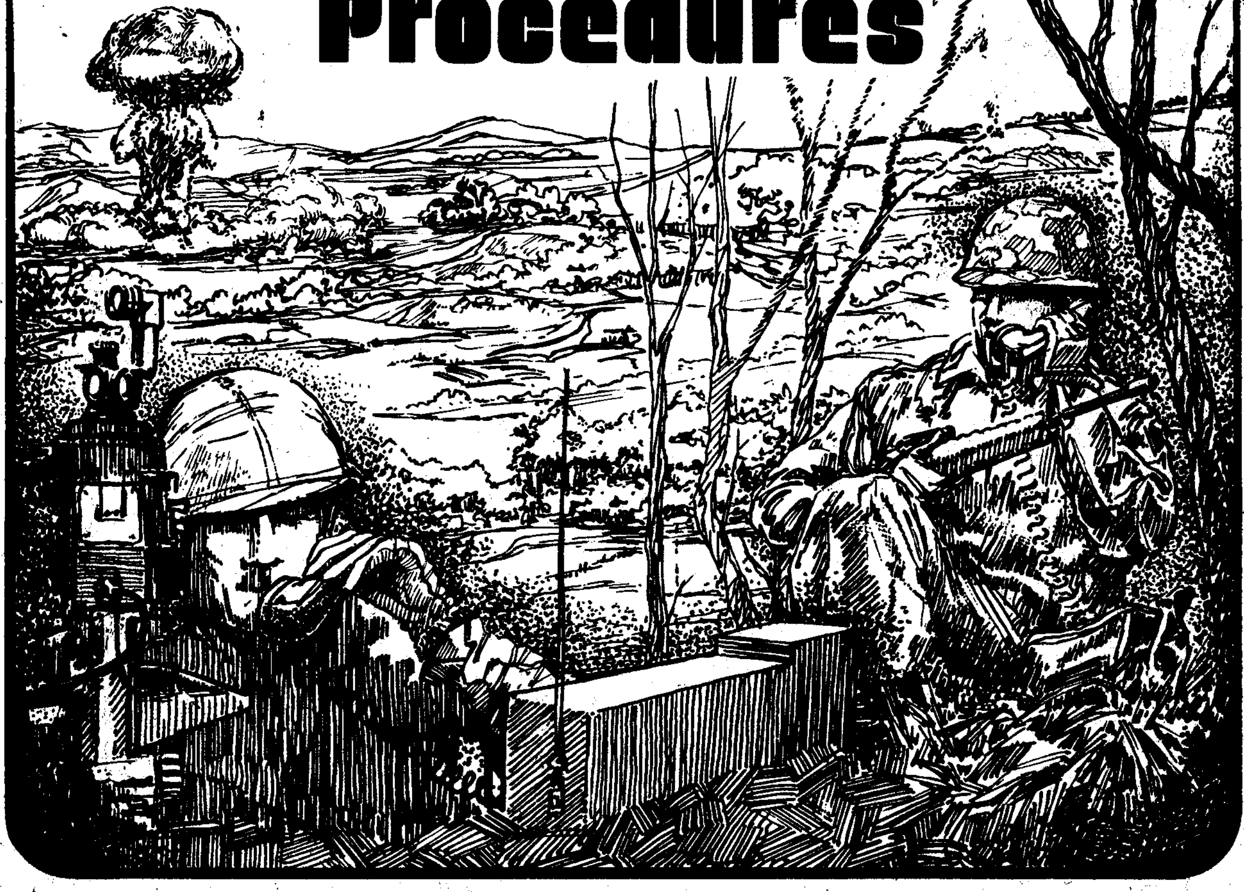
EX NR 5

DEPARTMENT OF THE ARMY FIELD MANUAL FM 101-31-1

MARINE CORPS FLEET MARINE FORCE MANUAL FMFM 11-4

Staff Officers' Field Manual

Nuclear Weapons Employment Doctrine And Procedures



MARCH 1977

FOREWORD

This manual provides procedures and employment doctrine for the employment of nuclear weapons available to the US Army and the Marine Corps for use against targets on the battlefield.

This manual represents a significant change from previous editions. This version of FM 101—31—1/FMFM 11—4 (in conjunction with FM 101—31—2) incorporates revised nuclear weapon employment doctrine and procedures. Major changes in the revised manuals include:

SPECIAL CONSIDERATIONS. There is now a chapter on special considerations in nuclear weapon employment.

EXPECTED COVERAGE. The normally used mathematical assurance associated with area target analysis has changed from high assurance (90 percent) to "expected" coverage.

PRECLUSION-ORIENTED ANALYSIS. An additional targeting methodology, preclusion-oriented method, has been developed. It provides for employment of higher yield weapons with constraint criteria as limiting factors. This procedure is a departure from use of the smallest yield weapons to achieve minimum coverage.

COLLATERAL DAMAGE. Collateral damage is defined and discussed, and collateral damage avoidance tables are included.

RADIATION CASUALTY CRITERIA. Radiation casualty criteria have been changed. Also, radiation is recognized as the primary casualty producer on the battlefield. The manual emphasizes the targeting of personnel, when appropriate, rather than materiel (e.g., tank crews rather than tanks).

SAFETY CRITERIA. The personnel risk (safety criteria) has been redefined. It incorporates additional considerations that have resulted in updated safety distance tables.

PACKAGE PLANNING. Procedures are outlined for the development of a nuclear weapon package, with emphasis on the defeat of the overall threat, rather than the defeat of individual targets.

DEFEAT CRITERIA. Threat and target defeat guidelines have been expanded. Broad defeat guidelines for both the offense and defense are discussed, and the consideration of time dependence in defeat criteria as a result of radiation effects is introduced.

FIELD MANUAL
NO 101—31—1
FLEET MARINE
FORCE MANUAL
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FMFM 11—4
DEPARTMENTS OF THE ARMY
AND THE NAVY
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Staff Officers' Field Manual

Nuclear Weapons Employment Doctrine and Procedures

* This manual supersedes FM 101—31—1/FMFM 11—4, February 1968, including all changes.
(Cutoff date for changes was 26 April 1976.)

Due to its stated purpose throughout this manual the word "he" is intended to include both the masculine and feminine genders and exceptions have been noted.

CHAPTER 1

INTRODUCTION

1—1. Purpose

This manual provides guidance to commanders and their staffs on the operational aspects of nuclear weapon employment in combat operations.

1—2. Scope

a. The procedures presented in this manual are concerned basically with nuclear weapon employment by the US Army and the US Marine Corps.

b. Guidance is presented for the employment of nuclear weapons in the attack of targets on or near the earth's surface. For guidance on the employment of nuclear weapons in the air defense role, see FM 44—1A; and for the employment of atomic demolition munitions, see FM 5—26 and FM 5—26A.

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

(1) Operational considerations in the employment of nuclear weapons.

(2) Methods of target analysis.

(3) Command responsibilities and staff procedures in nuclear weapon employment.

(4) The effects produced by nuclear bursts.

(5) Tabular information concerning target response, troop safety, collateral damage, and preclusion of damage for stockpile weapons and for a family of hypothetical weapons.

(6) Pertinent portions of STANAGs 2083, 2103, 2104, and 2111 and QSTAGs 187 and 189.

d. This manual repeats information presented in other field manuals only as required for clarity or consistency. This manual should, therefore, be used in conjunction with the applicable references listed in Appendix A.

1—3. Recommended Changes

Users of this manual are encouraged to submit recommendations to improve the manual. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded directly to the Commander, US Army Nuclear/Chemical Agency, ~~Fort Bliss, Texas 79916~~. Marine Corps users of this manual will submit comments to the Commanding General, Marine Corps Development and Education Command, Director, Development Center, Quantico, Virginia 22134.

1—4. Organization of the Manual Series

The material is divided into three manuals:

a. FM 101—31—1 provides procedural guidance applicable to nuclear warfare. It contains the concepts for nuclear weapon employment and the command and staff actions required to carry out these concepts.

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b. FM 101—31—2 contains classified operational characteristics of nuclear delivery systems and nuclear weapons in the US stockpile. It provides the effects data necessary for target analysis and items of information concerning technical procedures that are not included in FM 101—31—1 because of their security classification. For NATO use, a modified version is published that contains information similar to FM 101—31—2 that is directly applicable to NATO.

c. FM 101—31—3 provides unclassified data concerning a family of hypothetical nuclear weapons. It provides typical effects data necessary for target analysis and is designed specifically for use in unclassified training of staff officers and commanders.

d. The organization of the material in FMs 101—31—2 and 101—31—3 is identical in most cases, although differences between the US stockpile weapons and the family of hypothetical weapons exist. These differences are intentional and are designed to protect the security of information about actual weapons. Proficiency in the use of FM 101—31—3 will insure proficiency in the use of FM 101—31—2.

1—5. Terms and Definitions

A glossary is included in this manual (app F) to provide definitions of terms and phrases peculiar to nuclear weapon employment not included in AR 310—25 or JCS Pub 1.

1—6. Nuclear Training Exercises

FM 105—5 provides techniques and procedures for incorporating nuclear weapon employment and effects into umpire-controlled training exercises. It may be used in conjunction with FM 101—31—2 for field training and command post exercises.

CHAPTER 2
EMPLOYMENT CONSIDERATIONS

2—1. Purpose

This chapter provides an overview of significant considerations that furnish the framework for employment doctrine and procedures for the conduct of nuclear warfare. Such considerations are discussed because of the unique nature of nuclear warfare and the potential for national significance of decisions relating to nuclear weapon employment.

2—2. Nuclear Weapons and National Policy

a. General. National policy impacts on the conduct of nuclear operations by establishing guidelines of use of nuclear weapons in attainment of national goals.

b. Employment Policies.

(1) The ultimate objective of the employment of nuclear weapons is to terminate a conflict at the lowest level of hostilities on terms acceptable to the United States and its allies.

(2) National Command Authorities (NCA) would be expected to coordinate military and diplomatic efforts to insure that the conditions for use of nuclear weapons are both acceptable to allies and in accord with national goals.

(3) To realize the overall national purpose of the use of nuclear weapons, military operations should be conducted in consonance with diplomatic actions.

c. Employment Purpose. Since the national purpose of employment is to terminate a conflict, the employment of nuclear weapons should serve to demonstrate to enemy leaders that potential losses outweigh gains if a conflict is continued or escalated. To accomplish this end, nuclear weapons could be used to positively and dramatically alter the course of battle and preclude the enemy from achieving his objectives. Depending on enemy response to initial nuclear employment, additional employment of nuclear weapons may be required or directed. In all cases, follow-on strikes should support the basic purpose of decisively terminating a conflict at the lowest level of violence consistent with national and allied goals.

2—3. Nuclear Weapons in Support of Tactical Operations

a. General. The use of nuclear weapons in support of tactical operations requires detailed planning at all levels. The spectrum of tactical nuclear warfare may vary from limited to theaterwide friendly or enemy initiated use. Whatever the nature of the nuclear use, nuclear weapons cannot be used in isolation, but must be integrated with the rest of the fire and maneuver on the battlefield.

b. Nuclear Contingency Planning. Because of the potentially grave consequences of nuclear hostilities, the NCA will probably not approve the use of nuclear weapons until all lesser options are clearly perceived as inadequate to maintain the integrity of US and/or allied forces. This means that a field commander must keep higher headquarters well informed on the developing situation and when the time will come, in his judgment, that he cannot accomplish his mission without the use of nuclear weapons. As a part of contingency plans, a commander should prepare in advance to integrate nuclear weapons into force maneuver plans. He may be required to conduct conventional operations under the most adverse conditions before nuclear release is granted, but he must insure that his evaluation of the risks involved with the delay in release are made known to his immediate commander. It is the corps commander who will normally request the release of nuclear weapons. Corps is the critical level in planning for the employment of nuclear weapons on the battlefield, although input from division and lower echelon headquarters is incorporated into corps plans.

c. Nuclear Weapon Package. Although many weapons are present in a corps area, an initial release can be expected for only the numbers and types of weapons included in preplanned "packages" of nuclear weapons requested by the corps commander. To expedite the release of the requested package, the corps preplanned package will be forwarded to higher headquarters for tentative approval. The package is defined as a discrete grouping of nuclear weapons by specific yields for employment in a specified area during a short time period to support a corps tactical contingency. It should be treated as a single entity for purposes of request, release, and control. Whereas the basic package is planned, refined, requested, and controlled by corps, division and lower echelon groupings of weapons would be subpackages of a corps package. At any given time, corps should have a preplanned nuclear weapon package to support each probable tactical contingency; however, it would be expected that only one package at a time would be requested. A preplanned package that is actually executed would be modified for the situation that exists at the time of employment. A sufficient number of nuclear weapons will be planned for each package to positively alter the tactical situation and thus expedite accomplishment of the corps mission. The package will be planned for employment in a timeframe, normally expressed in hours, during which the corps foresees the need for nuclear weapons to contain the developing threat. Within the timeframe and at the discretion of the corps commander, all nuclear weapons will be employed in a pulse that is a shorter timespan. The timespan for this pulse of nuclear weapons will depend on technical capability, operational necessity, and national approval. The intensity of conventional firepower should not be decreased before, during, or after the nuclear pulse. The key to successful nuclear operations lies in detailed planning; coordination; and decentralized, aggressive execution. A more detailed discussion of the procedures in the planning of a nuclear package is in chapter 4.

2—4. Law of Land Warfare and Nuclear Weapon Employment

a. Through the history of warfare, a body of treaties and customs has developed that generally represents the collective views of the belligerents and tends to limit the application of excessive force and the manner in which force is applied to protect combatants and noncombatants, safeguard fundamental human rights, and facilitate the restoration of peace. The grouping together of these treaties and customs is known as the Law of Land Warfare. The applicable laws and customs and their interpretation are contained in FM 27—10, *The Law of Land Warfare.*

b. Modern weapons, to include nuclear weapons, have been measured against the Law of War for their applicability and validity of use. Devastation as an end in itself is not sanctioned by the Law of War or national policy. There must be some reasonable connection between the destruction of life and property and the defeat of the enemy's forces. Some absolute prohibitions exist, but the Law of War is tempered by the rule of military necessity, which justifies those measures not forbidden and which are indispensable for securing the complete submission of the enemy with the least possible expenditure of life and resources. The Law of Land Warfare encompasses the use of nuclear weapons; however, because of the potentially tremendous destructive power of these weapons, their use must be carefully controlled. The targeting procedures contained in this manual include measures to limit damage to populated areas.

2—5. Threat and Target Defeat Considerations.

a. General. When assessing the number of nuclear weapons required to make a positive change in the tactical situation and to defeat a threat, consideration must be given to defeat of individual targets composing the overall threat. There is no simple statement of threat and target defeat criterion that will pertain in all circumstances.

b. Threat Defeat.

(1) A threat is considered defeated by nuclear strikes when the resultant force ratios are such that the enemy forces are halted and can be controlled by conventional means throughout a sufficient pause for political channels to be utilized to terminate the conflict. The planning for threat defeat must consider the type of units and the percentage of the threat that must be destroyed.

(2) The planning of a nuclear weapon package to defeat a particular postulated threat is based on assumptions of the threatened area, its terrain, available weapons to defeat the threat, and the strategy and tactics of the enemy. The evaluation of a proposed nuclear weapon package, developed in contingency planning, is based on an analysis of the impact of the proposed package on those critical combat units thought to comprise the threat. The postulated threat is adjudged to be defeated when the predetermined number of critical units necessary for the threat to be defeated are attrited. Critical combat units that might be targeted for nuclear strikes include the following:

(a) Nuclear capable units.
(b) Tank and mechanized units.
(c) Conventional artillery units.
(d) Other units or locations, such as command and control headquarters, nuclear supply points, or bridges.

c. Target Defeat. Two basic categories of targets are area and point. Area target defeat criteria normally are expressed in terms of some level (percentage) of expected coverage of the target area with a specified level of materiel damage or personnel incapacitation. Point targets are generally single-element materiel targets. Because point targets are single elements or occupy a small area in comparison to a damage radius, only the probability (normally 90 percent) of a specific level of damage, moderate or severe, is considered when examining them.

(1) *Fractional coverage considerations.* Factors to be considered in estimating the fractional coverage requirements for defeat of area targets are:

(a) Mission of the unit being targeted. Because of greater control problems, coupled with the more demanding requirements of an attack, an attacking unit is generally more susceptible to mission abort than is a defending unit.

(b) Size of unit. The fractional damage required for target defeat can also vary for different sized units. Because of the greater amount of inherent self-sufficiency in smaller units, such as companies, they require a higher percentage of losses before they become combat ineffective than do larger units, such as battalions and higher.

(2) *Area target defeat guidelines.* The following are general guidelines for attack of troop targets:

(a) For units in the offense, an expected coverage of 30 to 40 percent of the target with immediate permanent (IP) (8,000 rad) incapacitation or immediate transient (IT) (3,000 rad) incapacitation criterion should result in an inability of the unit to accomplish its mission within minutes after the burst. (See app C for detailed discussion of radiation levels.)

(b) For units in the defense, an expected coverage of 40 to 60 percent of the target should result in the targeted unit being unable to continue to defend. The criterion used, IP, IT, or latent lethality (LL), depends on the length of time between the burst and the engagement of enemy units.

(c) For larger units, such as a battalion, with maneuver forces that can be separated and dispersed, two of the three unit's maneuver forces should be attacked to insure that the unit is incapable of accomplishing an assigned mission. Company-sized units may be attacked separately; however, a battalion in an assembly area might be a single target.

(d) Regimental-sized and larger units would normally be divided into smaller targets.

(e) For rear area units or units not in a position to be committed for some time, a less stringent defeat criterion, IT or LL can be used. The coverage criterion selected should consider the time-dependent effects of nuclear radiation. The evacuation of personnel with sublethal or delayed lethality doses may be adequate to reduce a unit's strength and capability sufficiently to abort a mission. For these reasons, use of the LL (650 rad) casualty criterion may be sufficient for targeting in some cases.

(3) *Consideration of lesser effects over entire target area.* An area target is attacked with a specified coverage and defeat criterion (IP, IT, or LL). It is important to realize that target degradation occurs beyond the distance where the specified radius of damage extends. The smallest nuclear weapon has potentially lethal effects that cover more than a square kilometer of area.

Also, to estimate the overall effect on a targeted unit, the combination of effects should not be overlooked. Each degrading effect by itself might not result in serious impairment of a soldier's performance. However, a soldier suffering with burns from thermal radiation, ear drum damage from overpressure, cuts and broken bones from flying objects, and vomiting from radiation sickness is not likely to be very effective in any capacity. Hence, when a commander requests that a certain percentage of the target receive a specified degree of damage, it should be recognized that much of the remaining portion of the target would receive damaging effects. A more detailed discussion of this is contained in appendix C. (Note: Combined effects data are not tabulated or predicted in employment manuals.)

2—6. Collateral Damage

a. Collateral damage is *undesirable* civilian materiel damage or personnel injuries produced by the effects of friendly nuclear weapons.

b. While the overall goal is to limit collateral damage, there must be a balance between collateral damage constraints and military effectiveness if operations are to be successful. Therefore, some damage to populated areas should be expected.

c. Determination of collateral damage constraints is a command responsibility. If collateral damage constraint levels are not predetermined by National Command or Theater Authorities, collateral damage constraint levels will normally be the responsibility of a corps or higher commander. Collateral damage avoidance tables are provided in FM 101—31—2 to assist the commander and his staff. Incorporation of collateral damage considerations into target analysis and the use of the tables are further discussed in chapters 4 and 5.

d. Specific techniques that can reduce collateral damage are:

(1) *Invoke civil defense procedures.* Evacuation of the civilian population from the battlefield would greatly reduce civilian personnel casualties. Although this action would be a highly effective measure, it requires a significant civil defense effort. If evacuation is infeasible, the friendly populace could be warned to remain in cellars or other shelters during periods of conflict near their areas.

(2) *Reduced yield.* One can reduce collateral damage by reducing the yield and accepting less coverage. Also, by using less stringent defeat criteria, i.e., for materiel targets use moderate damage in lieu of severe damage, and for personnel use IT incapacitation in lieu of IP incapacitation, one can achieve the desired fractional coverage while reducing the yield or number of weapons required.

(3) *Offset desired ground zero.* After determining the areas where damage is not desired, in some cases, it may be possible to reduce the level of collateral damage by offsetting the desired ground zero and still achieve the required damage to defeat the target.

(4) *Use of multiple weapons.* In attacking a large target, collateral damage can be reduced by dividing the target and using smaller yields rather than using one large weapon. This will allow for a more discriminate use of nuclear weapons.

2—7. Psychological Aspects of Nuclear Combat

Soldiers facing nuclear combat can be expected to behave essentially as they would under other severe combat and stress situations. Their behavior is affected by combat experience, training, and leadership. Normally, the effectiveness of a soldier in any combat experience first increases as he gains knowledge and proficiency, then begins to decrease with continued exposure to combat stress. Some of the specific ways that the nuclear environment (or severe combat) can be expected to impact on a soldier are:

a. Apprehension. Disruption of communications, rapid and frequent changes in the combat situation, and largely unknown hazards (such as radiation injury) tend to increase apprehension.

b. Isolation. Isolation is a source of stress and reduces a man's capacity for resisting the effects of other stress. Because of the possible destruction of large elements of a unit due to an enemy nuclear strike, isolation may be greater on the nuclear battlefield than in conventional combat.

c. Fatigue. The highly mobile, rapid, and, possibly, continuously changing nature of nuclear combat may result in greater fatigue than is typical of conventional combat.

d. Cumulative Stress. The cumulative nature of stress is probably the most important determinant of the rate at which psychological casualties may occur. Because of the capability of the enemy to deliver nuclear weapons to any point on the battlefield, stress on the soldier will be constantly present, whether he is on the forward edge of the battle area or in reserve.

2—8. Combined Nuclear / Chemical Considerations

a. Considerations discussed in this chapter have been concerned primarily with the impact of nuclear weapon employment on the battlefield. In any conflict where the employment of nuclear weapons to support tactical operations is possible, the employment of chemical weapons by a properly equipped enemy force *must* be considered probable.

b. Enemy chemical weapons may be employed to supplement, to enhance, or in lieu of nuclear weapons. Nuclear weapon effects on area targets, such as reserves or support installations, may be augmented by chemical and conventional fires. Chemical weapons may be used with conventional weapons in circumstances where the use of nuclear weapons might be restricted because of operational or safety constraints. They can be employed efficiently against small critical installations, such as command and control points or dispersed nuclear delivery units, where an immediate response and/or long-term effects are desirable.

c. Passive protection measures taken to reduce vulnerability to chemical weapon effects, particularly unit dispersion measures and emphasis on maintaining the appropriate mission-oriented protective posture (MOPP), can also provide some protection from nuclear weapon effects. Operational planning should always address the possibility of chemical agents being employed against friendly forces and contain guidance on appropriate defensive measures that should be taken.

CHAPTER 3
COMMAND RESPONSIBILITIES AND STAFF PROCEDURES

3—1. General

Command actions and staff responsibilities involving the employment of nuclear weapons generally follow established command and staff channels. There are, however, some unique aspects to the employment of these weapons, and this chapter will outline the procedures and techniques that are applicable. Additional guidance on operations involving nuclear weapons is contained in FM 100—5, *Operations,* FM 100—15, *Large Unit Operations,* FM 71—100, *Division Operations,* and FMFM 11—1, *Nuclear, Chemical, and Defensive Biological Operations in the FMF.*

3—2. Command Guidance

a. Since nuclear weapons can have a significant influence on ground operations, command guidance to initiate staff planning is vital. In his initial guidance, the commander should provide as much information concerning nuclear weapon employment as he does concerning the employment of maneuver forces and conventional fires.

b. It is essential that the commander and his staff officers have a good understanding of nuclear weapon effects, employment procedures, capabilities and limitations of available delivery systems, and combat support requirements for nuclear delivery systems. Technical advice and assistance will be provided to the commander and to his staff by the target analyst.

c. Command guidance normally consists of the following:

(1) Statement of result desired from the employment of nuclear weapons (i.e., halt an enemy attack, support a counterattack, or rupture the enemy's defensive position).

(2) Defeat criteria, when appropriate.

(3) Concept of subsequent use of weapons if the initial effort does not accomplish desired results.

(4) Risk commander is willing to accept on his own troops.

(5) Criteria for avoiding collateral damage.

(6) Intelligence collection and target acquisition guidance.

3—3. Acquisition of Surface Targets

a. Target acquisition, which is an integral part of the intelligence collection process, involves detection, identification, and location of a target in sufficient detail to permit effective employment of weapons. Information gained from target acquisition can be used for target analysis, target refinement, and employment of weapons. Information is collected from all available sources and agencies.

b. The effectiveness of a nuclear attack is enhanced by the accuracy, completeness, and timeliness of intelligence. Specific information on target areas, such as target location, size, shape, composition, concentration, vulnerability, recuperability, and permanence or direction and speed of movement, should be sought continually by all intelligence collection agencies.

c. The commander's initial planning guidance provides the basis for developing the essential elements of information, the detailed collection plan, and priorities for the intelligence collection effort.

d. The primary purpose of intelligence on the conventional battlefield is to provide the commander with sufficient information on enemy locations and probable courses of action so that he can commit combat power at the decisive point at the critical time. The primary purpose of intelligence does not change in the nuclear environment, although the commander's commitment of combat power may be in the form of nuclear weapons. The intelligence system's mission, then, is to provide combat information for the targeting of those weapons. The limitation of any single target acquisition technique demands that the intelligence system's collection effort be broadly based so that combat information for targeting can be obtained from all available sources.

e. The intelligence collection plan should be developed during the contingency planning phase and updated continuously throughout the operation. The collection plan coupled with an analysis of the terrain of interest, a knowledge of the enemy order of battle, and tactics should lead to the development of a target list of areas in which the enemy might locate assault elements, reserves, logistic installations, command posts, nuclear delivery units, or other profitable targets. This target list can be used to determine areas where enemy units could adversely affect the accomplishment of the mission or where employment could have a significant effect on enemy capabilities. These areas become the focal point for target acquisition efforts. The areas on this list must be held to a minimum to avoid overextension of the collection effort.

3—4. Nuclear Weapon Planning

a. The planning for nuclear weapon employment is an integrated effort. The target analyst must work closely with other staff elements to insure that plans for the use of nuclear weapons are consistent with the overall concept of operations.

b. Contingency planning develops alternate tactical nuclear weapon packages in support of the unit mission. Each contingency plan must have the potential for rapid modification to provide for effective tactical employment of nuclear weapons as the situation develops. Contingency plans evolve through an examination of feasible enemy actions and associated friendly reactions and the times and places where nuclear weapons might be required to prevent significant enemy goals from being achieved. Target areas are developed and weapons planned in those areas that will maximize enemy losses while minimizing collateral damage. Available information regarding the situation, terrain, and civilian dispositions must be thoroughly explored during the planning phase and may require preparation of multiple plans to provide for various enemy threats, attack avenues, and warning periods. The friendly situation should also be varied to examine possible force levels and unit dispositions to insure the timeliness of nuclear package release.

c. Nuclear contingency plans are corps responsibilities, but contingency planning should take place at both corps and division levels. Corps and division planning staffs must maintain continuous and close liaison to insure completeness of the plans. Corps integrates division planning into the corps plan and coordinates necessary reviews and updates so that specific orders can be developed rapidly from existing plans as the situation develops. Contingency plans should be provided to the next higher command so that request and release procedures can be expedited. General steps in the development of nuclear weapon packages are discussed in chapter 4.

3—5. Fire Support Coordination

Nuclear weapon packages planned for each contingency will normally specify target areas for engagement by the artillery units expected to be available. This may include division as well as corps artillery units. As a contingency plan becomes an order during the actual attack, units to fire and firing positions will be designated by appropriate headquarters. When the package is fired, the corps and division fire support elements will coordinate the firing to meet guidance in the release directive. The fire support element controlling the package must maintain communications with the delivery unit. A chain of succession for control of nuclear fire will be established to prevent loss of control resulting from loss of a headquarters.

3—6. Joint and Combined Operations

a. Operations with combined forces may impose additional restrictions on the use of nuclear weapons. The senior US commander in a combined command will promulgate directive guidance on the use of nuclear weapons by US forces in such commands. This guidance may modify the doctrine and procedures contained in this manual.

b. Commanders of unified commands may also publish directives that may modify doctrine and procedures contained in this manual. In this circumstance, the commander of the senior Army headquarters is responsible for determining that the modifications are written within established policy and insuring that all Army elements are aware of the modifications and that they adhere to them.

c. When US Air Force or Navy delivery systems are used to support Army operations, the Air Force or Navy commander may have the final decision concerning yields and delivery procedure used if, in exceptional circumstances, the analysis performed by the Army element is invalidated. Procedures used to determine the appropriate yield and desired ground zero will conform to the doctrine and procedures contained in this manual or as modified by circumstances discussed in the two preceding paragraphs. The commander of the delivery unit will coordinate any changes with the supported force commander through the tactical air control center (TACC). Information required by Army analysts for weapon selection, such as the expected delivery error for a given delivery system and method, will also be furnished through the TACC.

3—7. Control of Nuclear Weapons

a. Because of the importance of nuclear weapons in the conduct of the battle and their limited availability, the expenditure and resupply of nuclear weapons must always be controlled by the commander.

b. Nuclear weapons that are available to the unit should be included in fire support planning of contingency plans. If additional nuclear weapons are required in the contingency plans, the basic plan should provide for making them available.

c. The tactical commander controls the distribution of nuclear weapons by:

(1) Determining the number of nuclear weapons that will be carried as part of prescribed nuclear loads of organic or attached delivery units.

(2) Directing the stockage of nuclear rounds in special ammunition supply points under his control and arranging for the stockage of the additional nuclear weapons he may require as part of the prescribed nuclear stockage in a special ammunition supply point not under his control.

3—8. Distribution of Nuclear Weapons

a. Commanders and staff officers must continuously evaluate the capabilities of logistic systems to support nuclear weapon employment. Because of their decisive character and limited availability, the distribution of nuclear weapons is an operational as well as a logistic problem. Nuclear weapon distribution is affected by:

(1) Mission.

(2) Planned weapon packages for immediate and subsequent requirements.

(3) Ammunition availability.

(4) Unit carrying capacity.

(5) Requirements to carry other types of ammunition in the special ammunition load.

(6) Security.

(7) Support unit transportation capability.

b. The nuclear ammunition logistic system is tailored to operate in varied operational environments. Commanders and staff officers concerned with planning and controlling special ammunition support activities must consider the following requirements in planning:

(1) Continuous nuclear logistic support of tactical operations.

(2) Simplicity and uniformity in procedures.

(3) Minimum handling of nuclear weapons.

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

c. Positioning nuclear weapons for security and operational purposes may result in a commander having more or fewer weapons positioned in his command than are required when release authority is received. When fewer weapons are positioned, procedures must be established by which the additional weapons can either be obtained or fired by another command.

d. Nuclear weapons are stored by and issued to delivery units by ordnance special ammunition units. The details of ordnance ammunition support procedures are contained in FMs 9—6 and 9—47.

e. Replenishment of the prescribed nuclear load and the prescribed nuclear stockage is accomplished by directed issue. Because of the limited supply of nuclear weapons and the requirement for varying the location of weapons to meet the changing tactical situation, directed replacement is most feasible. A more detailed discussion of special ammunition logistic support is contained in FM 54—7.

3—9. Security of Nuclear Weapons

a. The critical nature of nuclear weapons requires continuous attention to security of storage sites and movement. Commanders and staff officers must insure that adequate measures are maintained to insure security in depth.

b. Security of nuclear weapons in special ammunition elements is performed by military police physical security companies. These units perform vital security missions. They are augmented in contingencies by reserve forces organized within the overall command.

c. Security plans must be developed based on vulnerability analyses of the storage facilities and movement routes. Criticality of munitions, extent of the enemy threat, and availability of sensor equipment and guard forces will all have a direct effect on security planning. All plans developed must provide for contingency operations.

d. Planning considerations that must be addressed in developing security plans for nuclear weapons and that may be modified for wartime operations, as necessary, include the following:

(1) *Physical safeguards.* These include perimeter barriers, protective lighting, and defensive positions.

(2) *Access controls.* These controls include access rosters, entry controls, adherence to the two-man rule, lock and key control, and identification systems.

(3) *Intrusion detection systems.* These systems include sensor employment within the storage facility, along restricted area perimeters, and within avenues of approach. These sensor systems should provide for interoperability to provide maximum flexibility and responsiveness.

(4) *Guard forces.* These include organization, screening, training, and supervision of military police guard forces, security alert team and backup alert force units, and reserve augmentation forces.

3—10. Warning of Friendly Nuclear Strikes

a. Advance warning of a nuclear strike is required to insure that friendly forces are not exposed to greater than acceptable risk. For strikes on distant enemy targets, advance warning is required only for aircraft that may be affected by such strikes.

(1) Notification concerning friendly strikes can be a time-consuming process even when procedures are carefully established. Dissemination of warnings earlier than is necessary just because the process is time-consuming should be avoided because it may alert the enemy to the planned strike, with a resultant decrease in attack effectiveness or, possibly, a preemptive nuclear strike by the enemy.

(2) Normally there is no requirement to warn subordinate units when the target analysis indicates that negligible risk to unwarned, exposed troops will not be exceeded and insufficient time exists to warn all personnel. In this case only those personnel who might receive more than negligible risk for the unwarned, exposed vulnerability conditions are warned.

(3) Aircraft are vulnerable to weapon effects, even low overpressures. In addition, dazzle can be a significant hazard to personnel flying in aircraft. Because aircraft can move rapidly from an area of negligible risk to one where unacceptable risks may be encountered, all aircraft within the area of operations should be given advance warning during both day and night operations.

(a) Army aircraft should be warned through unit command nets or airspace control stations.

(b) 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 world geographic reference of the nuclear burst. The AADCP will transmit a warning message to its associated tactical operation center (TOC) and the sector operation center/control and reporting center (SOC/CRC) so that agencies may transmit alerts to their airborne aircraft.

(c) Warnings to Air Force, Navy, or Marine Corps aircraft will be initiated by the fire support element (FSE) via communication links with the direct air support center (DASC) or the supporting arms control center (SACC).

(4) When low-yield weapons are employed in dynamic situations, operational requirements may dictate some relaxation of requirements for positive warning.

b. Nuclear strike warning (STRIKWARN) messages are disseminated as rapidly as possible and, insofar, as possible, over secure networks. For situations where secure networks are not available, unit communications-electronics operation instructions (CEOI) should contain authentication procedures and encoding instructions for nuclear STRIKWARN messages.

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

(2) The STRIKWARNs 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 outlined below.

(1) Warning responsibilities are as follows:

(a) Responsibility for issuing the initial warning rests with the commander executing the strike. He is

responsible for insuring that the subordinate headquarters whose units will be affected by the strike are informed.

(b) Commanders executing nuclear strikes will insure that strikes affecting the safety of adjacent commands and elements of other commands in the vicinity that might be affected are coordinated with these commands in sufficient time to permit them to disseminate the warning and to take protective measures.

(2) Figure 3—1 shows the format in which all friendly nuclear STRIKWARNs will be given. Determination of minimum safe distances (MSD) is discussed in chapter 5.

(3) The STRIKWARN message contains lines YANKEE and ZULU for transmitting fallout prediction data for surface bursts for yields of 0.15 KT and higher. For yields of less than 0.15 KT and for all subsurface bursts, line ZULU INDIA is used instead of line ZULU.

(4) When nuclear strikes are cancelled, units previously warned will be notified of the cancellation by the most expeditious means possible.

(5) Unit procedures will require that STRIKWARN messages be acknowledged. The meaning of the acknowledgement should be a unit SOP item.

d. To expedite the warning process, company-sized units should not receive the entire STRIKWARN message, but should receive specific instructions concerning protective measures to be taken if they are in an area of risk. The message should include:

(1) A statement that the message is a nuclear STRIKWARN.

(2) A brief, prearranged directive concerning the specific protective measures to be taken, to include, if required, evacuation to an alternate position. Protection requirements for friendly nuclear strikes correspond to:

(a) DGZ to MSD 1—Evacuation of all personnel. If evacuation is not possible, or if a commander elects a higher degree of risk, maximum protective measures will be required.

(b) From MSD 1 to MSD 2—Maximum protection. Maximum protection denotes that personnel are in "buttoned-up" tanks or are crouched in foxholes with improvised overhead shielding.

(c) From MSD 2 to MSD 3—Minimum protection. 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.

(d) MSD 3 and beyond—No protective measure except against dazzle.

e. While units outside the area in which effects may be received normally are not sent a nuclear STRIKWARN message, effective liaison may require that strike data be passed to adjacent units as a matter of procedure. Information concerning the strikes, such as that used to update situation maps and portray areas where obstacles to maneuver of friendly forces may exist, may also be of operational concern.

ALFA	:	Code word indicating nuclear strike (target number).
DELTA	:	Date/time group of burst and date/time group after which the strike will be cancelled (both in ZULU time).
FOXTROT	:	GZ or DGZ (UTM grid coordinates with a minimum of 6 numerical digits).
HOTEL	:	Indicate air, surface, or subsurface bursts.
INDIA	:	For all bursts: MSD 1 in hundreds of meters, 4 digits. (NEG RISK I WA DERS) MSD 2 in hundreds of meters, 4 digits. (NEG RISK I WE PERS) MSD 3 in hundreds of meters, 4 digits. (MOD RISK I UE PERS) LSD for light aircraft in flight in hundreds of meters, 4 digits.
YANKEE	:	For all bursts when there is less than a 99% assurance of no militarily significant fallout. Azimuth of left then right radial lines (degrees or mils—state which), 4 digits each.
ZULU	:	For bursts of 0.15 KT or greater (except subsurface bursts) when there is less than 99% assurance of no militarily significant fallout. Effective windspeed in kilometers per hour (kmph) to nearest kilometer, 3 digits. Downwind distance of zone I to nearest kilometer, 3 digits. Cloud radius to nearest kilometer, 2 digits. (Use of the ZULU line precludes use of the ZULU INDIA line.) NOTE: If effective windspeed is less than 8 kmph, line ZULU will contain only three significant digits; i.e., the radius of zone I.
ZULU INDIA	:	For bursts of less than 0.15 KT, and for all subsurface bursts. Effective windspeed in kmph to nearest kilometer, 3 digits. Downwind distance of zone I in hundreds of meters, 4 digits. Downwind distance of zone II in hundreds of meters, 4 digits. Cloud radius in hundreds of meters, 3 digits. (Use of the ZULU INDIA line precludes use of the ZULU line.) NOTE: If effective windspeed is less than 8 kmph, line ZULU INDIA will contain only four significant digits; i.e., the radius of zone I.

Figure 3—1. STRIKWARN message.

I NEGLIGIBLE RISK SHOULD NOT BE EXCEEDED UNLESS SIGNIFICANT ADVANTAGE CAN BE GAINED.

3—11. Tactical Damage Evaluation

Following a friendly nuclear strike every reasonable effort is made to determine the damage to enemy forces and their reaction to the attack. Post strike reconnaissance will be planned for each package in an operation plan and should consider all means of surveillance. This effort will also seek to obtain information concerning residual radioactivity, fires, and damage to civilian facilities and the need for a possible restrike of a target. Detailed procedures for post strike analysis are found in chapter 5.

3—12. Employment of Atomic Demolition Munitions

a. Atomic demolition munitions (ADM) may be employed in all types of tactical operations—offense, defense, and retrograde. They provide the commander with a means to delay or canalize enemy forces. ADM employment is planned by the operational staff as part of the corps package. They are emplaced by specially qualified engineer personnel or other trained individuals and may be detonated by a timer device or remote command equipment that provides the tactical commander with an "on-call" capability. Because there is no delivery error in the emplacement of the ADM, the smallest yield necessary to destroy the target or create the obstacle may be used, thereby minimizing damage to the surrounding area. For a detailed description of ADM employment, mission documentation, and weapon selection techniques, see FMs 5—26 and 5—26A. ADM effects data are contained in FM 101—31—2.

b. The atomic demolition plan (ADP) is the commander's summary guidance for the employment of ADM in his area of responsibility. The ADP is integrated with other contingency plans for tactical employment of nuclear weapons to insure that the ADM support those contingency plans.

c. ADM are normally employed in areas under friendly control and are integrated with barrier plans and fire support plans. Guidance on integration with these plans is included in FM 31—10. Typical employment of ADM includes: cratering in mountainous and unusual terrain to create a major obstacle to enemy motorized elements; cratering in forested areas, where production of fires and tree blowdown could create additional obstacles; destruction of critical elements of high-speed routes, such as bridges, highway overpasses, and tunnels; and destruction of installations, facilities, and industrial complexes that could have military significance if in enemy hands. Other potential sites are structures and facilities where other methods of destruction are not practical, such as airfields; railroad marshaling yards; major dams; navigation locks; and large petroleum, oil, and lubrication installations.

d. The typical ADP must have detailed information concerning the target area to permit an accurate determination of the best emplacement position and yield. A reconnaissance of the target is required to obtain the data needed by the target analyst and the mission planner.

e. The commander executing an ADM mission will normally direct the mode of transportation to be used for movement of the ADM to the target area, and he may provide resources and security personnel from units available to him.

f. Because ADM are normally detonated at or near the surface, a fallout prediction must always be made. The fallout prediction should be made as early as possible in the planning sequence to determine if collateral damage constraints can be met and to allow the necessary warning message to friendly forces. After the detonation, the fallout prediction should be revised using the actual winds that occurred at the time of detonation as part of the post strike analysis. Each step in refining the fallout prediction from initial planning data through post strike analysis permits the tactical commander to evaluate the impact of fallout on current and future plans.

3—13. Operational Considerations in Residual Radiation Areas

a. Radiation from a nuclear detonation that is emitted after 1 minute is called residual radiation. Residual radiation can appear as neutron-induced radiation within a relatively small circular pattern around ground zero or as fallout in a large, irregular pattern encompassing the ground zero and extending downwind from the burst point. Since neutron-induced radiation is within the area dominated by other effects, the major emphasis will be placed on fallout. A detailed discussion of residual radiation and its effects is contained in appendix B.

b. To satisfy command requirements at all echelons for determining possible effects of residual radiation, two procedures for predicting fallout have been established. A detailed fallout prediction is prepared by units with access to meteorological information, which is usually disseminated in the form of an NBC 3 (nuclear) message. A simplified fallout prediction, using the latest effective downwind message on hand, can be prepared with the M5A2 Radiological Fallout Area Predictor as soon as an NBC 2 (nuclear) report is received. The simplified prediction should be replaced with a detailed prediction when the NBC 3 message is received. Both of these methods are limited to producing only a warning sector; that is, an area within which most of the fallout is expected to occur.

