Student Manual

For

Fundamentals Course For Radiological Monitors

Federal Emergency Management Agency

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Introduction

This manual is intended as a student manual for the 12-hour course entitled *"Fundamentals Course for Radiological Monitors"* (FCRM). It is not intended as a stand-alone reference document.

Information included addresses both nuclear attack radiation hazards and radiation hazards resulting from peacetime radiation accidents. Information on both categories of hazards is included in this manual for convenience. However, it is important for the reader to recognize the extreme contrast between nuclear attack caused radiation hazards and those caused by peacetime radiation accidents.

The ***Fundamentals Course for Radiological Monitors*** (FCRM) describes this contrast in detail and delineates the operational procedures for each hazard. Users of this manual should attend the complete FCRM.

From a nuclear attack perspective the radiological monitor should be sufficiently familiar with the radiation protection principles taught in this course, and subsequent refresher courses and companion exercises, to serve as a self-support radiological monitor during a nuclear attack situation. Additional guidance for radiation protection from radioactive fallout can be obtained in CPG 2-6.4 ***Radiation Safety in Shelter.***

From a peacetime perspective information in this manual is designed at the first responder level only. The FCRM is intended to teach the first on-scene/emergency first responder the basics of emergency response to accidents involving radioactive material. Actions beyond the first responder level should be conducted under the guidance and supervision of professional radiological health personnel. In preparing for or actually carrying out an emergency response, EMT/paramedics, firefighters, law enforcement personnel, and others should not respond with fear and uncertainty to peacetime radiation hazards. Rather, radioactive materials should be considered as another class of hazardous materials whose potential danger can be reduced by following guidelines and procedures in this course. Additional guidance for first on scene and first responder actions can be obtained from the ***Emergency Response Guide*** published by the U.S. Department of Transportation.

It is important to remember to immediately notify the State Radiation Control Agency of any radiation emergency to obtain necessary guidance. A notification form is included at the end of this manual to be filled out with appropriate emergency personnel and phone numbers.

Understanding Radiation and Radioactivity

The information presented in this section is limited to the essential concepts needed to assure an adequate understanding of radiation physics. While it is not necessary for the emergency responder to have indepth knowledge of this subject, the reader is encouraged to pursue additional, more advanced material.

Atoms, Ions, and Ionizing Radiation

A fundamental knowledge of atomic structure and matter is helpful in understanding radioactivity. Elements are substances that cannot be broken down into simpler substances by any chemical means. There are 105 known elements, each with its own specific characteristics. The atom is the simplest unit into which an element can be divided and still retain the specific properties of the original element. Combinations of 2 or more atoms are called molecules.

The element hydrogen contains only an electron and proton, while the atoms of all other elements contain electrons, protons, and neutrons. Protons and neutrons make up the nucleus of an atom, and the nucleus is surrounded by electrons. Most atoms are stable but some are unstable. Unstable atoms become stable by emitting radiation.

The term "radiation" refers to such sources as visible light, radio waves, and sound waves, as well as to ionizing radiation. However, in this book the term "radiation" is used to mean ionizing radiation.

Ionizing radiation is radiation that can produce charged particles (ions) in any material it strikes. These charged particles can cause damage to molecules, cells, or tissues. Atoms that emit ionizing radiation are said to be radioactive; in other words, radioactivity is a process whereby atomic changes, called "decay" or "disintegration," occur through the emission of ionizing radiation. Radioactivity can be produced, as in nuclear reactors, or it can be found occurring naturally on our earth and in the surrounding universe. Ionizing radiation that occurs naturally is called "natural background radiation."

Types of Ionizing Radiation

The three most common types of ionizing radiation are alpha particles, beta particles, and gamma rays.

Alpha particles, designated by the Greek letter α, are positively charged particles consisting of 2 protons and 2 neutrons. Alpha particles are the least penetrating of the three types of ionizing radiation. They do not penetrate the skin and can be stopped by a piece of thin paper or clothing. A health hazard may occur when alpha-emitting materials are inhaled, swallowed, or enter the body through a wound. Thus, alpha particles are an internal hazard only.

Beta particles are high-speed, charged particles with a moderate penetrating power. These particles, designated by the Greek letter β, have the characteristics of electrons and may be positively or negatively charged. Beta particles can travel several hundred times the distance of alpha particles in air, can penetrate skin and tissue, and require a few millimeters of aluminum to stop them. Thus, beta particles can be both an external and internal hazard; that is, they can injure both the outside or inside of the body.

Gamma rays, designated by the Greek letter γ, are electromagnetic radiation emitted from the nucleus of a radioactive atom. Gamma rays are the most penetrating type of radiation and can travel many meters in air and many centimeters in tissue. Because gamma rays can travel through the body, they are sometimes referred to simply as "penetrating radiation." Like beta particles, gamma rays constitute both an internal and external hazard.

X-rays are another more familiar form of ionizing electromagnetic radiation. They are like gamma rays and can penetrate human tissue.

A fourth type of ionizing radiation (*neutron*) is produced by only a few elements during radioactive decay, fission, or fusion reactions. Exposure to neutron radiation is rare, but as in beta and gamma exposure, can injure both internally and externally.

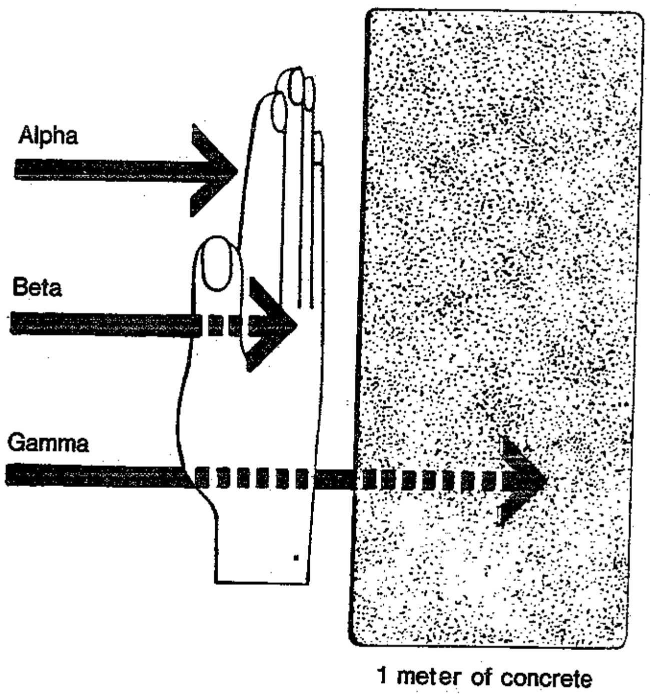


Figure A-1. The Penetrating Power of Radiation.

Adapted, with permission, from *Radiation—A Fact of Life*, a brochure printed and distributed by the American Nuclear Society, with permission of the International Atomic Energy Agency.

Alpha, beta, gamma, x-ray, and neutron radiation can all cause ionization when interacting with matter. The penetrating power of alpha, beta, and gamma radiation is illustrated in Figure A-1.

Radiation Quantities and Units

Specific terms used in measuring radioactivity are "activity," "exposure," "dose," and "dose equivalent." The curie (Ci) is the basic unit of *activity* and describes the amount of radioactivity in a sample of material. Because the curie is a relatively large amount of radioactivity, activity is often expressed as some fraction of a curie (e.g., millicurie or mCi = one one-thousandth of a curie; microcurie or μCi = one one-millionth of a curie).

Exposure is a measure of the amount of ionization produced by x- or gamma radiation. The basic unit of exposure is the roentgen (R). One roentgen represents the amount of exposure necessary to produce a certain number of ions in 1 cubic centimeter of air. The most common way of characterizing an x-ray or gamma-ray field is by expressing the exposure rate in roentgens per hour (R/hr). The exposure rate may also be expressed as milliroentgens per hour (mR/hr). One roentgen equals one thousand milliroentgens (mR). Other units are the rad (radiation absorbed dose) and rem (roentgen equivalent man), which are the measuring units of an absorbed *dose* of radiation. In emergency situations, assume the *dose equivalents* 1 roentgen = 1 rad = 1 rem for practical purposes.

International System of Units (SI)

SI Metric radiation units are used increasingly in the international community. Increased use of the metric radiation unit in the United States will occur over the next several years. Below is a comparison of radiation units currently used in the United States and SI Metric radiation units:

Current Units		SI Units
1 curie (ci)	=	37 billion Becquerel (Bq)
1 Roentgen (R)	=	2.58 X 10^{-4} coulomb per kilogram of air
1 rad	=	.01 Gray (Gy)
1 rem	=	.01 Sievert (Sv)

The Nature of Peacetime Radiation Accidents

Where Radiation Accidents Occur

Accidents involving radiation or radioactive materials generally can be grouped in six categories, based on where such accidents occur:

1. Nondestructive testing (industrial radiography)
2. Radionuclides in medical facilities
3. Isotope production facilities
4. Radionuclides in research facilities
5. Nuclear reactor sites
6. Transporting radioactive materials

On a worldwide basis, fewer than 1000 persons are known to have been involved in serious radiation accidents and only about 450 of these individuals received medically serious doses of radiation or contamination, resulting in about 21 fatalities. *No emergency medical responders or other rescuers have ever been injured by the radiation hazard in any radiation accident.* **(In the United States)**

Few radiation accidents of any medical consequence occur in commercially or government-operated nuclear reactors, in isotope production facilities, or during transportation. The most common radiation accident involves sealed radioactive sources used in industrial radiography or nondestructive testing. Victims of radiography accidents rarely require emergency medical services. Emergency personnel are more likely to be involved in accidents such as building fires or transportation accidents where radioactive materials are present. Considering all radiation accidents, high radiation levels are rarely caused by contamination.

Types of Radiation Injury

Any accident involving radioactive material can result in external irradiation, contamination (external or internal), or both. In addition, internal contamination can lead to incorporation of radioactive material into body cells or tissues.

Radiation accident victims rarely show immediate signs or symptoms caused by radiation alone. Because the degree of radiation injury depends on the amount of radiation received, emergency responders should presume a radiation-induced injury until proven otherwise.

External Irradiation

External irradiation occurs when all or part of the body is exposed to penetrating radiation from an external source. The degree of radiation-induced injury depends on the amount of radiation an individual receives. During exposure, this radiation can be absorbed by the body or it can pass completely through. A similar thing occurs during an ordinary chest x-ray. Following external exposure, an individual is not radioactive and can be handled without fear or concern.

Contamination

The second type of radiation accident involves *contamination* with radioactive materials. Contamination means that radioactive materials in the form of gases, liquids, or solids are released into the environment and contaminate people externally, internally, or both. An external surface of the body (the skin), can become contaminated, and if radioactive materials get inside the body through the lungs, digestive tract, skin, or wounds, the contaminant can become *deposited internally.*

Incorporation

Incorporation refers to the uptake of radioactive materials by body cells, tissues, and target organs such as bone, liver, thyroid, or kidney. In general, radioactive materials are distributed throughout the body based upon their chemical properties (e.g., radium to bone, iodine to thyroid, etc.).

These three types of accidents can occur in combination and can be complicated by physical injury; however, incorporation cannot occur unless contamination has occurred. Table 1 summarizes the types of radiation injuries.

Table 1. Types of Radiation Injury.

1. *External irradiation*—whole-body or partial-body
2. *Contamination by radioactive materials*—external (deposited on the skin) or internal (inhaled, swallowed, absorbed through skin, or introduced through wounds)
3. *Incorporation of radioactive materials*—uptake by body cells, tissues, or organs (bone, liver, kidney, etc.)
4. *Combined radiation injury*—combination of the above which may be complicated by trauma

Irradiation of the whole body or some specific part of the body does not constitute a medical emergency even if the amount of radiation received is relatively high. The effects of irradiation usually are not evident for days to weeks, and while medical treatment might be needed, prompt emergency care is not required. On the other hand, contamination accidents should be considered medical emergencies since they *can* lead to internal contamination and subsequent incorporation that might result in adverse health effects years after the accident.

The emergency responder should always use proper emergency priorities in caring for accident victims where radiation hazards exist.
When performing emergency stabilization or rescue procedures, use good judgment to protect yourself and to keep radiation exposure as low as reasonably achievable. The emergency responder's first priority is always to administer lifesaving emergency care, remove the accident victim from the radiation hazard area, and transport the victim to a hospital emergency department. Emergency physicians and nurses should have similar priorities: treat life-threatening problems first, limit the radiation due to both victim and personnel, and control the spread of radioactive contaminants. ***Life-threatening medical emergencies always have priority over concerns about radiation, such as radiation monitoring, contamination control, and decontamination.***

Peacetime Accidents Involving Nuclear Weapons

Nuclear weapons require special attention because of the potential contamination threat they pose. Basically, a nuclear weapon consists of uranium containing highly enriched uranium-235 or plutonium, a conventional high explosive (HE), and the necessary triggering device to detonate the weapon. The extreme care devoted to the design of equipment and procedures for transporting nuclear weapons has resulted in a record of no inadvertent or unintentional nuclear detonation. Present procedures and transport equipment for nuclear weapons are based on scientific knowledge, sound principles of safety engineering, and the results of field experiments.

In the United States, nuclear weapons may be transported by aircraft, truck, train, or naval vessel. In each case, weapons and other components are installed in special containers which are securely fastened to the transport vehicle by carefully designed tie-downs and mountings. Stringent safety measures have also been incorporated into the design of all nuclear weapons and should enable them to survive all but the most severe, abnormal accident conditions. A nuclear detonation can be produced only upon proper functioning of the weapon in the normal sequence of arming and firing. Therefore, the greatest threat to emergency response personnel is not nuclear detonation; it is indeed highly doubtful whether any nuclear weapon involved in a transportation accident would, or could, detonate in a nuclear fashion.

The two components of a nuclear weapon that constitute the most probable hazards in an accident are the conventional, nonnuclear high explosives and the plutonium. Other components may produce hazards, but these components are of such a nature that precautions taken against explosives and plutonium are more than sufficient for satisfactory control. Keep in mind that accidents involving nuclear weapons or components will usually involve other materials in more widespread use, such as gasoline or other volatile and explosive fuels. If fire occurs, acrid, suffocating, toxic fumes and smoke will probably be generated by the combustion of surrounding materials. In that event, take normal procedures and precautions applicable to the particular type of fire.

Most nuclear weapons will contain conventional high explosives in varying amounts up to many hundreds of pounds. These high explosives constitute the major hazard associated with accidents involving nuclear weapons. Accidents or fires involving such shipments should be treated like similar accidents involving conventional high explosives. If a nuclear weapon is enveloped in the flame of a gasoline fire, the high explosive may ignite, burn, and, in some cases, detonate in one large or several small explosions. Large quantities of burning high explosives are extremely difficult to extinguish, and torching (an emergence of jets of white flame from the weapon) might be observed but is not always evident.

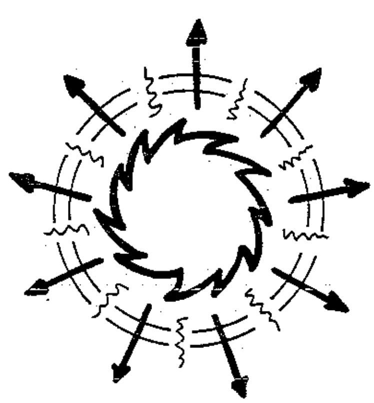
Regardless of the nature of fires or detonations of high explosives in nuclear weapons, the major radiological threat will be the release of plutonium. Plutonium is a heavy metal which looks like stainless steel when first processed but rapidly oxidizes to a characteristic brownish-black color. When associated with a fire, metallic plutonium may burn, producing radioactive plutonium-oxide particles, which may present serious hazards if inhaled or deposited in wounds. Also, detonation of the high-explosive component in nuclear weapons may pulverize plutonium into very small particles, which can cause contamination over a large area. If the high explosives burn instead of detonating, the amount of plutonium dispersed into the atmosphere usually is small and represents a serious health hazard only in the immediate area and from the smoke cloud. Plutonium is not a radiation hazard if it remains outside the body, because it is an alpha-emitter. While alpha particles have a very short range and lack the ability to penetrate the skin, widespread plutonium contamination can be a very serious hazard if inhaled or ingested into the body.

