Unit 4 Nuclear Threat

In this unit you will learn:

- Nuclear weapon detonation characteristics and effects
- Protective measures against effects
- Exposure rate determination after a detonation

INTRODUCTION

The end of the cold war and the dissolution of the Soviet empire has changed, not eliminated, the nuclear threat to the United States. Other countries who previously had the weapons but did not have weapon delivery vehicles able to reach the United States now have the ability to do so. Improvised nuclear devices (IND) or radioactive disperson devices (RRD) (radioactive material placed inside a conventional explosive device) are becoming increasingly possible. These IND weapons are within a terrorist's ability to employ. The threat of a terrorist using weapons of mass destruction is increasing. A critical priority for the United States is to stem the proliferation of nuclear weapons and their delivery systems. Efforts are being made to account for and control all existing nuclear weapons and radioactive material worldwide. The United States also seeks to prevent additional countries and terrorist groups from acquiring nuclear weapons.

There is no doubt that a nuclear weapon detonation, either from an accident or an attack, would be a catastrophe. This unit is not intended to trivialize the tremendous destructive power represented by nuclear weapons. It is designed to inform you of actions you can take to increase your chance of survival in the event of nuclear detonation.

This unit provides a basic understanding of the potential hazards you may encounter in the event of a nuclear detonation and protective measures required to minimize your exposure to these hazards. Upon completion of this unit, you should be able to recognize the severity of a nuclear detonation and prioritize your actions in order to minimize the potential effect that the situation and hazards may have on you.

This unit is divided into three major sections: Nuclear Detonation, Protective Measures, and Exposure Rate Determination. Each of these sections contains information that can be used to enhance your chances for surviving a nuclear detonation.

The **Nuclear Detonation** section describes the different types of hazards that result from the nuclear explosion. These hazards include the effects from the flash, thermal and blast waves, initial nuclear radiation, and the longer-term hazard from radioactive fallout.

The **Protective Measures** section describes actions you can take to protect yourself and others from the hazards discussed in the Nuclear Detonation section. These measures include actions that can help you survive the immediate thermal and blast hazards, and guidance for minimizing your exposure to radioactive fallout.

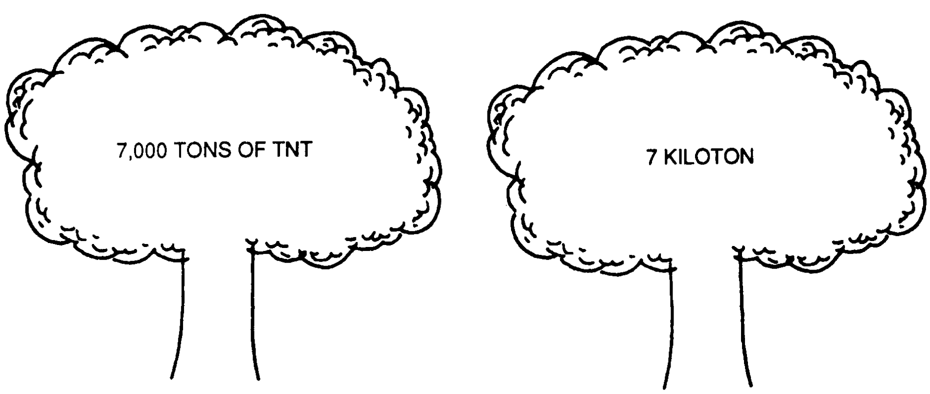
The **Exposure Rate Determination** section describes how to predict radiation exposure rates at various time periods after an initial radiation survey is performed. This section describes how to use a radiation survey instrument and presents a simple calculation for projecting exposure rates after a nuclear blast.

NUCLEAR DETONATION

In general terms, a blast or explosion is a rapid release of a large amount of energy within a limited space. There are five basic differences between nuclear and conventional blasts:

- Nuclear explosions are caused by an unrestrained fission reaction whereas conventional explosions are caused by chemical reactions.
- Nuclear explosions can be millions of times more powerful than the largest conventional explosions.
- Nuclear explosions create much higher temperatures and much brighter light flashes than conventional explosions, to the extent that skin burns and fires can occur at considerable distances.
- Nuclear explosions are accompanied by highly penetrating and harmful radiation
- Radioactive debris is spread by a nuclear blast, to the extent that lethal exposures can be received long after the explosion occurs.