(1) The warning sector is subdivided into two zones for operational purposes. Zone I is the zone of immediate operational concern. Within this zone, exposed, unprotected personnel may receive 150 or more rad within 4 hours after the actual arrival of fallout. This potential for exceeding the emergency risk dose may necessitate immediate actions to decrease the exposure of units located in this zone. Zone II is the zone of secondary hazard. Within this zone, exposed, unprotected personnel should not receive more than 150 rad within a period of 4 hours after fallout arrival, but may receive 50 or more rad within the first 24 hours. Outside these two zones, the total dose should not reach 50 rad for the first 24 hours or 150 rad for an infinite time.

(2) Basic inaccuracies in fallout prediction limit the use of these methods to depicting only suspect areas for early monitoring and survey or planning the

movement of units. *They are not* to be used as a basis for executing operational moves. The prediction methods also permit determination of the areas outside of which friendly troops are likely to be unaffected by the fallout hazard. Techniques for preparing detailed and simplified fallout predictions are contained in FM 3—12.

c. Command decisions in any fallout situation are based on consideration of two opposing factors: the risk of exposure of personnel to radiation and the demands of the tactical situation. At one extreme the total energies of the unit are directed toward keeping the radiation exposure to a minimum, and at the other the demands of the tactical situation are clearly dominant, and risk consideration must be suppressed.

(1) *Radiation hazard dominant.* This situation may occur when a unit that has been previously exposed to radiation is approaching the emergency risk total dose or its expected dose will exceed the operational exposure guide. In either case further exposure may cause the unit to become combat ineffective. Two general courses of action can be considered—move from the contaminated area or remain in position.

(a) Move from the contaminated area.

1. When air transportation is available, evacuation from the area as soon as possible is the best course of action.

2. When the shielding provided by the exit means is at least half of that available in the position (in the absence of air evacuation means), movement from the area is accomplished as soon as the minimum-dose exit route can be determined. Procedures for determining this route are contained in FM 3—12.

3. Fallout predictions are not sufficiently accurate to be used as a sole basis for such moves. When a unit is located within a predicted fallout area, plans and preparations for movement should be made. The decision to begin movement is 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 are determined. Based on this information, a minimum-dose exit route is selected. A method for determining the optimum time for exit from a fallout area is given in FM 3—12.

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

(b) Remain in position. When the total dose calculations indicate that a unit would receive a larger dose by moving out of the fallout area than by remaining in position, the unit remains in place. This situation may occur, for example, when the unit is in a well-fortified defensive position with good shielding and leaving the area would require an extensive foot movement over contaminated terrain.

(2) *Tactical demands dominant.*

(a) When the demands of the tactical situation clearly govern, a unit continues to place primary emphasis on the accomplishment of its mission. This situation may arise, for example, when a unit in contact with the enemy is being exposed to some radiation, but

actions necessary to reduce radiation exposure may increase the unit's casualties from enemy action. The unit may, however, be able to take some protective actions without jeopardizing its security or its mission.

(b) The decision to shift emphasis from mission accomplishment to countermeasures against radiation exposure is dependent on a capability to predict with reasonable accuracy the times at which critical radiation doses will be reached. Such predictions can be made when the peak dose rate at some known time after burst is obtainable. When this information is not obtainable, it should be assumed that the unit will be exposed to incapacitating radiation doses unless immediate countermeasures are taken.

d. Standing operating procedures should provide for radiological monitoring whenever surface bursts are known to have occurred in the area. These procedures should also establish methods of assembling the information necessary to make radiological contamination charts. After these charts have been plotted, probable dose-stay time calculations can be performed. (FM 3—12 describes these methods and calculations.) The commander can then estimate the risks involved in executing maneuvers through the area of militarily significant fallout or remaining in position. As a result of this estimation, the commander may alter his tactical plan, accept a risk of increased casualties, or delay his movement until the radioactivity has decayed to an acceptable level.

CHAPTER 4

ANALYSIS FOR NUCLEAR WEAPON EMPLOYMENT

4—1. General

a. The purpose of nuclear weapon employment analysis is to determine the most effective use of available nuclear weapons. The methods discussed in this chapter can be used to select the appropriate nuclear weapons for use against expected and confirmed tactical targets. The two methods discussed are the preclusion-oriented method and the target-oriented method.

b. The preclusion-oriented method is appropriate during fire planning, when detailed target information is not available. This method is used to select a weapon based on limiting requirements and an analysis of the threat. It will be used for suspected targets and areas that may contain nuclear targets based on the enemy's tactics, doctrine, and a terrain analysis.

c. The target-oriented method is used to select a weapon based on the characteristics of the acquired target, the desired effects on the target, the delivery errors, and the limiting requirements. Generally, in planning a nuclear package the target analyst will use a combination of these two methods, with the use of the preclusion-oriented method predominating. The target-oriented method will be used for priority targets that have been acquired and when sufficient information is known about the target to do the analysis. In general, the weapons that optimize effects while satisfying the limiting requirements will be selected. Finally, an important part in the target analysis process is the assessment of damage. This assessment is accomplished by a post strike analysis.

4—2. Assumptions

As with most analysis procedures, assumptions are made for certain variable aspects. In target analysis these assumptions are:

a. Reliability. Casualty or damage estimation methods are based on the assumptions that the weapon will arrive at the target area at the desired time, within predicted delivery error tolerances, and that a nuclear detonation of the expected yield will take place.

b. Targets. Target elements are assumed to be uniformly distributed and randomly oriented.

c. Target Location Error. No target location error (TLE) is assumed, but the target analyst can account for TLE in the target-oriented method if it is known.

d. Atmospheric Conditions. The effects of nonstandard atmospheric conditions on blast, nuclear, and thermal radiation radii of effects are not usually considered. Cases where effects may be significantly modified by atmospheric conditions are discussed in appendix B.

e. Terrain. A flat surface is assumed for all situations; however, nuclear weapon effects can be significantly modified by extreme terrain, such as mountains, which can shield targets from the effects, or valleys, which can enhance effects. No reliable system is known for modification of a weapon effect analysis because of terrain considerations which is adaptable to the methods discussed in this manual.

4—3. General Procedures for Analyzing Targets

The procedures outlined in figure 4—1 will assist the target analyst in his efforts to choose the appropriate weapon systems for a nuclear strike. They may be modified by the analyst based on his experience.

a. Step 1. Identify pertinent information. Frequently, some pertinent information, particularly detailed target information, may not be immediately available. In such cases, the analyst's estimate, based on his experience and available intelligence, must be used. The following information should be obtained to facilitate the analysis.

(1) *Target information.* Target information includes:

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

(b) Category of primary target and, if applicable, the degree of protection of the target against weapon effects; e.g., personnel in tanks.

(c) Distribution of the target elements. This is of particular importance for large targets, such as a battalion assembly area, because intelligence concerning the location of subordinate elements could result in a more effective attack of the target complex; e.g., the use of a few small weapons instead of one large weapon.

1. Identify Pertinent Information.
   - Target information.
   - Friendly elements and collateral damage information.
   - Terrain analysis in conjunction with the suspected threat.
   - Command guidance and standing operating procedures.
2. Methods for Target Analysis.
   - Target oriented.
   - Preclusion oriented.
3. Determine Suitable Weapons.
   - Target oriented.
     - a. Initial coverage/probability.
       - Visual.
       - Numerical.
       - Index.
     - b. Limiting requirements.
       - Troop safety.
       - Collateral damage.
       - Obstacle and damage preclusion.
     - c. DGZ selection.
     - d. Final coverage/probability.
   - Preclusion oriented.
     - a. Limiting requirement.
       - Troop safety.
       - Obstacle and damage preclusion.
       - Collateral damage.
     - b. Eliminate unsuitable weapons.
4. Evaluate Weapon Systems and Tactical Situation.
5. Make Recommendation.
6. Post Strike Analysis.

Figure 4—1. Target analysis procedures.

(*d*) Mobility of the target; that is, the expected stay time or rate of movement of a target.

(2) *Friendly element and collateral damage information.* This information includes:

(*a*) Weapons available for planning purposes and the location of the weapons.

(*b*) Location of the delivery means.

(*c*) Location of friendly troops in the area planned for the burst or bursts, their degree of protection, and their radiation exposure state (RES). (See app C.)

(*d*) Location of areas containing noncombatants and, if obtainable, their degree of protection.

(*e*) Location of structures, facilities, or equipment for which damage should not exceed a specified level.

(*f*) Response time of delivery units being considered to deliver a weapon. General planning guidance for each delivery system is contained in FM 101—31—2. This planning guidance does not take into account any additional time required to meet release procedure requirements. Whenever possible, actual response times should be obtained from the specific delivery unit.

(3) *Terrain analysis in conjunction with the suspected threat.* A terrain analysis must be made to determine the most likely avenues of approach, possible penetrations, and areas where lucrative nuclear targets should be located to support the enemy's operations based on his tactics and doctrine.

(4) *Command guidance and standing operating procedures.* The following criteria should be established by the division commander or higher based on his analysis of the mission requirements and the limiting requirements associated with mission accomplishment:

(*a*) Target defeat guidelines for the particular operation. For area targets, the guidelines should specify the level or casualties or damage desired over a specified fraction of the target. Guidelines should also be used to establish the level of assurance required for the defeat of point targets.

(*b*) Degree of acceptable risk to friendly troops. This is normally specified as negligible risk to unwarned, exposed personnel. A higher degree of risk may be specified if operationally warranted.

(*c*) Degree of acceptable risk to noncombatant personnel. This in normally a 5-percent incidence of ~~casualties~~ F at the edge of populated areas unless otherwise specified by the corps commander or higher authority.

(*d*) Prohibitions against creation of obstacles, as appropriate.

b. Step 2, Determine Methods for Target Analysis. The availability of target information as determined in step 1 will dictate which method, target-oriented or preclusion-oriented, will be used in determining suitable weapons.

(1) *Target-oriented.* This method is best suited for those circumstances where detailed target information is available. Using this method, damage estimations will be made to determine which weapons meet the target defeat guidelines.

F CIVILIANS AT RISK TO HOSPITALIZING INJURIES.

(2) *Preclusion-oriented.* This method is best suited for those circumstances where detailed target information is not available. Using this method, the target analyst identifies those weapon systems that meet the limiting requirements in the areas of the suspected targets, along likely avenues of approach, possible penetrations, and areas where nuclear targets may be located based on the enemy's tactics and doctrine.

(3) For the analyst to use the nuclear weapons available effectively, a combination of the preclusion-oriented and target-oriented methods will most likely be used.

c. Step 3, Determine Suitable Weapons.

(1) *Target-oriented.* Selection of weapons using the target-oriented approach consists of the following steps: determine initial coverage or probability of those weapons available, consider limiting requirements, select desired ground zero (DGZ) to meet these limitations, and determine final coverage or damage probability of weapons that meet the criteria.

(a) Determine initial coverage or probability of damage. Depending on the characteristics of the target, there are three techniques of estimating damage: visual, numerical, and index.

1. Visual. These graphical techniques estimate coverage of noncircular area targets.

2. Numerical. This technique estimates fractional coverage of circular area targets or probability of damage to point targets using area or point target graphs.

3. Index. This technique, using precomputed coverage tables, estimates damage against a circular area target when it is in a primary target category and the desired ground zero is at target center. Detailed explanations of the three techniques are contained in chapter 5.

(b) Consider limiting requirements. Restrictions placed on the employment of nuclear weapons are referred to as "limiting requirements" and are considered in three areas—troop safety, collateral constraints, and the preclusion of obstacles/ that could interfere with the tactical mission or other operational plans.

1. Troop safety. The analyst determines if the distance between friendly troops and the DGZ is sufficient to insure that the troops will not be exposed to a risk exceeding that specified by the commander.

2. Collateral damage. The analyst determines if the distance between the DGZ and locations containing noncombatant personnel or areas where damage preclusion has been directed is sufficient to insure that the specific preclusion criteria are met.

3. Obstacle and damage preclusion. The analyst determines if the distance between the DGZ and the point where obstacle/ preclusion has been directed is sufficient to meet the commander's guidelines.

(c) Select the final DGZ. The target center is initially selected as the DGZ. The final DGZ may be displaced to satisfy limiting requirements and/or to allow for an attack of multiple targets with a single weapon. An explanation of the techniques for selecting a DGZ is contained in chapter 5.

/ OR DAMAGE

/ OR DAMAGE

(d) Final coverage/probability. When a displacement of the tentative DGZ is made, then a revised prediction of casualties or damage using the new DGZ must be made. When there is no displacement of DGZ, initial coverage/probability becomes final coverage/probability.

(2) *Preclusion-oriented.* Using the preclusion-oriented approach, the analyst is concerned with selecting a weapon that meets the limiting requirements in the area of the threat. This method consists of an analysis of the terrain and threat, determination of the limiting requirements, and elimination of unsuitable weapons.

(a) Analysis of the terrain and threat. The analyst carefully analyzes the terrain for likely avenues of approach, probable penetrations, and areas where he suspects nuclear targets may be located based on current intelligence and enemy tactics and doctrine.

(b) Determination of limiting requirements. The analyst applies troop safety distances, obstacle preclusion distances, and collateral damage distances to the area of proposed employment.

(c) Elimination of unsuitable weapons. Weapons are eliminated when the limiting requirements offer no areas for possible DGZ selection.

d. Step 4, Evaluate Weapon Systems and the Tactical Situation.

(1) For the target-oriented method, the weapons that meet the guidance for each acquired target are identified. Factors that must be considered when selecting the most suitable weapon for a target are:

(a) The highest priority targets should receive first consideration.

(b) Weapons and yields selected must meet any release constraints.

(c) Retention of more effective systems by the commander for follow-on use should be considered.

(d) The weapon selected should give the highest coverage for area targets or the highest probability of defeat of a point target while meeting all troop safety, collateral damage, and obstacle/preclusion criteria. Nevertheless, there may be instances when the minimum yield weapon which gives adequate coverage or probability is selected. For example, minimum yield weapons may be used to conserve firepower or reduce both collateral damage and obstacles to a minimum.

(2) For the preclusion-oriented method, weapons and DGZs are selected that will give the most complete coverage for the proposed area of employment consistent with the limiting requirements, available intelligence, and the tactical situation.

e. Step 5, Make Recommendation. After the selection of suitable weapons has been completed based on the combined use of both methods, a recommendation for defeat of the threat group of targets or a target, as appropriate, is presented to the commander. When formulating his final recommendation, the analyst should place emphasis on the balance between military effectiveness and collateral damage. The recommendation should include:

(1) *Weapon system.* The weapon system consists of the recommended delivery system, weapon, and yield.

FOR DAMAGE

(2) *Height of burst option.* The height of burst (HOB) will be indicated so that the significance of any possible surface contamination can be assessed. When the HOB for a timer-fuzed weapon is furnished to the delivery unit, the exact HOB in meters will be transmitted. When appropriate, a recommendation for utilizing or precluding backup impact fuzing will be made when an airburst is the primary fuzing option.

(3) *Desired ground zero.* The DGZ is that point on the surface above, at, or below which the detonation is desired. It is designated by map coordinates.

(4) *Time on target.* The time of burst is dictated by both tactical considerations, such as the general concept of employing a package, and technical considerations, such as preinitiation. The acceptable interval for time on target will also be specified because of its impact on troop warning considerations and because it is an integral part of the employment package concept.

(5) *Predicted results.* If the target-oriented method is used, the fractional coverage of area targets or the probability of achieving a specified degree of damage or casualties on a point target will be indicated. For the preclusion-oriented method, the radii of damage can be graphically portrayed on the areas of proposed employment.

(6) *Limiting requirements.* The troop safety and collateral damage information will always be presented. It should be presented graphically, if possible.

f. Step 6, Conduct Post Strike Analysis. A nuclear strike can be deemed successful if the desired results are achieved (i.e., enemy attack is halted). However, the analyst can determine the extent to which the nuclear strike was successful or unsuccessful by a post strike analysis. (See chapter 5 for details of a post strike analysis.)

g. Target Analysis Worksheet. A target analysis worksheet can be locally devised, as appropriate.

This worksheet systematically leads the analyst through the required steps of target analysis for nuclear weapon systems. An example is shown in figure 4—2.

4—4. General Procedures in Nuclear Weapon Package Planning

a. The target analyst at corps and division will be involved in contingency planning of nuclear weapon packages during peace and war. These plans are developed in four distinct phases:

(1) Peacetime planning based on ~~assumed penetrations into the proposed corps defensive area~~. /F

(2) Wartime planning to supplement peacetime planning based ~~on actual threat~~. ON LIMITED REQUIREMENTS, TERRAIN, AND ACTUAL THREAT.

(3) Refinements to wartime planning to meet changing situations and to update package to be requested.

(4) Refinements to approved package based on tactical situations just prior to firing pulse.

F THE TYPE OF TACTICAL OPERATION (OFFENSIVE, DEFENSIVE, RETROGRADE) TO BE SUPPORTED, LIMITING REQUIREMENTS, TERRAIN, AND THE ASSUMED THREAT.

TARGET NO __________ DTG OF SELECTION __________ ANALYST __________

WEAPON SYSTEM							
Firing Position							
Yield							
Range							
Exp RD/RD min							
CEP/CD 90							
HOB (option/Meters)							
Initial Coverage/Probability							
TROOP SAFETY							
MSD							
Troop Distance from DGZ							
Displacement							
COLLATERAL DAMAGE							
Personnel	Materiel						
CDD	CDD						
Distance from DGZ							
Displacement							
PRECLUSION OF							
Obstacle	Damage						
LSD	LSD						
Distance from DGZ							
Displacement							
MAXIMUM DISPLACEMENT							
Area	Point						
RD/RT	RD/CD90						
CEP/RT, CD90/RT	d/CD90						
d/CEP, d/CD90	d/RD						
d max							
FINAL DISPLACEMENT							
RD/RT	RD/CD 90						
CEP/RT, CD90/RT	d/CD 90						
d/CEP, d/CD90	d/RD						
FINAL COV/PROB							

TARGET INFORMATION	
Description	
Category	
Radius	
Location	
Cov/Prob Desired	(IP)(IT)(LL)

TROOP SAFETY	
Risk:	(Neg) (Emer)
Vulnerability:	(Unwarned) (Exp) (Warned) (Prot)
RES:	(0) (1) (2) (3)
Distance from DGZ	

COLLATERAL DAMAGE
Personnel
Materiel
Level of Assurance
Distance from DGZ

PRECLUSION REQUIREMENTS	
Obstacles:	
Damage:	
Fallout:	(Auth) (Not Auth)
Other:	

RECOMMENDATION/FIRE ORDER		
Unit	Firing Point	
Tgt No	DGZ Grid	Tgt Alt
Del Sys	WHD(MK&Y#)	Yield
HOB Option	HOB	Backup Fuze
Desired Tot	Latest Tot	

Predicted Coverage/Probability		
Best Troop Safety		
UWE	WE	WP
MSD 3	MSD 2	MSD 1
NEG:		
MOD:		
EMER:		

SUPPLEMENTAL DATA		
LSD: Light a/c in flight		
LSD: Forest Blowdown (d)(c)		
LSD: Fire (d)(g)		
CRATER	Radius	
	Depth	
Fallout Prediction Rqd (yes)(no)		

POST STRIKE DATA		
Actual TOT		RD/RT
Actual GZ COORD		
Actual Yield		d/RT
Actual HOB		
Exp RD/RD min		d/RD
Coverage/Prob		

REMARKS

Figure 4—2. Example of nuclear target analysis worksheet.

b. The following steps outline a general approach to be taken by the target analyst in the planning of initial peacetime nuclear weapon packages.

(1) *Step 1, collect pertinent information.* This is the most important step in the planning of a nuclear weapon package. The gathering of information is a staff effort, and close coordination with all staff members is imperative.

(a) Threat analysis. In conjunction with the G2, detailed threat and terrain analyses are made throughout the area to be defended. Special emphasis will be placed on likely avenues of approach and employment of obstacles to canalize the enemy to the avenues where weapons can be used most effectively.

(b) Troop safety and collateral damage information. In coordination with the G3 and G5, the target analyst obtains all the information available about the expected deployment of friendly troops and the populated areas.

1. Troop safety. The G3 will provide the proposed locations of friendly troops in the area planned for the bursts.

2. Collateral damage. Unless otherwise directed by the corps commander or higher authority, preclusion of collateral damage will be based on avoiding more than 5 percent incidence of casualties at the edge of the populated area. The G5 will provide the G3 with information on areas containing noncombatants and their probable degree of protection, if obtainable. The locations of structures that should not be damaged should be designated. The number and yields of weapons in the package depend on these collateral damage constraints.

(c) Tactical situation. The nuclear package must be developed in conjunction with the conventional fire and maneuver plan. Of importance to the target analyst is the location of proposed phase lines, fixed defensive lines, and number and type of eneny units expected to be in the assumed penetrations.

(d) Friendly element information. The fire support element (FSE) will provide the target analyst with information concerning available Army weapons. The G3 will determine the composition of the prescribed nuclear load (PNL) for nuclear delivery units. Their anticipated locations can be obtained from the FSE or the G3. The analyst will coordinate with the Air Force liaison officer for information on available Air Force support. The target analyst will work closely with the division and corps engineers in the development of the package.

(2) *Step 2, plot the information.* Plot the data gathered in step 1 on a map using a series of overlays.

(a) Overlays depicting troop safety and collateral damage distances should be made for each weapon system and yield combination suitable for employment in areas of the postulated threat. In essence, these overlays will depict areas available for possible DGZ selection. To facilitate early planning, the initial information plotted on the limiting requirements overlay may be extracted from the simplified reference data in FM 101—31—2. In accordance with the commander's guidance and the unit SOP, the appropriate minimum safe distances (MSD) are extracted from the safety distance tables or calculated from effects data. Collateral damage avoidance radii are extracted from the data tables and the appropriate buffer

distance is added to calculate collateral damage distances (CDD). Similarly, the least separation distances (LSD) of concern are extracted from the safety distance tables or calculated from effects data. These LSD are also placed on the overlays, further restricting DGZ selection. The limiting requirement overlay depicts, for a specific weapon system and yield combination, the area in which that weapon can be employed. More than one weapon system and yield combination may be placed on an overlay to simplify the planning process.

(b) Friendly force information, to include the assumed forward area trace, general location of artillery units, and subsequent defense lines, will be plotted on the basic overlay.

(c) f ~~Assumed enemy routes of~~ advance, assembly areas, ~~and~~ natural obstacles will be ~~depicted~~ on the overlay for an ~~analysis~~ of the coverage afforded ~~by the package.~~

(3) *Step 3, selection of aimpoints.*

(a) The target analyst, in coordination with the G2 and G3, selects the aimpoints and weapon system and yield combinations that will defeat the postulated threat facing his unit. The overlays discussed in step 2 will be a valuable tool in selecting the aimpoints. Another consideration in selecting aimpoints is the role of direct support and general support artillery units. The direct support artillery units should be utilized, as much as possible, for the aimpoints close to friendly units to facilitate package refinements.

(b) A major consideration in the development of a nuclear weapon package is to insure the coordination of conventional fire and maneuver aspects with nuclear fires. Special emphasis should be placed on channeling the enemy into low-density collateral damage areas.

f THE ANTICIPATED THREAT IS ARRAYED ON AN OVERLAY BASED ON A TERRAIN ANALYSIS AND THEIR TACTICS AND DOTRINE FOR THE PARTICULAR ASSUMED FIGHTING POSTURE.

(c) The timespan for firing the package is developed. Scheduling considerations discussed in Chapters 2 and 3, FM 101—31—2, must be considered in determining timespan for the package. Critical elements of the timespan should be identified to simplify refinements at a later date.

(4) *Step 4, evaluation.*

(a) When the aimpoints have been selected, the target analyst should evaluate the package in its totality. An approach to the evaluation is to have the target analyst plot on an overlay the appropriate radii of damage extracted from the simplified reference data table for each weapon employed. This overlay is then superimposed on a map prepared by the G2 which shows the assumed location of all enemy company-sized elements. The target analyst, using the target-oriented methodology, makes a damage estimate for each nuclear weapon planned. From these damage estimates, the G3 evaluates the defeat of the threat by estimating total expected enemy casualties and broken enemy units.

(b) A separate estimate should be made for collateral damage. The G5 should prepare an overlay displaying all population centers, showing the centers' physical limits and population. This overlay is used in conjunction with the radii of damage overlay prepared by the target analyst to make estimations of collateral damage. Measures of collateral damage could be estimates of potential civilian casualties and the percentage of structures subjected to moderate damage.

(c) Step 4 is completed when the appropriate balance between military effectiveness and collateral damage has been achieved to the commander's satisfaction. The package is then identified by the number of nuclear weapons required, their associated yields, the timespan required, and the area for which the package is planned.

c. After the enemy attack has begun, additional packages may be required and developed by the methods indicated above. The contingency packages are evaluated against the actual threat as in step 4. All information concerning new areas of expected penetrations and priority enemy targets should be included in the revised plans. When new packages are developed or previous packages are revised, they should be forwarded to the next higher command to facilitate release procedures, when required.

d. Fire planning is a continuous dynamic effort. During the conventional defense, refinements to a nuclear weapon package should be made. These refinements include all elements of information in the package and are based on new developments in friendly and enemy situations. The status of friendly weapons and delivery systems is especially critical during this period. Refinements that affect the number of weapons required and the delivery units available, as well as major developments in the other elements of the plan, should be furnished to higher headquarters to facilitate release procedures. In steps 2 and 3 of peacetime package planning, the information plotted on the overlays is extracted from the simplified reference data in FM 101—31—2. This information is ideal for the initial planning of a nuclear weapon package. But once the package is planned in general terms and more information becomes available to the target analyst (such as ranges from delivery systems to aimpoints, time on target, which phase line will be occupied at execution time, or better enemy information), he will use this additional information and the detailed data tables to make final adjustments and refinements to the package. Aimpoints are adjusted to maximize the effectiveness of the weapons based on all sources of intelligence that provide information on the actual enemy situation and the size of the actual threat facing the command.

e. After release of a package, refinements should continue up to the time the weapons are fired. Aimpoints may be adjusted to incorporate the latest intelligence. Weapon yields may be adjusted accordingly to match revised constraints and target damage requirements. The CDD may be refined to correspond to the changing situation. These refinements are critical in package employment planning if the enemy attack is to be halted. Only the last hour's efforts of all staff elements will insure the match of delivery systems, weapons, and targets.

f. During the planning of the initial nuclear weapon packages, it must be kept in mind that subsequent packages might be required. Tentative plans should be formulated for subsequent packages to counter such situations as an enemy reinforcement and continuation of conventional efforts or an enemy nuclear response in the battle area or theater. In this sense, the post strike analysis of the initial package is critical if subsequent packages are to be timely and adequate. In addition to determining information of the specific strikes, the intelligence collection efforts must be intensified to detect failure of the initial pulse to terminate the conflict. In this event, continuous planning for such contingencies will enable the corps or higher commanders to respond to post strike situations in the least amount of time.

4—5. Data Used for Target Analysis

The data used for target analysis are obtained from FM 101—31—2, *Effects Data Manual,* which contains the effects data for stockpile weapons. FM 101—31—3 contains unclassified data which are organized in the same manner as FM 101—31—2, but contains data for hypothetical weapon systems. The manuals are organized into seven basic sections as follows: A description of the composition of the manual and weapon system information; coverage and safety distance tables for low airbursts; coverage and safety tables for surface bursts; atomic demolition munitions tables; collateral damage avoidance tables; weapon effects tables; and the charts and graphs used in the analysis procedures.

a. The first two chapters contain data concerning the criteria used to construct the tables in the later chapters and information pertaining to weapon system capabilities, yields, fuzing, and typical system response times.

b. The coverage tables contain personnel data for the three personnel target categories: exposed personnel, personnel in foxholes, and personnel in tanks. Each of these personnel categories is further divided into degrees of incapacitation—immediate permanent, immediate transient, and latent lethality (app C). Materiel damage categories listed are moderate damage to wheeled vehicles, tanks, and towed artillery. For example, figure 4—3 shows the coverage table for exposed personnel (latent lethality) for a system whose delivery errors are range dependent. The table consists of two parts: the section that lists the weapon effectiveness for different radii of the target and the section that lists the radii of damage and accuracy data. Use of these sections will be discussed in section II of chapter 5.

COVERAGE TABLE (Distances in meters) — **SHORT RANGE CANNON 1 KT** 5-24

EXPOSED PERSONNEL - LATENT LETHALITY
LOW AIRBURST

	EFFECTIVENESS										ACCURACY DATA			
	RADIUS OF TARGET								PROB	EXPT				
RANGE	500	600	700	800	900	1000	1300	1500	MIN RD	RD	CD 90	CEP	HOB	PEH
2000	.96/.98	.93/.96	.85/.88	.51/.55	.41/.43	.29/.32	.21/.22	.09/.12	460	526	80	38	49	9
3000	.96/.98	.91/.96	.85/.87	.52/.56	.41/.43	.30/.32	.20/.22	.10/.12	458	532	93	44	59	12
4000	.96/.98	.91/.95	.85/.87	.53/.56	.41/.43	.30/.32	.20/.22	.10/.12	454	532	99	47	59	12
5000	.96/.98	.91/.95	.84/.87	.53/.57	.41/.43	.30/.32	.20/.22	.10/.12	447	538	111	54	69	14
6000	.96/.98	.91/.95	.81/.86	.53/.57	.41/.43	.30/.32	.20/.22	.10/.12	448	540	128	62	82	17
7000	.95/.97	.91/.94	.80/.85	.55/.57	.41/.43	.30/.32	.20/.22	.10/.12	442	540	141	73	90	19
8000	.94/.96	.86/.92	.75/.83	.54/.57	.41/.43	.30/.32	.20/.22	.10/.12	434	538	176	86	101	22
9000	.92/.96	.78/.88	.68/.78	.53/.56	.37/.41	.28/.32	.20/.22	.08/.11	420	520	205	100	116	26
10000	.88/.94	.71/.85	.61/.75	.50/.55	.36/.40	.26/.31	.18/.21	.06/.11	400	490	234	115	132	30

Figure 4—3. Typical coverage table.

c. The safety distance table contains safe separation distances that must be maintained to insure that the appropriate safety or preclusion criteria are met. The table (fig 4—4) consists of the troop safety section, which contains minimum safe distances (MSD) to insure the safety of personnel, and a preclude section, which contains least separation distances (LSD) to preclude damage to materiel or to preclude the production of obstacles.

SAFETY DISTANCE TABLE **SHORT RANGE CANNON 1 KT** 5-24

(Distances in meters)

TROOP SAFETY (MSD) ------- PRECLUDE (LSD) -------

	UNWARNED EXPOSED			WARNED EXPOSED			WARNED PROTECTED			MOD DAM FIXED	LT DAM TO	LT ACFT IN FLIGHT OBSN UTIL		OV-1B CARGO	FOREST BLOWDOWN		WILDLAND FIRES CLASS	CLASS
RANGE	NEG*	MOD*	EMER*	NEG*	MOD*	EMER*	NEG*	MOD*	EMER	BRG	BLDG	HEL	ASLT HEL	HEL	DECID	CONIF	I	IV
2000	1200	1200	1000	1200	1100	1000	1000	900	800	200	1200	1400	1500	1200	500	400	800	500
3000	1200	1200	1000	1200	1200	1000	1000	1000	900	200	1200	1400	1500	1200	600	400	800	600
4000	1300	1200	1100	1200	1200	1100	1000	1000	900	300	1300	1400	1500	1200	600	500	800	600
5000	1300	1200	1100	1300	1200	1100	1100	1000	900	300	1300	1400	1500	1200	600	500	800	600
6000	1300	1300	1100	1300	1300	1200	1100	1100	1000	300	1400	1400	1500	1200	600	500	800	600
7000	1400	1300	1200	1300	1300	1200	1200	1100	1000	300	1400	1400	1500	1200	600	500	800	600
8000	1400	1400	1200	1400	1400	1300	1300	1200	1100	300	1500	1400	1500	1200	700	500	900	600
9000	1500	1400	1300	1400	1400	1300	1400	1300	1100	300	1600	1400	1500	1200	700	500	900	600
10000	1500	1500	1400	1500	1500	1400	1500	1300	1200	100	1600	1400	1500	1300	700	500	900	600

*Nuclear radiation effects are significant. If troops have history of previous exposure, consult Figure 5-24 for modification of risk radii.

Figure 4—4. Typical safety distance table.

d. The ADM chapter contains data primarily concerned with the effect of airblast against various materiel targets and structures. Several tables are included to show radii of effects for overpressures, for safety of personnel from the governing effect, and for cratering.

COLLATERAL DAMAGE AVOIDANCE TABLES **SHORT RANGE CANNON 1 KT** 5-24

(Distances in meters)

	PERSONNEL INJURY [5% incidence]			MODERATE DAMAGE TO FACILITIES [5% incidence]					THERMAL IGNITION [threshold level]			
HOB	URBAN	RURAL	IN OPEN	SINGLE STORY FRAME BUILDING	SINGLE STORY MASONRY BUILDING	LIGHT STEEL INDUST BLDG	FIXED BRIDGES	RAIL ROAD EQUIP	WOOD SHINGLES	DRAPES	NEWSPAPERS & DEBRIS	HOB
600	640	800	1070	1350	690	230	0	0	500	810	870	600
570	650	810	1080	1590	710	260	90	0	520	820	870	570
540	670	820	1090	1630	740	300	160	0	550	830	890	540
510	680	840	1090	1640	760	330	200	0	560	840	900	510
480	690	850	1100	1640	780	360	230	0	570	850	910	480
450	710	970	1100	1630	980	440	270	0	580	860	910	450
420	710	990	1120	1610	990	470	300	0	600	870	920	420
390	730	990	1130	1580	1000	620	480	0	610	870	920	390
360	740	1000	1130	1550	1010	640	500	0	620	880	930	360
330	750	1000	1130	1520	1000	630	530	10	630	890	940	330
300	750	980	1140	1480	980	610	520	240	640	900	950	300
270	760	950	1140	1430	950	590	500	360	650	910	950	270
240	760	920	1150	1380	920	570	480	390	650	910	960	240
210	770	910	1150	1330	890	560	470	390	660	910	970	210
180	770	910	1160	1270	860	540	450	390	670	910	970	180
*150	770	910	1160	1210	820	510	430	390	670	920	970	150*
120	770	910	1160	1150	780	490	410	390	680	920	980	120
90	760	900	1160	1090	750	470	400	390	680	920	980	90
60	750	890	1140	1020	700	440	380	380	680	910	960	60
30	740	880	1030	960	650	420	360	360	600	810	860	30
1	700	840	920	900	610	400	330	320	520	720	770	1

NOTE: Personnel injury normally governs collateral damage constraints. *: Preset or typical HOB

Figure 4—5. Typical collateral damage avoidance table.

e. The collateral damage avoidance tables (fig. 4—5) provide guidelines by listing radii to be used to avoid undesirable civilian materiel damage or personnel casualties produced by the effects of friendly nuclear weapons.

f. The effects tables (fig 4—6) contain radii of damage, radii of preclusion, and radii of safety. These radii are portrayed as a function of height of burst for a particular delivery system and yield. To give the target analyst additional flexibility, a table is included in chapter 1, FM 101—31—2, that lists multiplication factors which convert severe damage radii to moderate damage radii.

g. The last chapter of the effects data manuals contains graphs used for the numerical method of damage estimation, the comparable targets table, the radii of vulnerability table, and various tables relating to operations in residual radiation areas.

EFFECTS TABLES (Distances in meters) — SHORT RANGE CANNON 1 KT

PRECLUDE						SAFETY RADII									
1-PSI OVER-PRES-SURE	MOD DAM FIXED BRG	FOREST BLOWDOWN		WILDLAND FIRES		UNWARNED EXPOSED			WARNED EXPOSED			WARNED PROTECTED			
		DECID	CONIF	CLASS I	CLASS IV	NEG**	MOD**	EMER**	NEG	MOD**	EMER**	NEG	MOD	EMER**	HOB
1860	0	0	0	1110	550	2040	1900	1070	1120	1000	830	1210	780	620	600
1880	0	0	0	1110	570	2050	1900	1070	1130	1010	840	1460	1140	640	570
1880	0	0	0	1120	580	2050	1910	1090	1140	1020	860	1570	1180	650	540
1890	0	0	0	1130	600	2060	1920	1100	1140	1040	860	1580	1210	670	510
1860	0	0	0	1140	620	2060	1920	1110	1150	1040	870	1580	1330	690	480
1840	0	0	0	1140	630	2060	1920	1110	1160	1050	890	1580	1350	690	450
1810	0	650	0	1150	640	2070	1920	1120	1170	1060	900	1560	1360	710	420
1770	0	730	0	1160	650	2070	1930	1130	1180	1060	900	1540	1340	720	390
1740	0	730	0	1170	660	2070	1930	1140	1180	1070	910	1510	1320	720	360
1690	0	730	480	1170	670	2080	1940	1140	1180	1070	920	1480	1290	730	350
1640	0	720	510	1180	680	2080	1940	1140	1190	1080	930	1440	1260	740	300
1590	0	700	470	1180	690	2090	1940	1140	1190	1080	930	1390	1220	750	270
1530	250	680	480	1180	690	2090	1950	1150	1200	1090	930	1350	1180	760	240
1470	240	650	440	1180	700	2090	1950	1150	1200	1090	930	1290	1140	760	210
1400	230	620	410	1190	700	2090	1950	1160	1210	1100	930	1290	1100	760	180
1340	230	590	400	1190	710	2090	1950	1160	1210	1100	980	1180	1040	760	150
1270	230	560	380	1190	710	2090	1950	1160	1210	1100	930	1120	990	760	120
1210	230	530	360	1200	720	2040	1950	1170	1210	1100	930	1060	930	760	90
1140	230	500	340	1180	700	2060	1920	1140	1190	1090	920	1000	880	740	60
1090	210	480	340	1070	630	1890	1760	1040	1070	1010	900	930	830	720	30
1000	200	450	330	950	550	1730	1600	930	1020	970	860	870	790	690	1

EFFECTS TABLES (Distances in meters) — SEVERE DAMAGE — SHORT RANGE CANNON 1 KT

HOB	BRIDGES		SUPPLY DEPOTS	SURFACE TO AIR MISSILES		MISSILES & ROCKETS		HELICOPTERS RANDOMLY PARKED		RADIOS & FIRE CON EQUIP	OPEN GRID RADAR ANT	TRACKED VEHICLES (no tanks)		RAILROAD	
	FIXED	FLTG		EXPO	RVTTD	TVLG	ERECT	CGO TRANS	LT OBSN			EXPO	SHLD	LOCO	BOX & FLAT CARS
600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
570	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
540	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0
510	0	0	0	0	0	0	120	130	0	0	0	0	0	0	0
480	0	0	0	0	0	0	170	170	20	0	0	0	0	0	0
450	0	0	0	0	0	0	210	210	780	0	0	0	0	0	0
420	0	0	0	0	0	0	240	250	780	0	0	0	0	0	0
390	0	0	0	60	0	0	270	290	770	0	590	0	0	0	0
360	0	0	0	100	0	0	460	450	760	0	630	0	0	0	0
330	0	0	0	130	0	0	490	440	730	0	640	0	0	0	0
300	0	0	0	150	20	0	490	430	700	0	630	0	0	0	0
270	0	0	0	170	50	0	480	420	680	70	620	0	0	0	0
240	0	0	0	190	70	0	460	410	650	120	590	0	0	0	60
210	0	0	0	200	100	110	400	380	620	150	570	0	0	0	80
180	0	0	10	210	120	140	420	370	580	170	550	0	50	0	110
150	0	120	40	210	130	160	410	340	560	190	530	60	90	0	130
120	110	130	60	210	140	180	390	330	530	200	510	100	100	20	160
90	110	130	80	210	160	190	370	310	500	210	460	120	100	60	180
60	110	130	90	200	150	190	350	300	480	210	450	130	90	70	180
30	100	120	90	190	130	170	340	290	440	200	430	120	90	80	130
1	90	100	50	180	130	150	310	270	420	180	400	90	90	60	110

** Nuclear radiation effects are significant. If troops have history of previous exposure, consult figure 5-23 for modification of risk radii.