Unless it is necessary to approach a nuclear weapon to rescue injured individuals, first-on-the-scene responders at such an accident should establish an exclusion zone with a radius of 2000 feet from the weapon. To reemphasize, no attempt should be made to extinguish fires or otherwise approach a nuclear weapon involved in a transportation accident except to recover injured personnel. Notify the nearest military installation and the Joint Nuclear Accident Coordinating Center (JNACC) of the accident. JNACC is a combined Defense Nuclear Agency (DNA) and Department of Energy central office for the exchange and maintenance of information regarding radiological assistance capabilities in connection with accidents involving nuclear weapons and other radioactive materials. JNACC is located in Albuquerque, NM, and can be reached at 505/844-8279, or 505/844-4667.

Nuclear Weapon Detonations

This section addresses the basic effects of the detonation of nuclear weapons and is intended for the radiological monitor. More extensive training concerning nuclear weapons effects and necessary protective actions is provided to the local Radiological Response Team serving each community.

NUCLEAR WEAPONS



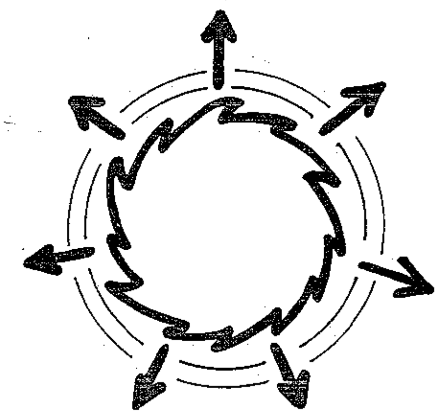
Nuclear weapons use nuclear energy to produce their destructive power. As weapons, they are many times more powerful than conventional or non-nuclear weapons. Like the conventional type, the destructive action comes mainly from the blast. But, unlike those weapons, nuclear weapons also produce intense thermal radiation which can cause widespread fires. They also release initial and residual nuclear radiation which can affect persons who are located near and far from the blast site.

Nuclear weapons produce three major direct effects: blast, heat, and nuclear radiation. How dangerous these effects are depends upon *time* — how long you have to protect yourself, — *distance* — how far away you are from the blast site, and *shielding* — how much protective covering between you and the radiation.

When a nuclear weapon explodes, tremendous amounts of energy are suddenly released. This energy creates a fireball of hot, compressed gases, an instantaneous release of thermal and nuclear radiations, and a blast or shock wave of tremendous force.

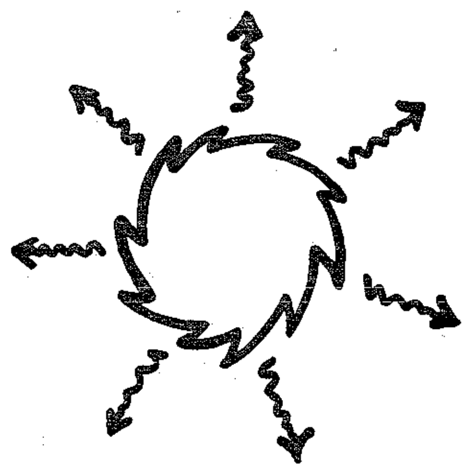
FIREBALL: HEAT FLASH AND THERMAL RADIATION

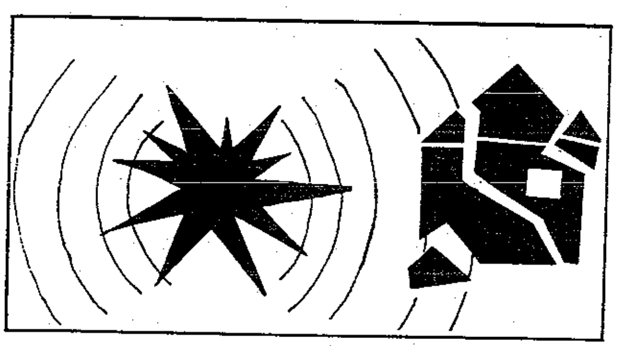
The fireball is a combination of heat and light of such brilliance and intensity that the flash can be seen hundreds of miles away. The heat, given off as "thermal radiation," is so intense that it can ignite flammable objects for several miles around the blast site.



NUCLEAR RADIATION

High levels of very penetrating and harmful invisible rays called the "initial nuclear radiation" are instantly released into the immediate blast area. The substances remaining after the explosion are also radioactive. These substances release radiation called "residual nuclear radiation." They will continue to emit harmful rays for several months or years after the explosion, but the most dangerous period will be the first several days after an attack.



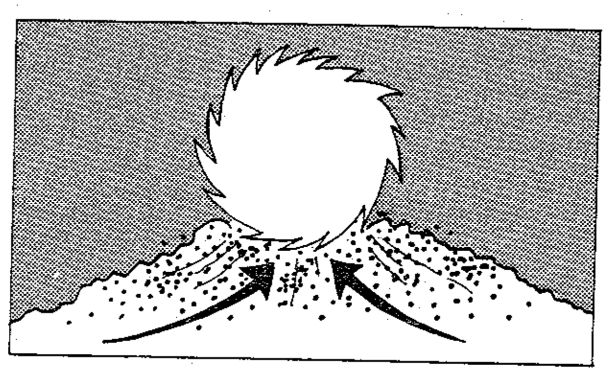


BLAST

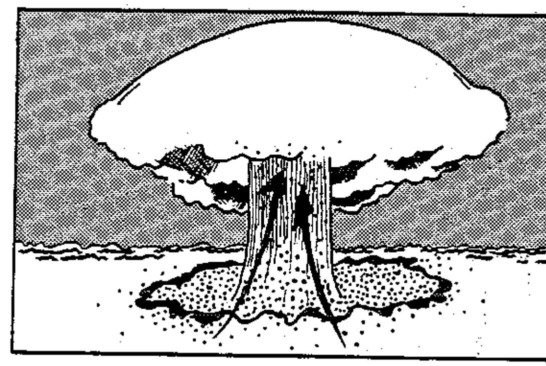
A fraction of a second after the heat flash, a blast or shock wave rocks the area and travels away from the explosion. The blast can be so powerful that it will destroy all but specially reinforced buildings for several miles around the blast site.

RADIOACTIVE CLOUD

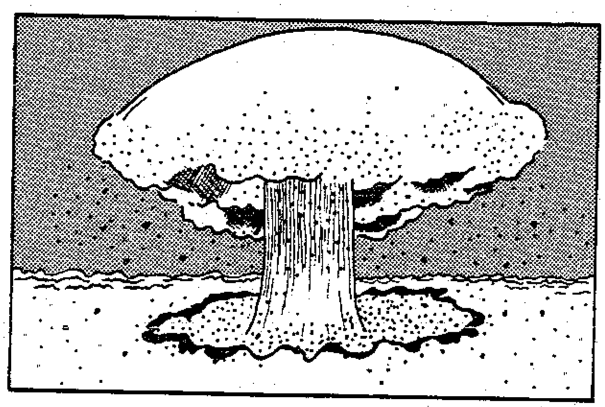
The fireball expands rapidly, heating the air around it. At the same time it rises to high altitudes like a hot air balloon to form the characteristic "mushroom cloud."



As the fireball rises it sucks the surrounding air, bomb materials, dust, and debris into its stem. When the fireball reaches the upper atmosphere, the superhot air begins to cool. Water condenses on the dust and debris particles to form a huge expanding cloud.



RADIOACTIVE FALLOUT



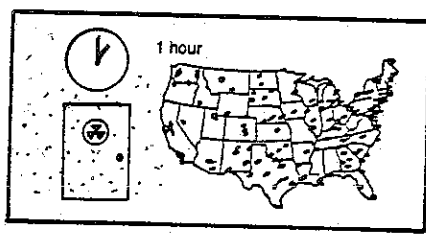
When a nuclear weapon explodes on or near the ground, it makes a huge pit or crater. Tons of earth in the crater are instantly changed from solids into hot gas and fine dust by the heat and pressure from the explosion. These materials combine to form the fireball and radioactive cloud. Much dust and earth are sucked up with the fireball to make up the mushroom cloud. The top of the "mushroom" spreads out, cools, and forms a cloud of fine particles of earth and bomb materials. This dust cloud is carried for miles by the wind and drifts down to earth as fallout. The dust in the stem and in the mushroom cloud is radioactive mostly because of radioactive materials from the nuclear explosion that become stuck to the dust particles. The air around the particles does not become radioactive, and neither do the surface materials on which they settle. The heavier, large particles settle closer to the explosion than small particles. Small particles can be carried up to several hundred miles by the wind. Most of the fallout with which you should be concerned will come to the ground within 24 hours. Very small particles come down very slowly and may be spread over large areas of the earth's surface over periods of many days, even weeks.

The fallout cloud may take as little as 15 minutes or as much as several hours to arrive and begin to deposit fallout in your area. The time will depend on many factors such as the number of ground explosions, their distance from you, and the speed and direction of the wind. The sky will probably darken as the cloud arrives and the fallout begins to come down. After fallout begins, it may keep falling in your area for an hour or more.

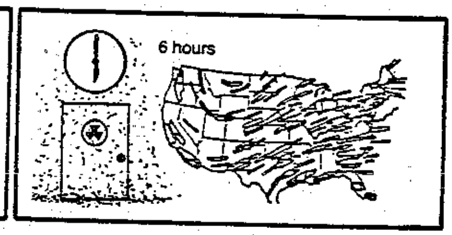
The majority of the fallout will look like sand or the gritty ash of a volcanic eruption. While most of the fallout will be visible as it forms a layer of dust on trees, cars, window ledges, and the ground, the radiation given off cannot be seen, heard, felt, smelled, or tasted. Only special instruments and devices will be able to detect the presence of radiation given off by fallout.

Fallout Distribution After
A Full-Scale Attack

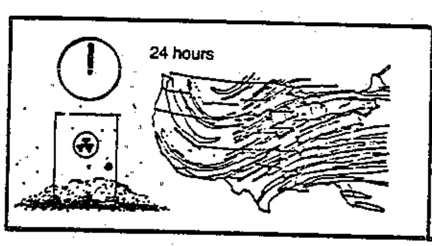
These illustrations represent possible fallout distributions after an hypothetical full-scale attack.



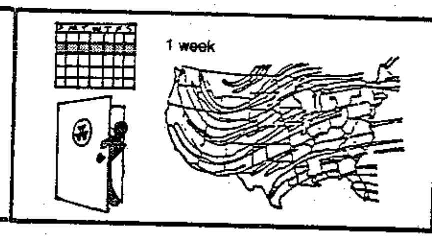
1 HOUR
Intense radioactive fallout in areas around explosion



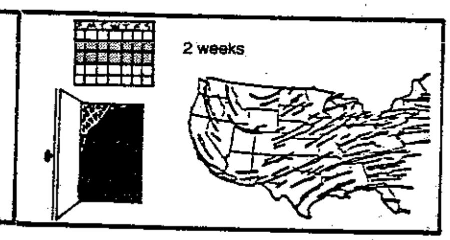
6 HOURS
Intense radioactive fallout over 40% of the country



24 HOURS
Most fallout deposited. Intense radiation over 70% of the country



1 WEEK
Dangerous radiation levels over 34% of country; short trips out of the shelter allowed in some areas; longer or permanent emergence in other areas.

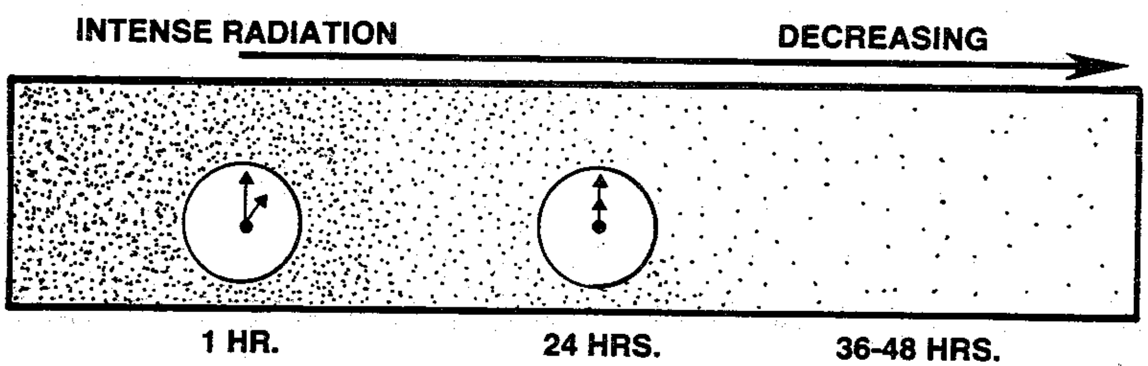


2 WEEKS
Radiation levels over most of country would be safe; emergence from shelters likely in most areas.

The distribution of fallout particles following a nuclear weapon explosion will be widespread and depend on many factors such as the size of the weapon, weather conditions, and wind speed and direction. The height of the cloud also will influence where particles fall. Considering the uncertainties related to all these factors, no area can be considered safe from fallout if a nuclear attack takes place.

RADIATION DECAY

After the cloud passes and most of the fallout from the cloud reaches the ground, the radioactivity from fallout will slowly decay and fade away by natural processes. The radioactive materials produced by the nuclear bomb explosion are unstable. These materials change or decay into a stable condition by shooting out invisible nuclear radiation. Some materials decay faster than others. Those that change fast are busy producing intense nuclear radiation in the first few moments after a nuclear explosion. Those that decay more slowly may be responsible for measurable nuclear radiation years after the explosion.



Decay of the radiation intensity from radioactive fallout particles takes place in the cloud as it is carried by winds toward you. The radiation intensity will also be decreasing because the cloud spreads out as it moves along, and the heavier particles will be dropping out, so the number of fallout particles per cubic inch of air will be decreasing as time goes on. Radioactive materials in the clouds from distant explosions will have more time to decay and spread out while they are on their way. Many of the materials that decay quickly will have decayed to undetectable levels before reaching you.

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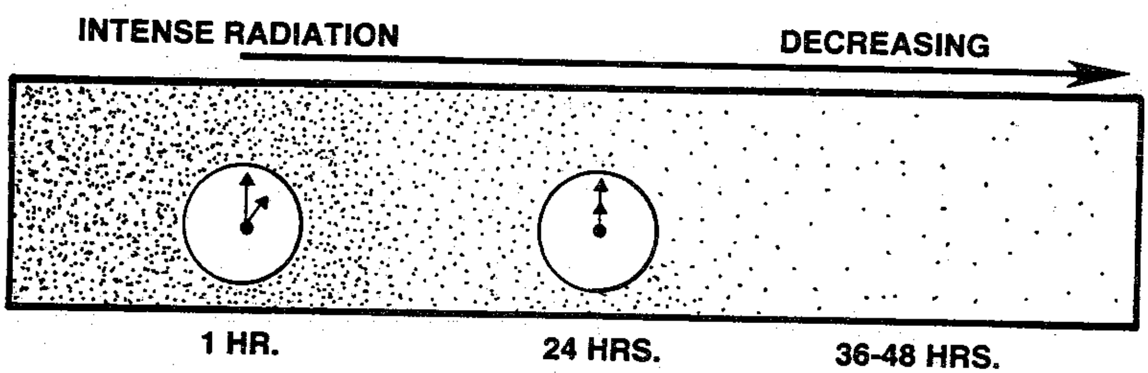

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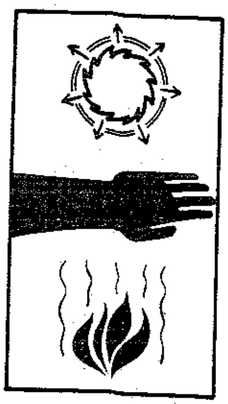
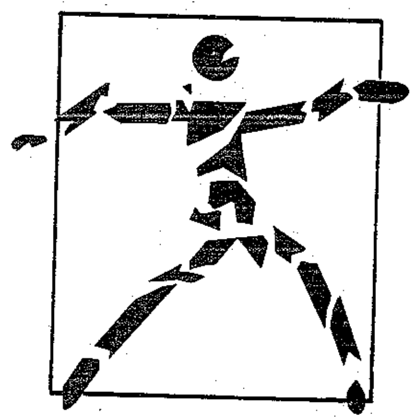
HAZARDOUS EFFECTS AND PROTECTION FOR PEOPLE

Protection from all three effects — heat, blast, and radiation — is critical to your survival. The heat flash can cause severe burns, either from direct exposure or from clothing and buildings being set on fire. The intense light can cause eye damage, both temporary and permanent, just from looking at the flash. The nuclear radiation can cause death if the whole body is exposed to high levels. The blast can cause serious injury from fractures and concussion either from being thrown about or from being struck by flying debris.



