area targets in damage estimation.

- (a) A *point target* is defined as a target with a single target element (e.g., a bridge (span) or a building).
 - (b) An *area target* is defined as a target with multiple target elements distributed over a definable area. (In this context a troop unit, vehicle park, or other such target would not be considered a target element even though it may be part of a larger defined target.)
- (2) Limiting requirements, as they pertain to troop safety and damage and obstacle preclusion.
 - (3) The selection of the most beneficial desired ground zero, taking into con-

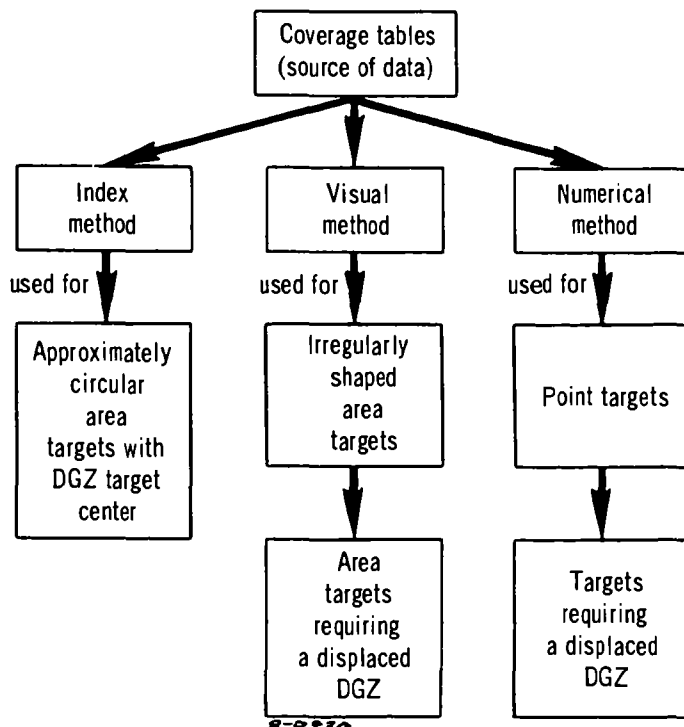


Figure 3-7. Methods of damage estimation.

to neutralize a unit. An emergency risk from exposure to nuclear radiation occurs either when a unit has a radiation-exposure history that is at the threshold 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 threshold for combat ineffectiveness from radiation sickness. *An emergency risk should be accepted only when it is absolutely necessary, and should be exceeded only in extremely rare situations that 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 explosion depends principally on the degree to which he is protected from the weapon effects. For example, a man who is well protected can safely be much closer to the ground zero than can be a man in the open. The degree of protection of the unit is considered in target analysis to be dependent on the amount of advance warning the unit has received. One or more of the following three conditions of *personnel vulnerability* can be expected at the time of burst: unwarned, exposed; or 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 dazzle. For example, such a condition can be expected to prevail in an offensive situation when the majority of the attacking infantry are in the open and 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. For example, such a condition may prevail 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 assumed degree of protection is that protection offered to personnel who are in "buttoned-up" tanks or crouched in foxholes with improvised overhead thermal shielding. When only a lesser degree of protection is available (e.g., only tracked carriers are available), personnel cannot be considered warned, protected. The target analyst would consider such personnel as exposed. A warned, protected condition generally is expected to prevail when nuclear weapons are used in a preparation prior to an attack.
- (d) It should be noted that there is no category for *unwarned, protected*. Although protection may be available to personnel, it cannot be assumed that they will be taking advantage of it unless they are warned of an impending burst. Procedures for warning friendly personnel are discussed in paragraph 4-6.

- (3) For each combination of negligible and emergency degree of risk and condition of personnel vulnerability, there is an associated "risk distance" known as the radius of safety. It is the horizontal distance from the actual ground zero beyond which the weapon effects are acceptable. Because a round may burst at the end of the dispersion pattern nearest to friendly troops, a buffer distance is added to the radius of safety. The buffer distance provides a very high assurance (99 percent) that unacceptable weapon effects will not reach friendly troops. The size of the buffer distance is dependent on the horizontal delivery error at the applicable range. The sum of the radius of safety and the buffer distance is the minimum safe distance shown in the safety distance tables in FM 101-31-2 and FM 101-31-3. Although these tables contain the minimum safe distances for the various stated combinations of risk and vulnerability, selection of an appropriate MSD is dependent upon whether or not radiation is the governing criteria.

Table 3-1. Yields for which Radiation is the Governing Troop Safety Criterion

Yield (KT)	Exposed		Protected
	Unwarned	Warned	Warned
Less than 8 -----	Yes -----	Yes -----	Yes.
8-15 -----	No -----	Yes -----	Yes.
16-200 -----	No -----	No -----	Yes.
More than 200 -----	No -----	No -----	No.

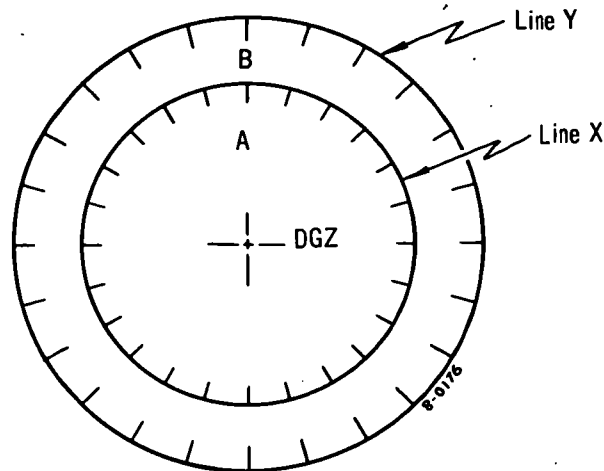
Note. Yes means that radiation is the governing criterion. No means that radiation is not the governing criterion.

d. Depending on weapon yield, the governing effect in establishing the minimum safe distance may be blast, thermal radiation, or initial nuclear radiation. For weapon yields in which nuclear radiation is the governing troop safety criterion (table 3-1), it is necessary that the unit's radiation-exposure history be considered. FM 3-12 discusses the procedures whereby unit radiation-exposure histories are determined and records maintained.

e. To consider a unit's radiation-exposure history properly, it is important that the quantitative meaning of the various minimum safe distances be understood insofar as nuclear radiation troop safety criteria are concerned. The following discussion refers to figure 3-8 and considers troops with no previous radiation exposure history.

- (1) Line X represents the emergency risk MSD. For units located in area A, between the DGZ and line X, there is a very high assurance that these units will be exposed to more than 50 rad (an emergency risk). The assurance decreases as the distance from the DGZ to the friendly troops decreases. Such units are exposed to more than an emergency risk.
- (2) There is a very high assurance that units located on line X or in area B will receive 50 rad or less and, therefore, will be exposed to no more than an emergency risk. Furthermore, units located in area B beyond a line visualized to be about midway between lines X and Y will receive no more than a moderate risk (20 rad or less).
- (3) Following the same reasoning, there is a very high assurance that units located on line Y or beyond will receive 5 rad or less and, therefore, will be exposed to no more than a negligible risk. The risk to a unit located beyond line Y decreases with the increase in distance from the DGZ until at some point, not mathematically defined or tabulated in any manual, there is no longer any risk of radiation exposure.

f. When examining troop safety in connection with a target analysis, table 3-1 must first be consulted to determine whether the weapon yield being investigated falls in the range where radiation is the governing troop safety criterion. If radiation does not govern, the unit's radiation history does not have to be considered, and the minimum safe distance is used without modification. If radiation does



LEGEND

Line X—Emergency risk MSD, FM 101-31-2, -3.

Line Y—Negligible risk MSD, FM 101-31-2, -3.

Figure 3-8. Minimum safe distance.

govern, the procedures outlined in Annex B-III, Appendix B should be used to determine the appropriate minimum safe distance.

3-8. Contingent Effects

a. Contingent Effects. The coverage tables are computed using the governing effect—that effect which extends the greatest distance to cause the desired degree of damage to the principal target element. Contingent effects are effects other than the governing effect. They are divided into bonus effects, which are desirable, and limiting effects, which are undesirable.

b. Bonus Effects. When a nuclear weapon is used on a target, there will be many effects other than the governing effect that will assist in the destruction of enemy elements. These are termed “bonus effects.” Some are predictable, others are not. The desirability of achieving bonus effects on the primary target ele-

ment or on another target element may influence the selection of a nuclear weapon. The target analyst checks to see whether a predictable bonus effect may exist at a certain point by obtaining the radius of damage for the effect from the effects tables. He then estimates the effect on the target by considering the effect of horizontal dispersion.

c. Limiting Effects. Limiting effects are effects that are undesirable and, consequently, may place restrictions on the employment of the weapon. These restrictions are referred to as limiting requirements. Examples of effects that may be undesirable in a given instance are the creation of obstacles to friendly movement as a result of tree blowdown, rubble, and forest and urban fires. The target analyst determines whether undesirable effects will be created. He does this by considering the radius of the limiting effect. He determines the least separation distance (LSD) from the safety distance tables.

Section III. SPECIAL CONSIDERATIONS

3-9. Time of Attack

a. Tactical Considerations.

- (1) *General.* A set rule for selecting the time for firing a nuclear preparation should not be made. To achieve sur-

prise, it may be desirable to fire all weapons at the same time or as close together as possible. Because well-trained troops may become prone as soon as they observe the flash of the first burst, surprise may often be achieved by delaying the delivery of subsequent rounds. Sometimes better results may be obtained by firing on targets at irregular time intervals. Weapons supporting a secondary attack may be fired first to assist in locating reserves or to cause the premature commitment of the enemy's reserve.

(2) *Time for tactical damage assessment.*

When a less reliable weapon system is employed (para 3-10), a backup weapon, if available, should be placed in an on-call status. In planning the nuclear attack, time should be allowed for making a tactical damage assessment of the first round to determine whether the backup weapon should be fired. This time interval will vary, depending on such factors as—the surveillance method used to determine if the first weapon hit the target, if it detonated, and if the target sustained the desired degree of damage; communications; visibility; and the maneuver plan (para VI-1, app B).

b. Preinitiation Considerations. The radiation from one nuclear weapon may cause a subsequent weapon to detonate prematurely. Such an occurrence is called "preinitiation." If two weapons are to be fired so that they may land within 10,500 meters of each other, the special data provided in FM 101-31-2 and chapter 3, FM 101-31-3 should be used. A more detailed discussion of preinitiation is included in FM 101-31-2.

3-10. Reliability

a. The reliability of a weapon system is the probability that the weapon will get to the target area at the desired time and a nuclear detonation of the expected order of magnitude

will take place. Reliability is a function of crew training, maintenance, communications, command, weather, terrain, delivery system, and weapon design. The reliability of any weapon system varies to such an extent that fixed values cannot be established; experience will dictate the reliability of a given system.

b. Reliability is not a consideration in selecting a weapon for attack of a target except as follows:

- (1) The most reliable systems are employed against the most important targets—those critical to the success of the mission.
- (2) Against other than the most important targets, less reliable systems are employed before the more reliable. This permits retention of the more reliable weapon systems for attack of future targets.

c. A backup weapon, if available, should be placed in an on-call status when a less reliable weapon system is employed.

3-11. Analysis of the Vulnerability of Friendly Troops

a. Target analysis procedures are used to estimate the possible results of an enemy nuclear attack on friendly dispositions or installations (annex B-VII, app B). Based on current intelligence and the enemy's past use of nuclear weapons, the yield of the weapon most likely to be employed against friendly elements is estimated.

b. Special tables are presented in figure B-VII-1, FM 101-31-2 and FM 101-31-3 that gives the radii to be used in analyzing the vulnerability of friendly dispositions. The target analyst assumes that the enemy can deliver a weapon at the point where it will do the greatest damage to the friendly installation, disregarding the effect of delivery errors. The target analyst then estimates what fraction of friendly dispositions might be endangered by such an attack.

c. The analysis of present and planned friendly dispositions is a continuing process. The commander must be kept informed of

River. Although we have a limited number of nuclear weapons for this operation, I am willing to expend 30 to 40 percent of them in penetrating the Aggressor main and secondary defensive belts and in advancing to the Blue River. Corps fires will be used to engage Aggressor nuclear delivery means and those reserve maneuver forces that have the capability to adversely affect the outcome of the battle. These fires will be delivered as soon as the targets are located. These fires, together with subordinate unit nuclear fires, will insure that we inflict maximum casualties and damage to Aggressor units west of the Blue River and will insure our successful attack to secure crossings over the Blue River.

"Once we are across the Blue River, we must be ready to exploit our crossings and to move rapidly through the passes of the Silver Mountains and seize the communications center of Foxville. Be extremely cautious in planning the employment of nuclear weapons in the Silver Mountains, because I want no obstacles to our advance created in these critical areas.

"Retain one-fourth to one-half of our nuclear weapons in reserve for the attack to seize Foxville, because I anticipate a stubborn enemy defense there, and for the defense against the Aggressor counterattacks that are sure to follow when we seize Foxville.

"Divisions will not be given authority to expend weapons over 50-kiloton yield."

j. The following is an example of a field army commander's initial guidance to his staff:

"The offensive to seize the passes through the Ruff Mountains is the most critical part of the coming operation. Once we have seized the passes and repulsed Aggressor counterattacks, we should regroup and advance rapidly to the northeast to seize the India-Bravo-Mike industrial complex, link-up with elements of the 12th Army Group, and destroy the enemy entrapped in the pocket thus formed.