The power of a nuclear explosion is expressed in terms of its relationship to TNT due to the enormous power possessed by a single nuclear weapon, the explosive energy available is equivalent to thousands of tons (kilotons) or even millions of tons (megatons) of TNT. For example, if a nuclear explosion releases energy equivalent to 7,000 tons (6 million kilograms) of TNT, it is called a 7 kiloton blast.



7,000 Tons of TNT = 7 Kiloton Blast

In this section, you will learn about the different types of hazards that result from a nuclear detonation. The energy yielded immediately by a blast presents hazards **from blast or shock effects, thermal radiation effects, and nuclear radiation effects**. You will also learn how longer-term hazards, such as radioactive fallout, could result from a nuclear detonation.

Types of Burst

The destructive forces associated with a nuclear explosion vary with the location of the point of burst in relation to the surface of the earth. The main types are:

- ***High Altitude Burst.*** Detonation above 100,000 feet. Destructive forces do not significantly affect the ground.
- ***Air Burst.*** The fireball does not touch the ground. Detonation is below 100,000 feet.
- ***Surface Burst.*** Detonation occurs at or slightly above the actual surface of the earth. The blast kicks up considerable radioactive debris. "Dirty Bomb"
- ***Sub-surface Burst.*** Detonation occurs under ground or under water. Depth determines destructive forces on the surface.

Energy Yield

The total energy released in nuclear explosion is called the weapon's energy yield. The energy yield of a nuclear explosion takes three forms:

- Thermal radiation (light and heat)
- Blast or shock effect
- Nuclear radiation

Thermal Radiation

The energy yield of a nuclear blast also includes tremendous amounts of light and heat, as if an enormous sun lamp was flashed on for a matter of seconds. This flash of light and heat, called **thermal radiation**, travels ahead of the winds and overpressure. The light flash is so intense that it can cause "flashblindness" and even skin burns. When flashblind, people are unable to see what is going on around them or what they are doing. A 6 kiloton blast could cause flashblindness 0.5 miles (0.8 km) away on a clear day, or 20 miles (32 km) away at night. Many people in Hiroshima and Nagasaki were blinded for several minutes. Some cases of flashblindness lasted up to three hours, and one person suffered permanent blindness. A nighttime blast probably would have caused more severe blinding effects due to the degree of pupil enlargement and focusing actions of the eye.

The high intensity of light is strong enough to cause skin burns. A 10 kiloton blast can cause first degree burns 2 miles (3.2 km) away on a clear day. First degree burns are equivalent to a bad sunburn. The same blast can cause second degree burns 1.5 miles (2.4 km) away. Second degree burns over 30 percent of the body will result in serious shock and death without medical attention. Blisters from second degree burns will become infected if untreated. The same blast can cause third degree burns about 1.0 miles (1.6 km) away. Third degree burns destroy skin tissue, to the extent that such burns over 24 percent of the body will cause serious shock and death without specialized medical care.

The temperatures at the center of a nuclear explosion can reach tens of millions of degrees. Although temperatures fall off rapidly with increasing distance, a nuclear blast is capable of causing skin burns and setting fires at considerable distances. There is evidence from data gathered in Japan that temperatures may exceed 3,000°F (1650°C) as far as 3,200 feet (975 meters) away.

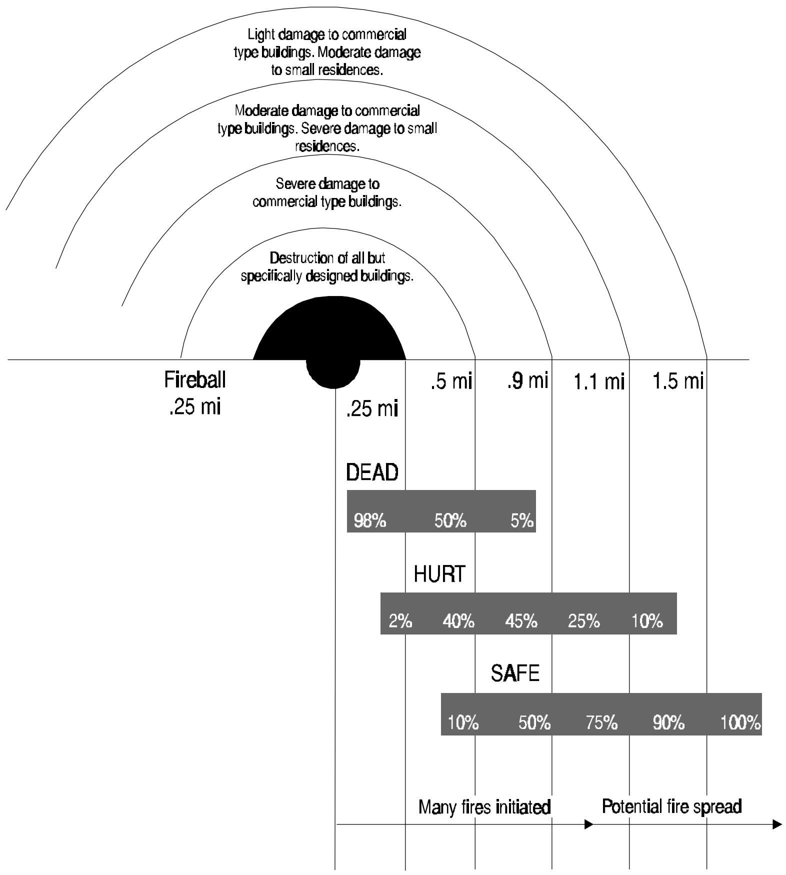
In a low yield surface burst, of the type possible in a terrorist attack, the amount of thermal energy reaching a target at a specific distance may be half to three fourths of that from an air burst of the same total energy yield. Thermal energy received at a distance will be affected by:

- Shielding due to buildings and terrain irregularities
- Absorption in low layer dust and water vapor
- Absorption by the heavier air near the earth’s surface

Blast or Shock Effect

Nuclear explosions are similar to conventional explosions to the extent that their immediate destructive action is due mainly to **blast or shock**. The rapid release of energy within a small enclosed space causes a considerable increase in temperature and pressure. All materials present within this space are converted into hot, compressed gases. These highly compressed gases expand rapidly, causing a **shock wave** in the surrounding medium (air, water or earth). The shock wave drives air away from the center of the explosion. This action produces sudden changes in air pressure that can crush objects and create high winds that can knock people and structures down. The shock wave is characterized by a sudden increase in air pressure at the front, followed by a gradual decrease.

DIRECT EFFECTS OF 10 KT BLAST (SURFACE BLAST)



Shock Wave Effects On Air Pressure

The resultant shock wave from a nuclear explosion can destroy buildings and other structures for miles around. For example, .25 miles (0.4 km) away from a 10 kiloton blast, the air pressure could exert an excess force of over 5 pounds per square inch (psi). This 5 psi (0.35 kg/cm^2) "overpressure" is the same as a force of over 180 tons (160,000 kg) slamming against the side of a typical two-story house. At the same place, there would be a wind of 160 miles per hour (260 km per hour). Although your body could withstand overpressure up to 30 psi (2.1 kg/cm^2), the winds accompanying an overpressure of as little as 2 to 3 psi (0.15 to 0.21 kg/cm^2) could blow people out of a typical office building.

Practice Exercise

33. The power of a nuclear explosion is expressed in terms of its relationship to ________________________________.

34. The total effective energy released during a nuclear explosion is called the weapon's _______________.

Nuclear Radiation

The third form of energy released by a nuclear blast is **nuclear radiation**. The radiation from a nuclear explosion is subdivided into two categories:

- Initial nuclear radiation
- Residual nuclear radiation (radioactive fallout)

Initial nuclear radiation is the radiation emitted within the first minute after a nuclear explosion. The initial radiation consists mainly of gamma rays and neutrons. As discussed earlier, these types of radiation are highly penetrating and travel great distances through air. Although they can neither be seen nor felt, gamma rays and neutrons can produce harmful effects even at a large distance from their source. The large quantity of gamma radiation absorbed by the surrounding air and ground will create a quick pulse of electromagnetic waves. This pulse, called the **electromagnetic pulse (EMP)**, is not considered a biological hazard to people. However, EMP will severely damage electrical components attached to power lines or communication systems.

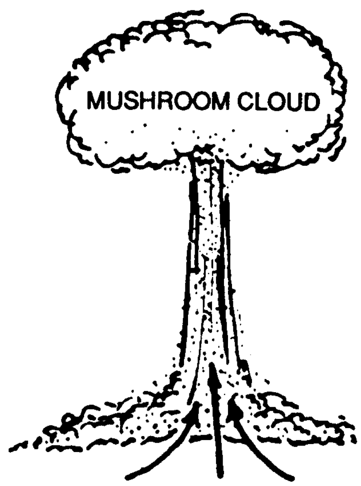
Residual nuclear radiation arises mainly from the radioactive materials produced during the blast. These radioactive materials, like all radioactive materials, attempt to become stable by emitting gamma rays, alpha particles, and beta particles.

