Chapter 4

Nuclear Protection

This chapter discusses aspects of nuclear protection that can be accomplished before, during, and after a nuclear attack, enemy or friendly. Soldiers on the battlefield must make defensive preparations to protect themselves. A soldier's NBC defense training is extremely important, as is the use of terrain and shelter.

Terrain Use

By knowing how terrain affects nuclear weapons, soldiers can greatly reduce the risk of becoming casualties. With training and practice, they can learn to recognize defensive positions that will give them optimum protection against a nuclear blast.

Hills and Mountains

Reverse slopes of hills and mountains give some nuclear protection. Heat and light from the fireball of a nuclear blast and the initial radiation tend to be absorbed by hills and mountains. What is not absorbed deflects above the soldiers because of the slope.

Depressions and Obstructions

The use of gullies, ravines, ditches, natural depressions, fallen trees, and caves can reduce nuclear casualties (see Figure 4-l). However, predicting the actual point of an enemy attack of a nuclear weapon is almost impossible. A friendly strike provides the soldier more time to prepare. The best protection remains an area below ground with some sort of overhead cover.

Obscuration

In an active nuclear environment or when the threat of nuclear weapons use is high, smoke can be used to attenuate the thermal energy effects from nuclear detonations. Chemical smoke units can provide this asset to a commander if they are available. For further information on the application of smoke on a nuclear battlefield see FM 3-50.

Actions Before an Attack

The actions taken before an attack are most critical because they will increase the unit's survivability to the greatest possible extent. These actions range from selecting the right shelters, fortifying those shelters, and protecting vital equipment, to using equipment to increase survivability. These actions and good prior planning will increase unit survivability.

Shelter Selection

Whenever the tactical situation permits, prepare unit defensive positions. These vary from individual fighting positions to improved defensive positions. In a nuclear environment, fighting positions and improved positions

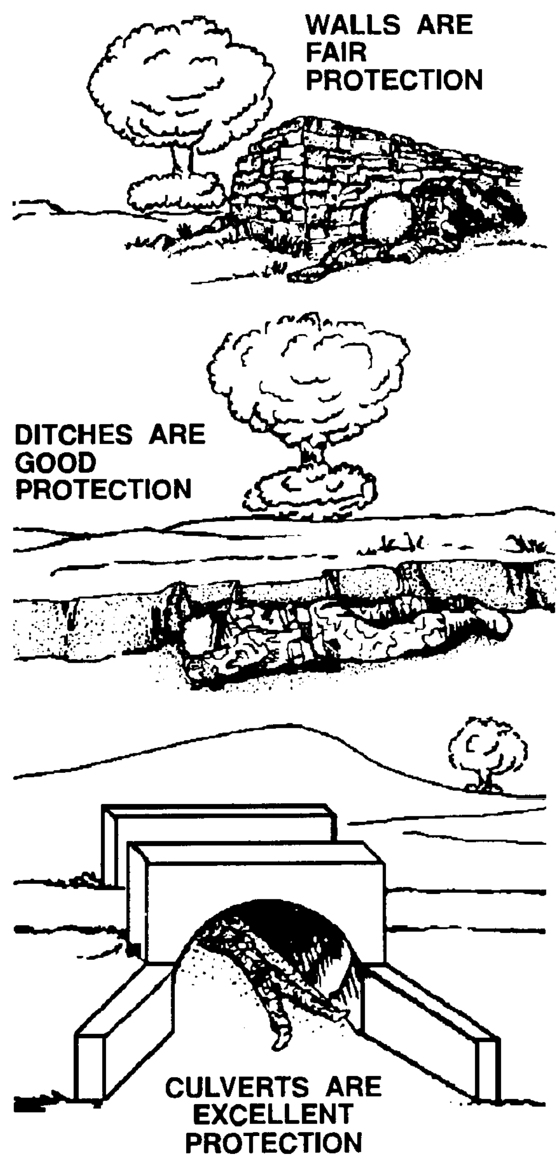


Figure 4-1. Expedient cover against blast and thermal effects.

protect against nuclear effects. Primary concern should be shielding from gamma and neutron radiation. Gamma radiation protection requires thick layers of dense or heavy shielding material. Examples are lead, iron, and stone. On the other hand, light, hydrogen-based material gives good neutron radiation protection. Examples are water, paraffin, and oil. These materials absorb neutrons, and additional gamma radiation results. Shielding must be provided against this secondary radiation. Generally, the thicker the layers of each type of shielding material, the better the overall radiation protection. The next paragraphs discuss protection against nuclear effects.

