NUCLEAR NOTES NUMBER 9

NUCLEAR WEAPONS EFFECTS MITIGATION TECHNIQUES

NUMBER NINE IN A SERIES OF INFORMATION PAPERS ON TOPICS ASSOCIATED WITH NUCLEAR WEAPONS, PRINCIPALLY DESIGNED FOR USE BY TRADOC SCHOOL INSTRUCTORS AND MAJOR COMMAND STAFF OFFICERS

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U.S. ARMY NUCLEAR AND CHEMICAL AGENCY
FORT BELVOIR, VIRGINIA 22060

FOREWORD

The series of USANCA papers entitled Nuclear Notes is intended to present unclassified discussions of nuclear phenomena in layman's terms. Nuclear Notes are a ready reference for use by TRADOC school instructors and major command staff officers in their support of the Army. They are intended to clarify and explain various aspects of nuclear weapon phenomenology, and are prepared in as nontechnical a manner as possible. Information in Nuclear Notes is appropriate for dissemination to fire planners, maneuver commanders and staff, training activities and service schools, and service/materiel organizations. Local reproduction and distribution are authorized.

The principal author of this paper is MAJ Daniel F. Uyesugi of the US Army Nuclear and Chemical Agency. Comments, views, and suggested additional mitigation techniques are desired and should be forwarded to: Commander, US Army Nuclear and Chemical Agency, 7500 Backlick Road, Bldg 2073, Springfield, VA 22150.

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LIST OF CURRENT NUCLEAR NOTES

The US Army Nuclear and Chemical Agency recommends that issues of Nuclear Notes be retained and filed in a loose leaf binder. Current issues are:

Nuclear Notes Number 1 - The Electromagnetic Pulse (EMP), June 1974

Nuclear Notes Number 2 - The Army Nuclear Survivability Program, January 1980 (Revised)

Nuclear Notes Number 3 - The New Nuclear Radiation Casualty Criteria, May 1975

Nuclear Notes Number 4 - Nuclear Blackout of Tactical Communications, August 1976

Nuclear Notes Number 5 - Rainout, December 1976

Nuclear Notes Number 6 - A Primer on Nuclear Weapons Capabilities, June 1977

Nuclear Notes Number 7 - Collateral Damage, April 1978

Nuclear Notes Number 8 - Armored Vehicle Shielding Against Radiation, May 1979

Nuclear Notes Number 9 - Nuclear Weapons Effects Mitigation Techniques, June 1982

Local reproduction and distribution are authorized; however, headquarters that do so are requested to maintain a record of internal distribution so that changes, updates, and corrections may be properly disseminated.

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INTRODUCTION

In order to fight and win on the AirLand battlefield, the US must be able to employ nuclear weapons decisively, and continue to fight effectively after enemy employment. Survival of personnel and equipment and recovery from injury or damage are essential to continued operations in the nuclear environment. Accordingly, the specific vulnerabilities of personnel and equipment must be understood and measures taken to lessen or minimize the impact of potential nuclear weapons effects. In recognition of this need, USANCA intends to publish several Nuclear Notes addressing a wide range of weapons effects mitigation techniques. Basic mitigation techniques for nuclear weapons blast, thermal, ionizing radiation, and electromagnetic pulse (EMP) effects will be summarized, and the payoffs associated with employment of each or a combination of techniques will be discussed.

This Nuclear Note addresses proposed mitigation techniques that can be employed before, during, and immediately after a nuclear attack. Two subsequent notes are planned to deal with "post attack recovery" and "continued operations in a nuclear environment."

WHAT ARE NUCLEAR WEAPONS EFFECTS MITIGATION TECHNIQUES?

Mitigation techniques are proposed configurations and procedures for employment of personnel and equipment to lessen or minimize their vulnerability to nuclear weapons effects. These techniques are intended to be field expedients that can be accomplished readily by individuals and units using only such equipment and material as are readily available. Potential mitigation techniques may be as simple as the use of anchors, tiedowns, and outriggers or digging in to prevent equipment turnover; the use of tracked vehicles as expedient overhead cover; and wetting down or compacting defensive positions to enhance radiation protection.

Mitigation techniques fall into three general categories: actions before, during, or after a nuclear attack.

1. Actions before a nuclear attack consist of long-range planning, training, and maintenance for operations on the nuclear battlefield and the assumption of prestrike protective postures by "strike-warned" troops.

2. Actions during and immediately after an attack include an individual's immediate actions to protect himself and reduce his response to the effects of the nuclear detonation.

3. Actions after the attack include recovery from the effects of the nuclear burst and continued mission operations in the nuclear environment.

Ideally, each of the potential injury producing and equipment damaging mechanisms associated with nuclear effects (e.g., foxhole/fighting position collapse, overpressure, vehicle turnover, debris, tree blowdown, initial radiation, EMP, ground shock, thermal radiation, fires, and fallout) should be examined and mitigation techniques compiled. The nature and effectiveness of each mitigation technique will depend strongly on the situation considered; i.e., the nuclear environment, protection available, unit mission, and specific hardness of the equipment affected. The selection of mitigation techniques contained in this note is by no means comprehensive. It is intended to be the beginning of a list of field expedient techniques that users should expand and tailor to individual and unit needs.

WHAT NUCLEAR EFFECTS ARE OF CONCERN?

Before addressing methods to minimize personnel and equipment vulnerability, it is important to understand how nuclear weapons effects cause personnel casualties and materiel damage in order to mitigate realistically the effects of enemy nuclear detonations.

Nuclear weapons effects may be classified as initial and residual. Figure 1 illustrates the partitioning of energy from a typical fission weapon. Initial effects occur in the immediate area within one minute after a detonation and are most important to the commander since they will create personnel casualties and materiel damage within the timespan of the current operation. The principal initial casualty producing effects are blast, thermal radiation, and initial nuclear radiation. Other initial effects (electromagnetic pulse (EMP) and transient radiation effects on electronics (TREE)) affect only electrical and electronic equipment and require protection of one's own equipment from the effects of both enemy and friendly weapons employment. Residual effects, i.e., fallout, are primarily of long term interest but, under certain circumstances, may also have serious impact on success or failure in the immediate battle area.

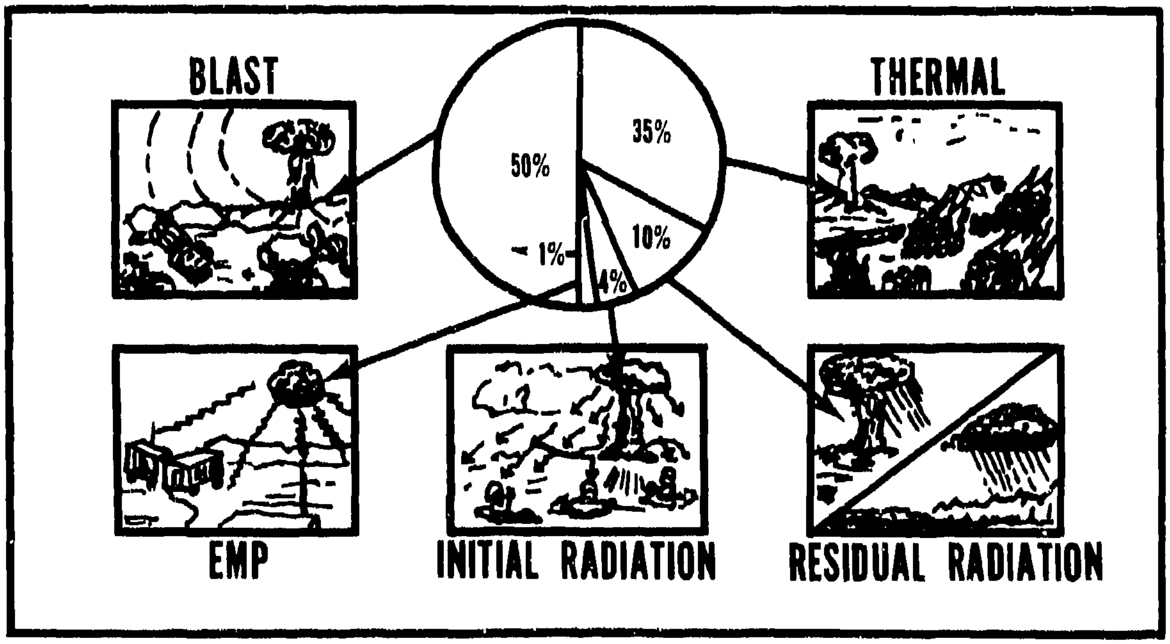


FIGURE 1. ENERGY PARTITION FOR FISSION WEAPONS.

HOW WILL THESE EFFECTS CAUSE INJURY OR DAMAGE?

The air blast from these bursts will overturn and crush equipment, collapse lungs, rupture eardrums, hurl debris, tumble personnel, and collapse foxholes. Thermal radiation will set fire to combustible materials, result in flash blindness or burns of the eyes, and cause personnel casualties due to skin burns. Nuclear radiation will affect critical biological systems by damaging cells which are components of all parts of the body. This radiation damage may cause headaches, nausea, vomiting and diarrhea that is generally called "radiation sickness." Although nuclear radiation is the dominant casualty producing effect for low yield tactical nuclear weapons, other initial effects may produce significant damage and/or casualties depending on the weapon type, yield, burst conditions, and the degree of personnel and equipment protection. Figure 2 shows typical radii of "dominant" effects at casualty levels (CAS) and safety levels (SAF) for nominal 1 KT and 10 KT fission weapons and further illustrates the range difference due to degree of protection of various targets. For example, personnel in tanks would receive 3000 rads at a distance from ground zero where exposed personnel would receive 8000 rads.

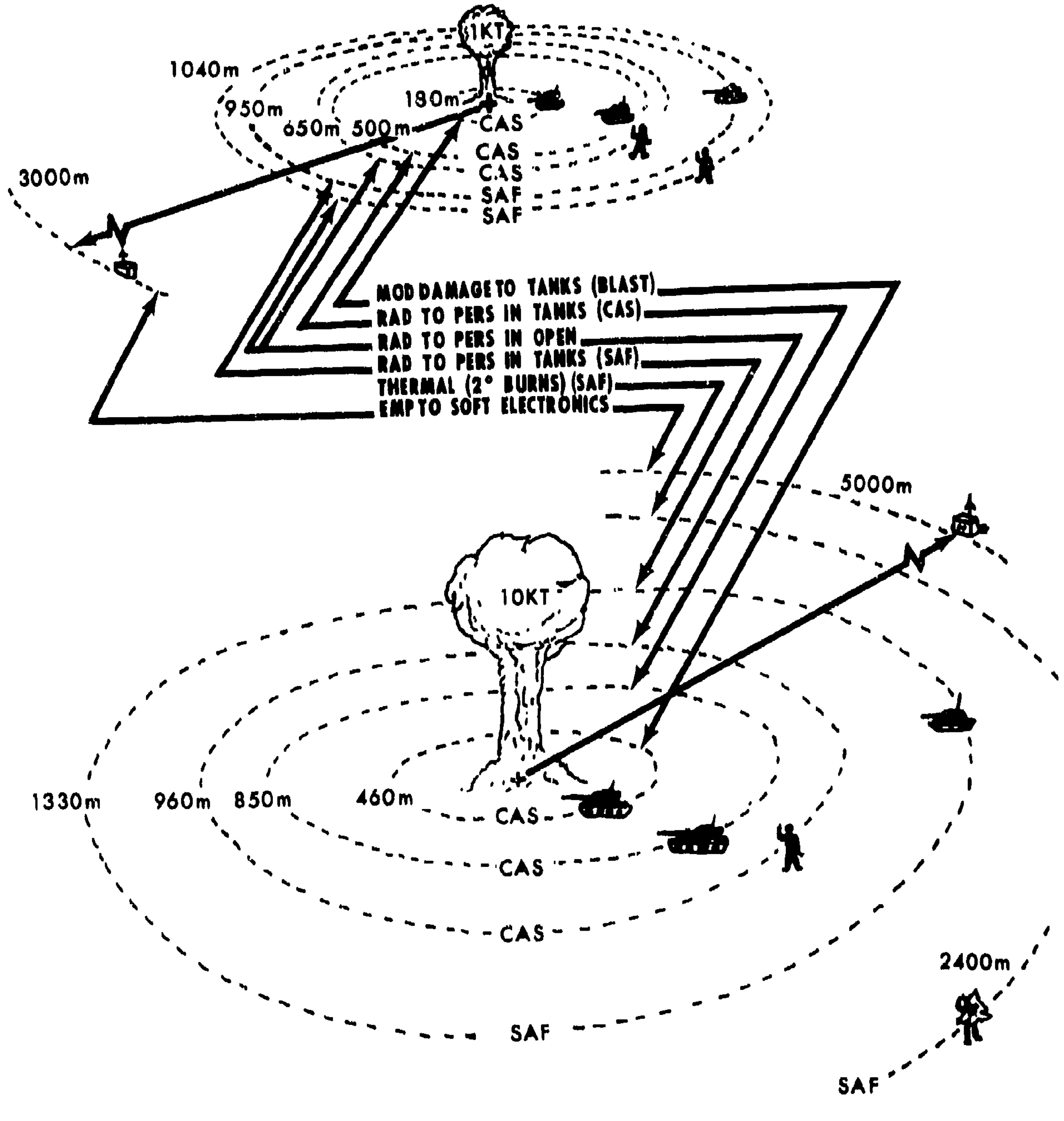


FIGURE 2. TYPICAL RADII OF EFFECTS FOR 1 KT AND 10 KT FISSION WEAPONS.

In addition to thermal and blast damage, electrical and electronic equipment may be upset or permanently damaged by EMP. This EMP is a broad frequency spectrum radio pulse of electromagnetic energy that lasts for less than a second after the burst. Its frequency range extends from extremely low (ELF) into the ultra-high (UHF) frequencies, with much of its energy concentrated in frequency ranges (high frequency (HF) into UHF) employed by Army tactical communications equipment. It is of concern because the damage and upset it causes can occur at distances from the burst far beyond where other nuclear weapons effects produce negligible or no damage. For example, vulnerable electrical and electronic equipment could be damaged by EMP at ranges up to 5 km from a 10 KT surface burst and hundreds of km from a similar high altitude burst. EMP damage occurs because voltages and currents, far in excess of safe levels, are induced in conductors and may burn out components and equipment in the same manner as a near miss lightning bolt can cause a circuit breaker to trip. A more detailed technical discussion of EMP effects is contained in Nuclear Notes Number 1, "The Electromagnetic Pulse (EMP)."

More detailed technical discussions of nuclear weapons effects are contained in DA Pamphlet 50-3 and FM 101-31-1; these effects are also the subject of Nuclear Notes Number 6, "A Primer on Nuclear Weapons Capabilities."

WHAT CAN BE DONE BEFORE A NUCLEAR ATTACK?

An enemy nuclear attack will probably come with little or no warning, and you can expect to be warned of a planned nuclear strike by friendly forces only minutes before the designated time-on-target. In either case, there will be little time to take protective actions. Individual and unit defensive measures must be automatic and instinctive. Therefore, long-range planning, training, and maintenance for operations on the nuclear battlefield as well as an understanding of the optimum protective postures for "strike-warned" troops are essential. Remember that even though the enemy does not target your unit directly, you still may be exposed to the effects of a nearby detonation. You can and must protect yourself from these long-range, low level effects.

Preparation of the Battlefield.

As with conventional operations, knowing the terrain and using it to your advantage is basic.

Shelter. Existing natural and manmade terrain features such as caves, ditches, ravines, culverts, overpasses, tunnels, and ammunition storage bunkers can be used as expedient shelters. Prior identification will help in finding cover during an attack.

Resources. Extraordinary consumption of expendable materials, medical supplies (particularly for burn treatment), and water can be anticipated. Prepositioning is one answer, as well as the use of commercially available assets such as heavy equipment and communication lines. Knowing the location and availability of water sources and storage and delivery assets such as wells, reservoirs, car washes, swimming pools, fire trucks, and street cleaners can greatly help decontamination efforts. As in most instances, it makes sense to insure that each man keeps his canteen full and that additional canteens of water are available.

Preparation of Personnel.

The need for training is obvious. The soldier should, and no doubt wants to, know the optimum protective postures to protect himself and his equipment from a nuclear burst. If we expect him to continue combat operations after an attack, he must also be taught how to recover from the effects of the nuclear explosion and how the unit plans to operate in the nuclear environment.

Psychologically, the soldier can properly be expected to view the possibility of undergoing a nuclear attack with great anxiety. Providing the soldier with realistic information about the often overstated or misunderstood aspects of nuclear weapons effects and providing some basic methods to reduce these effects will go a long way toward dealing with this fear.

Unit Operations.

Operationally, the most effective means of surviving on the nuclear battlefield is to avoid being detected and targeted from the start.

Dispersion. Dispersed units and equipment are less likely to be detected, present less desirable targets, and are less likely to be destroyed by the effects of a nuclear attack.