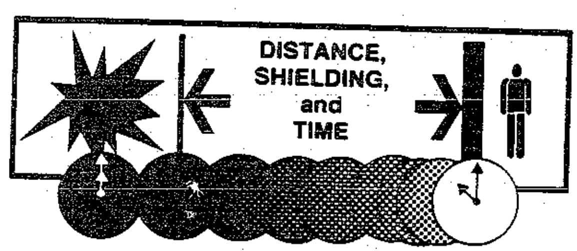
Burns

Radiation Sickness



Fractures

How then can you protect yourself? Distance, shielding, and time are your greatest protectors. The farther away you are from the explosion area, the fewer effects from which you must protect yourself. The more protective shielding between you and the blast, the safer you are. The more time that passes, the lower the danger to you from radiation from fallout.

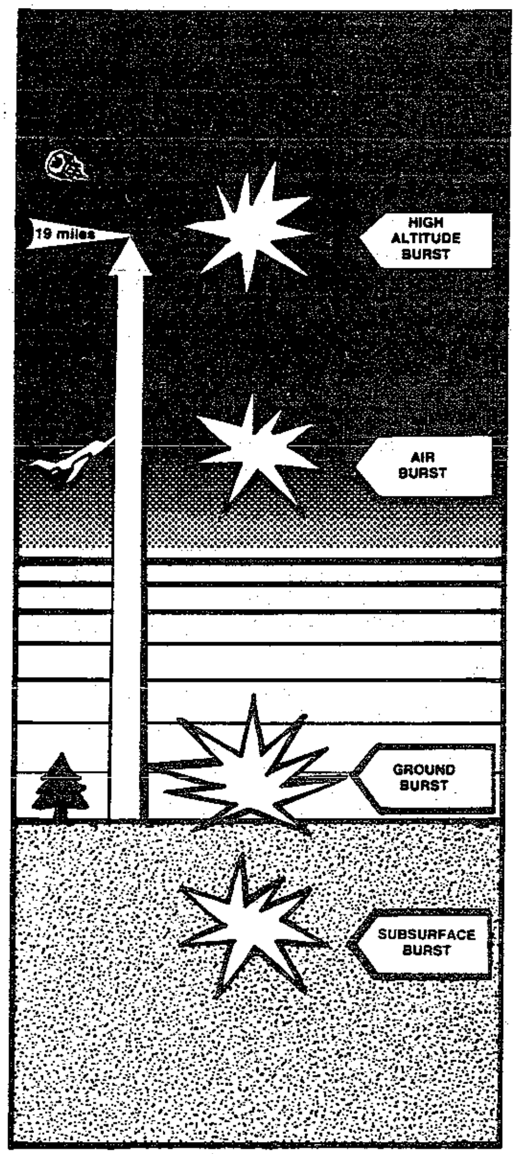


THE REACH OF BLAST AND FIRE

The best protection is a combination of distance and shielding. How great a distance and how much shielding depends on several conditions. These conditions include whether the weapon explodes on or above the ground, the size of the weapon, the weather conditions at the time of the explosion, and whether the terrain is flat or hilly.

TYPE OF BURST

The general reach or size of the area affected by a nuclear weapon depends mostly on where the explosion occurs. A weapon may burst under ground or water, on the ground, in the air, or at a high altitude.



SUBSURFACE BURST

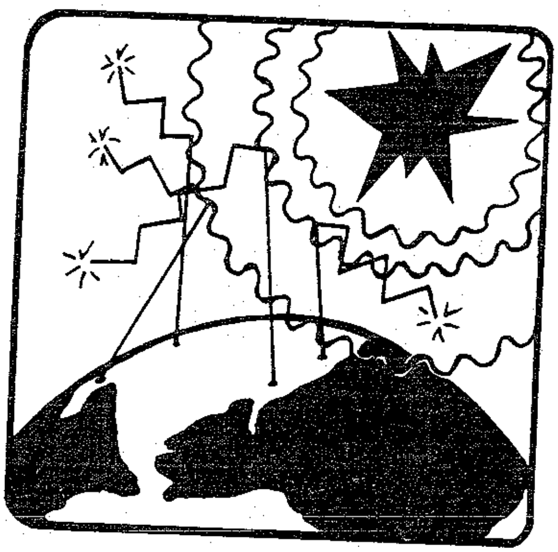
A subsurface burst is one in which the explosion occurs underground or underwater. This type of burst creates a shock wave which could cause an earthquake or sea surge. Much of the heat is absorbed by the ground or water; however, *the ground or water immediately surrounding the blast will be heavily contaminated with radioactive materials.*

GROUND BURST

When a nuclear weapon explodes on or near the ground so that the fireball touches the ground, it is called a ground burst. *Only ground burst weapons create significant fallout.* When the explosion occurs near the ground, the blast creates a crater that may be a mile wide. Vast amounts of pulverized radioactive debris and dust are sucked up into the rising fireball and become part of the radioactive cloud. The greater the amount of debris in the cloud, the greater the fallout.

AIR BURST

An air burst occurs when the explosion is high enough so that the fireball does not touch the ground. While almost no fallout is created by an air burst, *the area affected by the blast and heat is greater.*

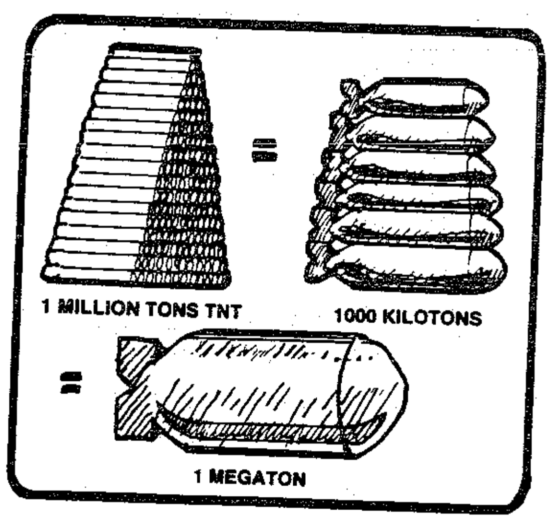


HIGH ALTITUDE BURST

A nuclear explosion that occurs 19 or more miles above the ground is called a high-altitude burst. This type of burst produces a brilliant fireball, but little, if any, heat, blast, or radiation will reach the ground. However, *a high altitude burst can disrupt communications over a wide area.*

SIZE OF THE WEAPON

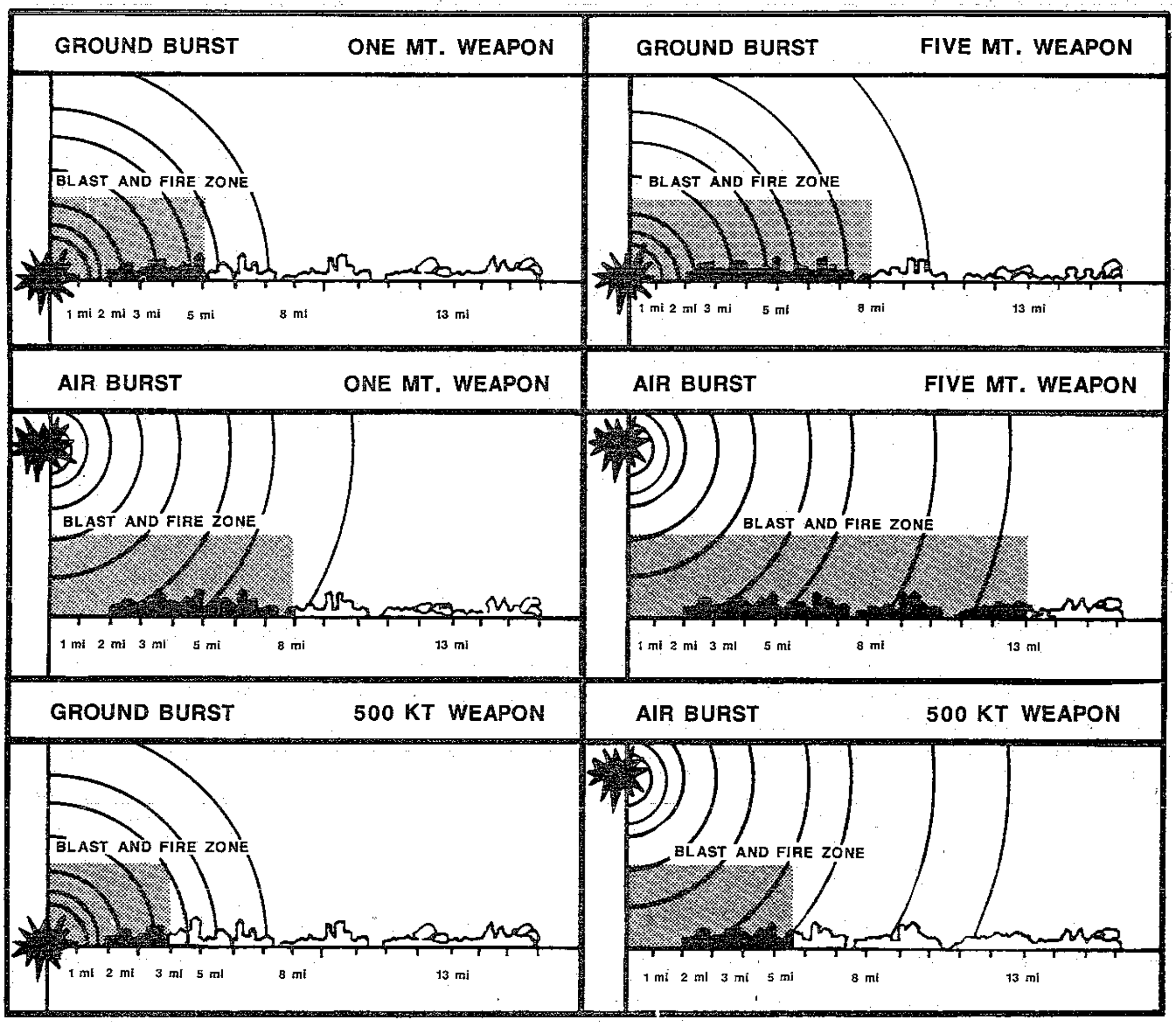
After the type of burst, the size of the weapon is most important in determining the size of the area that will be affected. Obviously, *the larger the weapon, the greater the reach of its blast.* Nuclear weapons are measured in kilotons (KT) or megatons (MT) of energy. One kiloton is equal to one thousand tons of TNT, and one megaton is equal to one thousand kilotons or one million tons of TNT. The most common weapons today are in the kiloton to small megaton range — 100 KT to 5 MT.



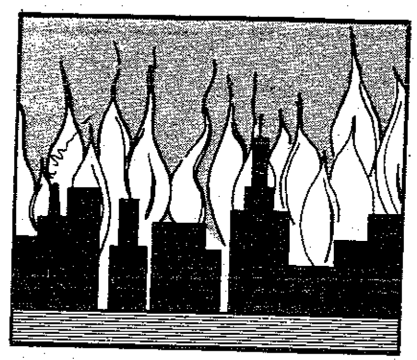
THE REACH OF VARIOUS SIZED WEAPONS

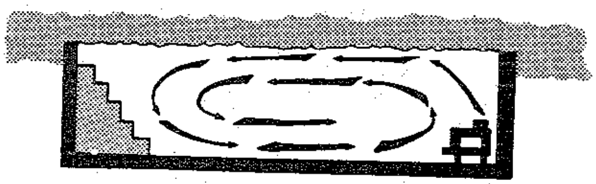
If a one megaton (1 MT) weapon bursts on the ground, the blast and fire damage is likely to extend 5 miles from the point of explosion. If the same size weapon bursts in the air, the reach of the blast and fire damage will increase to 8 miles.

If the size of the weapon exploded on the ground is increased to five megatons (5 MT), the reach of the blast and fire is approximately 8 miles. Exploded in the air, a 5 MT weapon will cause blast and fire damage 13 miles away.



The intense heat of the fireball and the waves of thermal radiation that travel outward from the blast will ignite flammable materials over a five to eight mile radius. Gas lines and fuel lines may break from the blast and be ignited by materials that are smoldering or burning from thermal radiation. Fires can spread through buildings, trash, dry trees, grass, weeds, and anything that burns.





Persons who survive the blast will require protection from the intense heat of the fires. Within one mile of the blast, persons in ordinary shelters would have little chance of surviving the heat. Specially designed and properly ventilated shelters are necessary for the survival of anyone close to the blast site or in the path of a fire.

Radiological Instruments

All radiological survey instruments are rate meters—they read out exposure per unit time. The two most commonly used radiation monitoring instruments are the Geiger-Mueller (G-M), or Geiger counter, and the ionization chamber. Each of these instruments detects radiation by collecting charged particles (ions). The Geiger-Mueller counter is designed to detect low-level radiation, while the ionization chamber is designed for both low- and high-level measurements. Some instruments read out in roentgens, rads, rems, milliroentgens, or millirads, while others read out in counts per minute (CPM).

The survey instruments most likely to be available in the field are those provided by the Federal Emergency Management Agency (FEMA), formerly called Civil Defense. These survey instruments are CD V-715 ionization survey meter and the CD V-700 G-M survey meter. These instruments were originally developed for use following nuclear warfare and thus have limited use in peacetime radiation accidents. *The CD V-715 will not detect or measure alpha or beta radiations and is further limited to rather intense gamma-radiation fields, For this reason, it is not the instrument of choice; instead, emergency personnel should use primarily the CD V-700 G-M survey meter.* The CD V-700 will detect most beta or gamma radiation but will not detect low-energy beta or alpha radiation. It is essential that emergency personnel choose a proper radiation monitoring device and become completely familiar with its operating principles.

The CD V-700 survey meter (Figure B-1) is a low-range instrument for estimating gamma-ray exposure rates and detecting the presence of most beta radiation. It has a probe with a movable shield that allows the operator to distinguish between gamma and beta radiations. With the detector shield open (Figure B-2), both beta and gamma radiation can be detected; with the shield closed beta radiation is blocked out and only gamma radiation reaches the detector tube. For emergency field monitoring operations the shield-open position should be used. The CD V-700 survey meter is used to determine background radiation levels and to determine whether accident vic-

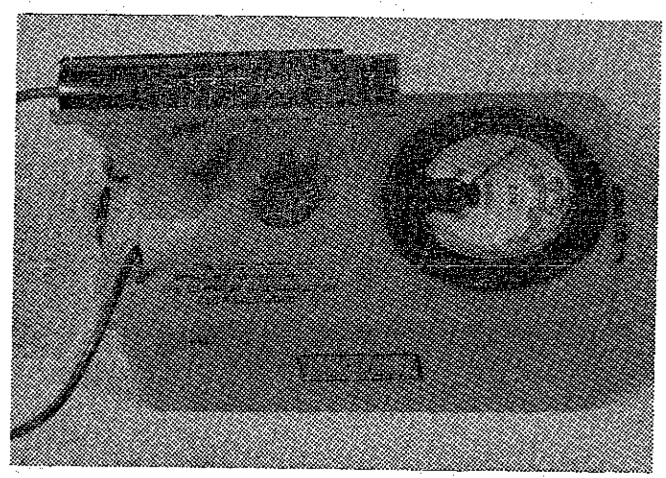


Figure B-1. CD V-700 Radiation Monitor.

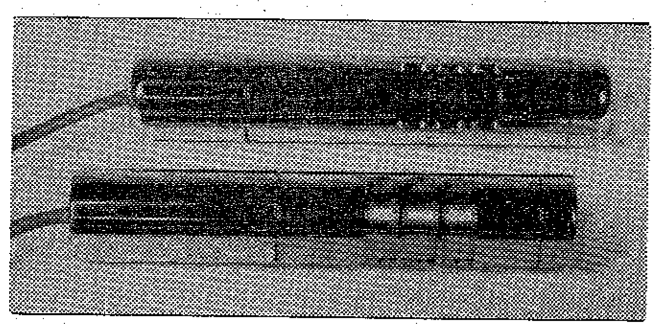


Figure B-2. Close-up View of Probe from CD V-700 Monitor.

Top: shield open; bottom: shield closed

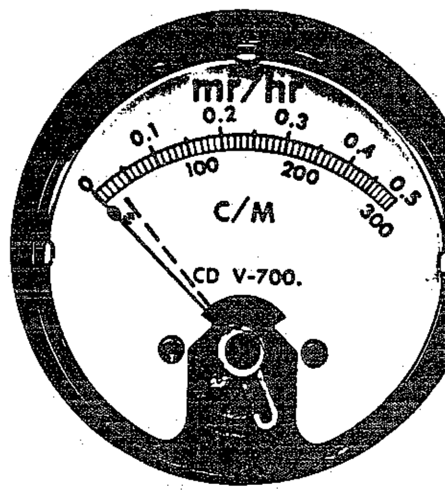
tims are contaminated. Headphones are provided with the instrument to permit monitoring without the need for continually watching the meter face.