"With the advance to the Ruff Mountains so critical, I am willing to expend one-half of the available nuclear weapons to destroy Aggressor resistance west of the mountains and to inflict maximum casualties and damage to his reserves in this area. Plan on a small nuclear weapon expenditure in the exploitation from the mountains to seize the India-Bravo-Mike complex. Insure that we retain a reserve of nuclear weapons for use during the initial attack to seize the mountain passes, to prevent any sizable reinforcement by reserves now located east of the mountains, and to destroy the Aggressor forces entrapped in the pocket.

"Surface bursts may be authorized by corps commanders, provided significant fallout is confined to the corps zone of action.

"Air defense is SOP. Available nuclear weapons released to air defense units for that purpose will not be employed in a surface-to-surface role without specific approval by me.

"The success of this offensive depends heavily on the delivery of nuclear fires when required. Insure that the special ammunition supply points supporting the corps are located well forward for this operation, and that all nuclear delivery units have a maximum special ammunition load. If required, give transportation priority to movement of nuclear weapons."

4-5. Fire Support Coordination

a. Fire support coordination is the coordinated planning and directing of fire support so that targets are adequately attacked by appropriate means of weapons available. This would include all fires on surface targets, whether planned or targets of opportunity, regardless of the source of these fires.

b. Proper fire support coordination integrates firepower and maneuver. The fire support element (FSE) of the tactical operations center in the Army and the fire support coordination center (FSCC) in the Marines performs the target analyses that result in a recommended plan for the employment of nuclear weapons. In the Army, if these plans involve means other than normal surface-to-surface delivery units, they are coordinated as follows:

- (1) Atomic demolition munitions with the engineer element.
- (2) Air-delivered weapons with the tactical air support element (TASE).
- (3) Air defense weapons employed in a surface-to-surface role with the air defense element.

c. During the fire support coordination process, measures are taken to insure that predicted effects of contemplated nuclear fires will not adversely affect projected operations. When undesirable effects of nuclear fires cannot be prevented, the implications of these effects are indicated, and alternative courses of action are recommended to the commander for decision.

d. During the process of fire support coordination, a series of recommendations is developed that will produce the following specific results:

- (1) Dispersal and positioning of nuclear weapons and release to executing units in a manner that most effectively supports the commander's concept of operations within his allocation.
- (2) Establishment of liaison and communications between nuclear delivery units and supported units.
- (3) Actions to insure troop safety. The nuclear weapon employment officer checks for troop safety as part of each target analysis. To accomplish this check, it is necessary to have data indicating the location and radiation exposure history of friendly forces. FM 61-100 prescribes procedures, such as the use of phase lines, for the reporting of location and for the control and coordination of movement. During the fire support coordination process, recommendations on the specific procedures to be employed are developed.

e. A detailed discussion of the duties of the fire support coordinator and of fire support coordination procedures is contained in FM 6-20-1 and FM 6-20-2.

4-6. Warning of Friendly Nuclear Strikes

(This paragraph is based on STANAG No. 2104.)

a. Advance warning of a nuclear strike is required to insure that friendly forces do not receive casualty-producing weapon effects. For strikes at distant enemy targets, advance warning is required only for adjacent units and aircraft likely to be affected by such strikes. When a nuclear weapon is part of a schedule of fires, there is usually adequate time to alert those personnel in an area where significant effects may be received. If it does not interfere with the mission, troops out to the limits of visibility should be warned. On

the other hand, when weapons are employed against surface targets of opportunity, an SOP is required that will permit rapid notification of personnel who could be affected by the weapons. When very low yield nuclear weapons are employed against targets of opportunity or when nuclear weapons are employed in the air defense role, there may not be sufficient time to warn friendly personnel. The difficulty of warning all personnel can be appreciated if the various activities in the forward battle areas are visualized. Messengers, wire crews, litter bearers, aid men, and others move about frequently in the performance of their duties. Often they may not be in the immediate vicinity of troop units when warning of an impending nuclear attack is disseminated. Small detachments of combat support troops, such as engineers, may be working in isolated areas where they may be subjected to casualty-producing effects if they are not warned. Effects that are completely tolerable to troops in tanks or foxholes can cause considerable casualties among those in the open in the same area (para 6-3).

- (1) Notification concerning friendly strikes is a time-consuming process unless procedures are carefully established and rehearsed. Dissemination of warning earlier than is necessary may permit the enemy to learn of the planned strike, with a resultant decrease in the effectiveness of the attack.
- (2) When there is insufficient time to warn personnel within the limits of visibility, only those personnel who might receive tactically significant weapon effects are given a nuclear strike warning. Warning of units not requiring the information causes them to assume a protective posture that interferes with the accomplishment of their mission. There is generally no requirement to warn subordinate units when the target analysis indicates no more than a negligible risk to unwarned, exposed troops.
- (3) Aircraft, particularly light aircraft, can be damaged by low 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 one where damaging overpressures 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 liaison personnel. At corps and division level, the notification of the planned employment of a weapon 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) Time permitting, air defense artillery will report via command and control nets to the Army Air Defense Command Post (AADCP) the intention to engage hostile aircraft with nuclear weapons, stating estimated time, altitude and GEOREF of the nuclear burst. The AADCP will transmit a warning message to its associated TOC and Sector Operation Center/Control and Reporting Center (SOC/CRC), and these agencies may transmit alerts to their respective airborne aircraft.
- (d) Warnings to aircraft in Marine Corps operating areas will be initiated by the FSCC which passes the warning to the Tactical Air Commander usually via the Tactical Air Command Center (TACC) and/or the Direct Air

Support Center (DASC) and/or the Supporting Army Control Center (SACC).

- (4) When very low yield weapons are employed against targets of opportunity, operational requirements may dictate some relaxation of the requirement for positive warning.

b. Nuclear strike warning (STRIKWARN) messages are disseminated as rapidly as possible. The requirement for speed frequently will be in conflict with a requirement for communications security. Authentication procedures and encoding instructions for nuclear strike warning messages are included in unit signal operation instructions.

- (1) The amount of information to be encoded is held to a minimum to expedite the dissemination.
- (2) Strike warnings are broadcast in the clear when insufficient time remains for the enemy to react prior to the strike.

c. Procedures for warning of friendly nuclear strikes are included in the subparagraphs below.

- (1) Warning responsibilities are as follows:
 - (a) Responsibility for issuing the initial warning rests with the requesting commander.
 - (b) Commanders authorized to release nuclear strikes will insure that strikes affecting the safety of adjacent and other commands are coordinated with these 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 commander responsible for issuing the warning should inform—

- (a) Subordinate headquarters whose units are likely to be affected by the strike.
 - (b) Adjacent headquarters whose units are likely to be affected by the strike.
 - (c) His next higher headquarters, when units not under the command of the releasing commander are likely to be affected by the strike.
- (3) Each headquarters receiving a warning of nuclear attack will warn subordinate elements of the safety meas-

ures they should take in view of their proximity to the desired ground zero.

- (4) Figure 4-2 shows the zones of warning for friendly nuclear strikes. The number of zones shown will be less whenever the data for two or more minimum safe distances (MSD) are the same (e.g., where MSD 2 is the same as MSD 3, only zones 1 and 2 would apply for the friendly nuclear strike.) Table 4-1 explains the protection requirements for personnel located in any of the warning zones.

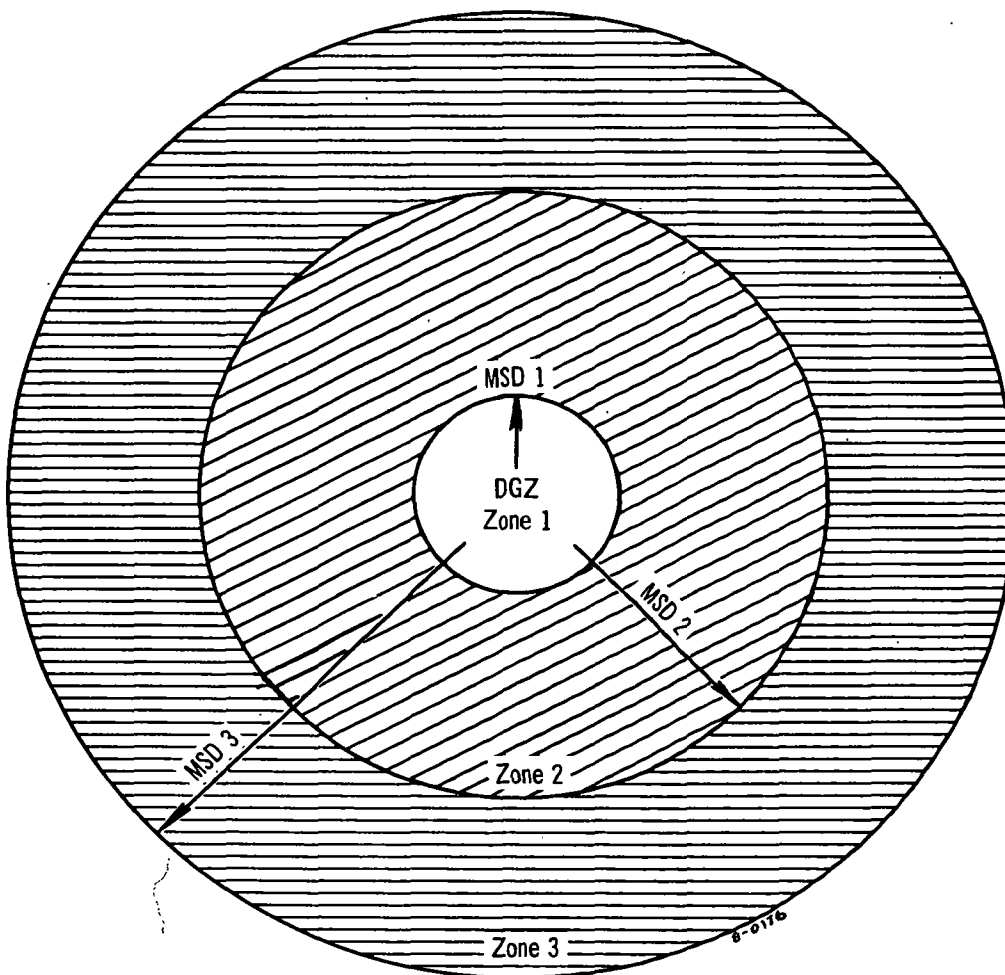


Figure 4-2. Zones of warning for friendly nuclear strikes.

Table 4-1. Protection Requirements for Friendly Nuclear Strikes

Area ^a	Corresponding to—	Zone	Requirement
DGZ to MSD 1 -----		1----	Evacuation of all personnel. ¹
From MSD 1 to MSD 2 --	Limit of negligible risk to warned, protected personnel. ²	2----	Maximum protection. ³
From MSD 2 to MSD 3. --	Limit of negligible risk to warned, exposed personnel. ⁵	3----	Minimum protection. ⁴
MSD 3 and beyond. -----	Limit of negligible risk to unwarned, exposed personnel. ⁵	-----	No protective measure, except against dazzle.

¹ If evacuation is not possible, or if a commander elects a higher degree of risk, maximum protective measures will be required.

² Negligible risk should normally not be exceeded unless significant advantages will be gained.

³ Maximum protection denotes that personnel are in "buttoned-up" tanks or are crouched in foxholes with improvised overhead shielding.

⁴ Minimum protection denotes that 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 summer uniform.

⁵ Minimum safe distances are increased by 50 percent when conditions of extreme reflectivity and good visibility exist. (See paragraph 2-25c(1).)

⁶ MSD means minimum safe distance. When surface bursts are used, the fallout hazard will be considered and appropriate buffer distances included.

- (5) Figure 4-3 shows the format in which all friendly nuclear strike warnings will be given. Figure 4-4 shows examples of friendly nuclear strike warning messages. Notification passed to those agencies or facilities responsible for disseminating warnings to airborne aircraft will include the least safe distance for light aircraft in hundreds of meters (four digits) as part of item India following the data for MSD 3. (Examples of MSD determination are presented in annex B-III, app B.)
- (6) When nuclear strikes are canceled, units previously warned will be notified in the clear by the most expeditious means as follows: "Code word (target number). Canceled."
- (7) The amount of information to be encoded is held to a minimum to expedite dissemination. Items Delta and Foxtrot (fig. 4-3) will not be sent in the clear unless the time will not allow encoding and decoding.
- (8) Unit SOP should require that strike warning 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).

d. Normally it is not necessary or desirable to transmit the strike warning message in the format shown in figure 4-3 to company-/battery-size units. Any such unit located in zone 3 (fig. 4-2) or closer to the desired ground zero should, by SOP, receive a message containing specific orders on the protective measures to be implemented by that unit. The message should include—

- (1) A proword indicating that the message is a nuclear strike warning.
- (2) A brief prearranged message that directs the unit to observe a specific protective measure (including evacuation to an alternate position if within Zone 1). The SOP should state the period of time during which the personnel must remain protected.
- (3) Expected time of burst.

e. All available communications means are used to permit rapid dissemination of warnings of the employment of nuclear weapons against targets of opportunity. These means include—

- (1) Sole-purpose telephone circuits, wire, or radio relay.