Foxholes

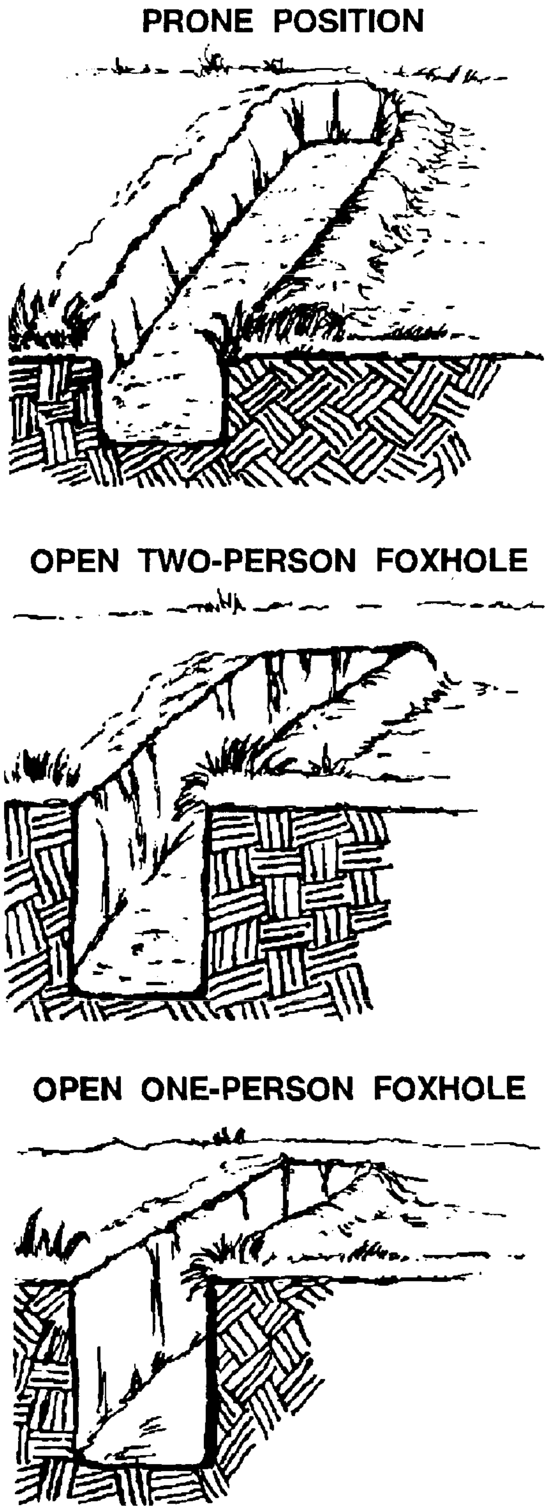
Digging in provides the best nuclear defense. This is because earth is a good shielding material. A well-constructed fighting position gives excellent protection against initial nuclear effects. It can also reduce residual radiation (fallout). Figure 4-2 shows examples of fighting positions that give good protection.

Soldiers must harden their foxholes/fighting positions against the blast wave as time permits. Lining or revetting foxholes can significantly increase survivability and decrease the size of the opening into the position. Smaller openings allow entry of less initial and residual radiation. However, many metal surfaces are good thermal reflectors. Cover these surfaces to prevent increased danger of burns from the heat of nuclear blasts.

The smaller the foxhole opening, the better. Most of the gamma radiation in the bottom of a foxhole enters in through the opening. The smaller opening of a one-person foxhole reduces gamma radiation two to four times below the amount a two-person foxhole allows to enter.

A deep fighting position or foxhole gives more radiation protection than a shallow one. It places a greater thickness of shielding material or earth between the occupant(s) and the nuclear detonation. Therefore, it provides greater reduction of initial radiation from entering the hole. In a two-person fighting position, radiation reduces by a factor of two for each 16 inches of foxhole depth. Therefore, a fighting position at depth of 4 feet provides six to eight times the protection than a shallow one.

Thermal radiation can reach soldiers in foxholes by line-of-sight exposure or by reflection off the sides. Use dark, rough materials to cover potential reflecting surfaces and as protective cover for soldiers and equipment. Examples are wool (such as blankets) and canvas (such as shelter halves). Remember that thermal exposure may still bum or char these materials. Avoid direct contact with them. Do not use ponchos or other



Caution:
Do not use ponchos or other rubber or plastic materials alone as foxhole covers.

Figure 4-2. Fighting positions that provide good nuclear protection.

rubber or plastic materials alone as foxhole covers. These items might melt and cause burns. Simply covering a foxhole with ordinary metal screening material blocks the thermal radiation by about 50 percent. Use this screening for thermal protection without entirely blocking soldiers' view through ports. Soldiers must cover exposed portions, and they must keep low. Keeping low reduces thermal exposure just as it reduces nuclear radiation exposure.

Field-Expedient Overhead Cover

An overhead covering of earth or other material reduces exposure to thermal and initial nuclear radiation and fallout. Overhead covering helps prevent collapse. It also provides missile protection.

Beware of poorly constructed overhead cover. The cover must be strong enough to withstand the blast wave. Figure 4-3 shows some examples of good field-expedient overhead cover. Use U-shaped metal pickets, timbers, or certain fabrics, and overlay them with sandbags or earth. Ammunition boxes filled with earth also make good cover. In constructing effective overhead cover, remember the following:

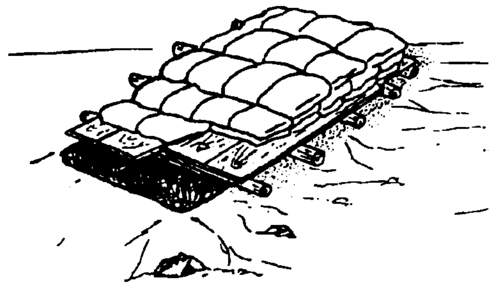
- Choose dense covering materials.
- Cover in depth.
- Provide strong supports.
- Cover as much of the opening as possible.