The only control on the CD V-700 is a selector switch that has an OFF position and three ranges labeled ×100 (times 100), ×10 (times 10), and ×1 (times 1). On the ×1 range, the measured radiation exposure rate is read directly from the meter. On the ×10 and ×100 ranges the meter readings must be multiplied by 10 and 100, respectively, to obtain the measured rate. The maximum capabilities of the three ranges are 0.5 mR/hr on the ×1 range, 5 mR/hr on the ×10 range, and 50 mR/hr on the ×100 range. A check source is provided on the side of the instrument to test operability and response. The CD V-700 can jam or saturate at radiation exposure rates above 1 R/hr (1000 mR/hr), causing the meter reading to be incorrectly low or off-scale. A higher-range instrument must be used whenever radiation exposure levels exceed 50 mR/hr, the maximum that the CD V-700 is capable of measuring.

Remember that some shipments of radioactive materials have radiation levels that exceed the limits of the CD V-700 survey instrument, even though such shipments are within acceptable DOT regulations for exclusive use vehicles (Table 2). Thus, radiation exposure levels that exceed 50 mR/hr do not necessarily mean that radioactive materials have contaminated the environment in an accident. If only a CD V-700 survey meter is available, back off from the area to be monitored to a distance at which the exposure rate is below 50 mR/hr and estimate the exposure rate (using the Inverse Square Law) at points closer to the source of radiation.

Operational Check for CD V-700

1. Check visually to see that fresh batteries are in place. If not, insert them, observing the indicated polarity.
2. Turn the selector switch to the ×10 range.
3. Allow 30 seconds for warm-up time.
4. Open the probe shield and place the open area directly against the check source. There should be a deflection of the meter needle indicating that the instrument is responding to radiation. *Note: Some instruments have been calibrated by state maintenance shops for use in peacetime radiation incidents. In this case, the specific reading obtained from the check source will be indicated on a calibration sticker on the instrument.*
5. Determine the background radiation level by setting the instrument on the most sensitive scale (×1) and observing it for about 30 seconds. Figure B-3 illustrates proper meter response to background radiation.



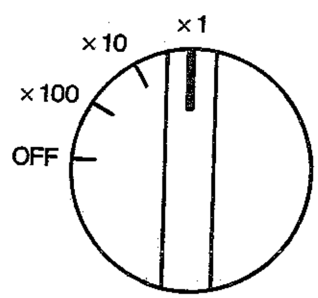


Figure B-3. Measuring Background Radiation with a CD V-700.

Background radiation is usually less than .05 mR/hr, or under 50 counts per minute (cpm), when the selector switch is on the ×1 range. The needle may jump about randomly on this setting because of erratic background radiation.

Model CD V-715 Ionization Chamber

The CD V-715, an ionization chamber survey meter (Figure B-4), is a high-range instrument for measuring gamma-ray exposure rates and should be used when high-level radiation hazards are suspected. It is not capable of detecting beta or alpha particles. In addition, the CD V-715 can be used to monitor only high-level (>50mR/hr) gamma radiation and is not capable of measuring low-level gamma contamination. The CD V-715 cannot be used to determine background radiation levels.

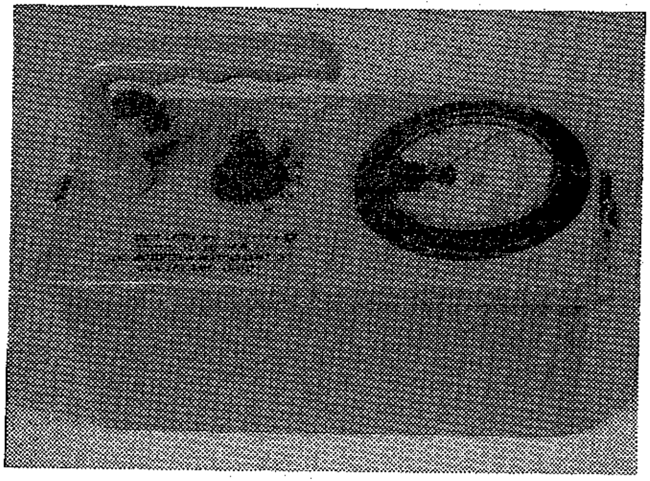


Figure B-4. External View of CD V-715 Radiation Monitor.

This meter has two controls. The selector switch has seven positions: CIRCUIT CHECK, OFF, ZERO, ×100 (times 100), ×10 (times 10), ×1 (times 1), and ×0.1 (times 0.1). On the ×1 range, the measured exposure rate is read directly from the meter. On the ×0.1, ×10, and ×100 ranges, the meter readings must be multiplied by factors of 0.1, 10, or 100, respectively, to obtain the measured exposure rate. A second control, the zero control, is used to adjust the meter reading to zero during the operational check and to adjust for drift during long periods of operation. Without proper zero adjustment, the instrument readings may have large errors. The maximum measurements are 500 mR/hr on the ×0.1 range, 5 R/hr on the ×1 range, 50 R/hr on the ×10 range, and 500 R/hr on the ×100 range.

Operational Check for CD V-715

1. Check visually to see that a fresh battery is in place. If not, insert one, observing the indicated polarity.
2. Turn the selector switch to the ZERO position.
3. Allow approximately 2 minutes warm-up time.
4. Adjust the zero control to make the meter read zero.
5. Turn the selector switch to CIRCUIT CHECK—the meter should read within the area marked CIRCUIT CHECK.
6. Recheck the zero setting on all four ranges.
7. Begin survey procedures with the instrument set on the ×0.1 range.

Alpha Monitoring

Except for nuclear weapons accidents, it is doubtful that alpha contamination will be encountered. A special type of instrument is needed to detect the presence of alpha radiation. One such instrument is shown in Figure B-5. Since alpha particles travel such short distances, the probe must be held within a few millimeters of the contaminated surface. Care must be taken not to contaminate the probe by touching the area being monitored. Alpha particles might not be detected in wounds since the blood or tissue fluids prevent the particles from reaching the monitoring surface. If you suspect alpha contamination, call for expert assistance as soon as possible.

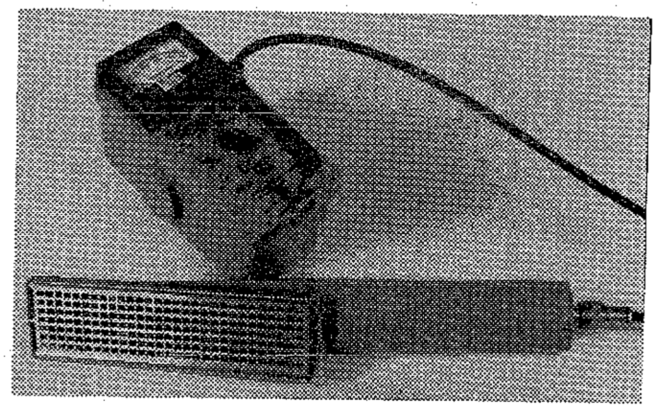


Figure B-5. Alpha Monitor.

Pocket Chamber Dosimeters

It is important that emergency responders limit their exposure when working in a radiation hazard environment. The responder should wear a device, if available, that measures accumulated radiation exposure. These devices are commonly called "pocket chambers," "pocket dosimeters," or "pencil dosimeters." The Federal Emergency Management Agency distributes several types of pocket chamber dosimeters: two examples are the CD V-138 and CD V-742 (Figure B-6).

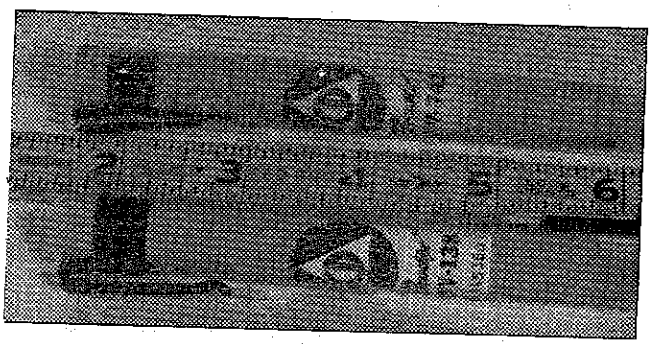


Figure B-6. CD V-742 (high-range) and CD V-138 (low-range) Pocket Dosimeters.

These dosimeters estimate the amount of gamma radiation to which the wearer is exposed. The CD V-138 measures relatively low levels of exposure and has a maximum scale reading of 200 milliroentgens, while the CD V-742 has a range of up to 200 R or 200,000 milliroentgens and is intended for measuring high levels of exposure.

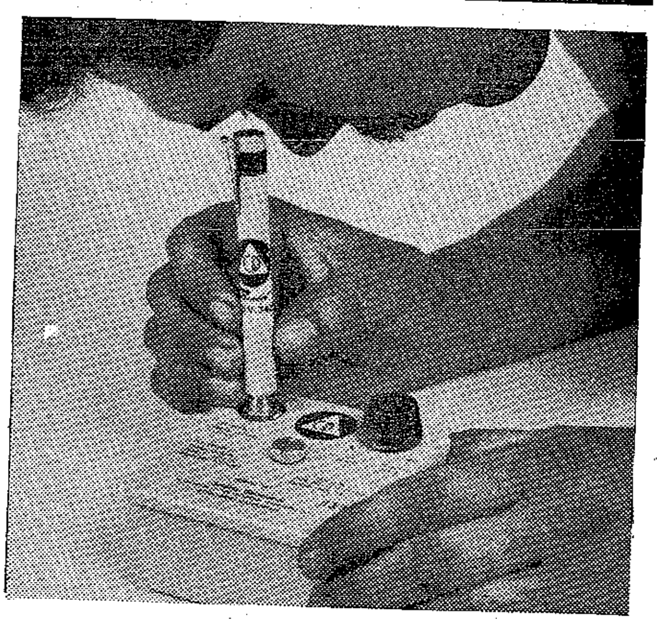


Figure B-7. Typical Technique for Zeroing Pocket Dosimeter.

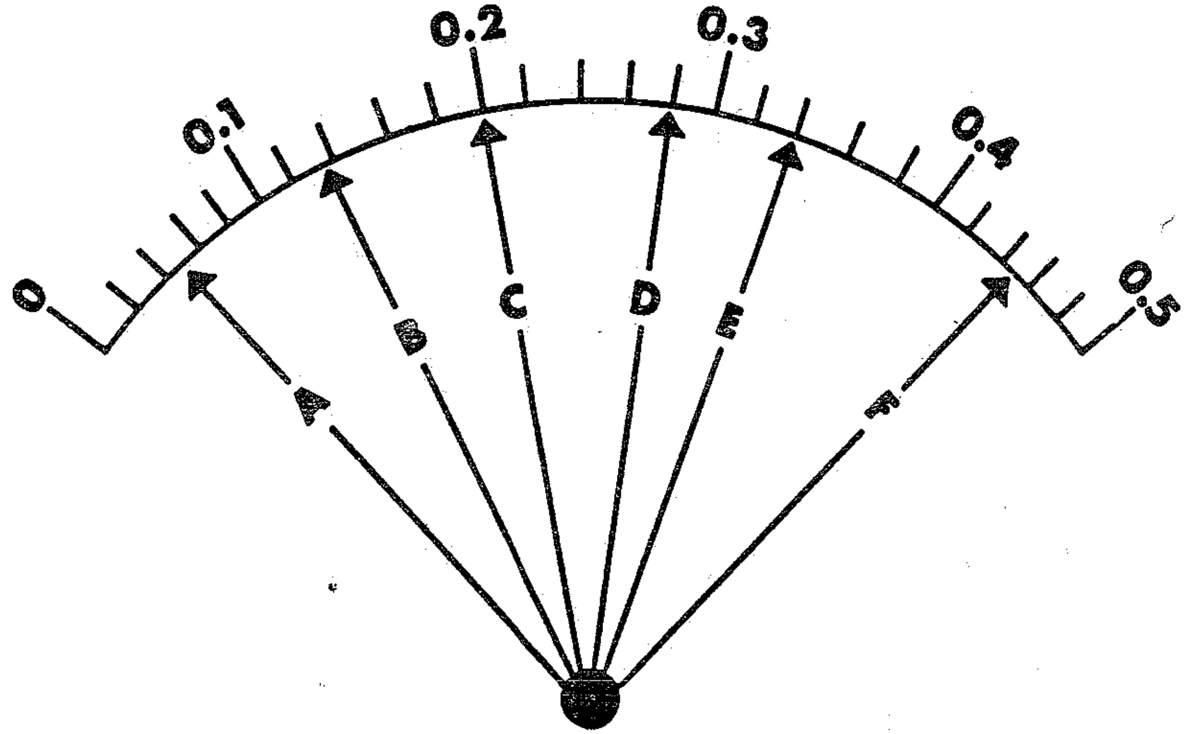
Even though it is extemely doubtful that emergency responders will have a need for the high-range dosimeter, in a peacetime environment it should be available. The low-range dosimeter should be checked every 15 minutes while in use in a radiation hazard area. Before use, the dosimeter chambers are reset or zeroed using model CD V-750 dosimeter charger (Figure B-7). After this initial setting, the wearer can read the dosimeter at any time. Readings should be reported to your supervisor or incident commander.

Operational Check and Use of CD V-750 Dosimeter-Charger

If time allows, emergency personnel should zero both models of these dosimeters and clip them on outer clothing pockets before approaching a radiation accident site, but do not delay lifesaving emergency care to perform the procedures listed below—dosimeters can be assigned while lifesaving emergency care is being administered.

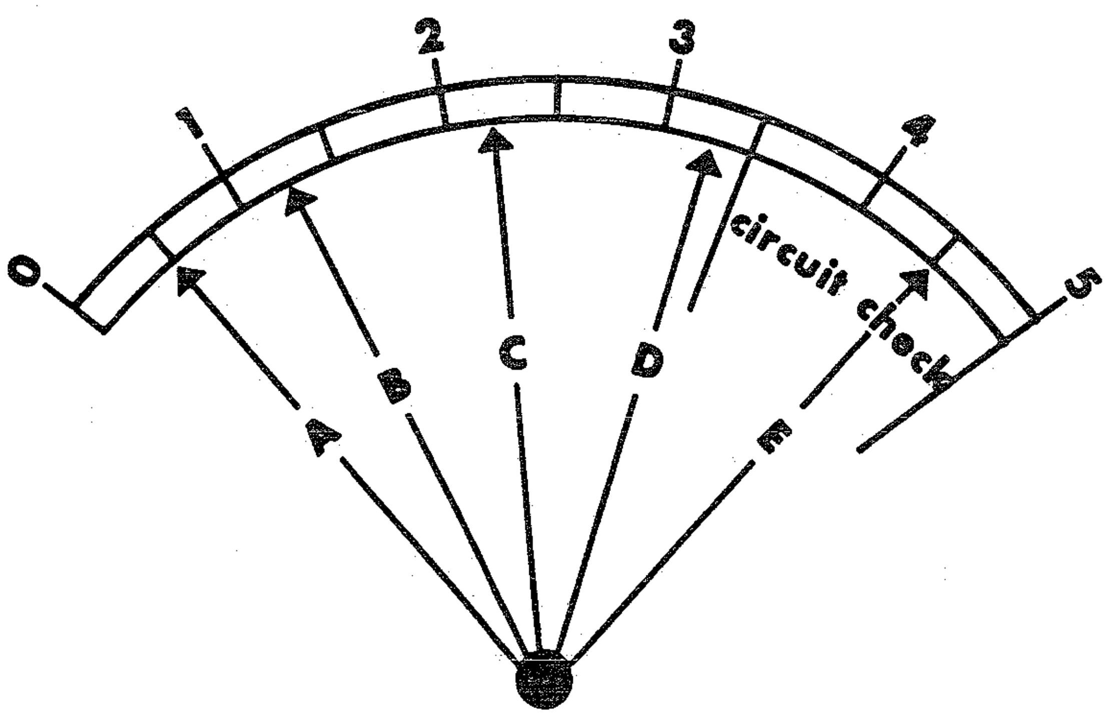
1. Check the CD V-750 dosimeter-charger visually to see that a fresh battery is in place. If not, insert one, observing the indicated polarity.
2. Remove the screw-on dust cap and place the CD V-138 or CD V-742 dosimeter on the charging contact.
3. Press down firmly while looking into the dosimeter.
4. Turn the charging knob on the CD V-750 and adjust until the cross hair falls on the zero mark on the scale.
5. Remove the dosimeter and note the position of the cross hair. If it has moved away from zero, repeat the charging procedures and compensate for the observed drift to obtain a reading of zero or slightly above zero.
6. Record this initial reading and the time to determine your total radiation exposure and the duration of that exposure after emergency procedures are completed.
7. Record the final readings upon leaving the radiation area.