- (2) FM and AM voice radio nets.
- (3) Continuous wave and radioteletype-writer nets.
- (4) One-way voice radio nets. This communication does not give the recipient the capability of acknowledgment; the recipient may be required to acknowledge over a different means of communications. The range and coverage of this net may cause the message to be sent to units that do not need to be warned.

f. A fragmentary warning order may be issued while a fire mission is being processed to alert unit personnel that they are in an area in which they may receive the effects of a weapon being considered for employment. The personnel are cautioned to remain alert for a followup message that will cancel, confirm, or alter the warning. The followup message is sent whenever the time of burst is determined or the decision is made not to fire the weapon.

g. While units outside the area in which effects may be received normally are not sent a nuclear strike warning message, effective liaison may require that strike data be passed to adjacent units as a matter of SOP, particularly for those friendly strikes that are in close proximity to a boundary between major units. Information concerning these strikes is of operational concern (e.g., information used to update situation maps in the TOC that portray areas radiological contamination and obstacles to maneuver of friendly forces).

4-7. Fire Requests

a. When a commander has a requirement for nuclear fires and has the weapon but not the authority to fire, he may request authorization to fire from the next senior releasing commander. When the commander has neither the weapon nor the authority to fire, he may request delivery of nuclear fires from the next higher commander. (Fig. 4-5 shows an example of a division nuclear fire request to corps.) Simultaneously, the fire direction center (FDC) or the tactical air control center is alerted. Requests contain sufficient informa-

tion to permit a complete evaluation of the fire mission. As a minimum, a request contains a description of the target, the results desired, and the desired time of burst. The request may contain additional information, such as limiting requirements, location of the desired ground zero, acceptable risk to friendly troops, or location and degree of protection of nearest friendly troops. If the target has been analyzed by the requesting agency, the request for fires may specify the desired weapon and yield.

b. The next higher releasing commander may approve or disapprove the request. In some cases, he may submit a request to his next higher commander for release of a weapon more suitable than any presently available to him.

c. Upon approval or disapproval of a fire request, the requesting agency is notified. Whenever possible, a commander who disapproves a request provides the requesting agency with the reason for the disapproval and will substitute another type of fire support whenever possible.

4-8. Fire Orders

a. Once a fire mission has been approved, fire support agencies are given the necessary orders to cause the weapons to be delivered on the target.

- (1) Orders to Army delivery units include—
 - (a) Unit to deliver the weapon.
 - (b) Firing site, if applicable.
 - (c) Delivery system/yield.
 - (d) Height of burst in meters or height-of-burst option.
 - (e) When applicable, fuzing option desired (e.g., contact backup or contact preclusion).
 - (f) Desired ground zero.
 - (g) Time of burst/latest time of burst.
 - (h) Resupply instructions, if applicable.
- (2) If air-delivered weapons have been provided an Army unit, the message to the tactical air control center includes—

STRIKWARN

Alfa : Code word indicating nuclear strike (target number).

Delta : Date-time group for time of burst in Zulu time. The time after which the strike will be canceled (Zulu time).

Foxtrot: DGZ (UTM grid coordinates).

Hotel : Indicate air or surface bursts.

India : For all bursts:

MSD 1 in hundreds of meters (four digits).

MSD 2 in hundreds of meters (four digits).

MSD 3 in hundreds of meters (four digits).

Yankee : For all bursts when there is less than a 99-percent assurance of no militarily significant fallout.

Direction measured clockwise from grid north to the left, then right, radial lines (degrees or mils--state which) (four digits each).

Zulu : For all bursts when there is less than a 99-percent assurance of no militarily significant fallout.

Effective wind speed in km/hr (three digits).

Downwind distance of zone I (km) (three digits).

Cloud radius (km) (two digits).

Figure 4-3. Format of STRIKWARN message for friendly nuclear strikes.

1. Airbursts $\geq$ 99-percent assurance of no militarily significant fallout:
 STRIKWARN. ALPHA TUBE SIX. DELTA PQ
 WM OT AR/AS DG WY OF. FOXTROT YM AB
 IM SK. HOTEL AIR. INDIA 0022 0031
 0045.

2. All bursts < 99-percent assurance of no militarily significant fallout:
 STRIKWARN. ALPHA TUBE SIX. DELTA PQ
 WM OT AR/AS DG WY OF. FOXTROT YM AB
 IM SK. HOTEL SURFACE. INDIA 0022 0031
 0045. YANKEE 0215 0255 DEGREES.
 ZULU 025 080 18.

Figure 4-4. Examples of STRIKWARN message.

- (a) Yield.
- (b) Permissible circular error probable (CEP).
- (c) Height of burst in meters; or, in the case of radar-fuzed weapons, height-of-burst option.
- (d) When applicable, fuzing option desired (e.g., contact backup or contact preclusion).
- (e) Desired ground zero.
- (f) Time of burst/latest time of burst.
- (g) Applicable coordination measures.
 For example—
 - 1. Special signal procedures, such as marking of the target, marking of the initial point, and abort signals.
 - 2. Flak suppression measures.
 - 3. Special air defense coordination procedures.

b. Early notification to the delivery unit reduces delays in firing. Advance information with which to occupy firing sites, compute firing data, and prepare the nuclear round is desirable. On some occasions, this information is given to the delivery unit prior to the time a decision is made to employ the weapon.

c. Fire support agencies may be ordered to prepare an alternate nuclear weapon system (either of the same type or of a different type) or to plan nonnuclear fires in the event the first weapon fails.

4-9. Employment of Atomic Demolition Munitions

a. Certain nuclear munitions are designed for emplacement at the desired ground zero by engineer personnel or by other qualified personnel who have been specially trained. Nuclear munitions employed in this manner are called atomic demolition munitions. Generally, ADM are employed against the same type of targets as are nonnuclear demolitions. ADM are also used to create large-scale obstacles and to produce fallout. They have the advantage of delaying repair or use of an area because of residual radiation. Once a decision has been made to employ ADM, suitable munitions are made available to the commander within whose area they can be used advantageously. For detailed description of ADM employment and analysis see FM 5-26.

b. An atomic demolition plan includes—

- (1) Target number and description.
- (2) Type of ADM, yield, depth of burst, and location of the desired ground zero.
- (3) Designation of emplacing unit.
- (4) Designation of supporting units, with coordination instructions.
- (5) Methods of firing.
- (6) Security instructions, including designation of the unit to furnish se-

CHAPTER 5

OPERATIONS IN RESIDUAL RADIATION AREAS

5-1. General

a. Nuclear radiation that results from a nuclear explosion and persists longer than 1 minute after burst is termed "residual radiation." Residual radiation can contaminate the airspace over the area of operations, the terrain itself, or both, depending primarily on the height of burst of the weapon. Contamination of the airspace is for a relatively short period of time, and the radiation hazard to aircraft flying within the area is minimal. Residual radiation consists primarily of gamma and beta radiations, both of which present a serious personnel hazard. The gamma radiations are by far the more significant because of their range and penetrating power. Residual radiation can appear on the ground as induced contamination, which is found within a relatively *small* circular pattern around the ground zero; and as fallout, which is found in a large, irregular pattern encompassing the ground zero and extending for long distances downwind from the burst point.

- (1) When a weapon is exploded at a height to preclude damage or casualties to ground targets, *neither* induced contamination *nor* fallout of tactical significance occurs. However, if rain (or snow) falls through the nuclear cloud, tactically significant *fallout* may result.
- (2) When the height of burst is lowered below that indicated above to produce damage or casualties on the ground, but is kept above the fallout-safe height, induced contamination occurs. Fallout considerations are the same as those in (1) above.
- (3) When a surface burst is employed, both induced contamination and sig-

nificant fallout result. The fallout pattern can be expected to overlap and to mask the entire induced contamination pattern.

- (4) Shallow subsurface bursts produce both induced contamination and fallout patterns on the ground.

b. Induced contamination and fallout have certain characteristics in common.

- (1) Both persist for relatively long periods.
- (2) Fallout consists largely of very fine particles and covers large areas. Induced contamination may be found to a depth of about one-half meter. For these reasons, the areas affected by both types of radiation are difficult to decontaminate.
- (3) The size, shape, and location of fallout patterns are sensitive primarily to the wind structure. The size and intensity of the area of induced contamination are extremely sensitive to the variability of the soil composition. For these reasons, areas affected by both types of radiation are difficult to predict; however, fallout prediction is by far the more difficult and important problem.

c. The large areas contaminated by fallout pose an operational problem of great importance. Potentially, fallout may extend to greater distances and cause more casualties than any other nuclear weapon effect. It exerts an influence on the battlefield for a considerable time after a detonation. Induced contamination is relatively *limited in area*, and *minor* tactical changes normally can be made to avoid any serious effects.

d. The biological response of humans to residual radiation is essentially the same as their response to initial radiation. The total dose of radiation absorbed by an individual is the sum of the initial radiation doses and the residual radiation doses he has received. Biological response to radiation is discussed in detail in paragraph 2-22.

5-2. Induced Contamination

a. All radioactive materials decay. The rate at which this decay takes place depends on the soil elements themselves. Some (e.g., sodium) decay slowly and others (e.g., aluminum) decay rapidly. This decay rate, measured in terms of "half-life," and the element's gamma radiation intensity determine the significance of the induced radiation hazard. The distance to which a 2-rad-per-hour dose rate extends 1 hour after burst is considered the limit of significant induced activity. Estimates of the extent of the 2-rad-per-hour contour, are contained in table B-III-1, FM 101-31-2 and chapter 18, FM 101-31-3.

b. Whenever a nuclear attack is being planned, the nuclear weapon employment officer advises the commander and the staff of the possible hazard of induced contamination. After the attack, a radiological contamination chart is made from the reports of radiological survey teams. In comparison with other nuclear weapon effects, however, induced radiation *does not pose a threat* of major military significance.

- (1) It may be extremely hazardous for troops to enter and to stay in an area of induced contamination. Because of the great destruction near the ground zero, where induced contamination may be found, there is seldom a requirement for troops to enter and stay in the area. In the event occupancy is necessary, radiation is monitored to insure that allowable total doses are not exceeded.
- (2) Thirty minutes after burst, troops in vehicles may usually pass through the ground zero and foot troops may usually pass within 300 meters of the

ground zero without undue radiation risk. (It is emphasized that this is true only if the burst was at sufficient altitude to preclude fallout. The area around GZ 30 minutes after fallout producing bursts will be subject to extremely high dose rates.)

The area of induced contamination is relatively *small*, and it should be possible to avoid it or to traverse it rapidly.

5-3. Fallout

a. Radioactive fallout also decays. The decay rate from a single weapon can be determined fairly accurately by using the M1 radiac calculator. For a quick estimate of fallout decay, the intensity can be considered to decrease tenfold as the time after burst increases by multiples of 7. Thus a 50-rad-per-hour dose rate (measured at H+1 hour) decays to a five-rad-per-hour dose rate in 7 hours and about one-half rad-per-hour dose rate at H+42 hours.

b. Use of fallout is discussed in paragraph 4-10.

c. Reduced to fundamentals, the major aspects of fallout deposition are as follows:

- (1) Fallout is formed whenever the nuclear fireball intersects the ground.
- (2) The heavier fallout particles start reaching the ground around the ground zero within a few minutes after burst. The lighter particles reach the ground farther downwind at later times. Figure 5-1 illustrates how total dose may vary with time and distance.
- (3) The size, shape, and location of the areas contaminated by fallout depend largely on the winds that blow the particles that rise with the nuclear cloud and then fall back to earth. Changing wind directions can subject some locations to long periods of fallout deposition.
- (4) Greatest intensity is usually close to the ground zero, but high-intensity "hotspots" and low-intensity "areas"

may occur throughout the pattern because of winds or rain.

d. The total radiation dose absorbed by an individual is a function of radiation intensity, exposure time, and protection.

e. Residual radiation is absorbed or reflected in the same manner as prompt gamma radiation.

See paragraph 2-21b for shielding considerations.

f. FM 3-12 provides procedures to compute permissible exposure times and total doses in fallout areas. The M1 radiac calculator can also be used to compute total doses and exposure times in single weapon fallout areas.

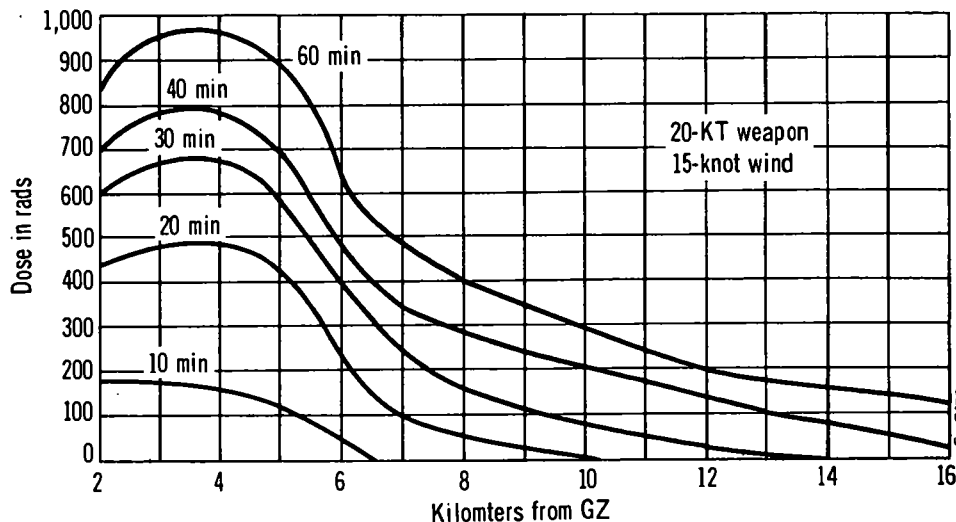


Figure 5-1. Total dose variation as a function of time after bursts and distance from the burst.