Radioactive Fallout

Even if individuals are not close enough to a nuclear blast to be affected by the energy yield, they may be affected by the resultant radioactive fallout. Any nuclear blast will result in some fallout. Explosions that occur near the earth's surface create much greater amounts of fallout than explosions that occur at high altitudes.

How Fallout is Created

The tremendous heat produced by any conventional or nuclear blast causes an up-draft of air which forms the familiar mushroom cloud. When a nuclear blast occurs near the earth's surface, millions of vaporized dirt particles are also drawn into the cloud. As the heat diminishes, any radioactive materials that have been vaporized condense on the drawn-up dirt particles, which are also condensing.



Particles of Earth Drawn Up Into Mushroom Cloud

Eventually these particles fall back to earth. This phenomenon is called **radioactive fallout**. This fallout material decays over a long period of time, and is the main source of the residual nuclear radiation.

Hazards of Fallout

Radioactive fallout emits alpha, beta, and gamma radiation. Alpha particles emitted from fallout on the ground are not considered a serious hazard, since the source is outside the body. However alpha particles are harmful if the alpha-emitting source is taken into the body. The beta radiation which is much less penetrating than gamma radiation, may cause skin burns if the fallout remains on the body surface for a prolonged period of time. Exposure from the gamma radiation is considered the major hazard as a result of fallout.

The extent, nature, and arrival time of fallout are difficult to predict accurately due to variables such as:

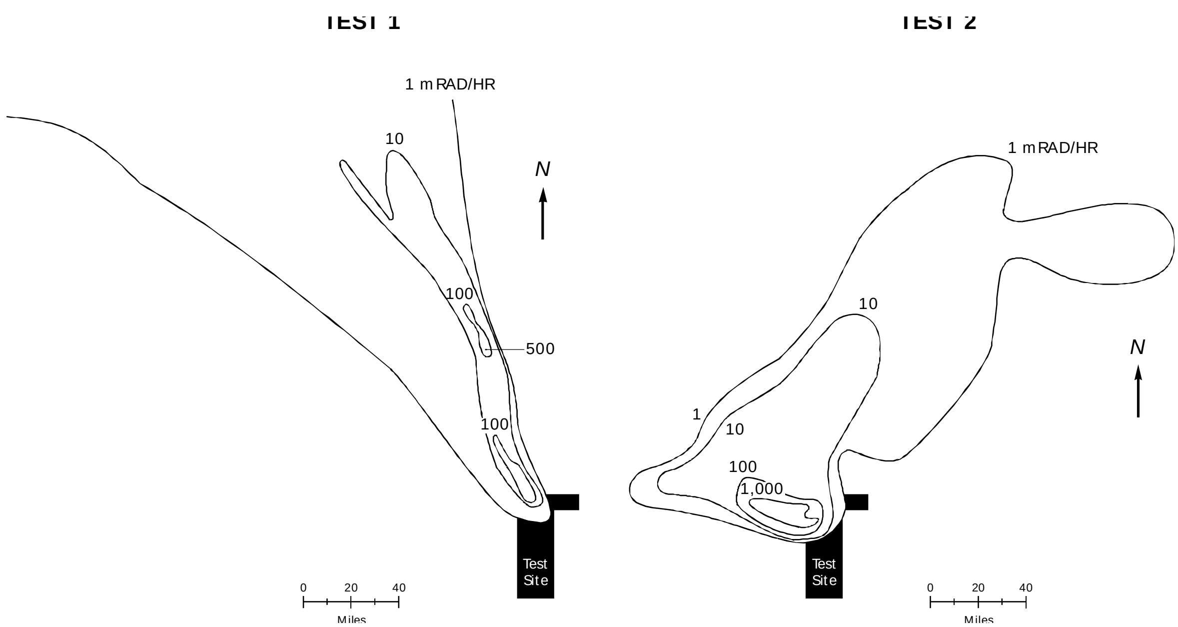
- Energy yield of the weapon--a more powerful bomb will produce more fallout.
- Height of explosion--a ground level blast will produce more fallout than an elevated blast.

- Nature of surface beneath explosion--some materials are more likely to become radioactive and to become airborne.

- Meteorological conditions--wind speed and direction will affect the arrival time of fallout; precipitation may wash out fallout from the atmosphere prematurely.