Concealment. Camouflage not only reduces detection, but can (particularly overhead camouflage and camouflage nets) significantly reduce the effect of thermal radiation and subsequent fallout. Battlefield concentrations of smoke, in addition to providing effective large area concealment, can reduce thermal radiation by as much as 95 percent.

Cover. Cover is the best protection from nuclear attack. Whenever the tactical situation allows, critical facilities, personnel, equipment, and supplies should be dug in or placed in the best shelter available. Foxholes and field shelters can provide excellent protection against the effects of nuclear weapons. Tanks and armored vehicles are normally good shelters.

The basements of masonry and light steel buildings can provide significantly more blast and radiation protection than wheeled vehicles in most configurations. This is especially true for field command, control, and communication (C^3) installations which typically consist of wheeled vehicles placed in concealed, wooded sites. These installations are particularly vulnerable to blast overpressure and drag effects as well as tree blowdown and forest fires.

In more fluid battlefield situations, at least one tactical (alternate or jump) command post (CP) should be established in a protected or built-up area. As a minimum, a good practice would be to provide maximum shelter for all off-duty personnel and critical replacement equipment.

Cover is also of concern during troop movements and convoy operations. Route reconnaissance should include locating expedient shelters such as culverts, tunnels, overpasses, caves, and built-up areas; enroute stops can be scheduled near these shelter locations for ready access.

Deception. Frequent helicopter traffic and radio transmissions are normally associated with critical C^3 locations and troop concentrations. Helipad and transmitter locations and aircraft flight patterns can be modified to detract from the enemy's target acquisition. In conjunction with the appropriate use of obscuring smoke, changing radio and helicopter traffic patterns can deceive enemy observers and further reduce the accuracy of enemy fires.

RECOMMENDED PROTECTIVE POSTURES FOR PERSONNEL.

Individual Actions.

If a nuclear strike is planned by friendly forces, you will be warned if the burst could affect your location. This strike warning may allow you hours or only minutes to find the best protection possible for yourself and your equipment. So what are some of the actions to consider for protecting yourself on the nuclear battlefield?

--"Protect your eyes. DO NOT LOOK AT THE FIREBALL." The intense light that is normally associated with a nuclear burst can also temporarily blind or dazzle you. At times, the light may be visible through tightly closed eyelids even with your back turned to the burst. Covering your eyes with the palms of the hands prior to the flash is the best move, and rolling eyeballs upward to place the pupil behind the eye socket could help. Also remove all types of eyeglasses to prevent subsequent injury from the blast wave.

--"Minimize exposed skin areas." As an individual, one of the simplest ways to protect yourself before a nuclear attack is to keep exposed skin areas to a minimum. The chances of your becoming a thermal radiation casualty depend on the amount and severity of the skin area burned. For example, second or third degree burns over only 30 percent of the body can cause incapacitation within 24 hours (25 percent incapacitation within 2 hours). Your uniform will reduce by at least 50 percent the thermal radiation on exposed skin. Gloves will protect hands. A scarf or hood can also be used effectively to cover and protect the more vulnerable areas of the head and the back of the neck. Light colored material is better than dark because it absorbs less thermal radiation.

--"Protect exposed skin areas." Thermal radiation will burn exposed areas of the skin. Your face, neck and hands will be especially vulnerable. You can be burned so quickly (in a second) by the thermal radiation of the burst that any attempt to cover the face and hands at the time of the burst will be too late. Therefore, immediately prior to the announced time of detonation, you should assume a position that protects the eyes and any exposed skin areas of the face, arms, or hands. For example, drop face-down to the ground or as low as possible in your covered position, shelter, or vehicle; put the palms of the hands over the eyes to protect from flash blindness; and keep the arms protected under your body. Obviously, try to keep your hat or helmet on.

--"Keep clothes loosely fitted." Skin burns occur more readily where the clothing is in direct contact with or drawn tightly over the skin, such as around the shoulders, elbows, waist, and ankles. Burns result from the conduction of heat from the hot fabric to the skin. Shirt tails should be left out. Trousers should not be tucked into boots.

--"Wear headgear at all times." Your helmet is probably the most immediately available blast and thermal protection that you have. Headgear can shield your face and eyes from thermal burns and (to a lesser degree) flash blindness, protect your head from debris or impact with solid objects, and provide some limited radiation protection for the head. The impact protection is worthwhile inside of shelters and vehicles as well.

--"Remove dark camouflage face paint." Darkly painted areas can absorb more thermal energy and may be burned more readily than bare skin. Application of an effective sun screen aid or cream over exposed skin areas may provide some additional protection.

--"Wear ear protection." Depending on the situation, ear plugs or head sets could be worn to protect you from eardrum rupture or hearing loss. Of course, this may not always be practical, and in most cases covering one's ears after detecting the flash will be adequate.

Individual Cover.

As stated before, digging in, or taking cover before an attack provides the best protection from nuclear effects. The amount of blast, thermal radiation, and both initial and residual radiation protection actually depends on the type of cover you choose. Figure 3 illustrates the degree of protection for cover typically available on the battlefield.

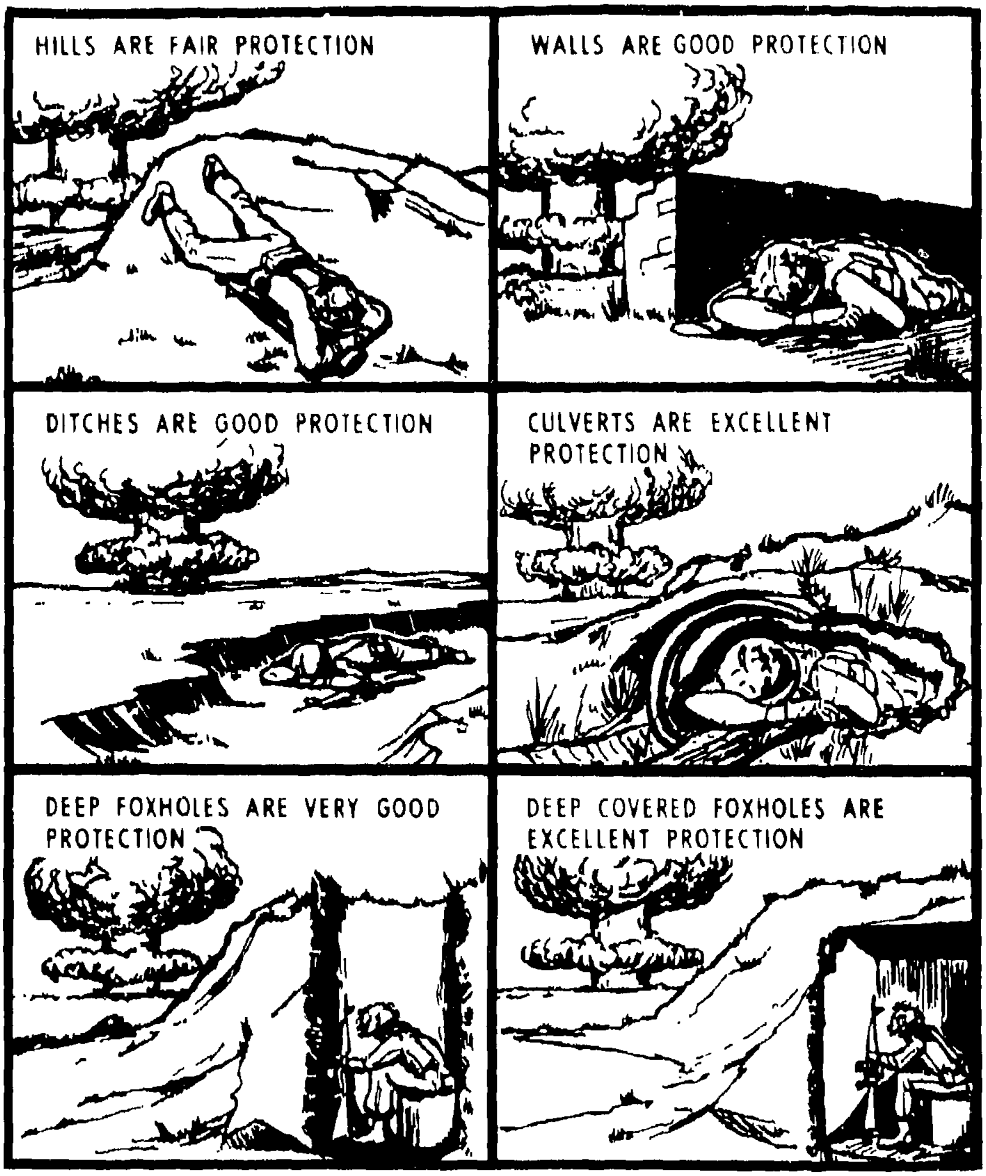


FIGURE 3. EXAMPLES OF EXPEDIENT COVER.

Digging In.

Nuclear radiation, not collapse of your fighting position (foxhole collapse), is the predominant casualty producing mechanism for personnel in foxholes. Thus, your primary concern should be shielding yourself from this initial gamma and neutron radiation. Gamma radiation protection requires thick layers of dense or heavy shielding material such as lead, iron, or stone. On the other hand, light, hydrogen-based material such as water, parafin, or oil provide good neutron radiation protection. Absorption of neutrons in these materials produces additional gamma radiation, and dense shielding must therefore be provided to protect against this "secondary" gamma radiation. As a general rule, the thicker the layers of each type of shielding material, the better the overall radiation protection.

--"Earth is a good shielding material." A properly constructed fighting position offers excellent protection against both initial and residual radiation. Examples of basic fighting position types that provide good protection are shown in figure 4.

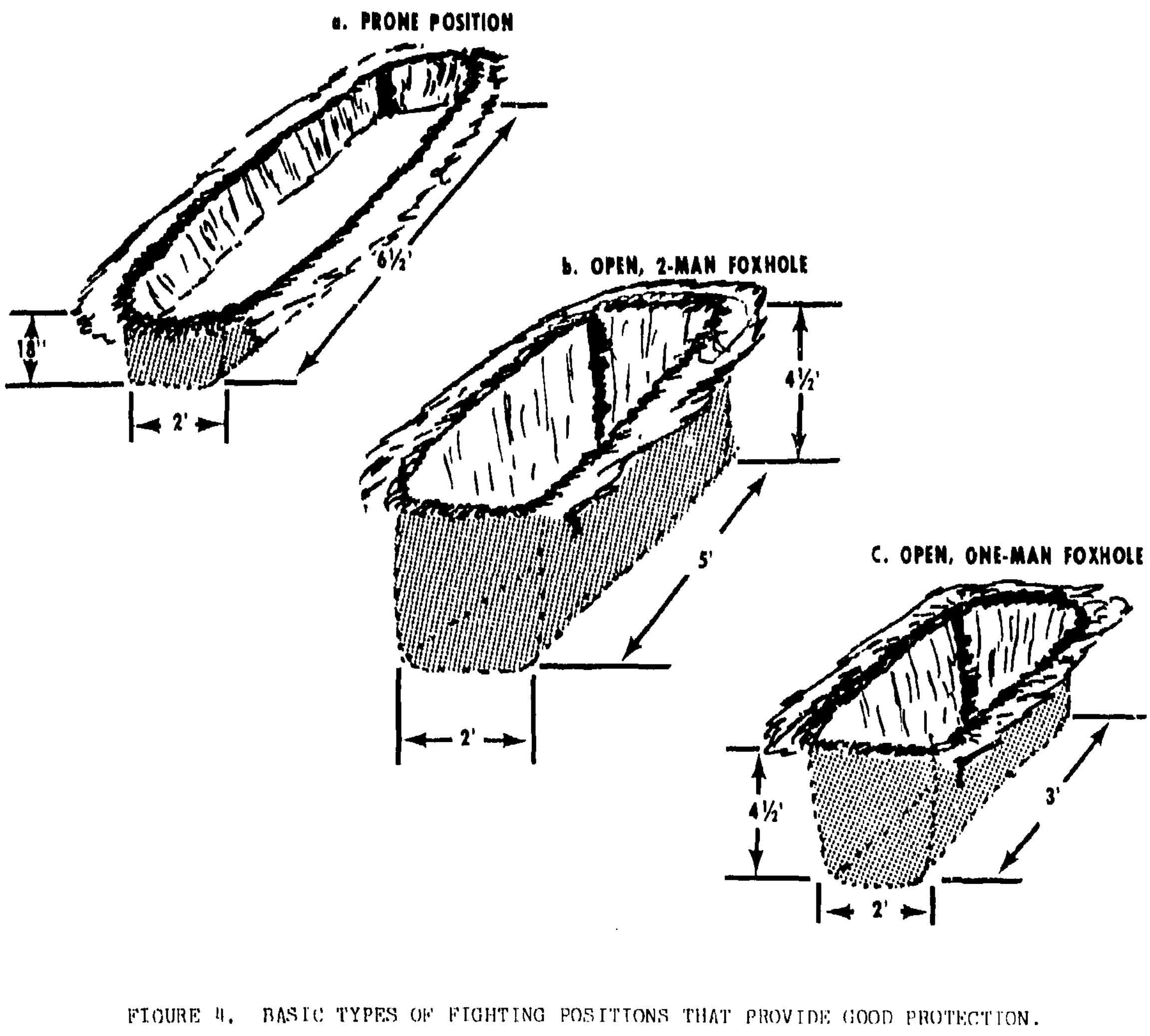


FIGURE 4. BASIC TYPES OF FIGHTING POSITIONS THAT PROVIDE GOOD PROTECTION.

--"Dig round foxholes." Foxhole walls can collapse under the force of the blast wave. Rounded walls will hold up better than square or rectangular walls and are easier to dig. Although foxhole collapse can cause casualties, gamma radiation is still the primary concern. Lining or revetting your foxhole with sheet metal or wooden planks can significantly reduce foxhole collapse, but more importantly lets you build a foxhole with a smaller opening which permits less initial and residual radiation to enter. Remember that many metal surfaces are good thermal reflectors and must be covered to prevent increasing the danger of burns.

--"The smaller the foxhole opening, the better." A majority of the gamma radiation in the bottom of a foxhole is scattered into the foxhole through the opening. The one-man foxhole, with its smaller opening, reduces the gamma radiation 2 to 4 times below the levels in the two-man foxhole. Don't put the unit into one-man foxholes just for radiation protection; but do make the smallest openings you can on all your foxholes.

--"A deep fighting position/foxhole gives more radiation protection than a shallow one." Deeper fighting positions/foxholes place a greater thickness of shielding material or earth between you and the nuclear detonation and therefore provide greater reduction of initial radiation entering the hole. In a two-man fighting position, radiation is reduced by a factor of two for each 16 inches of foxhole depth. Dig down 4 feet and get a factor of six to eight protection.

--"Keep as low as possible." Lowering your body in the foxhole obviously puts more dirt between you and the potential source of radiation. Curling up on your side or, better yet, lying on your back with knees drawn up to the chest is best (see figure 5). Instinctively, lying on your back may seem to be a vulnerable position, but remember that the limbs of the body are not as vulnerable to radiation as the head or trunk. Tucked-up legs and arms even tend to shield the body from radiation, especially from neutrons, since the body is largely water and is therefore an excellent neutron shield. Bulky equipment such as packs or radios can be stored in an adjacent pit if they prevent getting as low as possible in the foxhole. Alternately, they can be placed over one's face and hands to provide additional radiation and blast protection.

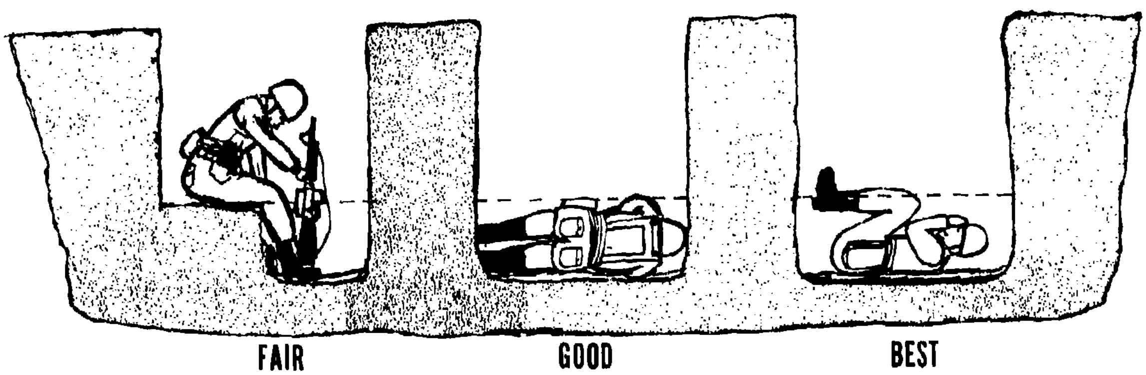


FIGURE 5. RECOMMENDED BODY POSITION IN A FOXHOLE.