A vehicle provides expedient overhead cover. A simple and fast method is to drive a vehicle over the top of a foxhole (Figure 4-4). 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 the fighting position through the earth sides or the openings in the sides of the vehicle (between treads, road wheels, and tires). If time allows, use sandbags to cover these openings. Remember, the vehicle is not a good neutron shield. Also, the blast wave may violently displace the vehicle and collapse a foxhole.

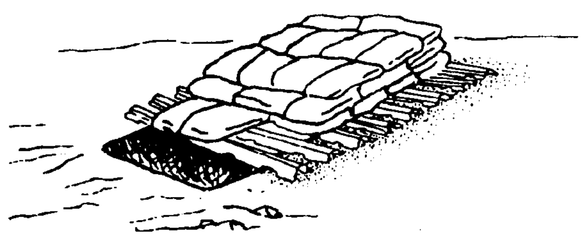
Earth-Shielded Positions

Well-constructed fighting positions and bunkers can provide excellent protection against all effects of a nuclear detonation. Radiation is still the greatest concern, though, because of its great penetrating power. Radiation scatters in all directions after a burst. Most, however, travels directly in a line-of-sight route from the fireball.

It is important that as much earth cover as possible be placed between the soldier and the burst. The more earth cover, the better the shielding. Table 4-1 illustrates the value of increasing amounts of earth shielding from a hypothetical free-in-air dose. An open fighting position gives a protection factor of eight. It blocks most of the



CUT TIMBER AND SCRAP MATERIALS AS ROOF SUPPORT SYSTEM



U-SHAPED METAL PICKETS AS ROOF SUPPORT SYSTEM

FABRIC FOXHOLE COVER OR FIELD PONCHOS

Figure 4-3. Examples of field-expedient overhead cover.

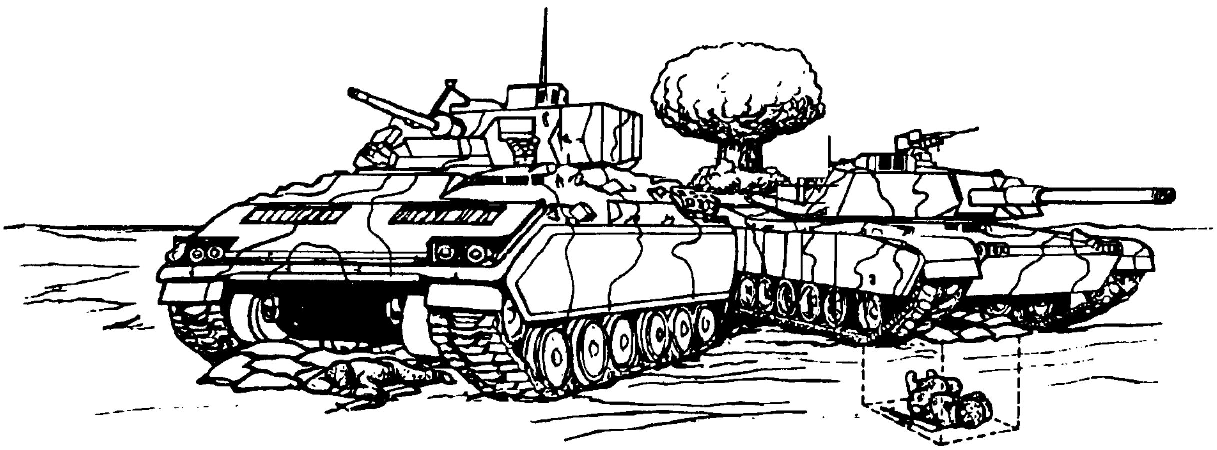


Figure 4-4. Tracked vehicle as expedient overhead cover.

line-of-sight radiation and allows only a fraction of scattered radiation to enter. Each added 6-inch thickness of overhead earth cover reduces the scattered radiation by a factor of two.

Flat earth cover of an underground shelter protects much better than an equivalent thickness of cover on a similar aboveground structure. This is because the underground line-of-sight thickness is greater. (See Figure 4-5.)

A second layer of sandbags gives more protection to fighting positions. Each layer of sandbags, if filled with sand or compacted clay, reduces the transmitted radiation by a factor of two. Table 4-2 shows the payoff for adding layers of sandbags for a hypothetical free-in-air dose of 2,400 cGy.

Sand or compacted clay gives better radiation shielding than earth because it is denser. Each layer of sand- or clay-filled sandbags can give up to 66 percent

Table 4-1. Shielding values of earth cover for a 2,400-centigray free-in-air dose.