5-4. Prediction of Fallout Areas

(This paragraph is based on STANAG No. 2103.)

a. A tactical fallout prediction system must be a compromise between speed and simplicity, on the one hand; and the time-consuming complexity that increases accuracy, on the other. The present U.S. Army method of predicting fallout gives only a warning sector, somewhere within which most of the fallout is expected to occur.

b. The U.S. Army and U.S. Marine Corps method of fallout prediction is explained in TM 3-210. The prediction results in portrayal of an area that is expected to contain most of the significant fallout. A detailed prediction is prepared in the tactical operations center, based on the best available weather and weapon data. Brigade and lower units use the M5 fallout predictor and effective wind message

to estimate the hazard area; the M5 predictor is applied using less precise data. Both predictions present a *graphical* portrayal of the expected hazard. The hazard area is subdivided into—

- (1) An area within which countermeasures may have to be taken immediately (divided into two separately defined sub-areas); and
- (2) An area in which early, but not immediate, action may have to be taken to counter the threat of unacceptable doses.

c. The basic inaccuracies in fallout prediction permit this method to be used in depicting suspect areas for early monitoring and survey, as well as for planning movement of units, but *not as a basis for executing operational moves* (para 5-5a(1)). The method also permits prediction of the areas outside which

friendly troops are likely to have relative immunity from the fallout hazard.

d. In an active nuclear war, it is reasonable to expect fallout at a given location occasionally to be caused by more than one nuclear burst, thereby causing multiple overlapping fallout patterns. See FM 3-12 and TM 3-210 for the proper technique to handle such situations.

5-5. Basis for Standing Operating Procedures for Operations in Fallout Areas

a. Command decisions in any fallout situation are based on consideration of two opposing factors: the demands of the tactical situation and the hazards due to radiation. At one extreme, the total energies of the unit are directed toward keeping the radiation exposure at a minimum. At the other extreme, the demands of the tactical situation are clearly dominant.

- (1) *Radiation hazard dominant.* In general, two courses of action are considered: early movement from the fallout area and remaining in position.

(a) *Early movement.*

1. When air or surface transport means are available, evacuation from the area as soon as possible normally is the best course of action.
2. When the shielding provided by the exit means is approximately equal to or better than that available in the position (and in the absence of air evacuation means), movement from the area is accomplished as soon as the minimum-dose exit route can be determined. See FM 3-12 for details.
3. Fallout predictions are *not* sufficiently accurate to be used as a sole basis for such moves. Therefore, movements normally are based on measured dose rates and dosimeter readings obtained *after* the fallout has begun. From such

readings, the direction of decreasing intensities and the limits of the fallout pattern nearest the unit are determined. From this, a minimum-dose exit route is selected. A method for determining the optimum time for exit of fallout areas is given in FM 3-12.

4. All available shielding measures are taken within the position until evacuation or movement has begun.

(b) *Remaining in position.* When the total dose expected in the position is significantly less than that which would occur by moving, the best solution is the remain in position for approximately 6 hours after the burst, at which time movement from the pattern can be made or decontamination operations can be begun.

(2) *Tactical demand dominant.*

- (a) When the tactical demand clearly governs, the unit continues to place primary emphasis on the accomplishment of its mission. The unit takes action whenever possible to keep radiation exposure to a minimum. These actions usually consist of decontamination and the use of available shielding.
- (b) Decisions to shift emphasis toward countermeasures against radiation are dependent on a capability to predict with reasonable accuracy the times at which the crucial radiation doses will be reached. Such predictions can be made when the peak dose rate and the time to peak (in minutes after burst) are known. When such predictions cannot be made because unit survey meters have gone off scale, it can be assumed that the unit will be exposed to incapacitating radiation doses within a few minutes unless immediate countermeasures are taken.

individuals and equipment with physical protection to reduce weapon effects. The best protection is afforded by deep underground shelters. Such structures are expensive in time and materials; their construction on the battlefield usually is not feasible. Reliance is placed on hasty field fortifications, such as trenches, foxholes, emplacements, revetments, bunkers, and simplified underground shelters. Tanks provide considerable protection against the effects of a nuclear explosion. Armored personnel carriers provide considerable protection against blast and thermal effects and some protection against initial nuclear radiation. Tracked carriers also provide some protection against residual radiation. Wheeled vehicles provide no protection against blast or initial nuclear radiation. Vehicle tarpaulins provide considerable protection against thermal radiation. Sandbags on the beds of trucks provide some protection against residual radiation. See FM 101-31-2 and chapter 18, FM 101-31-3 for appropriate transmission factors.

c. Minimization of the Time of Exposure.

Techniques for minimization of the time of exposure to radiation are discussed in chapter 5.

d. Radiological Decontamination. Radiological decontamination is the process of reducing to an acceptable level the hazard of radioactivity from residual contamination. Radioactive contaminants are fission products, fusion products, unfissioned active material, and matter in which radioactivity has been induced. Some methods of decontamination are surface cleansing or scraping, sealing, and disposal. Decontamination processes do not neutralize or destroy radioactivity. These processes seek to diffuse and dilute the contamination to a safe level. Individual decontamination measures reduce radiation hazards that would result from ingestion or inhalation of radioactive particles coming in contact with the skin and clothing. Area decontamination requires organization, supervision, and considerable time, effort, and materiel. Decontamination procedures are discussed in detail in TM 3-220.

Section II. INDIVIDUAL PROTECTIVE MEASURES

6-3. General

a. Paragraph 4-6 discusses a warning system that permits timely notification of intended friendly employment of nuclear weapons. This system is also used to warn friendly troops in the isolated cases when enemy nuclear weapon employment is known in advance. For friendly employment, adequate warning is required to allow the individual to achieve the degree of protection assumed in the target analysis leading to a given burst. In the case of possible enemy employment, each individual observes the best protective procedures that his situation permits (table 6-1).

b. Specific references that should be consulted for more detailed information pertaining to protective measures are FM 21-40 and FM 21-41.

6-4. Enemy Employment

a. Proper reaction to attack offers the in-

dividual some chance for survival and early continuation of his mission. All personnel are trained to react rapidly, as follows:

- (1) If exposed, move no more than a few steps to seek shelter.
- (2) Drop flat on the ground.
- (3) Close eyes.
- (4) Protect exposed skin surfaces.
- (5) Remain prone until after the blast wave has passed or debris has stopped falling.

b. Enemy nuclear weapons are expected to be followed by attacks involving enemy infantry, armor, or both. Individuals and units prepare to repel enemy followup operations, which may be accompanied by conventional artillery fires and use of chemical and biological agents.

Section III. UNIT PROTECTIVE MEASURES

6-5. Standing Operating Procedures

a. For the *friendly* employment of nuclear weapons, the SOP establishes the normal troop safety criteria, radiation exposure control procedures, maximum and minimum warning times, warning system procedures, and fallout prediction dissemination procedures.

b. Damage assessment, control, and repair responsibilities as well as monitoring and survey, decontamination, and reporting responsibilities are established.

c. Minimum separation distances between critical installations, such as command posts; nuclear delivery means; and reserve units are specified.

d. The succession to command, the shift of control among headquarters, and alternate means of communications, transport, supply, and evacuation are established.

e. A complete SOP minimizes the disruption caused by nuclear attack and establishes suitable patterns of action for surviving individuals, units, and staff sections. Commanders modify the SOP on a case-by-case basis as circumstances require.

6-6. Training

Individual and unit training emphasizes the protective actions leading to survival in nuclear war. This training embraces a knowledge of weapon effects, fallout, evasive actions, decontamination, and relative worth of battlefield shelters. Recovery plans are rehearsed and integrated into the scenarios of field exercises. Training in operations in areas of residual contamination is tied to instruction in monitoring and survey techniques (para 5-7).

6-7. Monitoring and Survey

a. Radiological monitoring involves the use of radiac instruments to detect and to measure ionizing radiation. (The individual who uses these instruments is known as the monitor.) Radiac instruments are of two types: *survey meters* to measure dose rate and *dosimeters* to

measure total dose. Monitoring provides warning of a hazard that, except for the use of radiac instruments, would go unmeasured. Monitoring is included in normal reconnaissance and intelligence activities and does not appreciably interfere with the primary mission of the monitor or his unit.

b. Radiological survey is the systematic, organized use of survey parties whose mission is to determine the location, extent, and dose rate of residual radiation in an area. When monitoring data are insufficient to the needs of brigade, division, and higher echelons, surveys may be directed to obtain essential information upon which to base tactical and combat service support plans. In the Army, the chemical officer and in the Marines, the NBC defense officer supervise the planning of surveys, the processing of survey data, and the marking of hazardous areas. Commanders at all echelons are responsible for the training of survey parties and for performing surveys as required or directed.

c. The information gained from the activities of radiological monitors and survey parties provides a basis for decisions on the requirement for protection, entry, stay, and departure times from contaminated areas and for movement of units and supplies.

d. Detailed procedures for monitoring and survey operations are discussed in FM 3-12.

6-8. Control and Communications

a. The problems of command and control multiply as tactical units disperse to avoid detection and attack. Even in the best trained units, some confusion will follow a nuclear attack because of surprise, shock, physiological and psychological casualties, materiel damage, and reduced visibility. An important means of maintaining or restoring command and control is the communications network, both within and between units.

b. Unless units are strictly controlled during the immediate post attack phase, communications will be overloaded by reports and requests

APPENDIX B

TARGET ANALYSIS

B-1. General

a. Target analysis is a comparison of the characteristics of the target(s) to be attacked with the effects that the available weapon(s) and delivery system(s) can produce. The analysis results in the selection of the most suitable weapon system for attack and in the prediction of damage that should be sustained in the target area as a result of the attack.

b. The target analyst must be proficient in analyzing targets for attack with chemical, biological, and nuclear weapons. Procedures and data for use in analyzing targets for attack with chemical and biological weapons are found in FM 3-10, FM 3-10A, and FM 3-10B.

c. This appendix outlines the procedures that the target analyst follows in analyzing targets suitable for nuclear attack. An understanding of the general discussion of target analysis in chapter 3 of this manual will assist the analyst in an understanding of the detailed explanations set forth in this appendix.

d. This appendix is organized as follows:

- (1) Annex B-I discusses probabilities and procedures used in computing a probability. Annex B-I also discusses the concept of damage and defines the term "radius of damage" (RD).
- (2) Annex B-II discusses the three methods used to compute damage estimation: index method, visual method, and numerical method.
- (3) Annex B-III discusses limiting requirements and their influence on nuclear weapon employment. The discussion of limiting requirements is divided into troop safety and preclusion of damage/obstacle considerations.

- (4) Annex B-IV discusses the desired ground zero, the effects on target coverage when the desired ground zero is displaced from the target center, and the procedures used in selecting the desired ground zero.
- (5) Annex B-V discusses the special considerations necessary when targets cannot be equated to one of the major categories listed in FM 101-31-2 and FM 101-31-3, or when nonstandard delivery errors are present in a weapon system.
- (6) Annex B-IV discusses poststrike analysis based on the refinement of damage estimation from known data, using the numerical or the visual method of damage estimation.
- (7) Annex B-VII discusses friendly vulnerability and the procedures used to predict the results of an assumed enemy nuclear attack on friendly troop dispositions and/or installations.

B-2. General Procedures for Performing Target Analysis

Figure B-1 outlines a four-step procedure for use as a guide in performing target analysis. Analysts will normally develop procedures that best fit their own experience, ability, and command guidance; however, use of the outlined procedure will insure a complete and correct analysis. An explanation of the information required in performing the steps listed in figure B-1 is included in *a* through *d* below.

a. *Step 1. Identify Pertinent Information.* Step 1 includes target information, friendly information, and information that normally

TARGET ANALYSIS PROCEDURE

1. Identify Pertinent Information
 - a. Target information.
 - b. Friendly information.
 - c. SOP and command guidance.
2. Determine Data for-
 - a. Damage estimation.
 - (1) Index method.
 - (2) Visual method.
 - (3) Numerical method.
 - b. Limiting requirements.
 - (1) Troop safety.
 - (2) Damage and obstacle preclusion.
 - c. DGZ selection.
 - d. Final coverage.
3. Evaluate Weapon Systems and the Tactical Situation
4. Make Recommendation

B-0176

Figure B-1. Target analysis procedure.

will be found in standing operating procedures and received from command guidance.