	PERSONNEL CASUALTIES														
	EXPOSED			IN OPEN FOXHOLES			IN APC'S			IN TANKS			IN EARTH SHELTERS		
HOB	IMMED PERM	IMMED TRAN	LAT LETH	IMMED PERM	IMMED TRAN	LAT LETH	IMMED PERM	IMMED TRAN	LAT LETH	IMMED PERM	IMMED TRAN	LAT LETH	IMMED PERM	IMMED TRAN	LAT LETH
600	0 *	300	570	0	0	340	0	250	520	0	40	410	0	0	0
570	100 *	330	580	0	0	370	0	280	550	0	130	440	0	0	0
540	160 *	350	600	0	60	400	100 *	310	560	0	190	460	0	0	0
510	200 *	370	620	0	130	420	160 *	340	580	0	230	480	0	0	0
480	240 *	400	630	0	180	440	200 *	370	590	0	260	490	0	0	100
450	270 *	420	640	0	220	460	230 *	390	610	100 *	270	510	0	0	160
420	300 *	440	650	20 *	250	480	260 *	410	620	140 *	310	520	0	0	200
390	310 *	450	660	100 *	270	480	290 *	420	630	180 *	330	530	0	0	230
360	340 *	470	680	140 *	300	500	300 *	440	640	210 *	350	550	0	0	250
330	350 *	480	690	180 *	310	510	330 *	450	650	230 *	370	560	0	0	270
300	370 *	490	690	200 *	330	520	340 *	460	650	260 *	380	570	0	60	290
270	380 *	500	700	230 *	340	530	350 *	470	660	270 *	390	580	0	110	300
240	390 *	510	700	240 *	360	540	370 *	480	670	290 *	410	580	0	130	320
210	400 *	510	710	260 *	370	550	370 *	480	680	300 *	410	590	30	160	330
180	410 *	520	710	270 *	370	550	380 *	490	680	300 *	410	590	70	170	340
150	410 *	520	710	270 *	370	550	380 *	490	680	310 *	420	590	100	190	340
120	410 *	520	710	270 *	370	550	380 *	490	680	310 *	420	590	110	200	340
90	410 *	520	710	270 *	370	550	380 *	490	670	310 *	410	580	120	200	340
60	410 *	510	700	270 *	370	540	370 *	480	660	310 *	410	580	120	200	340
30	390 *	500	690	260 *	360	520	370 *	470	650	300 *	400	560	120	190	320
1	360 *	470	650	230 *	330	490	310 *	440	610	270 *	360	520	100	160	290

	PERSONNEL CASUALTIES								MODERATE DAMAGE				SEVERE DAMAGE		
	IN MULTI-STORY BRICK APTS			IN WOOD FRAME BUILDINGS			2nd DEGREE BURNS		WHEELED VEHICLES						
HOB	IMMED PERM	IMMED TRAN	LAT LETH	IMMED PERM	IMMED TRAN	LAT LETH	SUMMER UNIFORM	WINTER UNIFORM	EXPO	SHLD	TANKS	TOWED ARTY	WOOD FRAME BLDG	MULTI STORY BRICK APT	FACTORIES
600	0	260	540	280	280	530	0	0	0	0	0	0	280	0	0
570	0	300	550	340	340	550	0	0	0	0	0	0	340	0	0
540	110 *	320	570	400	400	570	0	0	0	0	0	0	400	0	0
510	160 *	350	580	450	450	280	0	0	0	0	0	0	450	0	0
480	200 *	370	600	510	510	600	90	0	0	0	0	0	510	200	0
450	240 *	390	620	560	560	620	140	0	0	0	0	0	560	230	0
420	270	410	620	610	610	620	190	70	0	0	0	0	610	270	0
390	340	430	640	640	640	640	220	130	0	0	0	0	640	340	0
360	480	480	650	640	640	650	240	160	0	0	0	0	640	480	0
330	500	500	650	630	630	650	270	200	0	0	0	0	630	500	0
300	500	500	660	620	620	660	280	220	0	0	0	0	620	500	0
270	480	480	670	610	610	670	300	240	0	0	0	0	610	480	0
240	470	480	680	590	590	680	310	260	0	60	0	0	590	470	160
210	440	490	690	570	570	690	330	270	110	100	0	0	570	440	150
180	420	500	690	550	550	690	340	280	140	140	60	0	550	420	140
150	410	500	690	530	530	690	340	290	160	140	100	60	530	410	150
120	390 *	500	690	510	510	690	350	300	170	130	130	100	510	380	
90	390 *	500	680	500	500	690	350	300	190	130	150	120	480	370	160
60	380 *	490	670	490	490	670	360	310	190	130	150	130	460	350	160
30	370 *	480	650	480	480	660	320	270	170	130	140	130	440	340	140
1	340 *	440	620	440	440	620	280	240	150	130	100	100	400	330	130

* Subtract 100 meters from the 8,000 rad RD to obtain the approximate 18,000 rad RD.

Figure 4—6. Extract of typical effects table.

CHAPTER 5
DAMAGE ESTIMATION TECHNIQUES

Section I. DAMAGE ESTIMATION CONCEPTS

5—1. General

In conventional fires, weapon effects on the target result from firing many rounds and allowing the inherent dispersion of those rounds to distribute the effects over the target area. In nuclear fires, generally, only a single weapon is used on a target. Consequently, it is necessary to have methods of estimating weapon effects on the target so that the best use can be made of the nuclear weapons available. Because of the inherent dispersion of any delivery system and the variability of target response to nuclear weapon effects, estimation methods must be based on probability considerations. As a result of computer calculations, some of the data tabulated in FM 101—31—2 are to the nearest meter. One should not attach a false sense of exactness to these data, either as to their reliability or need for precise calculation. In fact, many of the field calculations performed with these data may be rounded off to the nearest 10 to 50 meters with little or no operational impact. However, for ease of understanding, the calculations in the following paragraphs are done without rounding and without regard to the uncertainties associated with the data extracted from FM 101—31—2. The relationship of probability to delivery error of artillery pieces is discussed in detail in FM 6—40.

5—2. Effects of Horizontal and Vertical Accuracy

In chapter 4 it was pointed out that a basic assumption for all damage estimation procedures was that the weapon would function at the rated yield and within the established accuracies of the delivery system. Because of this assumption, any damage estimation analysis will be affected principally by the delivery accuracy of the system. If many rounds are fired at some aimpoint under identical conditions, the impacts of the rounds would form a pattern around the aimpoint called a dispersion pattern. This dispersion of rounds is characterized by a higher percentage of small misses or deviations from the aimpoint rather than larger deviations. The distribution of the dispersion, called a normal distribution pattern, follows the laws of probability. This gives the target analyst the ability to predict probability of not exceeding some particular miss distance; e.g., 60 percent of the rounds will land less than 100 meters from the aimpoint and 40 percent will land more than 100 meters from the aimpoint.

a. Horizontal Delivery Error. The shape of the dispersion pattern will vary among delivery systems, generally ranging from elliptic shapes for cannons and free flight rockets to circular shapes for guided missiles and bombs. For damage estimation purposes, elliptic dispersion patterns are mathematically converted to approximately equivalent circular dispersion patterns. Two terms are used to express circular horizontal dispersion patterns. They are circular error probable (CEP) and circular distribution 90 (CD90). The CEP and CD 90 data have been tabulated for each weapon system and are in the accuracy data portion of the coverage tables in FMs 101—31—2 and 101—31—3.

(1) *Circular error probable.* By definition, 1 CEP represents the radius of the circle within which a weapon has a 50-percent probability of arriving. A 2 CEP circle includes approximately 93.75 percent of the rounds fired or bombs dropped. These relationships are shown in figure 5—1.

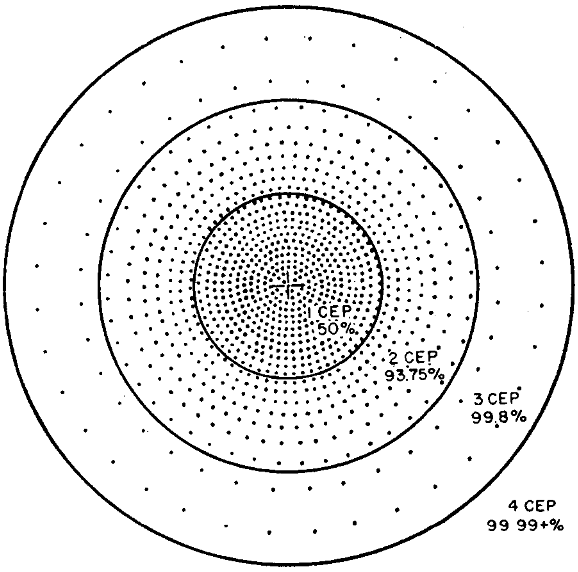

Figure 5—1. Circular pattern—normal distribution.

(2) *Circular distribution 90.* The CD90 represents the radius of a circle within which 90 percent of the rounds will fall. Stated another way, a round fired at an aimpoint has a 90-percent assurance of falling within the area of the circle described by the CD90 radius around the aimpoint. The CD90 is used in the high assurance damage estimation methods to insure a 90-percent probability of obtaining at least a specified amount of fractional coverage or damage. CD90 can be calculated by multiplying the CEP by a factor of 1.83 (CD90 = 1.83 CEP).

b. Vertical delivery error. The vertical error for all weapons is measured in the vertical plane in terms of probable error in height-of-burst (PEH). A PEH is the vertical distance above and below the desired height of burst within which a single round has a 50-percent probability of detonating. The distribution pattern for height of burst errors is assumed to be normally distributed about the desired height of burst. The relationship between the burst distribution pattern and the PEH is shown in figure 5—2. The PEH associated with each weapon system has been tabulated and is included in the accuracy data portion of the coverage tables in FMs 101—31—2 and 101—31—3.

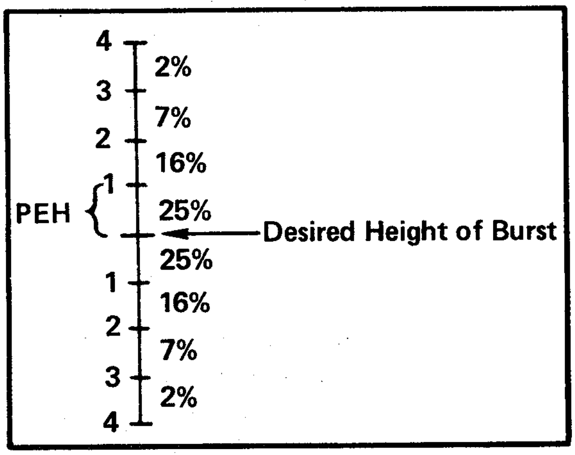

Figure 5—2. Vertical distribution pattern.

5—3. Concept of Damage

a. When a nuclear weapon is burst over a target, a typical response is as shown in figure 5—3. As can be seen from the figure, all target elements near the burst point receive *at least* the defined level of damage. As the distance from the burst point increases, a larger number of target elements, indicated by circles rather than dots, do not respond in the specified manner; that is, a materiel target might receive less than the desired damage. At some distance from the aimpoint, no target elements receive the specified level of damage.

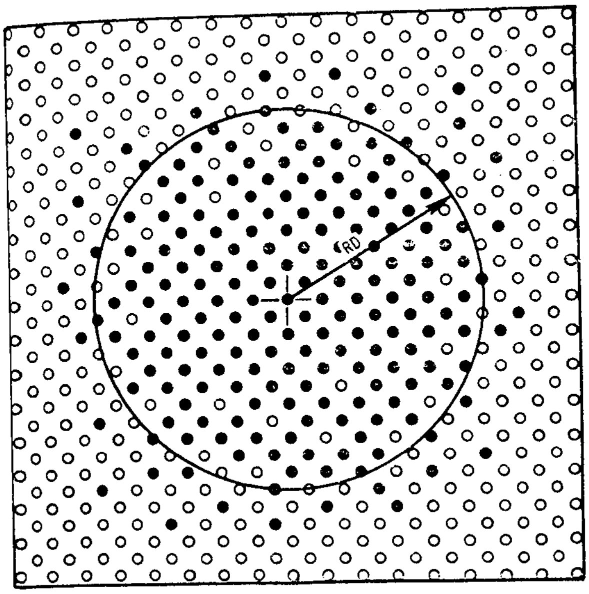

Figure 5—3. Relation of radius of damage to damage and casualty pattern.

b. The radius of damage (RD), which is indicated in figure 5—3, is defined as that distance from the burst point at which a target element has a 50-percent probability of receiving the specified degree of damage; or, in the case of personnel, half the personnel at that distance will respond in the manner described by the specified casualty criterion. Because of variability, some target elements inside the RD escape the specified degree of damage. Variability of response is discussed in appendix D. The elements that do not respond in the desired manner inside the RD are approximately balanced by those that respond in the desired manner outside the RD circle.

c. The RD is a distance determined for every weapon and is dependent on the type of target, the yield of the weapon, the damage or casualty criterion, and the HOB of the weapon.

5—4. Prediction of Damage to Targets

a. Best results can be achieved against a target by locating the desired ground zero (DGZ) at target center. This centers the RD of the weapon over the target. Additionally, the desired HOB is as close as possible, while still precluding fallout, to the HOB that gives the largest RD against the target.

b. In general, delivery errors will reduce the damage caused to a target. A burst occurring at the outer limits of the horizontal dispersion pattern will cause the center of the weapon effects to be offset from the DGZ and might result in a substantial decrease in the damage to the target. Vertical delivery errors might cause the actual HOB to differ from the desired HOB and may result in a smaller than optimum RD. All nuclear weapon delivery systems have associated delivery errors, and these errors must be taken into account in the estimation process. The damage estimation procedure for an area target consists of determining the fraction of the target covered by the RD. There are two methods of considering the effect of delivery errors on area target fractional coverage—the expected coverage method and the high assurance method. *The expected coverage method is the preferred method.* With the high assurance method, the target analyst determines that weapon system that will have a 90-percent assurance of achieving *at least* a minimum fractional coverage of the target. This approach results in a conservative statement of the weapon's effect and should only be used when a single target is of a critical nature. Expected fractional coverage is the sum of the product of all possible fractional coverages times their probability of occurring. This approach results in the best estimate of the effect that the weapon will have on the target.

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c. In estimating the damage to a point target, the analyst is not concerned with the percentage of the target that will be covered by the damage circle. Rather, he is concerned with the probability that the effects of the weapon will inflict the desired level of damage or casualties on the target element. A high assurance (P = .90) is normally sought.

Section II. TARGET-ORIENTED METHOD AND PRECLUSION-ORIENTED METHOD

5—5. Damage Estimation for Target-Oriented Method

a. General. This paragraph discusses the determination of both expected and high assurance coverage by the use of the visual, numerical, and index damage estimation techniques.

b. Visual Technique.

(1) *Introduction.* The visual technique of damage estimation may be used for any shape target and is the only damage estimation technique that can be used to analyze area targets that cannot be equated to a circle (i.e., the long axis is greater than or equal to two times the short axis). The visual technique consists of estimating the fraction of the target covered by the RD while considering the effect of delivery error.

(2) *Procedure for damage estimation—expected coverage.*

(a) To perform the estimate, an expected RD and CEP must be obtained from the appropriate coverage table. Figure 5—4 illustrates a typical coverage table. The target analyst selects the appropriate coverage table based on target category, target response, delivery system, yield, and HOB option. The parameters in figure 5—4 are exposed personnel, latent lethality, short-range cannon, 1 KT, low airburst. For range-dependent systems, he enters the table at the nearest listed

COVERAGE TABLE **SHORT RANGE CANNON**
(Distances in meters)
1KT 5-24

E X P O S E D P E R S O N N E L - L A T E N T L E T H A L I T Y
L O W A I R B U R S T

RANGE	EFFECTIVENESS RADIUS OF TARGET 500	600	700	800	900	1000	1300	1500	PROB MIN RD	EXPT RD	ACCURACY DATA CD 90	CEP	HOB	PEH
2000	.96/.98	.93/.96	.85/.88	.51/.55	.41/.43	.29/.32	.21/.22	.09/.12	460	526	80	38	49	9
3000	.96/.98	.91/.96	.85/.87	.52/.56	.41/.43	.30/.32	.20/.22	.10/.12	458	532	93	44	59	12
4000	.96/.98	.91/.95	.85/.87	.53/.56	.41/.43	.30/.32	.20/.22	.10/.12	454	532	99	47	59	12
5000	.96/.98	.91/.95	.84/.87	.53/.57	.41/.43	.30/.32	.20/.22	.10/.12	447	538	111	54	69	14
6000	.96/.98	.91/.95	.81/.86	.53/.57	.41/.43	.30/.32	.20/.22	.10/.12	448	540	128	62	82	17
7000	.95/.97	.91/.94	.80/.85	.55/.57	.41/.43	.30/.32	.20/.22	.10/.12	442	540	141	73	90	19
8000	.94/.96	.86/.92	.75/.83	.54/.57	.41/.43	.30/.32	.20/.22	.10/.12	434	538	176	86	101	22
9000	.92/.96	.78/.88	.68/.78	.53/.56	.37/.41	.28/.32	.20/.22	.08/.11	420	520	205	100	116	26
10000	.88/.94	.71/.85	.61/.75	.50/.55	.36/.40	.26/.31	.18/.21	.06/.1[illegible]	400	490	234	115	132	30

Figure 5—4. Typical coverage table.

F AND IS USED TO CALCULATE THE EXPECTED INDEX OF THE COVERAGF [illegible] TABLES. WHEN USING THE NUMERICAL METHOD, THE EXPECTED COVERAGE IS CALCULATED USING THE EXPECTED RD, WHICH IS THE SUM OF THE PRODUCTS OF ALL POSSIBLE RDs TIMES THEIR PROBABILITY OF OCCURRING.

range, unless the range is halfway between two listed ranges, then the worst case is used, i.e., smaller RD. (e.g., reference fig. 5—4; if the range is 7,300, the expected RD of 540 and CEP of 73 are extracted, corresponding to an entry range of 7,000. If the range is 7,500, the expected RD of 538 and CEP of 86 are extracted, corresponding to an entry range of 8,000.) For range-independent systems, the entry argument for the coverage table is yield (enter with yield and CEP for bombs). The analyst places the expected RD and CEP on the appropriate circular map scale template as shown in figure 5—5.

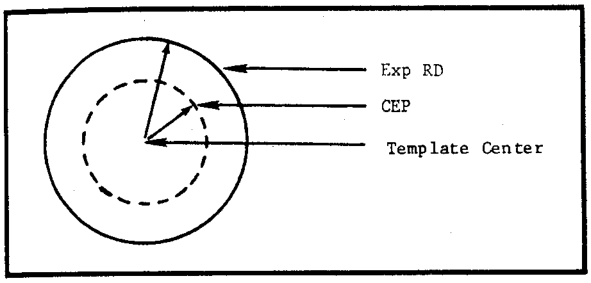

Figure 5—5. Expected RD and CEP as would be drawn on circular map scale template.

(b) The analyst selects a point on the circumference of the CEP circle and fixes this point on the DGZ. The circular map scale template is then rotated about this point to evaluate the effect of horizontal error (vertical error has already been considered in the determination of the RD), and the analyst estimates the fraction of the target covered by the RD as the template is moved around the DGZ. Fractional coverages are estimated in several different orientations and the average of these values is taken. Normally, values of four equally spaced positions are sufficient. This approach obtains the most realistic fractional coverages for very irregularly shaped targets since it does take into account the effect of missing the DGZ in different directions.

(3) *Procedure for damage estimation—high assurance coverage.* The data required for the high assurance coverage estimation are the RD minimum and the CD90. The use of the minimum RD accounts for variations in HOB and the use of CD90 accounts for variations in delivery error. The analyst selects a point on the circumference of the CD90 circle and fixes this point on the DGZ. The circular map scale template is then rotated about this point to evaluate the effect of horizontal error (vertical error has already been considered in the calculation of the RD). The analyst then estimates the fraction of the target covered by the RD as the template is moved around the DGZ. Although 90 percent of the rounds will land on or inside the CD90 circle, the analyst has no way of knowing which part of the circle the round will land in. For this reason, the template is moved until the orientation that gives the least fractional coverage of the target is obtained. This is the fractional coverage selected for high assurance (f90). This procedure insures attaining at least the coverage estimated. Figures 5—6 and 5—7 demonstrate the procedure. In figure 5—6, approximately 50 percent of the target area is covered by the RD. In figure 5—7, only about 30 percent of the target is covered. The value used for the f90 coverage estimation is, therefore, 30 percent.

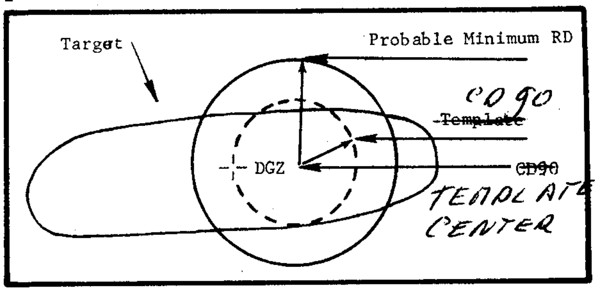

Figure 5—6. Coverage estimation using circular map scale template—maximum coverage.

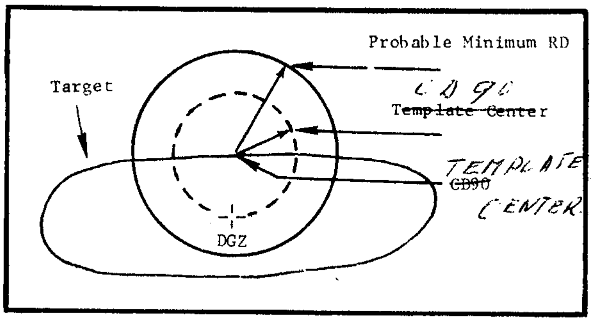

Figure 5—7. Coverage estimation using circular map scale template—minimum coverage.

(4) *Procedure for damage estimation—desired ground zero displaced from target center.* Because of limiting requirements or when attacking multiple targets with a single weapon, it may be necessary to displace the DGZ from the center of the target. In such case, the procedure discussed in paragraph 5—5b(2) or (3), above, is followed using the displaced DGZ as the reference point from which to offset the circular map scale. The type of coverage desired (high assurance or expected) will determine which set of RD and delivery error values to use.

c. Numerical Technique for Area Targets.

(1) *General.* The numerical technique of damage estimation can be used to estimate fractional coverage for targets which are circular or equatable to a circle. Two area target graphs are contained in FMs 101—31—2 and 101—31—3 for this purpose—an area target graph (expected coverage) for expected value target coverage determination and the area target graph (high assurance coverage) for 90-percent assurance calculations. These graphs are reproduced as figures 5—8 and 5—9, respectively. Each graph consists of a family of curves that represents different fractional coverages. The fractional coverage for a target depends on the radius of the target, the radius of damage, and the delivery error. To consider all three variables, two of them must be "normalized" by dividing them by the third variable. In this case, it is the radius of the target. On the left side of each graph is a curve labeled Displaced DGZ which is used when the DGZ is not at target center. Although only expected techniques are discussed, the techniques described in the following paragraphs apply to both the expected graph or high assurance graph. When using the expected graph, the expected RD and the CEP will be used. When using the high assurance graph, the RD minimum and CD90 will be used.

(2) *Procedure for damage estimation, DGZ at target center.*

(a) Enter the appropriate coverage table with the range and extract the expected RD and the CEP.

(b) Compute the ratios RD/RT and CEP/RT.

(c) Enter the expected area target graph with the RD/RT ratio value on the vertical axis and the CEP/RT ratio value on the horizontal axis. The curve on which the two entry ratios intersect is the *expected* fractional coverage (f). If the intersection is between curves, linearly interpolate between curves to determine expected fractional coverage.

(d) Example problem (fig. 5—10):

Given: RT = 800 meters
RD = 600 meters
CEP = 100 meters

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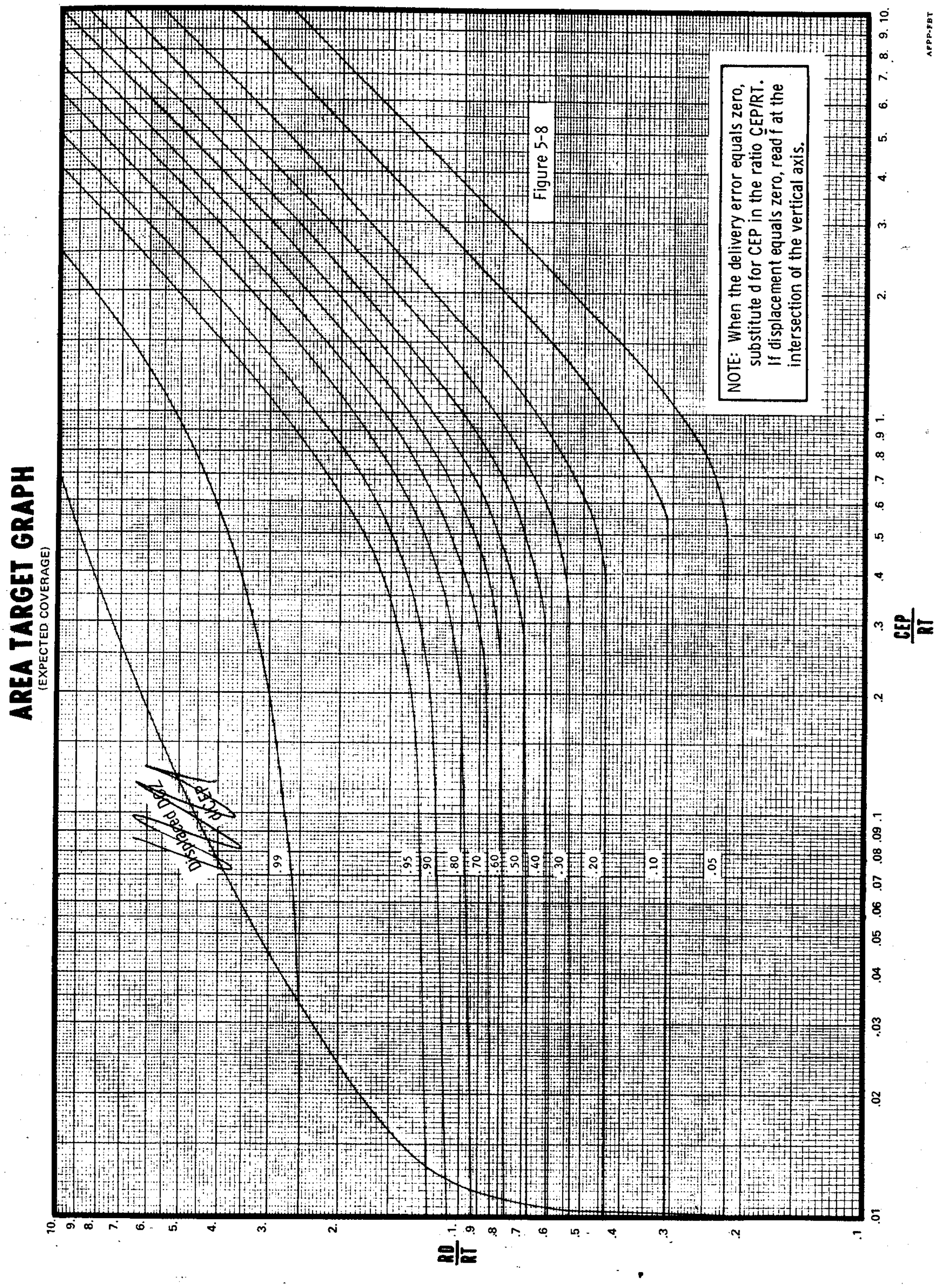

Figure 5—8. Area target graph—expected coverage.

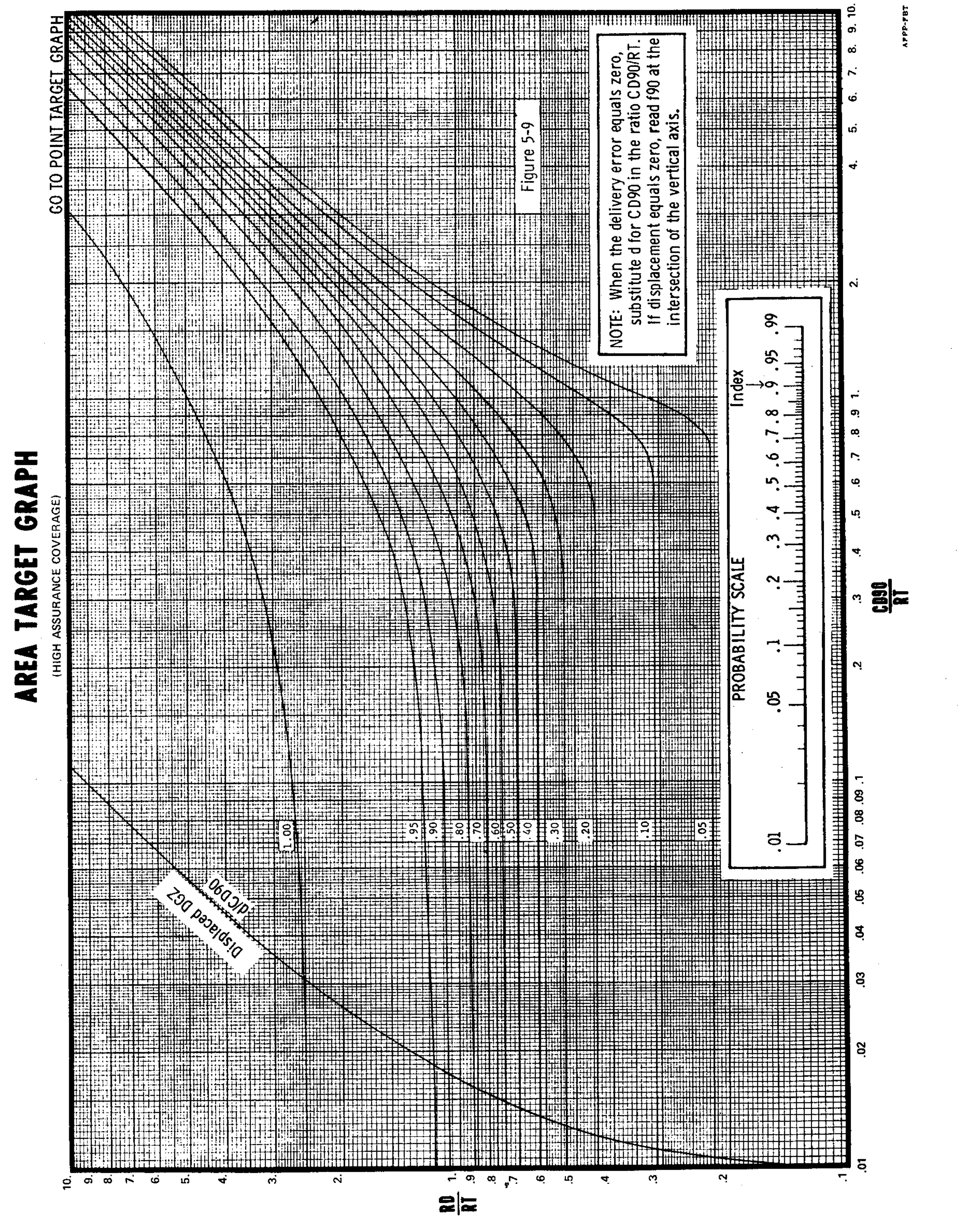

Figure 5—9. Area target graph—high assurance coverage.

Find: The expected fractional coverage

Solution: $\frac{RD}{RT} = \frac{600}{800} = .75$

$\frac{CEP}{RT} = \frac{100}{800} = .125$

Read the fractional damage curve at the intersection of the two graph entry values on the expected coverage area target graph. The intersection of the values falls mid-way between the .50 and the .60 fractional coverage curves. Therefore,

$$f = .55$$

(3) *Procedure for damage estimation, DGZ displaced from target center.*

(a) Repeat steps (*a*) through (*c*) in (2), above.

(b) Compute the d/CEP ratio, where d is the displacement distance from target center to DGZ.

(c) Measure the horizontal distance from d/CEP value on left vertical axis to the displaced DGZ curve on the graph.

(d) Apply this distance horizontally and to the *right* of the point of intersection of the RD/RT and the CEP/RT ratios. Read the new fractional coverage. This is the coverage obtained with the displaced DGZ.

(e) Example problem (Fig. 5—11):

Given: RT = 800 meters
RD = 600 meters
CEP = 100 meters
Displacement distance d = 300 meters

Find: The expected fractional coverage with the DGZ displaced.

Solution: First, determine the fractional coverage *without* the displacement, using the technique described in the preceding paragraph.

$\frac{RD}{RT} = \frac{600}{800} = .75$

$\frac{CEP}{RT} = \frac{100}{800} = .125$

f (without displacement) = .55
Determine the d/CEP value

$$d/CEP = \frac{300}{100} = 3.0$$

Measure the distance from the left vertical axis of the graph to the displaced DGZ curve, using as the entry value for the vertical axis the value calculated for d/CEP; in this example 3.0. Apply the measured distance from the point of intersection of the RD/RT and CEP/RT values horizontally to the right and read the expected coverage f = .42 for a displaced DGZ of 300 meters.

(4) *Procedure for calculation of the maximum allowable displacement (dmax) ~~to~~ of the DGZ.*

(a) Enter the appropriate coverage tables with the range and extract the expected RD and the CEP.

(b) Compute the ratios RD/RT and CEP/RT.

(c) Enter the expected area target graph with these two ratios to determine the fractional coverage without displacement.

(d) Measure the horizontal distance from the intersection in *(c)*,

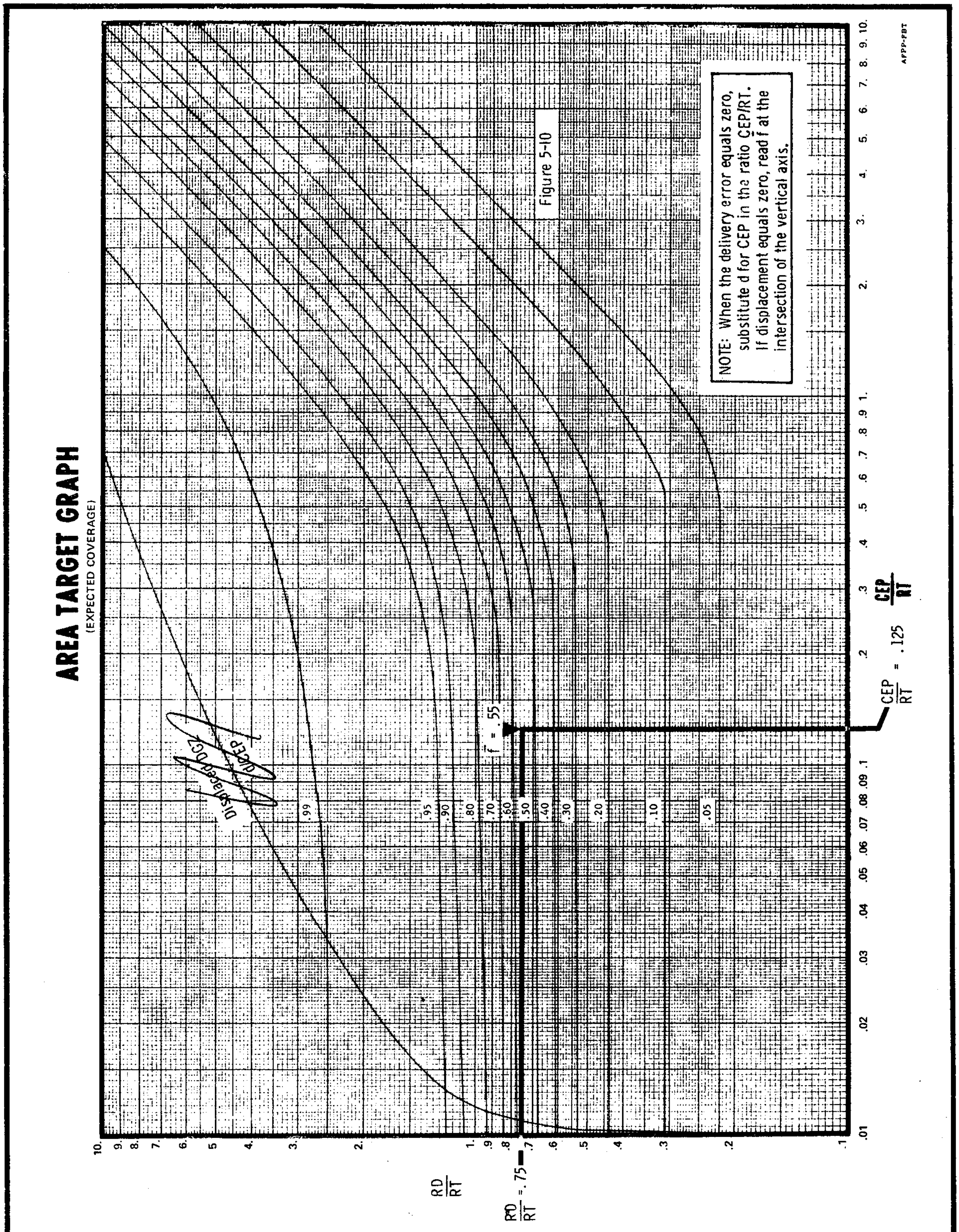

Figure 5—10. Area target graph—expected coverage.

above, to the fractional damage curve representing the minimum desired coverage. (If the minimum desired coverage is greater than or equal to the fractional coverage determined in *(c)*, above, the DGZ cannot be displaced.)

(e) Using the measured distance from (d), move the measuring device up the left *vertical* axis (RD/RT) of the graph until the distance between the vertical axis and the displaced DGZ curve matches the distance on the measuring device. Read the d/CEP value from the vertical scale.

(f) Solve for dmax by multiplying the d/CEP value obtained in *(e)*, above, by the CEP. This product is the maximum distance that the DGZ can be displaced from the target center and still achieve the desired fractional coverage.

(g) Example problem (fig. 5—12):

Given: RT = 800 meters
RD = 600 meters
CEP = 100 meters
Minimum coverage $\bar{f}$ = .30

Find: The dmax, or maximum displacement, that can be made of the DGZ and still meet the minimum coverage requirement.

Solution: First, determine the fractional coverage without a displacement, using techniques described above.

$$\frac{RD}{RT} = .75$$

$$\frac{CEP}{RT} = .125$$

$\bar{f}$ = .55

Measure the horizontal distance from the point of intersection (f = .55) to the curve representing the minimum coverage desired (for this example, f = .30). Using this measured distance, move up the RD/RT axis until this distance coincides with the horizontal distance between the vertical axis and the displaced DGZ curve. The point of coincidence is the d/CEP value.

d/CEP = 3.8

dmax = 3.8 X CEP = 3.8 X 100 = 380 meters

(5) *Target coverage.* If the high assurance area target graph is used to determine target coverage, a target coverage can be determined for other than a 90-percent assurance by using the probability scale on the high assurance target graph.

(a) Compute the ratios RD[/RT] and CD90[/RT]

(b) Enter the area target graph with the ratio values determined in *(a)*, above. The point at which these two entry ratios intersect is the fractional coverage for a 90-percent assurance of success.

(c) On the probability scale located in the lower center of the graph, measure the distance between the index at 90 percent and the desired assurance.

(d) Apply the distance obtained in *(c)*, above, horizontally and in the same direction, ~~to the point of intersection of the RD and CD90 ratio values.~~ [FROM THE ORIGINAL RD/RT AND CD90/RT INTERSECTION]

(e) Read ~~the~~ [A NEW] fractional coverage, which will be expressed as a percentage of coverage for the desired degree of assurance.

$\frac{CEP}{RT} = .125$

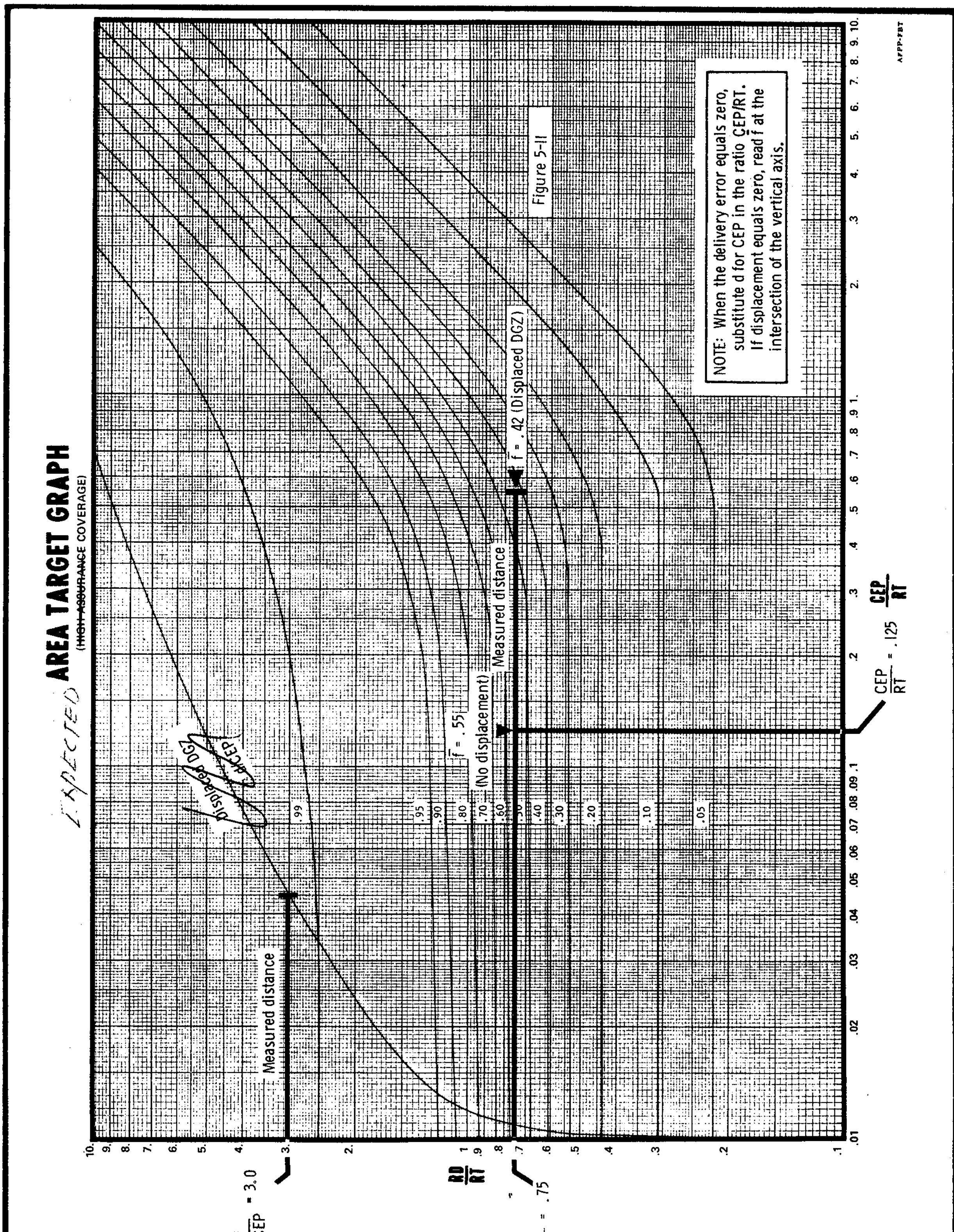

Figure 5—11. Area target graph—expected coverage.