--"You can be burned." Thermal radiation can reach you in a foxhole by line-of-sight exposure or by reflection off the sides. Dark and rough materials such as wool and canvas (blankets and shelter halves) can be used to cover potential reflecting surfaces and as protective cover for personnel and equipment. Remember that these materials may still burn and char as a result of the thermal exposure, and direct contact with personnel and equipment should be avoided. Do not use ponchos or other rubber or plastic materials as foxhole covers because they might melt and cause burns. Simply covering a foxhole with ordinary metal window screening material will block the thermal radiation by about 50 percent and could be used for thermal protection without entirely blocking the view, such as in viewing ports of observation posts. Reflected thermal radiation can also be reduced by insuring the walls of the foxhole are dark and rough to absorb and scatter the energy. Exposed portions of the body should be covered, and keeping low reduces thermal exposure just as it reduces nuclear radiation exposure.

Overhead Cover.

An overhead covering of earth or other material will reduce the amount of thermal and initial nuclear radiation that reaches you, help prevent the entrance of fallout, and reduce blast overpressure in the foxhole.

--"Massive overhead cover is best." Tables I and II show the radiation protection provided by various layers of earth and sandbags. Beware of poorly constructed overhead cover; it must be able to withstand the blast wave. The increased protection may not be sufficient to warrant covering only for radiation protection purposes because of the increased hazard from collapse by blast. Some examples of good field expedient overhead cover are shown in figure 6. U-shaped pickets, landing mat sections, timbers, and certain fabrics can be overlain with sandbags or earth. Ammunition boxes filled with earth can also be used. The important factors to remember in constructing effective overhead cover are:

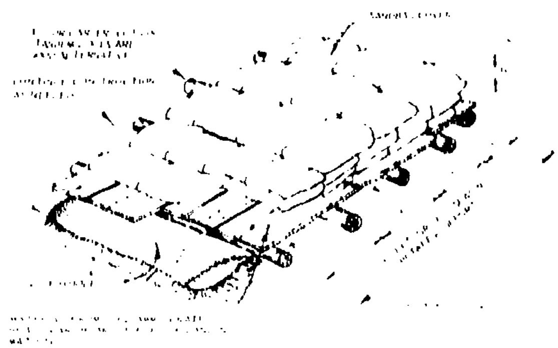
--Choose dense covering materials.

--Cover in depth.

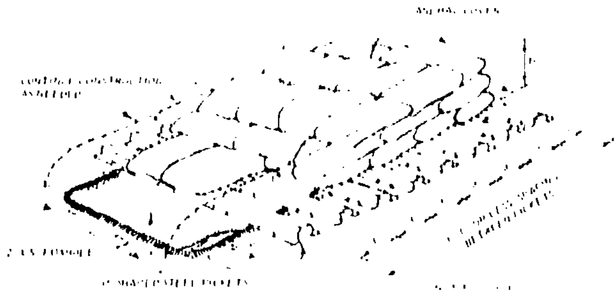
--Provide strong supports.

--Cover as much of the opening as possible.

A more detailed discussion of field-expedient fortifications for protection from the effects of nuclear weapons is contained in Waterways Experiment Station Technical Report N-74-7, "Expedient Field Fortifications for Protection from the Effects of Nuclear Weapons," Sep 74.



a. CUT TIMBER AND SCRAP MATERIALS AS ROOF SUPPORT SYSTEM (20 PSI)



b. U SHAPED METAL PICKETS AS ROOF SUPPORT SYSTEM (20 PSI)

c. FABRIC FOXHOLE COVER AS ROOF SUPPORT SYSTEM (15 PSI)

FIGURE 6. EXAMPLES OF FIELD EXPEDIENT OVERHEAD COVER.

--"Vehicles make good expedient overhead cover." If you don't have a concrete slab or a chain saw handy to help construct sturdy overhead cover, a simple and fast alternative is to drive a vehicle over the top of your foxhole (see figure 7). A heavy armored vehicle is better than a wheeled vehicle (of course being inside an armored vehicle is even better). As with any type of overhead cover, initial radiation can still enter your foxhole through the earth sides or by line-of-sight between the openings in the sides of vehicles (between treads, road wheels, and tires) and the burst. Sandbags can be used to cover these openings. Remember, the vehicle is not a good neutron shield, and both neutron and gamma radiation protection can be enhanced considerably by placing wet sandbags over the top of the vehicle. Also remember that the blast wave may violently displace the vehicle and tend to collapse a foxhole. Orienting the armored vehicle head- or rear-on to the expected direction of the burst will help reduce this problem.

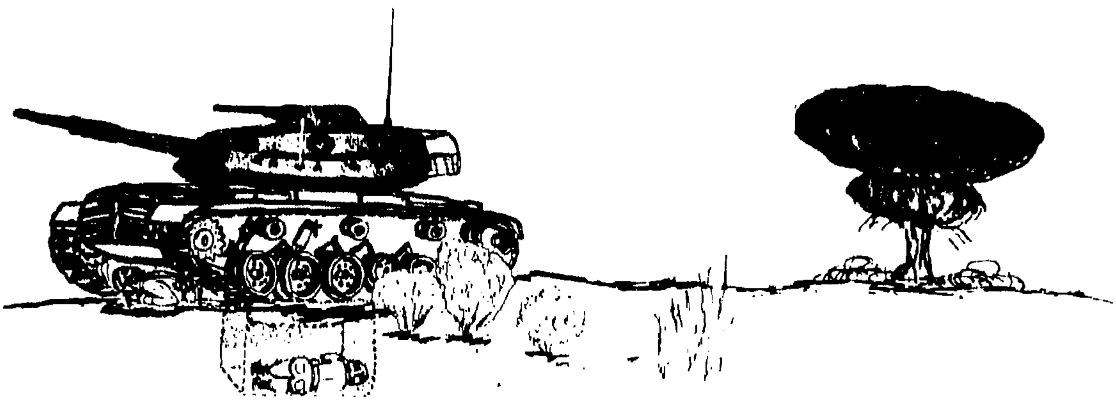


FIGURE 7. USING TRACKED VEHICLES AS EXPEDIENT OVERHEAD COVER.

Taking Shelter.

Well-constructed fighting positions and bunkers provide excellent protection against all the effects of a nuclear detonation. However, radiation is still the greatest concern because of its great penetrating power.

--"The more earth cover, the better the shielding." It is important that as much of the earth cover as possible be placed in between you and the burst because the greatest percentage of radiation enters the foxhole in direct line-of-sight from the fireball. Table I illustrates the value of increasing amounts of earth cover for shielding from a hypothetical free-in-air dose of 2400 rads. An open foxhole provides a protection factor of eight because it blocks most of the line-of-sight radiation and passes only a fraction of the scattered radiation to the bottom of the foxhole. Each added 6-inch thickness of overhead earth cover will reduce the scattered radiation by a factor of two.

TABLE I. THE SHIELDING VALUES OF EARTH COVER FOR A HYPOTHETICAL 2400 RADS FREE-IN-AIR DOSE.

Depth of Earth	Radiation Protection Factor	Resultant Dose (Rads)
Man in open	None	2400
Man in 4 foot deep open foxhole	8	300
with 0.5 ft of earth cover	12	200
" 1.0 ft "	24	100
" 1.5 ft "	48	50
" 2.0 ft "	96	25

Although radiation is scattered from all directions, most of it comes from direct line-of-sight to the fireball. Therefore, the flat earth cover of an underground shelter (see figure 8) provides much more protection than an equivalent thickness of cover on a similar aboveground structure because the line-of-sight thickness is greater.

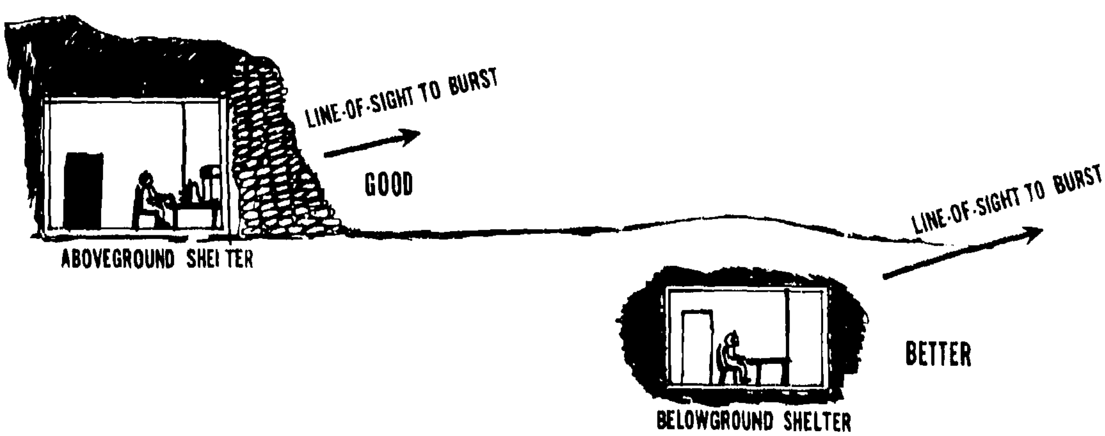


FIGURE 8. SECTION VIEWS OF SHELTERS.

--"Add a second layer of sandbags." Each layer of sandbags, if filled with sand or compacted clay, will reduce the transmitted radiation by a factor of two. The payoffs for adding layers of sandbags are shown in Table II for a potential free-in-air dose of 2400 rads.

TABLE II. RADIATION PROTECTION FACTORS OF SAND- AND CLAY-FILLED SANDBAGS.

Layers	Radiation Protection Factor	Resultant Dose (Rads)
Man in open	None	2400
Man in 4-foot-deep foxhole	8	300
with 1 (4") layer	16	150
" 2 (8") layers	32	75
" 3 (12") "	64	38

--"Sand or compacted clay provides better radiation shielding than earth because it is more dense." Each layer of sand- or clay-filled sandbags can provide up to 66 percent better protection from radiation than the same thickness of soil (or soil-filled sandbags) alone. For example, Table I shows that 12 inches of earth gives a protection factor of 24 (100 rads) while Table II indicates that 12 inches (3 layers) of sand- or clay-filled sandbags provides a radiation protection factor of 64 (38 rads). As a general rule, heavier sandbags will provide better radiation protection than lighter ones, and cracks between sandbags should be avoided to prevent leakage of radiation into the shelter.

--"Neutron radiation can be stopped." Water will slow down and absorb neutrons, but since some gamma radiation is given off in the process, dense shielding is still required. Damp earth or concrete will protect from both forms of radiation. For example, only 12 inches of concrete or 24 inches of damp earth are required to reduce neutron radiation exposure by a factor of 10. Wet sandbags can be used instead to achieve a factor of two reduction for every 4-inch layer used. Some other expedient neutron shielding materials include: containers of water, fuel oil, paraffin, and even boxes of Boraxo cleaner. Remember that radiation is scattered in all directions, and shielding must be designed for all-around protection.

--"Protect your sandbags." Sandbags exposed to thermal radiation will burn and spill their contents, which can then be moved more easily by the blast wave. Covering sandbags with a small amount of earth and/or sod will eliminate this problem, enhance your camouflage, and provide valuable additional conventional fragmentation protection (see figure 9).

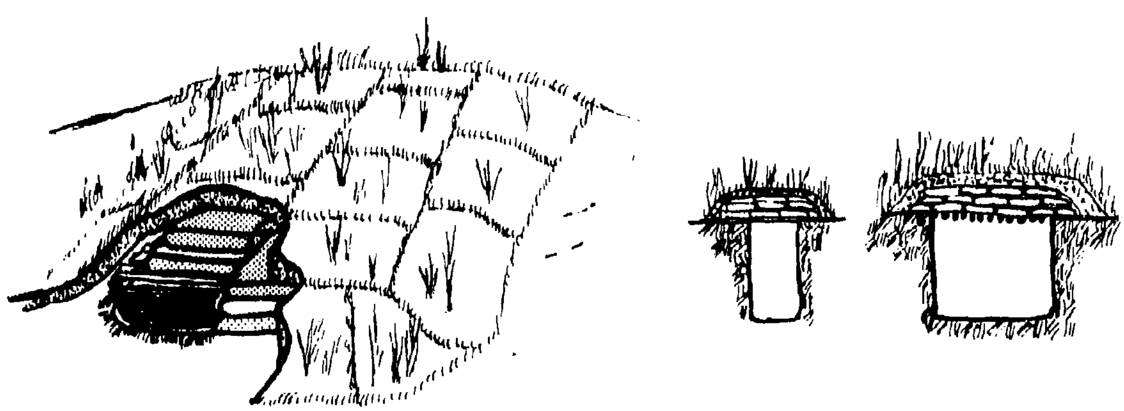


FIGURE 9. PROTECTING SANDBAGS WITH SOD AND EARTH COVER.

--"Keep the openings to your shelter small." A blast wave can enter a shelter and be reflected to increase the interior pressure to hazardous levels. This pressure increase depends strongly on the ratio of the size of the opening to the total volume of the shelter as shown in figure 10.

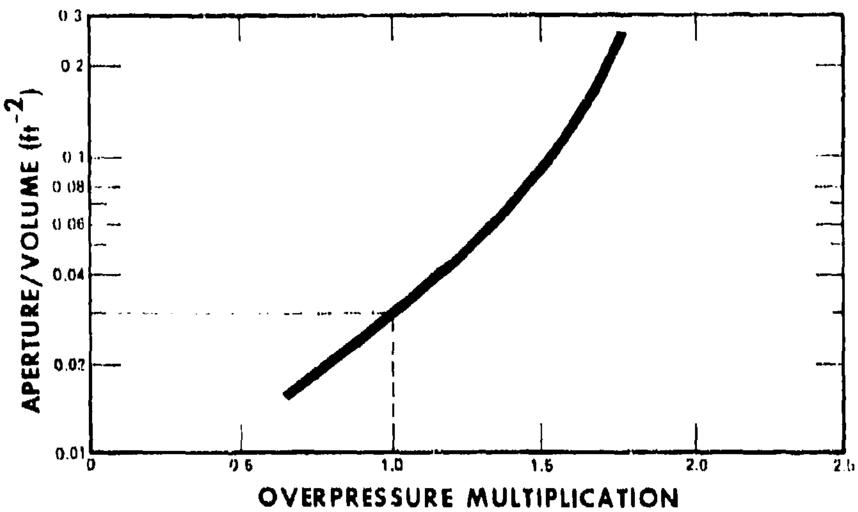
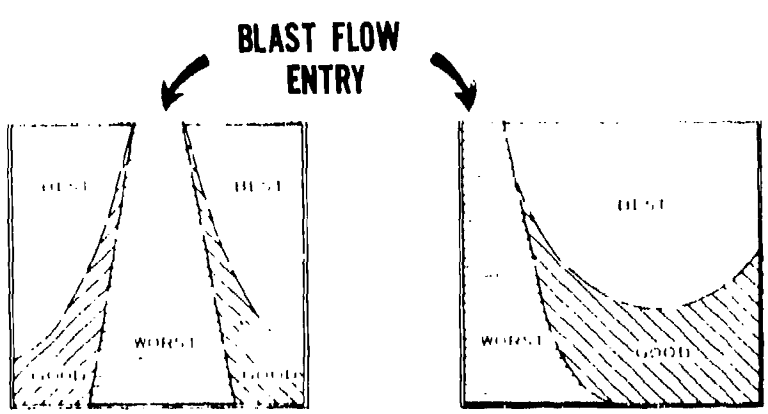


FIGURE 10. OVERPRESSURE MULTIPLICATION PLOTTED AS A FUNCTION OF OPENING/VOLUME RATIO.

Opening-to-volume ratios of less than 0.03/ft will actually reduce the internal overpressure while larger ratios will amplify. Therefore, assuming you have built a 5 ft x 10 ft x 6 ft shelter, the door and windows should not exceed a total area of 9 ft (i.e., 2 ft x 4.5 ft) to prevent pressure multiplication.

--"Protect yourself even inside a shelter." A blast wave can enter your shelter with great force carrying hot sand and burning debris that can cause burns and translational and missiling injuries. As in the case for personnel in the open, lying face-down on the floor of the shelter offers worthwhile protection. However, the violent flow of air from a door or window should be avoided. Lying on the floor near a wall where the pressure wave may be increased due to reflection still appears safer than standing away from the walls and being blown about and injured by the blast (see figure 11). Where possible, constructing baffles or turns in the entrance to shelters can be effective in preventing overpressure buildups and the entry of dust and debris.



b. PERSONNEL PLACEMENT ZONES FOR VARIOUS LEVELS OF PROTECTION

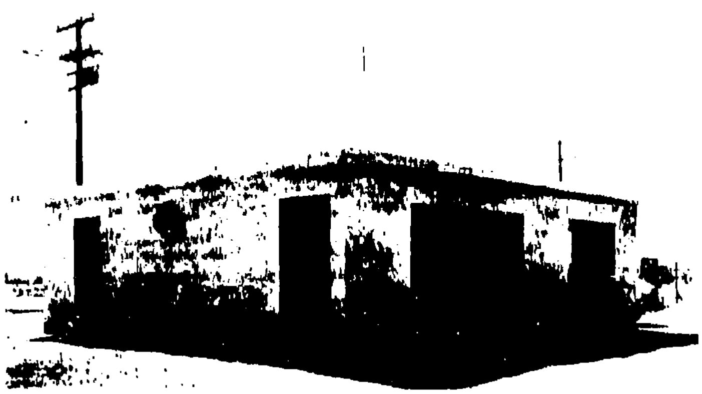
FIGURE 11. PROTECTION FROM BLAST FLOW INTO SHELTERS.