Soldier In	Radiation Protection Factor	Resultant Dose cGy
Open	None	2,400
Open foxhole, 4' deep	8	300
Same with 6" earth cover	12	200
Same with 12" earth cover	24	100
Same with 18" earth cover	48	50
Same with 24" earth cover	96	25

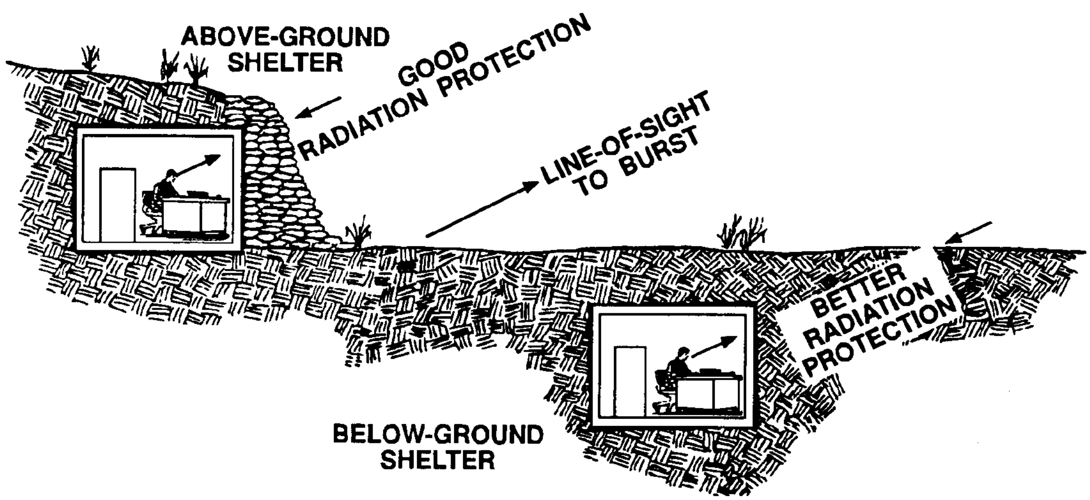


Figure 4-5. Section views of shelters.

Table 4-2. Radiation protection factors of sand- or clay-filled sandbags.		
Soldier In	**Radiation Protection Factor**	**Resultant Dose cGy**
Open	None	2,400
Open foxhole, 4' deep	8	300
Same with 1 layer (4 inches)	16	150
Same with 2 layers (8 inches)	32	75
Same with 3 layers (12 inches)	64	38

more radiation protection than the same thickness of soil or soil-filled sandbags. For example, Table 4-1 shows that 12 inches of earth gives a protection factor of 24 (100 cGy) for a hypothetical 2,400 cGy dose, and Table 4-2 shows that 12 inches (three layers) of sand- or clay-filled sandbags gives a protection factor of 64 (38 cGy) for the same dose. Generally, heavier sandbags protect better than lighter ones. Avoid cracks between sandbags to prevent radiation leakage.

Neutron radiation can be stopped. Water delays and absorbs neutrons, but since some gamma radiation is given off in the process, dense shielding is still required. Damp earth or concrete protects from both forms of radiation. For example, only 12 inches of concrete or 24 inches of damp earth reduce neutron radiation exposure by a factor of 10. Wet sandbags achieve a reduction factor of two for every 4-inch layer. Other expedient neutron-shielding materials include containers of water, fuel, or oil. Remember that radiation scatters in all directions, and shielding must provide all-around protection.

Protect sandbags from exposure to thermal radiation. Sandbags can burn and spill their contents, which can then be moved more easily by the blast wave. Cover sandbags with a small amount of earth and / or sod (see Figure 4-6) to eliminate this problem. Covering sandbags also enhances camouflage and provides valuable additional conventional fragmentation protection.

Buildings

Certain types of buildings offer excellent shelter from nuclear hazards and require a minimum of time and effort to adapt for use. Choose buildings carefully. The stronger the structure, the better the protection against blast effects. The strongest are heavily framed buildings of steel and reinforced concrete. The worst choices are the shed-type industrial buildings with light frames and long beam span. Even well-constructed frame houses are stronger than the latter. Figure 4-7 shows some examples of typical structures that provide good protection. Ammunition storage bunkers also give exceptional protection. These are usually large enough for most vehicles and equipment.

Many European rural and urban structures can provide good protection. Many types of pre-World War II European buildings provide good blast and radiation protection. Examples are farmhouses, churches, and municipal buildings. See Figure 4-8 for typical European rural and urban structures that provide such protection. Characteristics to look for include the following:

- Pre-World War II design and construction. These have thick, full-span floor and ceiling beams; heavy roofing tiles; dense, reinforced walls; and, in most cases, a full basement.
- Full basements constructed of concrete or stone. Make sure there is an exit directly to the outside as well as through the upper floors in case of emergency.
- Thick-walled, masonry structured. A thickness of 36

Figure 4-6. Sandbags protected with sod and earth cover.