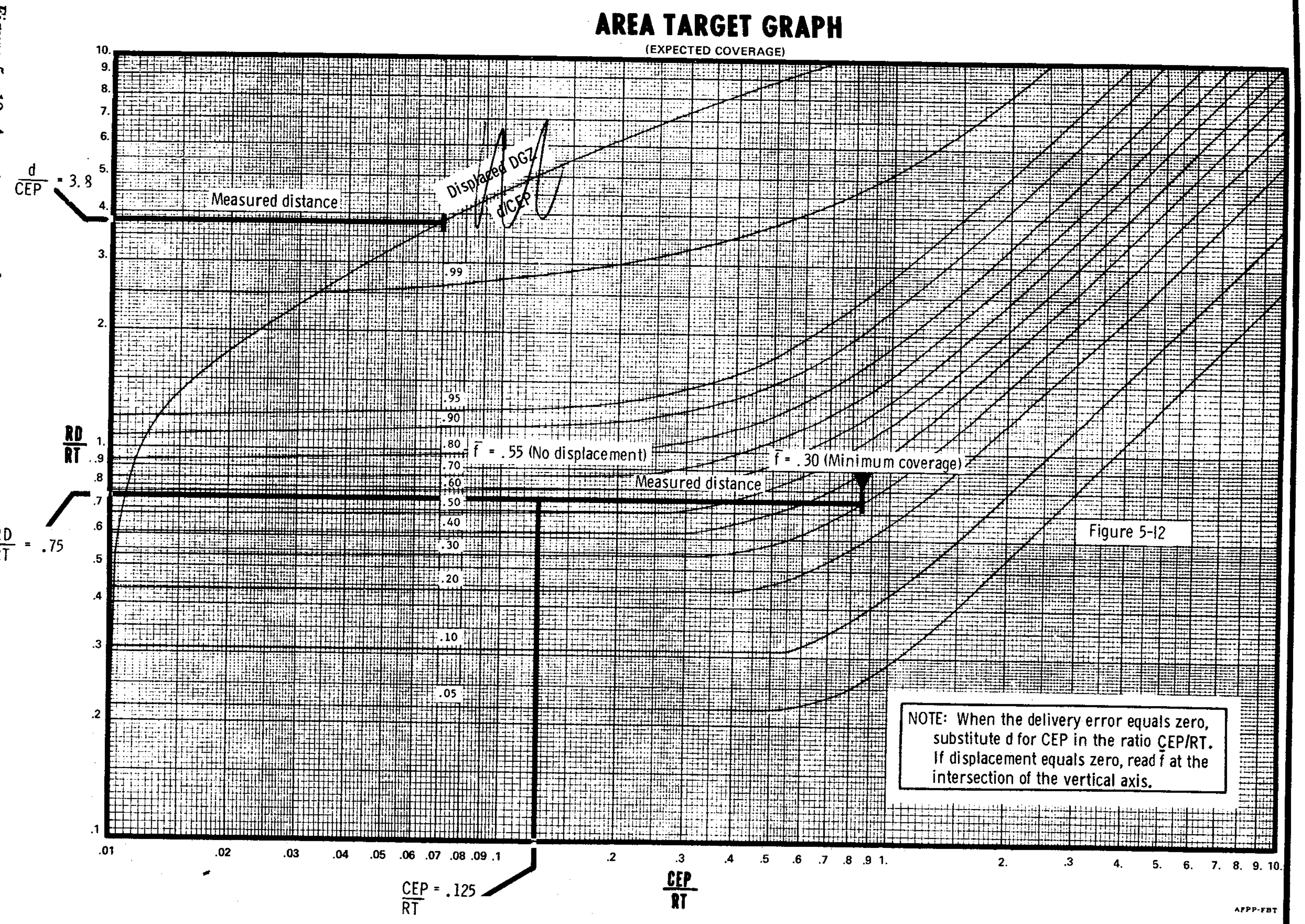

Figure 5—12. Area target graph—expected coverage.

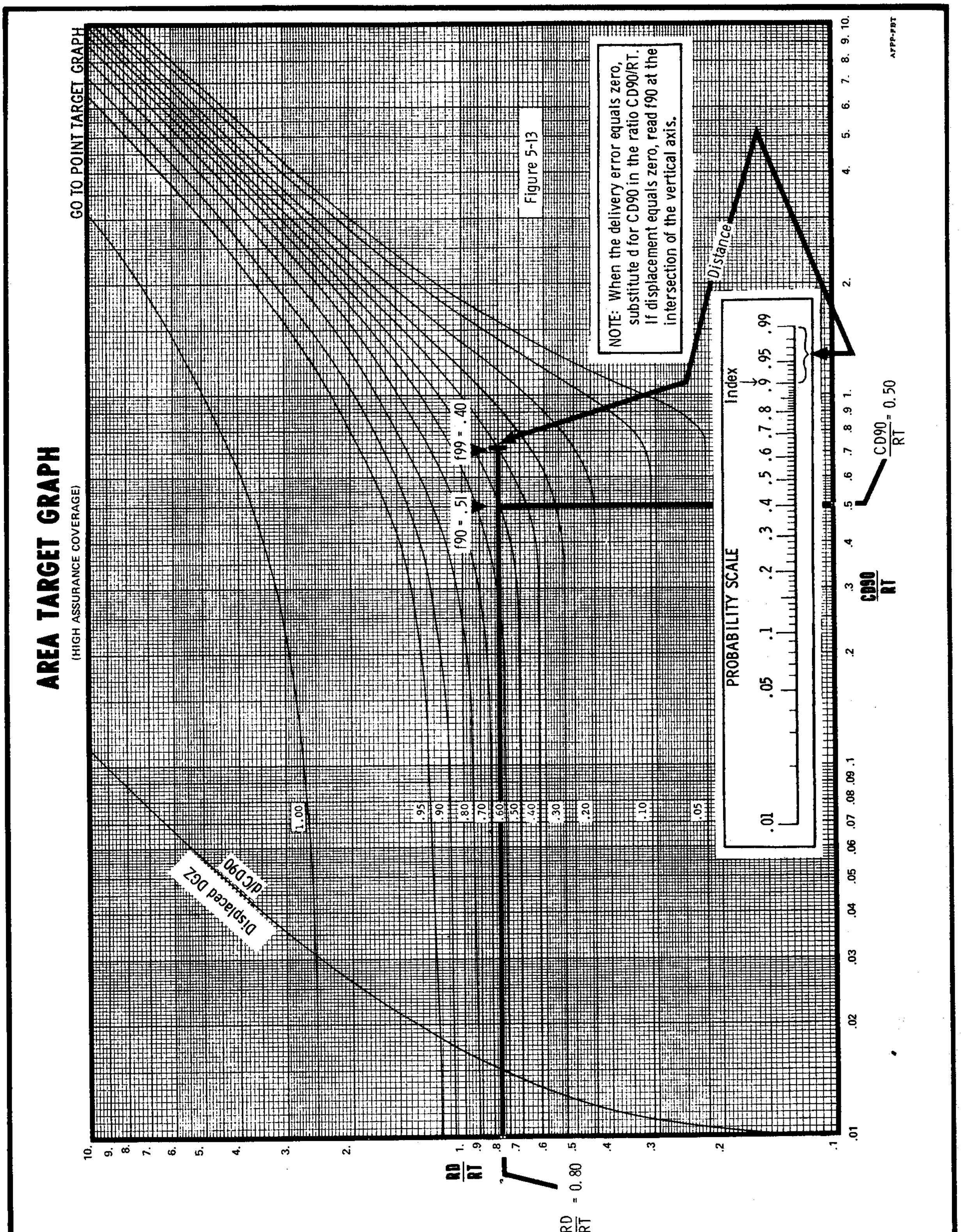

Figure 5—13. Area target graph—high assurance coverage.

(f) Example problem (fig. 5—13).

Given: RD = 400 meters
RT = 500 meters
CD90 = 250 meters

Find: The fractional coverage that will be achieved with a 99-percent assurance (f99).

Solution: Compute

$$\frac{RD}{RT} = \frac{400}{500} = 0.80$$

$$\frac{CD90}{RT} = \frac{250}{500} = 0.50$$

Enter the high assurance area target graph with these two ratios and determine the point of intersection. This point of intersection is the coverage achieved with an assurance of 90 percent (f90 = .51). On the probability scale, measure the distance between the index at 90 percent and 99 percent. Apply this distance horizontally to the right from the initial intersection point. Read the fractional coverage achieved with a 99-percent assurance (f99 = .40).

d. Numerical Technique for Point Targets.

(1) *Point targets.* Single element targets, such as bridges or missile launchers, are defined as point targets. Additionally, area targets in which the RD is large compared to the

$$RT \left(\frac{RD}{RT} \geq 10\right)$$

or in which the horizontal delivery error, CEP or CD90, is large compared to the

$$RT \left(\frac{CEP}{RT} \text{ or } \frac{CD90}{RT} \geq 10\right),$$

are also considered point targets. 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 at least 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.

(2) *Point target graph.* The point target graph is contained in FMs 101—31—2 and 101—31—3 as is shown in figure 5—14 in this manual. The curves on the graph represent probability curves and indicate the probability of achieving the specified degree of damage when the graph is entered with the appropriate ratios. As with the area target graphs, there are three variables that can influence the probability of damage. They are the radius of damage (RDmin); the delivery error (CD90); and the distance from the target to the DGZ, indicated on the graph as d. The vertical axis represents the

$$\frac{RD}{CD90}$$

while the horizontal axis represents

$$\frac{d}{CD90}$$

For any given consideration of radius of damage (RD), horizontal dispersion (CD90), and displacement distance (d) of the DGZ, the probability of achieving the desired degree of damage to a point target may be calculated. In the upper left portion of the graph is the point target graph extension for use when

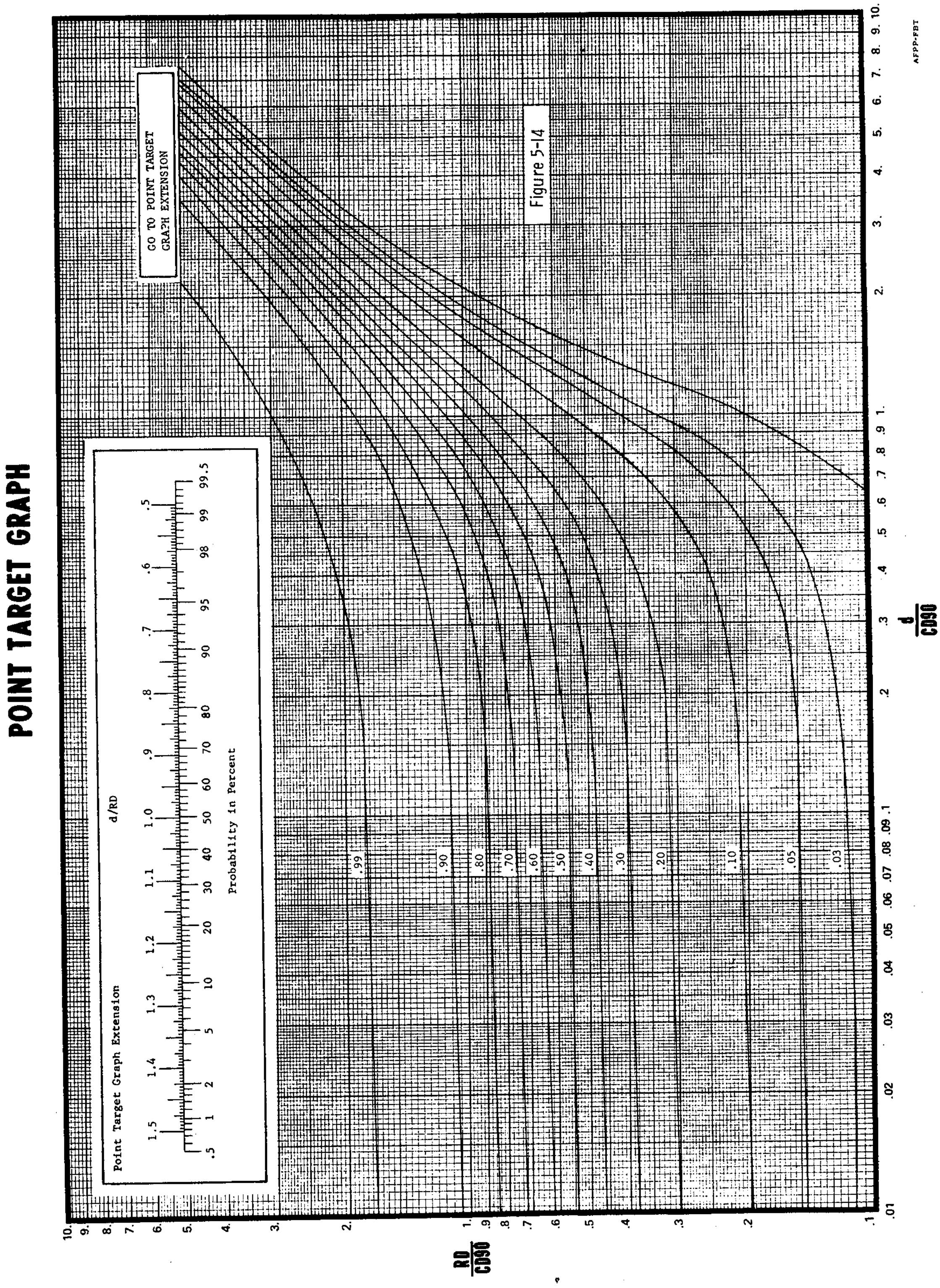

Figure 5—14. Point target graph.

$\frac{RD}{CD90}$ is greater than 5 *and* $\frac{d}{CD90}$ is greater than 2.2. 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. The point target graph extension shows the probability (P) of achieving the desired degree of damage to a point target when the horizontal dispersion is 0. This graph uses the ratio d/RD for the entry value.

(3) *Procedure for estimating probability of damage.*

(a) Enter the appropriate coverage table with the range and extract the probable minimum RD and the CD90.

(b) Compute the ratio RD/ CD90 and, if a displacement exists, d/CD90.

(c) If there is no DGZ displacement, the probability of damage is read directly from the vertical (RD/CD90) axis of the graph. If the DGZ is displaced from the point target, the probability of damage is read at the intersection of the RD/CD90 ratio and the d/CD90 ratio. If the point of intersection falls between curves, linearly interpolate between the curves.

(d) If RD/CD90 is greater than 5 and d/CD90 is greater than 2.2, calculate d/RD, enter the point target graph extension with that value and read the corresponding probability.

(e) Example problems.

1. Probability of damage, no DGZ displacement. (See fig. 5—15.)

Given: RD = 300 meters
CD90 = 200 meters

Find: Probability of damage, P.

Solution: $\frac{RD}{CD90} = \frac{300}{200} = 1.50$

Read the probability of damage for

$$\frac{RD}{CD90} = 1.50$$

On the left side of the graph, the value of 1.5 is about 3/4 of the way between the curves representing .90 and .99.

P = .97

2. Probability of damage, DGZ displacement. (See fig. 5—16.)

Given: RD = 300 meters
CD90 = 200 meters
displacement distance, d = 200 meters

Find: Probability of damage, P.

Solution: $\frac{RD}{CD90} = \frac{300}{200} = 1.5$

$$\frac{d}{CD90} = \frac{200}{200} = 1.0$$

Read the probability of damage at the intersection point

of $\frac{RD}{CD90}$ and $\frac{d}{CD90}$.

P = .76

3. Probability of damage, point target graph extension. (See fig. 5—16.)

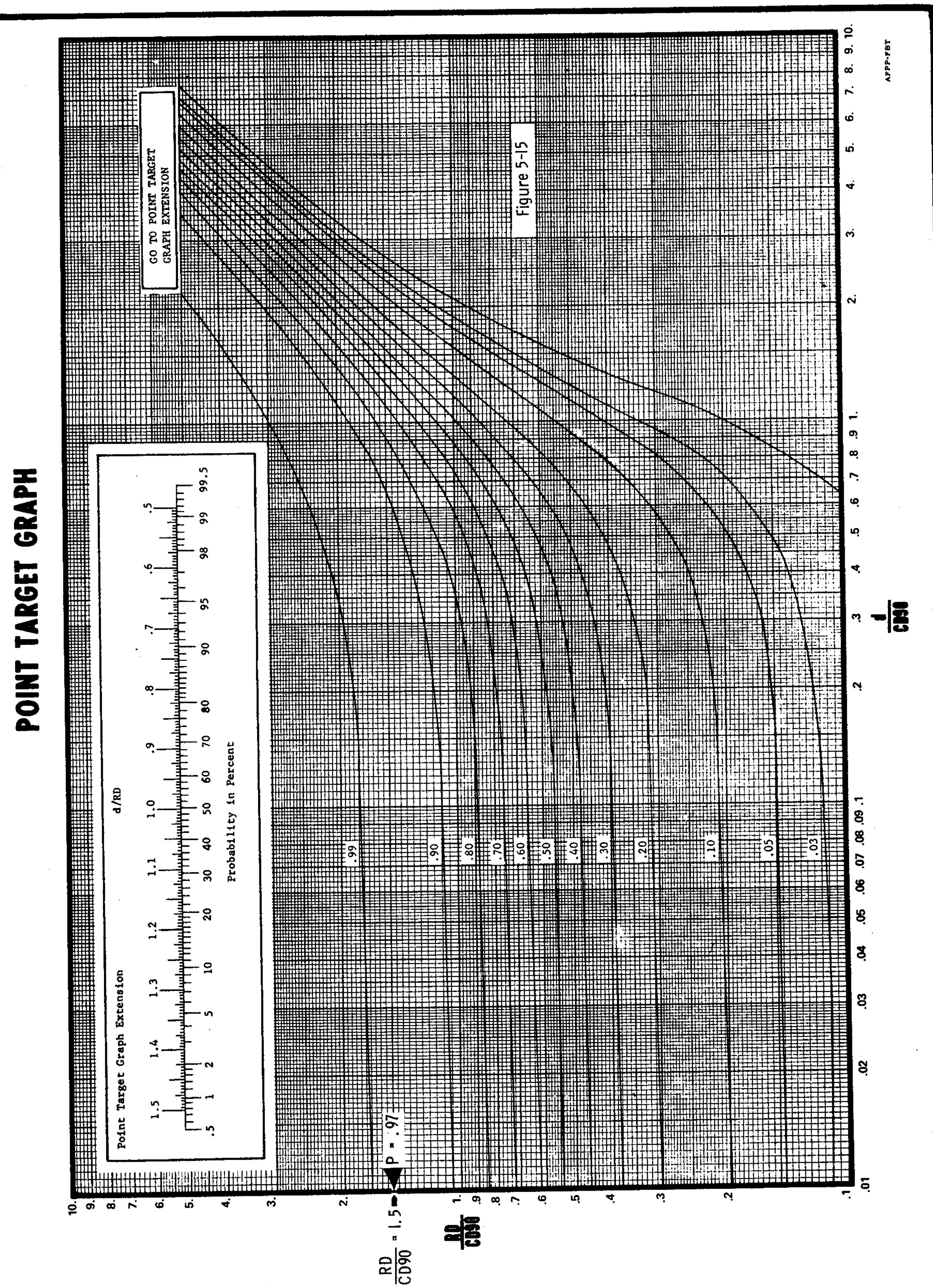

Figure 5—15. Point target graph.

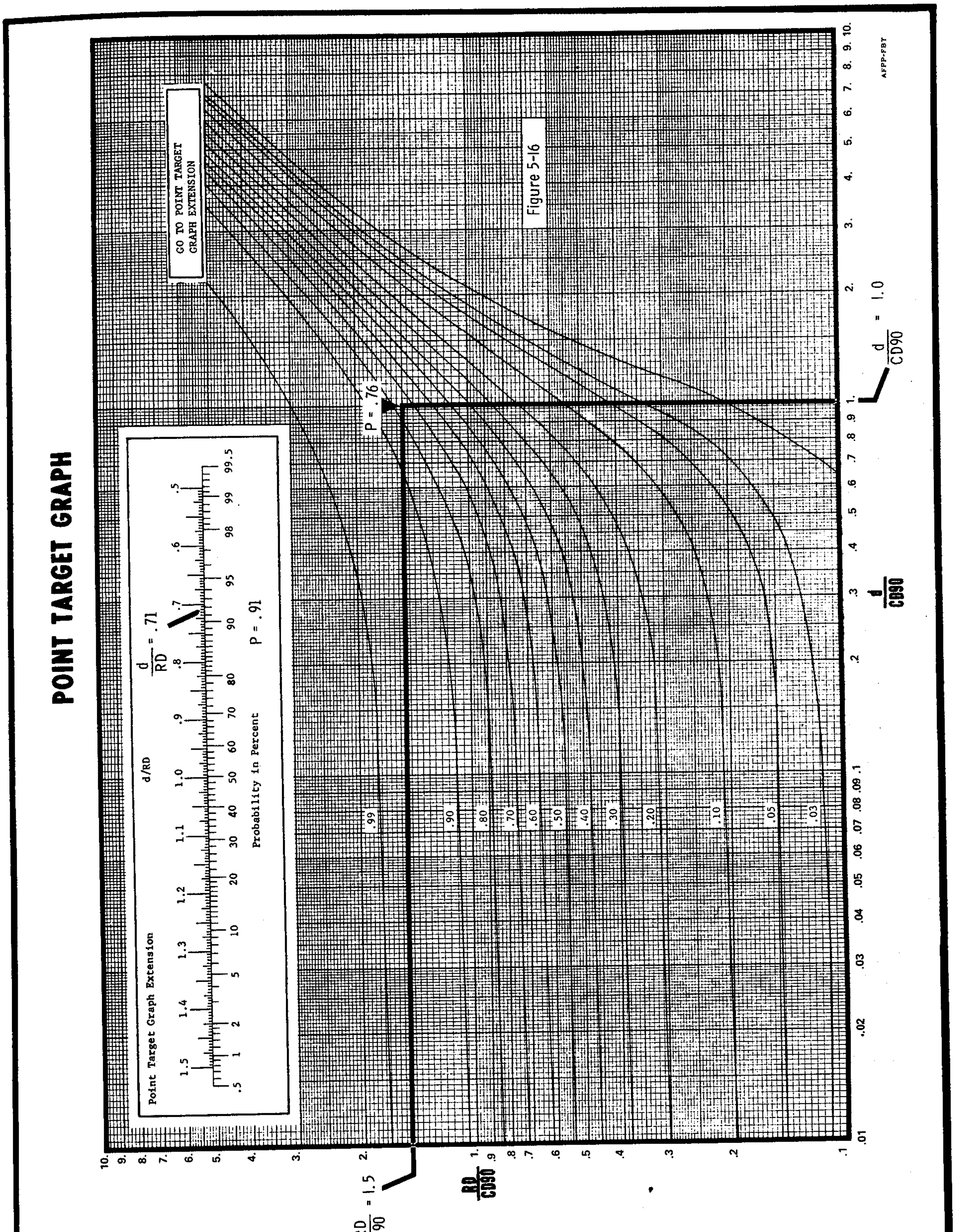

Figure 5—16. Point target graph.

Given: RD = 700 meters
CD90 = 100 meters
displacement distance, d = 500m

Find: Probability of damage, P.

Solution: $\frac{RD}{CD90} = \frac{700}{100} = 7.00$

$$\frac{d}{CD90} = \frac{500}{100} = 5.00$$

Since this value for RD/CD90 is greater than 5.0 and $\frac{d}{CD90}$ is greater than 2.2, the point target graph extension must be used. Calculate d/RD.

$$\frac{d}{RD} = \frac{500}{700} = .715$$

Entering the point target graph extension with d/RD = .715 on the top line, read the probability to the lower whole percent:

P = .91

(4) *Procedure for finding the maximum displacement (dmax).*

(a) Enter the appropriate coverage table with the range and extract the probable minimum RD and the CD90.

(b) Compute the RD/CD90 ratio.

(c) Enter the graph with the RD/CD90 ratio and move horizontally across the graph to the right until that entry intersects the minimum acceptable probability curve.

(d) Determine the d/CD90 value for the point of intersection found in *(c)* above. Solve for dmax by multiplying the CD90 by the d/CD90 value at the point of intersection of the RD/CD90 ratio and the probability curve.

(e) Example problem. (See fig. 5—17)

Given: RD = 300 meters
CD90 = 200 meters
Minimum acceptable probability of damage = .90

Find: Maximum displacement distance (dmax).

Solution: Calculate the RD/CD90 ratio

$$\frac{RD}{CD90} = \frac{300}{200} = 1.5$$

Read the d/CD90 value at the point of intersection of the RD/CD90 value and the 0.90 probability curve.

$$\frac{d}{CD90} = .66$$

dmax = .66 X 200 = 132 meters.

(5) *Procedure for finding the maximum displacement (dmax) when required to use the point target graph extension.*

(a) Enter the appropriate coverage table with the range and extract the probable minimum RD and the CD90.

(b) Compute the RD/CD90 ratio. If this ratio is greater than 5, the point target graph extension must be used. (The probability curves cannot be intersected when entering the point target graph with RD/CD90 > 5).

(c) Using the point target graph extension, determine a $\frac{d}{RD}$ value corresponding to the required probability (if required, P = 0.90, $\frac{d}{RD}$ = .73). If desired, a different P can be used.

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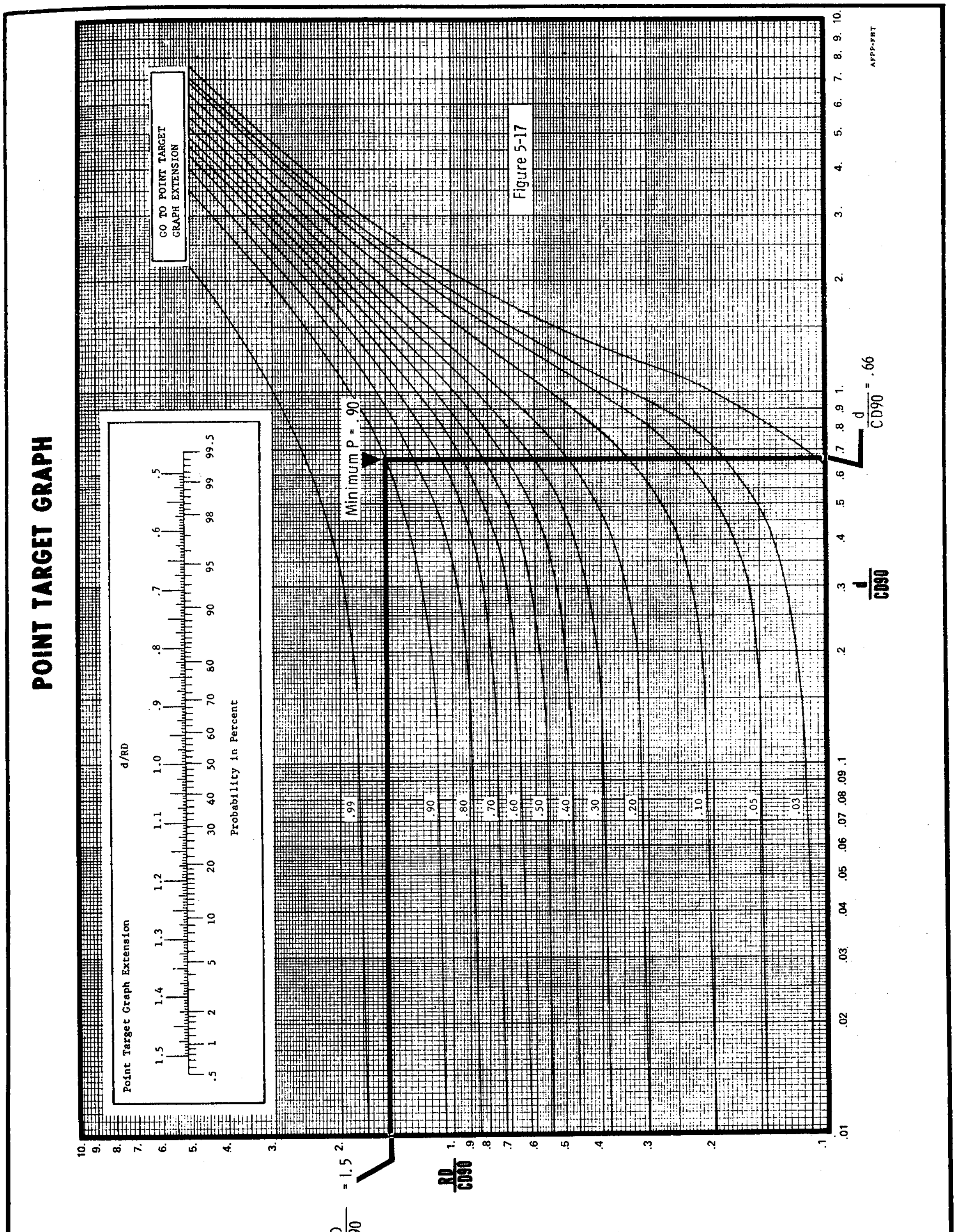

Figure 5—17. Point target graph.

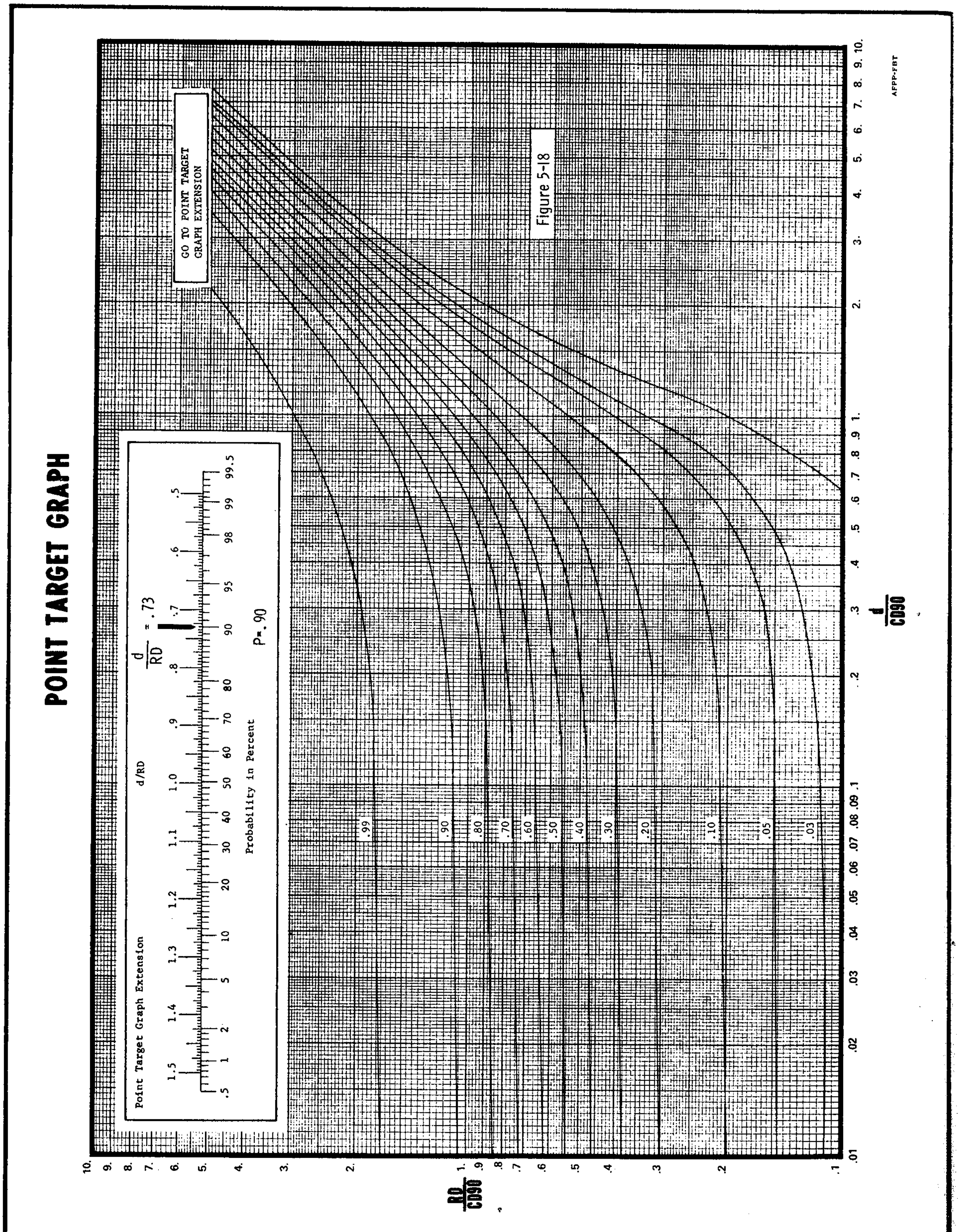

Figure 5—18. Point target graph.

(d) Multiply the $\frac{d}{RD}$ values by the RD to obtain the dmax. (If P = 0.90, dmax = .73 X RD.)

(e) Example problem. (See fig. 5—18.)

Given: RD = 1,200 meters
CD90 = 200 meters
Minimum acceptable probability of damage = 0.90

Find: Maximum displacement distance (dmax).

Solution: Calculate the RD/CD90 ratio

$$\frac{RD}{CD90} = \frac{1,200}{200} = 6.0$$

This RD/CD90 ratio is > 5; therefore, the point target graph extension must be used.

Enter the point target graph extension with a P = 0.90 and read d/RD = .73

dmax = d/RD X RD
= .73 X 1,200 = 876 meters

e. *Index Technique.*

(1) *Introduction.* The index technique of damage estimation is the fastest and most accurate technique available to the target analyst. The relationship between horizontal and vertical dispersion probabilities is considered in the computation of coverage tables. The index technique of damage estimation should be used whenever the following four conditons can be met.

(a) The target is an area target.

(b) The target is circular or equatable to a circle. The target is assumed equatable to a circle if the long axis is *less than* two times the short axis.

(c) The target elment is, or is comparable to, one of the six primary target categories shown in coverage tables of FM 101—31—2.

(d) The desired ground zero is located at target center.

(2) *Circular targets.* 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 (or using a circular map scale) that includes an area outside the target equal to the target area outside the circle (fig. 5—19). 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.

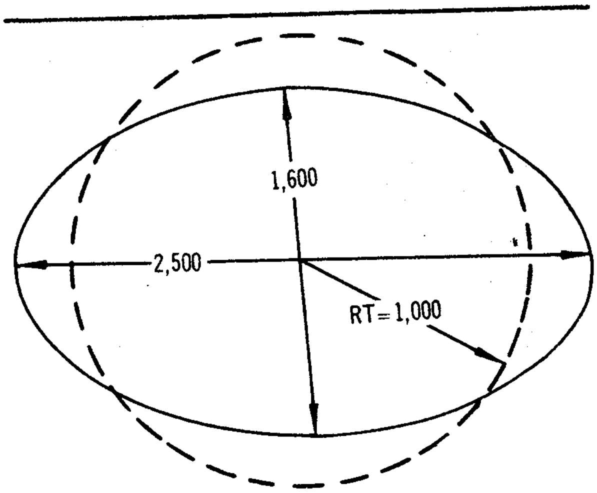

Figure 5—19. Determination of the target radius.

(3) *Comparable target table.* Although data for only six personnel and materiel target categories have been tabulated for the effects data manual, there are other targets whose response is quite similar to one of the six primary categories. The comparable target table (fig. 5—20) has been constructed to allow comparisons between targets. This table is also in FM 101—31—2 and FM 101—31—3. To use it, the analyst inspects the secondary target column to determine if the target of interest is considered a secondary target. If it is listed, he then moves across the appropriate row to determine to which primary target category the secondary is comparable.

PRIMARY TARGET / SECONDARY TARGET			Exposed Personnel (LL)	Personnel in open foxholes (IT)	Personnel in tanks (IT)	Moderate damage to tanks	Moderate damage to towed artillery	Moderate damage to wheeled vehicles
Factories (25-50 ton Crane Capacity)	All yields	Severe Damage				●		
Fixed Bridges	≤ 55 KT	Severe Damage					●	
Floating Bridges	≤ 55 KT	Severe Damage					●	
Missiles/Rockets in Open	≤100 KT	Severe Damage						●
Railroad Boxcars and Flat Cars (loaded)	All yields	Severe Damage						●
Tracked Vehicles (not tanks)	All yields	Severe Damage					●	
Personnel in Brick Apartment Buildings	< 55 KT	LL	●					
	≤ 10 KT	IP			●			
Personnel in APC	≤100 KT	IP		●				
Personnel in Earth Shelters	All yields	LL		●				

Figure 5—20. Comparable target table.

(4) *Coverage indexes.* Figure 5—21 is an example of a coverage table. To determine the fractional coverage for a target, the analyst selects the table that represents the target category, target response desired, delivery system, yield, and HOB option. Entering with the range and radius of the target, he extracts the "coverage index" at the intersection of these two entry arguments. Using figure 5—21, with a range to target value of 6,000 meters and an RT of 700 meters, the coverage index is .81/.86. The number to the left of the divider (slanted line), .81, is the 90-percent, or high assurance, fractional coverage. The number to the right of the divider, .86, is the *expected* fractional coverage for the target. *The expected fractional coverage value is normally used.* A wide difference between the indexes results when a weapon system with large inherent inaccuracies is employed against a target. The index values were computed with the DGZ located at target center. If the DGZ must be moved from target center, fractional coverages obtained from the index method are invalid and other estimation methods must be used.

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COVERAGE TABLE (Distances in meters) **SHORT RANGE CANNON 1KT**

EXPOSED PERSONNEL - LATENT LETHALITY
LOW AIRBURST

RANGE	EFFECTIVENESS RADIUS OF TARGET 500	600	700	800	900	1000	1300	1500	PROB MIN RD	EXPT RD	ACCURACY DATA CD 90	CEP	HOB	PEH
2000	.96/.98	.93/.96	.85/.88	.51/.55	.41/.43	.29/.32	.21/.22	.09/.12	460	526	80	38	49	9
3000	.96/.98	.91/.96	.85/.87	.52/.56	.41/.43	.30/.32	.20/.22	.10/.12	458	532	93	44	59	12
4000	.96/.98	.91/.95	.85/.87	.53/.56	.41/.43	.30/.32	.20/.22	.10/.12	454	532	99	47	59	12
5000	.96/.98	.91/.95	.84/.87	.53/.57	.41/.43	.30/.32	.20/.22	.10/.12	447	538	111	54	69	14
6000	.96/.98	.91/.95	.81/.86	.53/.57	.41/.43	.30/.32	.20/.22	.10/.12	448	540	128	62	82	17
7000	.95/.97	.91/.94	.80/.85	.55/.57	.41/.43	.30/.32	.20/.22	.10/.12	442	540	141	73	90	19
8000	.94/.96	.86/.92	.75/.83	.54/.57	.41/.43	.30/.32	.20/.22	.10/.12	434	538	176	86	101	22
9000	.92/.96	.78/.88	.68/.78	.53/.56	.37/.41	.28/.32	.20/.22	.08/.11	420	520	205	100	116	26
10000	.88/.94	.71/.85	.61/.75	.50/.55	.36/.40	.26/.31	.18/.21	.06/.11	400	490	234	115	132	30

Figure 5—21. Typical coverage table.

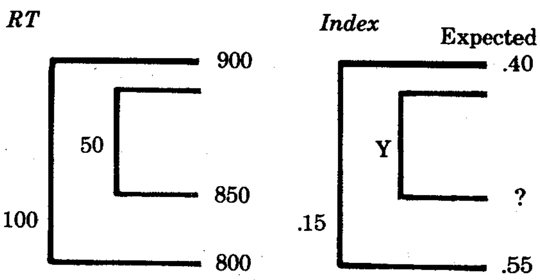
(5) *Target radii selection basis.* Because of the limit on the number of target radii that could be listed in the effectiveness section of the coverage tables, it was necessary to list only part of the spectrum target sizes. Moving from the left of the table, the first three target radii columns are oriented toward high fractional coverage, and the remaining five target radii columns are oriented toward lower expected fractional coverages. Depending on weapon yield, target category, and delivery error, there may be considerable gaps between radii of targets to fit this basis. Interpolation may be used to determine coverage for target radii not listed.

(6) *Coverage table.* The coverage table is entered using the nearest listed range. If the range is exactly halfway between two listed ranges, the target analyst will use the worst case by extracting the smaller coverage index. Interpolation between radii of target is accomplished by using linear interpolation and rounding down to two significant figures as shown in the example problem below:

Given: Target radius (RD) is 850 meters.
Range to target is 10,000 meters.

Find: The expected coverage index for an 850 meter RT.

There is no index listing for the RT in the coverage table shown in figure 5—21, but the expected coverage indexes for an RT of 800 meters and 900 meters are listed. These indexes are XX/.55 for the 800-meter RT and XX/.40 for the 900-meter RT.



Expected

$$\text{Ratio} = \frac{50}{100} = .50$$

Y = (.55 — .40) (Ratio)

Y = (.15) (.50)

Y = .075

.40 + Y = .475

Expected coverage index = XX/.47

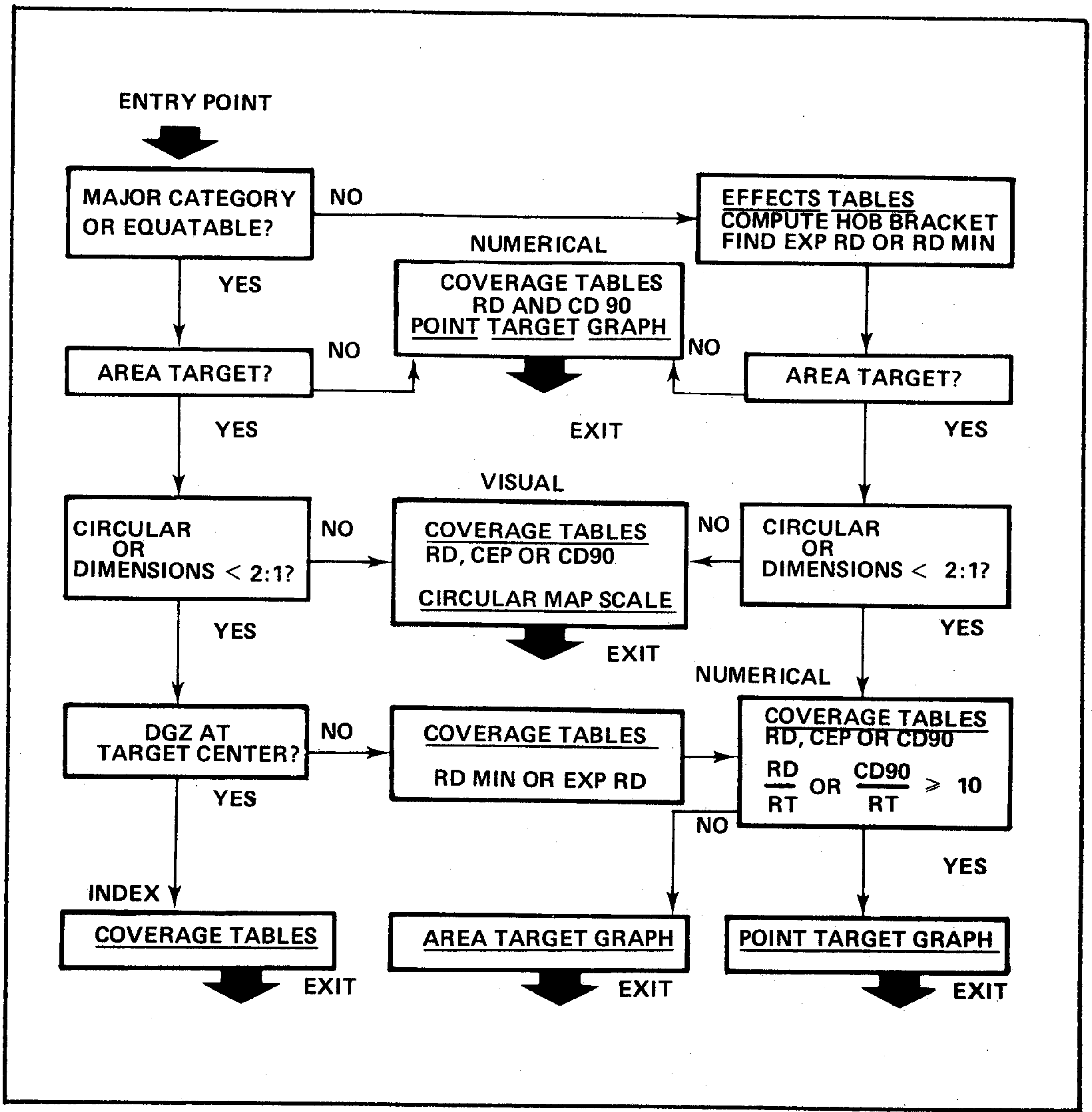


Figure 5—22. Damage estimation chart.