CDV-700 METER AND PRACTICE READINGS



DIAL INDICATOR	RANGE	EXPOSURE RATE
A	X10	________ mR/hr
B	X100	________
C	X10	________
D	X10	________
E	X100	________
F	X100	________

CDV-715 METER AND PRACTICE READINGS



DIAL INDICATOR	RANGE	EXPOSURE RATE
A	X100	________ R/hr
B	X10	________
C	X1	________
D	X0.1	________
E	X10	________

RADIATION EXPOSURE RECORD

Name ______________________________ Date of Birth ______________
Last, First, Middle Int. Month/Day/Year

Social Security No. ________________ Course No. ______________

Location ____

Name of Licensee ______________________ License No. ______________

Date	Dosimeter Number	Initial Reading	Final Reading	Total Dose Final–Initial

Total Dose ______________ mR.

Dose recorded for whole body

Method of Monitoring is Self–Reading Dosimeter, CDV–138, 0–200mR. range for X and gamma radiation. (or equivalent dosimeter)

Statement of requirement and Privacy Act will be provided upon request.

Replaces NRC Form 5, Current Occupational External Radiation Exposure Form.

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WORKSHEET FOR
OPERATION PROSPECT EXERCISE

SOURCE	LOCATION OF SOURCE
0	(Base of fire hydrant).
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Basic Radiation Protection Principles

When responding to a radiation accident involving personnel injury, the emergency responder's first priority always is administering lifesaving emergency care. In addition, the emergency responder can use specific radiation protection principles to decrease the amount of radiation exposure to both himself and the accident victim.

These principles are based on consideration of *four radiation protection factors* that alter radiation dose: time, distance, shielding, and quantity.

Time

Time is an important factor in radiation protection. The principle states that the shorter the time spent in a radiation field the less radiation will be accumulated. Many radiation monitoring devices measure exposure in milliroentgens (mR) per hour. An exposure rate of 60 mR/hr means that for each minute spent in a radiation field, a person will be exposed to 1-mR (60 mR/hr ÷ 60 min/hr = 1 mR/min). Obviously, the longer a person remains in a radiation field, the greater their exposure. A *rotating team approach* can be used to keep individual radiation exposures to a minimum if personnel are available.

Distance

The second radiation protection factor is *distance*, and the principle is the farther a person is from a source of radiation, the lower the radiation dose. This principle is known as the inverse square law. By measuring the radiation exposure rate at a given distance from a source and then doubling the distance from the source, the intensity of the radiation is decreased by a factor of four. For example, a source of radiation that measures 8 mR/hr at 2 feet from a source would measure only 2 mR/hr at 4 feet. Conversely, when the distance from the source of radiation is reduced by half, for example, from 2 feet to 1 foot, the exposure rate increases from 8 mR/hr to 32 mR/hr, a factor of four. Figure C1 illustrates the inverse square law.

The inverse square law is valid only for small point sources such as those used in radiography. The inverse square law does not apply in accident situations where radioactive materials are released and scattered or when radioactive fallout is present. However, the level of radiation exposure is always *greatly* reduced by moving away from radioactive materials.

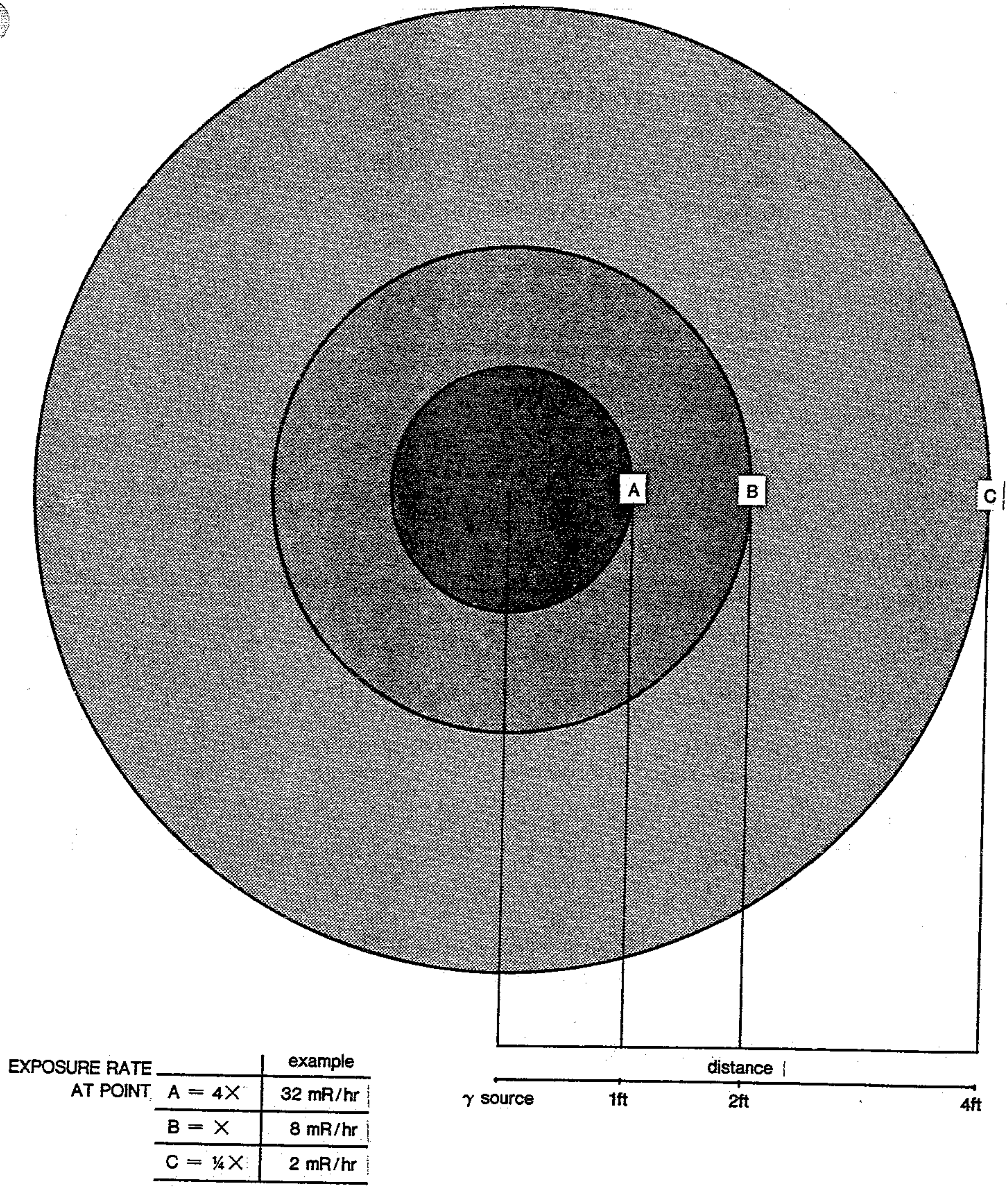
Shielding

The third radiation protection factor is *shielding*. The principle follows that the denser a material, the greater is its ability to stop the passage of radiation. In most cases, high-density materials such as lead are used as shields against radiation. Many materials, such as a vehicle, a mound of dirt, or a piece of heavy equipment between the emergency responder and the source of radiation, can diminish the exposure level in the working area. However, in many emergency situations shielding is often limited to light-weight protective clothing such as gloves, shoecovers, standard fire turnout gear, coats and jackets, or surgical clothing to protect the individual against contamination. Such clothing is sufficient to stop all alpha and some beta radiation, but it does not stop penetrating gamma radiation. Shielding is not always practical during emergency field operations, but the administration of emergency care should not be delayed to seek shielding materials. Rather, the principles concerning the factors of time and distance can be used to reduce radiation exposure.

Quantity

The fourth radiation protection factor is *quantity*. Because the exposure rate from a given radioactive material is directly related to the amount or quantity of the material present, the principle involves limiting the quantity of radioactive material in the working area to decrease radiation exposure. Any technique that reduces the amount of radiation or radioactive material in the accident area is very useful. Examples include removing contaminated clothing from victims and responders, carefully moving containers of radioactive materials from the immediate area while avoiding direct contact with the materials, and bagging all contaminated items and removing them from the immediate area. While these protection principles are not unique to hazardous materials (hazmat) response situations, they can grealy reduce the potential risks involved when radioactive materials are present. An emergency responder, when required to respond to any hazmat incident, should

1. *Spend as little time as possible in the immediate danger area* (TIME)
2. *Stay as far away from danger as possible* (DISTANCE)
3. *Wear protective clothing and stay behind barriers when possible* (SHIELDING)
4. *Keep the amount of hazardous material in the work area contained, isolated, limited, etc.* (QUANTITY)

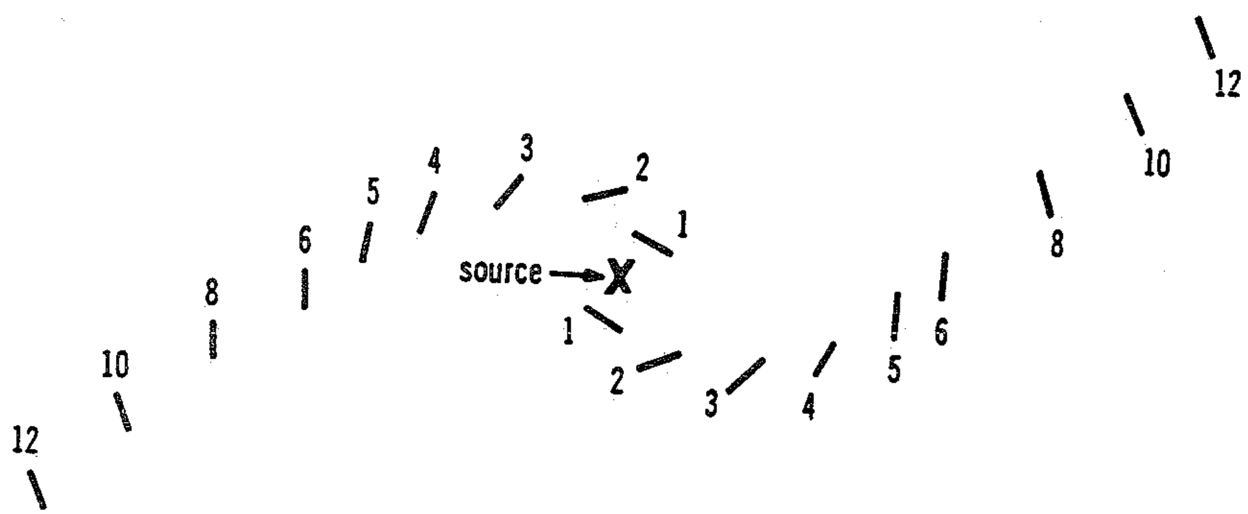


EXPOSURE RATE AT POINT		example
	A = 4X	32 mR/hr
	B = X	8 mR/hr
	C = ¼X	2 mR/hr

Figure C1. The Inverse Square Law.

Spiral Exercise

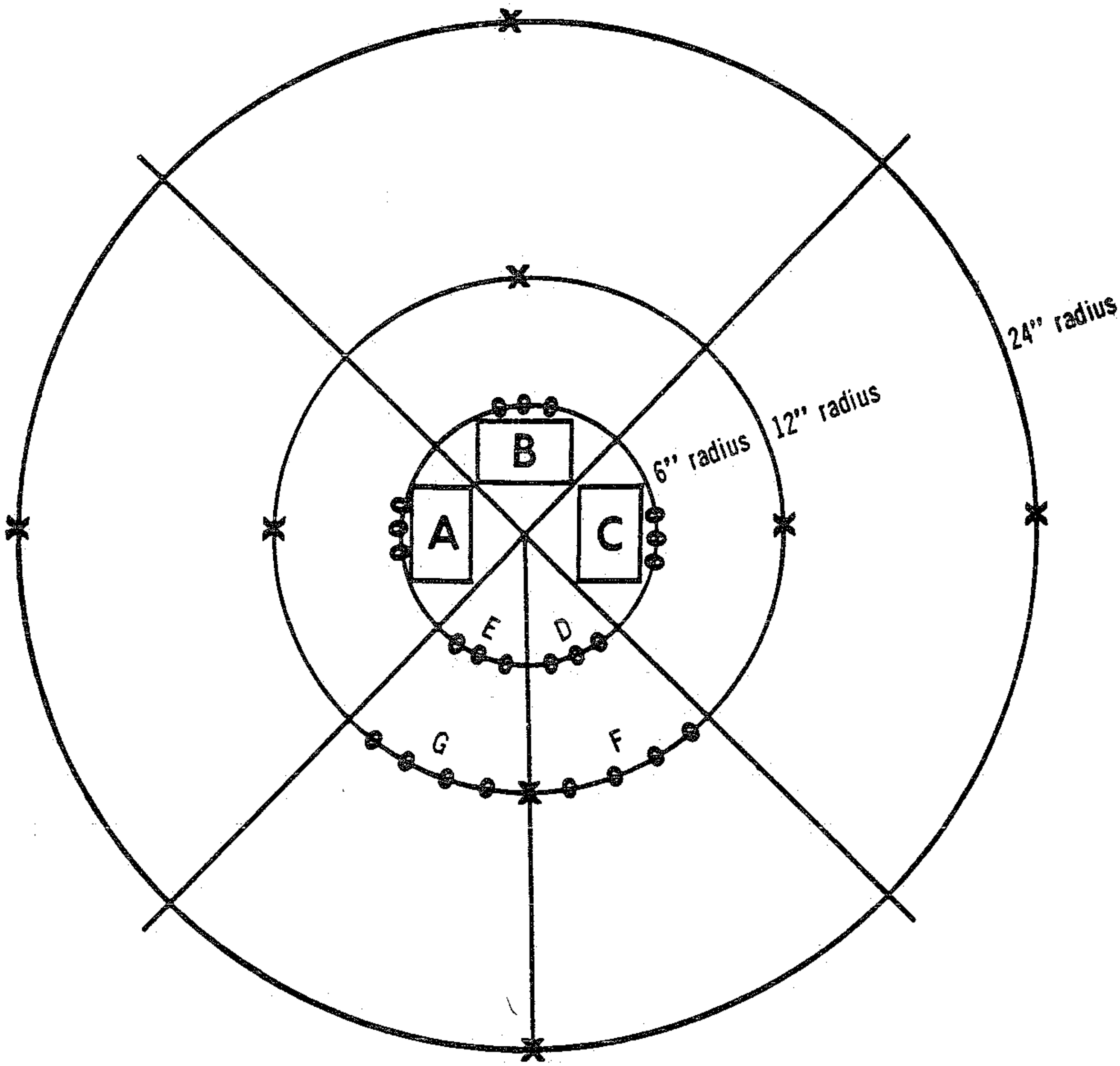
Numbers and bars represent measuring locations and distance in feet from point source.



Worksheet
For
Spiral Exercise

DISTANCE (FEET)	RANGE	×	METER READING	=	MEASURED EXPOSURE RATE (mR/hr)
1		×		=	
2		×		=	
3		×		=	
4		×		=	
5		×		=	
6		×		=	
8		×		=	
10		×		=	
12		×		=	
14		×		=	
16		×		=	
18		×		=	
20		×		=	
		×		=	
		×		=	
		×		=	
		×		=	
		×		=	

Radiation Protection Exercise Layout



0 CDV–138 Dosimeter Exposure Positions
X Locations of CDV–700 Survey Meter Readings
A Shielding Material – Wood
B Shielding Material – Earth
C Shielding Material – Brick

Worksheet for Radiation Protection Exercise

UNSHIELDED QUADRANT

TIME (Min.)	DISTANCE (inches)	DOSIMETER READINGS							AVERAGE READING	CALCULATED READING	SURVEY METER READING
10	6										
10	12										
20	6										
20	12										
	24										

WOOD SHIELDED QUADRANT

TIME (Min.)	DISTANCE (inches)	DOSIMETER READINGS							AVERAGE READING	CALCULATED READING	SURVEY METER READING
20	6										
	12										

EARTH SHIELDED QUADRANT

TIME (Min.)	DISTANCE (inches)	DOSIMETER READINGS							AVERAGE READING	CALCULATED READING	SURVEY METER READING
20	6										
	12										

BRICK SHIELDED QUADRANT

TIME (Min.)	DISTANCE (inches)	DOSIMETER READINGS							AVERAGE READING	CALCULATED READING	SURVEY METER READING
20	6										
	12										

COMPUTING PERCENT REDUCTION

SHIELDING MATERIAL	UNSHIELDED DOSIMETER AVERAGE	SHIELDED DOSIMETER AVERAGE	DIFFERENCE	PERCENT REDUCTION
WOOD				
EARTH				
BRICK				

Worksheet for Individual Exercise Stations

Purpose: This worksheet will be used to annotate results determined at each numbered station. The instructor will check/approve sheet at the completion of the exercise.