Shelter in Buildings.

Certain types of buildings offer excellent shelter from the effects of nuclear detonations and require a minimum of time and effort to adapt to your needs.

--"Choose the buildings carefully." The strongest structures are heavily framed steel and reinforced concrete buildings, while the worst choices are the shed-type industrial buildings having light frames and long beam span. Even well constructed frame houses are stronger than the latter. Examples of some typical structures that will provide good protection are shown in figure 12. Ammunition storage bunkers will also provide exceptional protection and are generally large enough to accommodate most vehicles and equipment.

a. REINFORCED-CONCRETE STRUCTURE



b. REINFORCED MASONRY-BLOCK HOUSE

FIGURE 12. TYPICAL STRUCTURES THAT PROVIDE GOOD PROTECTION.

--"European rural and urban structures can provide good protection." Many types of pre-WWII European buildings such as farm houses, churches, and municipal buildings were constructed with thick, full span floor and ceiling beams; heavy roofing tiles; dense, reinforced walls; and in most cases a full basement that will provide good blast and radiation protection. Typical European rural and urban structures that can provide such protection are shown in figure 13. Characteristics to look for include:

- Pre-WWII design and construction.

- Full basements constructed of concrete or stone. Make sure you can exit directly to the outside as well as through the upper floors in case of emergency.

- Thick-walled, masonry structures. Thirty-six centimeter wall thickness (greater than 1 foot) is an indication of good, pre-WWII wall construction. In areas (particularly southern Germany) where construction detail is typically concealed by stucco finish, desirable interior wall features such as diagonal supports and blockwork can be seen when the wall is wet.

- Buildings with the least amount of glass. European windows and doors typically are protected by rollup or folding shutters which can provide some additional blast and thermal protection.

FIGURE 13. TYPICAL EUROPEAN STRUCTURES THAT PROVIDE GOOD PROTECTION.

--"Select a shielded building." Buildings located in the interior of closely arranged groups (towns) will be shielded by exterior rows of houses. Blast overpressures and structural damage are significantly reduced for such shielded structures. Debris and rubble problems and fire hazards may increase toward the center of the town, and you should consider assuming shelter two or three rows of buildings from the edge of town to avoid serious hindrance to post-attack maneuver.

--"Get below ground level." The basement, because it is below ground, will provide increased blast protection and much more line-of-sight radiation protection due to the surrounding earth fill than the aboveground floors. Additional radiation protection can be added by placing a layer of earth or sandbags on the floor above you. This additional dead weight will be significant, and shoring up the floor should be considered. ..ernately, more protection can be gained by sandbagging a smaller shelter in the basement (e.g., a sturdy table) without increasing the possibility of the entire floor collapsing. Windows can be blocked by sandbags, and the radiation protection and structural strength of any aboveground exterior walls can be enhanced by piling dirt and sandbags against the walls. Generally speaking, you can expect radiation to be reduced by a factor of 10 in basements compared to levels in aboveground floors.

--"Position inside of the building can make a difference." On aboveground floors the greatest protection from both initial and residual radiation is achieved in the center of the building, whereas below ground the greatest protection is achieved in the corners of the building. In either case the dose to your body in a prone position would be about one-half of the dose when standing. The lesson here is to seek shelter in an underground structure and lie in a corner or, if an underground shelter is not available, lie down in the center of a shelter under a sturdy table, unless significant radiation shielding or structural strength is available at some other location (see figure 14) such as inside a fireplace, under a stairway, or in a bathroom where the plumbing and relatively close spacing of walls might provide increased structural strength.

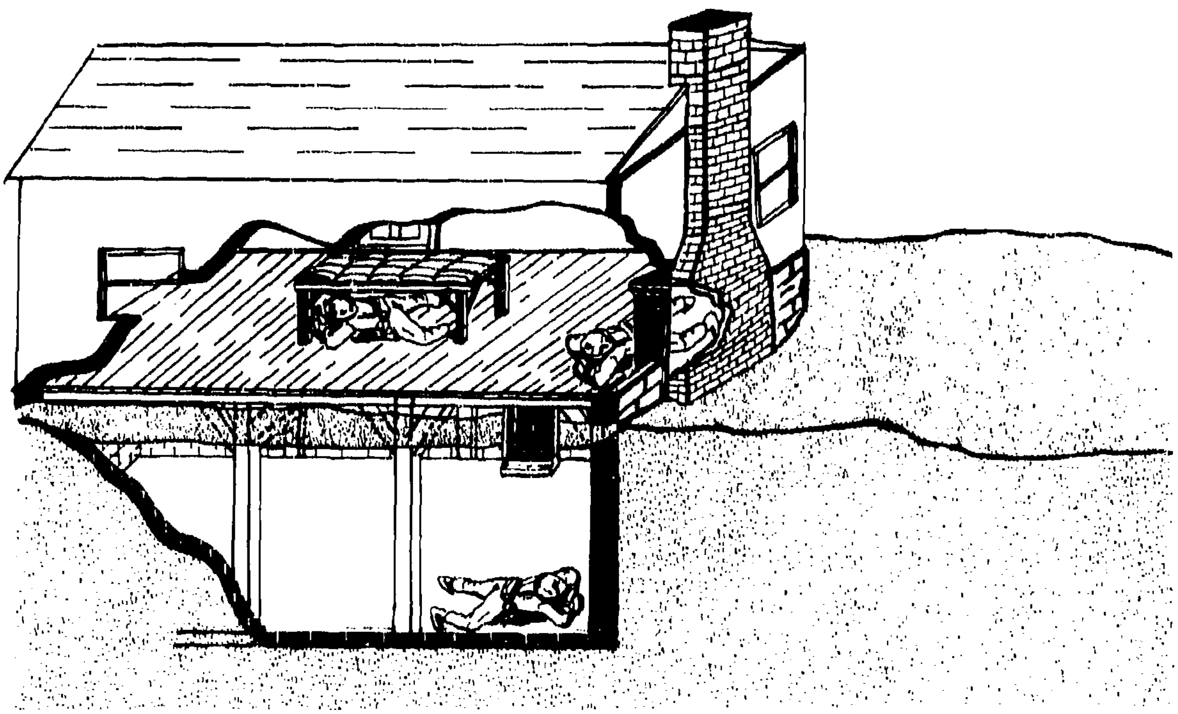


FIGURE 14. SEEKING SHELTER IN BUILDINGS.

--"Beware of windows." People behind windows exposed to blast are subject to severe injury from flying glass. Windows also allow the entry of blast winds and create the possibility of your being blown about or burned by the blast winds and debris. Ideally, window openings should be blocked off with sandbags and any observation ports covered with ordinary window screen to protect viewers from thermal radiation.

Shelter in Tents.

Obviously, a tent is not a preferred shelter against the effects of nuclear weapons. Personnel routinely conducting activities in tents, such as medical, maintenance, and supply personnel, will be particularly vulnerable.

--"A tent can provide protection." A tent will initially provide good thermal radiation protection. The secondary fire hazard is serious, and in most cases you cannot count on the blast wave to blow the smoldering tent far enough away to prevent damage and injury from subsequent fires (see figure 15).

FIGURE 15. SHELTER IN A TENT.

--"Beef up your tent." If the situation requires that you continue to operate in a tent, such as may be the case for some field hospital situations, some degree of protection can be achieved by piling dirt and sandbags as far up the sides of the tent as possible. Lying on the floor is still the safer profile for personnel and may be preferable for patients who must remain in bed.

--"Secure loose equipment and glassware." Since your tent will offer essentially no resistance to the blast winds, all loose pieces of equipment such as small instruments, chairs, clipboards, and bottles, will be propelled by the blast and can cause serious traumatic injuries.

--"Beware of tentpole breakage." You can be seriously injured by the tentpole breaking and splintering. Piling sandbags around the centerpole will provide some additional support and may help insure enough clearance to the ground to allow you to evacuate the smoldering tent after the initial flash.

RECOMMENDED PROTECTIVE POSTURES FOR PERSONNEL IN VEHICLES

Armored Vehicles.

In most situations tanks will provide the best vehicular protection available, and lightly armored vehicles such as the armored personnel carrier, self propelled artillery, and some heavy engineer equipment, also give good protection. If warned beforehand that a nuclear attack is expected, some of the things that can be done to improve this protection are:

--"Get as low as possible inside an armored vehicle." Assuming a position in the bottom of an armored vehicle can reduce by as much as a factor of four the radiation exposure expected for elevated crew positions normally in a tank turret, i.e., tank commander, gunner, and loader.

--"Keep all hatches shut." Obviously an open hatch will expose the crew unnecessarily to the effects of the explosion and could subsequently allow the entry of fallout particles and scattered gamma radiation. Any other openings such as the main gun breech should also be closed.

--"Protect yourself while inside an armored vehicle." Personnel inside an armored vehicle will be violently thrown about when the blast wave hits. Wearing CVC helmets and steel pots with chin straps secured will help prevent head injuries. The need to wear seat belts and shoulder straps when available goes without saying.

--"Secure all loose equipment inside the vehicle." If not secured, loose items of equipment inside the vehicle, such as tools, rifles, and helmets can also be thrown about by the force of the blast and cause you injury or death.

--"Dig in armored vehicles." Digging in your armored vehicles (hull defilade) or placing them in trenches or cuts in roadways provides some limited line-of-sight radiation protection and considerable blast protection. A hull-down fighting position or trench covering over half of the sides of the vehicle can reduce the gamma radiation by as much as a factor of two (see figure 16).

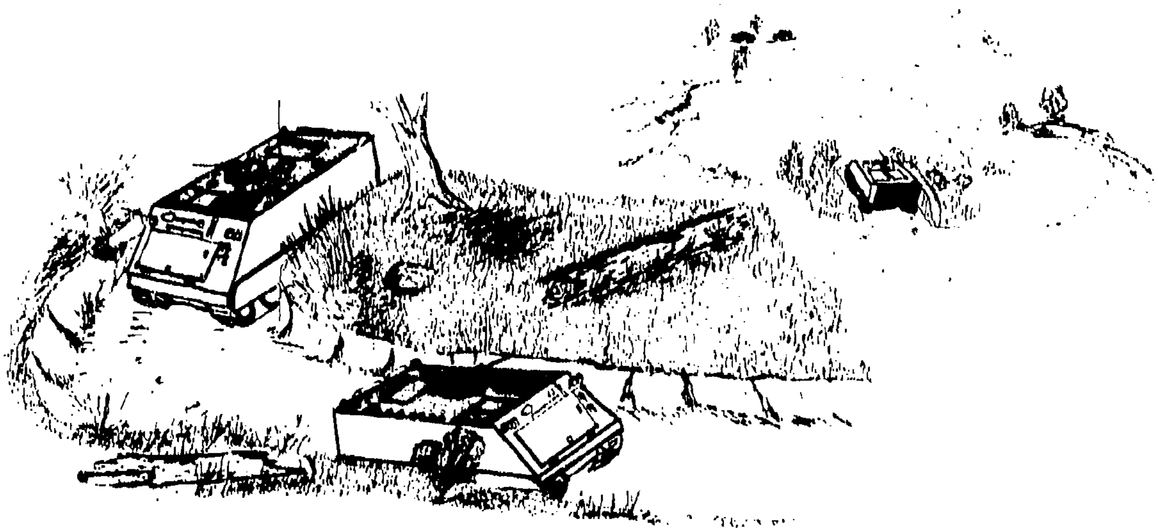


FIGURE 16. PROTECTION OF ARMORED VEHICLES.

--"Use sandbags as radiation shielding." A single layer of sandbags can provide valuable overhead gamma shielding if placed on top of a tank turret or armored vehicle hull. Remember, each layer of sandbags will reduce the gamma radiation by a factor of two. Wetting the sandbags will enhance neutron radiation shielding and protect the sandbags from thermal damage.

--"Orient your tank rear-on to the area of anticipated blast." Although blast damage is generally least for head-on orientations, the rear-on orientation appears preferable because it places the mass of the vehicle's engine between the potential radiation source and the crew. This rear-on orientation can reduce potential radiation exposure to half that of a head-on or side-on exposure. At distances beyond the median lethal dose to the crew in a rear-on orientation, the tank is not expected to be damaged significantly.

Wheeled Vehicles.

Generally, wheeled vehicles not only provide little or no protection from the effects of nuclear explosions, but are particularly vulnerable to vehicle overturn and therefore expose driver and passengers to increased risk.

--"Avoid the use of wheeled vehicles." Table III illustrates that for a nominal 10KT fission weapon the percent of casualties for blast effects is dramatically greater for personnel in wheeled vehicles than for personnel in the open while the percent of casualties expected from radiation is the same for both.

TABLE III. COMPARISON OF PERCENTAGE CASUALTIES TO PERSONNEL IN THE OPEN VERSUS IN WHEELED VEHICLES DUE TO BLAST FROM A 10KT FISSION WEAPON

Range (Meters)	200	300	400	700	800	900	1000	1400
In Open (%)	100	80	41	11	8	5	4	0
In Wheeled Vehicle (%)	100	100	100	99	80	62	43	1

--"Protect yourself inside the vehicle." If mission essential activities such as communications, command, and control (C^3) must be accomplished in a wheeled vehicle, wearing of helmets and steel pots with chin straps secured will help prevent head injuries if the vehicle is overturned.

--"Secure all loose equipment inside the vehicle." Loose or inadequately secured equipment such as weapons, radios, desks, file cabinets, field safes, racks, and generators can tip over or slide across a van floor and cause serious injuries. Tiedowns, blocking, and bracing will help, but remember that such items can also be thrown to the ceiling as well as along the floor if the vehicle is turned over.

--"Prepare alternate shelters." Adequate field shelters should be planned and prepared immediately adjacent to facilities requiring personnel to continue operations in wheeled vehicles.

--"Park the vehicle inside a shelter." Some protection of personnel in wheeled vehicles can be accomplished by parking inside, or under, existing or natural structures such as ammunition bunkers, underpasses, tunnels, and caves.

RECOMMENDED PROTECTIVE POSTURES FOR EQUIPMENT

Your equipment is vulnerable to the same basic nuclear effects that you are. However, air blast will normally dominate by overturning or crushing equipment. Thermal radiation can cause fire damage, and initial radiation can cause transient radiation effects on electronics (TREE). In general, the same procedures you would consider essential to adequately protect yourself will be needed to protect your equipment and in many cases will provide valuable added conventional blast and fragmentation protection.

Cover and Concealment.

--"Dig in." As in the case of individual protection, properly constructed foxholes or underground shelters will offer excellent protection for equipment. However, a separate hole for equipment is preferable. Individual equipment stowed in your foxhole may hinder you in getting as deep as possible or require digging a larger hole thus exposing you to a greater potential initial and residual radiation hazard. Packs, rations, and tents (not your helmet or other items that can be used for additional protection) should be stowed separately in a nearby shallow hole and covered with a protective layer of earth or sandbags to give adequate shielding.

--"Secure all loose equipment." In addition to separate burial of individual equipment, all loose unit equipment should also be secured. Burial and pit stowage are options that will not only enhance survivability but reduce the chance of equipment being thrown by a blast wave and causing you personal injury. Equipment may also be expediently stowed in tanks, lightly armored vehicles, and field shelters. However, remember to securely immobilize the equipment to prevent subsequent injury to the vehicle's passengers, crew, or other occupants. Explosives and flammables should be dispersed within the unit area and covered with at least 4 inches of earth or one layer of sandbags (covered with earth) to preclude ignition by thermal radiation and impact by rocks and debris.

--"Even underwater storage makes sense." Storing equipment and supplies underwater will provide excellent protection from all nuclear effects. Smaller items could be stored in sealed plastic bags or waterproof containers, and larger items such as bulk POL storage drums and bladders can be floated on a river or lake or weighted and sunk below the surface.

--"Seek shelter." For larger pieces of equipment and vehicles tunnels, caves, and storm drains provide good shelter. Culverts and ditches also provide some protection. Again, the lowest floor or basement of a reinforced concrete or steel-framed building will offer good protection. Remember that exhaust fumes can build up to lethal levels if equipment such as generators or filter blower systems are operated in enclosed, unventilated areas.

--"Anchor and/or tie down when possible." When adequate shelter is not available, anchors, tiedowns and outriggers can be used singly or together to help prevent equipment turnover or translation (see figure 17a). Some specific examples of anchors and tiedowns and expedient holdfasts and deadmen that can be readily emplaced in the field are shown in figure 17b and 17c respectively. The holding ability of an anchor, tiedown, or holdfast is determined by the type and size of the anchor and the soil conditions such as moisture content. FM 11-486-5 contains guidance for selection and emplacement of standard, requisition-from-stock anchors and tiedowns while FM 5-34 addresses emplacement of field expedient deadmen and holdfasts.