(7) *Estimation chart.* A damage estimation chart, figure 5—22, has been devised to assist the target analyst in selecting the proper technique for damage estimation to use in analyzing a target. This chart not only provides the analyst with the technique to be used but also with the items that are required to perform the analysis.

5—6. Limiting Requirements

a. General.

(1) Restrictions placed on the employment of nuclear weapons are referred to as "limiting requirements." These requirements are imposed to

avoid or mitigate the impact of undesirable effects caused by nuclear weapons in the form of:

(a) Casualties to friendly troops.
(b) Collateral damage.
(c) Creation of fire areas and obstacles to movement.
(d) Damage to structures, such as bridges, desired for use by friendly troops.
(e) Damage to organic aviation, such as helicopters in flight.

(2) Because of their importance, limiting requirements may influence the selection of the yield, the delivery system, the DGZ, or the time of burst. When guidance on limiting requirements cannot be met, one of the following actions must be taken:

(a) Move the DGZ so that limiting requirements are met.
(b) Use a more accurate delivery means to reduce the safety or preclusion distance required.
(c) Use a lower yield weapon to reduce the separation distance.

(d) Modify the troop safety criteria by increasing the protection of friendly troops from weapon effects, accepting a higher degree of risk or withdrawing troops to increase the separation distance. These actions can be taken only with the commander's approval.

(e) Use other forms of combat power, such as improved conventional munitions or maneuver elements.
(f) Request that the guidance be changed (e.g., accept less coverage, reduce damage or preclusion requirements).
(g) Request that the limiting requirements be exceeded.

b. *Troop Safety.*

(1) The analyst uses the minimum safe distance (MSD) to make troop safety calculations. The MSD is the sum of the radius of safety for a specified degree of acceptable risk and vulnerability and a delivery error buffer (the buffer distance).

(a) Risk. Three degrees of risk are considered.

1. Negligible risk. This risk level is associated with 1 percent incidence of casualties or 2.5 percent incidence of nuisance effects. Nuisance effects on the nuclear battlefield (such as eardrum rupture, first degree burns, and vomiting from radiation effects) are injuries that may cause a significant degree of temporary performance degradation in a soldier. They may require that he be examined by medical personnel but should not require evacuation from the battlefield as a casualty. A negligible risk is considered acceptable. *Negligible risk should not be exceeded unless significant tactical advantage will be gained.*

2. Moderate risk. This risk level is associated with 2.5 percent incidence of casualties or 5 percent incidence of nuisance effects. Moderate risk should not be exceeded if troops are expected to operate at full efficiency after a friendly burst.

3. Emergency risk. Five percent of the troops exposed to emergency risk effect levels will become combat ineffective. A larger number will suffer nuisance effects. Because of the possible effect on the combat efficiency of a unit, *emergency risk should be accepted only when it is absolutely necessary.*

(b) Vulnerability. Associated with the degrees of risk is the vulnerability OF THE SOLDIER, OR THE

protection he has from the weapon effects. To account for the various situations, three vulnerability categories exist: unwarned, exposed; warned, exposed; and warned, protected. These categories are defined as follows:

1. Unwarned, exposed. Personnel in this category are assumed to be standing in the open at the time of the detonation, but will 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.

2. Warned, exposed. Warned, exposed personnel are assumed to be prone on open ground with skin areas covered or protected from thermal effects by at least the equivalent of a two-layer summer uniform. Such a condition may exist when a unit is warned of an impending burst, but has insufficient time to obtain protective shelter, such as a personnel carrier or a foxhole.

3. Warned, protected. Personnel in this category are assumed to have significant protection against blast, and thermal and nuclear radiation. Protected categories include personnel in tanks, APCs, foxholes, weapon emplacements, and shelters.

(2) For each combination of risk and vulnerability, there is an associated risk distance known as the radius of safety (RS). The RS is the distance beyond which weapon effect levels are considered acceptable. As an example, if the RS for negligible risk to unwarned, exposed personnel is 2,000 meters, then personnel in the unwarned, exposed vulnerability category who are 2,000 meters or more from the *actual* detonation point will be exposed to no more than negligible risk. As a result of horizontal dispersion, a weapon might burst closer to friendly troops than the aimpoint. In order to account for this circumstance, a buffer distance is added to the RS to provide a very high or 99 percent assurance that the stated risk will not be exceeded for friendly troops in the stated vulnerability condition. The RS is found in the effects tables. The MSD values have been calculated and are contained in the safety distance tables in FMs 101—31—2 and 101—31—3. An example of these tables is shown in figure 5—23. Troops, which are

SAFETY DISTANCE TABLE SHORT RANGE CANNON
(Distances in meters)
1KT 5-24

	TROOP SAFETY (MSD)									PRECLUDE (LSD)									
	UNWARNED EXPOSED			WARNED EXPOSED			WARNED PROTECTED			MOD DAM FIXED	LT DAM TO	LT ACFT IN FLIGHT			FOREST BLOWDOWN		WILDLAND FIRES	
												OBSN UTIL	ASLT	OV-1B CARGO				
RANGE	NEG*	MOD*	EMER*	NEG*	MOD*	EMER*	NEG*	MOD*	EMER	BRG	BLDG	HEL	HEL	HEL	DECID	CONIF	CLASS I	CLASS IV
2000	1200	1200	1000	1200	1100	1000	1000	900	800	200	1200	1400	1500	1200	500	400	800	500
3000	1200	1200	1000	1200	1200	1000	1000	1000	900	200	1200	1400	1500	1200	600	400	800	600
4000	1300	1200	1100	1200	1200	1100	1000	1000	900	300	1300	1400	1500	1200	600	500	800	600
5000	1300	1200	1100	1300	1200	1100	1100	1000	900	300	1300	1400	1500	1200	600	500	800	600
6000	1300	1300	1100	1300	1300	1200	1100	1100	1000	300	1400	1400	1500	1200	600	500	800	600
7000	1400	1300	1200	1300	1300	1200	1200	1100	1000	300	1400	1400	1500	1200	600	500	800	600
8000	1400	1400	1200	1400	1400	1300	1300	1200	1100	300	1500	1400	1500	1200	700	500	900	600
9000	1500	1400	1300	1400	1400	1300	1400	1300	1100	300	1600	1400	1500	1200	700	500	900	600
10000	1500	1500	1400	1500	1500	1400	1500	1300	1200	100	1600	1400	1500	1300	700	500	900	600

*Nuclear radiation effects are significant. If troops have history of previous exposure, consult Figure 5-24 for modification of risk radii.

Figure 5—23. Typical safety distance table.

separated from the DGZ by a distance equal to or greater than the MSD that describes their risk and vulnerability condition are considered safe.

(3) The safety distance table is entered with the nearest listed range. If the range is halfway between two listed ranges, the larger of the two MSDs is extracted. (Ref. fig. 5—23.) If the range is 6,300 and troop risk and vulnerability condition is negligible to unwarned, exposed personnel, an MSD of 1,300 is extracted corresponding to the range of 6,000. If the range is 6,500, an MSD of 1,400 is extracted corresponding to the range of 7,000.

(4) On a nuclear battlefield, units may be exposed several times to some levels of radiation from friendly as well as enemy nuclear weapons. In view of these possible multiple exposures and the slow overall recovery, the analyst must consider the consequences of exposing personnel previously exposed to nuclear radiation. Friendly units are placed in one of four radiation exposure states (RES), such as RES 0, RES-1, RES-2, or RES-3, based on previous exposure history. (Additional information on the subject may be found in app C to this manual and in FM 3—12.) The MSDs listed in the safety distance tables are based on no previous (RES-0) OR radiation exposure history of ~~RES1 or~~ [redacted] If units have a radiation exposure history of RES–1 or greater, then the analyst determines from the appropriate Safety Distance Table whether radiation is the governing effect and must be considered in safety calculations. If it must be considered, then figure 5–24 must be used to modify the appropriate MSD (e.g., if unit in the above example (range 6300) were in RES–2 category, then modify the MSD by adding 200 meters)."

MSD MODIFICATION AS A FUNCTION OF PREVIOUS EXPOSURE

Radiation Exposure State	Total Past Cumulative Dose (rads)	Commanders Risk Guidance Negligible Moderate Emergency		
		MSD	MSD	MSD
RES-O	O	NEG	MOD	EMER
RES-1	>O, ≤70	NEG+100m	NEG	MOD
RES-2	>70,≤150	NEG+200m	NEG+100m	NEG
RES-3	>150	NEG+300m	NEG+200m	NEG+100m

Figure 5—24. Modification table (in meters).

c. *Collateral Damage.*

(1) A major consideration in the employment of nuclear weapons is collateral damage. To conduct initial planning, the analyst can use the simplified reference data provided in the back of the effects manuals. For detailed target analysis, collateral damage avoidance tables for each weapon system and yield are contained in FM 101—31—2 and similar unclassified versions are provided in FM 101—31—3. For systems in which the HOB is preset (radar fuzing) and cannot be changed in the field, there are seven HOB entries listed in the effect manuals. The middle entry is the preset

HOB nd is normally the one selected for entering the tables (indicated in the tables by an asterisk). For systems where the HOB can be set in the field (time dependent fuzing), there is a continuum of HOB provided; but typically, the HOB marked in the tables with an asterisk is the one used to enter the tables. The basic reason for entering the tables at the asterisked HOB is to simplify the analysis procedure. This procedure is operationally aedquate. However, if the desired HOB differs from the asterisked HOB, the analyst may enter the table at the desired HOB and extract the appropriate radius of collateral damage (RCD). A typical table for a system in which the HOB can be set in the field is shown in figure 5—25. Horizontal accuracy (buffer distance) is not included in the tabulated data and should be added commensurate with the commander's guidance. *In the absence of specific guidance, a horizontal buffer distance of 1 CEP should be used. This provides an assurance of not exceeding constraints of at least 50 percent for multi-directional considerations, and could provide an assurance up to 88 percent for a one-directional consideration.* The magnitude of the delivery error should be considered in determining the value to use.

(a) Governing personnel risk radii. The radii listed for personnel injuries represent a 5-percent incidence of injuries requiring hospitalization. In addition to the 5-percent incidence of hospitalization injuries, there will be an unspecified number of lesser injuries that do not require hospitalization. Civilians are assumed to be in one of the three environments discussed below:

1. Urban environment. Civilians in this environment are assumed to

COLLATERAL DAMAGE AVOIDANCE TABLES

(Distances in meters) **SHORT RANGE CANNON 1KT**

	PERSONNEL INJURY [5% incidence]			MODERATE DAMAGE TO FACILITIES [5% incidence]					THERMAL IGNITION [threshold level]			
HOB	URBAN	RURAL	IN OPEN	SINGLE STORY FRAME BUILDING	SINGLE STORY MASONRY BUILDING	LIGHT STEEL INDUST BLDG	FIXED BRIDGES	RAIL ROAD EQUIP	WOOD SHINGLES	DRAPES	NEWSPAPERS & DEBRIS	HOB
600	640	800	1070	1350	690	230	0	0	500	810	870	600
570	650	810	1080	1590	710	260	90	0	520	820	870	570
540	670	820	1090	1630	740	300	160	0	550	830	890	540
510	680	840	1090	1640	760	330	200	0	560	840	900	510
480	690	850	1100	1640	780	360	230	0	570	850	910	480
450	710	970	1100	1630	980	440	270	0	580	860	910	450
420	710	990	1120	1610	990	470	300	0	600	870	920	420
390	730	990	1130	1580	1000	620	480	0	610	870	920	390
360	740	1000	1130	1550	1010	640	500	0	620	880	930	360
330	750	1000	1130	1520	1000	630	530	10	630	890	940	330
300	750	980	1140	1480	980	610	520	240	640	900	950	300
270	760	950	1140	1430	950	590	500	360	650	910	950	270
240	760	920	1150	1380	920	570	480	390	650	910	960	240
210	770	910	1150	1330	890	560	470	390	660	910	970	210
180	770	910	1160	1270	860	540	450	390	670	910	970	180
*150	770	910	1160	1210	820	510	430	390	670	920	970	150*
120	770	910	1160	1150	780	490	410	390	680	920	980	120
90	760	900	1160	1090	750	470	400	390	680	920	980	90
60	750	890	1140	1020	700	440	380	380	680	910	960	60
30	740	880	1030	960	650	420	360	360	600	810	860	30
1	700	840	920	900	610	400	330	320	520	720	770	1

NOTE: Personnel injury normally governs collateral damage constraints.
*: Preset or typical HOB

Figure 5—25. Typical collateral damage avoidance table.

assumed to be in the basements of one-story masonry buildings. Injuries to these individuals can occur because of either radiation or blast. The larger of the two radii (blast and radiation) is tabulated. Thermal effects are not considered for personnel injuries inside of buildings.

2. Rural environment. Civilians in this environment are assumed to be in one-story wood-frame houses without basements. As discussed in the preceding paragraph, the larger radius associated with blast or radiation is tabulated. Again, thermal effects were not considered for civilians inside of buildings.

3. Personnel in open. The radii listed for this category equate to emergency risk to unwarned, exposed troops. Thermal, blast, and radiation effects are all considered, and the largest of the three radii is tabulated.

(b) Damage to facilities radii. Radii listed are for 5-percent incidence of moderate damage due to blast.

(c) Thermal ignition radii. Radii listed are the distances at which ignition, not necessarily sustained burning, is achieved. A probability of building damage cannot be associated with these radii.

(2) The collateral damage distance (CDD) has two components—the radius of collateral damage (RCD), which is obtained by entering the appropriate collateral damage avoidance table at the proper (typically the asterisked) HOB, and the appropriate horizontal delivery error buffer distance (a certain number of CEP corresponding to the level of assurance specified). The procedure for determining the CDD is as follows:

(a) Determine the RCD. The analyst simply enters the appropriate Collateral Damage Avoidance Table at the proper HOB and extracts the RCD under the appropriate column. If the analyst must consider more than one column category, then he extracts the largest RCD.

(b) Obtain the horizontal buffer distance. The coverage tables are used to obtain the CEP. The analyst enters that coverage table corresponding to the weapon system and yield he is considering with the gun to target range and extracts the CEP. (If the range is unknown, then he enters the table at 2/3 maximum range.) This CEP is then multiplied by the appropriate factor extracted from Table 5—1, corresponding to the level of assurance specified.

(c) Find the CDD. The CDD is equal to the sum of the RCD and the horizontal buffer distance as determined in paragraphs *(a)* and *(b)*, above.

Table 5—1. Assurance Versus CEP

Assurance (%)	Number of CEPs
10	0.39
20	0.57
30	0.72
40	0.86
50	1.00
60	1.15
80	1.53
90	1.83
99	2.58

(3) As discussed earlier in this paragraph, the radii of collateral damage avoidance in the tables are associated with a 5-percent incidence level. Table 5—2 shows it is not practical to change the incidence level from 5-percent since the band between a 1-

percent and a 20-percent incidence is so narrow (i.e., the multiplication factor variation is from 1.1 to 0.96). However, if required or operationally feasible, the level of collateral damage risk can be altered by varying the amount of buffer distance added to the RCD.

Table 5—2. Incidence Level Multiplication Factors

Incidence Level	Multiplication Factor
1%	1.1
5%	1
10%	.98
20%	.96

(4) Examples of CDD computations are presented below.

(a) Example problem.

Given: Short-range cannon (~~SCR~~ SRC)

Yield: 1 KT

Gun to target or suspected target range: 7,000 meters

Find: CDD, 5-percent incidence level, for urban personnel with a 50-percent assurance

Solution: From figure 5—21, extract CEP = 73 meters corresponding to an entry value of 7,000 meters

Enter the collateral damage avoidance table for the SRC, 1 KT (fig. 5—25), at the asterisked HOB of 150 meters and extract 770 meters as the RCD under the urban personnel column. To account for horizontal delivery error, add 1 CEP (73 meters) to this value to obtain 843 meters as the CDD with an associated 50-percent asurance.

(b) Example problem.

Given: Short-range cannon (SRC)

Yield: 1 KT

Gun to target or suspected target range: 7,000 meters.

Find: The governing CDD, considering all listed categories (except thermal ignition), with a 90-percent assurance and an incidence level of 5 percent.

Solution: From figure 5—21, extract CEP = 73 meters corresponding to an entry value of 7,000 meters

Enter the collateral damage avoidance table for the SRC, 1 KT (fig. 5—25) at the asterisked HOB of 150 meters and extract 1,210 meters under the single story frame building column as the largest RCD. This radius, 1,210 meters, is associated with a 5-percent incidence level. To account for horizontal delivery error, extract from table 5—1, 1.83 and add (1.83) (CEP) = 134 meters to 1,210 meters to obtain 1,344 meters as the CDD with a 90-percent assurance.

d. Preclusion of Damage and Obstacles.

(1) In addition to troop safety and collateral damage considerations, preclusion of damage to structures, forests, or material that might create an undesirable obstacle is often a consideration in planning a nuclear strike. Because of this, the last nine columns of the safety distance table contain LSDs for the preclusion of obstacles or damage. The preclusion of these obstacles can influence the selection of

the yield, the delivery system, and the DGZ. While the MSD for troop safety is based on 99-percent assurance, the LSD uses 90-percent assurance to account for delivery system dispersion. The DGZ must be separated from the point where obstacles or damage are to be precluded by a distance equal to or greater than the LSD.

(2) The procedure for extracting the LSD is the same as that used for the MSD. If type of aircraft, tree, or fuel is unknown, the worst case is used by extracting the largest LSD for each respective category.

5—7. Desired Ground Zero Selection

a. The target center should be initially selected as the DGZ; however, at times it will become necessary to displace the DGZ to accomplish the mission. The primary reasons for displacement of the DGZ include:

(1) Limiting requirements.

(2) Multiple targets.

(3) A combination of (1) and (2), above.

b. The analyst determines the appropriate limiting requirements (MSD, CDD, and LSD) for the delivery system and yield. The DGZ must be located from the limiting requirements a distance equal to or greater than the LSD, CDD, or MSD. The DGZ is located as close as possible to target center while still satisfying the limiting requirements. The following examples illustrate the selection of a DGZ to satisfy limiting requirements:

(1) *Single limiting requirement.*

(a) Given: Delivery system, short-range cannon

Yield: 1 KT

Range: 7,000 meters

HOB: low air

RES-0

Degree of risk and vulnerability condition: No more than negligible risk to unwarned, exposed troops located 1,300 meters south of the target center; no other limiting requirements are present.

(b) Find: The location of the DGZ.

(c) Solution:

1. Determine the displacement required. Using a target analysis worksheet, enter the safety distance table for the short-range cannon, 1 KT (fig. 5—23), with the range of 7,000 meters. An MSD of 1,400 is extracted. Because friendly troops are located 1,300 meters south of the target center, displacement of the DGZ for troop safety is, therefore, 100 meters north of the target center. The troop safety calculations entered in the target analysis worksheet are as follows:

(a) MSD—1,400 meters.

(b) Troop distance from the DGZ—1,300 meters south.

(c) Displacement of DGZ—100 meters north.

2. Locate the DGZ. When the DGZ must be moved from the target center because of 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. Compute the final coverage. Whenever the DGZ is displaced, final coverage is determined, using the visual or numerical technique of damage estimation.

(2) *Multiple limiting requirements (fig. 5—26).*

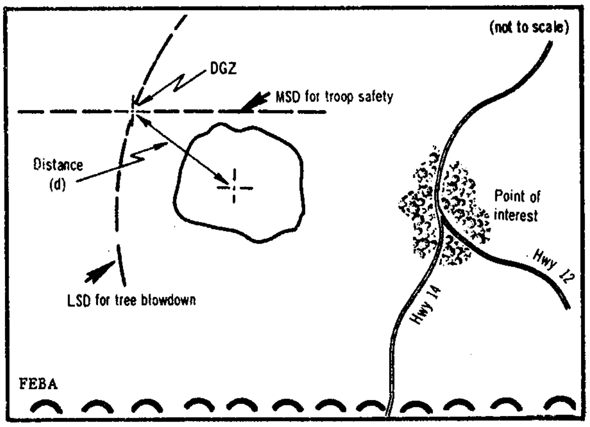


Figure 5—26. Graphic solution of the desired ground zero selection (multiple limiting requirements).

(a) Given: Delivery system, short-range cannon.

Yield: 1 KT

Range: 7,000 meters

HOB: low air

RES-0

Degree of risk and vulnerability condition: No more than negligible risk to unwarned, exposed personnel located 1,200 meters south of the target center.

Limiting requirement: No tree blowdown at the intersection of highways 12 and 14, 300 meters east of the target center.

Type of trees: deciduous

(b) Find: The location of the DGZ.

(c) Solution:

1. Determine the displacement required. Using a target analysis worksheet, enter the safety distance table for the short-range cannon, 1 KT (fig. 5—23), with the range of 7,000 meters. An MSD of 1,400 and an LSD of 600 are extracted from the appropriate columns. Because friendly troops are located 1,200 meters south of target center, displacement for troop safety is, therefore, 200 meters north of target center. To preclude tree blowdown at the intersection, 300 meters east of target center, the DGZ is displaced 300 meters west of the target center. The troop safety and preclusion of obstacles calculations entered in the target analysis worksheet are as follows:

(a) Troop safety.

(1) MSD: 1,400 meters.

(2) Troop distance from the DGZ: 1,200 meters south.

(3) Displacement: 200 meters north.

(b) Preclusion of obstacles.

(1) LSD: 600 meters.

(2) Distance from the DGZ: 300 meters east.

(3) Displacement: 300 meters west.

2. Locate the DGZ. Because the DGZ is displaced in more than one direction, the mathematical technique is not used in determining the DGZ displacement. Locate the DGZ by graphically plotting preclusion and safety distances.

(a) Draw a line parallel to the friendly forward areas at a distance equal to the MSD (1,400 meters in this case).

(b) Draw an arc at a 600-meter distance from the intersecting point of highways 12 and 14 because the preclusion of obstacles LSD indicates that the DGZ must be 600 meters away from the intersection to preclude tree blowdown.

(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) that is used in computing the final coverage.

3. Compute the final coverage, using either the numerical or the visual technique of damage estimation.

c. For multiple targets the analyst determines the dmax for the appropriate targets. The DGZ must be located at a distance equal to or less than the dmax from the respective targets. An area of overlap identifies an area in which the DGZ may be located that gives additional coverage or probability above the minimum required. This additional coverage is normally divided among the area targets. If all targets are point targets, the additional probability is divided among them. One target may be specified to receive all the additional coverage. In this case, the dmax is not computed for that target. The DGZ is located as close as possible to the target center while still providing the minimum acceptable coverage or probability to the other targets. The following examples illustrate DGZ selection for multiple targets:

(1) 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 5—27.

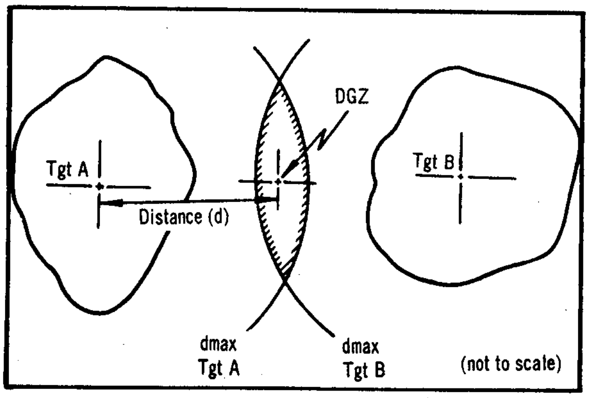


Figure 5—27. Graphic solution of the desired ground zero selection (multiple target attack with one weapon, all area targets or all point targets).

(a) Given: Two area targets, A and B.

(b) Find: The location of the DGZ and the final coverage of targets A and B for a given weapon.

(c) Solution:

1. Determine the displacement required. In analyzing multiple targets of the same type, find the maximum allowable distance (dmax) that 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. Locate the DGZ.

(a) 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 coverage. 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. Compute the final coverage for each target individually, using either the numerical or the visual method of damage estimation.

(d) Consideration of more than two targets: When more than two targets are being analyzed, the overlap area used in selecting the DGZ is that which is overlapped by the dmax of all targets under consideration. A graphical example is shown in figure 5—28.

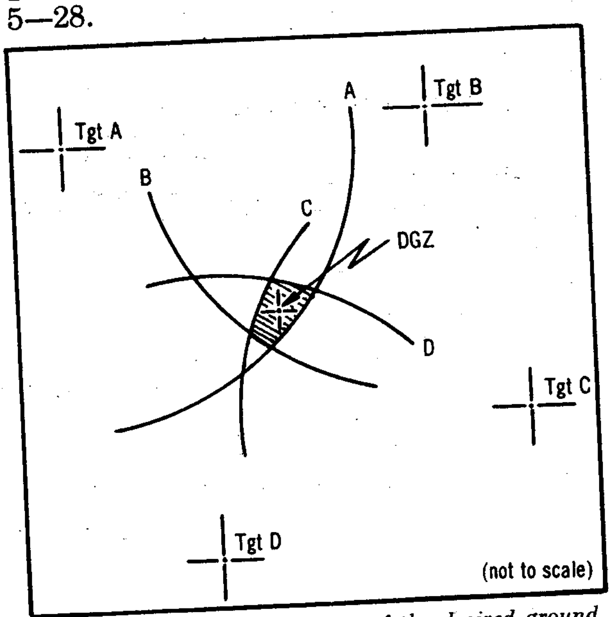


Figure 5—28. Graphic solution of the desired ground zero selection (multiple targets).

(2) Attack of multiple targets with a single weapon (one point target and one area target).

(a) Compute the dmax for the point target only.

(b) 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 dmax (fig. 5—29).

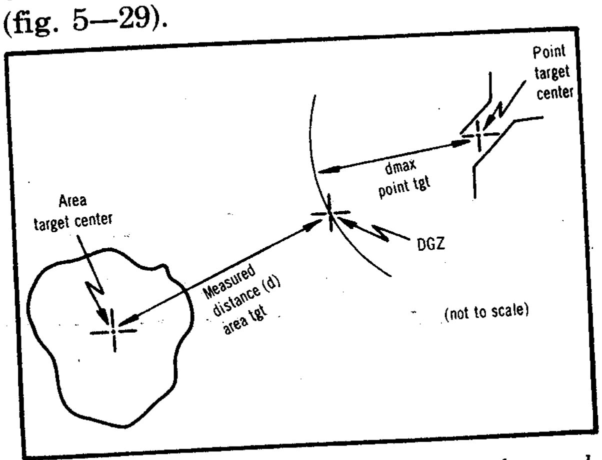


Figure 5—29. Graphic solution of the desired ground zero selection (multiple target attack, mixed targets).

(c) Measure the distance (d) from the area target center to the DGZ and compute the final coverage for the area target only.

(d) In the event that the required coverage cannot be obtained with a single weapon attack, the dmax 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.

d. When a DGZ is selected because of a combination of reasons (multiple targets and limiting requirements), the techniques used in each step are the same as those discussed above.

(1) Compute the distance and the direction the DGZ is to be displaced. (Determine MSD, CDD, LSD, and dmax.)

(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 in figure 5—30. In the event a limiting requirement forces the DGZ outside the area of coverage overlap, a command decision will be required on which requirement or restriction will be changed.

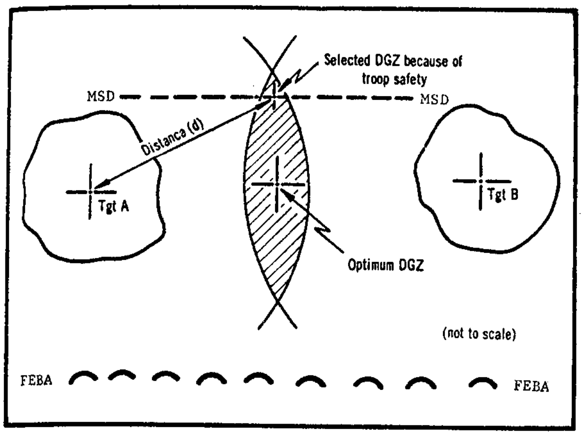


Figure 5—30. Graphic solution of the desired ground zero selection (combination of reasons).

(3) Measure the distance (d) to the DGZ from each target center and compute the final coverage, using either the numerical or the visual technique of damage estimation.

5—8. Damage Estimation for Preclusion-Oriented Method

a. The damage estimation techniques discussed in the previous section are most appropriate for target analyses when detailed target information is available. The preclusion-oriented method is used when detailed target information is not available. This method will permit the analyst to make weapon selections based on ⌐troop safety, obstacle and damage preclusion, and collateral damage constraints.

b. The preclusion-oriented method consists of two steps:

ƒ THE ANTICIPATED THREAT, TERRAIN ANALYSIS

(1) *Step 1,* ⌐*determine and graphically display the limiting requirements.* The appropriate MSDs, LSDs, and collateral damage distances are determined (as previously stated in the target-oriented method) for the available weapon systems and yields and then graphically displayed. An important consideration the analyst must keep in mind is to insure that he obtains the appropriate system—DGZ ranges for entering the appropriate tables.

(2) *Step 2, eliminate unsuitable weapons.* Weapons are eliminated when their limiting requirements offer no areas for possible DGZ selection. For weapon systems that are not eliminated, DGZs are selected so that the RDs (based on target categories and commander's guidance for the defeat of these targets) will give the most complete coverage for the proposed area of employment. These DGZs must be consistent with limiting requirements, weapon systems and yields available, the threat, and the tactical situation.

c. The preclusion-oriented method is described in the following example:

Given: Collateral damage constraints
Troop safety constraints
Preclusion constraints
Yields and weapon systems available

Normally, the analyst will have the above information provided to him. Based on the collateral damage, troop safety, and preclusion constraints, the analyst will determine the appropriate collateral damage, troop safety, and preclusion distances for each weapon and yield combination available. He then graphically applies these distances to the area of proposed employment.

ƒ THE STAFF PLANNERS MAKE A TERRAIN ANALYSIS AND ARRAY THE THREAT ON A OVERLAY BASED ON THE ENEMY'S TACTICS AND DOCTRINE measuring from the leading edge of populated areas or friendly troops, thus portraying areas for suitable and unsuitable DGZ selection for each weapon and yield combination. For instance, the analyst may determine those appropriate distances as illustrated in figures 5—31 through 5—33. Figure 5—31 shows the 10 KT free flight rocket's (FFR) limiting requirements drawn on the proposed area of employment. Clearly, within the limiting requirements, this illustrates that within the area of the suspect target, there are no suitable areas for possible DGZ selection.

Figures 5—32 and 5—33 illustrate the limiting requirements for two different weapon and yield combinations applied to the same area. However, in these cases, suitable DGZ selection areas are available.

If only one weapon were available for each yield (2 KT or 5 KT), the analyst would select the 5 KT (SRC) as shown in figure 5—32 because the RD associated with this yield weapon gives the most coverage. The final selection of weapon and yield combinations to be employed is based on those available combinations that will give the best coverage in the area of the suspected threat.

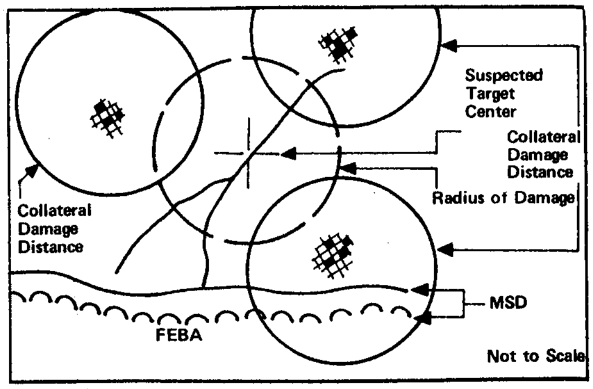


Figure 5—32. 5—KT short-range cannon.

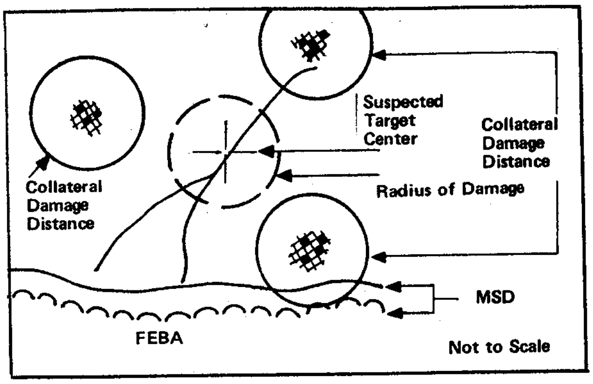


Figure 5—33. 2—KT short-range cannon.

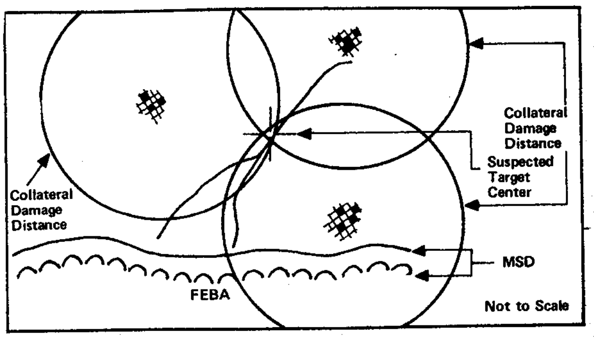


Figure 5—31. 10—KT free flight rocket.

Section III. SPECIAL PROCEDURES

5—9. General

a. The precomputed data in the coverage and safety distance tables of FM 101—31—2 have 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. In this situation, the data required for target analysis must be obtained using the effects tables in FM 101—31—2.

b. There may be circumstances when target or preclusion categories other than those listed in the coverage and safety distance tables need to be considered. The data required for target analysis are again obtained using the effects tables.

5—10. Effects Data as Related to Fuzing

Depending on the type of fuze a weapon system has, two different formats of effects data are used in the weapon effects tables. If the radar fuze system is preset, the effects data for each target category are shown for the surface burst, (if the weapon has a surface burst capability,) and for a low airburst, with the airburst effects radii at plus and minus 3.5 PEH, 2.5 PEH, and 1 PEH, centered around the preset HOB. For systems with a timer fuze that must be set in the field, the radii of damage and safety are listed for a continuum of feasible HOB.

5—11. Height of Burst.

a. The low airburst tabulated in the coverage tables provides the best effects on the target while providing a very high assurance (99 percent) of no significant fallout. If PEH changes, this desired HOB must be recomputed. Additionally, the target analyst must compute a desired HOB when analyzing a target that is not a primary target category, OR EQUIVALENT

b. The desired HOB is computed in the following manner:

(1) Height of burst fallout-safe (HOBfs) is the HOB at which no significant fallout will occur. HOBfs for weapon systems with a field selectable HOB are listed in chapter 2 of FM 101—31—2. It is computed by the equation:

$$HOBfs = 30(W)^{1/3} \text{ for } W \leq 100 \text{ KT}$$ (where W is the yield of the weapon in kilotons) or

$$HOBfs = 55(W)^{1/3} \text{ for } W > 100 \text{ KT}.$$

(2) A buffer distance (db) must be added to HOBfs to obtain the aimed HOB. This accounts for the vertical dispersion of the delivery system. A buffer distance of 3.5 PEH added to the HOBfs will provide an aimed HOB that will preclude significant fallout with a 99-percent assurance.

$$HOB99 = HOBfs + 3.5 \text{ PEH}.$$

(a) If HOBfs were the aimed HOB, figure 5—2 shows that there would be a 50-percent probability of the round detonating below HOBfs and producing significant fallout. There would also be a 50-percent probability of the round detonating above HOBfs. If a buffer distance corresponding to a probability of 49 percent is added to HOBfs, there is a 99-percent (50 percent + 49 percent) probability of no significant fallout.

(b) For a distance expressed as a multiple of probable errors, table 5—3 may be used to determine the associated probability that a nuclear weapon will function within that distance. The probability (P) column in table 5—3 expresses the probability that a weapon will burst no farther away in the vertical direction from the desired HOB than the number of PEH shown in the multiplying factor (MPF) column. The MPF is the distance (h) expressed in the multiples' of probable error in height (PEH); i.e., MPF = h/PEH.

From table 5—3, obtain an MPF of 3.5 corresponding to a probability of 49 percent (MPF = 3.5 for P = 0.49). The buffer distance corresponding to a probability of 49 percent is, therefore, equal to 3.5 PEH.

Table 5—3. Probability as a Function of Multiples of Probable Error in Height

P	MPF	P	MPF
0.05	0.2	0.44	2.3
0.10	0.4	0.45	2.5
0.15	0.6	0.46	2.6
0.20	0.8	0.47	2.8
0.25	1.0	0.48	3.0
0.30	1.3	0.49	3.5
0.35	1.6	0.495	3.8
0.40	1.9	0.499	4.5
0.42	2.1	0.499+	4.5+

(3) Height of burst optimum (HOBopt) is the HOB that gives the best effects against a specific target category. HOBopt is obtained from the appropriate effects table by selecting the HOB resulting in the largest RD for that target. If more than one HOB is associated with the largest RD, normally one selects the lowest HOB to provide enhanced blast damage. If a single weapon is to be used to attack a target array consisting of different target categories, HOBopt is that for the priority target in the array. If there is no priority target specified, HOBopt is that for the hardest target in the array.

(4) The higher of the two HOB, HOB99 and HOBopt, is used as the desired height of burst (DHOB).

5—12. Damage Estimation for Nonstandard Conditions

a. Radius of Damage.

(1) *General.* The RD used in damage estimation must be obtained from the effects table when:

(a) HOB changes.

(b) PEH changes.

(c) The target is noncomparable (when the target is not a primary target and cannot be equated to a primary target using the comparable target table).

(2) *Expected radius of damage.*

(a) Vertical dispersion may cause the round to detonate at a height other than the aimed HOB. The possible effect of this dispersion on the RD must be considered. The vertical expected HOB bracket should be used to obtain the expected RD. This bracket can be approximated by 1 PEH on each side of the DHOB (DHOB ± 1 PEH).

(b) The procedure for determining the expected RD for a low airburst is as follows:

1. Determine HOB and PEH. Except in the case of a change to a new preset HOB in a fixed HOB system, the desired HOB must be computed using the procedures from paragraph 5—11. The analyst obtains the PEH from the appropriate coverage table unless there has been a PEH change.

2. In the preset HOB system, the center HOB for the group is the desired HOB. The radii on either side of the center HOB radius are radii for the DHOB ± 1 PEH. The other two sets of radii represent effects radii for the DHOB ± 2.5 PEH and the DHOB ± 3.5 PEH. For these weapon systems, the expected RD is the ***smallest RD*** of the three center radii in the appropriate column.

3. For weapon systems that have a range dependent HOB, calculate the expected HOB bracket. (Expected HOB bracket = DHOB ± 1 PEH.) Enter the effects table with the nearest listed

HOB to the upper and lower limits of the HOB bracket. If the upper limit of the bracket falls exactly halfway between two listed HOB, enter with the higher listed HOB. If the lower limit of the bracket falls exactly halfway between the two listed HOB, enter with the lower listed HOB. These two entry HOB define a spectrum of RD that corresponds to the various HOB within the HOB bracket. Select the *smallest RD* occurring at or between the limits of the bracket as the expected RD.

(3) *Probable minimum RD.*

(a) The probable minimum RD is the RD that will be equaled or exceeded 90 percent of the time. Probability distributions indicate that 45 percent of the rounds fired will burst within 2.5 PEH above the aimed HOB and 45 percent of the rounds will burst within 2.5 PEH below the aimpoint (table 5—3). This distance above and below the DHOB defines a bracket in which the detonation has a 90-percent probability of occurring.

(b) The procedure for determining the probable minimum RD for a low airburst is as follows:

1. Determine the HOB and PEH.

2. For weapon systems with a preset HOB, the probable minimum RD is the *smallest* of the five radii centered around the DHOB.

3. For weapon systems with a range-dependent HOB, calculate the 90-percent HOB bracket (90-percent HOB bracket = DHOB ± 2.5 PEH). Enter the effects table with the upper and lower limits of the HOB bracket. The 90-percent bracket identifies 90 percent of the possible RDs that could occur. The probable minimum RD is the *smallest radius* that occurs in the range of values established by the HOB bracket in the appropriate RD column. There is a 90-percent probability of achieving *at least* the probable minimum RD.

b. Horizontal Accuracy Data. The following approximations may be used to convert horizontal accuracy data to an equivalent CD90:

(1) *Cannon- and rocket-delivered weapons (elliptical dispersion pattern).* CD90 = 3 PE larger. PE larger is probable error in range (PER) or probable error in deflection (PED), whichever is larger.

(2) *Aircraft- and guided missile-delivered weapons (circular dispersion pattern).* CD90 = 1.83 CEP.

c. Incorporation of Known Target Location Error. The assumption is made in target analysis that there is no target location error (TLE). If TLEs associated with target acquisition equipment are *known,* they may be incorporated into ~~the~~ "the horizontal dispersion error by taking the square root *of the sum of the* squares of horizontal dispersion error and TLE (i.e., $\sqrt{(TLE)^2 + (CEP)^2}$ for expected values or $\sqrt{(TLE)^2 + (CD90)^2}$ for high assurance values)." ~~center to the DGZ) when using the appropriate graph, area or point, in the determination of final coverage or probability. If the DGZ is located at target center, the final displacement (d) is equal to the TLE.~~

d. Damage Estimation Techniques. The expected RD and CEP or probable minimum RD and CD90 determined above may be used to estimate damage by the visual or numerical technique. The index technique is not applicable when delivery errors vary from the accuracy data shown in the coverage tables or when targets are not comparable to the primary target categories.

e. *Example.* ~~The following is an~~ example of determining coverage of a noncomparable target:

(1) Given: Delivery system, short-range cannon.
Yield: 1 KT
Range: 6,000 meters
HOB option: low air
Target category: Severe damage to open grid radar antennas.