- (1) *Target information.*
 - (a) Location, size, and shape of the target.
 - (b) Category of target element (e.g., personnel).
 - (c) Distribution of target elements within the target complex and their degree of protection against weapon effects.
 - (d) Stability of the target.
- (2) *Friendly information.*
 - (a) Weapons available.
 - (b) Location of available weapons.
 - (c) Location of delivery means.
 - (d) Location of firing positions.
 - (e) Location of friendly troops in zone(s) of planned burst, their degree of protection from weapon effects, and their radiation exposure status.
 - (f) Location of installations not to be damaged.
 - (g) Response times. The state of train-

ing and amount of time required by a unit to delivery its weapon (response time) must be considered along with the stability of a target. General planning guidance for each weapon system is given in FM 101-31-2. However, the analyst must acquire more definitive guidance from the units assigned to the command.

- (3) *Standing operating procedures and command guidance.*
 - (a) Desired damage to the target.
 - (b) Degree of acceptable risk to preclude undesirable effects on friendly units.
 - (c) Prohibitions against the creation of obstacles.
- (4) *Remarks.*

- (a) Some of the target information contained in (1) above, will frequently be missing. Consequently, the target analyst must coordinate with the G2 and make assumptions concerning the size and composition of the target. When target intelligence does not indicate otherwise, the target elements are assumed to be uniformly distributed in a random orientation; the area

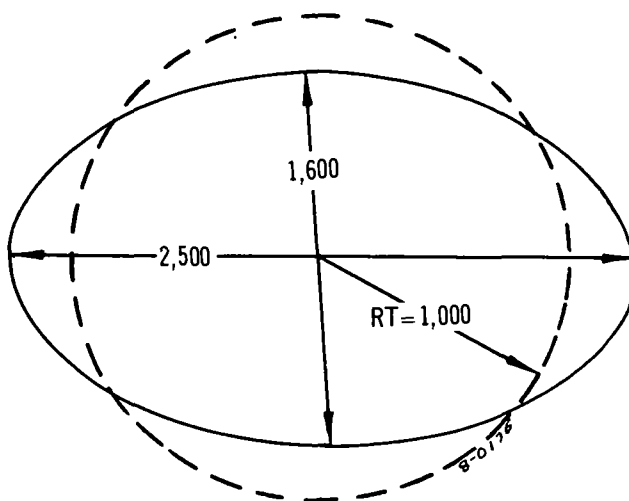


Figure B-2. Determination of the target radius.

is assumed to be circular; and a radius is determined based on the best information available.

- (b) If the target is circular, or nearly so, the radius of target (RT) is the radius of the target circle. If the target is more nearly elliptical or rectangular in shape, with its major dimension less than twice the length of the minor dimension, the radius can be established by drawing a circle that includes an area outside the target equal to the target area outside the circle (fig. B-2). The radius may also be established by visual inspection with a circular map scale. When the major dimension is equal to, or more than, twice the length of the minor dimension, the target cannot be equated to a circle and the visual method must be used.
- (c) Based on the target information, the target analyst determines which category of target best fits the target under analysis.
 1. For each weapon system and yield, tables are provided for four target vulnerability categories: exposed personnel (prompt and delayed casualties); protected personnel (prompt and delayed casualties); wheeled vehicles; and tanks and artillery.
 2. Target vulnerability categories have been established for the primary types or ground tactical targets expected. These categories can be equated to other types of targets as shown in the equivalent target table in FM 101-31-2 and chapter 18, FM 101-31-3. (The equivalent target table is reproduced as figure B-II-2 in annex B-II to this appendix.) The accuracy of such application is usually consistent with target intelligence and knowledge of weapon effects.

b. *Step 2. Determine Data.*

(1) *Estimate damage to the target.*

- (a) Depending on the characteristics of the target, there are three methods of estimating damage: index, visual, and numerical.
 1. *Index method.* The indexes in the coverage tables contained in FM 101-31-2 and FM 101-31-3 are an indication of the suitability of a particular weapon system for attack of a given target. Coverage tables have been designed for targets consisting of exposed personnel, protected personnel, tanks and artillery, and wheeled vehicles. Other targets of similar vulnerability are equated to one of the four major categories in the equivalent target table (fig. B-II-2, annex B-II to this app). Using the indexes in the coverage tables, the analyst can estimate the effectiveness of an attack.
 2. *Visual method.* The radii of damage in the coverage tables have been precomputed taking into consideration the vertical dispersion associated with the system at the range of interest. The target analyst applies the appropriate radius visually to the target, considering horizontal dispersion. He then visually estimates how much of the target area is covered by the radius of damage.
 3. *Numerical method.* The target analyst uses the radius of damage, the radius of target, the displacement distances, and the characteristics of the horizontal dispersion pattern to enter the area target graph. The result of this operation presents the analyst with an estimate of the coverage of the target or the probability of destroying it. The estimate of coverage of a circular area target is

more accurate if the index method is used. Therefore, the numerical method is used primarily for estimating damage to point targets, or when the desired ground zero is displaced from the center of a circular area target.

4. *Special Methods.* Because of certain differences regarding target analysis when considering the use of Atomic Demolition Munitions, the techniques described herein must be modified. For analysis of targets with ADM the reader is referred to the detailed explanation in FM 5-26.
 - (b) A detailed explanation of the techniques employed in each of the three methods of target analysis is contained in annex B-II.
- (2) *Consider limiting requirements.*
 - (a) Restrictions placed on the employment of nuclear weapons 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.
 1. *Troop safety.* The target analyst checks the distance that separates friendly troops from the desired ground zero to insure that the troops will not be exposed to a risk exceeding that specified by the commander.
 2. *Preclusion of damage/obstacles.* The target analyst checks to insure that undesirable results are avoided. These undesirable results usually consist of obstacles to movement (tree blowdown and/or fires), damage to structures (bridges, supply dumps) or damage to heavily populated civilian areas.
 - (b) A detailed explanation of limiting requirements is contained in annex B-III.

- (3) *Select the desired ground zero.* To obtain the maximum effectiveness of a weapon, the target center, or the center of mass of a target, is selected initially as the desired ground zero. However, limiting requirements, or the attack of multiple targets with a single weapon, may require the desired ground zero to be displaced. The effects of this displacement and a detailed explanation of the techniques used in selecting the desired ground zero are contained in annex B-IV.
- (4) *Predict the final coverage.* When displacement of the desired ground zero is required, or when attacking multiple targets, a prediction of the final coverage of the target must be made, using either the visual or the numerical method of damage estimation (annex B-II). This predicted final coverage will be a factor in the selection of a weapon system.

c. Step 3. Evaluate Weapon Systems and the Tactical Situation. In this step, the most suitable weapon system is selected to attack each target; the best weapon-target combination must be determined. This determination involves consideration of several factors, some of which are as follows:

- (1) The highest priority target will receive first consideration.
- (2) The weapons selected must be within the total number of each type that have been authorized for expenditure.
- (3) Based on command guidance, the more responsive, reliable, and accurate weapon system may be retained for later employment on targets of opportunity.
- (4) If all other considerations are equal, the minimum yield weapon with a sufficiently high probability of providing the coverage that insures the desired results should be selected.

d. Step 4. Make Recommendation.

- (1) *General.* After the target analysis has

ANNEX B-I

PROBABILITY AND CONCEPT OF DAMAGE

(This annex is based on SOLOG No. 89.)

B-I-1. General

In conventional artillery fires, weapon effects are obtained by firing many rounds and allowing the inherent delivery errors to place the rounds randomly throughout the target area. In nuclear fires, weapon effects are dependent on the delivery errors of a single round. Consequently, it is necessary to predict the weapon effects on the target. This prediction is accomplished based on a comparison of the weapon effects with the characteristics of the target; and includes the effects of the weapon, measured by its radius of damage and the delivery errors. To analyze targets properly, a nuclear weapon employment officer should possess an understanding of probability and concept of damage as presented in this annex.

B-I-2. Definition of Probability

Probability may be defined as the chance of a certain event occurring. It may be expressed at the ratio, fraction, or percentage of the number of favorable (or unfavorable) events to the total number of possible events. Thus, probability may be expressed in terms of success or failure. For instance, the probability of a coin falling "heads" is $\frac{1}{2}$ (1 in 2), 0.5, or 50 percent (usually expressed as 0.50). The probability that the coin will *fail* to fall "heads" is 0.50. The probability that a die will stop rolling with the 2 spot up may be stated as $\frac{1}{6}$ (1 in 6) or 0.167, and the probability that it will not show a 2 spot is $\frac{5}{6}$ or 0.833. The probability that a nuclear weapon will fall within a given distance of the desired ground zero or will burst within a given distance of the desired height of burst may also be determined. The terms "probability," "assurance" and "chance" are synonymous within this manual.

B-I-3. Assumptions

a. Analysis is based on the assumption that a given nuclear weapon will function at ap-

proximately the rated yield within the established accuracies of the delivery system. This assumption simplifies target analysis procedures, but the implications should be understood. The influence of the *reliability* of a weapon system (its probability of getting the weapon to the target and detonating it) on the overall probability of a successful attack must be considered. Cannon- and rocket-delivered weapons have reliabilities of essentially 1.0. The more intricate weapon systems (e.g., guided missiles) have reliabilities less than those of cannon and rockets.

b. Based on the assumption that a nuclear weapon delivery system will perform successfully, probability considerations are applied at the desired burst point in the target area. The probability of success will be affected principally by the delivery accuracy of the system.

B-I-4. Effects of Horizontal and Vertical Accuracy

a. General. The assumption is made that many rounds are fired from an artillery piece at a given range at the same target under identical conditions. The rounds falling in the impact area will form an elliptical pattern. The mean point of impact (MPI) for this pattern can be determined. Variation from this mean is called "dispersion," and the pattern is referred to as the "normal distribution pattern." The shape of the pattern formed in the impact area will vary among delivery systems; but, for damage estimation purposes, these dispersion deviations are mathematically converted to circular equivalent patterns, which are called circular errors probable (CEP). In target analysis involving the employment of nuclear weapons, it is assumed that the distribution of errors connected with nuclear delivery systems will conform to this normal distribution pattern. It is also assumed that the mean

point of impact will coincide with the desired ground zero.

b. Horizontal Dispersion. Horizontal dispersion associated with nuclear target analysis is expressed in two terms—circular error probable and circular distribution 90 (CD90).

(1) *Circular error probable.*

- (a) By definition, 1 CEP represents the radius of a circle within which one weapon has a 50-percent probability of arriving. Figure B-I-1 represents the normal circular distribution pattern around the mean point of impact for a large number of weapons. A 2-CEP circle, which is twice the radius of a 1-CEP circle, includes approximately 94 percent of the weapons fired or dropped. A 4-CEP circle contains essentially all such weapons. Some erratic rounds, although very few, may fall outside the 4-CEP circle.

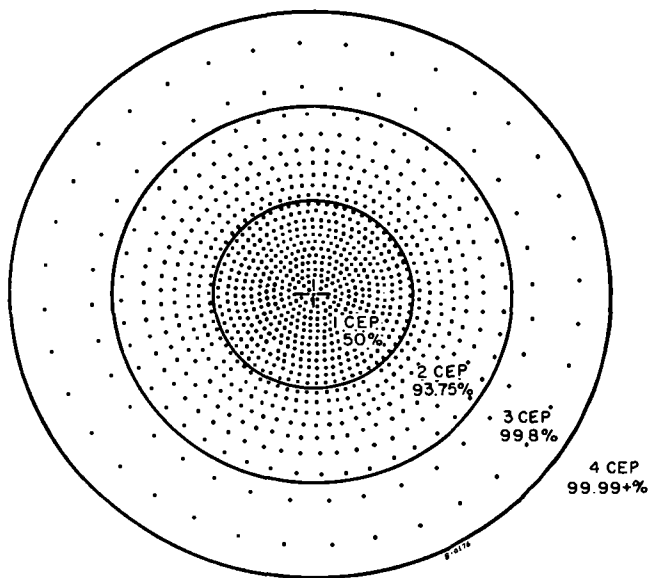


Figure B-I-1. Normal circular distribution pattern.

- (b) It should be noted that 99 percent of all rounds fired will fall on one side of the tangent to the 2-CEP circle (fig. B-I-2). This factor is a

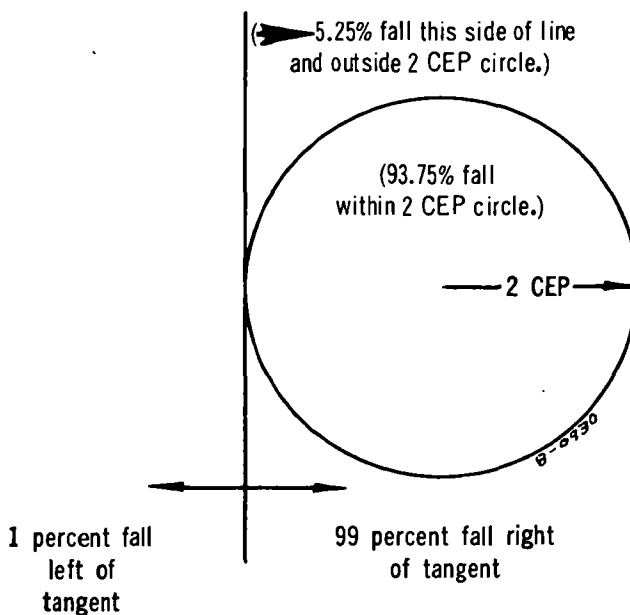


Figure B-I-2. Tangent to the 2-CEP circle.

consideration in determining troop safety criteria.