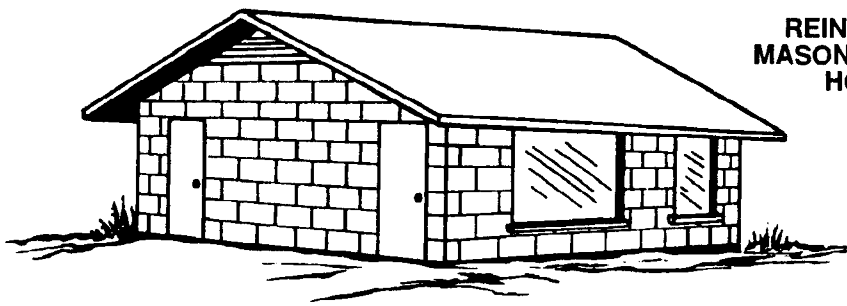


Figure 4-7. Typical structures that provide good nuclear protection.

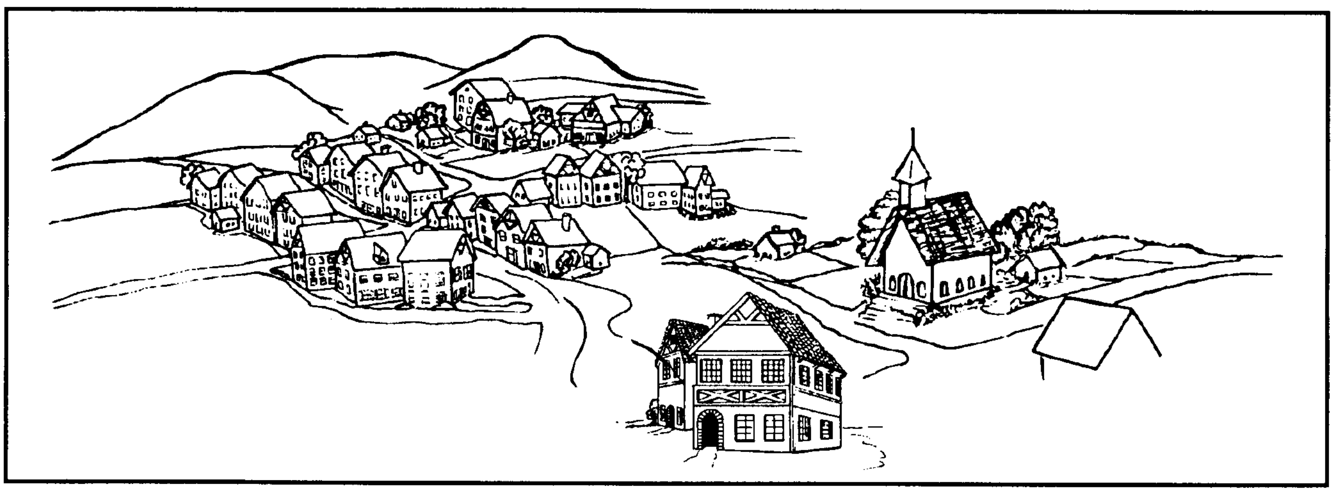


Figure 4-8. Typical European structures that provide good nuclear protection.

centimeters (greater than 1 foot) is an indication of good, pre-World War II wall construction. In areas, particularly southern Germany, where construction details are typically concealed by stucco finish, desirable features underneath are noticeable when the outside walls are wet. These features include diagonal supports and clockworks.

- Buildings with the least amount of glass. European windows and doors typically are protected by roll-up or folding shutters. These coverings provide some additional blast and thermal protection.

A shielded building is best. Exterior rows of buildings in closely arranged groups (towns) shield buildings in the interior. These shielded structures suffer less blast overpressure and structural damage than exposed structures. However, debris and rubble problems and fire hazards may increase toward the center of town. Commanders should consider using shelters located two or three rows of buildings from the edge of town to avoid serious hindrance to postattack maneuver.

Soldiers should get belowground level. The basement, because it is below ground, provides increased blast protection and much more line-of-sight radiation protection than aboveground floors. This additional protection results from the surrounding earth fill. Add additional radiation protection by placing a layer of earth or sandbags on the floor above. This additional dead weight will be significant and may require shoring up the floor. Alternately, more protection can be gained by sandbagging a smaller shelter in the basement (such as a sturdy table) without increasing the possibility of the entire floor collapsing. Block windows with sandbags, and enhance the radiation protection and structural strength of any aboveground exterior walls by piling dirt and sandbags against the walls. Generally speaking, soldiers can reduce radiation by a factor of 10 in basements as compared to levels in aboveground floors.

Positions inside of the building can make a difference if sufficient time is available to properly prepare it. On floors above ground, the center of the building offers the greatest protection from both initial and residual radiation. Below the ground, the corners of the building give the greatest protection. In either case, the dose to a prone soldier would be about one-half the dose to a standing soldier. The lesson here is to seek shelter in an underground structure and lie in a corner. If an underground shelter is not available, lie in the center of a shelter under a sturdy table (see Figure 4-9). Other options include lying inside a fireplace, under a stairway, or in a bathroom where the plumbing and relatively close spacing of walls might provide increased structural strength.

Tents

Tents are not a preferred shelter against the effects of nuclear weapons. Personnel routinely conducting activities in tents, such as medical, maintenance, and supply personnel, are particularly vulnerable.

A tent does provide some protection. It initially provides good thermal radiation protection. The secondary fire hazard is serious, however, and in most cases, the blast wave will not blow the smoldering tent far enough away to prevent damage and injury from subsequent fires.