(2) Find: Expected fractional coverage with DGZ located at the target center.

(3) Solution: The target is not one of the primary target categories, nor is it a secondary target in the comparable target table (fig. 5—20). The coverage table, therefore, cannot be used to obtain the data for damage estimation. The weapon effects table must be used to obtain the data.

(a) Enter a low airburst coverage table for the short-range cannon, 1 KT (fig. 4—3), with a range of 6,000 meters.
Extract: CEP = 62
PEH = 17

(b) Compute DHOB.

$HOBfs = 30(W)^{1/3} = 30(1)^{1/3} = 30$ meters

HOB99 = HOBfs + 3.5 PEH = 30 + 3.5 (17) = 30 + 60 = 90 meters

HOBopt = 330 meters (from fig. 4—6)

DHOB = 330 meters

(c) Compute expected HOB bracket.

Expected HOB bracket = DHOB ± 1 PEH = 330 ± 17 = 347 to 313 ~~meters~~

(d) ~~Enter the effects table for the~~ short-range cannon, 1 KT (fig. 4—6), with the nearest listed HOB corresponding to the limits of the bracket (360 to 300 meters). In the column for severe damage to open grid radar antennas, extract the smallest RD within the bracket. Expected RD = 630 meters.

Using the numerical method of damage estimation, enter the expected coverage area target graph with the ratios:

$$\frac{RD}{RT} = \frac{630}{400} = 1.575 \text{ and } \frac{CEP}{RT} = \frac{62}{400} = 0.155$$

At the intersection of the two ratios, read f = .97.

5—13. Minimum Safe Distances

a. The MSD must be computed using the effects table when:

(1) HOB changes.

(2) PEH changes.

(3) CEP changes.

b. The MSD has two components, the radius of safety (RS), which can be obtained from the effects tables, and the delivery error buffer distance. The procedure for determining the MSD is as follows:

(1) Obtain the HOB, PEH, and CEP.

~~(2) Determine the RS.~~

(a) [redacted] For systems with range-dependent probable errors, determine the HOB bracket (DHOB±3.5 PEH). Note that 3.5 PEH is used in the MSD HOB brackt calculation, which equates to a 98% bracket (±3.5 PEH),

not 99%. However, the probability associated with the detonation occurring on one side or the other of the aimed HOB is 50%; this, coupled with the fact that the governing effect which determines a radius of damage will peak at or on one side of the aimed HOB, allows the addition of *either* +3.5 PEH or −3.5 PEH to give the 99% assurance (50% + 49% = 99%) desired for the more stringent troop safety requirements. Enter the appropriate RS column with the HOB bracket (DHOB ± 3.5 PEH) and extract the *largest* radius of safety from the range of values established by the entry points. This is the RS."

(b) For systems with a range-independent HOB, enter the appropriate column and pick the *largest* value that occurs in the grouping of seven values around the DHOB.

(3) Determine the buffer distance that provides a 99-percent assurance that troops will not receive the specified effects because of the horizontal error of the delivery system. To calculate the buffer distance, multiply the CEP by 2 (fig. 5—34) or the PE larger by 3.5. PE larger is the PER or PED, whichever is larger.

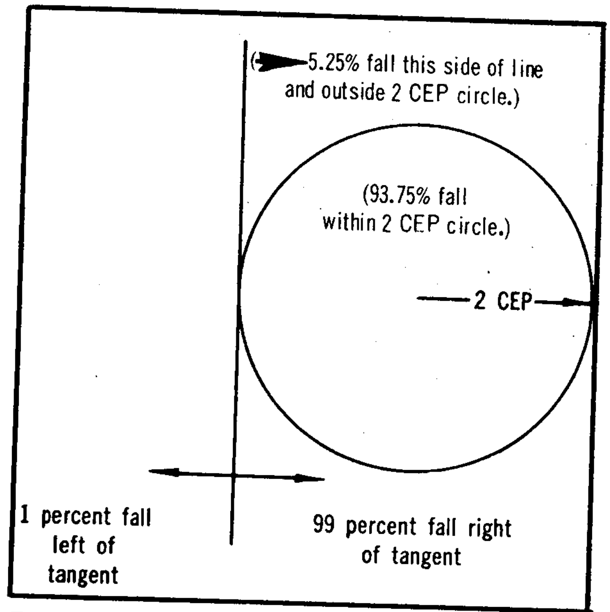


Figure 5—34. Tangent to the 2—CEP circle.

(4) The MSD is equal to the sum of the RS and the buffer distance.

(5) An example of MSD computation is as follows:

(a) Given: Delivery system, short-range cannon

Yield: 1 KT

Range: 6,000 meters

DHOB: 360 meters to maximize effects on cargo helicopters.

Troop safety—Negligible risk to unwarned, exposed personnel.

(b) Find: MSD.

(c) Solution: Since an MSD has not been precomputed for a DHOB = 360 meters at a range of 6,000 meters, the MSD must be computed using the effects table.

1. Enter a low airburst coverage table for the short-range cannon, 1 KT (fig. 4—3), with a range of 6,000 meters.

Extract: CEP = 62

Extract: PEH = 17

2. Compute 99-percent HOB bracket.

~~99-percent~~ ΔHOB ± 3.5 PEH
~~bracket = HOB ± 3.8~~ = 360 ± 3.5(17)
~~PEH = 360 ± 3.8 (17)~~ = = 360 ± 60
~~360 ± 65 = 425 to 295~~ = 420 TO 300
~~meters.~~

3. Enter the effects table for the short-range cannon, 1 KT (fig. 4—6), with the nearest listed HOB corresponding to the limits of the bracket (420 to 300 meters). In the safety radii column for negligible risk to unwarned, exposed personnel, extract the largest RS within the bracket. RS = 2,080 meters.

4. To insure a 99-percent assurance of not exceeding a negligible risk to unwarned, exposed personnel, a buffer distance must be computed to account for the horizontal dispersion of the delivery system.

db = 2 CEP = 2(62) = 124 meters

5. MSD = RS + db = 2,080 + 124 = 2,204 meters.

5—14. Preclusion of Damage or Obstacles

a. The LSD must be computed using the effects table when:

(1) HOB changes.

(2) PEH changes.

(3) CEP changes.

(4) Preclusion category is listed in the effects table but is not listed in the safety distances table.

b. The LSD is used to preclude obstacles or damage to material items. The DGZ must be separated from the *nearest point* of the item by a distance at which the item has a 10-percent probability of receiving the specified damage (or a 90-percent probability of not receiving the specified damage). This distance is the LSD.

c. The procedure for determining the LSD is as follows:

(1) Obtain the HOB, PEH, and CD90.

(2) Determine the radius of damage.

(a) For systems with range-dependent delivery errors, determine the 90-percent HOB bracket (90 percent bracket = DHOB ± 2.5 PEH). Enter the appropriate RD column with the 90-percent HOB bracket. The *largest radius* within this bracket is the RD.

(b) For systems with range-independent HOB, select the *largest* of the center five radii from the appropriate RD column for the RD.

(3) Calculate the RD/CD90 ratio. Enter the point target graph with the RD/CD90 ratio and read horizontally to the right until it intersects the 10-percent probability curve (10-percent probability of specified level of damage).

(4) Determine the d/CD90 value for this intersection point. LSD equals the d/CD90 value multiplied by the CD90.

(5) If the $\frac{RD}{CD90}$ ratio is greater than 5, the point target graph extension must be used to compute the LSD. Entering the point target graph extension with a probability of 10 percent, a $\frac{d}{RD}$ ratio of 1.26 is obtained. The LSD = 1.26 X RD.

(6) An example of LSD computation is as follows:

(a) Given: Delivery system, short-range cannon
Yield: 1 KT
Range: 5,000 meters
HOB option: low air
Target: Latent lethality to exposed personnel
Preclusion requirement: Preclude severe damage to supply depot.

(b) Find: LSD.

(c) Solution: Since this preclusion category is not listed in the safety distance table, the PLSD must be computed, using the effects table.

1. Enter a low airburst coverage table for the short-range cannon, 1 KT (fig. 4—3), with a range of 5,000 meters.

Extract: CD90 = 111
DHOB = 69
PEH = 14

2. Compute 90-percent HOB bracket.

90-percent HOB bracket = DHOB ± 2.5 PEH = 69 ± 2.5 (14) = 69 ± 35.0 = 104.0 to 34.0

3. Enter the effects table for the short-range cannon, 1 KT (fig. 4—6), with the nearest listed HOB corresponding to the limits of the bracket 90 to 30 meters. In the radii of damage column for severe damage to supply depots, extract the largest RD within the bracket. RD = 90 meters.

4. Enter the point target graph with the ratio:

$$\frac{RD}{CD90} = \frac{90}{111} = 0.811$$

and read horizontally to the right until it intersects the 10-percent probability curve. Read $\frac{d}{CD90} = 1.35$ corresponding to this intersection point.

$$LSD = \left(\frac{d}{CD90}\right) X\ CD90 = (1.35)$$

$$(111) = 149.85 = 150 \text{ meters.}$$

Section IV. POST STRIKE ANALYSIS

5—15. General

a. When nuclear weapons are used to attack targets, post strike surveillance is accomplished to ascertain degrees of success. Before this surveillance can be completed, the target analyst refines his prediction of damage by means of a post strike analysis, based on receipt of the following information:

(1) Actual location of ground zero.

(2) Estimation of the yield.

(3) The actual HOB.

FM 3—12 provides information concerning nuclear burst surveillance, data collection, and reporting techniques. In instances where the actual ground zero and HOB are not known, post strike damage estimations must rely on intelligence reports or actual observation of the target area.

b. Two techniques are used to estimate post strike damage based on size and shape of the target. These techniques are:

(1) The visual technique.

(2) The numerical technique.

(a) Area targets (when circular).

(b) Point targets.

c. Each technique requires knowledge of the actual location of the ground zero, the realized yield, and the actual HOB. (Yield and HOB 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 HOB is considered normal if the detonation occurred with ± 2.5 PEH of the predicted burst point. If the HOB occurs beyond ± 2.5 PEH, the appropriate expected RD for the actual HOB should be used.

5—16. Examples

a. Visual Technique.

(1) The visual technique of post strike damage estimation is used to refine damage predicted against irregularly shaped targets. To use this method, the analyst plots the actual location of ground zero in relation to the target. Once ground zero has been plotted, the analyst extracts the RD from the effects table based on the actual HOB or uses RD expected based on target category, type of burst, yield, and gun-to-target range. Using this RD on the appropriate circular map scale, the analyst places the center of the map scale over ground zero and visually estimates the fractional coverage of damage.

(2) An example of the visual technique of post strike prediction is shown below.

(a) Given: Delivery system, short-range cannon (extracted from fig. 5—4)

Yield: 1 KT
Range: 8,000 meters
HOB: low air
Target category: exposed personnel, latent lethality

(b) Post strike data: target, fig. 5—35

GZ: fig. 5—35
HOB: normal
Yield: normal

(c) Find: The post strike estimation.

(d) Solution:

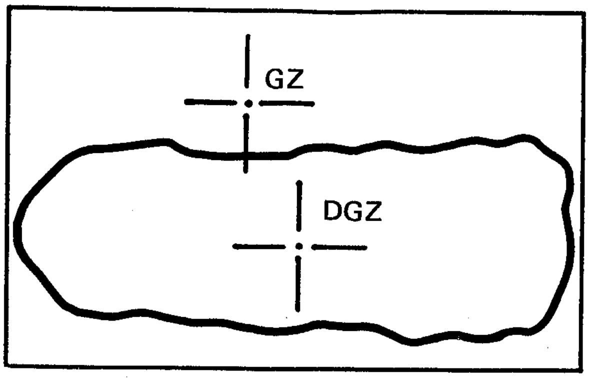


Figure 5—35. Example of post strike analysis.

1. Step 1 Enter the proper coverage table (i.e., 1 KT, SRC, Exposed personnel, latent lethality) at the range of 8,000 meters and extract an expected RD of 538 meters."
~~588 meters~~.

2. Step 2. Draw the RD on the template, place the center of the template over the actual ground zero, and visually estimate a fractional coverage of 20 percent (fig. 5—36). *Because the weapon has already detonated, no consideration need be given to the probable errors inherent in the delivery system.*

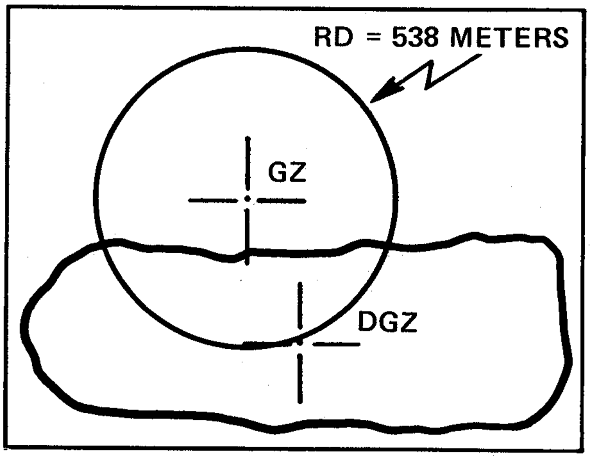


Figure 5—36. Visual post strike damage estimation.

b. Numerical Technique. The numerical technique of post strike damage estimation is used against circular area and point targets.

(1) When this technique is used on circular area targets, the analyst must know the actual location of ground zero (distance) in relation to the target center, the radius of target, and the expected RD. Using the numerical technique discussed in section II, the analyst enters the area target graph (expected coverage) with the ratios

$$\frac{RD}{RT} \text{ and } \frac{d}{RT}$$

(note that the ratio $\frac{d}{RT}$ has been substituted for the ratio $\frac{CEP}{RT}$), and, at the intersection of the two ratios, he reads the fractional coverage of damage.

(2) An example of the numerical technique of post strike prediction against a circular area target is shown below.

(a) Given: Delivery system, short-range cannon
Yield: 1 KT
Range: 8,000 meters
HOB: low air
RT: 1,000 meters
Target category: exposed personnel, latent lethality.

(b) Post strike data:
GZ: 200 meters north of the target center
HOB: normal
Yield: normal

(c) Find: The post strike estimation.

(d) Solution:

1. Step 1. Enter the proper coverage table with the range of 8,000 meters. Moving to the right, under the column for expected RD, extract an expected RD of 538 meters.

2. Step 2. Using the numerical technique, enter the area target graph, figure 5—8, with the ratios $\frac{RD}{RT} = \frac{538}{1,000} = 0.538$ and $\frac{d}{RT} = \frac{200}{1,000} = 0.2$. At the intersection of the two ratios, read the fractional coverage of damage (f = 29 percent). *The probable errors inherent in the delivery system are not considered in post strike analysis.*

(3) The numerical technique of post strike 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 with the proper ratio value for $\frac{d}{RD}$ and reads the probability of the target being destroyed.

(4) An example of the numerical technique of post strike analysis against a point target is shown below.

(a) Given: Delivery system, short-range cannon
Yield: 1 KT
Range: 8,000 meters
HOB: low air
Target category: missile launcher, moderate damage.

(b) Post strike data:
GZ: 250 meters north of the target center
HOB: normal
Yield: normal

(c) Find: The post strike estimation.

(d) Solution:

1. Step 1. The comparable target table, figure 5—20, equates missile launchers to wheeled vehicles.

Enter the proper coverage table, figure 5—37, with the range of 8,000 meters. Moving to the right, under the column for probable minimum RD extract a minimum RD of 225 meters.

2. Step 2. Using the point target graph extension, figure 5—14, enter with the ratio $\frac{d}{RD} = \frac{250}{225} = 1.11$ and read the probability as 30 percent.

COVERAGE TABLE (Distances in meters) — **SHORT RANGE CANNON 1KT** 5-24

MODERATE DAMAGE TO WHEELED VEHICLES
LOW AIRBURST

RANGE	EFFECTIVENESS RADIUS OF TARGET 300	350	400	450	500	550	600	650	PROB MIN RD	EXPT RD	ACCURACY DATA CD 90	CEP	HOB	PEH
2000	.68/.70	.52/.34	.41/.46	.28/.32	.25/.28	.18/.24	.16/.19	.14/.16	250	256	25	14	49	5
3000	.65/.68	.49/.54	.40/.44	.31/.32	.25/.28	.18/.24	.16/.19	.14/.16	250	256	38	21	55	8
4000	.62/.66	.49/.53	.40/.44	.31/.32	.25/.28	.18/.23	.16/.19	.14/.16	250	255	51	28	62	10
5000	.62/.66	.49/.53	.40/.44	.31/.32	.25/.28	.18/.23	.17/.19	.14/.16	250	255	64	39	73	13
6000	.54/.58	.40/.42	.30/.26	.25/.20	.18/.22	.16/.18	.14/.14	.12/.12	225	234	77	42	80	15
7000	.55/.58	.40/.42	.32/.34	.25/.26	.18/.17	.16/.14	.14/.14	.12/.12	225	234	90	49	90	18
8000	.55/.58	.40/.48	.32/.34	.25/.28	.18/.22	.16/.18	.14/.15	.12/.12	225	234	102	56	97	20
9000	.47/.48	.30/.38	.25/.34	.18/.24	.15/.18	.13/.14	.11/.12	.09/.10	200	214	116	67	108	23
10000	.38/.36	.25/.28	.18/.24	.14/.18	.12/.14	.09/.12	.08/.10	.06/.08	175	190	128	70	115	25

Figure 5—37. Typical coverage table.

APPENDIX A

REFERENCES

A—1. Field Manual

FM 3—12/FMFM 11—5	Radiological Defense
FM 5—26	Employment of Atomic Demolition Munitions (ADM)
(C) FM 5—26A	Employment of Atomic Demolition Munitions (ADM) (U)
FM 6—40	Field Artillery Cannon Gunnery
FM 9—6	Ammunition Service in Theater of Operations
FM 9—47	Special Ammunition Unit Operations
FMFM 11—1	Nuclear, Chemical, and Defensive Biological Operations in the FMF
FM 21—40	Chemical, Biological, Radiological and Nuclear Defense
FM 21—41	Soldiers' Handbook for Defense Against Chemical and Biological Operations and Nuclear Warfare
FM 27—10	The Law of Land Warfare
FM 31—10	Denial Operations and Barriers
FM 54—7	Theater Army Support Command
FM 71—100	Division Operations
FM 100—5	Operations
FM 100—15	Large Unit Operations
FM 105—5	Maneuver Control

A—2. Other Publications

DA Pam 39—3	The Effects of Nuclear Weapons
(S—RD) DNA EM—1	Defense Nuclear Agency Effects Manual —1, Capabilities of Nuclear Weapons (U)
(S—RD) RADCAS	Radiation Casualty Criteria for Battlefield Targets (RADCAS) (U), US Army Nuclear Agency (Limited distribution)
(C) PRCC	Personnel Risk and Casualty Criteria for Nuclear Weapons Effects (U), US Army Nuclear Agency (Limited distribution)
PRCC Addendum	Addendum to Personnel Risk and Casualty Criteria for Nuclear Weapons Effects, US Army Nuclear Agency (Limited distribution)

APPENDIX B

EFFECTS OF NUCLEAR WEAPONS

Section I. GENERAL

B—1. Introduction

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 appendix presents a general, qualitative discussion of the effects of nuclear weapons. Those effects produced by a nuclear detonation that occur in an area of military interest *within the first minute* after the burst are defined as initial effects. Those effects which occur in this area after the first minute are called residual effects. It may be hours or days before the consequences of these effects are known, and they may last for extended periods of time.

c. A more detailed discussion of nuclear weapon effects is presented in the Defense Nuclear Agency Effects Manual Number 1 (DNA EM—1), *Capabilities of Nuclear Weapons,*[1] and in unclassified terms in DA Pam 39—3, *The Effects of Nuclear Weapons.* This manual provides the target analyst with the means by which he can determine the distance to which various effects extend and detailed descriptions of all aspects of weapon effects.

B—2. Description of Nuclear Detonations

a. Release of Energy. The magnitude of the energy release in a nuclear explosion enormously exceeds the energy released from the detonation of a chemical explosive. This energy released, or yield, is measured in terms of thousands of tons of TNT equivalent (kiloton (KT)) or in millions of tons of TNT equivalent (megaton (MT)).

b. Partition of Energy. When a nuclear weapon is detonated at low altitudes, a fireball is formed as the result of the sudden release of immense quantities of energy. The initial temperature of the fireball ranges into millions of degrees, and the initial pressure ranges to millions of atmospheres. Most of the energy from a nuclear weapon detonation appears in the target area in the form of three distinct effects.

(1) *Blast.* A blast wave with accompanying drag effects is produced and travels outward from the burst.

(2) *Thermal radiation.* Intense thermal radiation is emitted from the fireball, causing heating and combustion of objects in the surrounding area.

(3) *Nuclear radiation.* Neutron and gamma radiation from the weapon detonation produces casualties and, in many cases, material damage as well. Ionized regions, which may interfere with the propagation of electromagnetic waves associated with communication systems and radars, are produced when nuclear radiation is absorbed into the atmosphere.

c. Variation of Energy Partition. In the detonation of a typical fission-type nuclear weapon, the percentage of the total energy 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. For bursts within a few kilometers of the earth's surface, slightly more than 50 percent of the energy may appear as blast, approximately 35 percent as thermal energy, and the remainder, about 15 percent, as nuclear radiation.

[1]Classified SECRET-RESTRICTED DATA in the US version, and NATO SECRET in the NATO version.

B—3. Types of Burst—Definition and Significance.

Nuclear weapons may be burst at any point from deep below the surface to very high altitudes. Generally, nuclear bursts are classified according to the manner in which they are employed. The terms listed below and their associated definitions are used in this manual.

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 for creation of barriers and obstacles. Shallow subsurface bursts may produce a significant amount of fallout.

b. Impact or Contact Surface Burst (0 Meter Height of Burst). This type of burst is used to cause blast, ground shock, and cratering. It may be used against hard underground targets located relatively near the surface of the earth. Fallout is produced.

c. Near-Surface Burst. This type of burst occurs in the atmosphere but is close enough to the earth for the fireball to come in contact with the earth's surface. Fallout will occur as a result of this contact. This type of burst should not be used when fallout is undesired.

d. Low Airburst. This height of burst (HOB) option provides the most effective materiel or personnel casualty coverage to ground targets expected to be on the battlefield while still giving a very high assurance (99% or more) of precluding militarily significant fallout. The low air HOBs tabulated in FM 101—31—2 are the larger of (1) and (3) or (2) and (3), below, depending on whether the target is blast or radiation sensitive and the governing effects:

(1) The optimum HOB for blast effects is HOB = 53 $W^{1/3}$ meters, where W = yield.

(2) The optimum HOB for radiation effects are extracted from HOB versus radius of effects curves based on weapon design.

(3) The HOB that has a 99-percent assurance of not producing fallout can be calculated as:

(a) HOB99 = 30 $W^{1/3}$ 3.5 PEH meters, for W $\leq$ 100 kilotons.

(b) HOB99 = 55 $W^{1/3}$ 3.5 PEH meters, for W $\geq$ 100 kilotons.

e. High Airburst. A high airburst is used in special cases for maximum blast coverage to "soft" targets, such as light frame buildings and exposed personnel, and to reduce the intensity of induced radiation in the vicinity of ground zero. ~~The basic~~ "However, this height of burst reduces the radius of damage for most target elements and, consequently, receives little attention." ~~meters (for, HOB = 100 W 3.5 PEH meters). If the above HOB is less than 120 $W^{1/3}$ meters (fallout safe), use HOB = 120 $W^{1/3}$ meters as the high airburst HOB.~~

Section II. BLAST AND SHOCK

B—4. Airblast Effects

a. Most of the materiel damage and a considerable number of the casualties caused by an airburst are due to the blast wave produced by the detonation. For this reason, it is desirable to consider the phenomena associated with the passage of a blast wave through air.

b. The expansion of the intensely hot gases at extremely high pressures within the fireball causes a blast wave to form in the air, moving outward at high velocities. The main characteristic of the blast wave is the abrupt rise in pressure above ambient conditions. This difference in pressure with respect to the normal atmospheric pressure is called the overpressure. The peak overpressure is the value of the overpressure at the leading edge or shock front of the blast wave. As the blast wave travels in the air away from its source, the peak overpressure steadily decreases, and the pressure behind the shock front decreases until it is below that of the surrounding atmosphere, forming the negative phase of the blast wave. This is illustrated in figure B—1. The negative phase of the overpressure is characterized by an underpressure (pressure below that of the surrounding air). It is significantly less in magnitude than the peak overpressure. Initially, the velocity of the shock front is many times the speed of sound. However, as the front progresses outward, it slows down and ultimately propagates with the speed of sound.

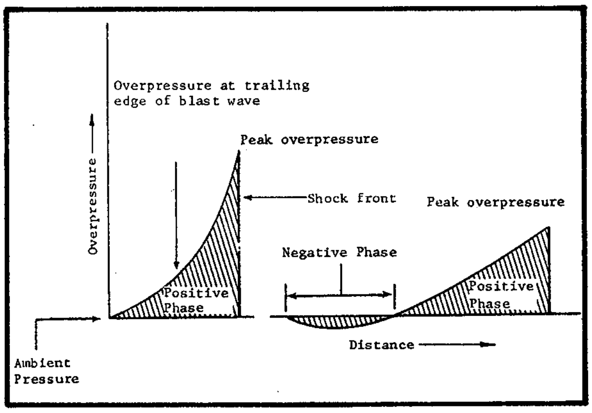


Figure B—1. Variation of overpressure with distance at two successive times.

c. The characteristics of the blast wave are dependent on the distance from the burst point and the yield of the weapon. Figure B—2 shows that the duration of a blast wave (the time it takes the blast wave to pass a fixed point) increases with distance; whereas, the peak overpressure decreases with distance. As indicated in figure B—3, both the duration and peak overpressure increase with yield at a given distance from the burst point. In both of these figures, it should be recognized that the velocity of the shock front is decreasing with distance from ground zero.

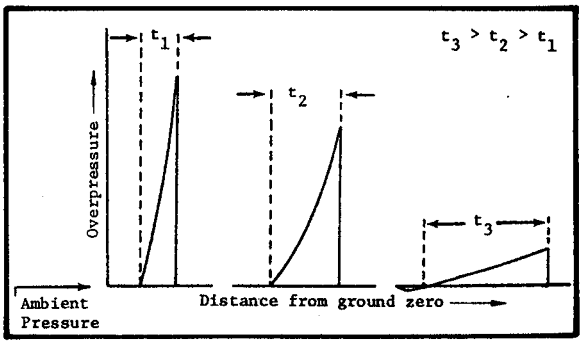


Figure B—2. Increase of duration of the blast wave with distance from ground zero.

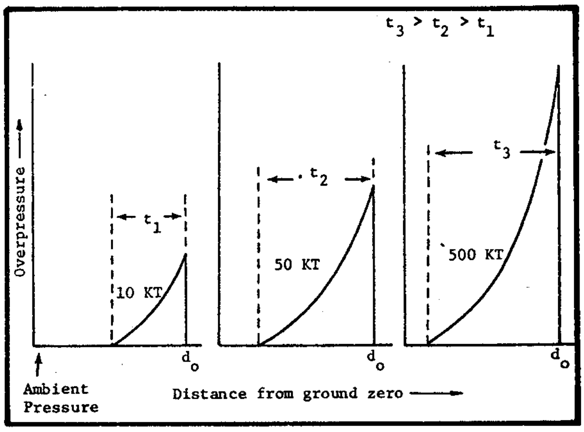


Figure B—3. Increase of duration of the blast wave with yield at a given distance, d_c, from ground zero.

d. The parameters of the blast wave which are of the greatest importance in the consideration of the blast wave's destructive capabilities are the overpressure and the dynamic pressure. *Overpressure* is the difference in the pressure in the blast wave relative to that of the ambient air. *Dynamic pressure* is proportional to the square of the air velocity directly behind the blast wave, and thus relates to the winds associated with the blast wave. The dynamic pressure also exhibits a negative phase, but it is small and not militarily significant. The damage mechanisms associated with these parameters are discussed in more detail in paragraph B—5.

e. The magnitude of the airblast parameters is dependent on the yield of the weapon, height of burst, and the distance from ground zero. For example, a 1-KT weapon might produce an overpressure of about 5 psi at 500 meters from the burst; whereas a 10-KT weapon would produce 5 psi at approximately 1,100 meters from the burst. The duration of the blast wave (both the overpressure and dynamic pressure aspects) may last from tenths of a second to seconds, depending on the yield and the distance from the burst.

B—5. Airblast Damage Mechanisms

The damage mechanisms of interest for military targets result from both overpressure and dynamic pressure.

a. Overpressure. When a blast wave begins to interact with an object, high pressures are applied to the side of the object nearest the burst. Since the side of the object away from the burst is still at ambient pressure, initially there is a temporary pressure difference about the object, producing a net force away from the burst. As the blast wave envelops the object, the overpressure is applied to all sides of the object and produces a squeezing or crushing force on the object that might result in damage. Targets, such as buildings with small window areas, that are damaged primarily by overpressures are called diffraction targets.

b. Dynamic Pressure. Dynamic pressure is a measure of the mass motion of the air accompanying the blast wave and the drag-type forces resulting from the winds associated with the dynamic pressure. The dynamic pressure can cause damage by pushing, tumbling, or tearing targets apart. Targets damaged primarily by dynamic pressure are called drag-type targets. Most military materiel targets are drag sensitive. Personnel can also become casualties when they are subjected to translational motions or missiling caused by these high winds.

c. Comparison of Overpressure and Dynamic Pressure. Figure B—4 shows the manner in which both the overpressure and the dynamic pressure vary with time at a fixed distance from the burst. Except for very high pressures, the positive and negative pressures of the overpressure are greater in magnitude than those of the dynamic pressure. Even though the dynamic pressure is generally less in magnitude than the overpressure, it makes an important contribution to damage caused by the blast wave. The time durations of the positive phase of the overpressure and the dynamic pressure are approximately equal.

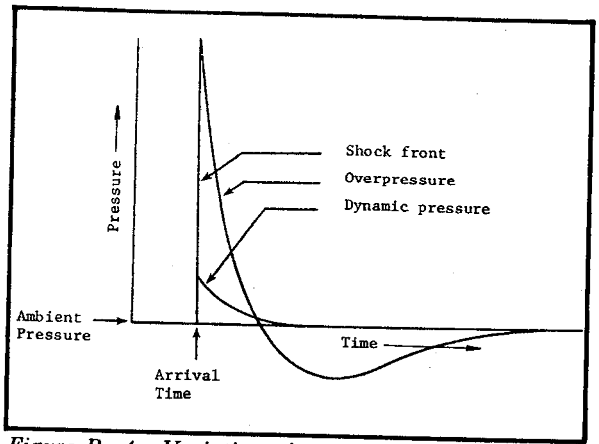


Figure B—4. Variation of overpressure and dynamic pressure with time at a fixed location.

B—6. Dependence of Blast Waves on Altitude of Burst

Airblast is produced by airbursts, surface bursts, and subsurface bursts.

a. Airbursts. When a blast wave from an airburst is reflected from the earth's surface, it reinforces the incident wave and increases the overpressure and the dynamic pressure wave. This reinforcement results in greater blast effects over a larger surface area than those that would be associated with either the reflected or incident wave. The magnitude of this reinforcement is dependent on the height of burst, increasing to a maximum and then decreasing as the height of burst increases. Since greater blast wave pressures are obtainable with low airbursts, they may be employed against hard materiel targets, such as tanks, artillery pieces, and missile launchers. In high airbursts, the blast pressures are reduced, but the area coverage is increased. Such high bursts are suitable for use against large area targets, such as most buildings and forests.

b. Surface Bursts. A surface burst produces less total airblast area coverage to most military targets than an airburst because there is less reinforcement of the blast wave. Moreover, since some of the energy of the weapon goes into crater formation and the generation of ground shock for a given yield, the amount of available blast energy is reduced.

c. Subsurface Bursts. Most of the energy from subsurface bursts goes into crater formation and/or ground shock. (This actual fraction depends on yield and depth of burst.) Except for very shallow subsurface bursts, the airblast wave produced by buried bursts is weak in comparison with air bursts and surface bursts. As a result, only small amounts of damage can generally be expected from the airblast produced by a subsurface burst.

B—7. Modifying Infuences on the Blast Wave

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

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

c. Topography. Most data concerning blast effects are based on flat or gently rolling terrain. There is no quick and simple 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 highly dependent on line-of-sight considerations because the blast waves will bend or diffract around obstacles. The influence of small hills or folds in the ground is considered negligible for target analysis. Hills may decrease dynamic pressures and offer some local protection from flying debris.

d. Cities or Built-Up Areas. Built-up areas are not expected to have a significant effect on the blast wave. Structures may provide some local shielding from flying debris and cause local pressure increases because of the channeling of 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, in general, do not have a significant effect on the overpressure but do degrade the dynamic pressure of an airblast wave.

B—8. Cratering and Ground Shock

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, compacts and throws a large quantity of earth material upward and outward, thereby forming a crater. This crater may be quite large depending on weapon yield, depth of burst, and soil characteristics. For example, a 1-KT weapon burst at a depth of 40 meters in wet soil would form a crater about 130 meters in diameter and nearly 35 meters deep (see fig. B—5). Material thrown from the crater in rocky or cohesive soil includes ejecta ranging from a fraction of a pound to many tons. These ejecta pose a hazard to personnel, materiel, and structures. Generally speaking, more than half of the crater ejecta is contained in the crater lip extending from the crater rim to about 3-crater radii from ground zero (GZ). The remaining ejecta fall to the ground at distances that may extend out to the fractional psi overpressure range. A typical crater is shown in figure B—6.

b. A portion of the energy of the burst is transmitted to the surrounding earth in the form of a ground shock wave that travels radially outward through the earth. This ground shock wave is attenuated much more rapidly than the airblast wave, with the attenuation characteristics being highly dependent on local geological characteristics. As a result, damage radii for ground shock waves are much less than those for airblast for most targets.

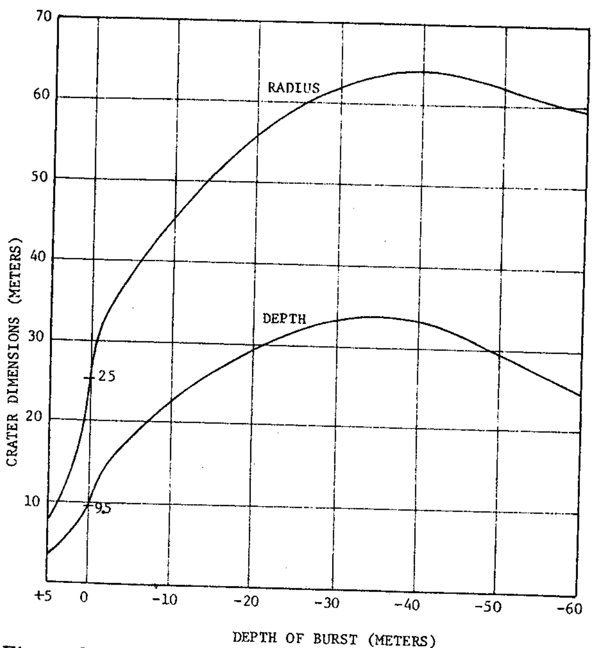


Figure B—5. Apparent crater radius and depth for a 1-KT burst in wet soil or soft rock.

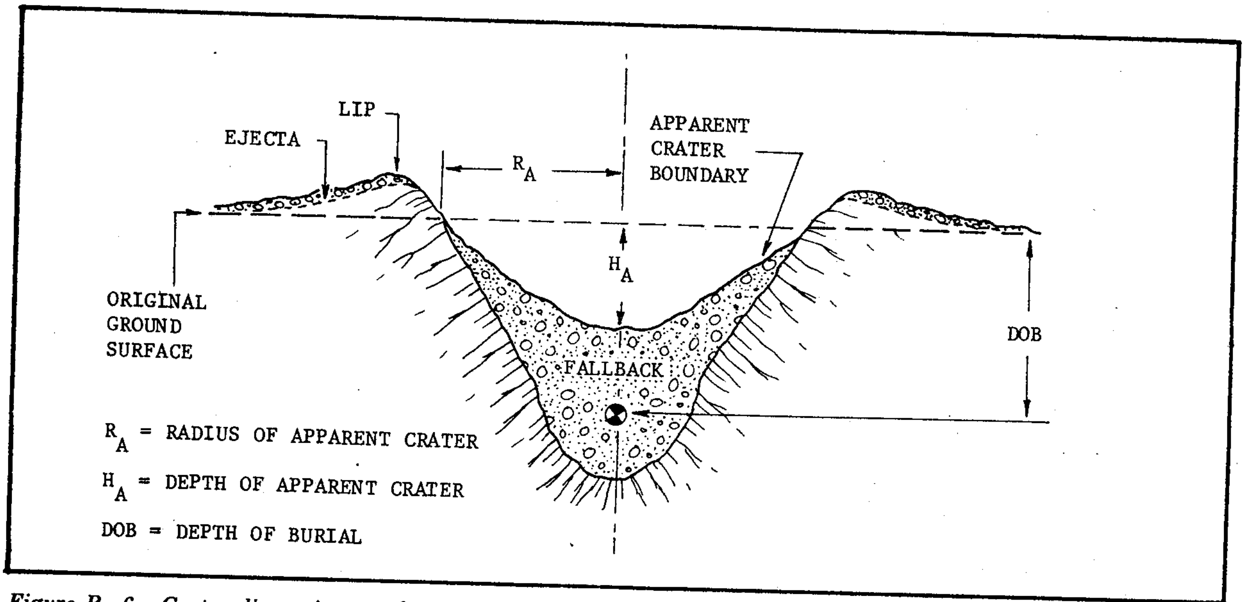


Figure B—6. Crater dimensions and terminology.

Section III. THERMAL RADIATION

B—9. General

a. Thermal radiation results from the heat and light produced by the nuclear explosion. During a nuclear explosion, the immediate release of an enormous quantity of energy in a very small space results in an initial fireball temperature that ranges into millions of degrees. The temperature drops rapidly as the fireball expands and its energy is transmitted to the surrounding medium. For nuclear weapons detonated in the atmosphere, the thermal energy is emitted in two distinct pulses. Curve I of figure B—7 gives the relative intensity of radiated thermal energy as a function of time. The percentage of total thermal energy radiated as a function of time is given in curve II.

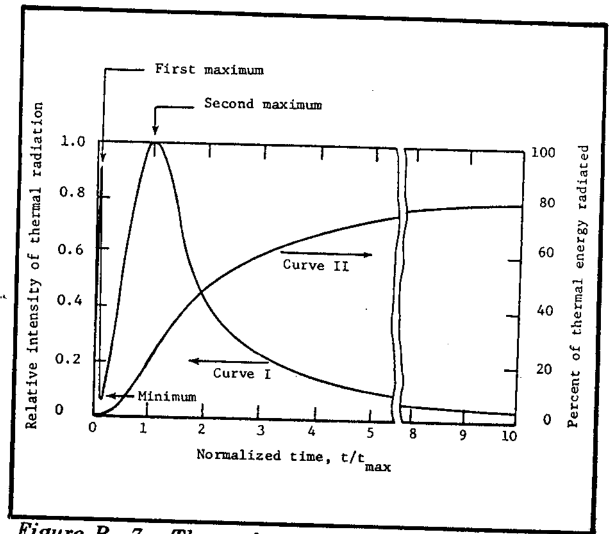


Figure B—7. Thermal radiation versus time for a given yield.

b. The first pulse is not militarily significant because the energy emitted during this pulse consists primarily of x-ray and ultraviolet radiations. For low-altitude bursts, these radiations are rapidly attenuated in air and do not travel beyond distances for which other effects predominate.

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

d. For a given type of weapon, the total amount of thermal energy available is directly proportional to the yield. As depicted in figure B—7, approximately 20 percent of the total thermal energy is delivered by the time the second thermal pulse reaches its maximum intensity. The time at which the second maximum occurs for different yields is given in table B—1. The duration of the second pulse is nominally taken as being equal to ten times the time at which the second maximum occurs.

e. From the data given in table B—1, it is apparent that it would be very difficult to take evasive action to prevent skin burns from bursts of less than a megaton in yield.

Table B—1. Time to Second Thermal Maximum as a Function of Weapon Yield.

Yield	Time to Second Maximum
1 KT	0.04 sec
10 KT	0.11 sec
50 KT	0.23 sec
100 KT	0.31 sec
500 KT	0.64 sec
1 MT	0.87 sec
10 MT	2.39 sec
100 MT	6.58 sec

B—10. Characteristics

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

a. Travels at the speed of light.

b. Travels in straight lines.

c. Can be scattered.

d. Can be reflected.

e. Can be easily absorbed.

B—11. Modifying Influences

a. Weather. Any condition that significantly affects the visibility or the transparency of the air affects the transmission of thermal radiation. Clouds, smoke (to include artificial), fog, snow, or rain absorb and scatter thermal energy. Depending on the concentration, they can stop as much as 90 percent of the thermal energy. On the other hand, clouds above the burst may reflect additional thermal radiation onto the target that would have otherwise traveled harmlessly into the sky.

b. Terrain. Large hill masses, trees, or any opaque object between the fireball and the target 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 still receive thermal injury because of reflection from buildings or other objects. Good reflecting surfaces, such as water, snow, or smooth sand, may reflect heat onto the target and intensify the thermal radiation effect. Even the backs and sides of open foxholes will reflect thermal energy. The reflective capability of foxhole materials varies from 8 percent for wet black soil to 93 percent for snow. Because of atmospheric scattering and reflections, thermal casualties may be caused at a greater range than casualties from other effects.

c. Height of Burst. The amount of thermal radiation that a surface target receives from a nuclear burst of a given yield will vary with the height of burst. The maximum thermal effect at the target will usually be produced by an airburst. A surface burst produces about one-half the amount of the thermal radiation that would be produced by an airburst because of the interaction of the fireball with the surface. No significant amount of thermal radiation is received from a subsurface burst where the fireball is not visible.