- (c) Circular error probable data have been precomputed for each weapon system and are provided in the accuracy data portion of the coverage tables in FM 101-31-2 and FM 101-31-3.
- (2) *Circular distribution 90.*
- (a) By definition, the circular distribution 90 represents the radius of a circle around the desired ground zero within which one weapon has a 90-percent probability of arriving. An understanding of the circular distribution 90 is important to the analyst, because it is the circular distribution error used in all methods of target analysis to insure at least a 90-percent probability of obtaining a specified amount of coverage.
- (b) Circular distribution 90 data have been precomputed for each weapon system and are provided in the accuracy data portion of the coverage tables in FM 101-31-2 and FM 101-31-3.

- (3) *Unsuitable index values.* An unsuitable index is one in which the index is less than the minimum required. For example, a .1/.1 index normally would be unsuitable for neutralization of a target and therefore is not listed with those indexes considered suitable. An index in excess of the minimum required is never considered unsuitable, even though indiscriminate use could lead to a waste of combat power. Table B-II-1-1 displays the indexes considered suitable when using the index method of damage estimation.

Table B-II-1-1. Index Guidance Criteria

Commander's guidance	Minimum coverage	Maximum coverage	Results
10	0.1/0.2	0.9/0.9	Neutralization.
20	0.2/0.3	0.9/0.9	Neutralization.
30	0.3/0.4	0.9/0.9	Destruction.
40	0.4/0.5	0.9/0.9	Destruction.
50	0.5/0.6	0.9/0.9	Destruction.
60	0.6/0.7	0.9/0.9	Destruction.
70	0.7/0.8	0.9/0.9	Destruction.
80	0.8/0.9	0.9/0.9	Destruction.

- (4) *Large index-number variations.* A wide difference (more than .4) between the indexes (e.g., .3/.8) results when a large weapon, with its inherent inaccuracies, is employed against a target.
- (5) *Determination of coverage index values.* To determine the coverage index for the target being considered, the target analyst selects the appropriate coverage table.
- (a) A coverage table is provided for each target category, delivery system, yield, and low airburst and surface burst options.
- (b) The target analyst enters the appropriate coverage table, using the appropriate radius of target and the nearest range. Interpolation between ranges is not required. If the given range is exactly halfway between two listed ranges, he enters at the nearest listed range in even-

numbered thousands (e.g., if a given range is 10,500 meter, round off *downward* to 10,000 meters; if a given range is 11,500 meters, round off *upward* to 12,000 meters).

- (c) Figures B-II-1-1 and B-II-1-2 show examples of coverage tables for a short-range cannon with a 1-kiloton yield and a low airburst option against protected personnel. If the target range is 8,000 meters and the radius of target is 600 meters, the following extract of the tables results:

1. If the plan of maneuver requires prompt casualties, the 3,000-rad or the translational-effect criterion is used: an index of .5/6 results (fig. B-II-1-1).

2. If delayed casualties are acceptable, the 650-rad criterion is used; an index of .9/.9 results (fig. B-II-1-2).

3. The estimate of damage, in this case, indicates that there is —

- (a) Fifty-percent probable minimum coverage and 60-percent average coverage for prompt casualties to protected personnel; or

- (b) Ninety-percent probable minimum coverage and 90-percent average coverage for delayed casualties to protected personnel.

- (d) When it is necessary to interpolate between target radii in the coverage tables, a straight-line interpolation is used, and rounding off is always downward (e.g., .38—.3). An example problem is given below.

Data from table:	Radius of target			
	800	900	1,000	1,200
	.6/.9	.4/.6	.3/.4	.2/.2

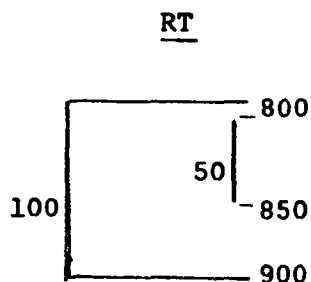
1. Given: RT = 850 meters.

2. Find: The coverage index.

3. Solution:

- (a) The 850-meter RT falls exactly halfway between two indexes listed in the table; thus, inter-

polate halfway between the two indexes, *considering the number on each side of the divider separately*, to obtain .5/.75. Round off downward to the nearest tenth, or .5/.7.



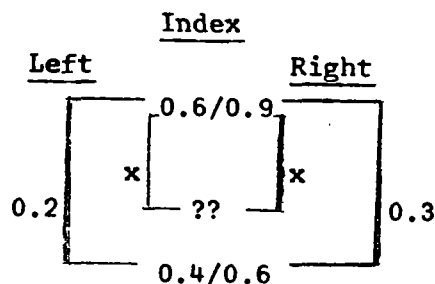
$$\text{Left: } \frac{50}{100} = \frac{x}{0.2}$$

$$100x = 0.2(50)$$

$$x = 0.1$$

$$0.6 - 0.1 = 0.5$$

(b) The same solution can be reached using the standard interpolation formula, again considering the number on each side of the index divider separately, as follows:



$$\text{Right: } \frac{50}{100} = \frac{x}{0.3}$$

$$100x = 0.3(50)$$

$$x = 0.15$$

$$0.9 - 0.15 = 0.75$$

The interpolated index is .5/.75; round off downward to the nearest tenth, or .5/.7.

(c) Other interpolations, using the same example problem, are as follows:

<u>RT</u>	<u>Interpolated index</u>
920	.38/.56 = .3/.5
1,100	.25/.3 = .2/.3

B-II-1-3. Average Coverage

If an attack were directed against a small area target, some fraction of the target would be damaged. If this attack could be repeated many times, the identical fraction of damage would not result each time; rather, some distribution of values of fractional damage centered around some particular average value would result. This average fractional damage represents the *average coverage* of this particular area. This damage is symbolized by $\bar{f}$

($\bar{f}$ -bar). The probability (P) of damaging a point target to some desired level and the average coverage ($\bar{f}$) of a small area target have the same meaning. For example, assume that the average coverage of a small area target is .60 ($\bar{f}=.60$) for severe damage. This is interpreted to mean that, on the average, 60 percent of the target will receive severe damage and the remaining 40 percent will be damaged to some degree less than severe. This $\bar{f}$ factor is similar to the average coverage in the combined coverage index. However, because no assurance (probability) is associated with this average coverage and the radius of damage is so great in relation to the target, the analyst considers only the probability of destroying the target.

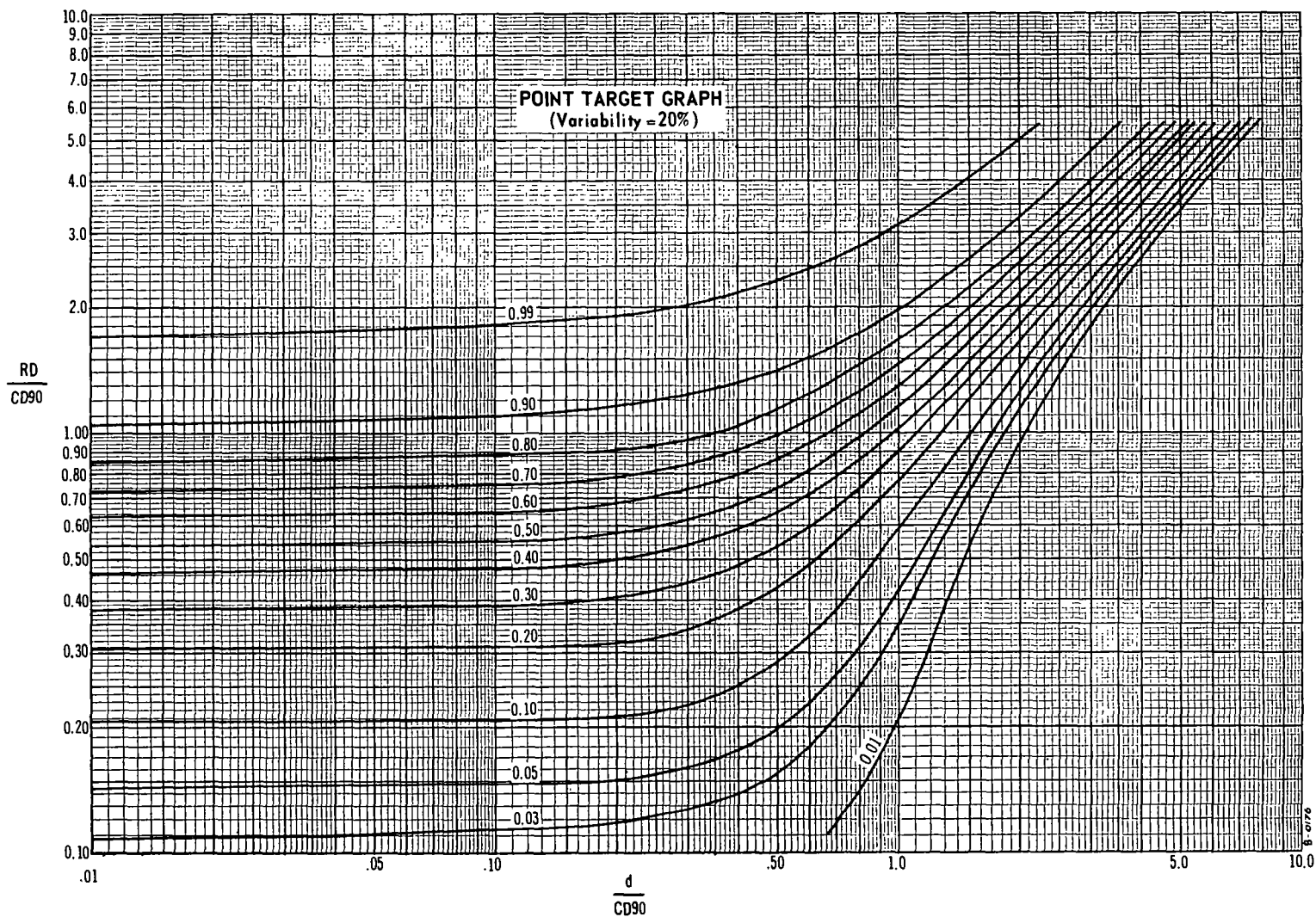


Figure B-II-3-3. The point target graph.

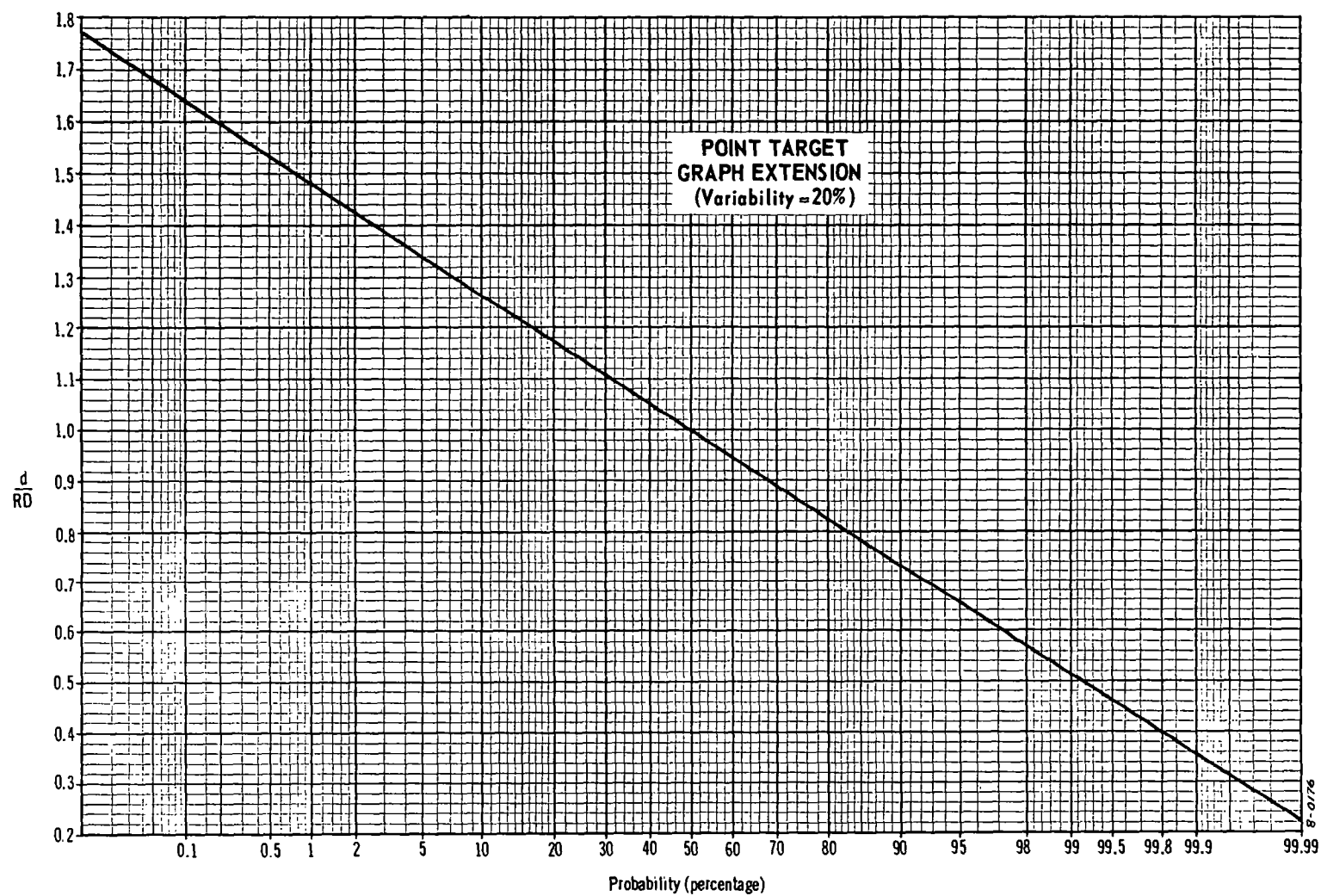


Figure B-II-3-4. The point target graph extension.