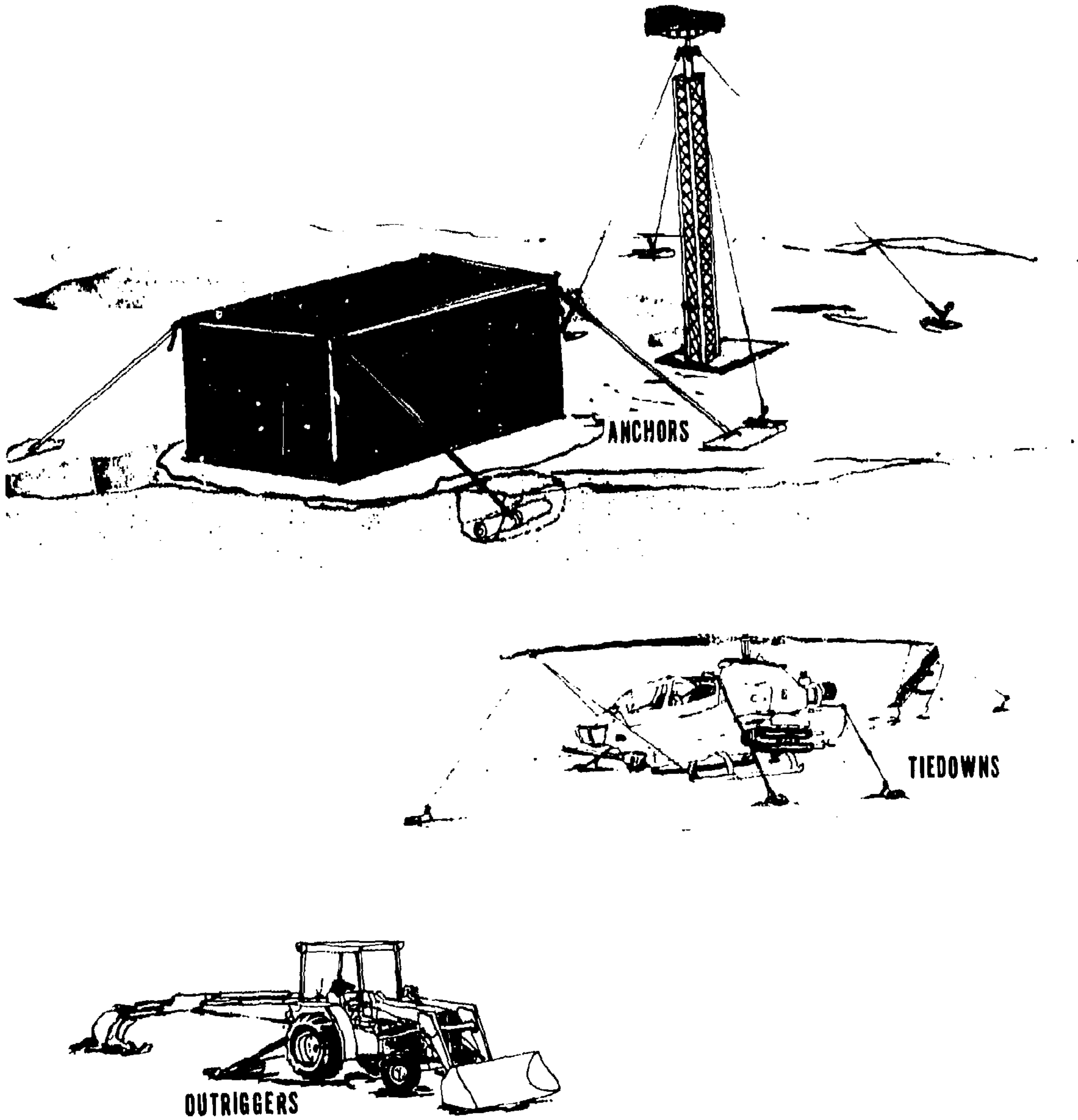


FIGURE 17a. ANCHORS, TIEDOWNS, AND OUTRIGGERS.

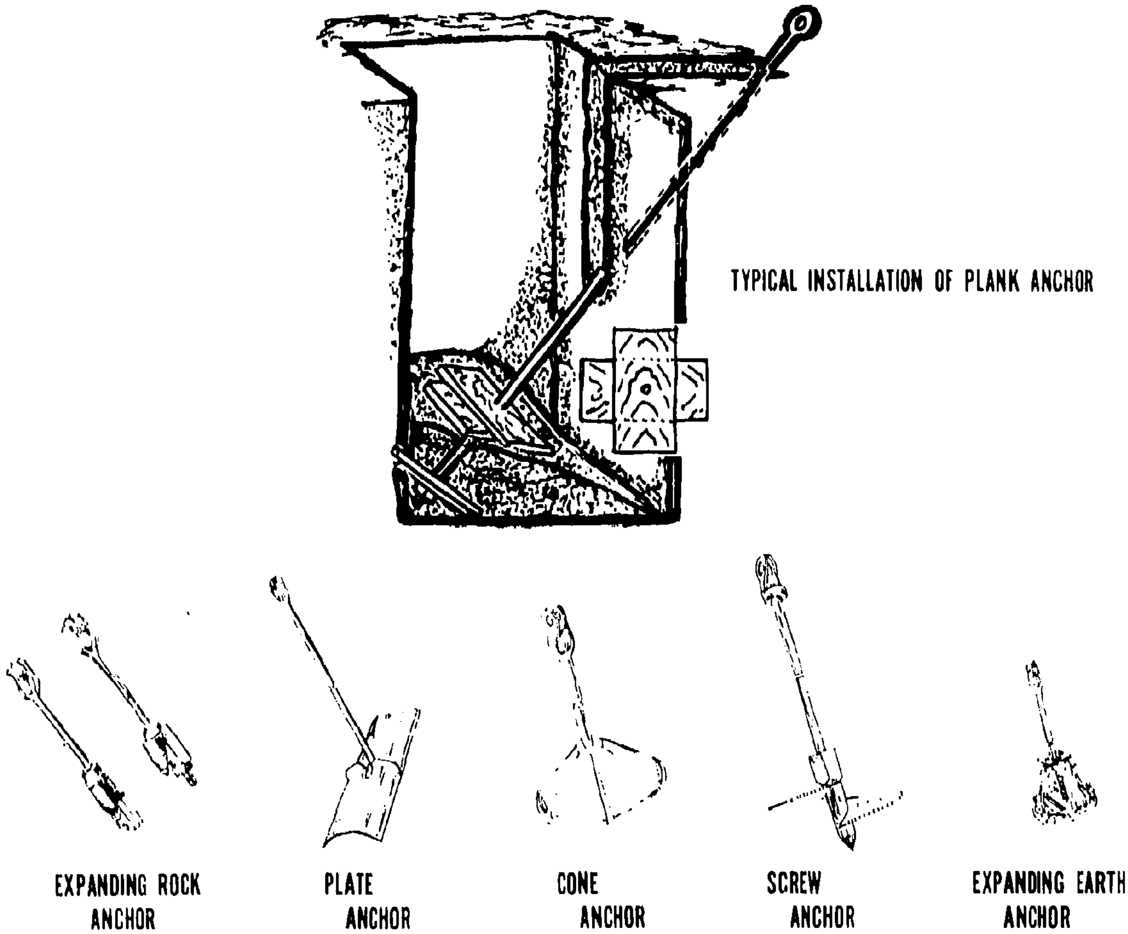


FIGURE 17b. STANDARD ANCHORS.

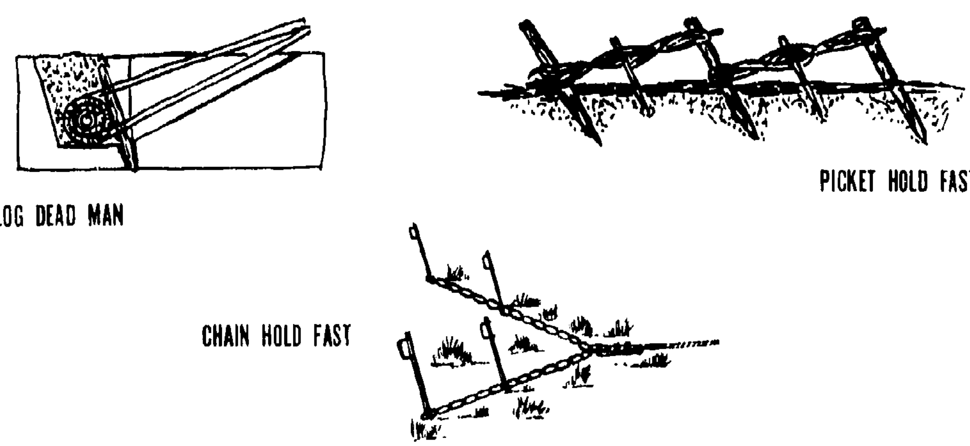


FIGURE 17c. EXPEDIENT DEADMEN AND HOLDFASTS.

Tanks and Armored Vehicles.

--"Rear-on or head-on to the blast is best." From a blast-only environment, the most survivable configuration for a tank or armored vehicle is head-on to the blast. Damage is generally least for the head-on orientation, while side-on, and sometimes rear-on vehicles are overturned and damaged at distances where head-on vehicles are not significantly affected. From the standpoint of total systems survivability, a rear-on orientation to the blast appears preferable because radiation shielding by the engine results in about half as much gamma exposure to the crew as does a side-on or head-on exposure.

--"Assume positions at the bottom of hills." As shown in figure 18, the peak pressure and overpressure impulse caused by a nuclear blast wave increase significantly as the blast wave travels up an increasingly steep slope, while peak pressures and impulse on the reverse or leeward side of the hill are significantly less than what would be expected over level terrain. The greatest decrease in airblast pressure occurs part way up the reverse slope. This suggests that the best shielded position is over the brow of a hill and part way down the slope. Of course, this would be the worst position if a burst occurred on the same side of the hill. Assuming a position at the bottom of a hill will obtain some benefit of shielding from a burst on the other side but will not result in exposure to increased pressures should the burst occur on your side of the hill.

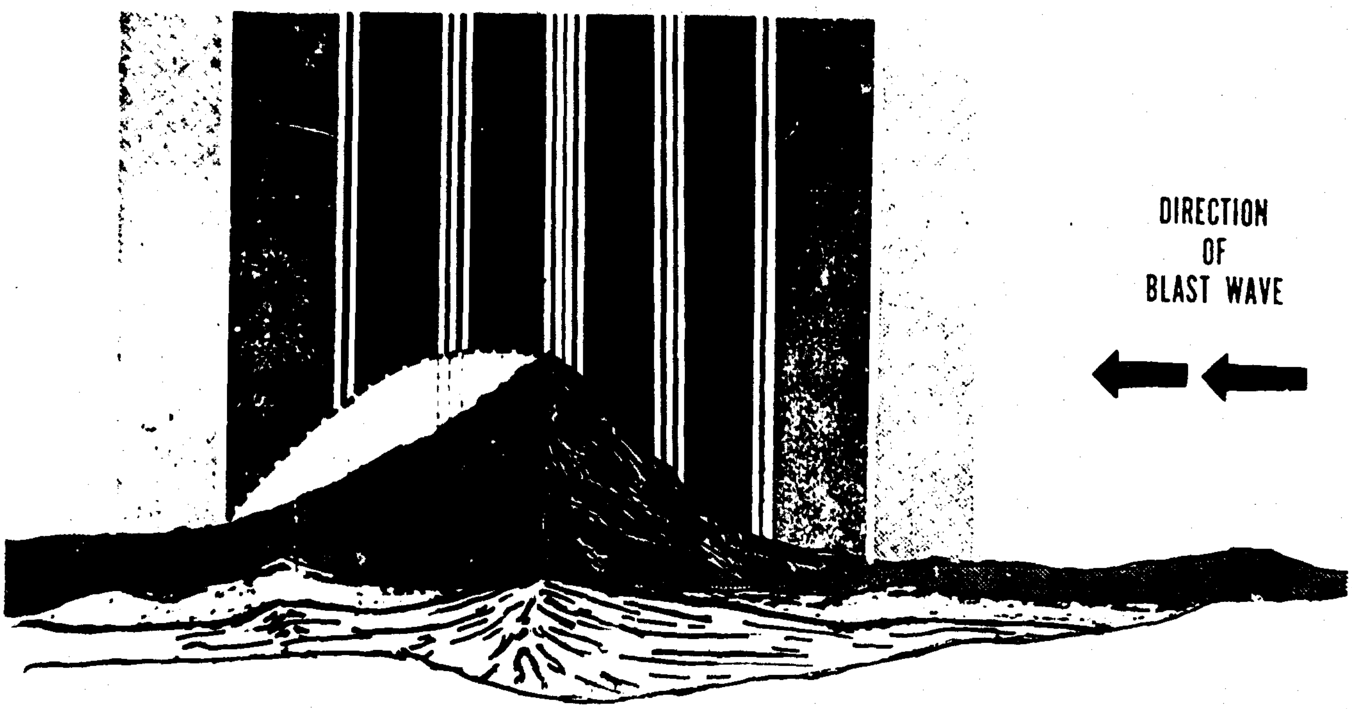


FIGURE 18. BLAST WAVE INTERACTION WITH HILLS.

--"Cover exterior optical sighting equipment." Glass surfaces on armored vehicles such as optical sighting devices and searchlights can be sandblasted and sooted at distances where blast damage is otherwise insignificant. This damage can occur even when the devices are pointed away from the blast. Ordinary metal window screen, if attached securely to the hull, can provide some blast and thermal protection while still allowing limited observation. Noncritical night vision devices should be turned off, and all other glass surfaces covered or taped.

--"Cover the gun muzzles and rotate the turret away from the blast." Considerable amounts of sand and debris can be blown into the gun bore if not covered and/or rotated away from the blast. This material will have to be removed from the barrel before firing and the firing mechanism may have to be cleaned.

--"Remove or secure equipment from the exterior of the vehicle." Of particular concern are combustible or explosive items such as fuel cans, smoke grenades, and canvas which may be damaged and/or ignited by blast and thermal effects. Where possible, critical signal and sighting equipment should be removed and secured inside the vehicle. Radio antennas should be removed or securely tied down when the radios are not needed.

Wheeled Vehicles.

Blast damage to wheeled vehicles is one of the predominant effects you can expect from a nuclear burst. The majority of the damage will be the direct result of vehicle turnover. Any personnel or equipment in or near a wheeled vehicle during a blast will therefore be subject to injury or damage, respectively.

--"Place vehicles head-on to the blast." As you might expect, wheeled vehicles are also more vulnerable in a side-on orientation than face-on or rear-on.

--"Place two or more vehicles side-by-side." As shown in figure 19, two or more vehicles can be securely attached side-by-side by connecting turnbuckles between the top tiedown rings of each van or vehicle. This adds to the effective wheel base of the vehicles and allows the suspensions of the vehicles to work in unison to cushion the impulse of the blast wave and resist overturn. Parking the cab of every other vehicle in opposite directions will also add to the effective bumper-to-bumper length and further resist overturn from a head-on or rear-on blast wave.

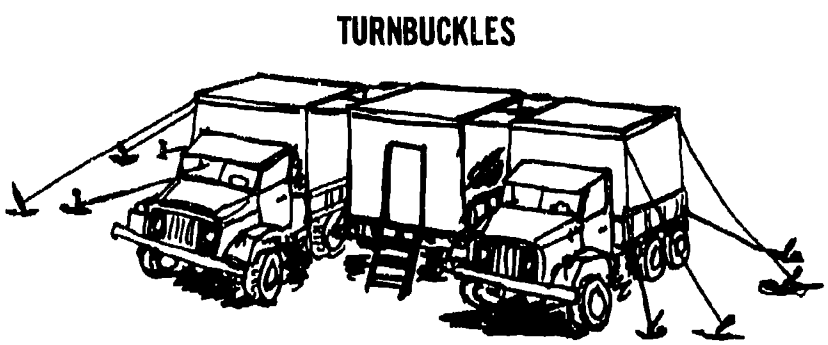


FIGURE 19. MULTIPLE WHEELED VEHICLE ASSEMBLIES.

--"Equip vehicles with roll-over safety bars." In addition to protecting strapped-in personnel, roll-over safety bars can effectively minimize damage to seats, steering wheels, etc., thus decreasing the maintenance time required to restore the vehicle to combat use. Although addition of roll bars may increase the height of the vehicle profile, commanders should consider such wartime modification to enhance the overall survivability of wheeled vehicles.

--"Leave brakes and transmissions disengaged." Damage to vehicles facing a blast will be less if you leave the brakes and the transmission disengaged to allow vehicle movement. This is generally true of tanks and armored and wheeled vehicles to include self propelled howitzers. Displacement of vehicles free to move is not expected to be large (several feet) compared to displacements of vehicles not free to move.