STATION 1 Determine the type and the exposure rate of the radiation being emitted from the CDV 787 Training Source. Annotate the results below.

CDV 700 BETA _____ GAMMA _____ Exposure Rate ___________

CDV 715 BETA _____ GAMMA _____ Exposure Rate ___________

STATION 2: Determine the type of radiation and the exposure rate (if Applicable) being emitted from the source provided. Annotate as appropriate below.

CDV 700 BETA _____ GAMMA _____ Exposure Rate ___________

CDV 715 BETA _____ GAMMA _____ Exposure Rate ___________

STATION 3: Determine instrument defect and the solution to correct defect.

CDV 700 Defect ________________________________

Solution ________________________________

CDV 715 Defect ________________________________

Solution ________________________________

CDV 717 Defect ________________________________

Solution ________________________________

CDV 750 Defect ________________________________

Solution ________________________________

STATION 4: Zero the CDV 138's and the CDV 742's provided using the Dosimeter charger (CDV 750)

STATION 5: Read the exposure on the dosimeters provided and annotate results below.

Dosimeter # 1	________	6	________
2	________	7	________
3	________	8	________
4	________	9	________
5	________	10	________

STATION 6: Perform an operational check on the CDV 700.

STATION 7: Perform an operational check on the CDV 715.

STATION 8: Determine the exposure rate on the pre-set CDV 715's instruments and annotate results below. (NOTE: Do not operationally check instruments)

CDV 715:

1.	________	6.	________
2.	________	7.	________
3.	________	8.	________
4.	________	9.	________
5.	________	10.	________

STATION 9: Determine the type of radiation and the exposure rate (if applicable) from the sand pit provided.

CDV 700	BETA	______	GAMMA	______	Exposure Rate	________
CDV 715	BETA	______	GAMMA	______	Exposure Rate	________
CDV 717	BETA	______	GAMMA	______	Exposure Rate	________

STATION 10: Read the exposure rate on the pre-set CDV 700 instruments and annotate results below.

CDV 700:

1.	________	6.	________
2.	________	7.	________

3. ____________________ 8. ____________________

4. ____________________ 9. ____________________

5. ____________________ 10. ____________________

Recognition of Potential Peacetime Radiation Hazards

Overview

When emergency response personnel arrive at the scene of an emergency they may not know in advance if radioactive materials are involved. Because radiation is not evident to the senses like many other hazardous materials, such as ammonia, the first step should be to survey the site visually for hazardous conditions. Various distinctive signs, labels, or placards indicate the presence of radioactive or other hazardous materials.

Transportation

Motor vehicles, rail cars, and freight containers often display radioactive warning placards when transporting certain types and quantities of radioactive materials (Figure D-1). As a guideline, the presence of such placards indicates that radiological safety controls might be necessary during emergency response activities. Placards are required on all vehicles that transport yellow-III-labeled packages or on exclusive use vehicles which may have packages without labels. However, in some cases radiation hazards can be minimal even when a *RADIOACTIVE* placard is present. Placards are required on vehicles transporting radioactive material of significant levels. However, unplacarded transport vehicles might carry packages of low-level radioactivity that present little hazard. See Figure D-2 for specific information regarding package labeling.

Every shipment of radioactive material should be accompanied by documents, such as shipping papers or bills of lading, which are of great value in assessing potential hazards in transportation accidents.

All shipments of radioactive material, with the exception of those containing limited quantities or those of low-level radiation, bear two identifying warning labels affixed to opposite sides of the *outer package*. Three different labels—white-I, yellow-II, or yellow-III— are used on the external surface of packages containing radioactive material, as illustrated in Figure D-2. The shipper chooses

Figure D-1. Typical Radioactive Warning Placard

Standard size is approximately 10 × 10 inches.

All sole-use surface vehicles carrying any quantity of LSA- or yellow–III-labeled packages or those carrying more than 1000 pounds of any radioactive material must display placards.

The placard is the standard Department of Transportation (DOT) hazardous materials warning placard for shipments of radioactive materials.

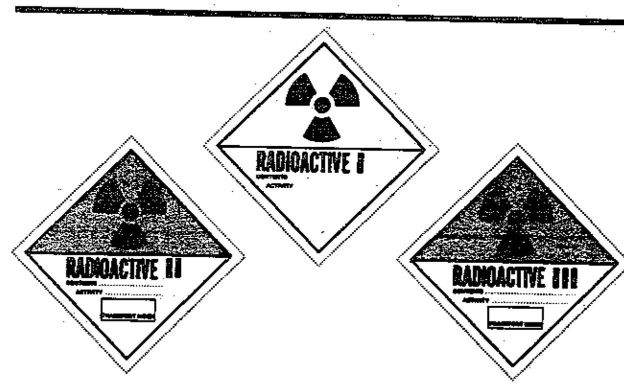


Figure D-2. Labels Required on Package Exterior.

Standard size is approximately 4 × 4 inches.
See Table 2 for usage explanation.

and applies the label based upon Department of Transportation (DOT) regulations governing the external radiation level, or, in some cases, the type and quantity of radioactive material within the package. Package labels specify the radioactive content and the quantity in curies. Yellow-II and yellow-III labels also specify the transport index (TI), which is equal to the maximum radiation level (measured in mrem/hr) at 1 meter from the undamaged package. For all practical purposes, one mrem equals one mR. The requirements for label use are summarized in Table 2.

Table 2. Requirements for Package Labels.

Label	*Radiation level associated with intact package*
Radioactive— White-I	Almost no radiation—0.5 mrem/hr maximum on surface
Radioactive— Yellow-II	Low radiation levels—50 mrem/hr maximum on surface; 1 mrem/hr maximum at 1 meter
Radioactive— Yellow-III	Higher radiation levels—200 mrem/hr maximum on surface; 10 mrem/hr maximum at 1 meter Also required for fissile class III or large-quantity shipments, regardless of radiation level

Fixed Facilities

Emergency responders also should be alert for radiation hazards that can exist at hospitals, universities, or industrial sites. Remember, wherever radioactive materials or radiation-generating devices such as an x-ray machine or accelerators are used, their presence will usually be indicated by posted signs on entry doors, storage vaults, cabinets, or containers. Typical signs or labels indicating the presence of radiation or radioactive materials at fixed facilities are illustrated in Figure D-3. Watch for signs that will state what radioactive materials or radiation-generating devices are inside. The signs also will state the amount of any radioactive material present. Rooms or areas posted with the sign "*CAUTION—HIGH RADIATION AREA*" should be entered only to rescue injured individuals or upon the advice of health physics personnel.

Emergency responders should become familiar with local industries handling or using radioactive materials.

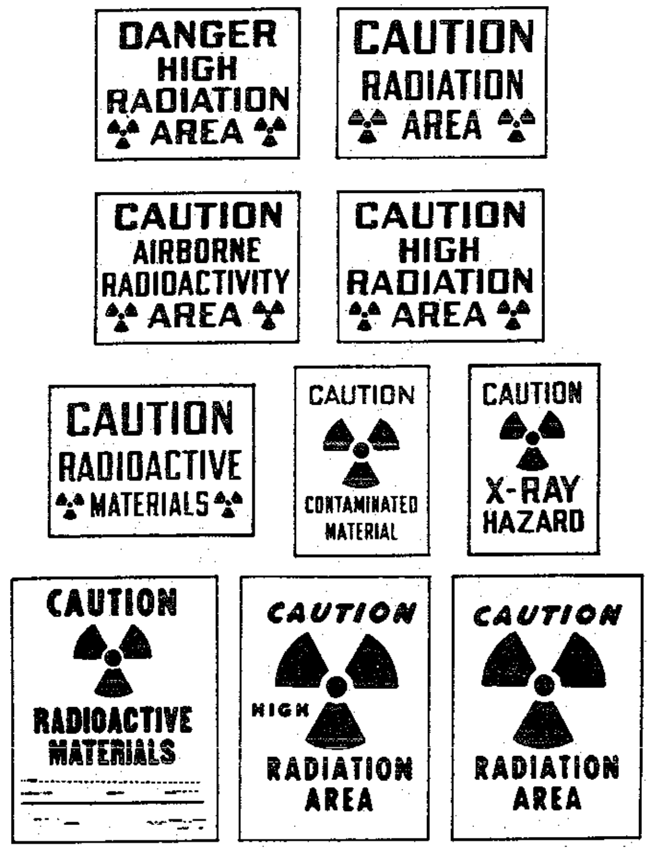
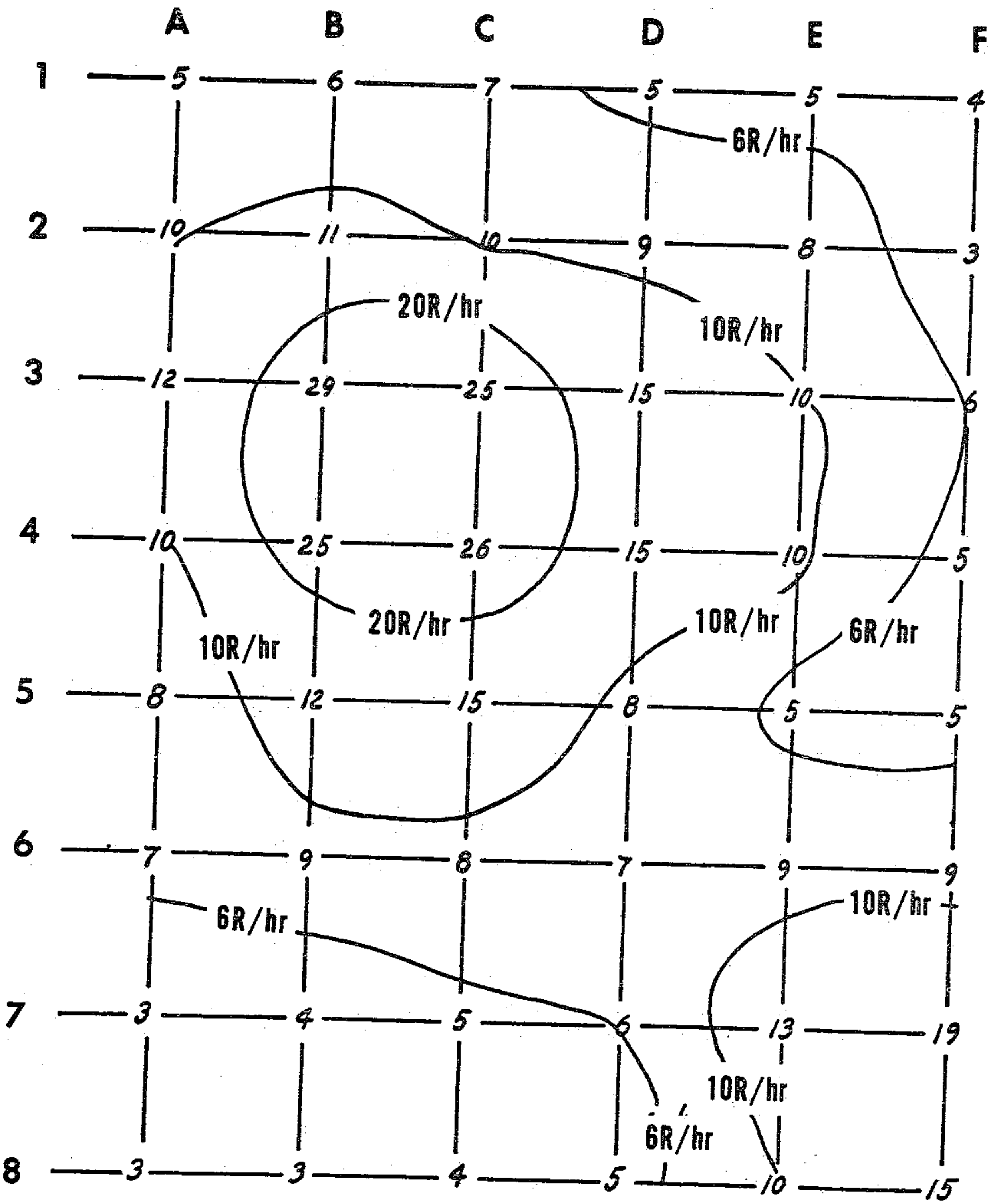


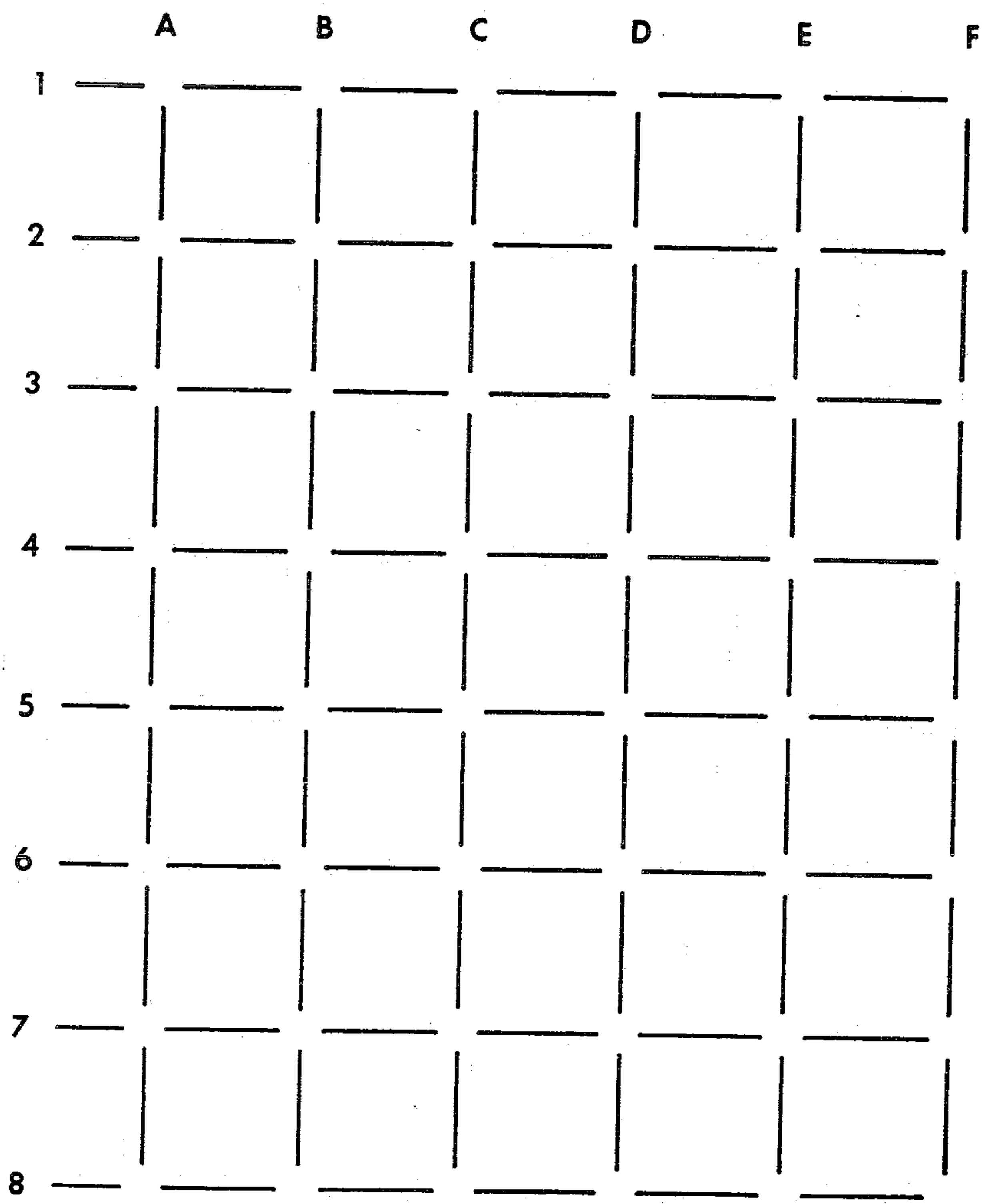
Figure D-3. ***Typical Signs or Labels Indicating the Presence of Radiation or Radioactive Materials.***

Immediate guidance and advice should be sought from the local Radiological Response Team (RRT) when any radioactive hazard is suspected.