- (6) Use other forms of combat power, such as nonnuclear fires or maneuver elements.

c. The nuclear weapon employment officer uses a least separation distance (LSD) to make preclusion-of-obstacle calculations. Both the delivery error and the distance to which certain weapon effects extend are incorporated in the least separation distance. If this least separation distance extends from the desired ground zero to the point of interest, there is better than a 95-percent probability that obstacles will not be produced at that point.

d. A discussion of obstacles to the movement of friendly troops is included in (1) through (5) below.

- (1) *Neutron-induced gamma activity.* When a nuclear detonation takes place in the proximity of the earth's surface, free neutrons from this detonation bombard the elements in the soil, making some of them radioactive. The subsequent decay of these radioactive elements produces the residual nuclear radiation known as neutron-induced gamma activity, and is a definite hazard to troops occupying or passing through the area. The distance to which this obstacle-producing effect will extend is extremely variable and cannot be predicted to within a reasonable degree of accuracy. Therefore, the areas within the distances shown in table B-III-1 are considered hazard areas and require monitoring for accurate information on radiation intensity and size of the pattern.

Table B-III-1. Estimated 2-Rad-Per-Hour Radius of Induced Contamination

Yield	Horizontal radius (meters)
1 KT -----	400
10 KT -----	700
100 KT -----	1,000
1 MT -----	1,400

- (2) *Fallout.* Militarily significant fallout from surface or near-surface bursts

is also a nuclear radiation hazard to troops who must occupy or cross these contaminated areas. The distance to which fallout will extend can be estimated using the procedures outlined in TM 3-210. The actual location of fallout within the predicted area of hazard must be ascertained by radiological monitoring and survey.

- (3) *Tree blowdown.* Uprooted trees, broken crowns, and fallen limbs can present a considerable obstacle to foot and wheeled- and tracked-vehicle movement. However, the distances to which tree blowdown will occur is predictable, and these distances are listed in the safety distance tables included in FM 101-31-2 and FM 101-31-3 under the columns for preclusion of obstacles (fig. B-III-3). These distances are the least separation distances required between the desired ground zero and the point at which tree blowdown is to be precluded. For the purpose of determining the least separation distance for tree blowdown, trees are classified into two groups.

- (a) *Deciduous.* Deciduous trees lose their leaves at the end of the growing season.
- (b) *Coniferous.* Coniferous trees are of the evergreen family.

Knowing the type of trees in the area of interest, the target analyst can enter the appropriate safety distance table for the delivery system and yield (at the nearest listed range) and extract the least separation distance from the proper column for tree blowdown. Because the least separation distance is not dependent on the target category, any of the safety distance tables for the delivery system, yield, and height of burst may be used ((5) below).

- (4) *Fires.* The thermal energy emitted from a nuclear detonation is capable of starting fires at considerable dis-

FREE FLIGHT ROCKET 10.0 KT

RANGE	PRECLUDE DAMAGE			PRECLUDE OBSTACLES			
	MOD DAMAGE TO FIXED BRIDGES	LIGHT DAMAGE TO BUILDINGS	LIGHT A/C IN FLIGHT	TREE BLOWDOWN		FIRES	
				DECIDU- OUS	CONIFER- OUS	DRY FUEL	GREEN FUEL
15000	1100	4000	6700	1400	1300	3200	2100
16000	1100	4100	6800	1400	1300	3200	2100
17000	1100	4200	6900	1400	1300	3200	2100
18000	1100	4200	6900	1400	1400	3200	2200
19000	1200	4300	7000	1500	1400	3300	2200
20000	1200	4400	7100	1500	1400	3300	2200
21000	1200	4400	7200	1500	1400	3300	2200
22000	1200	4500	7300	1500	1400	3300	2200
23000	1200	4500	7300	1500	1500	3300	2200
24000	1200	4600	7400	1500	1500	3300	2200
25000	1200	4600	7500	1600	1500	3400	2300

Figure B-III-3. Example of preclusion-of-damage/-obstacles portions of the safety distance table.

tances from the ground zero. These distances are predictable for normal atmospheric conditions. However, the distance to which these fires, once started, will extend is dependent on terrain, type of fuel, wind velocity, and other parameters and cannot be predicted. The least separation distances required to preclude ignition of fires are listed in the safety distance tables in FM 101-31-2 and FM 101-31-3 under the columns for preclusion of obstacles (fig. B-III-3). For the purpose of determining the least separation distances for fires, fuels are classified into two groups: dry and green (see descriptions in FM 101-31-2 and FM 101-31-3). Knowing the type of fuel in the area of interest, the target analyst can enter the safety distance table for the appropriate delivery system and yield (at the nearest listed range) and extract the least separation distance from the proper column for fires.

(5) Example of use of the safety distance table.

- (a) *Given:* Delivery system—free-flight rocket
Yield = 10 KT
Range = 23,400 meters
HOB—low air
Type of trees—coniferous
Type of fuel—dry.

(b) *Find:* The LSD for tree blowdown and the LSD for fire.

(c) *Solution:*

- Step 1.* Enter figure B-III-3 with the range of 23,000 meters. (Remember that LSD is not dependent on target category.) Moving to the right, under the column for tree blowdown, coniferous, read the LSD as 1,500 meters. This is the least distance that must separate the DGZ and the area of interest to preclude tree blowdown.
- Step 2.* To find the LSD for fire, use the same procedure as that in

ANNEX B-V

SPECIAL CONSIDERATIONS

B-V-1. General

a. The information presented in the weapon selection tables included in FM 101-31-2 and FM 101-31-3 has been computed using the best available accuracy data. Subsequent test firings, changes in firing technique, or experience in the field may indicate that the accuracy data are not correct. Further research or experience in the field may also indicate that it would be desirable to change a preset height of burst (*HOB*) to maximize weapon effects.

b. A change in the height of burst or the height-of-burst probable error (*PEh*) may cause significant changes to the probable minimum radii of damage and to the coverage indexes.

c. A change in horizontal delivery errors may cause a significant change in the circular distribution 90 (*CD90*), the coverage index, and the minimum safe distance.

d. Until new information concerning delivery accuracy and heights of burst can be distributed to the field, the following procedures may be used by nuclear weapon employment officers in target analysis. The procedures may also be used when, for some special reason, a height of burst other than that shown in the weapon selection tables is required.

B-V-2. Height of Burst

a. The preset heights of burst for some radar-fuzed weapons can be changed by ordnance personnel in the field. Nuclear weapon employment officers and delivery units will be notified of any new height of burst and height-of-burst probable error. The heights of burst for timer-fuzed weapons can be varied by the nuclear weapon employment officer through actions at the delivery unit to vary the damage to a particular target element; a new timer height of burst is computed using the procedure outlined in *b* and *c* below. When these new required heights of burst have been deter-

mined, the nuclear weapon employment officer follows the procedures outlined in this annex.

b. A desired height of burst is determined by the equation $HOB = HOB(fs) + db$.

- (1) *HOB(fs)* is the fallout-safe height of burst and is shown in the effects tables in FM 101-31-2 and FM 101-31-3.
- (2) *db* is the buffer distance. The size of the buffer distance is dependent on the probability required for fallout preclusion.
- (3) Table B-I-1 in annex B-I shows the various probabilities of an event occurring within various multiples of probable error (*PE*). By entering this table with the probability of interest, the buffer distance can be determined as shown below.

c. The target analyst generally is concerned with using one of the burst options provided in the weapon selection tables.

- (1) *Low airburst*. This height of burst generally provides the greatest coverage of enemy targets and precludes fallout.
 - (a) This height of burst is computed by adding 3.5 *PEh* to the fallout-safe height of burst. This provides a very high assurance (99 percent) of no significant fallout. ($HOB(99) = HOB(fs) + 3.5 PEh$.)
 - (b) Because of the good "across-the-board" effects obtained at $HOB = 53(W)^{1/3}$ meters (where *W* is the weapon yield in kilotons), this height of burst is used as the lower limit of the low airburst option. This height of burst is shown as *HOB_{opt}* at the bottom of the effects tables.
 - (c) The *higher* of the two heights of burst determined in (a) and (b)

above, is used as the desired height of burst.

- (2) *High airburst.* This height of burst may be used in special cases for maximum coverage for damage to "soft" ground targets such as exposed personnel, most buildings (particularly frame) and forests. This height of burst is computed using the equations below. The *higher* of the two *HOBs* is used.

$$HOB = 120 (W)^{1/3} + 3.5 PEh$$

$$HOB = 105 (W)^{1/3} \text{ meters}$$

(where *W* equal the weapon yield in kilotons)

- (3) *Impact burst.* This height-of-burst option is used to cause cratering and fallout. Obviously, the height of burst is 0. Changes in the height-of-burst probable error will not influence the height of burst or the radius of damage.

d. If heights of burst other than those shown in *c* above, are desired, they may be computed as indicated below.

- (1) Figure B-I-3 in annex B-I indicates that 48 percent of the rounds fired will burst within 3 *PEh* below the desired height of burst. Fifty percent will detonate above the desired height of burst. Therefore, if a buffer distance of 3 *PEh* is added to the fallout-safe height of burst, there will be a 98-percent (50 percent + 48 percent) probability of no significant fallout. ($HOB(98) = HOB(fs) + 3 PEh$.)
- (2) A similar calculation using probability data shows that by adding only 1.9 *PEh* to the fallout-safe height of burst, there will be a 90-percent probability of no significant fallout. ($HOB(90) = HOB(fs) + 1.9 PEh$.)
- (3) Lowering the height of burst below that required for a 90-percent probability of no significant fallout does not appreciably increase the radius

of damage, and the risk of fallout increases rapidly with a decrease in the height of burst. Under current doctrine, when a weapon is employed at a height of burst that provides less than a 99-percent probability of no significant fallout, a fallout prediction must be made.

B-V-3. Damage Estimation for Nonstandard Conditions

a. General.

- (1) With the exception of special cases, data to determine the amount of coverage/damage to a specified target element are located in the coverage tables in FM 101-31-2 and FM 101-31-3. The information in the coverage tables has been computed using the best available data; however, cases will arise when these data cannot be used for one or more of the reasons listed in (a) through (c) below.
- (a) The target elements are not equatable to one of the four major target categories.
- (b) The height of burst is changed to improve or to preclude a specific weapon effect.
- (c) The delivery errors used in the computation of the coverage tables are found to be in error.
- (2) To assist the nuclear weapon employment officer in computing coverage/damage due to these nonstandard conditions, the procedures in *b* through *g* below, may be used.

b. Radius of Damage.

- (1) Determine the height of burst (para B-V-2) and enter the appropriate column for the target element of interest in the effects tables. Vertical dispersion may cause the burst to occur at some height other than that desired; it is necessary to consider the effect of this dispersion.
- (2) Probability distribution indicates

damage calculations of target elements listed in the effects tables but not listed in the safety distance tables, use the following procedure:

- (1) Determine the desired height of burst.
 - (2) Determine the trial heights of burst.
(Trial HOB = desired $HOB \pm 2.5 PEh$.)
 - (3) Enter the proper effects table at the trial heights of burst. Search for the *largest* radius of damage occurring at or between the trial heights of burst.
 - (4) Determine the probable maximum radius of damage for the target element of interest. (The probable maximum radius of damage is the largest radius of damage listed at or between the two trial heights of burst.)
 - (5) Using the numerical method of damage estimation (tab B-II-3 to annex B-II), compute the least separation distance the desired ground zero must be from the target element for a 90-percent assurance of not causing the type of specified damage to the target element.
- b. An example is shown below.
- (1) *Given:* Delivery system—free-flight rocket
Yield = 10 KT
Range = 18,000 meters
 HOB —low air
Target category—prompt casualties to protected personnel
Limiting requirements—preclude fallout and severe damage to the fixed bridge located 750 meters east of the target center.
 - (2) *Find:* The distance the DGZ must be separated from the bridge.
 - (3) *Solution:* Entering the safety distance table, the analyst finds no data for preclusion of severe damage to a fixed bridge. Because he is unable to use the safety distance table, the analyst reverts to the effects tables to

determine the LSD the DGZ must be in relation to the bridge.