--"Remove doors, hoods, and trunk lids." Large sheet metal panels generally buckle or break away under blast pressures. Removing these panels prevents damage and relieves loading on adjacent areas.

--"Remove, cover, or tape glass." Obviously, windows, mirrors, head and tail lights, and instrument panel glass will shatter and become potential missile hazards. Removing or rolling down windows will help if the doors are not removed. Large sections of glass that cannot be removed can be taped (edges and diagonals) to reduce fragmentation. Head and tail lights and some instrument panels may also require taping (see figure 20). Clear or transparent tape can be used on instrument dials and indicators.

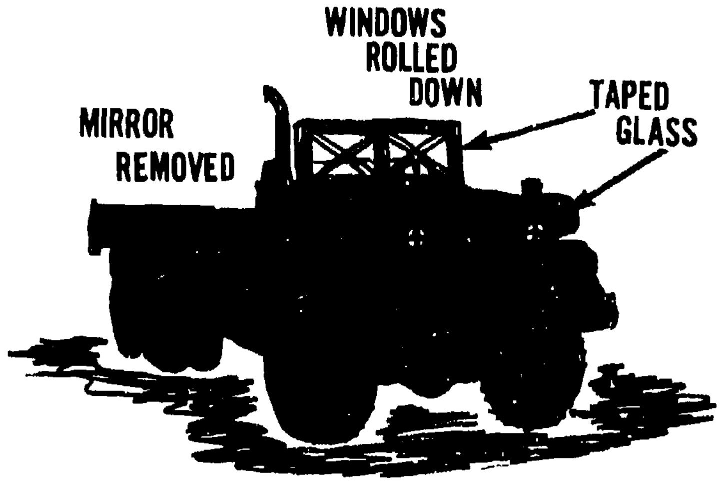


FIGURE 20. PROTECTING VEHICLE GLASS.

--"Protect critical areas of the vehicle." The fuel tank, radiator, and battery are particularly vulnerable to missile damage that can make the vehicle inoperable. Shielding these components with ordinary metal window screen and sturdy wire mesh material will provide good protection from missiling and sandblasting and also reduce the amount of thermal radiation received.

--"Anchor and/or tie down your vehicle and cargo." Wheeled vehicles and any cargo or shelters can be severely damaged if overturned by a blast wave. Anchors, tiedowns, and outriggers have been shown to nearly double the overpressure required to overturn wheeled vehicles. If the tiedown is secured to the top of the cargo or vehicle only, the blast wave may separate the vehicle frame from the bed. Ideally, the cargo or shelter tiedowns or straps should be passed completely around the vehicle frame and cargo, if any, and both the cargo and frame should be anchored to the ground. In general, removing cargo will enhance vehicle survivability.

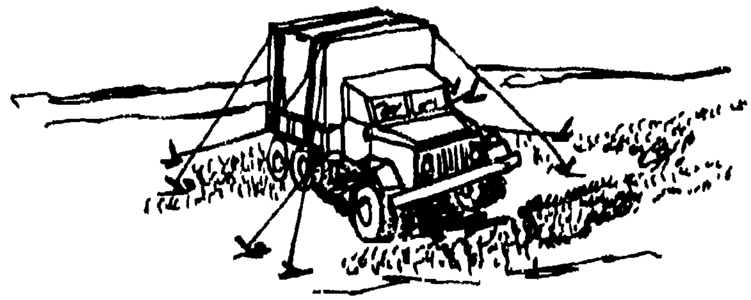


FIGURE 21. ANCHOR AND TIE DOWN VEHICLE AND CARGO.

--"Cushion and shock-secure sensitive equipment." Particularly shock sensitive pieces of equipment such as glassware, electronics, and optics can be further isolated from the shock by padding the items inside of packing crates, carrying cases, and storage racks. Some expedient padding materials include: loose dirt, styrofoam packing, air mattresses, inner tubes, and rolled blankets. Where possible, 2 to 4 inches of space should be left between van/shelter walls and equipment and equipment racks to protect against the shock produced by the rapid inward movement of the wall that can dislodge and damage equipment. Where provided, latches, catches, and panels securing equipment to mounting brackets and racks should be locked shut.

--"Protect vehicles in slot trenches." Slot trenches or natural depressions in the ground will provide valuable protection against blast, thermal, and radiation effects. The important objective is to lower the vehicle center of gravity down to or below the surface of the ground to reduce its susceptibility to turnover. The sides of the trench will also help to protect the tires and fuel tank from ignition by the thermal pulse and from damage by missiles (see Figure 22).

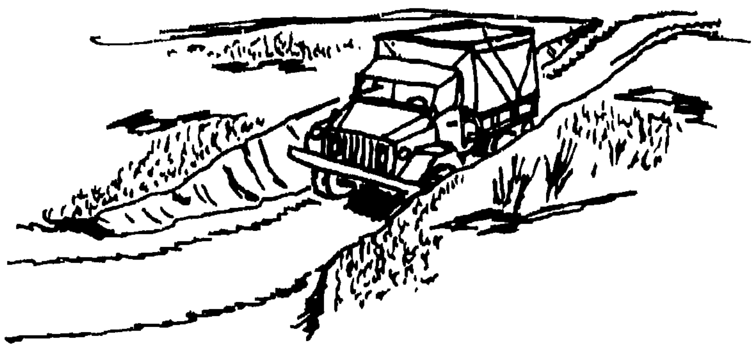


FIGURE 22. PROTECTION OF VEHICLES IN SLOT TRENCHES.

--"Do not park vehicles on asphalt." Asphalt surfaces may catch fire and burn as a result of the thermal pulse. Vehicles parked on an asphalt roadway or motor pool hard stand will be subject to fire damage. The tires and electrical and fuel systems appear most vulnerable to secondary fire damage.

--"Paint vehicle fuel tanks and tires with the lightest color of a camouflage pattern." Lighter colored or painted surfaces will absorb relatively less thermal radiation from a nuclear burst. The more vulnerable ignition points on a vehicle, such as the fuel tank and some tires, can be painted primarily with the lighter color of a multicolor camouflage paint pattern to reduce thermal effects.

--"Consider removing vehicle canvas and seats." Vehicle canvas and seat upholstery can be readily ignited by a thermal pulse and burn the cargo and vehicle. As in the case of tent canvas, the blast wave cannot be depended on to blow away the canvas or blow out the fire. Removing vehicle canvas and seats will reduce the possibility of a secondary vehicle fire. However, canvas may be left on vehicles to provide initial thermal protection for passengers or thermally sensitive cargo.

Aircraft (Airborne).

--"Gain distance." Given adequate warning of a pending nuclear attack, both fixed and rotary wing aircraft should turn away from the anticipated direction of the burst and fly away as fast as possible to beyond the announced Minimum Safe Distance (MSD). Initial nuclear and thermal radiation decrease at least with the square of the distance; for example, doubling your distance from the detonation, say from 1000 to 2000 meters, reduces the effect by a factor of four or more.

--"Remove doors and open windows." As the blast wave envelopes an aircraft, a temporary pressure difference is rapidly built up between the aircraft interior and its exterior which tends to crush surfaces inward. Aircraft plexiglass windows are particularly vulnerable to even the lowest of these overpressures, and doors can be buckled and become inoperable. Removing the doors and opening windows will help to equalize the pressure difference between the inside and outside of the craft and avoid the possibility of being unable to exit the aircraft readily if necessary.

--"Fly with sun visors down." Due to the intense brightness of the flash associated with a nuclear explosion, a temporary loss of vision may be encountered. Flash blindness is primarily a hazard at nighttime and should be of concern to pilots because of the probability of an aircraft crash if the pilot is temporarily blinded or incapacitated. At nighttime, increasing cockpit illumination in the event of a flash will compensate for general loss of night vision. However, aircraft flying nap-of-the-earth (NOE) flight levels in daytime will be particularly vulnerable to crash. Flying with at least one of the pilots with his sun visor down or one eye covered (an eye patch) will help provide for positive control of the aircraft in the event of a blast.

--"Tape window glass." Aircraft plexiglass windows will shatter creating fragments at low blast overpressures (1.5 psi) where no other significant damage will be expected. Taping the edges and centers of windows will serve to reduce the extent of fragmentation and the nuisance these fragments may cause to cockpit operations.

Aircraft (On the Ground).

--"Place aircraft in revetments." Although revetments provide little significant protection against blast overpressure and may in some cases magnify the blast effect, revetments and barricades will protect the aircraft from damage by dynamic winds and the impact of rocks, sand, and other aircraft or aircraft debris (see figure 23). The tactical situation may also require revetting for protection from conventional weapon blast and fragmentation damage.

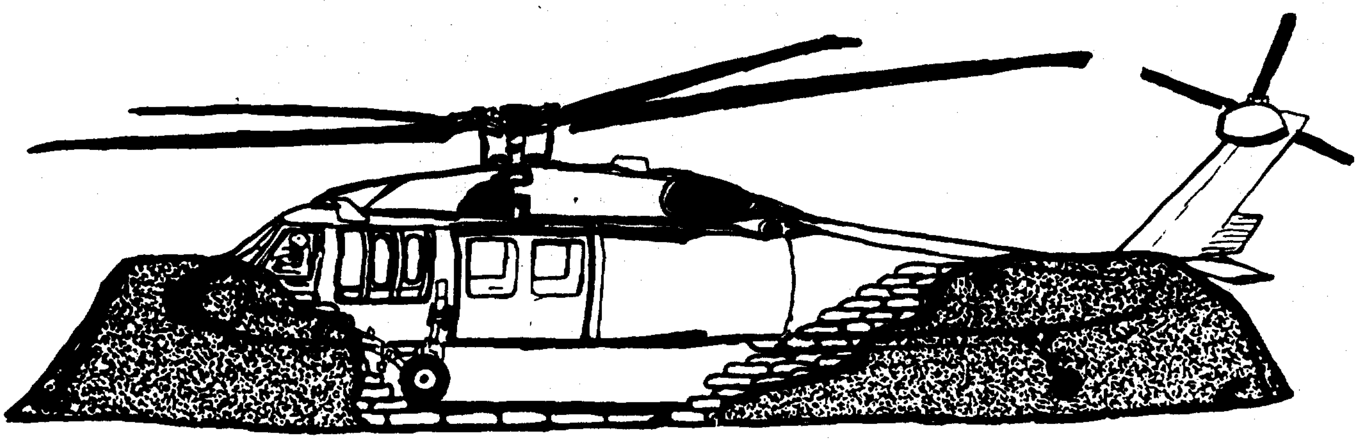


FIGURE 23. AIRCRAFT PROTECTED IN REVETMENTS.

--"Tie down aircraft." Tiedowns can also be effective in reducing blast damage due to translation or tumbling of the aircraft. Generally, tiedowns do not seem to produce excessive stress on tiedown points.

--"Cover exposed areas of the cockpit." Care must be taken to insure that in leaving doors and windows open to mitigate damaging overpressure effects, such openings do not expose compartment interiors to damaging thermal radiation. As a matter of routine, cockpits should be covered to protect interiors from thermal radiation. Covers will simultaneously provide valuable camouflage protection.

Communications and Electronic Equipment.

Tactical communications systems and components will be vulnerable to nuclear blast and thermal effects, as are other tactical systems. Further, the routine transportation, storage, and operation of communication equipment in or on wheeled vehicles suggests that mitigation techniques valid for wheeled vehicles are applicable to most mobile communications systems. In addition, such equipment requires EMP protection.

a. Blast and Thermal Mitigation Techniques.

--"Cover wires and cables." Surface and overhead cables and wires are susceptible to blast and thermal damage. Covering (not burial) with even 1 inch of earth will significantly reduce the combined blast and thermal damage and insure survival of field wire and cables at distances from the burst where wheeled vehicle mounted terminal equipment will be moderately damaged.

--"Turn radar disks and horn antennas away from the blast." As might be expected, radar disks and horn antennas are more seriously damaged/deformed if set facing the blast wave. Radomes or antennas oriented side- or rear-on to the blast wave should not be damaged at the same blast overpressures where the face-on equipment orientation will be seriously damaged.

--"Leave covers and wrapping on wire and cable reels." Exposed wire on reels can be severely damaged by direct thermal radiation while wire on reels wrapped, even in paper, will suffer negligible thermal damage despite burning of the paper.

--"Protect generators and other support equipment." Don't forget that generators are essential to the operation of most communications systems and must be provided an equivalent level of protection. Digging in below ground level or revetting will normally provide adequate blast and fragment protection. (It will also muffle their sound and aid in avoiding detection.) The hole should be at least one and one half times larger than necessary to accommodate the generator to provide adequate ventilation and avoid burning up the generator motor. The fuel tank should also be placed in a separate hole to help prevent damage to the generator if the fuel is ignited (see figure 24).

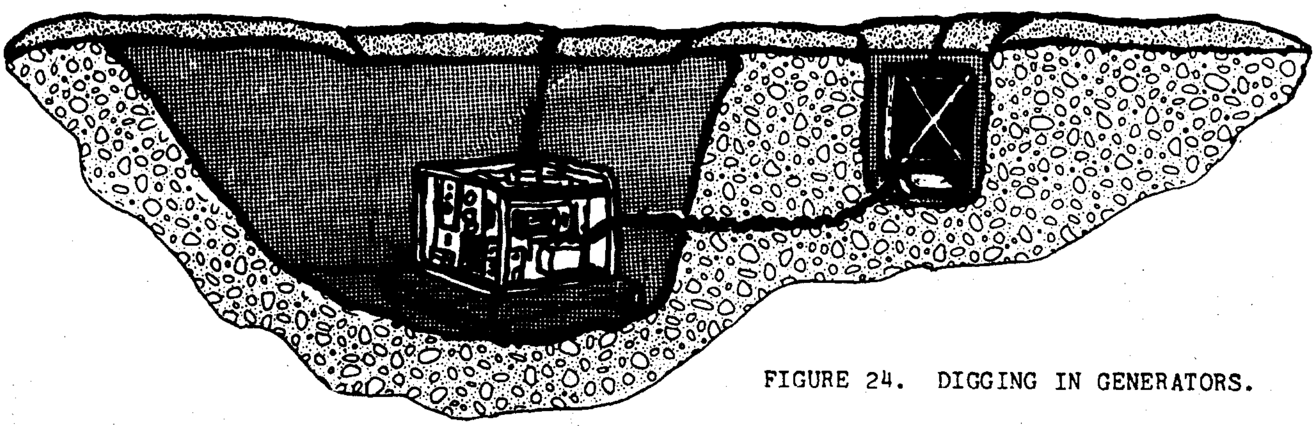


FIGURE 24. DIGGING IN GENERATORS.

b. EMP Mitigation Techniques.

Mission essential tactical radios will continue to be operated before, during, and after a nuclear attack. Most tactical communications systems will be subjected to some degree of risk from either the long range EMP effects of a high altitude nuclear burst or the shorter range EMP from a low air burst. Some EMP-induced communications equipment failures can be expected at troop safety ranges for "warned, exposed" soldiers; a lesser degree of risk can be anticipated beyond safety distances for "unwarned, exposed" troops, depending on the type of equipment. Remoting radios adds length of cable which can result in collection of additional EMP energy. Response of specific operating systems is discussed in Appendix D, FM 101-31-2 (SECRED RESTRICTED DATA), and information on available EMP-related product improvements can be obtained from this agency, ATTN: MONA-WE.

--"If the mission permits, you should as a general rule remove exterior conductors." As shown in figure 25, EMP can couple with external metal conductors even if they are covered with insulation. Examples of potential EMP conductors include: (1) All types of radio antennas; (2) any wire or cable connections to include handset, external speaker and headset cables, power cables, computer interface connectors, rechargers, telephone lines, field wire, and extension cords; and (3) other metal conductors such as pipes, ducts, and fences. When use is not essential, such conductors should be disconnected or removed to prevent EMP-induced currents from being transmitted into the piece of equipment and damaging critical components (burnout) or upsetting the equipment by blowing fuzes, tripping circuit breakers, and garbling computer memories.

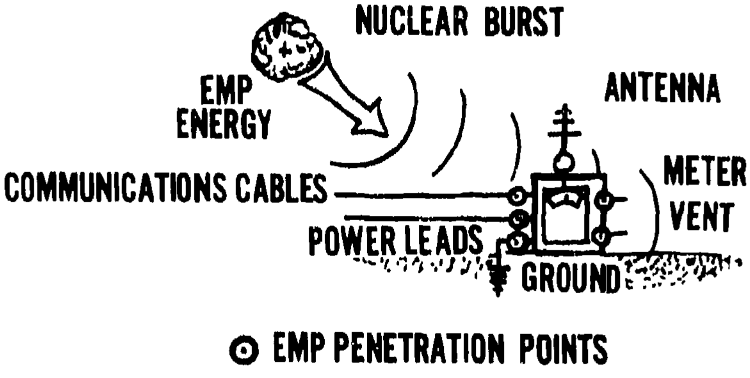


FIGURE 25. EMP COUPLING POINTS.