Distribution of Fallout

The irregularity of the fallout distribution is demonstrated in the figure below, which shows the fallout patterns of two separate Nevada weapons tests. The high altitude winds of the day play a major role in determining the fallout distribution pattern. In Test-1, the winds carried fallout predominately to the north. In Test-2, the winds initially carried fallout to the west, then shifted to the northeast. The numbers associated with each gradient of fallout represents the dose rate (in mRAD/hr) in that area.



Effect of High-Altitude Winds on Fallout Distribution

Emergency plans state that the expected time of fallout arrival will be announced during an official public warning. However, any notice of an increasing surface buildup of gritty dust and dirt should be a warning of a need for protective measures.

PROTECTIVE MEASURES

The previous section described the different types of hazards from a nuclear detonation. This section describes the types of protective actions one can take to minimize the harmful effects of an explosion. The protective actions against immediate blast hazards are much different than the protective measures against fallout.

Minimizing Immediate Blast Hazards

Within a certain radius of a given blast, total destruction of life and property from the blast and thermal effects is inevitable. High initial neutron and gamma radiation exposures may result in additional casualties. Table 4-1 below shows typical distances associated with certain effects of a 10 kiloton explosion.

Table 4-1
Distances of Effects From a 10 Kiloton Nuclear Bomb

Effect	Range		Area	
	miles	km	square miles	square km
Blast and Thermal				
Crater (everything is vaporized)	0.25	0.4	0.19	0.5
Destruction of brick structures	0.9	1.4	2.5	6.1
Destruction of wooden structures	1.5	2.4	7	18
Forest fires (dry conditions)	3-6	5-10	28-113	78-314
Nuclear Radiation				
Immediate death from initial radiation	.5	.8	1	2
Fallout sufficient to kill persons in the open	10	16	314	803

Obviously, the distance away from the blast is very important in determining survival chances. Within the most destructive radius, protection from the blast and thermal pulse is highly unlikely. If warned of an impending nuclear detonation, take shelter in the best protected facility available.

It is also possible to avoid blast effects and exposure to much of the thermal radiation if **evasive action,** such as falling face down behind a substantial object and shielding the eyes, is taken immediately. In certain circumstances it may mean the difference between life and death. Weapons tests suggest that a typical residence will be collapsed by an overpressure of about 5 psi (0.35 kg/cm^2). People standing in such a residence have a 50 percent chance of being killed by an overpressure of 3.5 psi (0.25 kg/cm^2), but people who are lying down at the moment the blast wave hits have a 50 percent chance of surviving a 7 psi (0.5 kg/cm^2) overpressure. This leaves the survivors of the blast with a need for protective measures against the radioactive fallout.

Minimizing Exposure to Fallout

Fallout, as you have learned, is radioactive material. This means that fallout emits radiation. This section describes how to minimize the dose of nuclear radiation one receives from fallout. The section begins by showing the important distinction between radiation and contamination. This section also describes how one can use the three factors of time, distance, and shielding to minimize dose. The section concludes with procedures that can be used enroute to a shelter and while inside a shelter.

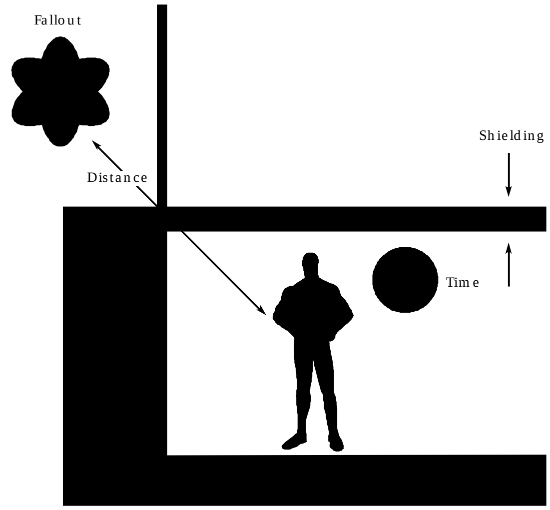
Contamination vs. Radiation

Radioactive material deposited in undesired locations is called radioactive contamination. The difference between contamination and radiation is important to understand. You can be exposed to radiation without becoming contaminated. When you are exposed to radiation, the radiation does its damage, expends all its energy, and is gone. If you carry contamination on your clothes or body, the material continues to emit radiation as long as it is radioactive.