Sample Worksheet
For
Area Monitoring Exercise



Worksheet
For
Area Monitoring Exercise



Rescue and Care of Victims Involved in Peacetime Radiation Accidents

Assessing the Site and Initial Entry

If radiation hazard indicators are evident at the accident site, appropriate safety precautions should be initiated. Generally, these procedures are the ones used when any toxic or hazardous material is present. Whenever practical, emergency vehicles should be parked upwind, away from any smoke, fumes, or areas of liquid spills. If possible, emergency personnel should also approach from the upwind area.

Emergency personnel making the initial site assessment should notify their dispatcher to alert the appropriate state radiological health office or local radiological survey personnel to monitor the scene (see inside back cover for call list).

The primary responsibility of the first emergency medical team on the scene is to determine whether injured victims are present and to provide necessary rescue and emergency medical care. If available, various items of protective clothing, such as fire turnout gear, boots or shoe covers, coveralls, and coats or jackets, should be quickly donned if radioactive contamination is suspected. Protective clothing prevents skin contamination by radioactive materials but does not stop penetrating gamma radiation. Use good judgment, but do not delay emergency lifesaving care if protective clothing is not readily available.

The use of self-contained breathing apparatus is based on potential nonradiological hazardous conditions, such as fire, smoke, dust, or gas, which could cause radioactive materials to become airborne. Surgical or disposable gloves can be worn to treat injured accident victims. Firefighting personnel can deal with fires and other site hazards as they do when toxic chemicals are involved.

Radiological survey instruments, if available, are recommended for initial entry to the site. Before entering the accident area, determine the background radiation level using the CD V-700, or a similar survey instrument. Background radiation levels cannot be determined using the CD V-715 or other high-range gamma-detecting instruments; therefore, a positive response on high-range meters such as these should stimulate the emergency medical team to work quickly. While survey meter readings above the background radiation level indicate the presence of a potential radiation hazard, a positive meter reading does not always mean that a dangerous situation exists.

Radiation exposure should always be kept as low as possible. Guidelines recommend accumulation of not more than 25,000 mrem (25 rem) in general emergency situations or 100,000 mrem (100 rem) to save a life; however, do not delay giving lifesaving care to attempt precise measurements of radiation exposure levels.

Emergency Medical Procedures

Because serious medical emergencies have priority over radiological hazard assessment, the emergency medical team should immediately assess and assure the airway, breathing, and circulation of any accident victim. It is unlikely that cardiopulmonary resuscitation (CPR) will be needed by a victim whose only problem is external irradiation or contamination with radioactive materials. In the event that CPR is required, breathing can be supported through use of a pocket mask or positive pressure ventilator. Since serious contamination is unlikely, the EMT/paramedic should not be concerned about providing mouth-to-mouth resuscitation if necessary. If self-contained breathing apparatus is needed by the rescue team, it will also be needed by the accident victim. The presence of radiation will not interfere with any rescue or extrication equipment used and will not influence the extinguishing properties of firefighting products.

If possible, move victims away from areas of potential radiation exposure or contamination before initiating advanced life-support measures. Use good judgment, but do not delay control of hemorrhage, fracture stabilization, administration of fluids, or advanced life support if extrication procedures delay victim removal and you must work in the radiation hazard area. Above all, do not delay lifesaving medical procedures in order to decontaminate accident victims. Once life-threatening injuries have been treated, rescuers move the victim from areas of radiation exposure or contamination for further treatment and radiological monitoring. Backboards can be used for spinal injury protection and to move other accident victims from the immediate accident area.

Radiation exposure or contamination *usually* does not cause unconsciousness or immediate, visible signs of injury. However, many radioactive materials are corrosive and contact may result in chemical burns or respiratory injury. Chemical burns from corrosive radioactive materials are managed like any other corrosive injury. If intravenous fluids (IVs) are required, routine procedures for skin preparation and fluid introduction should be used regardless of skin contamination. However, the IV should be introduced in uncontaminated skin areas if possible. Precautionary IVs are not recommended because of the possibility of introducing contaminants into the body. If antishock trousers are needed, they should be used without regard to radioactive contamination, because they can be washed by standard techniques and monitored before returning to normal use. Health physics personnel should supervise the decontamination of equipment and supplies.

Nonmedical Personnel Procedures

While emergency medical actions are being carried out, police, firefighters, and other personnel should be isolating and securing the area by establishing the boundaries of a controlled (contaminated) area and a noncontrolled (noncontaminated) buffer area. Control lines are established in the same way as for nonradiological hazardous materials accidents. Several control lines can be used. The outer perimeter control line should be located where radiation exposure levels do not exceed background radiation levels, and the command post should be established near the outer perimeter control line. Information regarding the nature, type, and quantity of radioactive materials involved should be relayed to the appropriate agencies or organizations by the incident commander, who also notifies the dispatcher if accident victims are to be transported to hospitals (see *Hospital Notification*), Recommendations for establishing control lines for radiological accident response are illustrated in Figure E-1.

In addition, no personnel or equipment can

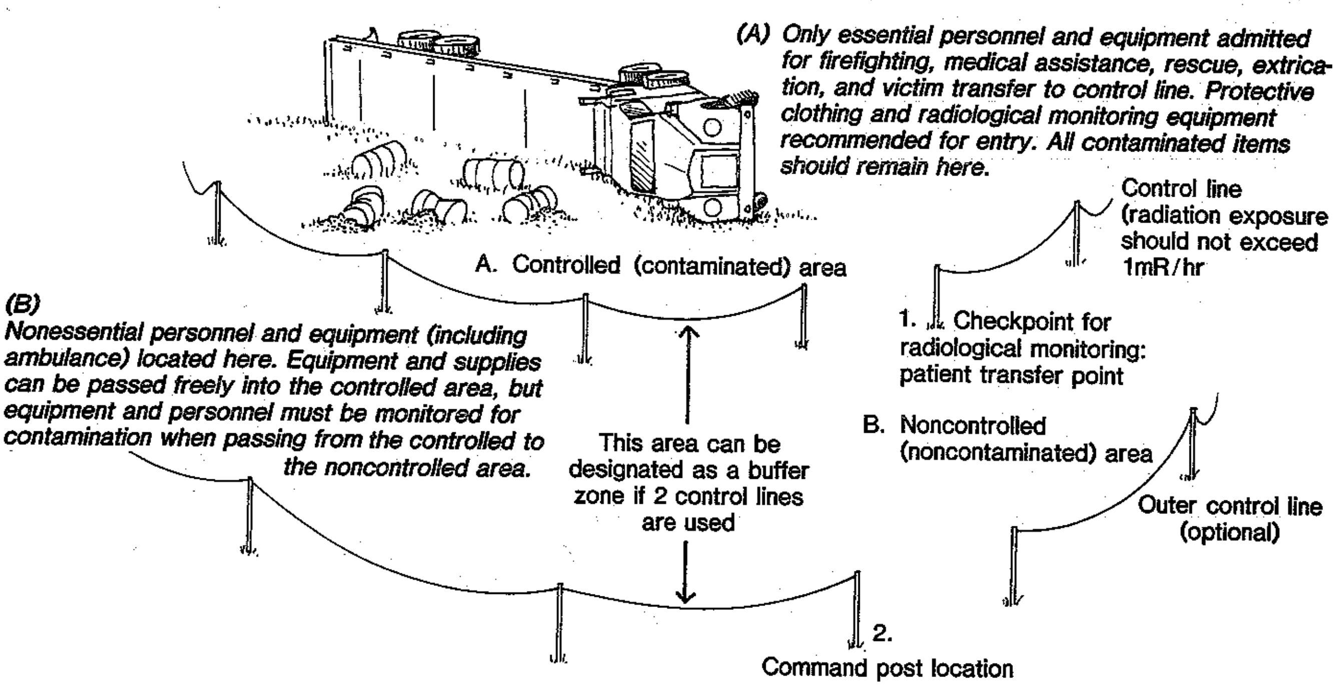


Figure E-1. Establishing Control Lines

leave the controlled area without being monitored for possible radioactive contamination. All civilians at the accident scene before emergency personnel arrive should be detained for identification and monitoring, and all contaminated equipment, supplies, and clothing should remain within the controlled area to prevent the spread of radioactive contamination.

Monitoring Accident Victims for Radioactive Contamination

When their medical condition permits, accident victims should be moved to the control line separating contaminated and noncontaminated areas for further care and radiological monitoring. The terms "monitor" and "survey" mean to detect the presence of ionizing radiation. Special electronic instruments must be used to detect ionizing radiation. Emergency response teams should be equipped with these radiation monitoring instruments and know how to use them. Emergency personnel should not attempt to make precise measurements of radiation. Their primary concern is to detect the presence of radiation.

Monitoring is done with a low-range instrument such as the CD V-700. During monitoring, the probe is held about 1 inch from the victim and moved slowly back and forth until the entire body has been surveyed. A total-body survey will depend upon the victim's medical condition. Any increase in radiation levels above a previously determined background radiation level is an indication that contamination has occurred. A procedure for determining victim contamination is outlined in Table 3.

Even if the accident scene is contaminated the victims might not be. If any doubt about contamination exists, accident victims should be handled as if they were contaminated. Uninjured victims who are contaminated also should be taken to a hospital emergency department for medical evaluation and decontamination. All other persons who have been in the controlled area should be detained for radiological monitoring, identification, and possible decontamination.

Usually, field decontamination of emergency responders is directed by health physics personnel. However, if health physics personnel are not available, contaminated emergency responders are packaged and transported to the hospital emergency department for decontamination.

Table 3. Determining if an Accident Victim is Contaminated.

1. Perform an operational check of the survey instrument CD V-700* (see page 20), keeping the probe shield open.

2. Set range selector switch to the most sensitive scale (×1).

3. Using the proper procedure, determine the background radiation level.

4. When necessary, adjust the range of the instrument by moving the selector switch. ***Meter readings should not be taken when the dial indicator reads in the lower 10 percent of the scale when on the × 100 and × 10 ranges. Turn the selector switch to the next most sensitive range to measure the exposure rate more accurately.***

5. Holding the probe about 1 inch from the patient, systematically survey the patient from head to toe on all sides. Avoid touching the probe to any contaminated surface. Move the probe slowly—approximately 1 inch per second. Pay particular attention to wounds, body orifices, and hands. An increase in count rate or radiation level above the previously determined background level indicates the presence of contamination with materials emitting gamma or high-energy beta radiation.

6. Note contaminated areas to be reported to the hospital emergency department. *Do not delay or hinder emergency medical care to survey victims for contamination. Do not move or turn a victim to perform a radiation survey if movement is medically contraindicated.*

*The CD V-700 cannot determine contamination from alpha or low-energy beta radiation. Therefore, if you suspect contamination with radioactive material that emits alpha or low-energy beta particles, handle the victim as contaminated.

Decontamination of Accident Victims

First, remove the clothing of contaminated victims. Often this will remove most of the contamination. The clothing should be sealed in labeled plastic bags and left at the accident scene. Wallets and other valuables can be put into a separate plastic bag and handled according to routine procedures. It is recommended that no other decontamination procedure be initiated because this might spread contamination on the accident victim. Most importantly, do not delay needed advanced life support to attempt decontamination in the field. However, keep in mind that the chemical form of some radioactive materials is corrosive, and accident victims contaminated with such materials are decontaminated using established procedures for corrosives.

Some local or state disaster plans spell out other decontamination procedures to be used when handling contaminated radiation accident victims. For example, loose, dry forms of contamination can be gently brushed away, and liquids can be blotted. The rescuer must use common sense to avoid spreading contamination, being especially careful not to contaminate the nose, mouth, eyes, ears, or wounds, since internal contamination can occur. Finally, *do not delay transporting seriously injured victims* to attempt field decontamination. *Remove the victim's contaminated clothing, unless medically contraindicated, prepare, and transport the victim as soon as possible.* Any further onsite decontamination of the victim should be directed by health physics personnel.

Transporting Contaminated Victims

A clean stretcher should be covered with a sheet or blanket and placed near the control line separating the controlled (contaminated) from the noncontrolled (noncontaminated) areas. The victim is then transferred to the covered, clean stretcher, and the sheet or blanket folded to securely "package" the victim. An arm can be extended through an opening in the sheet to measure vital signs or administer intravenous fluids. Figure E-2 illustrates the proper technique for preparing the radiation accident victim for transport. If available, an ambulance crew that has not been in the controlled area should transport the accident victim.

Prevent contamination of the attendant's hands with gloves. If a second ambulance crew is not available, the rescuers should remove their outer protective clothing, except for gloves, and place the victims in the ambulance. Protective clothing removed at the scene is properly controlled by bagging, and clean gloves are put on for handling the victims enroute to the emergency department. As an additional precaution, the floor of the ambulance can be covered with a securely taped sheet to decrease the possibility of contaminating the ambulance; however, proper packaging of the accident victim will greatly reduce this risk.

There is little chance that ambulance drivers and attendants will receive any significant radiation exposure when transporting a contaminated person. Persons in direct contact with contaminated patients might receive somewhat higher radiation exposures, but these are potentially significant only if patients have extremely high levels of beta or gamma contamination. Remember, increasing the distance from the contaminated patient even slightly can reduce the amount of radiation exposure to attendants.

It might be necessary to transport radiation accident victims by air if local treatment facilities are not available. Again, properly packaging the victims will greatly decrease the possibility of aircraft contamination. Initial skin decontamination by knowledgeable persons should be considered if travel time is prolonged and close contact with the victim is required.

Deceased accident victims should remain at the accident site until the usual investigation is completed. Public health officials, assisted by health physics personel, should direct the handling and transporting of contaminated human remains.

Hospital Notification

If contamination of accident victims is suspected, hospital emergency department personnel should be alerted as soon as possible to prepare a radiation emergency area (REA), which will take about 20 to 30 minutes. Hospital personnel will also need to know the following things:

1. Number of victims
2. Medical status of each victim
3. Number of contaminated victims

To assist the hospital emergency department, a radiological status report can be relayed in transit at the same time the victim receives proper medical attention. The information most useful to the emergency department is the following:

1. Reevaluation of medical status

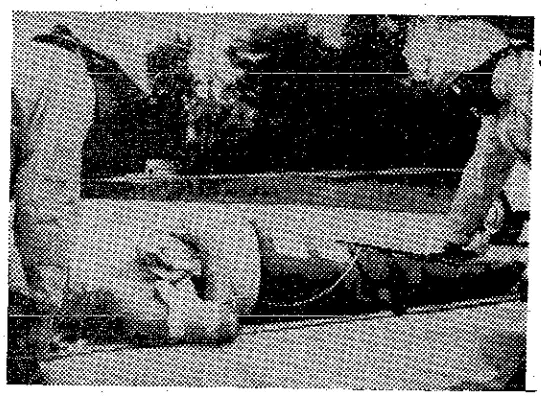
1

1. Vital signs rechecked at patient transfer point
2. Wounds exposed by cutting away clothing
3. Wounds covered with sterile dressings
4. Remainder of clothing removed unless medically contraindicated
5. Patient, wearing antishock trousers, placed on stretcher covered with sheet or blanket
6. One side of sheet or blanket folded over patient
7. Other side of sheet or blanket folded to overlap and "package" patient
8. Patient loaded into ambulance for transport

2

3

4



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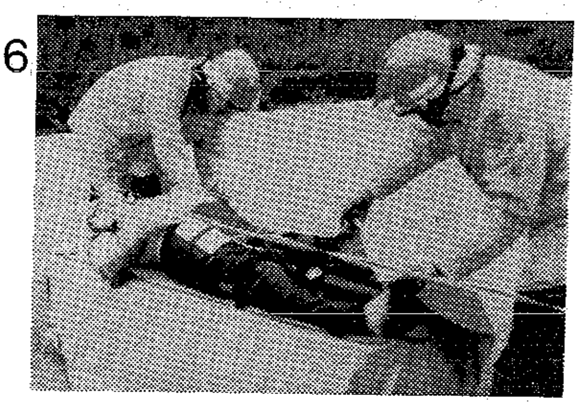

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Figure E-2. Preparing a Radiation Accident Victim for Transport.

2. Extent of contamination, if known
3. Areas of greatest contamination, if known
4. Any evidence of internal contamination
5. Identity of radionuclides and the chemical form, if known from shipping papers, labels, posted signs, etc.
6. Exposure to nonradiological hazardous materials, if any

Ambulance personnel should ask if there is a special entrance for patients contaminated with radioactive materials to aid contamination control of the hospital emergency department.