--"Use ultra high frequency (UHF) and super high frequency (SHF) communications equipment in preference to VHF equipment when possible." Communications equipment operating at UHF and SHF (225 MHz and higher) is less sensitive to EMP damage than VHF and HF (2 to 225 MHz) equipment.

--"Avoid the use of broadband radios." Radios operating at frequencies below UHF are particularly sensitive to EMP. Broadband radios will receive greater voltages and currents from EMP than will narrowband radios.

--"Shut down and protect unneeded and redundant radio systems." To provide "high assurance" that unit tactical field communications will survive EMP, any nonessential and redundant radio systems and equipment should be shut down and protected from the EMP.

--"When possible, use antennas that have small radiating elements." The smaller the radiating elements, the less EMP energy will be picked up and consequently the less is the susceptibility of the associated equipment to EMP. Wide-angle doublet or omnidirectional antennas such as the RC-292 should be avoided. Long wire field expedient or AT-984-directional antennas are good collectors of EMP energy.

--"Keep cable and wire runs as short as possible." The longer the run, the greater the EMP energy that will be collected by the cable and transmitted into the equipment to which it is attached.

--"Keep cable runs as straight as possible - AVOID LOOPS." Loops or bends in cables represent potential unintentional loop antennas that will pickup more EMP energy than straight runs. This is especially important for shorter, intrasite cable runs and is true even for ground cables.

--"Keep cables and wires on the ground where practical to do so." Elevating cables and wires may increase the EMP-generated voltages and currents. (Burying cables and wires a few inches or even a foot does not provide a significant added degree of EMP protection.)

--"Use shielded twisted pair cables where options in use of cable exist." Twisted pair cables pickup significantly less EMP energy than do coaxial or unshielded cables. However, such reductions with shielded twisted pair cable can be obtained only if the cable and shields are properly connected and terminated at both ends.

--"Shielding is effective for EMP." Electrical and electronic equipment can be protected from the effects of EMP if placed in a totaly enclosed electric shield. Ideally, this shield should be made out of metal (steel or aluminum); for most tactical radios the fully closed metal case will provide adequate protection if all external conductors have been removed. Metal ammunition cans and propellant charge cans make excellent storage containers for smaller electronic items such as handheld calculators and radio components. Items can be effectively protected by placement in armored vehicles, vans, and underground shelters. Wrapping in metal foil will also provide a lesser degree of protection for smaller items that do not have their own metal case such as circuit boards and electrical components. Burial is not recommended since items would have to be placed under at least 10 feet of earth to be adequately protected.

--"An effective EMP shield requires that all openings be closed with metal covers." EMP may enter a shield through any opening. Metal vans and shelters provide excellent all-around shielding as long as doors, windows, vents, and cable access ports are kept closed. Command posts consisting of a number of adjacent wheeled vehicles and tents should avoid "platform" configurations where side or rear doors are permanently left open solely for convenient passage from one vehicle to another.

--"Maintain your EMP shields and shelters." If for some reason the equipment is not needed for a period of time, disconnect the external cables (power, information, and antenna) and button up the unit. In this configuration, vulnerability has been reduced or eliminated. At all times, whether operational or nonoperational, <u>keep all doors and access panels closed</u>. The integrity of shields/shelters and therefore shielding effectiveness can and does deteriorate with time and usage. If it is maintained, a significant level of protection can be obtained. The types of maintenance required are:

1. Where gasketing and finger stock are used around doors, vents, etc., maintain clean metal contact and, if possible, replace the gasketing and finger stock if it becomes damaged, loose, or makes poor contact.

2. Check and repair, if necessary, the connection of cable shields at connectors. Good connections are mandatory.

3. Insure that any new cables brought into the enclosure have the cable shields terminated at the entrance to the enclosure. The termination should provide good peripheral connection to an electrically bonded entry panel.

4. Keep all access panels and other apertures closed except when they must be removed for maintenance.

5. Eliminate or minimize cable loops whenever possible and keep cable runs as short as possible.

6. Maintain power systems filters. Check periodically for proper installation and repair or replace if necessary.

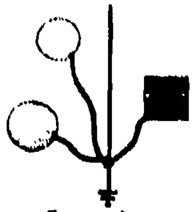
7. Check and repair any holes in the skin of protective shelters or vans.

--"Cable entry panels should be electrically bonded to the metallic shelter/shield." This can be achieved through approprate electromagnetic gasketing. This also should be maintained and checked for corrosion and bolt torque.

--"Keep exterior grounds short and of low impedance." Exterior grounds can be a source of current collection and thereby increase EMP pickup. Exterior grounds should therefore be as short as possible and be designed to be of low impedance (a good conductor). Use the maximum diameter of cable permissible; stranded cable provides better (lower) impedance than solid cable, and straps are even better.

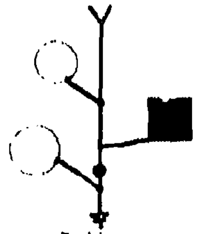
--"Establish good exterior grounds when possible." Good exterior grounds can lessen system vulnerability to EMP. Good grounding procedures are also of primary concern for system operations and safety.

--"Use a common ground for equipment." A common ground avoids creating inadvertent ground-loop antennas between van interconnections, individual grounds, and the earth. Several of the accepted grounding configurations are shown in figure 26a. Since the classical "Star" or "Crow's Foot" is not practical in large facilities or field complexes, it can be replaced by a "Tree" system as shown in figure 26b. The "Tree" system is a combination of shielded areas (rooms or shelters), each utilizing a classical "Star" system ground, for signal reference and local hazard, with the local shields grounded to the main structure ground. These zone grounds are for safety grounds only, and signal grounds are isolated by the area shield connections. These grounds may be obtained by ground buses or by grounding directly to the conducting structure depending on the facility geometry. Signal connections between areas must utilize wired returns and not provide additional ground paths between area shields.



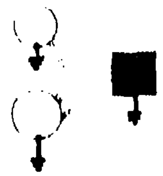
Crow's Foot
(Single Point)

"Crow's Foot" or "Star" (single-point) is the preferred choice since it minimizes coupling in the ground connections.



Fishbone
(Ground Bus Single Point)

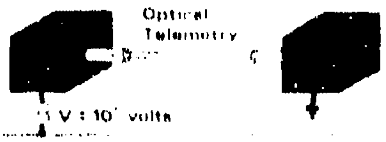
Fishbone -- the lower frequency (higher sensitivity) circuits should usually be at the far end, where ground currents are lower.



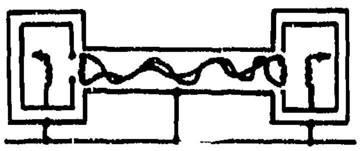
Multi Point

Multipoint -- the least desirable due to the opportunities for ground loops and common impedance IZ_{common} voltage rises.

Recognized Geometries



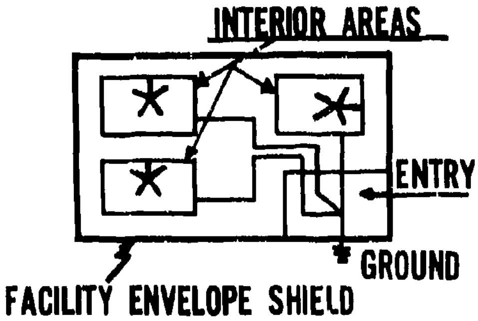
Floating



Floating grounds -- often employed where a single-point ground is impractical and where a multipoint system could cause trouble. Here, each subsystem case assumes its own potential without ill effects, provided that good isolation (common-mode rejection) is realized.

a. CONNECTING TO GROUND.

FIGURE 26. GROUNDING CONFIGURATIONS.



b. "Tree" SYSTEMS.

FIGURE 26. GROUNDING CONFIGURATIONS.

--"Insure all antenna guy lines are properly insulated." If not properly insulated, antenna guy lines will collect additional current that will be directed through the antenna to the radio equipment.

--"Avoid the use of commercial sources of power." Commercial power systems and long haul power grids are more susceptible to EMP damage than mobile power generators because the longer runs of overhead commercial power lines will collect larger EMP currents.

--"Keep a supply of critical spares." If possible, keep a supply of critical spare electronic components and small electronic items (such as fuzes and circuit boards) to quickly replace and/or repair EMP-damaged equipment. In most cases, replacing the whole unit can only be accomplished once; this procedure is not a viable alternative to good operational and maintenance protection measures.

Computers and Data Processing Equipment.

Blast and thermal radiation may damage computers that are also potentially vulnerable to both EMP and TREE. The EMP energy is picked up by the internal components of the computer and can cause system upset, permanent or temporary loss of memory, or damage. Exposure to relatively low levels of nuclear radiation can also permanently damage solid state components.

--"Store duplicate data tapes at two separate locations." Redundant disk, drum, or tape storage further protects critical data from loss not only to nuclear blast effects but also to conventional attack. Data can then be "bused" or copied directly after the attack.

--"Store critical information and programs on drums, disks, or tapes." Most digital memory systems are potentially susceptible to memory upset and erasure of the core memories. Drum, disk, and tape systems on the other hand are relatively hard to radiation. An EMP can then erase only a small fraction of the recorded information immediately under the recording heads.

--"Reload your programs." Because of the potential vulnerability of core memories to TREE-induced systems upset, both programs and data inputs should be reloaded after a nuclear attack.

--"Shield handheld calculators and constant read only memories (CROMs) from EMP." Handheld calculators and CROMs should be used in vans and shelters when possible and further protected in ammunition cans and metal foil when not in use. Replacement calculators and CROMs should be maintained and protected as indicated above.

Bridges.

--"Construct bridges with extra wide (up to 1 meter wide on each side) piers and abutments." Prefabricated bridging sections can be blown or slid off their piers at distances from the blast where the sections are essentially undamaged from other effects. Extra wide piers will accommodate additional displacement of the sections.

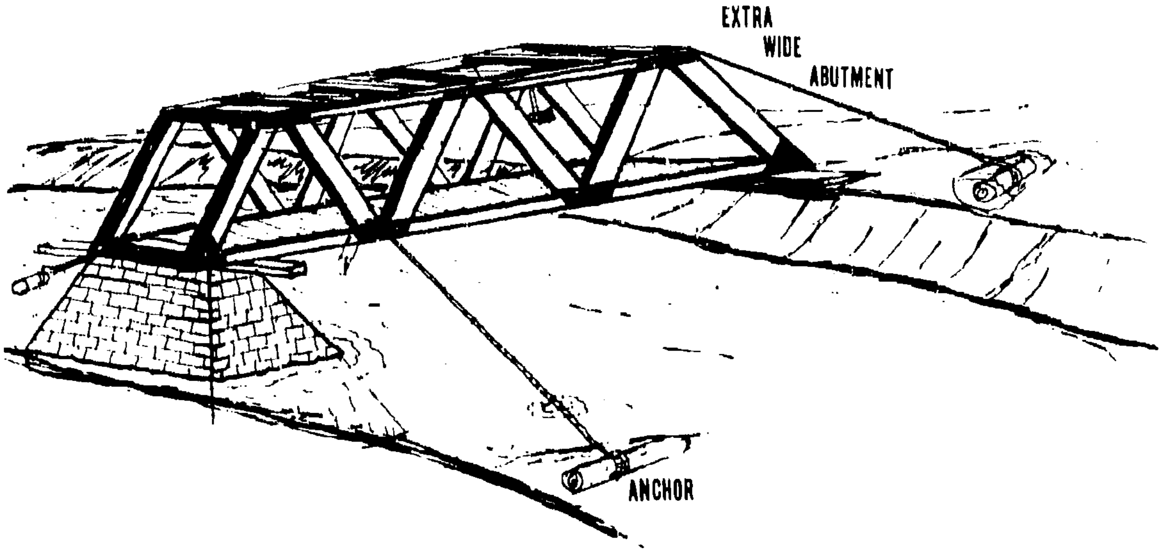


FIGURE 27. PROTECTING BRIDGES.

--"Anchor truss bridges." In some cases the blast wave can have a significant upward component which can lift the upwind side of a bridge causing the entire bridge to act as an airfoil and to become airborne. The intrinsic weight of many bridges will not prevent lifting and displacement. Anchoring truss bridges to piers is not desirable because these bridges need to skid to relieve airblast stresses. Earth anchors using cables that "give" under a certain tension to prevent excessive displacement and stressing of the bridge are recommended.

Petroleum, Oil, and Lubrication (POL) Supply Equipment.

Obviously, fire is the primary threat to bulk POL storage and handling installations and equipment. However, the thermal pulse is not the main cause of such POL fires. Most of the irradiance is complete before the blast wave can rupture or damage POL containers and cause leakage. The most likely cause for POL fires is contact of the fuel with the ground surface or debris that has been heated and left smoldering by the thermal pulse.

--"Keep POL containers low." The most effective means of protecting fuel storage containers is to place them in a trench or pit just below the surface of the ground. Exposure to excessive translation forces and the missiles and debris that can rupture the containers is reduced, as is the initial exposure to the thermal pulse. More importantly, leakage of the total volume of POL in the container can be confined in the hole, preventing fuel from coming in contact with ignited debris in the area. The top of the container should be protected from initial thermal radiation and smoldering debris that may be blown onto the container. A thin layer of earth (1 to 4 inches) or sand bags is recommended (see figure 28).

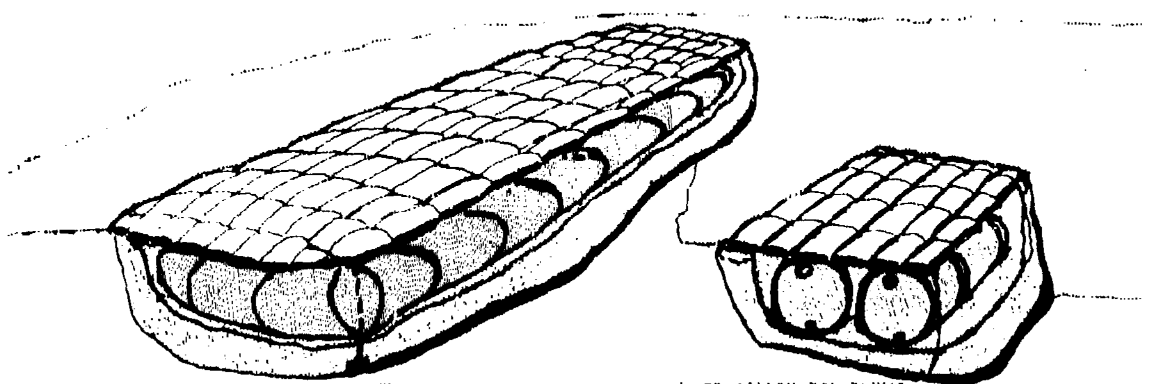


FIGURE 28. PROTECTING POL BULK STORAGE CONTAINERS.

--"Control fuel runoff." As a minimum, trenches or troughs should be dug around aboveground fuel tanks to direct runoff away from inhabited areas or potential ignition sources such as trees, wooden buildings, or other fuel stacks or containers. This runoff should eventually be collected in a sump to confine the spill and reduce chances of being ignited by secondary fires.

--"Clear the area of potential kindling material." Ideally, underbrush, trees and dried leaves which could become potential ignition points for spilled fuel should be cleared away from the fuel containers. The area around fuel tanks and stacks can also be kept wet to reduce surface heating. Remember that ground cloths, covers, ropes, and wooden pallets are also potential ignition points if not shielded from thermal radiation. Storage in holes or trenches where possible is still the best idea. However, covering with a 1- to 4-inch layer of earth will provide some valuable thermal protection as will the general use of fire-resistant camouflage nets.

--"Secure stacks of fuel drums and cans." Banding together and tying down stacks of 55-gallon drums and 5-gallon cans will help prevent breakup and scatter caused by the blast winds and reduce the threat of impact with other solid objects or personnel.

--"Store fuel stacks and containers in revetments." Storing fuel stacks and containers in revetments provides an alternative to the more desirable but time-consuming belowground storage in holes or trenches. Revetments will significantly restrict movements of drums and cans as well or better than tiedowns and will also protect against missiles and confine some fuel spills.

WHAT CAN BE DONE DURING A NUCLEAR ATTACK?

An enemy nuclear attack will no doubt come without warning. The first indication you will have will be a very intense light followed by extreme heat. Initial radiation comes with the light and the blast wave and hurricane-like winds follow within seconds. There will be little time, possibly a second, to take protective actions. Individual protective actions must therefore be automatic and instinctive. Here is what can be done.

In the Open.

--"Immediately drop to the ground!" The chances of your being blown about or displaced by a blast wave depend on the exposed cross sectional area of your body. In a prone, head-on or foot-on position you have reduced this cross sectional area to about 15 percent of the standing-facing posture. Average displacement can be reduced by a factor of about three for a side-on orientation and by a factor of about 17 for a prone, head-on orientation. Evidence exists that prone, head-on personnel will not be displaced significantly at peak overpressures below 14 psi. The prone, head-on position may also have advantages over the feet-first position. Head and body injuries are the primary concern when the body impacts against a solid surface. A head-first position would increase the chances of impacting feet-first, at least for short distances of up to 10 to 15 feet. Beyond this distance tumbling occurs.