Radiation is related to contamination in the same way that odor is related to manure and fertilizer. The following analogy illustrates this point. If you stand next to a freshly fertilized field, you can smell the fertilizer (manure). When you walk away from the field, you leave the odor behind. If you had stepped into the field, you would carry some of the fertilizer (manure) away with you on your shoes, and may be able to smell the odor of fertilizer until you clean your shoes. In the same way, if you stand next to contamination, you will be exposed to radiation. As long as you don't get the contamination on your body or clothes, you can walk away and leave the source of radiation behind. If you get contamination on your body, you will continue to be exposed to radiation until you wash the contamination off of your body. The radioactive material continues to emit radiation, but you are no longer carrying it with you.

Protection from Radioactive Fallout

As discussed in Unit 1, the three important methods of reducing radiation exposure are **time, distance, and shielding**. To minimize exposure to fallout, these methods are implemented by seeking shelter.



A Basement Provides Some Protection From Radioactive Fallout
-- Shelter Provides Time, Distance and Shielding

If a warning is given, or fallout starts to arrive, proceed to shelter that provides the best possible shielding. These include locations such as basements, interior rooms of a house, highway culverts, etc.

Remember that fallout consists of particles of earth, fission products and other materials returning to the earth's surface. If dust like particles are visible in the air or on surfaces, they should be considered a radiation hazard.

If fallout has arrived before reaching shelter, cover as much of the body as possible to keep particles from depositing on the skin. This should include, as a minimum, long sleeves, hat and gloves. If adequate clothing is not available or time not sufficient, make use of any available material such as newspaper to cover the head. Placing hands in the pockets help keep them as fallout free as possible. Remember that fallout particles that remain on the skin for several hours may cause skin burns.

When fallout particles are seen on clothing, brush them off. It is a good idea to minimize the amount of fallout transported into the shelter. Remember, radioactive fallout on a surface does not make the surface itself radioactive. The particles themselves are radioactive, not the surface they come in contact with. The surface can usually be cleaned of any contamination.

It is unlikely that enough fallout particles could be inhaled into the lungs to cause significant harm. However, if it is very dusty, a folded cloth over the nose and mouth may act as a filter. This can prevent some ingestion or inhalation of the fallout particles.

The primary objective at this point is survival. If it becomes necessary to take shelter, the outside exposure rate will be much greater than any fallout an individual could track into a shelter. Do not delay entry into a shelter for the purpose of removing fallout completely from clothing.

Actions Inside Shelter

Once safely in a shelter, secure all unnecessary vents or openings to prevent the wind from blowing fallout particles into the shelter. Unnecessary openings would be doors and windows since they are not necessary for the survival of the occupants. Ventilation passages must be kept open all or most of the time; they are considered vital to the survival of the shelter's occupants.

Contamination of food and water supplies is not a big problem. Public water supplies will generally be safe for use, and any food or water stored in a shelter should be used. Uncontaminated food and water supplies should be used first. Thereafter, contaminated supplies should be used. Do not keep anyone from eating or drinking on the basis that supplies may be contaminated. The remote health risks associated with consuming contaminated food and water are preferable to starvation .

Take every precaution to keep stored food and water from becoming contaminated by fallout particles. Keep water and food covered or in closed containers. Any water or food brought to a shelter from the outside should be carefully inspected for contamination. If contamination is visible or detected, wipe the outside of all containers. Fruit and vegetables should be washed if possible, and peeled or pared where applicable.

If it becomes necessary to perform urgent missions outside of the shelter, take every precaution possible to protect the body from fallout particles. Wear outer clothing that can be removed and disposed of upon return to the shelter. Plan your route and safe travel times in advance, and minimize the time spent outside the shelter. Finally, postpone ventures outside the shelter as long as possible to allow the natural radioactive decay of the fallout to reduce radiation levels.

Generally, the actions and measures that can be taken for protection from radioactive fallout, both inside and outside a shelter, are limited. However, when you take the time to consider the basic protective factors - time, distance and shielding - common sense will be your greatest asset.