You can increase protection inside the tent. If the situation requires continuing operations in a tent—such as may be the case for some field hospital situations—achieve some degree of protection 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 bed patients.

A tent offers essentially no resistance to blast winds. Ensure that equipment and glassware are secure. All loose pieces of equipment, such as small instruments, chairs, clipboards, and bottles, will be propelled by the blast and can cause serious injuries.

Beware of tent pole breakage. A broken and splintered tent pole can cause serious injuries. Piling sandbags around the center pole gives some additional support. It also helps ensure enough clearance to the ground to allow soldiers to evacuate the smoldering tent after the initial flash.

Armored Vehicles

Armored vehicles give good NBC protection. In most situations, tanks provide the best vehicular protection available. Lightly armored vehicles also give good protection. These vehicles include infantry fighting vehicles, armored personnel carriers, self-propelled artillery, and some heavy engineer equipment. If time is available, improve this protection with any of the

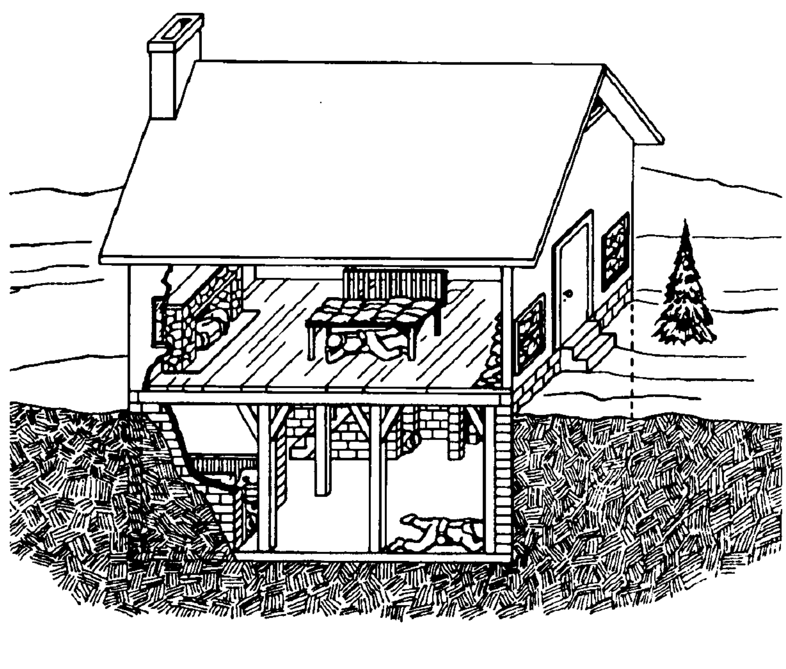


Figure 4-9. Shelter in a building.

following seven actions.

Get as low as possible inside an armored vehicle. Crew members normally elevated in a tank turret should get on the floor of the armored vehicle. This applies to the tank commander, gunner, and loader. Assuming such a low position reduces the radiation received by a factor of four.

Keep all hatches shut. Obviously, an open hatch will expose the crew unnecessarily to explosion effects. It could also subsequently allow the entry of fallout particles and scattered gamma radiation. Close any other openings, such as the main gun breech.

Prevent injury while inside an armored vehicle. The blast wave will throw soldiers violently about inside an armored vehicle. Wear combat vehicle crew (CVC) helmet or kevlar helmet with chin strap secured to help prevent head injuries.

Secure all loose equipment inside the vehicle. The force of the blast can throw about unsecured, loose equipment inside the vehicle, such as tools, weapons, and helmets, and cause injury or death.

Dig in armored vehicles (hull defilade) or place them in trenches or cuts in roadways (see Figure 4-10). This provides some limited line-of-sight radiation protection and considerable blast protection. A hull defilade fighting position or trench that allows half of the vehicle sides to be covered can reduce gamma radiation by as much as a factor of two.

Use sandbags as radiation shielding. A single layer of sandbags placed on top of a tank turret or armored vehicle hull provides valuable overhead gamma shielding. Each layer of sandbags reduces the gamma radiation by a factor of two. Wetting the sandbags enhances the neutron radiation shielding and protects the sandbags from thermal damage.

Although blast damage is generally least for head-on orientation, rear-on orientation may be preferable. This 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 broadside exposure. At distances above the median lethal dose to the crew in a rear-on orientation, significant damage to the tank is not expected.

Wheeled Vehicles

Avoid using wheeled vehicles as shelter. Generally, wheeled vehicles provide little or no protection from the effects of nuclear explosions. Worse still, they are particularly vulnerable to overturning. This exposes drivers and passengers to increased risk.

The percent of casualties from blast effects is dramatically greater for personnel in wheeled vehicles than for those in the open (see Table 4-3). The percent of casualties expected from radiation is the same for both.

Soldiers should protect themselves as much as possible inside vehicles. If they must accomplish mission-essential activities, such as communications, command, and control, in a wheeled vehicle, they should wear their kevlar helmets with chin straps secured. This precaution helps prevent head injuries if the vehicle is overturned.