Hospital Procedures

The hospital emergency response team will probably meet the ambulance outside the emergency department. A contaminated victim in stable condition should not be taken immediately into the hospital but should be transferred to a clean hospital stretcher at the ambulance. This procedure will reduce the possibility that any contamination on the ambulance cot, sheet, or blanket will be taken inside the emergency department. The ambulance can return immediately to the radiation accident site to transport additional contaminated victims, but if the ambulance is no longer needed, it should be locked and kept at the hospital until it can be monitored for contamination. Decontamination and subsequent use of the vehicle and equipment is done under the direction of health physics personnel. In rural areas or where no alternate emergency vehicle exists, a contaminated ambulance and crew can be used to respond to another emergency. However, any patient transported in this ambulance must be handled as possibly contaminated until proven otherwise.

Before returning to regular service, ambulance personnel must be monitored and, if contaminated, shower and change clothing. A final survey by a radiation safety officer is required before leaving the controlled area at the hospital. In addition, any dosimeters issued in the field will be read by the hospital health physicist and the dosimeter readings recorded. A complete protocol summary for EMT/paramedic response to radiation accidents is shown in Table 4. A recommended list of equipment to be kept in the emergency response vehicle is given in Table 5.

Response in the Exposure Hazard Environment

Information in the preceding sections is intended to guide emergency medical service actions when they are complicated by radioactive contamination. However, there are accident response situations in which the only potential hazard is from exposure to ionizing radiation from sealed sources or radiation-generating devices such as x-ray machines or teletherapy units. These exposure hazards can involve high-intensity penetrating radiation.

The most common type of radiation accident involves exposure to penetrating radiation from sealed sources used in industrial radiography or nondestructive testing. Industrial radiography is a technique that uses gamma-ray emitters and x-ray film to take pictures of pipe welds to determine the integrity of high-pressure tanks, lines, etc. Radioactive materials commonly used in industrial radiography sources include iridium-192 (^{192}Ir), cesium-137 (^{137}Cs), cobalt-60 (^{60}Co), and radium-226 (^{226}Ra). Such sources can be small, but usually contain high levels of radioactive material. The sources rarely break open, but if they do contamination will probably occur. The sources are also extremely hazardous if touched or held in the hand and can expose individuals to excessively high doses of penetrating gamma radiation. Excessive exposure can occur when the source is not shielded by dense metal and if it is located less than 6 to 10 feet from an individual for several minutes or longer. Such exposures generally do not result in immediate signs or symptoms, and do not usually involve emergency medical personnel.

It is possible for an individual to be incapacitated by injury or serious illness, such as a coronary, while working with an industrial radiography unit. This person is not radioactive and can be handled like any other patient.

If a radiography source is unshielded, a radiation monitor will detect levels well above background radiation on approach to the immediate area. A high-range meter like the CD V-715 is recommended for initial approach. Also, rescuers should use personnel monitoring devices (dosimeters) if available. In rescuing persons under these conditions, the radiation protection principles of time, distance, and shielding can be applied. Rescuers should work quickly but efficiently to manage life-threatening problems. The victim can be moved from the source of radiation as soon as airway, breathing, and circulation are assured and necessary spinal stabilization accomplished. If rescue procedures are prolonged, personnel should be

Table 4. Field Operation Protocols for Radiation Accidents.

1. Approach site with caution—look for evidence of hazardous materials.

2. If radiation hazard is suspected, position personnel, vehicles, and command post at a *safe distance* (200–300 feet) upwind of the site.

3. Notify proper authorities and hospital (see inside back cover for call list).

4. Put on protective gear and use dosimeters and survey meters if immediately available.

5. Determine the presence of injured victims.

6. Assess and treat life-threatening injuries immediately. Do not delay advanced life support if victims cannot be moved or to assess contamination status. Perform routine emergency care during extrication procedures.

7. Move victims away from the radiation hazard area, using proper patient transfer techniques to prevent further injury. Stay within the controlled zone if contamination is suspected.

8. Expose wounds and cover with sterile dressings.

9. Victims should be monitored at the control line for possible contamination only after they are medically stable. Radiation levels above background indicate the presence of contamination. Remove the contaminated accident victims' clothing.

10. Move the ambulance cot to the clean side of the control line and unfold a clean sheet or blanket over it. Place the victim on the covered cot and package for transport. Do not remove the victim from the backboard if one was used.

11. Package the victim by folding the stretcher sheet or blanket over and securing them in the appropriate manner.

12. Before leaving the controlled area, rescuers should remove protective gear at the control line. If possible, the victim should be transported by personnel who have not entered the controlled area. Ambulance personnel attending victims should wear gloves.

13. Transport the victims to the hospital emergency department. The hospital should be given additional, appropriate information, and the ambulance crew should ask for any special instructions the hospital may have.

14. Follow the hospital's radiological protocol upon arrival.

15. The ambulance and crew should not return to *regular* service until the crew, vehicle, and equipment have undergone monitoring and necessary decontamination by the radiation safety officer.

16. Personnel should not eat, drink, smoke, etc., at the accident site, in the ambulance, or at the hospital until they have been released by the radiation safety officer.

Table 5. Suggested Equipment for Emergency Vehicles Responding to Radiation Accidents.

1. Standard turnout gear or other clothing to cover bare skin
2. CD V-700 and CD V-715 or other type radiation monitors or dosimeters, and fresh batteries
3. Surgical or disposable gloves
4. Plastic bags, trash bags, and ties
5. Full-sized sheets or blankets
6. Rope or barrier tape to mark the contaminated area

rotated. Persons not involved in rescue should stay away from the radiation area.

Never touch a sealed source. If it is necessary to move the source, use a shovel, broom, or rake, and use shielding if it is available. Do not stay in the area to measure radiation levels. If the victim's condition is satisfactory, a survey can be done at the ambulance to determine if contamination is present, which is highly unlikely. The hospital should be notified of the victim's contamination status.

The radiation area should be roped off, locked, or otherwise secured to prevent access by anyone other than radiation health specialists. Accurate reporting of details concerning this type of accident are helpful to accident investigators. As soon as possible after the rescue, record

1. Where the victim was located in relation to the radiation source
2. How long the victim was in the radiation field
3. Names and addresses of the rescuers

In addition, retrieve any film badge or dosimeter worn by the accident victim and place it with the victim's personal belongings.

Summary

The information presented in this book is intended to teach the emergency responder the basics of emergency response to accidents involving radioactive materials. In preparing for or actually carrying out an emergency response, EMT/paramedics, firefighters, and other personnel should not respond with fear and uncertainty to peacetime radiation hazards. Rather, radioactive materials should be considered just another class of hazardous materials whose potential danger can be reduced by following the guidelines in this book. The DOT ***Emergency Response Guide*** and guidance from the State Radiation Control Agency should always be used in radiation emergencies.

Glossary

Words in boldface type are also separate entries in this glossary.

Absorbed dose — The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the radiation absorbed dose (rad). (see **Rad; Dose**).

Activity — The rate of decay of radioactive material, expressed as the average number of nuclear disintegrations per second. (see **Curie**).

Alpha particle — A specific particle ejected spontaneously from the nucleus of some radioactive elements. It is identical to a helium nucleus (He), which has an atomic mass of 4 and an electrostatic charge of +2. It has low penetrating power and short range. The most energetic alpha particle will generally fail to penetrate the skin. The danger occurs when matter containing alpha-emitting radionuclides are introduced into the lungs or wounds. Symbol: α.

Atom — The smallest particle of an element which cannot be divided or broken up by chemical means. It consists of a central core called the **nucleus**, which contains protons and neutrons. Electrons revolve in orbits around the nucleus.

Background radiation — The radiation in man's natural environment, including **cosmic rays** and radiation from the naturally radioactive elements, both outside and inside the bodies of men and animals. It is also called natural radiation. Man-made sources of radioactivity contribute to total background radiation levels. Approximately 90 percent of background radiation from man-made sources is related to the use of ionizing radiation in medicine and dentistry.

Beta particle — A small particle ejected spontaneously from a nucleus of a radioactive element. It has the mass of an electron and has a charge of minus one or plus one. It has medium or intermediate penetrating power and a range of up to a few meters in air. Beta particles will penetrate only a fraction of an inch of skin tissue. Symbol: β^-, or β^+.

Charged particle — An **ion**; an elementary particle that carries a positive or negative electrical charge.

Controlled area — An area where entry, activities, and exit are controlled to assure radiation protection and prevent the spread of contamination.

Cosmic rays — High-energy particulate and electromagnetic radiations which originate outside the earth's atmosphere.

Contamination, radioactive — Deposition of radioactive material in any place where it is not desired, particularly where its presence can be harmful.

Curie — The basic measuring unit used to describe the amount of **radioactivity** in a sample of material. One curie is equal to 37 billion disintegrations per second. Symbol: Ci.

Decay, radioactive — Disintegration of the nucleus of unstable atoms by spontaneous emission of charged particles, electromagnetic radiation, or both.

Decontamination — The reduction or removal of contaminating radioactive material from a structure, area, object, or person.

Detector — A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection instrument.

Dose — A general term for denoting the quantity of radiation or energy absorbed. If unqualified, it refers to absorbed dose. For special purposes it must be appropriately qualified. If used to represent exposure expressed in **roentgens** (R), it is a measure of the total amount of **ionization** that the quantity of radiation could produce in air (see **Absorbed dose**).

Dose rate — The **absorbed dose** delivered per unit time. It is usually expressed as rads per hour, or in multiples or submultiples of this unit, such as millirads per hour. The dose rate is commonly used to indicate the level of hazard from a radioactive source. (see **Rad; Dose**).

Dosimeter — A small, pocket-sized ionization chamber used for monitoring radiation exposure of personnel. Before use it is given a charge, and the amount of discharge that occurs is a measure of the accumulated radiation exposure.

Electromagnetic radiation — A traveling wave motion that results from changing electric and magnetic fields. Familiar electromagentic radiations range from those of short wavelengths, like **x-rays** and **gamma rays**, through the ultraviolet, visible, and infrared regions, to radar and radio waves of relatively long wavelengths.

Encapsulated source — A radionuclide sealed in a container such as a tube or needle. Also called a **sealed source**.

Exposure — A quantity used to indicate the amount of **ionization** in air produced by x- or gamma radiation. The unit is the roentgen (R). For practical purposes, one **roentgen** is comparable to 1 **rad** or 1 **rem** for x- and gamma radiation.

Gamma rays, or gamma radiation — Electromagnetic radiation of high energy, originating in atomic nuclei and accompanying many nuclear reactions, including fission, radioactive decay, and neutron capture. Gamma rays are identical with **x-rays** of high energy, the only essential difference being that the x-rays do not originate from atomic nuclei but are produced in other ways; for instance, by slowing down fast, high-energy electrons. Gamma rays are the most penetrating type of radiation and represent the major external hazard. Symbol: γ.

Geiger counter, or G-M meter — An instrument used to detect and measure radiation. The detecting element is a gas-filled chamber operated by a voltage whose electrical discharge will spread over the entire anode when triggered by a primary ionizing event.

Inverse square law — The relationship which states that gamma radiation intensity is inversely proportional to the square of the distance from a point source.

Ion — Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.

Ionization — The separation of a normally electrically neutral atom or molecule into electrically charged components. The term is also employed to describe the degree or extent to which this separation occurs. Ionization is the removal of an electron (a negative charge) from an atom or molecule, either directly or indirectly, leaving a positively charged ion. The separated electron and ion are referred to as an ion pair.

Ionizing radiation — Electromagnetic radiation (**x-ray** and **gamma-ray** photons) or particulate radiation (electrons, positrons, protons, neutrons, and heavy particles) capable of producing ions by direct or secondary processes.

Irradiation — Exposure to ionizing radiation.

Milli — A prefix meaning one one-thousandth of any unit. Examples include 1 milliliter (1/1000 of a liter) or 1 milliroentgen (1/1000 of a roentgen).

MPBB — *M*aximum *p*ermissible *b*ody *b*urden. The maximum amount of a specific radionuclide considered to produce no adverse health effects if deposited inside the body.

Monitoring — Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present for purposes of health protection. Also referred to as "surveying."

Nucleus, atomic — The small, positively charged core of an atom. It is only about 1/100,000 diameter of the atom but contains nearly all the atom's mass. All nuclei contain both protons and neutrons, except the nucleus of ordinary hydrogen, which consists of a single proton.

Rad — *R*adiation *a*bsorbed *d*ose. A (rad) is the unit of **absorbed dose**. The rad is a measure of the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest. A rad is approximately equal to the absorbed dose in tissue when the exposure in air is one roentgen (R) of medium-voltage x-radiation.

Radiation — The energy propagated through space or through a material medium such as waves; for example, energy in the form of electromagentic waves or of elastic waves. Radiation, or radiant energy, when unqualified, usually refers to electromagnetic radiation; such radiation commonly is classified, according to frequency, as Hertzian, infrared, visible (light), ultraviolet, **x-ray**, and **gamma ray**. Also, particles such as **alpha** and **beta** radiation, or rays of mixed or unknown type—for instance, **cosmic rays**—can be called radiation.

Radiation accident — An accident in which there is an unintended exposure to ionizing radiation or radioactive contamination.

Radioactivity — The spontaneous emission of radiation, generally **alpha** or **beta** particles often accompanied by **gamma rays**, from the nucleus of an unstable atom. As a result of this emission, the radioactive atom is converted, or **decays**, into an atom of a different element that might or might not be radioactive. Ultimately, as a result of one or more stages of radioactive decay, a stable, nonradioactive atom is formed.

Rem — *R*oentgen *e*quivalent *m*an—a special unit of radiation dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose multiplied by the quality factor (Q), the distribution factor, and any necessary modifying factors.

Roentgen — The unit of exposure from x- or gamma rays. (see **Exposure**).

Sealed source — A radioactive source, sealed in an impervious container, which has sufficient mechanical strength to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed. Generally used for radiography or radiation therapy.

Shipping package, or warning label — Label affixed to a package of hazardous material to identify the package contents. Department of Transportation (DOT) regulations establish the design and use requirements for these labels.

Shipping papers, or shipping documents — Forms containing a description of the materials being transported which must accompany all packages of radioactive material.

Survey instrument — A portable instrument used for detecting and measuring radiation under varied physical conditions. The term covers a wide range of devices.

Transport index — The number placed on a radioactive materials package label that indicates the control required during transport. The transport index is the radiation level, in millirems per hour, at 3 feet from the accessible external package surface; or, for fissile Class II packages, an assigned value based on criticality safety requirements for the package contents. Abbreviation: TI.

Vehicle warning placard — A sign displayed on the outside of a carrier of hazardous material indicating the nature of the cargo. The design and use of placards is specified by Department of Transportation (DOT) regulations.

X-rays — Penetrating electromagnetic radiation whose wave lengths are shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In nuclear reactions, it is customary to refer to photons originating in the nucleus as **gamma rays,** and to those originating in the extranuclear parts of the atom as x-rays. These rays are sometimes called roentgen rays after their discoverer, W. C. Roentgen.

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RADIOLOGICAL INCIDENT CALL LIST

Offices may have different names in your locale; change those below to fit your situation.

Phone: ______________________________
Local law enforcement agency

Phone: ______________________________
Local fire department

Phone: ______________________________
Local medical facility

Name: ______________________________
Physician

Phone: ______________________________
State radiological health office/civil defense

Phone: ______________________________
Local civil defense or disaster office

Name: ______________________________
Civil defense officer

Phone: ______________________________
State Governor's office

Phone: ______________________________
Local government office

Name: ______________________________
Local government official

Phone: ______________________________
Local individual known to you to be trained as hazardous materials expert

CHEMTREC*

Toll free: 800/424-9300

Calls from D.C. area: 483-7616

Calls outside continental U.S.: 202/483-7616

*CHEMTREC is the Chemical Transportation Emergency Center, a public service of the Manufacturing Chemists Association, Washington, D.C. CHEMTREC operates on a 24-hour basis and is designed to deal with *chemical* transportation emergencies. Note: CHEMTREC is *not* intended to function as a general information source. For more information, write: Manager, Chemical Transportation Emergency Center, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009.

NFPA†

617/328-9290

†NFPA is the National Fire Protection Association and provides information and training related to handling hazardous materials in emergencies involving fire or the potential for fire. For more information, write: NFPA, Batterymarch Park, Quincy, MA 02269.

Phone: ______________________________
Additional contact

Name: ______________________________

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