- (a) *Step 1.* Enter the proper coverage table with the range of 18,000 meters. Moving to the right, under the columns for HOB and PEh , extract an $HOB99$ of 379 meters, a PEh of 90 meters, $CD90$ of 463 meters and CEP of 254 meters.
- (b) *Step 2.* Determine trial HOB .
(HOB $379 \pm 2.5 \times 90$ (PEh).)
Thus, the trial HOB are 154 and 604 meters.
- (c) *Step 3.* Enter the effects table at the nearest listed HOB (165 m. and 605 m.) associated with the trial HOB (154 m. and 604 m.); and, in the column for severe damage to fixed bridges, extract the largest RD (490 meters) occurring at or between the trial HOB . The probable maximum RD (490 meters) is the largest RD at or between the two trial HOB .
- (d) *Step 4.* Using the numerical method of damage estimation, compute the LSD that the DGZ can be in relation to the bridge. Using the ratio $\frac{RD}{CD90} = 1.06$, enter the point target graph. Move horizontally to the 10-percent probability scale and read the vertical $\frac{d}{CD90} = 1.6$. Multiply the ratio value by the $CD90$ to obtain the LSD (740 meters) that the DGZ must be separated from the bridge for a 90-percent assurance of causing no more than severe damage to the bridge. (In this example, a 10-percent probability of causing severe damage is the same as stating that there is a 90-percent assurance of the bridge not receiving this amount of damage.)

B-V-5. Computation of Minimum Safe Distance (MSD)

- a. Annex B-III discusses in detail the meth-

ods and techniques used to prevent casualties to friendly troops. FM 101-31-2 and FM 101-31-3 have listed in the safety distance tables, associated with each major target category, precomputed *MSD* based on standard conditions. In the event the horizontal or vertical errors (*PEh*, *PER*, *PEd*, or *CEP*) associated with the weapon system are found to be in error, the following procedure will be used to compute the new *MSD*.

- (1) Determine the desired height of burst.
- (2) Determine the trial heights of burst. (Trial $HOB = \text{desired } HOB \pm 2.5 PEh$.) If a corrected *PEh* has been received, this *PEh* will be used to compute trial *HOB*.
- (3) Enter the proper effects table at the trial heights of burst. In the appropriate Radius of Safety (*RS*) column extract the *largest RS* occurring at or between the trial height of burst.
- (4) To insure a 99-percent assurance that friendly troops will not be subjected to greater than the authorized effects, a buffer distance computed by multiplying the corrected *PER* or *PEd* (whichever is the greater) by 3.5, or the corrected *CEP* by 2 is added to the Radius of Safety. The *MSD* equals the Radius of Safety plus the buffer distance.

b. An example is shown below.

- (1) *Given*: Delivery system—free-flight rocket.

Yield = 50 *KT*

Range = 20,000 meters

HOB = low air

Target Category—prompt casualties to protected personnel

Troop Safety—Negligible risk to warned protected personnel

- (2) As a result of modifications performed on the free-flight rocket, the following corrected probable errors have been received.

Range 20,000 meters $PEH = 50$
 $PER = 100$
 $PEd = 140$

- (3) Compute the corrected *MSD*.

- (4) *Solution*: In view of the recorded changes in the free-flight rockets horizontal and vertical dispersion pattern, the analyst is unable to use the precomputed *MSD* in the Safety Distance Tables and is required to use data in the Effects Tables to compute a corrected *MSD*.

- (a) *Step 1*. Determine the desired *HOB*. Compare *HOB₉₉* to *HOB* optimum and select that with the large *HOB*. Enter the Effects Table for the free-flight rocket, 50 *KT*, and extract the required information from the bottom of the page.

$$HOB_{99} = HOB_{opt} + 3.5 (PEh)$$

$$HOB_{99} = 121 + 3.5(50)$$

$$HOB_{99} = 296 \text{ meters}$$

In that *HOB₉₉* (296 meters) is greater than *HOB_{opt}* (195 meters), the desired *HOB*=296 meters.

- (b) *Step 2*. Determine the trial *HOB*.

$$(\text{Trial } HOB = \text{desired } HOB \pm 2.5 PEh.)$$

$$\text{Trial } HOB = 296 \pm 2.5(50) =$$

		421
	+	
Desired HOB	296	
	-	
		171

- (c) *Step 3*. Enter the Effects Table for the free-flight rocket, 50 *KT*, at the trial *HOB* (or nearest listed). In the radius of safety column for negligible risk to warned protected personnel, search for, and extract the *largest* radius of safety (3090 meters) occurring at or between the trial *HOB*.

- (d) *Step 4*. To insure a 99-percent assurance that friendly troops will not be subjected to greater than the authorized effect level, a buffer distance is computed multiplying the

ANNEX B-VII

FRIENDLY VULNERABILITY

(This annex is based on SOLOG No. 89.)

B-VII-1. General

a. Target analysis procedures are used to estimate the possible results of an enemy nuclear attack on friendly dispositions or installations. Based on current intelligence, or the enemy's past use of nuclear weapons, the weapon yield most likely to be employed against friendly elements is estimated.

b. The radius of vulnerability (R_v) is the radius of a circle within which friendly troops will be exposed to equal to or greater than emergency risk criteria and may become casualties. A vulnerability radii (R_v) table is included in FM 101-31-2 and FM 101-31-3 that gives the radii to be used in analyzing the vulnerability of friendly dispositions. (This table is reproduced in figure B-VII-1.) For friendly target analysis, an assumption is made that the enemy can deliver a weapon at the point where it will do the greatest damage to a friendly installation, *disregarding* the effect of delivery errors. Then, the analyst estimates what fraction of friendly dispositions would be destroyed by such an attack.

c. The analysis of present and planned

RADIUS OF VULNERABILITY (meters)

Yield	Exposed personnel	Protected personnel	Tanks, APC	Wheeled vehicles	Supply depots
1 KT	1,460	1,220	240	420	190.
10 KT	3,480	1,650	600	1,060	480.
50 KT	7,110	2,410	1,150	2,010	910.
100 KT	9,650	3,220	1,510	2,650	1,200.
500 KT	19,220	6,360	2,880	5,040	2,280.
1 MT	25,920	8,590	3,800	6,660	3,010.
5 MT	50,200	16,700	7,200	12,600	5,700

NOTE: To obtain a radius of vulnerability, enter the yield column at the appropriate yield if shown, otherwise use linear interpolation.

Figure B-VII-1. Vulnerability radii table.

friendly dispositions is a continuing process. The commander must be kept informed of vulnerability conditions so that he can make decisions concerning changes in existing or planned dispositions. While dispersion decreases the risk of destruction from nuclear attack, it greatly increases the possibility of defeat in detail and complicates the problem of control. The degree to which units can be dispersed in any situation will depend on the mission of the command and on the risk the commander is willing to accept. Accomplishment of the mission and avoidance of formations that present profitable targets to the enemy are frequently conflicting requirements. The commander should take full advantage of all characteristics of the battle area that contribute to the fulfillment of both requirements.

d. Vulnerability may be reduced through one or more of the following means:

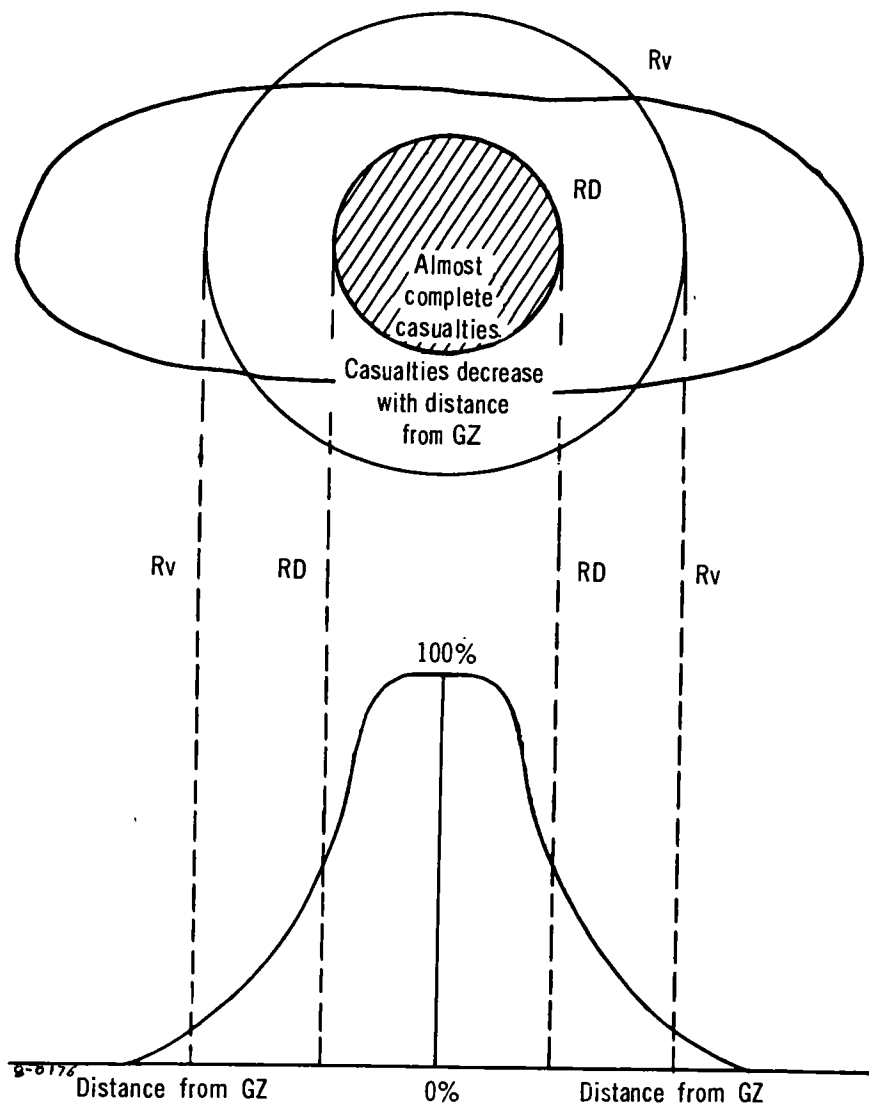
- (1) Dispersion.
- (2) Depopulated-center disposition.
- (3) Linear configuration.
- (4) Increased protection.

B-VII-2. Analysis of Friendly Disposition and Installation Vulnerability

The analysis of the vulnerability of friendly dispositions and installations to attack by an enemy-delivered nuclear weapon is performed in the following four steps:

a. *Step 1.* Determine the appropriate yield. Based on current intelligence, or the enemy's past use of nuclear weapons, the intelligence officer assumes a weapon yield that the enemy is likely to use against friendly dispositions or installations.

b. *Step 2.* Determine the degree of exposure of friendly units. The assumed conditions of exposure of friendly troops are provided by the G3 (G4 for logistical installations).



NOTE 1. Not to scale.

2. Vertical axis represents probability of individual becoming a casualty.

Figure B-VII-2. Relationship of percentage of casualties to the distance from the ground zero.

c. *Step 3.* Determine the vulnerability radii. Appropriate radii from the vulnerability radii table are obtained and are marked on the appropriate circular map scale.

d. *Step 4.* Estimate the results of the enemy nuclear attack. The circular map scale is superimposed on a map representation of the disposition or installation to be analyzed. The center of the circular map scale is placed over the

center of the greatest concentration. With the aid of the labeled circles, the area is estimated within which casualties may occur, or within which materiel damage will probably occur, if the ground zero were at this location. The ground zero for this type of analysis is selected, on a worst-case basis, as the point that would result in the *greatest* loss to friendly forces. This is the same procedure that is used in the

GLOSSARY

This glossary is provided to enable the user to have readily available terms peculiar to nuclear weapon employment, as used in this manual. Terms that appear in JCS Pub 1 and AR 320-5 are not reproduced herein.

Across the board—Used in connection with weapon effects curves. It indicates that consideration is given to all the effects curves that describe radiation doses, blast effects on various drag-type targets, thermal effects, and overpressures.

Atmospheres—A measure of normal atmospheric pressure (e.g., 2 atmospheres indicate two times the normal atmospheric pressure).

Graphical portrayal—A two-dimensional representation (generally to scale) of the distance that the specified effects extend. It is also a visual representation of the results of an analysis.

Militarily significant weapon effects—Those effects that will have a definite influence on the military capabilities or the degree of risk.

See also *Tactically significant weapon effects*.

Minimum-dose exit route—The route of egress from a radioactive-contaminated area that presents the smallest amount of radiation to the exiting party or parties.

Nonsymptomatic dose—A dose of radiation that may not be detected because the recipient does not display the behavior or

physical characteristics that would normally accompany such a dose.

Readiness status—Indicate the degree of preparation of both the weapon and the delivery unit for delivery of nuclear fires (to include airdelivered weapons).

Soft targets—Those targets that are easily damaged by low-magnitude nuclear weapon effects (e.g., exposed personnel, most buildings (particularly frame), forest, and crops).

Tactically significant weapon effects—Those effects that will have a definite influence on the military action currently underway.

See also *Militarily significant weapon effects*.

Weapon—An assembled and ready-for-delivery nuclear device in the military configuration. For artillery, a weapon is a complete round; for a rocket, the motor plus the warhead; for a missile, the complete missile, to include the warhead; for an air-delivered weapon, the warhead in the bomb; and for an atomic demolition munition, the complete munition.

See also *Weapon system*.

Weapon system—The complete weapon plus the associated delivery means.

See also *Weapon*.

Worst-case burst—In analyzing targets, it indicates the location of the burst that occurs at the outer limits of the acceptable dispersion in both range and elevation. In considering the vulnerability of friendly forces, it indicates the point of maximum damage.

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