Secure all loose equipment inside the vehicles. Inadequately secured equipment, such as weapons, radios, desk, file cabinets, field safes, racks, and generators, can tip over or slide across a van floor and cause serious injuries. Such items can also be thrown to

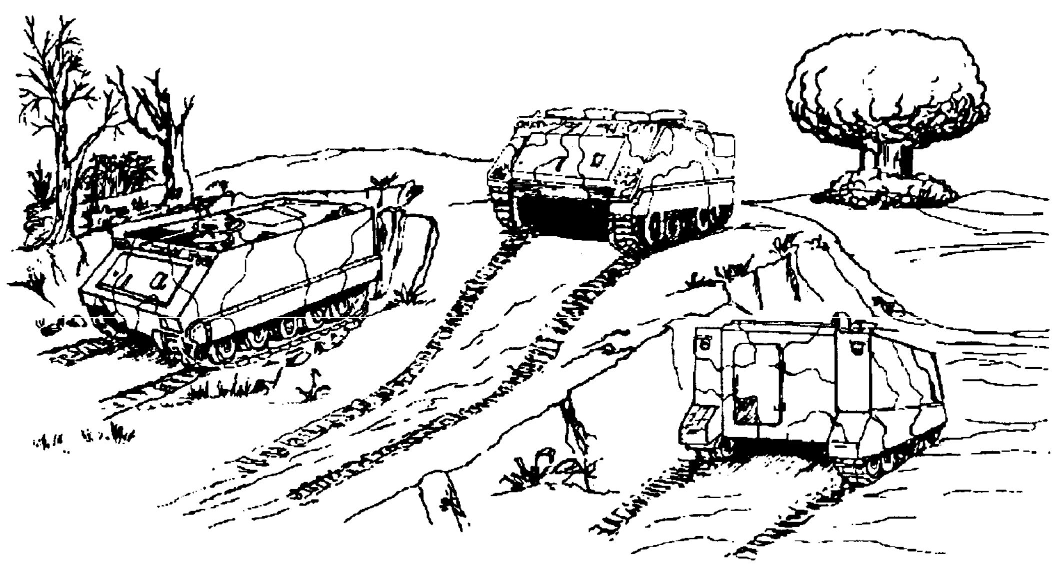


Figure 4-10. Protection of armored vehicles.

Table 4-3. Comparison of blast casualties from a 10-kiloton fission weapon.

Range (Meters)	200	300	400	700	800	900	1,000	1,400
Personnel in Open (Percentage)	100	80	41	11	8	5	4	0
Personnel in Wheeled Vehicle (Percentage)	10	100	100	99	80	62	43	1

the ceiling and cause injuries when the vehicle turns over. Tying down, blocking, and bracing the equipment will help.

Plan for and prepare adequate field shelters immediately adjacent to facilities that require soldiers to continue operations in wheeled vehicles. Parking the vehicle inside or under a shelter gives some protection to soldiers inside. Existing or natural structures such as ammunition bunkers, underpasses, tunnels, and caves, are in this category.

Aircraft Ground Operations

Revetments give little protection against blast overpressure. However, revetments and barricades protect aircraft from damage by dynamic wind. These also protect aircraft from other hazards, such as the impact of rocks, sand, and other aircraft or aircraft debris. The tactical situation may require revetting for protection from conventional weapons blast and fragmentation damage. Use overhead cover for aircraft, if it is available. Close doors and windows against damaging overpressure. These openings expose the compartment interior to damaging thermal radiation.

Tiedowns can reduce damage from tumbling of the aircraft. Generally, tiedowns do not produce excessive stress on tiedown points. Aircraft plexiglass windows shatter into fragments. This can happen at low blast overpressure (1.5 pounds per square inch) when there is no other significant damage. Tape the edges and the centers of windows. This reduces the extent of fragmentation and the nuisance fragments may cause to cockpit operations.

Electromagnetic Pulse

Prior to an attack where enough warning has been given to the soldiers, commanders must ensure that any electronic equipment such as radios and computers is turned off and protected. Electromagnetic pulse (EMP) is the high-energy, short duration pulse (similar in some respects to a bolt of lightning) generated by nuclear detonation. It can induce a current in any electrical conductor and temporarily disrupt or overload and damage components of improperly protected or unprotected electronic equipment. Transient radiation effects on electronics (TREE) and EMP are discussed in FM 3-3.

Actions During an Attack

Nuclear attack indicators are unmistakable. The bright flash, enormous explosion, high winds, and mushroom-shaped cloud clearly indicate a nuclear attack. An enemy attack would normally come without warning. Initial actions must therefore be automatic and instinctive. Dropping immediately and covering exposed skin provide protection against blast and thermal effects.

Immediate Actions

An attack occurring without warning is immediately noticeable. The first indications will be very intense light. Heat and initial radiation come with the light, and blast follows within seconds. Time to take protective action will be minimal. If exposed when a detonation occurs, soldiers should do the following:

- Immediately drop facedown. A log, a large rock, or any depression in the earth's surface provides some protection.
- Close eyes.
- Protect exposed skin from heat by putting hands and arms under or near the body and keeping the helmet on.
- Remain facedown until the blast wave passes and debris stops falling.