Practice Exercise

35. The major hazard to the public resulting from radioactive fallout is exposure due to ____________________.

36. Radioactively contaminated food in a shelter (should/should not) be consumed if uncontaminated food is unavailable.

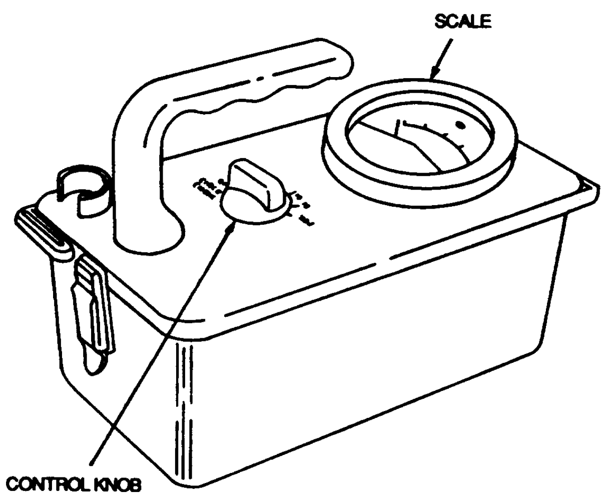
EXPOSURE RATE DETERMINATION

At some point after a nuclear detonation, sheltered personnel will find the need to begin performing outside operations (i.e., gathering additional food supplies or medical equipment). Such operations cannot begin until the exposure rate is low enough to support limited outside emergency activities without damaging those who leave the shelter. The proper evaluation of exposure rates and exposures is an integral part of public safety following a nuclear detonation, and the subject of the remainder of this unit.

Fallout particles accumulate on the ground, roofs of buildings, bushes, ledges, and all other surfaces exposed to the environment. As fallout accumulates, the unsheltered exposure rate will increase until most of the particles have fallen. At this point, exposure rates will begin to decrease with time due to **radioactive decay**. The decrease is rapid at first, then gets slower and slower. The exposure rates decrease according to the rate of radioactive decay.

Radiological Survey Instruments

The most effective method for determining exposure rates is with the use of **radiological survey instruments**. These survey instruments typically consist of a chamber in which nuclear radiation interacts, yielding an electric pulse or current, and electronic circuitry which converts the current into a meaningful readout. Most survey instruments maintained for emergency management are powered by standard D cell batteries making them portable and fairly easy to maintain in operational condition.



Radiological Survey Instrument

To determine exposure rates with a survey instrument, follow the operating instructions for that instrument. The procedure varies for different detectors.

The 7:10 Rule of Thumb

From the exposure rate determined by a survey instrument, future exposure rates may be predicted from a basic rule known as the **"7:10 Rule of Thumb."** The 7:10 Rule of Thumb states that for every 7-fold increase in time after detonation, there is a 10-fold decrease in the exposure rate, where the rate is the same unit as the time increase; i.e., 7 days, R/day.

Like any rule of thumb, the answers obtained are only approximations. Also, the rule assumes that the time of detonation is known and that fallout from only one detonation is present in relatively significant quantities. For accuracy and reliability, nothing can replace a direct instrument reading. However, depending on circumstances, it may become necessary to apply this general rule to predict when conditions may allow short trips outside a shelter.

Two example problems are worked out step-by-step. A third problem is presented for you to work on your own.

Example Problem 1

If the exposure rate 1 hour after detonation is 1,000 R/hr, what will the exposure rate be 343 hours after detonation?

There are three steps involved in solving this kind of problem. The first step is to determine the number of seven-fold increases in time after detonation between when the initial measurement was obtained and the future time of interest. The second step is to determine the expected magnitude of decrease during the time period of interest. The third step is to calculate the predicted exposure rate.

- Step 1: Between the initial measurement (taken 1 hour after detonation) and the future time of interest (343 hours after detonation), there are 3 seven-fold increases in time after detonation:

$$(1 \text{ hour})\,(7)(7)(7) = 343 \text{ hours}$$

- Step 2: During three seven-fold increases in time, the magnitude of decrease in exposure rates is 1,000-fold. One thousand was calculated by multiplying 10 by itself three times:

$$(10)(10)(10) = 1{,}000$$

- Step 3: The predicted exposure rate is 1 R/hr, which is 1,000 times less than the initial measurement of 1,000 R/hr. The solution for this step was performed as follows:

$$\text{Predicted exposure rate} = \frac{\text{Initial measurement}}{\text{Magnitude of decrease}}$$

$$= 1 \text{ R/hr}$$

For this example, the solution for this step looks as follows:

$$\text{Predicted exposure rate} = \frac{1{,}000 \text{ R/hr}}{1{,}000}$$

$$= 1 \text{ R/hr}$$

Example Problem 2

If the exposure rate 5 hours after detonation is 200 R/hr, what will the exposure rate be 35 hours after detonation?

- Step 1: There is one seven-fold increase in time after the detonation:

(5 hours)(7) = 35 hours

- Step 2: The expected magnitude of decrease in exposure rates is ten-fold (10 times itself once).