Section IV. INITIAL NUCLEAR RADIATION

B—12. General

a. Initial nuclear radiation is defined as that nuclear radiation that is emitted by a nuclear explosion within the first minute after the burst. The nuclear radiation emitted after 1 minute is designated as residual radiation. Residual radiation is discussed in section V.

b. Nuclear radiation is a flow of neutrons, alpha and beta particles, and electromagnetic energy in the form of x-rays and gamma rays. From the reactions of a nuclear explosion, the principal types of radiation emitted are neutrons and gamma rays. As the neutrons travel through the air, they lose energy in collisions with air molecules. These collisions produce gamma rays called secondary gamma rays. Radioactive fission fragments, called fission products, are also produced in a nuclear explosion. The radioactive decay of these fission products starts immediately after the burst, producing alpha and beta particles, x-rays, and more gamma rays.

c. The alpha and beta particles have an extremely limited range in air, have little ability to penetrate the skin, and are of little significance unless the radiation emitters come in direct contact with the skin or are inhaled or ingested. X-rays are rapidly attenuated in air, and x-ray effects do not dominate in the lower regions of the atmosphere. Neutrons and gamma rays have a long-range in air, are highly penetrating, and are the chief producers of casualties from initial nuclear radiation. Therefore, in the consideration of initial nuclear radiation, neutrons and gamma rays are militarily significant; whereas the alpha and beta particles and x-rays do not play a direct role as a casualty producer.

B—13. Units of Measurement

a. For various scientific and technical reasons, nuclear radiations are measured and expressed in a variety of units. Among these are units of exposure (roentgen, R), absorption (radiation absorbed dose, rad), and dose equivalency (roentgen equivalent mammal, rem).

b. For Army operations, the preferred measure of radiation is absorbed dose (rad). Dosimeters and other radiac meters may be calibrated in roentgens but should be read directly as rad for practical military use.

B—14. Characteristics of Initial Nuclear Radiation

a. The principal characteristics of initial nuclear radiation are:

(1) It travels at or about the speed of light.

(2) A portion is absorbed and/or scattered by the atmosphere through which it passes.

(3) Even though such radiation travels along straight lines between interactions, there is enough scattering by the atmosphere that at ranges of normal interest the initial nuclear radiation can be considered to come from all directions.

(4) It can penetrate and cause damage to materiel and personnel.

b. The initial gamma ray radiation received at a target consists primarily of the prompt gamma rays from the burst and the secondary gammas resulting from the collisions of neutrons with air molecules. The prompt gamma radiation is received at the target essentially within the first second. Most neutrons from a burst are emitted during the first second, but because of their slower rate of travel and the large amount of scattering by the atmosphere, they and the secondary gammas they produce arrive at the target over periods somewhat longer than a second.

B—15. Modifying Influences

For a given burst altitude, the amount of gamma ray and neutron radiation received by a target at a given range from the burst point depends primarily on the yield of the weapon used. In general, the larger the yield of the weapon, the larger the dose of initial radiation received at a given slant range. However, other factors affect these quantities, such as the following:

a. Air Density. For a given weapon, the range for various quantities or doses of initial nuclear radiation is affected primarily by the air density. The denser air at sea level absorbs and scatters more radiation than does the thinner air at high altitudes. As the altitude of the burst or the temperature of the air increases, the air density is decreased; and initial nuclear radiation travels farther.

b. Terrain. Topographic features of the target area may significantly influence initial nuclear radiation. Minor terrain irregularities, such as ditches, gullies, and small folds in the ground may offer a little protection. Major terrain features between personnel and the burst, such as large hills and mountains, may provide almost complete protection from initial nuclear radiation. Forests can provide significant protection, depending on height of burst and forest type.

c. Surface and Subsurface Bursts. Initial radiation is sharply attenuated as the result of absorption of radiation by the surrounding ground.

d. Target Elevation. The radiation received by a target is greater when the target is above the terrain than when it is on the terrain surface. Targets, such as personnel in aircraft 100 meters or more above the terrain, may receive much larger doses than they would receive on the surface at the same distance from the burst.

B—16. Shielding and Attenuation

a. One of the factors influencing the amount of radiation received by a target is the shielding that may be provided between the nuclear burst and the target. All material will absorb some nuclear radiation. However, because of the high penetrating power of neutrons and gamma rays from a nuclear detonation, a considerable thickness of intervening material is required to provide significant protection to personnel. Dense materials, such as iron and lead, offer excellent protection against gamma rays. Some readily available low-density materials, such as water, offer the best protection against neutrons. Depending on its moisture content, soil may be a fair neutron shield. Sufficient material to protect against gamma rays will also provide some protection against neutrons from a nuclear burst. As a general guideline, shields of minimum thickness that are intended to absorb both neutrons and gamma rays may be constructed by alternating layers of high- and low-density materials or by homogeneously mixing such materials.

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 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 provided in FMs 101—31—2 and 101—31—3 contain the appropriate transmission factors for neutron, initial gamma ray, and residual radiation for different equipment and protection configurations.

Section V. RESIDUAL RADIATION

B—17. General

a. In addition to initial nuclear radiation, a nuclear burst produces radioactive particles that may be a lingering and possibly widespread radiation hazard of operational significance. Nuclear radiation that is emitted from these radioactive particles after 1 minute from burst time is called residual radiation. Residual radiation will be present in and near the radioactive cloud and, depending on weather and height of burst of the weapon, may be present on the ground. The airspace hazard outside of the radioactive cloud exists for only a relatively short time, and the radiation hazard to aircraft flying within the area is minimal. The hazards on the ground are due to—

(1) Neutron-induced radiation from radioactive materials produced within a relatively small circular pattern around ground zero.

(2) Fallout, which is usually found in a large, elongated pattern around ground zero.

(3) Rainout, which is the deposition of radioactive materials on the ground due to scavenging of radioactive materials by precipitation when falling through a weapon debris cloud or resulting from interaction of a weapon debris cloud with a potential precipitation center. Rainout may be more concentrated than fallout and it may or may not include ground zero.

b. The extent of the hazards resulting from radioactivity on the ground depends primarily on the height of burst as follows:

(1) When a nuclear weapon is detonated at a height that precludes damage or casualties to ground targets, such as in an air defense role, neither induced radiation nor fallout of tactical significance occurs.

(2) When a nuclear weapon produces damage or casualties on the ground, but the burst is kept above the minimum fallout-safe height, only neutron-induced radiation occurs.

(3) When a surface burst or near surface burst is employed, both neutron-induced radiation and fallout result. The fallout pattern can be expected to overlap and overshadow the entire induced radiation pattern.

(4) Subsurface bursts produce both induced radiation and fallout on the ground.

(5) If the proper atmospheric conditions exist, rainout may occur for each of these heights of burst.

c. Neutron-induced radiation, fallout, and rainout have certain characteristics in common.

(1) They persist for relatively long periods.

(2) The areas affected are difficult to decontaminate.

(3) The extent of the area affected is difficult to predict. The size, shape, and location of fallout patterns are sensitive to the wind structure. The size and intensity of the neutron-induced radiation area are extremely sensitive to the soil composition. The size and intensity of the rainout areas are dependent on the location of the precipitation centers with respect to the weapon debris cloud and the time after burst that interaction occurs.

(4) The most significant radiation from these areas is gamma radiation that presents a serious personnel hazard because of its range and penetrating power. Residual radiation is attenuated or scattered in the same manner as initial gamma radiation. Paragraph B—16 contains pertinent shielding considerations.

(5) The biological response of humans to residual radiation is essentially the same as their response to initial radiation. Biological response to radiation is discussed in detail in appendix C, section IV.

d. The large area contaminated by fallout from large surface bursts poses 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. Radiation levels for rainout will usually be higher than those for fallout areas because deposition rates of radioactive materials are greater for rainout than for fallout. Thus, rainout may also be militarily significant. However, the probability of its occurring will usually be much less than that of fallout. Neutron induced radiation is relatively limited in area, and changes in tactical plans can normally be made to ensure that it does not grossly interfere with military operations.

B—18. Neutron-Induced Radiation

The boundary of the significant area of induced activity is considered to be the distance to which a 2-rad-per-hour dose rate extends at 1 hour after burst. The maximum horizontal radius of this dose rate contour for yields of 1 MT or less is about 2,000 meters; it is usually substantially less, depending on the yield and height of burst of the weapon. See FM 3—12 for the details of induced soil radiation hazard prediction.

B—19. Fallout

a. Sources. The weapon debris from a nuclear burst is highly radioactive. The main source of activity is the fission products (remnants of fissioned atoms). Soil that is swept into the radioactive debris cloud in near-surface, surface, or subsurface bursts combines with the radioactive debris and creates a radioactive hazard when it falls to the ground.

b. Major Aspects. The major aspects of fallout are:

(1) Fallout will occur whenever the nuclear fireball touches the ground.

(2) The heavier fallout particles start reaching the area around ground zero shortly after a burst. The lighter particles reach the ground farther downwind at later times.

(3) The size, shape, and location of the areas contaminated by fallout depend largely on the winds that affect the debris cloud and fallout particles. Changes in wind direction can result in some locations being subjected to long periods of fallout.

(4) Greatest fallout intensity is usually close to ground zero, but high-intensity "hotspots" and low-intensity areas may occur throughout the pattern because of effects of winds, precipitation (rainout), or unusual terrain features.

c. Decay Rate. The decay rate of radioactive materials from a single weapon can be determined fairly accurately by using the ABC—M1A1 radiac calculator, a component of the M28A1 Calculator Set. 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 seven. For example, a 50-rad-per-hour dose rate (measured at H + 1 hour) decays to a 5-rad-per-hour dose rate in 7 hours and to about one-half rad per hour dose rate in 49 hours. The boundary of the significant areas of newly deposited fallout is taken as the 20-rad-per-hour dose rate contour at 1 hour after burst for short-term (24-hour) occupancy of the area, or the 10-rad-per-hour dose rate contour at 1 hour after burst for longer term occupancy. FM 3—12 contains specific details of fallout prediction, decay, and total dose calculations.

B—20. Rainout

a. The probability of rainout occurring is generally much less than the probability of fallout occurring. However, it must be recognized that radiation contamination of the ground can result from rainout from bursts not otherwise expected to produce residual contamination.

b. The information required to reliably predict rainout is not available. Complexities involved in such predictions indicate that it is unlikely that simple tools for such predictions will be available in the near future. Radiological monitoring is the only effective way at present to assess this hazard.

Section VI. ELECTROMAGNETIC PULSE, INTERNAL ELECTROMAGNETIC PULSE, AND TRANSIENT RADIATION EFFECTS ON ELECTRONICS

B—21. General

In addition to the obvious equipment damage mechanisms of blast and thermal radiation, there may be equipment damage due to the electromagnetic pulse (EMP), internal electromagnetic pulse (IEMP), and transient radiation effects on electronics (TREE). These phenomena primarily affect electronic or electrical systems and are due, directly or indirectly, to nuclear radiation. Although environments producing these effects are of short duration, the effect can be momentary or permanent.

B—22. Characteristics

a. EMP. Prompt gamma rays, emitted radially from a weapon burst point, collide with air molecules and knock off electrons that travel in the same general direction as the gamma rays. This flow of electrons through the air (electric current) creates an intense local electric field. Additionally, this pulse of electric current in the air may radiate an electromagnetic wave similar to the manner in which an electric current in an antenna radiates electromagnetic waves. These local and radiated fields are called the electromagnetic pulse.

(1) The tactical use of nuclear weapons with heights of bursts ranging from very shallow subsurface bursts to high airbursts will produce a significant local and radiated EMP. The local EMP fields extend roughly to radiation safety distances for personnel from the burst point. The radiated fields extend a few kilometers beyond these radiation safety distances, but the strengths of the fields decrease with range from the burst.

(2) Weapons burst at altitudes from 2 to 20 kilometers, such as in an air defense role, will produce a local EMP in the air surrounding the burst but will not radiate significant EMP to the ground.

(3) Nuclear radiation from weapons detonated at extremely high altitudes, tens or hundreds of kilometers, will travel long distances in the rarified atmosphere and will produce electric currents in the upper regions of the atmosphere. These currents will produce intense radiated fields that may cover areas of hundreds of thousands of square kilometers on the surface of the earth with significant levels of EMP.

b. IEMP. Gamma radiation that enters an enclosure, such as a signal shelter or a missile body, will free electrons by reactions within materials in the enclosure and may generate intensely damaging electric fields inside the enclosure. This phenomenon is referred to as IEMP.

c. TREE. At distances from a burst where personnel will survive initial radiation effects there can still be materiel damage caused by neutron and gamma radiation. Semiconductors and other electronic components are especially sensitive. This damage phenomenon is referred to as transient radiation effects on electronics. The term "transient" indicates that the radiation is a pulse. The effects on materiel can be either temporary or permenent.

Section VII. SPECIAL CONSIDERATIONS

B—23. Extremely Cold Environments

a. General. Nuclear weapon effects can be altered by ice, snow, high winds, and low temperatures. Knowledge of the variations in particular effects produced by these environmental factors is essential for realistic operational decisions in extremely cold environments.

b. Airblast and Cratering.

(1) *Airblast.* At temperatures of about —45°C (—50°F), airblast damage radii for materiel targets, such as tanks, artillery, and military vehicles can increase by as much as 20 percent. This increase is somewhat offset by the reduction in radius of effects resulting from the dynamic pressures produced by reflecting surfaces, such as thick-layered ice and snow that are associated with extreme cold in an Arctic-type environment. For extremely cold conditions (i.e., —45° or colder) combined with deep snow and ice surface conditions, the radius of expected damage should not be increased more than 10 percent.

(2) *Cratering effects.* The cratering effects in ice and frozen soil are similar to the cratering effects in solid rock; however, the crater size would probably be larger than that in rock. Crater dimensions in soil covered with deep snow (several feet) are reduced.

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

(a) Blast disturbance of permafrost may reduce trafficability.

(b) Blast effects may interfere with movement over frozen waterways and, in the spring, cause a spring breakup.

(c) Blast effects may produce avalanches in mountainous areas in appropriate seasons.

c. *Thermal.* While thermal effects normally are not considered in selecting the governing effect for casualty production, a significant adjustment may be required in troop safety distances in extremely cold environments.

(1) In conditions of extreme reflectivity (e.g., snow and ice), coupled with good visibility, the minimum safe distances to unwarned, exposed and forewarned, exposed personnel are increased by adding 30 percent to the thermal radius of safety and then adding the weapon system buffer distance.

(2) There will be some increase in the numbers of unwarned personnel suffering a loss of visual acuity because of flashblindness, particularly at night.

(3) Because of the materials habitually used for clothing, personnel in an extremely cold 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.

B—24. Hot Environments

Varaitions of the effects of weapons used in hot and tropical environments are not as pronounced as those for extremely cold environments. Consequently, no special discussion of the impact of such environments on nuclear effects is included in this manual. However, personnel in hot environments will be more vulnerable to thermal effects since they will be wearing less clothing and a greater area of the skin will be exposed.

APPENDIX C

RESPONSE TO EFFECTS OF NUCLEAR WEAPONS

Section I. GENERAL

C—1. Military Effectiveness of Nuclear Weapons

The military effectiveness of nuclear weapons is determined by consideration of two specific types of information that are developed through weapon tests and laboratory experiments.

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

b. The distance to which the required levels will extend from a given nuclear detonation.

C—2. Damage

Damage is the destruction of materiel or structures to the extent that performance of these items is degraded. Damage is classified according to degrees as follows:

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. Light damage includes damage categorized as "light" and "moderate, type I" in the Defense Nuclear Agency Effects Manual Number 1 (DNA EM-1).

b. Moderate damage prevents use of an item until extensive repairs are made. This degree of damage is normally sufficient to deny the use of equipment. In most situations, achievement of this degree of damage will be sufficient to support tactical operations. This degree of damage equates to "moderate damage, type II" in DNA EM-1.

c. Severe damage prevents use of an item permanently. In this case, repair is generally impossible or is more costly than replacement. There may be some situations, such as the attack on a bridge, where severe damage is the only adequate degree of destruction.

C—3. Personnel Casualties

a. Personnel casualties (combat ineffectives), unlike materiel damage, are not classified as to degree. Whenever personnel cannot perform their duties as a result of the weapons employed against them, they are considered casualties. Some personnel, while still effective immediately following attack, will become combat ineffective later because of the delayed effects of nuclear radiation and/or burns.

b. A person may receive some injury from blast or thermal radiation or a dose of nuclear radiation that, taken individually, 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. While there will be many casualties from combined effects, estimating these casualties is difficult.

C—4. Collateral Damage Guidelines

Collateral damage is defined as undesirable civilian materiel damage or personnel injuries produced by the effects of friendly nuclear weapons. To assist the target analyst in avoiding collateral damage or in estimating its impact, tables of collateral damage avoidance radii have been developed. Several structure types and civilian postures were considered in developing these avoidance radii, which are included in FM 101—31—2. Generally, the avoidance radii are the distances from the burst point to which a 5-percent probability of moderate damage or of a hospitalizing injury extends. For fires, however, the avoidance radii are the distances from the burst point to which the thermal ignition threshold level extends. The operational philosophy is to reduce collateral damage by ensuring that the probability of materiel damage or personnel injury at the leading edge of a populated area does not exceed 5 percent. This philosophy is illustrated in figure C—1 where arcs that represent distances from the burst to which several predicted probabilities of damage or injury extend are shown. Ground zero is chosen so that the 5-percent level is at the leading edge of the town. The 1-percent damage level extends an additional 10-percent in range into the town. Thus, most of the town receives only minuscule damage.

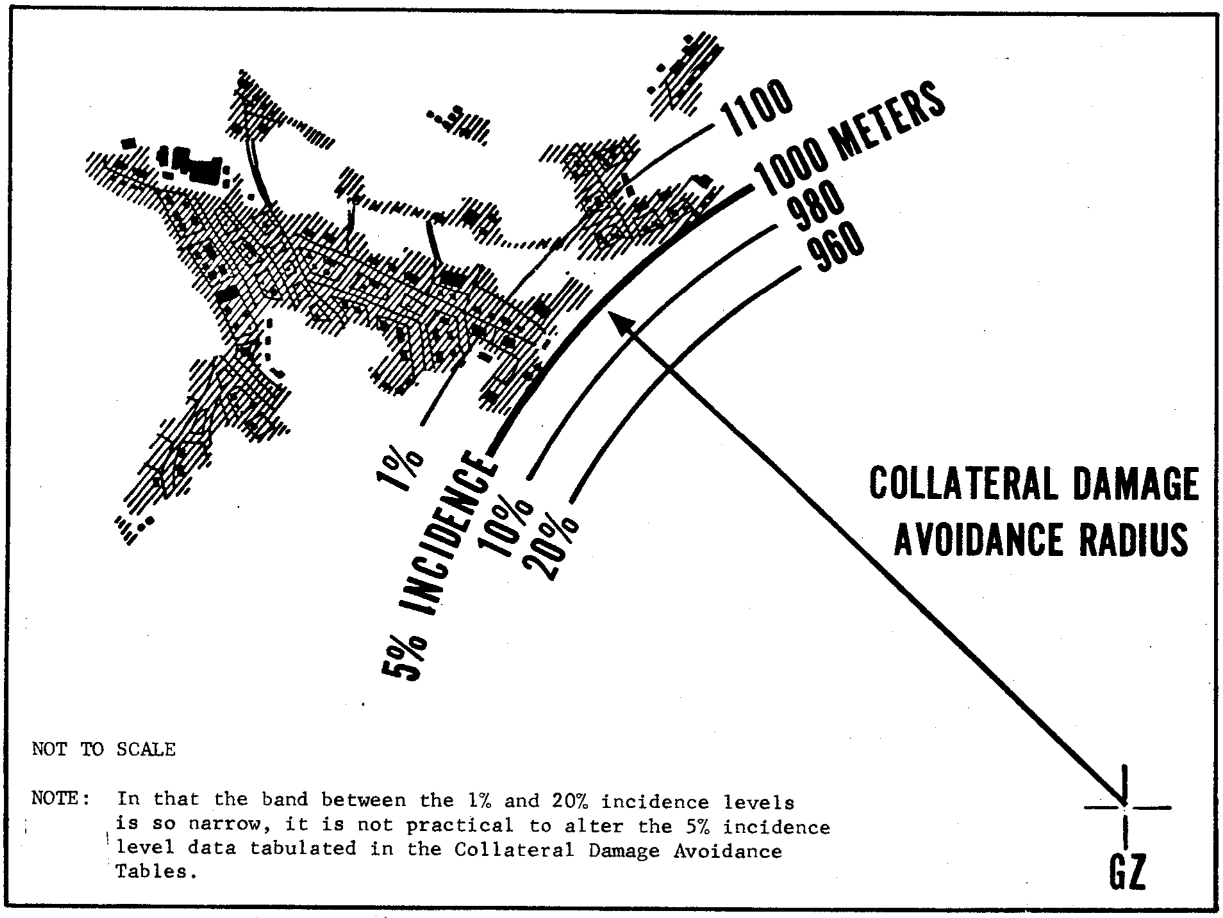


Figure C—1. Predicted probabilities of damage and injury.

Section II. AIRBLAST, CRATERING, AND GROUND SHOCK

C—5. Ground Target Response to Airblast, Cratering, and Ground Shock

a. The blast effects from a nuclear weapon are significant damage mechanisms against materiel and personnel. Blast may be the only effective damage producer against some types of military targets.

b. Most types of military equipment are drag sensitive and, hence, are damaged primarily by the dynamic pressures associated with the passage of the blast wave. However, sensitive internal equipment such as electronic equipment, and personnel on or within a particular item of equipment can be damaged or injured, respectively, by direct overpressure or the induced shock resulting from the overpressure.

c. Parked aircraft, structures, and forests are damaged by a combination of overpressures and dynamic pressures. Aircraft plexiglass windows are particularly vulnerable to low overpressure effects.

d. Pressure sensitive mines may be detonated by overpressures.

e. The damaging effects of blast against personnel result from both overpressures and dynamic pressures.

(1) Very high overpressures (hundreds of psi) are required to cause immediate deaths, provided no translational motion occurs. Lower overpressures (tens of psi) may cause severe internal injuries, especially to the lungs or abdominal organs. Eardrum rupture, which is painful but not necessarily disabling, may result from still lower overpressures (less than 10 psi). Personnel in shelters, foxholes, and other types of field fortifications can become casualties at lower incident overpressures than can personnel in the open since the blast pressures may build up as a result of multiple reflections within such inclosures.

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

f. Damage by cratering and ground shock is discussed below.

(1) The destruction of underground targets and bridges may be accomplished by cratering and/or ground shock. Since the repair of underground structures and utilities is usually difficult, moderate damage in such instances should be sufficient to satisfy tactical requirements.

(2) Ejecta from a crater formed by a nuclear burst falls to the earth over a very wide area and can be an important casualty producing mechanism as well as doing significant damage to equipment.

g. Indirect effects of the blast wave that may cause significant military and collateral damage are:

(1) Debris, stones, and sand coverted to missiles by the blast wave can cause damage to both materiel and personnel. The magnitude of casualties that may result from missile effects is predictable only to low accuracies because of the variability in the terrain and in the degree of protection of personnel in the target area. Risk to friendly troops from missiling can be adequately predicted. Sand and dust may limit visibility and movement in the target area for an extended period and may affect electromagnetic transmissions for a short period of time after detonation.

(2) Collapse of buildings or fortifications results in both materiel damage and personnel casualties.

C—6. Obstacles

a. Rubble within built-up areas and tree blowdown from airblast often extend to considerable distances beyond the primary target area. The resulting obstacles with possible associated effects, such as intense firestorms and residual nuclear radiation, may block avenues of approach or hinder the accomplishment of the military mission.

b. Cratering is a primary means of producing large-scale obstacles that can prevent or impede military movements.

C—7. Military Significance

a. Airblast is an important damage mechanism to military equipment, structures, and personnel. The specific damage mechanism and magnitude required for military damage vary, but sufficient experimental data exist to predict damage with confidence for generic classes of military vehicles.

b. Cratering is the primary mechanism for the production of obstacles to movement, and can also be used to damage structural targets. Ejecta from a crater can result in damage to personnel and military equipment.

c. Ground shock can damage structural targets but is not considered as a primary damage mechanism in the tactical application of nuclear weapons, except for underground targets.

Section III. THERMAL RADIATION

C—8. Target Response

a. General. Essentially all of the thermal radiation absorbed by a target element is immediately converted to heat and may cause injury, damage, or ignition of combustible materials. Since significant amounts of thermal energy may be reflected from a target, the amount absorbed may be only a small fraction of the incident thermal energy.

b. Effects on Personnel. Personnel may be vulnerable to the effects of thermal radiation. There are two general categories of thermal radiation injury: thermal burns and visual effects.

(1) *Thermal burns.* Thermal burns may be produced directly by absorption of the thermal energy (flash burns) or indirectly by fires caused by the thermal energy (flame burns).

(a) Flash burns are caused directly by the thermal radiation either striking the bare skin or being transmitted through the clothing to the skin. Since thermal radiation travels in a straight line except for scattering, any opaque objects between the fireball and the body will shield and protect the individual from flash burns to some degree.

(b) Flame burns are caused by the thermal radiation igniting clothing or other nearby materials. Thus, flame burns are indirectly caused by the thermal pulse. In an area where there are numerous flammable objects, flame burns will likely predominate.

(2) *Visual effects.* The flash of light produced by a nuclear explosion may be many times brighter than the sun. A temporary loss of vision to an observer resulting from this bright flash, called flashblindness, or dazzle, may be experienced even if the fireball is not in direct view. Retinal burns, which are permanent, may occur if sufficient direct thermal radiation is focused by the eye lens onto the retina. These effects can be produced at greater distances from the burst than those at which skin burns can be produced. Sufficient thermal energy arrives in such a short time that reflex actions to protect the eyes, such as blinking, give only limited protection, if any at all.

(a) Flashblindness (dazzle) occurs when more light is received than is necessary for image perception, but less than is required to produce a retinal burn. This effect is a localized, temporary bleaching of the visual elements in the eye, resulting in image persistence or afterimage formation. Vision may be partially or totally impaired. The time for recovery of normal vision ranges from several seconds to about half an hour, depending on exposure conditions. Since the eye pupils are opened wider during periods of darkness, flashblindness is more severe at night than during daylight, and at night the effect may extend to far greater distances from a burst than during the day.

(b) Retinal burns are painless and usually occur only if a person is looking at the fireball. The size of the blindspot produced by a retinal burn depends on parameters, such as distance from burst and fireball diameter. The chance that individuals will be looking directly at the fireball, however, is small.

c. Forest Fires.

(1) Whether fires of consequence will be started by thermal radiation depends on availability of forest fuels, tree canopy,

seasonal and recent weather (hot, dry, or wet), wind, humidity, and topography (steep or level terrain).

(2) Forest fuels are generally a mixture of dry fuels (surface litter, fallen branches, dead leaves, and dry grass) and green fuels (living branches, green grass, and other living foliage). 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 may smoke and char but will not ordinarily sustain ignition. The tree canopy can reduce or eliminate the exposure of the ground surface to thermal energy.

d. Fires in Urban Areas.

(1) *Sources of fires.* There are two general sources of fires in a city exposed to the thermal radiation of a nuclear weapon.

(a) Ignition by direct thermal radiation of fuels, such as paper, trash, window curtains, dry grass or leaves, and dry, rotted wood.

(b) Indirect effect of the destruction caused by the blast wave, such as fires started by upset stoves, electrical short circuits, or broken gas lines.

(2) *Casualties from fires in urban areas.* In areas where fires are likely to result from the detonation of a nuclear burst, 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.

C—9. Military Significance

a. Personnel can be burned at great distances from the burst, but it is extremely difficult to predict enemy casualties from thermal effects because of the ease with which protection can be gained. Therefore, thermal radiation usually cannot be depended on to produce casualties on the battlefield and is not considered in predicting casualties to enemy forces. It can be considered a bonus effect, and data have been furnished in the effects tables of the effects data manuals on radii of thermal effects.

b. In considering the safety of friendly troops, thermal radiation as well as the other effects must be considered. The possibility of fires should also be considered from the standpoint of collateral damage.

c. Flashblindness is considered a hazard, particularly to pilots, because of the probability of an aircraft crash if the pilot were even temporarily blinded. Such crashes could have a significant impact on tactical operations conducted and supported by extensive use of aircraft. Similar hazards also exist where the operation of any piece of equipment is dependent on continuous visual acuity.

Section IV. INITIAL NUCLEAR RADIATION

C—10. Personnel Response

a. General.

(1) Personnel are vulnerable to initial nuclear radiation. For yields of 50 KT or less, nuclear radiation is the dominant casualty producing effect. The response of an individual to nuclear radiation depends on several factors, including:

(a) The composition of nuclear radiation to which an individual is exposed.

(b) The total dose accumulated from previous radiation exposures.

(c) The periods over which the doses are received.

(d) The recuperation time between exposures.

(e) The physical condition, sex, and age of the individual.

(f) The presence of any additional injuries.

(2) The amounts of initial nuclear radiation and residual nuclear radiation received are directly added, and the sum is called the total dose.

(3) The term "acute dose" is used to describe any total dose received within 1 day. The extent of radiation injury for acute doses is reasonably independent of how the dose has been accumulated. When the period of continuous or intermittent exposure to radiation is larger than 1 day, the term "chronic" is used.

(4) The time it takes for a previously unexposed individual in good health to become sick or die depends primarily on the total dose received and on individual body tolerances. Some individuals are more resistant than others, and to produce the same biological effect in these individuals will require larger total doses.

(5) Experimental data indicate that the human body has a limited ability to repair radiation injury. However, since the recovery cannot yet be described quantitatively, all exposures to radiation are considered simply as additive with no allowance made for recovery.

b. Biological response of personnel.

(1) Since exposure of the whole body, or of a large part of it, to sufficient amounts of penetrating ionizing radiation causes variations of individual body tolerances, it is impossible to predict the effect of a specified dose of radiation on any one individual. However, the average effect on a large group may be predicted with enough accuracy for military purposes.

(2) Table C—1 shows the expected response of groups of individuals to radiation. The data in this table are based on the following assumptions:

(a) The individuals are healthy, rested, and well-fed.

(b) They have had no previous exposure.

(c) They have received uniform whole-body exposures.

(d) They have received an acute dose.

(e) They have received no other injuries.

(f) Equal doses of neutrons and gamma rays produce the same effect.

(3) Radiation sickness is called "acute" when the symptoms and signs occur early and do not last beyond 6 months; it is called "chronic" when the symptoms and signs persist beyond 6 months. For example, radiation damage to blood-forming tissue and the resulting depression in the white-blood-cell count cause an increased susceptibility to secondary infection which may last beyond 6 months. Thus, the sickness would be termed chronic.

c. Casualties. Quantitative acute doses of nuclear radiation are associated with the following qualitative descriptions of personnel response.

(1) *Incapacitated.* An incapacitated individual is one who performs at 50 percent or less of his pre-irradiation performance level. Incapacitation is manifested by shock and coma at the high dose levels. At lower dose levels, incapacitation is manifested by a simple slowing down of the rate of performance resulting from physical inability and/or mental disorientation.

(2) *Functionally impaired.* Functionally impaired personnel are those who, while not incapacitated, exhibit some decreased ability to perform their assigned tasks. These personnel suffer acute radiation sickness in varying degrees of severity and at different times. Radiation sickness is manifested by various combinations of projectile vomiting, propulsive diarrhea, dry heaving, nausea, lethargy, depression, and mental disorientation.

Although these effects are transitory, whenever an individual is experiencing them he generally is unable to perform his assigned task. Performance levels are lower than pre-irradiation levels and will decrease slowly until a precipitous decline occurs just prior to death.

Table C—1. Biological Response to Nuclear Radiation

Estimated Dose Range (rad)	Initial Symptoms	Onset of Symptoms	Incapacitation	Hospitalization	Final Disposition
0—70	None to slight incidence of transient headache and nausea. Vomiting in up to 5% of exposed personnel in upper part of dose range.	Within 6 hours.	None.	None.	Duty.
70—150	Transient mild headache and nausea. Some vomiting in up to 50% of group.	Approx 3 to 6 hours after exposure.	None to slight decrease in ability to conduct normal duties in up to 25% of group. Up to 5% of group may become combat ineffective.	Eventual hospitalization (20 to 30 days in upper part of dose range) required for less than 5% in upper part of dose range.	Duty. No deaths anticipated.
150—450	Headaches, nausea and fatigue. Slight incidence of diarrhea. More than 50% of group vomits.	Within 3 hours after exposure.	Can perform routine tasks; sustained combat or performance of complex task may be hampered. More than 5% of group expected to become combat ineffective increasing with increasing dose.	Hospitalization (30 to 90 days) indicated for those in the upper dose range following a latent period* of 10 to 30 days.	Some deaths anticipated; probably less than 5% at lower part of dose range, increasing to 50% toward upper end; return to duty questionable in upper dose range.
450—800	Severe nausea and vomiting. Diarrhea. Fever early in upper part of dose range.	Within 1 hour after exposure.	Can perform simple tasks. Significant reduction in combat effectiveness in upper part of dose range. Lasts more than 24 hours.	Hospitalization (90 to 120 days for those surviving) indicated for 100% of exposed personnel. Latent period 7 to 20 days.	Approx 50% deaths at lower part of dose range, increasing toward upper end; all deaths occurring within 45 days.

Table C—1. Biological Response to Nuclear Radiation (continued)

Estimated Dose Range (rad)	Initial Symptoms	Onset of Symptoms	Incapacitation	Hospitalization	Final Disposition
800—3,000	Severe and prolonged vomiting, diarrhea, and fever.	Approx 1/2 to 1 hours after exposure.	Significant reduction in combat effectiveness. In the upper part of the dose range, some personnel will undergo a transient period of complete combat ineffectiveness followed by incapability for some response until end of latent period.	Hospitalization indicated for 100% of exposed personnel. Latent period of less than 7 days.	100% deaths occuring within 14 days.
3,000—8,000	Severe and prolonged vomiting, diarrhea, fever, and prostration. Convulsions may occur at higher doses.	Within 5 minutes after exposure.	Will become completely incapacitated within 5 minutes and will remain so for 30 to 45 minutes. Will then recover but will be functionally impaired until death.	Hospitalization indicated for 100% of exposed personnel. Latent period of 1 or 2 days.	100% deaths occurring within 5 days.
8,000—18,000	Severe and prolonged vomiting, diarrhea, fever, and prostration. Convulsions may occur at higher doses.	Within 5 minutes after exposure.	Will become completely and permanently incapacitated for performing physically demanding tasks within 5 minutes.	Hospitalization indicated for 100% of exposed personnel. No latent period.	100% deaths occurring within 2 days.
Greater than 18,000	Convulsions and prostration.	Within 5 minutes after exposure.	Will become completely and permanently incapacitated for performing any task within 5 minutes.	Hospitalization indicated for 100% of exposed personnel. No latent period.	100% deaths occur within 15 hours.

d. Casualty Criteria. The casualty criteria for exposure to nuclear radiation are:

(1) *Immediate permanent (IP) incapacitation.*

(a) Physically undemanding tasks [immediate permanent undemanding (IPU)], 18,000 rad. Personnel become incapacitated within 5 minutes of exposure and for *any* task remain incapacitated until death. Death occurs within 1 day.

(b) Physically demanding tasks [immediate permanent demanding (IPD)], 8,000 rad. Personnel become incapacitated within 5 minutes of exposure and for physically demanding tasks remain incapacitated until death. Death occurs in 1 to 2 days.

(2) *Immediate transient (IT) incapacitation, 3,000 rad.* Personnel become incapacitated within 5 minutes of exposure and remain so for 30 to 45 minutes independent of the physical demands of the task. Personnel then recover, but are functionally impaired until death. Death occurs in 4 to 6 days.

(3) *Latent lethality (LL), 650 rad.* Personnel become functionally impaired within 2 hours of exposure. More than half of this group will die; those personnel that die will do so in several weeks.

(4) Figures C—2 and C—3 show the expected response of personnel for various combinations of dose received and time elapsed following exposure. Figure C—2 shows the expected response of personnel performing physically demanding tasks, as are most combat tasks, and figure C—3 shows the expected response of personnel performing physically undemanding tasks, such as command post radio operators. To better understand the use of figures C—2 and C—3, consider the example of the expected responses of a group of people whose jobs involve physical tasks and who receive 6,000 rad of radiation. From the dashed line on figure C—2, it can be seen that the group will be temporarily incapacitated at about 3 minutes after exposure. This group will remain temporarily incapacitated for about half an hour, after which the people in the group will have recovered sufficiently to categorize the group as functionally impaired. The group will remain functionally impaired for about 24 hours, after which the conditions of the people in the group will deteriorate enough to again place the group in the incapacitated category. Death can be expected about 3 days after exposure. Similar information can be derived from figure C—3 for physically undemanding tasks.

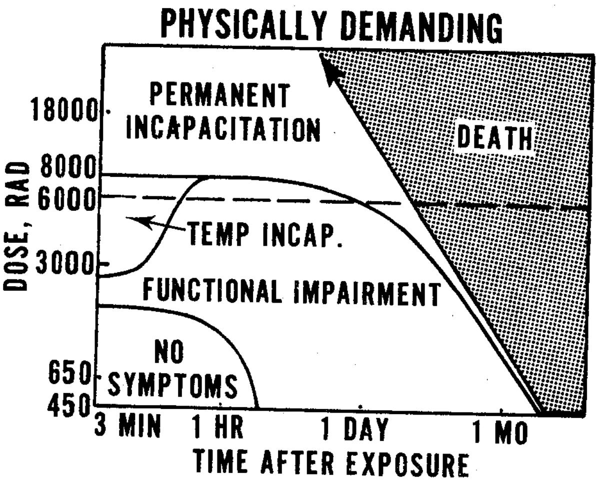


Figure C—2. Expected response to radiation for physically demanding tasks.

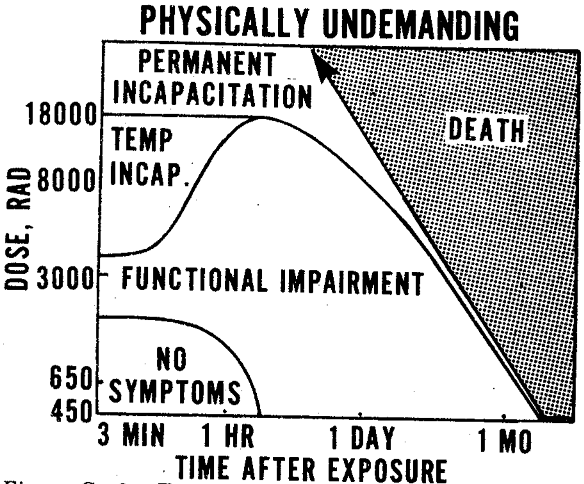


Figure C—3. Expected response to radiation for physically undemanding tasks.

e. Late Effects. Late effects of radiation injury occur many months or years after the exposure and include leukemia, cataracts, and cancer. A late effect can develop in an individual who has recovered from the initial radiation injuries, or even in an individual who has never been sick, despite repeated exposures.

f. Repeated Exposure. On a nuclear battlefield, units may be exposed several times to some levels of radiation from friendly as well as enemy nuclear weapons. In view of these multiple exposures and the slow overall recovery, the commander must consider the consequences of utilizing personnel previously exposed to doses of radiation that may not have resulted in their exhibiting the signs and symptoms of acute radiation sickness. To assist the commander, the operations officer maintains the status of units assigned. Friendly units are placed in one of four radiation exposure states based on previous exposure history. Additional information on this subject may be found in FM 3—12.

(1) *Radiation exposure state-0 (RES-0).* RES-0 applies to a unit that has never been exposed to nuclear radiation—a unit which has received no dose.

(2) *Radiation exposure state-1 (RES-1).* RES-1 applies to a unit that has received a dose greater than 0 but less than or equal to 70 rad.

(3) *Radiation exposure state-2 (RES-2).* RES-2 applies to a unit that has received a significant but not dangerous dose of radiation—a dose greater than 70 rad but less than or equal to 150 rad. If the situation permits, units in this category should be exposed less frequently and to smaller doses than the units in RES-1 or RES-0 categories.

(4) *Radiation exposure state-3 (RES-3).* RES-3 applies to a unit that has already received a dose of radiation greater than 150 rad; consequently, further exposure is dangerous. This unit should be exposed only if unavoidable because additional exposure in the immediate future will result in sickness and the probability of some deaths.

C—11. Military Significance

a. All radiation is potentially harmful and should be avoided, if possible. Tactically, however, it may be necessary to accept some radiation exposure. Nevertheless, the commander should appreciate the significance of the exposure and weigh it carefully against any immediate or short-range advantage he may gain.

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

c. 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. However, the delayed effects may significantly reduce the unit's overall combat effectiveness for a long period of time.

d. 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 amount and frequency of doses received in past operations and the requirements of the tactical situation will determine the degree to which friendly troops can be exposed during a nuclear attack.

(5) Figure 5—24 is an aid in computing modified safe distance for personnel with previous radiation exposure. The accumulation of data reflecting personnel absorbed doses will be difficult. Currently fielded dosimeters are not capable of measuring the initial radiation a soldier may receive. Procedures for determining unit radiation doses are found in FM 3—12.

Section V. ADDITIONAL TARGET RESPONSE CONSIDERATIONS

C—12. General

Two considerations that should not be overlooked in considering the response of a targeted unit to a nuclear strike are additional target response occurring beyond the distance where the specified degree of damage extends and the response resulting from multiple effects acting on personnel.

C—13. Area Target Response

Knowledge of the relationship between weapon effects and target response is necessary in understanding why a particular fractional coverage is used as part of the defeat criterion. Additional target response occurs beyond distances where the specified degree of damage extends. To illustrate this, consider the following example: a commander desires to attack an enemy defensive position which has a radius of 750 meters. The stated defeat criterion is 30 percent coverage with immediate transient incapacitation for personnel in foxholes. Figures C—4, C—5, and C—6 illustrate the distances to which the three basic weapons effects—nuclear radiation, blast, and thermal radiation produced by a 5 KT weapon—extend for certain levels of effect on personnel. The yield and ground zero are selected so that there is at least 30-percent coverage of the depicted target (radius of target = 750 meters; personnel in foxholes) with 3,000 rad (immediate transient incapacitation) as the specified degree of desired damage. Figure C—4 illustrates that immediate transient (IT) nuclear radiation casualties (dose of 3,000 rad) are attained over 30-percent of the target, but that the latent lethality criterion (650 rad) will be experienced over an additional 20 percent of the target, and soldiers will experience severe vomiting in half of the remaining 50 percent of the target. Although the blast level for 50-percent combat ineffectiveness is not achieved on the target (fig. C—5), members of the unit may receive nonincapacitating blast injuries (6 psi overpressure) over approximately 60 percent of the target area. Light damage to buildings extends far beyond the target limits. Although thermal radiation is not used as a casualty producer, for reasonably clear weather, personnel in open will receive second and third degree burns over about 80 percent of the target area and first degree burns over all of the area (fig. C—6). Hence, when a commander requests that 30 percent of the target receive a specified degree of damage, it should be recognized that significant portions of the remainder of the target will receive damaging effects.