Stay calm, check for injury, check weapons and equipment damage, and prepare to continue the mission.

Soldiers in foxholes can take additional precautions. The foxhole puts more earth between soldiers and the potential source of radiation. They can curl up on one side, but the best position is on the back with knees drawn up to the chest (see Figure 4-11). This belly-up position may seem more vulnerable, but arms and legs are more radiation-resistant and will protect the head and trunk. Store bulky equipment, such as packs or radios, in adjacent pits if they prevent soldiers getting low in their foxholes, or place these items over the face and hands for additional radiation and blast protection.

Soldiers inside shelters should take protective actions. A blast wave can enter the shelter with great force, and the debris it carries can cause injuries. Lying facedown on the floor of the shelter offers worthwhile protection. However, soldiers should avoid the violent flow of air from doors or windows. Lying near a wall appears safer than standing away from a wall. Near a wall, reflection may increase the pressure wave. This is better, though,

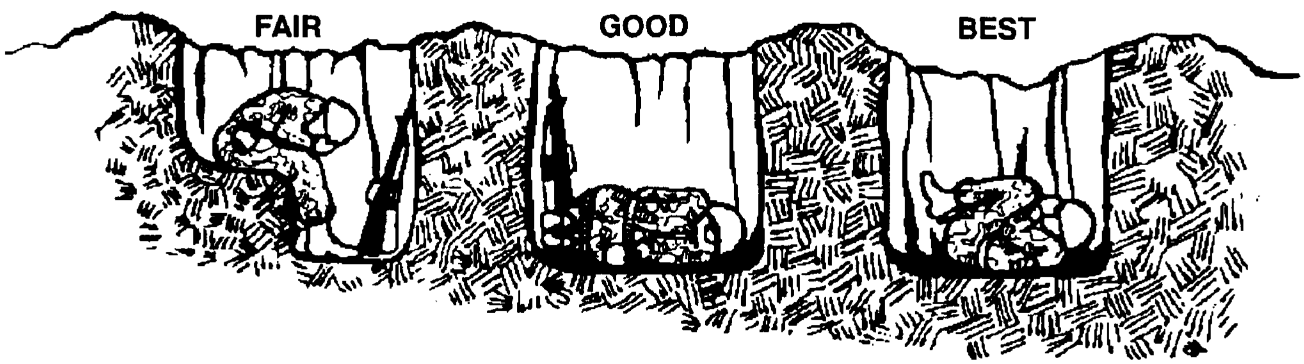


Figure 4-11. Recommended body positions in a foxhole.

than risking being blown out and injured by the blast. Constructing baffles or turns in shelter entrances can prevent overpressure buildups and entry of dust and debris (see Figure 4-12).

Nuclear Casualties

Blast, thermal radiation, and nuclear radiation all cause nuclear casualties. Except for radiation casualties, treat nuclear casualties the same as conventional casualties. Wounds caused by blast are similar to other combat wounds. Thermal burns are treated as any other type of burn. First aid cannot help radiation casualties. These casualties will be referred to medical facilities that can handle them.

Actions After an Attack

Protection must not stop when the attack ends. Immediately after an attack, soldiers must check for radioactive contamination, and then must reduce the hazard with basic soldier skills decon. Decontamination techniques to reduce radioactive contamination are to brush, scrape, or flush radiological contamination from surfaces. As a minimum, unit personnel cover foxholes and shelters, and radiac operators begin continuous monitoring. Covering the mouth with a handkerchief reduces the contaminants entering the lungs. This method is generally preferable to masking to avoid trapping contamination in the mask filter. For the commander, posts trike actions include damage assessment and restoration of combat power.

Nuclear Effects in Special Environments

The effect of a nuclear attack in different geographic and climatic environments is very distinguishable. The effects of terrain and weather on the use of nuclear devices may cause special problems for commanders having to operate in these extremes. Appendix A discusses these conditions in further detail.

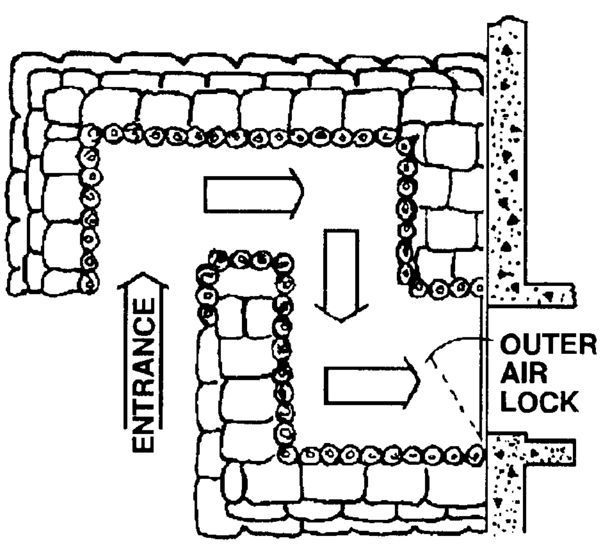


Figure 4-12. Protection from blast flow into shelters.