--"Protect your eyes and exposed skin areas." Your eyes, face, neck, and hands will be especially vulnerable to injury from the dust, sand, and debris blown by the blast wave. Your first reactions should include covering the eyes and face with your hands. This can be accomplished after you have dropped face-down to the ground or have assumed a position as low as possible in your covered position, shelter, or vehicle by putting the palms of the hands over the eyes and face and keeping the arms protected under the body. Obviously, try to keep your hat or helmet on.

--"Protect your ears." If possible, you should also attempt to cover the ears to help prevent eardrum rupture or hearing loss while still protecting your eyes and face. One possible, but somewhat awkward, method of simultaneously protecting your eyes and ears, is to cover the eyes with the palms of the hands and then using the fingers or thumbs to cover the openings to the ear canals.

--"Stay down." Even after the initial shock wave has passed, the immediately following violent winds will pick up rocks, branches, debris, dust, equipment, and even barbed wire, creating missiles which can cause personnel injuries (see figure 29). Wait for the winds to die down and the debris to stop falling before getting up.

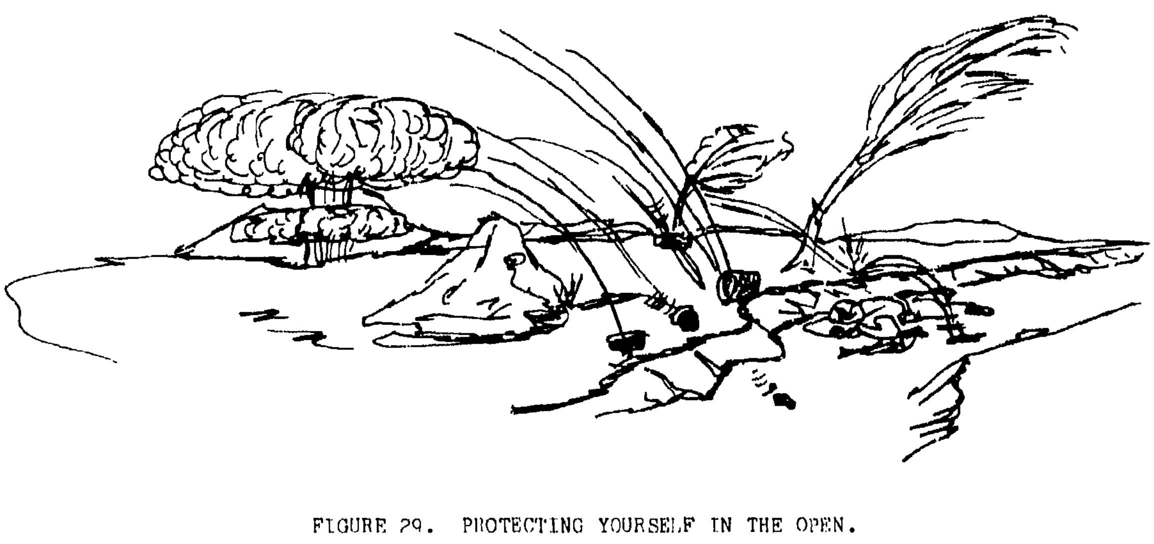


FIGURE 29. PROTECTING YOURSELF IN THE OPEN.

--"If you can count to five, you'll stay alive." Generally speaking, if the blast wave does not arrive within 5 seconds after the flash, you were far enough from the burst that the initial radiation exposure will not exceed 150 rads. Of course, if you were protected from radiation at the time of the burst (e.g., in an armored vehicle, foxhole, or shelter), this dose will be significantly lower. Now is the time to stay calm, check for injury, check weapons and equipment for damage, improve your cover, and prepare to continue the mission. Counting to 5 seconds (one thousand one, one thousand two, etc) will also provide some indication of flash-to-bang time which can be useful for later calculations of the estimated yield of the nuclear weapon detonated. Of course, this should not detract from the more important actions to protect yourself.

In a Foxhole.

--"Get as low as you can as fast as you can." Obviously, the lower you get in the foxhole the more earth you put between you and the burst. As previously discussed, lying on your back or curling up on your side in the bottom of the foxhole seems to be the best position. Protecting your eyes from dust and debris and your ears from overpressure with the palms and fingers or thumbs of your hands still makes sense in a foxhole.

--"Stay down." While the blast winds are still blowing debris and rocks along the ground, the best place to be is in the bottom of your foxhole. Wait until the winds have calmed and the debris has stopped falling to sit up and consider leaving. Normally, after about 90 seconds the greatest danger from the thermal radiation, the blast wave, initial radiation, and probably from falling debris will be over.

In a Shelter or Building.

--"Dive for cover." If a nuclear flash is observed, dropping to the floor and better yet under a desk or table is simply taking advantage of the best cover available.

--"Avoid windows and doors." As a minimum you should dive out of the way of any windows or doors. Tests have shown that window glass tends to be driven straight in even from oblique nuclear blast angles, so any position off to the side is safer. Of course, diving out of any inward air flow is also important to minimize the possibility of your being translated or burned by the blast winds and debris (See figure 11).

In Tanks and Armored Vehicles.

--"Brace yourself." Head and shoulder injuries from being thrown against the inside of the hull will be the biggest problem. Bracing yourself will help. It will be too late to remember where you put your helmet or whether you fastened your seat belt and shoulder straps.

--"Stay buttoned up." Your tank is as good a shelter as you will find for the time being.

In a Wheeled Vehicle.

--"Get outside." In most cases you will be safer lying prone in the open than inside of a wheeled vehicle when the blast wave hits. Some thermal protection may be provided by the vehicle initially, but the blast wave will rapidly follow and can turn over or roll the vehicle. If the flash is detected, you may have a second or seconds to dive from the vehicle to a face-down, prone position. Dive in the direction of the flash to avoid the vehicle if it overturns when the blast wave arrives. If you cannot get out, get low, brace yourself, be prepared for a rough ride, and hope that you have properly secured yourself and any onboard cargo, equipment, or furnishings (e.g., desks or tables in command, control, and communications vans and shelters).

In an Aircraft.

--"Gain altitude." Pilots should attempt to gain as much altitude as possible since the probability of aircraft survival is based on altitude. The greater the altitude of the aircraft, the longer the pilot has to prevent a crash. Pilots should immediately cease flying nap-of-the-earth (NOE) flight levels in order to gain altitude and possibly distance from the burst. Gaining altitude will also take the aircraft out of the more severe dust, debris, and missile environment close to the ground (see figure 30).

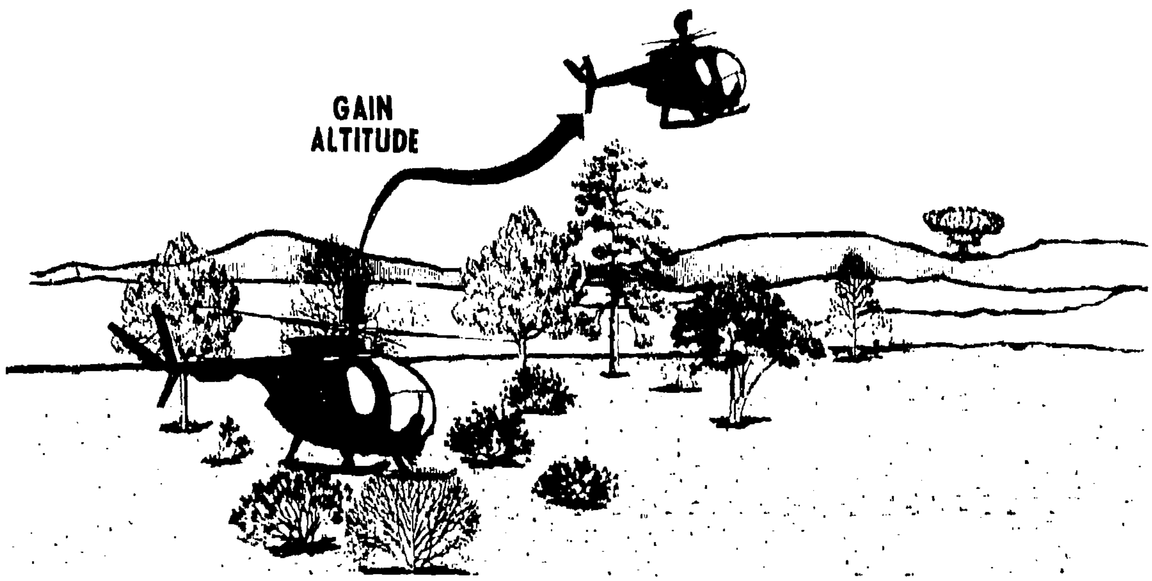


FIGURE 30. PROTECTIVE ACTIONS FOR AN AIRCRAFT.

--"At night, increase cockpit illumination and prepare to fly by instruments." Flash blindness is primarily a nighttime problem. During the first few seconds after the burst, the intense light from the fireball will brightly illuminate the surrounding terrain and the interior of the aircraft. Now is the time to orient oneself with respect to the ground and any obstacles, turn up cockpit illumination to compensate for loss of night vision, and begin flying by instruments.

--"Head-on is better." As might be expected, head-on to the expected burst reduces the area of your aircraft on which the blast wave will impact and therefore the aircraft vulnerability.

In a Tent.

--"Get outside." Except for initial thermal protection, your tent provides little or no protection from nuclear effects. In fact, the subsequent fire hazard creates an additional threat to personnel if the fire is not blown out or the tent carried away by the blast winds. Getting out of the tent and later extinguishing any fires are essential.

WHAT CAN BE DONE IMMEDIATELY AFTER A NUCLEAR ATTACK?

Immediately after a nuclear attack is the time when several actions, if planned for and taken soon after the burst, can reduce the eventual effects of the detonation on yourself and your equipment.

Things To Remember.

--"Stay down and/or under cover until the debris stops falling." While the blast waves are still blowing debris and rocks along the ground, the best places to be are prone on the ground, in the bottom of your foxhole, or buttoned up in your armored vehicle or shelter. Normally, after 90 seconds the greatest danger from the thermal radiation, blast wave, initial radiation, and probably falling debris will be over.

--"Stay calm." The violence of the blast winds, personal burns or injuries, dazzle, and possible concern over radiation exposure may combine to make it seem impossible to stay calm. But remember:

1. The blast winds will generally end in 1 to 2 minutes after the burst.

2. Your burns, cuts, or bruises are no different than conventional injuries.

3. Dazzle is temporary, and vision should return in seconds.

4. If you have survived the blast, the chance of being exposed to an eventually lethal dose of radiation is relatively small unless you are located in an early fallout area.

5. In terms of ground distance, only 200 meters separate the 1 percent and 99 percent lethality distances for radiation.

--"Consider your options before you move." Now is the time to consider how best to secure and organize equipment, repair and reinforce your position, assist casualties, and begin to prepare or improve protection against possible fallout.

--"Things may look different." The blast wave may blow down and carry away many prominent and familiar terrain features such as trees, rocks, and underbrush and displace or overturn equipment and vehicles (see figure 31). There may also be many small fires in the area and some smoke and dust. You should expect some initial disorientation and not become alarmed if the medical aid station or latrine is not where you last saw it. Aircraft pilots flying VFR can also expect terrain modification and may need to reverify their positions prior to entering a nuclear blast area.

FIGURE 31. TERRAIN MODIFICATION BY THE BLAST.

Things To Do.

--"Beware of weakened structures and trees." Damaged structures and trees may remain standing after the blast. Movement of personnel and operation of equipment such as armored vehicles or large caliber weapons may shake loose additional debris, collapse walls, and topple large trees and branches. Helicopter rotor blade "down wash" could also bring down shattered trees and severed branches during takeoffs, landings, and NOE flights endangering not only the aircraft but also personnel on the ground.

--"Put out fires before they spread." Secondary fires caused by smoldering debris, overturned stoves and heaters, and damage to electrical wiring will be the immediate fire hazard resulting from the burst. Quick action to extinguish or eliminate these initial fires will preclude having to fight large-area fires later.

--"Right overturned vehicles as soon as possible." Surprisingly, much of the serious damage caused by overturning a wheeled vehicle consists of loss of its coolant, fuel, and battery fluids. Generally, from 1/2 to 2 hours of organizational maintenance will be required to restore these moderately damaged vehicles to combat use. However, if an overturned vehicle (nondiesel) is not righted quickly (i.e. within 30 minutes), oil can seep between the piston and cylinder walls into the firing chambers and prevent piston movement when the truck is righted. Removing the spark plugs and cranking the engine will then be necessary to release this hydrostatic lock.

--"Field strip and clean weapons." Weapons systems can become unserviceable beyond the limits of blast damage due to sand blown into gun bores and mechanisms. Field stripping and cleaning may be required before firing.

--"Re-lay artillery pieces." You can expect that at distances from the burst beyond where howitzers, guns, or launchers will be moderately damaged or inoperable, some displacement will occur. Re-laying and registering may be necessary before executing the next fire mission.

--"Look before you move." If the situation allows, you should inspect tracked vehicles for damage and any debris that may have blown into the tracks or under the hull. Some of this debris could include trees, radios, weapons, ammunition that could explode if crushed, and even injured personnel (see figure 32). Of course, armored vehicles placed over foxholes should not be moved until after personnel have evacuated the hole, in case the blast weakened walls collapse during movement.

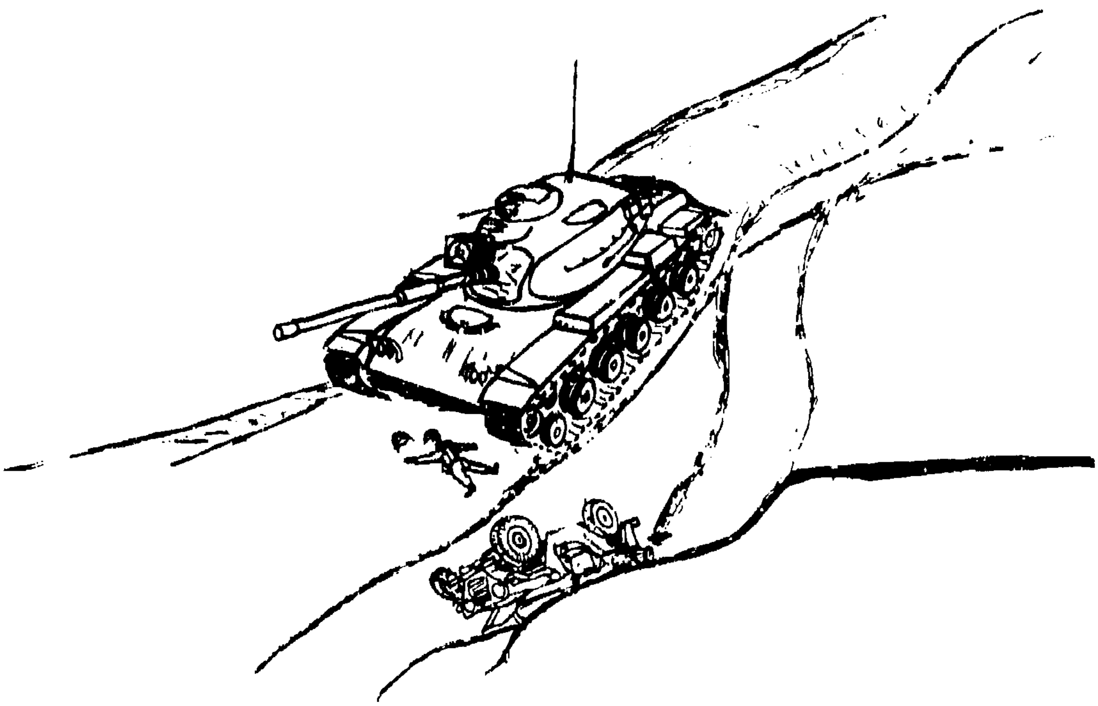


FIGURE 32. LOOK BEFORE YOU MOVE.

--"Small debris is also a problem." Masses of pine needles, dust, and leaves created by the blast may be sucked into the intakes of helicopters during takeoffs, landings, and flights at NOE altitudes. Ventilation and collective protection devices, if not protected by screens and particle separators, may also be clogged with small debris and blower motors burned up.

--"Improve your cover if possible." You cannot rule out the possibility that enemy or friendly forces will employ additional nuclear weapons or that you may receive fallout from the first attack. Improved cover is still the best protection from both initial and delayed effects. As a minimum, foxholes and shelter openings should be covered (e.g., by a shelter half) to prevent the entry of fallout particles.

WHAT MUST BE DONE TO RECOVER FROM A NUCLEAR ATTACK AND HOW ARE OPERATIONS CONDUCTED IN A NUCLEAR ENVIRONMENT?

"Post attack recovery" and "continued operations in a nuclear environment" are being examined by USANCA as possible subjects for additional Nuclear Notes. If you have any suggested mitigation techniques or issues that could be considered in discussing either of these areas, you are invited to forward them to:

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