- Step 3: The predicted exposure rate is 20 R/hr, which is 10 times less than the initial measurement of 200 R/hr.

$$\text{Predicted exposure rate} = \frac{200\ \text{R/hr}}{10}$$

$$= 20\ \text{R/hr}$$

Example Problem 3

If the exposure rate 1 hour after detonation is 1,000 R/hr, what will the exposure rate be 49 hours after detonation?

- Step 1: Number of seven-fold increases in time =______________________________

- Step 2: Magnitude of decrease =______________________________

- Step 3: Predicted exposure rate =______________________________

The correct answers for each step, and their solutions, are shown below:

Step 1: Number of seven-fold increases in time = 2

(1 hour) (7) (7) = 49 hours

Step 2: Magnitude of decrease = <u>One hundred-fold</u>

(10) (10) = 100

Step 3: Predicted exposure rate = <u>10 R/hr</u>

$$\frac{1000\ \text{R/hr}}{100} = 10\ \text{R/hr}$$

Practice Exercise

37. After most of the fallout particles have accumulated, radiation levels will begin to decrease due to _________________.

38. If the exposure rate due to radioactive fallout is 50 R/hr six hours after detonation, the exposure rate expected after 42 hours is __________________.

39. If the exposure rate due to radioactive fallout is 1,000 R/hr one hour after detonation, the exposure rate expected after 49 hours is __________________.

UNIT 4 REVIEW

This unit described the hazards and protective measures associated with a nuclear detonation. The energy yield of a nuclear explosion takes the form of blast or shock, thermal radiation and nuclear radiation. Each of these energy forms has distinct hazards. Radioactive fallout presents a potential long term hazard after the immediate energy yield no longer threatens life or health.

Radiological survey instruments provide the most effective way to determine exposure rates. Once an exposure rate is determined, the "7:10 Rule of Thumb" can be used to predict future exposure rates.

UNIT 4 REVIEW QUESTIONS

Answer the following questions to review your knowledge of the Nuclear Threat unit. Read each question carefully and circle the correct answer.

1. Nuclear explosions share one similarity with conventional explosions in that their initial destructive action is mainly due to which of the following effects?

   a. Blast or shock

   b. Thermal radiation

   c. Nuclear radiation

   d. Fallout

2. The total effective energy released during a nuclear explosion is called the weapon's:

   a. Thermal release

   b. Nuclear release

   c. Yield

   d. Radioactivity

3. The major hazard to the public resulting from radioactive fallout is exposure due to:

   a. Alpha particles

   b. Beta particles

   c. Gamma rays

   d. Neutrons

4. Identify which of the following actions should be followed if radioactive fallout begins to arrive before an individual reaches adequate shelter.

    a. Immediately take the closest shelter available and wait for fallout to cease.

    b. Adjust clothing to cover as much of the skin as possible and proceed to adequate shelter.

    c. Stand still to avoid excessive contact with fallout particles and proceed once fallout has ceased.

    d. No action necessary, since neither alpha nor beta particles can harm people.

5. Which of the following is a true statement concerning food and water supplies in a fallout shelter?

    a. Consume contaminated food and water first.

    b. Do not consume any contaminated food or water.

    c. Do not prevent food or water consumption on the basis that they might be contaminated.

6. The phenomenon which accounts for the decrease in fallout exposure rates over time is called:

    a. Radioactive decay

    b. Acid rain

    c. Spontaneous fission

    d. Fusion

7. The most accurate and reliable tool for determining exposure rates is:

    a. Fallout dust color

    b. 7:10 Rule of Thumb

    c. Survey instruments

    d. Exposure probes

8. Most radiological survey instruments are powered by:

    a. AC line current

    b. High voltage AC current

    c. Solar energy cells

    d. Batteries

9. Using the 7:10 Rule of Thumb, how long will it take an exposure rate of 1,000 R/hr, measured l-hour after detonation, to decrease to 10 R/hr?

    a. 7 hours

    b. 10 hours

    c. 49 hours

    d. 100 hours

10. If the exposure rate due to radioactive fallout is 60 R/hr five hours after detonation, the exposure rate expected after 35 hours is:

    a. 2 R/hr

    b. 6 R/hr

    c. 30 R/hr

    d. 40 R/hr

UNIT 4
REVIEW ANSWER KEY

1. a
2. c
3. c
4. b
5. c
6. a
7. c
8. d
9. c
10. b