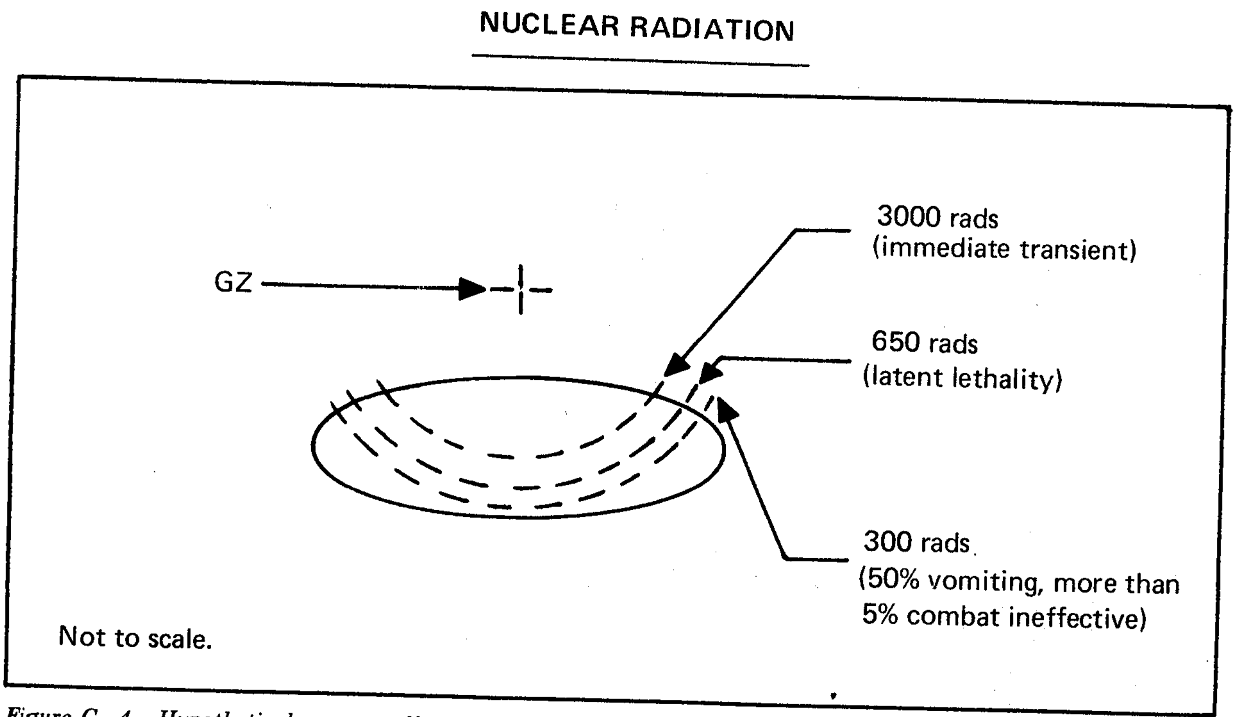


Figure C—4. Hypothetical weapon effects coverage.

BLAST

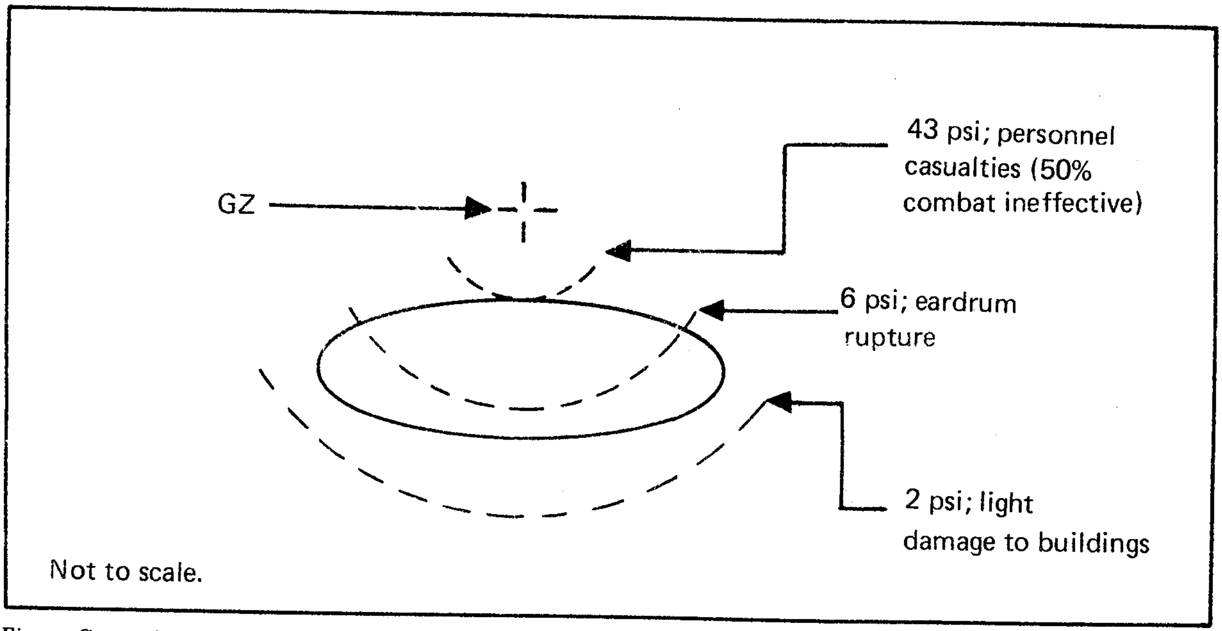


Figure C—5. Hypothetical weapon effects coverage.

THERMAL RADIATION TO PERSONNEL IN OPEN

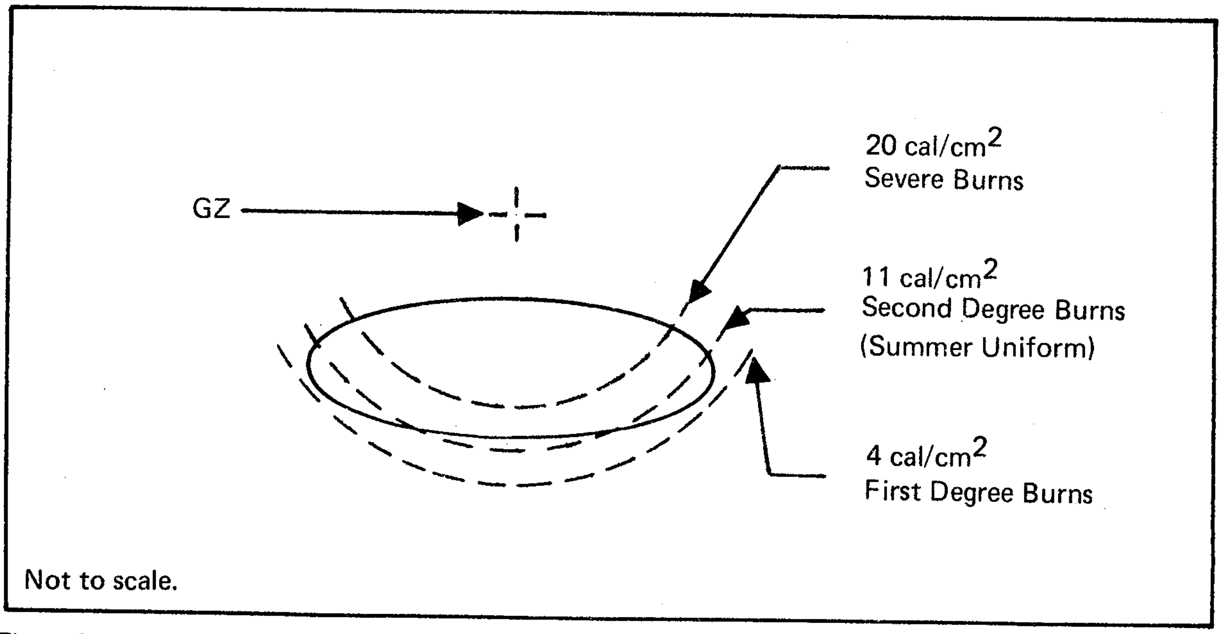


Figure C—6. Hypothetical weapon effects coverage.

C—14. Combined Effects

Another consideration that should not be overlooked in the evaluation of the effectiveness of a nuclear strike is the result due to combined effects. Each degrading effect by itself may not result in serious impairment, but a combination, i.e., first degree burns, eardrum rupture and sickness due to radiation, could well result in a soldier being combat ineffective.

Section VI. ELECTROMAGNETIC PULSE, INTERNAL ELECTROMAGNETIC PULSE, AND TRANSIENT RADIATION EFFECTS ON ELECTRONICS

C—15. Target Response

a. Types of Equipment Damage. Electromagnetic pulse (EMP), internal electromagnetic pulse (IEMP), and transient radiation effects on electronics (TREE) effects may cause permanent damage or temporary degradation of electronic equipment by burning out or degrading components or by introducing undesirable signals. Modern equipment using solid state components and microcircuitry is likely to be more susceptible to permanent damage than older equipment using vacuum tubes. At lower levels of effects, upset of digital circuitry and loss of memory information may cause errors in computer calculations. Optical and infrared components may also be susceptible to TREE.

b. Damage Radii. The levels of EMP, IEMP, and TREE effects which will cause equipment damage are greatly dependent on the type of equipment, the details of the electronic circuitry, the physical configuration of the equipment, including antennas and connecting cables, and on deliberate measures that may have been employed to make the equipment more survivable. Damage may occur to some equipment at ranges greater than the radii of damage for nuclear radiation effects on man and blast and thermal effects. The radii of damage for specific equipment are unpredictable and are often dependent on employment configurations. Moreover, hardening measures can be employed in the design and production of equipment.

C—16. Military Significance

a. The EMP, IEMP, and TREE effects will cause damage and electrical malfunction of components of some types of military equipment at distances beyond the radius of damage for the dominating blast, thermal or nuclear radiation effect.

b. Damage to the command and control equipment of an organization may be a major impairment to continued military operations of survivors.

c. The EMP, IEMP, and TREE effects are not considered as primary kill mechanisms; however, EMP effects can be significant for friendly unit vulnerability and damage preclusion considerations. Tables are provided in FM 101—31—2, appendix D, giving information pertaining to damage and safety radii for communication equipment.

APPENDIX D

CONCEPT OF DAMAGE

D—1. Introduction

To understand and predict the results of nuclear weapon effects on a target, the analyst should have a mental picture of the pattern of damage on the target area and how the effects of the yield of one weapon on a target can be related to the effects caused by another yield. To form this picture, two factors are used: the radius of effect, and the variability of target response to an effect.

D—2. The Concept of The Radius of Damage

a. A weapon's radius of effect is normally specified by the type of effect of concern (i.e., blast, nuclear radiation, and thermal radiation). When specified levels of effects are given, e.g., 5 psi, 3,000 rad, 4 cal/cm^2, that effect which extends the farthest is called the governing effect. When target element response or degree of damage is associated with a specific level of effect, a radius of damage (RD) can be determined. To illustrate how the concept of the RD is developed, consider figure D—1 to be a

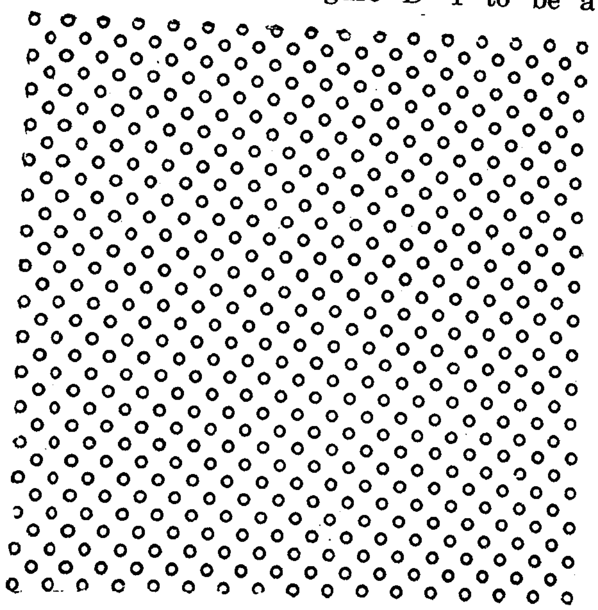


Figure D—1. Uniform distribution of target elements.

representation of a group of targets uniformly distributed in an area. In this example moderate damage will be assumed. If a nuclear weapon burst point is placed over the center of the field, the targets directly under the burst point and all those a short distance away from ground zero will receive *at least* moderate damage and will probably be more severely damaged. Farther away from the burst point, some targets would receive less than moderate damage because of factors such as shielding or target orientation, although they still might receive light damage. The number of targets escaping moderate damage increases as the distance from ground zero increases until no targets receive moderate damage. Figure D—2 illustrates the damage pattern by

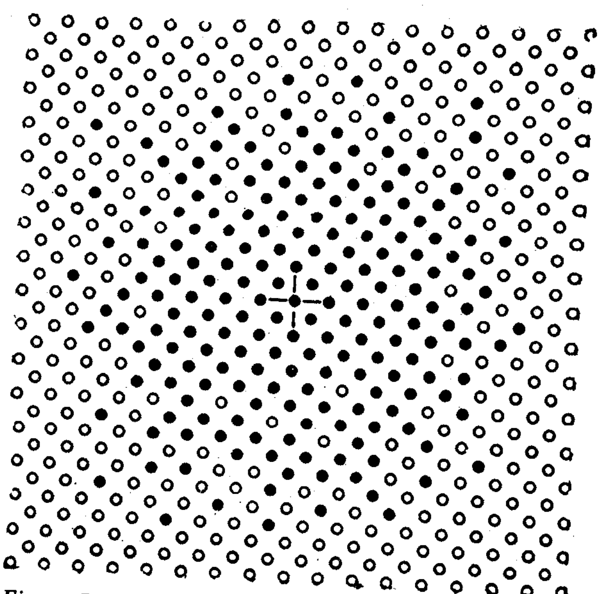


Figure D—2. Typical damage or casualty pattern.

using the black dots to indicate the targets receiving at least moderate damage. This pattern is also valid for the other degrees of damage and for the response of personnel to casualty producing weapon effects. In the case of personnel, the target defeat pattern is related to the response of an individual to the casualty producing effect; i.e., the response of a group of personnel to a radiation dose of 3,000 rad. In this case, the black dots represent those personnel who met or exceeded the response defined by the immediate transient casualty criterion.

b. To translate a pattern of damage from a mental picture into a useful estimation tool, the RD must be defined. In this manual, the RD is that distance from ground zero at which there is a 50-percent probability of a specified amount of damage to a specified target. An RD depends on the yield of a weapon; the height of burst; the type and degree of damage, or casualty criterion; and, in the case ot personnel, the protection of the target (e.g., personnel in tanks or exposed personnel). Figure D—3 shows the radius of damage superimposed on the damage pattern discussed previously. As can be seen, at the RD distance from the burst point, 50 percent of the targets receive the specified degree of damage. Another relationship that is illustrated in this figure is that the number of target elements *outside* the RD that receive the specified degree of damage is approximately equal to the number of targets *inside* the RD that escape the specified degree of damage.

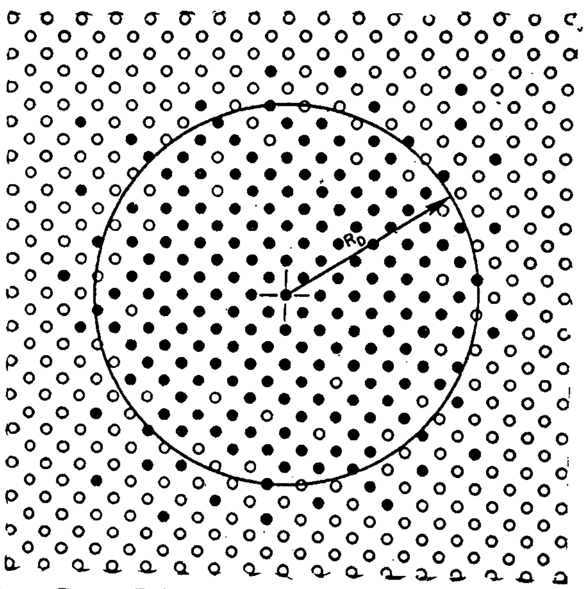


Figure D—3. Relationship of damage radius to damage or casualty pattern.

c. Some targets, particularly personnel targets, will respond to more than one weapon effect. In these cases, the effect that extends the farthest, or the governing effect, has been used in determining the RD. Thermal radiation is not considered in RD determination because of the difficulty in predicting its effect on targets.

d. There are two columns of radii of damage listed in the coverage tables of the effects data manuals—the probable minimum RD and the expected RD. These radii of damage take into account the different methods of considering the effect of vertical dispersions around the aimpoint. Since most of the rounds will detonate relatively close to the desired height of burst (DHOB), the expected RD is usually not much different from the RD that would occur if the round detonated exactly at the DHOB. Generally, the assurance related with the expected RD is greater than 70 percent. In fact, for weapon systems that have relatively small vertical errors, the assurance approaches the high assurance value. The probable minimum RD is the RD that will be *equaled or exceeded by 90 percent of rounds fired.* If a weapon system has a large vertical probable error, it is possible that there will be a considerable difference between the expected RD and the more conservative probable minimum RD.

D—3. Variability

Variability describes the variance in which a target element responds to a particular effect. When variability is considered, the probability of damage curves change for each effect. The variability is expressed as a percentage, i.e., 10, 20, 30 percent variability. Figure D—4 shows several variability curves with distance from the burst point shown in terms of the RD. The 20-percent variability curve is used in the 101—31 series of manuals.

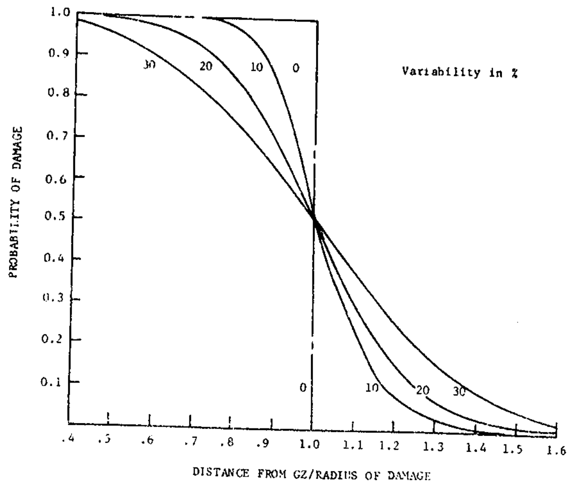


Figure D—4. Variability of effects.

D—4. Determination of The Radius of Safety

a. The radius of safety (RS) is used, together with a delivery error buffer distances listed in the safety tables of the effects data manuals. The RS, like the RD, requires criteria for defining the effects level of interest and weapon effects information for the yield of interest so that the distance to which the effects level extends can be determined. The criteria used in determining the radii of safety in the effects data manuals are based on the Department of Army-approved study, *Personnel Risk and Casualty Criteria for Nuclear Weapons Effects*. The weapon effects data have been obtained primarily from Defense Nuclear Agency sources.

b. Safety radii for specific yields and weapons are listed in the effects section of FM 101—31—2. Those radii listed are a result of comparing nuclear, blast, and thermal radii of effects and selecting the governing effect for each vulnerability/risk combination. Vertical dispersion errors are considered in a similar manner as for the probable minimum RD; however, in this case, the *maximum* RS that results from detonation within a vertical bracket that contains 99 percent of the rounds is used.

D—5. Determination of the Radius of Vulnerability

Radii of vulnerability (RV) are drawn from both radii of damage and radii of safety. For personnel, the RV is the emergency risk criterion; this represents the effects level that results in a 5-percent incidence of combat ineffectiveness. For materiel RV, the maximum possible RD for a target category, such as moderate damage to wheeled vehicles, is determined. Since this value represents the distance at which the target has a 50-percent chance of receiving the specified damage, it is multiplied by 1.34, a multiplication factor obtained from the 20-percent variability curve, which provides the distance from the burst point that the materiel target must be to have only a 5-percent chance of receiving the specified damage.

APPENDIX E

ANALYSIS OF FRIENDLY VULNERABILITY

E—1. Friendly Vulnerability Considerations

a. Because of the far ranging effects of nuclear weapons, large units can suffer unacceptable casualties from the attack of a single weapon unless measures are taken to reduce vulnerability to these effects. Units that are stationary for relatively long periods of time and rear area units should be considered especially vulnerable.

b. Analyses of present and planned friendly dispositions must be a continuing process. Dispersion of units, individual protective measures, and avoidance of visual and electromagnetic detection should be stressed as passive measures to reduce the effectiveness of enemy targeting. However, these measures are not employed without penalty. For example, dispersion can decrease the risk of destruction from nuclear attack, but it can also complicate the control of a unit and inhibit the effecient functioning of support units. Efficient accomplishment of the mission and avoidance of dispositions that are profitable targets are frequently conflicting requirements. The resolution of these conflicting requirements must be made by the commander based on risk-benefit analysis of the specific situation.

RADII OF VULNERABILITY
(DISTANCES IN METERS)

Category / Yield	CASUALTIES TO PERSONNEL IN						MODERATE DAMAGE						SEVERE DAMAGE		
	Open	Tanks	APC	Wheeled Vehicles	Earth Shelters	Fox-holes	Wheeled Vehicles Exposed	Wheeled Vehicles Shld	Towed Arty	Tanks APC SP Arty	Fixed Bridges Hard	Fixed Bridges Soft	Supply Depots	Randomly Parked Helicopters Cgo/Trans	Randomly Parked Helicopters Lt/Obsn
.1 KT	700	500	600	600	300	600	200	150	100	100	100	150	100	400	500
.5 KT	900	700	800	700	450	800	300	250	200	200	200	300	200	500	800
1 KT	1200	800	900	800	500	900	400	350	250	300	300	400	250	700	1100
2 KT	1700	900	1100	900	600	1000	500	450	300	400	400	500	300	850	1300
3 KT	2000	1000	1200	1000	700	1100	600	500	400	500	500	600	450	1000	1600
5 KT	2500	1100	1250	1100	800	1200	700	600	500	600	600	750	500	1200	1900
10 KT	3200	1250	1300	1300	900	1300	800	700	600	700	700	850	600	1500	2500
15 KT	3700	1300	1400	1400	950	1400	900	800	700	800	800	1000	700	1800	2800
20 KT	4000	1400	1450	1600	1000	1500	1000	900	800	900	900	1100	800	1900	3400
30 KT	5000	1500	1500	1800	1100	1600	1200	1100	900	1000	1000	1200	950	2200	3700
40 KT	5500	1600	1600	2000	1200	1700	1400	1250	1000	1100	1100	1350	1200	2500	4100
50 KT	6000	1700	1700	2200	1300	1800	1700	1500	1200	1200	1200	1450	1400	2700	4500
100 KT	8000	1800	1800	2500	1400	1900	2200	1900	1300	1300	1350	1600	1700	3200	5700
200 KT	12000	1900	1900	3200	1500	2000	2500	2000	1500	1500	1600	1900	1900	3700	6200
500 KT	18000	2000	2000	4700	1700	2200	4000	2500	1900	2000	2200	2500	2300	4200	7100
600 KT	19000	2200	3000	5400	1800	2500	4500	2900	2800	3000	3400	3700	2500	5900	8000
1.0 MT	23000	2500	4000	6000	2000	2900	5200	3200	3000	3500	4000	4400	2700	6700	9000
1.2 MT	24000	3000	5000	6500	2100	3400	5400	3400	4000	4200	4500	5000	3100	7900	11000

NOTES:

(1) Radii listed are distances at which 5% incidence of effects occurs.
(2) To obtain a radius of vulnerability, enter the YIELD column at the nearest listed yield.

Figure E—1. Radii of vulnerability (distance in meters).

E—2. Analysis of Friendly Dispositions

a. The primary tool for conducting the analysis of friendly dispositions is the radius of vulnerability (RV). RV is defined as the radius of the circle within which friendly troops will be exposed to a risk equal to or greater than the emergency risk criterion (5-percent combat ineffectiveness) and materiel will be subjected to a 5-percent probability of the specified degree of damage. The RV table is contained in chapter 15 of FM 101—31—2; a hypothetical unclassified version of the table is reproduced in figure E—1. The ground zero for the RV is always assumed to detonate at the point where it will do the greatest damage to the friendly unit or installation. Delivery errors are not considered in the analysis.

b. The analysis of the vulnerability of friendly dispositions and installations consists of five steps:

(1) *Step 1.* Determine the appropriate threat yields based on current intelligence.

(2) *Step 2.* Determine the disposition of personnel in friendly units.

(3) *Step 3.* Obtain the appropriate vulnerability radii from the RV table.

(4) *Step 4.* Estimate the fractional coverage of the unit by use of the visual or numerical techniques discussed in chapter 5. The ground zero (GZ) selected is the GZ that results in the highest fractional coverage of the target. From this, estimates can be made as to the amount of casualties or materiel damage that might result from the postulated strike.

(5) *Step 5.* If the estimated damage exceeds the acceptable loss criteria established by the commander, the analyst should recommend a course of action to decrease the vulnerability of the unit or increase its protection so that the criteria are met.

APPENDIX F

GLOSSARY

Alpha particle—A particle emitted from the nuclei of some radioactive elements. It is identified as a helium nucleus, which has an atomic weight of four and an electric charge of plus two.

Beta particle—A particle ejected spontaneously from a nucleus of either natural or artificially radioactive elements. It is identified as an electron, which has an atomic weight of 1/1840 and an electric charge of negative one.

Circular distribution 90 (CD90)—The radius of a circle around the mean point of impact within which a single round has a 90-percent probability of impacting or within which 90 percent of the rounds fired will impact.

Circular error probable (CEP)—The radius of a circle around the mean point of impact within which a single round has a 50-percent probability of impacting.

Collateral damage—Undesirable civilian personnel injuries or materiel damage produced by the effects of friendly nuclear weapons.

Collateral damage distance—Minimum distance in meters that a DGZ must be separated from civilian personnel and materiel to insure that a specific incidence of injuries or property damage will not be exceeded with a stated degree of assurance.

d—Distance or displacement from DGZ or GZ.

Desired ground zero (DGZ)—The point on the ground on, above, or below which it is desired that a nuclear weapon be detonated.

Flashblindness (dazzle)—A temporary loss of vision. Flashblindness from a burst during daylight hours persists for about 2 minutes for personnel facing directly toward the burst or a reflective surface. At night, flashblindness affects almost all personnel in the target area.

f—Fractional coverage associated with expected radius of damage (RD) and CEP.

f90—High assurance fractional coverage associated with RDmin and CD90.

Gamma rays—High energy electromagnetic radiation emitted from the nucleus of the atom of many radioactive elements.

Governing effect—~~The~~ THAT nuclear effect ~~that~~ WHICH ~~acceptably degrading their efficiency from the effects of heat stress, psychological stress, and other factors affecting the senses.~~ EXTENDS THE FARTHEST FROM GROUND ZERO.

Nuclear weapon package—A discrete grouping of nuclear weapons by specific yields planned for employment in a specified area during a short time period.

Preinitiation—If a weapon is exposed to a sufficient number of neutrons during assembly of the fissionable material, there is an appreciable probability that a premature sustained nuclear reaction will be produced that will cause the warhead to detonate prematurely with a significantly reduced yield.

Prescribed nuclear load (PNL)—A specified quantity of nuclear weapons to be carried by a delivery unit. The establishment and replenishment of this load after each expenditure is a command decision and is dependent on the tactical situation, the nuclear logistic situation, and the capability of the unit to transport and use the load.

Probable error in height (PEH)—That vertical distance above and below the desired HOB within which there is a 50-percent probability that a weapon will detonate.

Radiation absorbed dose (RAD)—A measure of any ionizing radiation in which energy is imparted to any matter.

$$1 \text{ rad} = \frac{100 \text{ ergs of energy}}{\text{gram of absorber}} \text{ for Army}$$

operations used as the standard unit of measurement.

Radius of damage (RD)—The distance from ground zero at which a single target element has a 50-percent probability of receiving the specified degree of damage.

Residual nuclear radiation—All the nuclear radiation that is emitted one minute after a nuclear detonation.

Target analyst—The nuclear and chemical target analyst qualified for duty in a unit with a TOE/TD position that requires knowledge of the techniques and procedures required for nuclear and chemical target analysis. He is awarded a prefix-5 on completion of required training, and it is added to his current MOS. See AR 611—101 for initial and refresher requirements.

Variability—The variance in which a target element responds to a particular nuclear effect.

~~extends the farthest from ground zero.~~

Height of burst (HOB)—That vertical distance above the ground at which a nuclear detonation occurs.

Immediate permanent incapacitation dose (IP)—8,000 rad. Personnel receiving such a dose will become incapacitated within 5 minutes of exposure and for *physically demanding* tasks will remain incapacitated until death. Death will occur in 1 to 2 days.

Immediate transient incapacitation dose (IT)—3,000 rad. Personnel receiving such a dose will become incapacitated within 5 minutes of exposure and will remain so for 30 to 45 minutes. Personnel will then partially recover but will be functionally impaired until death. Death will occur in 4 to 6 days.

Induced radiation—As a result of neutron capture by certain soil elements, these elements become radioactive and emit beta particles and gamma radiation for extended periods following the explosion.

Initial nuclear radiation—All the radiation that occurs within the first minute after a nuclear detonation.

Latent lethality dose (LL)—650 rad. Personnel receiving such a dose will become functionally impaired within 2 hours of exposure. Personnel may respond to medical treatment, if available, and survive this dose; however, the majority of the exposed personnel will remain functionally impaired until death, which occurs in several weeks.

Least separation distance (LSD)—Minimum distance in meters that a DGZ must be separated from an object to preclude damage or preclude obstacles with 90-percent assurance.

Minimum safe distance (MSD)—Minimum distance in meters from a DGZ at which a specific degree of risk and vulnerability will not be exceeded with a 99-percent assurance.

Mission-oriented protective posture (MOPP)—A flexible system of chemical protection for operations in a toxic chemical environment. This posture requires personnel to wear individual protective clothing and equipment consistent with the chemical threat, work rate imposed by their mission, temperature, and humidity without un- "acceptably degrading their efficiency from the effects of heat stress, psychological stress, and other factors affecting the senses."

APPENDIX G

COMMON ACRONYMS

ADM Atomic demolition munitions

ADP Atomic demolition plan

CEP Circular error probable

CD90 Circular distribution 90

CDD Collateral damage distance

d Distance from ground zero

DGZ Desired ground zero

DHOB Desired height of burst

f Expected fractional coverage

f90 Fractional coverage associated with high assurance (90%)

FSE Fire support element

GZ Ground zero

HOB Height of burst

IPD Immediate permanent demanding

IPU Immediate permanent undemanding

IT Immediate transient

LL Latent lethality

LSD Least separation distance

MSD Minimum safe distance

PEH Probable error in height of burst

PNL Prescribed nuclear load

Rad Radiation absorbed dose, unit of measurement

RCD Radius of collateral damage

RD Radius of damage

RES Radiation exposure state

RS Radius of safety

RT Radius of target

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INDEX (continued)

INDEX (continued)

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DEPARTMENTS OF THE ARMY AND THE NAVY
WASHINGTON, DC, *21 November 1977*

NUCLEAR WEAPONS EMPLOYMENT DOCTRINE AND PROCEDURES

FM 101-31-1, 21 March 1977, is changed as follows:

Pages 31, 32, 33, 38, 59, 62, 64, 82; figures 4-3, 4-4, 4-5, 4-6, 5-4, 5-21, 5-23, 5-25, 5-37. Add the short name: "(5-24)" to each table in vicinity of the 1 KT yield.

Page 1, paragraph 1-3. The address beginning on line 7 is changed to read: "Commander, US Army Nuclear and Chemical Agency, 7500 Backlick Rd, Bldg 2073, Springfield, VA 22150."

Page 16, figure 3-1. Change line INDIA to read:

INDIA : For all bursts:
MSD 1 in hundreds of meters, 4 digits (negligible risk[1] to warned protected personnel).
MSD 2 in hundreds of meters, 4 digits (negligible risk[1] to warned exposed personnel).
MSD 3 in hundreds of meters, 4 digits (negligible risk[1] to unwarned exposed personnel).
LSD in hundreds of meters, 4 digits (light aircraft in flight).

[1] Negligible risk should not be exceeded unless significant advantage can be gained.

Page 23, Paragraph 4-3a(4)(c). In line 3, change: "casualties" to: "civilians at risk to hospitalizing injuries."

Page 24, paragraph 4-3c(1)(b). In line 7, add: "or damage" after "obstacles."

Page 24, paragraph 4-3c(1)(b)3. In line 4, add: "or damage" after "obstacle."

Page 25, paragraph 4-3(1)(d). In line 6, add: "and damage" after "obstacle."

Page 26, paragraph 4-4a(1). Revise the paragraph to read: "Peacetime planning based on the type of tactical operation (offensive, defensive. retrograde) to be supported, limiting requirements, terrain, and the assumed threat."

Page 26, paragraph 4-4a(2). In line 3, replace: "on actual threat" with: "on limiting requirements, terrain, and actual threat."

Page 28, paragraph 4-4b(1)(b). In line 4, change: "imformation" to "information."

Page 29, paragraph 4-4b(2)(c). Revise the paragraph to read: "The anticipated threat is arrayed on an overlay based on a terrain analysis and their tactics and doctrine for the particular assumed fighting posture."

Page 35, paragraph 5-2a. In line 9, change: "ito" to: "into."

Page 38, paragraph 5-4b. Add to the end of the paragraph: "and is used to calculate the expected index of the coverage tables. When using the numerical method, the expected coverage is calculated using the expected RD, which is the sum of the products of all possible RDs times their probability of occurring."

Page 39, figure 5-6. Change: "Template" to "CD 90" and change: "CD 90" to: "Template Center."

Page 40, Figure 5-7. Change: "Template Center" to: "CD 90" and change: "CD90" to: "Template Center."

Page 40, paragraph 5-5b(4). In line 8, change: "case" to: "cases."

Page 43, paragraph 5-5c(4). In line 3, change: "fo" to: "of."

Page 45, paragraph 5-5c(5)(a). In line 1, change: "RD" to "RD/RT" and in line 2, change: "CD90" to: "CD90/RT."

Page 45, paragraphs 5-5c(5)(d) and (e). Combine paragraphs *(d)* and *(e)* to read:

"(*d*) Apply the distance obtained in (*c*) above horizontally in the same direction from the original RD/RT and CD90/RT intersection. Read a new fractional coverage, which will be expressed as a percentage of coverage for the desired degree of assurance."

Page 46, figure 5–11. Change: "(high assurance coverage)" under heading "AREA TARGET GRAPH" to: "(expected coverage)."

Page 49, paragraph 5–5c(5)(f). Change the paragraph letter from: *(f)*" to *(e)*".

Page 51, paragraph 5–5d(3)(e). In examples 1 and 2, change:

"Given: RD =*300 meters*
CD90=200 meters"
to: "Given: RD =300 meters
CD90=200 meters"

Page 54, paragraph 5–5d(3)(e). In example 3, change:

"Given: *RD =700 meters*
CD90=100 meters"
to: "Given: RD =700 meters
CD90=100 meters"

Page 54, paragraph 5–5d(5)(b). In line 6, change: "RD/CD90 5" to: "RD/CD90 5."

Page 57, paragraph 5–5(5)(d). In line 14, change: "This RD/CD90 ratio is 5" to: This RD/CD90 ratio is 5."

Page 58, paragraph 5–5e(3). In line 10, change: "FMs" to: "FM."

Pages 61–62, paragraph 5–6b(1)(b). After "vulnerability" in line 3, add: "of the soldier, or the."

Page 62, paragraph 5–6b(2)(b)3. Change: "FMs 101–31–2 and 101–31–3" to: "FM 101–31–2 and FM 101–31–3."

Page 63, paragraph 5–6b(4). Change lines 16 through 27 to read: "The MSDs listed in the safety distance tables are based on no previous radiation exposure history (RES–0). If units have a radiation exposure history of RES–1 or greater, then the analyst determines from the appropriate Safety Distance Table whether radiation is the governing effect and must be considered in safety calculations. If it must be considered, then figure 5–24 must be used to modify the appropriate MSD (e.g., if unit in the above example (range 6300) were in RES–2 category, then modify the MSD by adding 200 meters)."

Page 63, paragraph 5–6c(1). In line 13, change: "Tradar fuzing)" to: "(radar fuzing."

Page 64, paragraph 5–6c(1). In line 1, change: "HOB nd" to: "HOB and."

Page 65, paragraph 5–6c(1)(a)1. In line 3, delete: "assumed to."

Page 65, paragraph 5–6c(1)(a)2. In line 5, change: "preceeding" to: "preceding."

Page 66, paragraph 5–6c(4)(a). In line 2, change: "SCR" to: "SRC."

Page 66, paragraph 5–6c(4)(b). In line 23, change: "1,244" to: "1,344."

Page 71, paragraph 5–8. In line 9, after: "based on" insert: "the anticipated threat, terrain analysis,".

Page 71, paragraph 5–8b(1). Insert at the beginning of the paragraph: "The staff planners make a terrain analysis and array the threat on an overlay based on the enemy's tactics and doctrine."

Page 72. Note that figures 5–31, 5–32, and 5–33 are *not* in numerical order.

Page 73, paragraph 5–11a. Add to the end of the paragraph: "or equivalent."

Page 75, paragraph 5–12c. Replace lines 7, beginning with: "the target analysis . . .", through 17 with: "the horizontal dispersion error by taking the square root *of the sum of the* squares of horizontal dispersion error and TLE (i.e., $\sqrt{(TLE)^2 + (CEP)^2}$ for expected values or $\sqrt{(TLE)^2 + (CD90)^2}$ for high assurance values)."

Page 75, paragraph 5–12d. In line 2, change: "he expected D and CEP or" to: "The expected RD and CEP or".

Page 76, paragraph 5–12e(1). In line 4, change: "Range, 5,000 meters" to: "Range: 6,000 meters."

Page 76, paragraph 5–12e(3)(b). In line 2, change: "HOBfs=30(W)=30(1)=30 meters" to "HOBfs=30(W)$^{1/3}$=30(1)$^{1/3}$=30 meters."

Page 76, paragraph 5–12e(3)(d). In line 14, change: $\frac{\text{"RD"}}{\text{RT}}$ (without bar) to: $\frac{\text{"RD"}}{\text{RT}}$ and change: $\frac{\text{"CEP"}}{\text{RT}}$ (without bar) to: $\frac{\text{"CEP"}}{\text{RT}}$

Pages 76–77, paragraph 5–13b(2)(a). Change the paragraph to read: "For systems with range-dependent probable errors, determine the HOB bracket (DHOB±3.5 PEH). Note that 3.5 PEH is used in the MSD HOB brackt calculation, which equates to a 98% bracket (±3.5 PEH), not 99%. However, the probability associated with the detonation occurring on one side or the other of the aimed HOB is 50%; this, coupled with the fact that the governing effect which determines a radius of damage will peak at or on one side of the aimed HOB, allows the addition of *either* +3.5 PEH or −3.5 PEH to give the 99% assurance (50%+49%=99%) desired for the more stringent troop safety requirements. Enter the appropriate RS column with the HOB bracket (DHOB±3.5 PEH) and extract the *largest* radius of safety from the range of values established by the entry points. This is the RS."

Page 77, paragraph 5–13b(5)(c)2. Change the paragraph to read:

"2. Compute the HOB bracket.

$$\begin{aligned} \text{DHOB}\pm 3.5\ \text{PEH} &= 360\pm 3.5\ (17) \\ &= 360\pm 60 \\ &= 420 \text{ to } 300 \end{aligned}$$

Page 78, paragraph 5–14. Delete the entire paragraph. (Subsequent to the printing of this manual, it was determined that the procedure for calculating a nonstandard LSD as written in this paragraph was incorrect, and the additional data required to perform nonstandard LSD calculations correctly is not available in the field. The correct procedure and data will be published in the next edition to this series of manuals.)

Page 80, paragraph 5–16a(2)(b). In lines 1 and 2, change: "fig. 5–32" to: "fig. 5–35."

Page 80, paragraph 5–16a(2)(d). Change the paragraph to read: "Enter the proper coverage table (i.e., 1 KT, SRC, Exposed personnel, latent lethality) at the range of 8,000 meters and extract an expected RD of 538 meters."

Page 81, paragraph 5–16b(2)(d)2. In line 3, change: $\frac{\text{"RD"}}{\text{RT}}$ to: $\frac{\text{"RD"}}{\text{RT}}$.

Page 82, paragraph 5–16b(3)(d)1. In line 5, change: "figure 5–35" to: figure 5–37."

Page B–2, paragraph B–3d(3)(a). Change the paragraph to read: "HOB 99= $30W^{1/3}$+3.5 PEH meters, for W≤100 kilotons."

Page B–2, paragraph B–3d(3)(b). Change the paragraph to read: "HOB 99=$55W^{1/3}$+3.5 PEH meters, for W100 > kilotons."

Page B–2, paragraph B–3e. Delete lines 6 through 13 beginning with: "The Basic . . ." and add: "However, this height of burst reduces the radius of damage for most target elements and, consequently, receives little attention."

Page B–3, figure B–3. In line 2 of the figure caption, change: "d_c" to: "d_o".

Page B–8, paragraph B–11c. In line 10, change: "th" to: "the."

Page B–9, paragraph B–13b. In line 2, change: "abosrbed" to: "absorbed."

Page B–9, paragraph B–14a(2). In line 1, change: "abosrbed" to: "absorbed."

Page B–10, paragraph B–16a. In line 22, change: "abosrb" to: "absorb."

Page B–10, paragraph B–16b. In line 6, change: "abosrbed" to: "absorbed."

Page B–14, paragraph B–24. In line 1, change: "Varaitions" to: "Variations."

Page C–8, table C–1. In line 11, under the column for Incapacitation, change: "effectiveness" to: "ineffectiveness."

Annex F. Note that the glossary is *not* in alphabetical order.

Page F–1. Change the definition of "Governing effect" to read: "That nuclear effect which extends the farthest from ground zero."

Page F–2. In line 4, under definition of "Variability," delete: "extends the farthest from ground zero."

Page G–1. At the end of the definition for "Mission-oriented protective posture (MOPP)," add: "acceptably degrading their efficiency from the effects of heat stress, psychological stress, and other factors affecting the senses."

Page index 5. Reverse the order of: "Total Dose" and "Training."

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